THÈSE

En vue de l'obtention du

DOCTORAT DE L'UNIVERSITÉ DE TOULOUSE

Délivré par :
Université Toulouse 1 Capitole (UT1 Capitole)

Discipline ou spécialité :

Sciences économiques

Présentée et soutenue par :
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le : 30 septembre 2010

Titre :

New contenders in the large commercial aircraft manufacturing industry

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Ecole doctorale :
Midi-Pyrénées Sciences Economiques (MPSE)

Unité de recherche :
CRM

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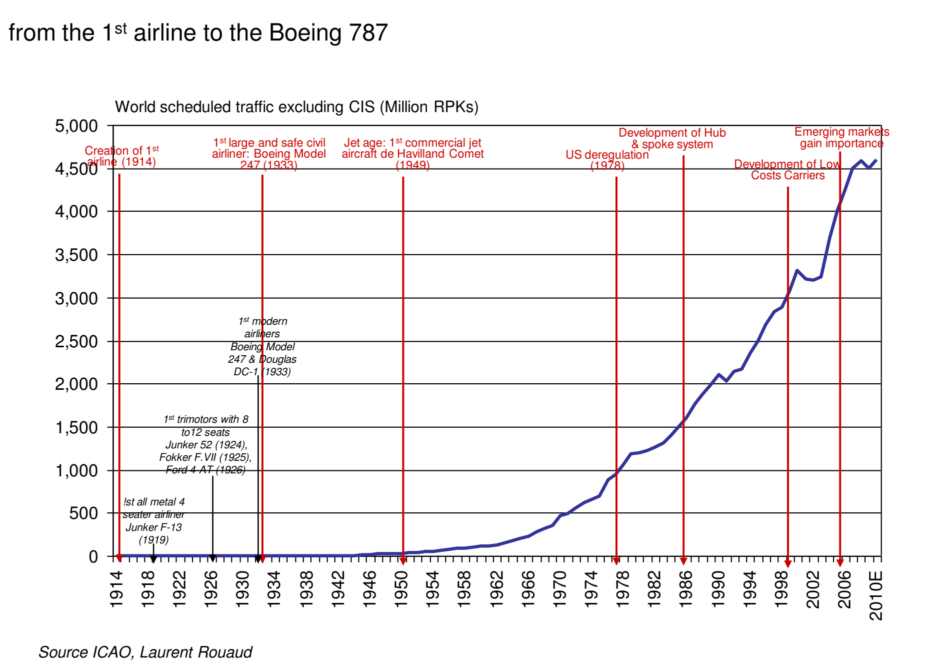
PART 1: The Large Commercial Aircraft Duopoly

I The air travel market

<u>I-1 The beginning of air travel: From 1913's Safety First to today's Kingfisher Airlines</u>

The most important developments in air travel were: (1) the first airline, (2) the first large and safe piston engines airliners, (3) the jet age, (4) the deregulation, (5) the development of the hub-spoke system, (6) the low costs airlines, and (7) the new emerging markets. While the first two have come and gone, deregulation is still ongoing in some markets such as India and even looming in others such as China. The low cost airlines (LCC) are still in their development stage except in Europe and North America.

Figure 1: World air traffic development 1914-2010



I-1-1-A First major development: The first airline

The first commercial airline named "Safety First" was created in December 1913 in Tampa Florida, only 10 years after the Wright Brothers first flight[1]. On January 1, 1914, Safety First started the true first commercial flight between Tampa and St. Petersburg on a Benoist airboat, a 34km trip across the Bay of Tampa that took 23 mn instead of the hours long trip by boat. The Ex-mayor of St. Petersburg, A. C. Pheil, became the world's first scheduled airline passenger when he bid $400 for the first flight. Mr. Noel E. Mitchell was second, with a $175 bid[2].

Figure 2: Benoist Airboat from St Petersbourg Historical Museum

The line which was subsidized by Florida business men, made two daily flights, six days a week. The regular fare was $5 per person and $5 per one hundred pounds of freight or express carried. Shortly after the opening of the line, a new Benoist airboat was added which had an improved front on the hull that protected its occupants from water spray during take offs and landings. The line then extended and flights made to Manatee, Bradenton and Sarasota. Most passengers were either local businessman or celebrities from the entertainment industry. A total of 1,205

[1] Mousseau J (2003), Conquering the sky, 1903 to 1933, Perrin, Paris
[2] Clark James, (2000) A quick look at Florida History

passengers were carried without injury and while the line did not make any money, the airline idea proved sound.

Besides Safety First, there were very few passenger services in the early 1920s. Most airlines at that time were carrying mail. The limited payload of the aircraft of the time was too small to develop a profitable passenger service business[3].

The world first civil airplane is considered to be the Junker F13[4], an all-metal low wing, mono-engine German airplane capable of carrying 4 passengers that first flew in June 25th, 1919. It became the world's first all-metal airliner and it seems to be the first aircraft, which was fully designed as a passenger aircraft. A total of 322 Junker F13s were produced between 1919 and 1932 and delivered to 70 airlines outside Germany. The highest annual production rate was reached in 1925 with a total of 68 aircraft built during that year (geocities). The main airlines that operated the Junkers F13 included AB Aerotransport (Sweden), Ad Astra Aero (Switzerland), Aero-Express (Hungary), Aerolot (Poland), Aeronaut (Estonia), Aero O/Y (Finland), Aero Traffic (Switzerkand), CSA (Tchekoslovakia), Deruluft , Deutsche Aero Llyod, Deutsche Luft Hansa (Germany), Dobrolet (URSS), Junkers Luftverkehr (Germany), LARES (Romania), Lloyd Aero Boliviano, Ölag (Autria), Pacific Airways (Canada), Sabena (Belgium), SAM (Italia), SAP (Portugal), SCADTA (Colombia), Sindicato Condor (Brazil), Transadriatica (Italia), UAE (Spain), Union Airways/South African Airways, Varig (Brazil) and Western Canada Airways. The Junker F-13a (wing extended 2.9m vs F-13) were capable of flying at 195km/h with 4 passengers over 930kms.

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[3] Blowers P (1966) Boeing aircraft since 1916, Putman, London
[4] Jane (1970), All the world aircraft

Figure 3: Junker F-13 in 1926

The Junker was soon followed by the Fokker monoplane high wing aircraft that was capable of flying 5 passengers. Although, these two aircraft were principally used for mail service, their technology definitely led the way towards the first breakthrough in civil air transport: the tri-engine aircraft. The tri-engine aircraft were bigger, capable of carrying up to 9-12 passengers, faster and much more robust than their predecessors. In 1924, Junker flew its first tri-engine low wing airplane, the JU-52/3m, followed 1 year later by Fokker's tri-engine high wing aircraft, the Fokker F.VII.

Fokker Tri-motor F.VII 1925

Junker 52 in Lufthansa livery

In 1926, Ford used the metal structure of the Junker and the high wing concept of the Fokker F.VII to build the Ford Trimotor 4-AT and 5-AT. The Ford Trimotor was an all aluminum corrugated sheet metal body and wing with fabric covered control surfaces. The Ford 4-4T were capable of flying a crew of 3 and 8 to 9 passengers. A total of 199 Ford Tri-motors were built between 1926 and 1933, including 79 of the 4-AT variant, and 117 of the 5-AT variant, plus some experimental aircraft. Well over 100 airlines in the world flew the Ford Tri-motor. The 5-AT had the more powerful Pratt&Whitney engine equipped with 12 seats with a cruise speed of 115 mph, a -13,500 lb. maximum gross take-off weight and a range of 560 miles.[5] The Ford Trimotor was popular with the military and is considered as the aircraft that launched modern civil air travel. Like the cars and tractors, these Ford aircraft were well designed, relatively inexpensive, and reliable. While Ford did not make a profit on its aviation business, Ford's reputation leant credibility to the infant aviation industry, and Ford helped introduce many aspects of the modern aviation infrastructure, including paved runways, passenger terminals, hangars, airmail, and radio navigation. Transcontinental Air Transport, which later became part of Trans World Airlines, used the Ford Trimotor to begin its transcontinental air service from San Diego to New York in 1929.

Figure 4: Ford5-AT

[5] Jane 51970), All the world aircraft

Figure 5: Interior of a Ford5-AT

Table 1: Ford Trimotor specification

Crew: 3 (1 Flight Attendant)
Capacity: Eight passengers
Cost: US$42,000 in 1933
Maximum take-off weight: 13,500 lb (6,120 kg)
Powerplant: 3× Pratt & Whitney 9-cylinder, 420 hp Performance
Maximum speed: 150 mph (241 km/h)
Cruise speed 90 mph (145 km/h)
Range 550 mi (885 km)
Ceiling 18,500 ft (5,640 m)

In Europe, the first airline was KLM, the oldest international airline of the world still in operation. The first KLM commercial flight transported two English passengers from London to Amsterdam on May 17th 1920 with a De Havilland DH-16 aircraft. From 1920, KLM development was essentially due to the need to link its extensive colonies settlements. KLM 1st intercontinental flight took off from Amsterdam for a 2 weeks journey to Batavia (now Jakarta) on a Fokker F.VII. Regular Amsterdam-Batavia service started as early as 1929.

Figure 6: 1st KLM flight London-Amsterdam 1920

In Britain, the airline Aircraft Transport and Travel started the world's first regular international flight between London to Paris on August 1919. New routes opened to Brussels and Amsterdam but the companies struggled without government support while across the channel continental competitors received generous help.
In December 1920, Air Transport and Travel ceased operations, and in February 1921 all British airlines ceased operations due to subsidized European competition. In March 1921, a temporary Government subsidy was granted and British air services restarted with Handley Page Transport operating the first subsidized London-Paris service. In 1924, Imperial Airways was created as the "chosen instrument" of the British government with the mission of developing British commercial air transport on an economic basis. Imperial Airways received a government subsidy of £1 million spread over ten years on the basis that they would be required to develop routes to the Empire to South Africa, India and ultimately Australia particularly for the carriage of mail.

In Asia, it is only in 1941 that the first airline, Philippine Airlines founded in 1941, started daily service with a Beech Model 18 aircraft between Manila and Baguio. Philippines Airlines were credited with a number of "first" in the Asia aviation history, most notably the first transpacific charter flight on July 31 1946 and regular transpacific service between Manila to San Francisco in December of the same year. Using a DC-4 with stops in Guam, Wake Island, Johnston Atoll and Honolulu, Hawaii.

I-1-2-The second major development: The first large and safe piston engines airliners and the start of competition in airline service

The Ford Trimotor can arguably be consider as the first airliner, however, only a few were developed. As in most subsequent commercial aircraft programs throughout history, the first successful US commercial aircraft program came from the US government stimulation from its military requirement that manufacture use as an opportunity to develop commercial application. In 1929, the US Army awarded The Boeing Company a contract to build the new B-9 twin engine bomber aircraft. The design was converted into the Boeing 247 with two new Pratt & Whitney engine. The much improved performance, comfort level, payload and safety quickly established the B-247 as the first modern airliner. The first prototype flew on February 8th 1933. With a range of 745miles, the Model-247 was able to fly from New York to Los Angeles in under 20 hours with as many as 7 stops, a real progress considering the 70 hours journey by train.

Table 2: Boeing Model 247 Specifications

First flight:	Feb. 8, 1933
Model number:	247
Classification:	Commercial transport
Span:	74 feet
Length:	51 feet 7 inches
Gross weight:	13,650 pounds
Top speed:	200 mph
Cruising speed:	189 mph
Range:	745 miles

Ceiling:	25,400 feet
Power:	Two 500-horsepower P&W Wasp engines
Accommodation:	3 crew, 10 passengers, 400 pounds of mail

The subsequent modern airliner came to life as a combination of 2 factors: (1) the spectacular and much publicized crash of a TWA Fokker F-10A trimotor monoplane in a thunderstorm over Kansas on March 31st 1931 and (2) the exclusivity arrangement Boeing had with the first operator of its Model-247 (Jane's): United Aircraft and Transport (now United Airlines.).[6]

Figure 7: Boeing Model 247

The crash obtained much media attention at that time as it killed everyone onboard, and in particular, a famous American football coach, a last minute passenger that replaced another passenger that was a witness in a gang related crime in Chicago. Structural failure of the wing was listed as the probable cause of the crash.

Shortly after the conversion of the B-9 bomber into a dual military – commercial program with the Model-247, Boeing received an order for 60 passenger transport aircraft from Boeing wholly owned airline: United Aircraft and Transport, one of the

[6] Jane (1970), All the world aircraft, 1970

first US airline (United Airlines remained a subsidiary of Boeing until 1934). Because of the Model 247 significant advance in technology compared to the Ford ad Fokker previous model, the exclusivity arrangement with United conferred a tremendous competitive advantage to the airline vs. TWA, its main competitor at the time. Boeing had rejected a demand from TWA to purchase its Model-247, an unthinkable practice in today's market conditions.

The Model 247 was clearly seen as a breakthrough in the development of civil air transport. It allowed the realization of its potential as a new form of efficient long distance transportation throughout the US. United Airlines competitors understood that the airlines with the best equipment could generate huge profits. This pushed TWA, under the initiative of Jack Freye, TWA Vice President Operations, to ask in 1932 for a major American airplane manufacturer included Consolidated, Curtis Wright, General Aviation, Glenn Martin and Douglas Aircraft Corporation to build a competitor to the Boeing 247.[7]

TWA specifications for the airplane was already a step change compared to the Model 247. TWA needed a fast plane and a safe plane but also a plane that could maintain sufficient altitude to cross the high mountains of the Rockies. Passenger comfort was also a high priority including the issue of interior noise control and cabin temperature. Because of its competitor advance, TWA was also in a hurry Douglas Aircraft Corporation was a small military aircraft manufacturer that started only 11 years before with small military aircraft, with no experience in the civil market. However, Donald Douglas [8]was determined to outstrip the model-247 in size and range. In less than 2 months, Douglas submitted a design to TWA that the airline accepted The contract called for a payment of $125,000 in gold for development of the first prototype and $58,000 for each of the production airframe (without the engines). Douglas designed the DC-1 prototype, a multicellular wing

[7] McDonnell Douglas (1990), A tale of two giants,
[8] Douglas Aircraft Company,(1963) A condensed history of Douglas Commercial Transports DC-1 through DC-9

and a monocoque fuselage powered by 2 Wright Cyclone engine fitted with a Hamilton Standard variable-pitch propeller. In June 1933, less than one year after TWA contacted Douglas Aircraft Corporation, the DC-1 prototype rolled out of Douglas hangars of Santa Monica California and completed its first flight on July 1st 1933. The 1st DC-1 was delivered to TWA in December 1933. All TWA specifications were met with the DC-1 bringing a step change in terms of passenger comfort. TWA promptly gave Douglas a $1,625,000 contract for 25 additional airplanes that will be called the DC-2. In 1935, the DC-1 in TWA operation set a new transcontinental US record, covering the Los Angeles to New York distance in 11 hours and 5 mn.

Figure 8: Douglas DC-1 in TWA livery

Table 3: Specification of Douglas DC-1

First flight:	July 1, 1933
Wingspan:	56 feet
Length:	60 feet
Height:	16 feet
Ceiling:	23,000 feet
Range:	1,000 miles
Weight:	17,500 Pounds
Power plant:	Two 710-horsepower Wright engines
Speed:	190 mph
Accommodation:	2 crew, 12 passengers

Figure 9: Interior of a DC-2

The speed, comfort, and reliability of the DC-2 brought air transport acceptance by the general public to a new level. Air travel was no longer considered as a risky luxury but as a serious means of transportation. Anthony Fokker, one of the greatest European aircraft designers of that time, bought a license to sell DC-2 in Europe. KLM was the first European airline to fly the DC-2 between Amsterdam and Djakarta of the Netherland East Indies at the time. A total of 156 DC-2 were manufactured. More importantly, the DC-2 was the precursor of what is still seen today as one of the most successful civil program: the DC-3. The DC-3 was capable of flying up to 28 passengers over 1,495 miles in even greater comfort than of the DC-2. Quickly, the DC-3 performance brought commercial success and superseded the Boeing Model-247. Even, United Airlines, the exclusive Model-247 customer, saw the advantage of the DC-3 and become the second US operator. By 1939, 93% of the world’s air traffic was performed on DC3s. World War II pushed the DC-3 program to military application. More than 10,000 DC-3s would be manufactured, better than any aircraft program to date.

I-1-3 The third major development: the jet age

The technology principle of jet engines was known as early as 1928 by Frank Whittle but the metal that a jet engine would have required had not been developed at the time. Whittle were able to build his engine in 1937 when he was supplied with Stayblade steel and a new nickel-chrome alloy. [9]

At about the same time in Germany, Pabst von Ohain, a student, brought a similar idea to airplane builder Ernst Heinkel. A few years later, the first test of a jet-driven airplane took place on July 3, 1939, when the Heinkel He- 176 jet plane flew in front of Hitler and Goring, and the entire Luftwaffe top Command.

The war was instrumental in bringing jet engine to air transport. The first airliner application of the jet engine was done by the British on a turboprop-powered aircraft, the Vickers Viscount, which flew for the first time in 1948. In a turboprop, the propulsion is provided by a propeller that is not driven by a combustion engine, but by a jet engine that turns a turbine connected to a propeller shaft. British European Airways was the first operator of the Vickers Viscount that began service in July 1950. The Vickers Viscount type 700 could transport up to forty-eight passengers, at a cruising speed of 308 mph (496 km/h). A total of 445 Vickers Viscounts would be built.

The turbojet engine is the basic engine of the jet age. It works by compressing air, forcing it into a combustor, which sprays fuel on it and ignites it. The air burns continuously like a blow torch, through the turbine, which extracts energy to work the compressor, and out the back to thrust the aircraft forward.

[9] Allen Roy, (1961), Pioneering the big eight, Aeronautics

Figure 10: De Havilland Comet 1

The supremacy of British jet engine technology brought the first jet airliner shortly after. While American plane makers such as Lockheed, Douglas and Boeing were still producing piston engine airplanes, the British had the lead in jet propulsion technology. In 1949, the De Havilland flew the first jet airliner: the Comet 1. The Comet 1 could carry 36 to 44 passengers in great comfort, fly above the turbulent area at 35,000 feet, 50% faster than the most rapid piston engine powered aircraft such as the DC-6 (490 mph for the Comet compared to 315 mph for the DC-6B). New York was only twelve hours flying time away from London instead of the eighteen hours it took piston-engine planes. The world's first commercial jetliner, the Comet, began service on May 2, 1952 between London and Johannesburg. The clean design, the great comfort and speed made the Comet an instant success to the flying public. The Comet 1 had three developments each bringing higher thrust engine, higher take-off weight and longer fuselage to accommodate more payload. The Comet 4 was able to fly up to 81 passengers. However, the public and airlines' enthusiasm for the Comet stopped after a series of fatal crashes. In 1954 two Comets crashed in the Mediterranean and service on the plane was suspended. Extensive investigation revealed that metal fatigue was the cause of the crashes. The repeated re-pressurization would weaken the Comet's square-shaped windows, causing high pressure cabin air to burst through the slightest fracture, ripping a large slice in the aircraft's wall. Of the thirteen aircraft lost in fatal accidents, five were considered to have been caused by aircraft design or fatigue problems. In 1954, all Comets were grounded until the line of jets could be redesigned. The redesign of the Comet was completed in 1958, but De Havilland would never recover from the public perception created by the previous crashes. A total of 114 aircraft were completed and flown: 12 Comet 1s, ten Comet 1As, 15 Comet 2s, one Comet 3, 74 Comet 4, and two maritime patrol versions. [10]

After the Comet accidents, the Soviets were the fastest to develop a jet airliner. Stalin ordered its aircraft industry to produce a jet airliner to match the Comet for prestige reasons and to reduce travel times across the immense 11-time-zone country. Quickly, Tupolev produced a simple airliner, called the TU-104, based on its Tu-16 Badger twin jet bomber. The Tu-104 flew for the first time in 1955, a year after the 707 prototype, but beat the 707 entry into service by 2 years, beginning in 1956.

However, the unfortunate design problem of the Comet allowed the American manufactures to regain some of the lost ground in jet engine technology in the early 1950s to become the undisputed leader of the jet airliner age. As many of the Boeing commercial programs, the development of its first jet airliner was closely linked to its military program.

Boeing developed its jet engine aircraft experience with 2 military contracts: (1) the B-47, and (2) the B-52. The origin of the B-47 Stratojet can be traced back to the Second World War. In June of 1943, an informal USAAF request led several aircraft manufacturers to begin studies of multi-jet aircraft for fast photographic reconnaissance or medium bombing missions. On November 17, 1944, the USAAF issued formal requirements for a jet-powered medium bomber with a range of 3,500 miles, a service ceiling of 45,000 feet, and a maximum speed of 550 mph.

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[10] DMS market intelligence report(1965), The Comet, February

Even before the end of World War II, the US Army Air Forces (USAAF) was also looking forward to a next-generation strategic bomber to follow the huge Convair B-36, then in development. In late 1945, the USAAF began evaluating their requirements for such a new bomber, and in 1946 issued a formal specification for it, specifying greater speed than the B-36 and an operational radius of 8,050 kilometers (5,000 miles) Boeing responded with a six Wright "T35" Typhoon turboprop engines aircraft. USAAF liked the idea, and on 5 June 1946 awarded Boeing a study contract for the machine, which was presently given the military designation "XB-52". However, after several version of full size mock-up the USAAF were on the verge of cancelling the project. In June 1948, Stalin imposed a blockade on Berlin, bringing the Cold War on in earnest. The Air Force immediately brought the B-52 project back to the front burner, awarding a contract for a mock-up and two flying prototypes, with the first prototype to be ready by early 1951. Government funding began to ramp up. USAF was no longer interested in turboprop propulsion, as it couldn't provide adequate performance. The Air Force wanted now a jet-powered aircraft. [11]

The insight, the skills and the facilities derived from the development of the B-47 and B-52 were most directly applied by Boeing to develop its first commercial jet, the 707.

Boeing plan was to develop an aircraft with dual military/commercial use, satisfying the Air Force requirement for a jet-powered air-refueling tanker and the airline with a large jet airliner. The Air Force development funding will help defray costs, and to economize by building both types on the same assembly line. The prototype first (Boeing Model 367-80) flew on 15 July 1954, and the initial aircraft off the production line were military KC-135A flight refueling tanker/transports. The Model 367-80 or Model 80 (that became the 707 in its airliner version used the same basic design specifications (aerodynamic and structural features) as the B-47

[11] Jane (1975), All the world aircraft

and B-52 bomber. The Air Force ordered a first batch of 29 KC-135 Stratotankers to replace its propeller-driven tankers.

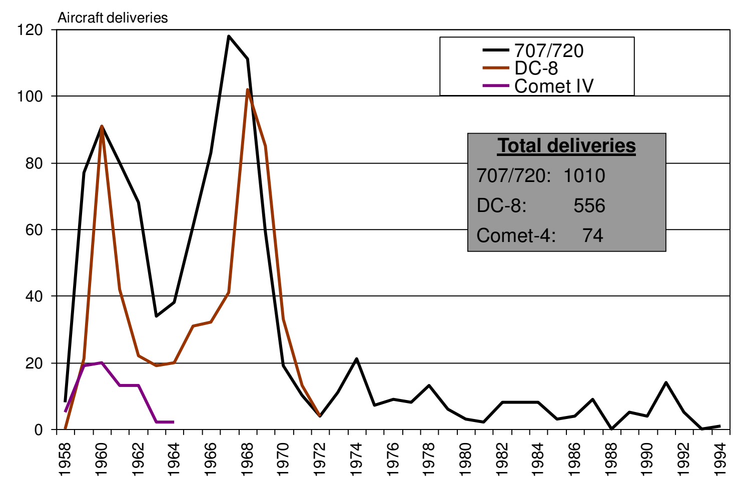
Figure 11: Boeing 707

Meanwhile, Douglas with its solid reputation as commercial aircraft builder with the successes of the piston engined DC series, started to offer its first jet airliner, the DC-8.[12] The DC-8 was faster, larger in length and a wider fuselage of 147 inches capable of accommodating comfortably six seats per row. PAA and American Airlines initial response to the 707 was that they wanted six-across passenger seating, longer range, and more powerful engines. Because of competitive pressure, Boeing decided to widen the 707 for six-across seating to 148 inches, 1 inches wider that the DC-8. Similarly, to compete against the more capable DC-8, Boeing offered several fuselage lengths, larger wings for more range, and more powerful engines. Pushed by competitive pressure, Boeing had to develop a family of 707 models, that unknowingly will lead them to the 707 great successes. The first production airplane of the Boeing 707 commercial jet series made its maiden flight December 20, 1957, with Pan American World Airways putting the airplane into transoceanic flight, from New York City to Paris, on October 26, 1958, and American Airlines

[12] Aviation daily (1966), Douglas DC-8, April

following with transcontinental service January 25, 1959. A total of 1010 Boeing 707 will be produced, installing Boeing as the prime airliner manufacture in the jet age.

Figure 12: Deliveries of the first three jet airliners



Source: Boeing, Douglas, Laurent Rouaud

The 720 is a smaller capacity, lighter, medium range variant of the 707, given its own model number to indicate significant engineering changes

Table 4: Specification of Boeing 707

Wingspan	145 feet 9 inches (44.42 m)
Length	152 feet 11 inches (46.6 m)
Wing Area	3,010 square feet (280 m^2)
Gross Weight	336,000 pounds (152,400 kg)
Cruising	607 mph (977 km/h)
Range	6,160 miles (9,913 km)
Service	36,000 feet (10,973 m)
Power	Four Pratt & Whitney JT3D turbofans of
Passenger	141 passengers mixed class or a maximum

Air travel in its modern form took off following the availability of jet aircraft. As for the Benoist aircraft in 1919, the Junkers, the Fokker F.13, the Ford Trimotor and the DC3, the 707, and the DC-8, the supply of aircraft that brought step changes in aircraft technology, efficiency and comfort resulted in demand for air travel. After the jet age though, it is the demand for air travel and competition between manufacturers that brought the availability of new aircraft, a more logical market relationship. The jet age contributed to bring air travel to a wide range of socio-economic population and most importantly the ease of international long-haul travel. Worldwide air traffic almost quadruple in the 10 years following the jet age, typical of today's emerging market.

I-1-4-The fourth major development: the US deregulation of 1978

In the 5 years prior to the US deregulation, air traffic growth decrease slightly to 9% per year. In 1978, only about 30 airlines were operating in the US. In the 40 years prior to deregulation, the federal government set fares and determined which carriers served which markets. The US airlines deregulation was a crucial development not only for the air transport industry but was also the precursor of deregulation of the entire US industry such as the US railroads,[13] banking, and telecommunications. It was also important because it set the motion and model for deregulation in other countries.

Prior to deregulation

Regulation of airline passenger service started in the US with the creation of the Civil Aeronautics (CAA) in 1938 and reorganized into the Civil Aeronautics Board (CAB) in 1940 [14]. At that time, an airline had to demonstrate that its entry was required by "Public Convenience and Necessity" before offering scheduled service. There were 16 airlines in the US before the 1938 regulation. Those 16 airlines

[13] Caves R, Christensen L, (1980), Productivity growth in US Railroads, Bell Journal of Economics, Spring Vol. 11, Number 1
[14] Levine M, (1965), Is regulation necessary, California Air Transportation Policy, Yale Law Journal, Volume 75, July

evolved through merger and acquisition into only 10 airlines by 1976. The high growth of air travel resulted in many application from potential airlines to enter the market, however only one airline were allowed to start operation during the 1938-1978 regulation period (Northeast Airlines). The CAB was also not so permissive regarding new services for existing airlines. The certificate to open new route for existing carrier was not granted if the same route was already served by another airline if the incumbent carrier were to object on the ground that it would cause "financial hardship".[15] Most routes were in monopoly situation. Furthermore, regulation was also controlling fares through two mechanisms: (1) approving, modifying or rejecting fares changes requested by airlines and (2) by setting directly the fare or a range of fare allowed. Although route and fare were regulated, the number of frequencies and the quality of service or amenities were not regulated. As a result, airlines could only engage in non-pricing competition through frequency and quality of service. Only limited opportunities existed for new carriers except through (1) very local service, (2) non-scheduled carrier or jet services and (3) intra-state carrier that was free from the CAB regulation. The local service airline became commuter airlines that later took advantage of the new small jet aircraft such as the ERJs or CRJs of Embraer and Bombardier in the 1990s. The non-scheduled airlines became the competitors of the trunk airlines on international routes.[16] The intra-state carrier such as Southwest, were able to experiment with different level of fare and service and to become the new entrant of the post deregulation era as they evolved into interstate carriers. Southwest Airlines, which started in Texas, was an intrastate airline that had the freedom of setting its own fares. Southwest Airlines fares level depended on peak and off-peak timing of demand, charging more in peak and less in off-peak demand. Southwest Airlines, in particular, has become the most profitable airlines of all the US airlines ever. Intrastate airlines started to draw passengers that would have otherwise travelled

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[15] Meyer J, Peck M, Stenason J and Zwick C, (1959), The economics of competition in the transportation industries, Cambridge, MA, Harvard University Press

[16] Meyer John and Oster Clinton (1984), Deregulation and the new airline entrepreneurs, The MIT press

by car. Because it used mostly secondary airports, were flying their equipment back and forth on the same route with high utilization, fast turnaround service, simplified scheduling and maintenance, the intrastate airline developed themselves as the low cost operators of the regulated era. They used the same equipment of the larger interstates regulated airlines, with a denser seating configuration, higher load factor and much higher aircraft productivity. There also had low labor and operating costs which contributed to higher profitability than any of the larger inter-state carriers. Not only did Southwest become a model for the post deregulation era in the US, but it also inspired new low coasts airline that came in the US starting in the mid 1990s and in Europe in the late 1990s (Easy jet, Ryanair for example) up to today and the foreseeable future.

US Deregulation of 1978: the new rules

Classic Schumpeterian [17] suggests that capitalistic innovations from entrepreneurship contribute to expand general economic welfare and that regulations prevented the introduction of new or different market concepts from entrepreneurs.Very few market meaningful initiatives were taken during the period of regulations, and certainly none in providing a better product at a better price. Deregulation, however, quickly unleashed a lot of airline entrepreneurs in the Schumpeterian sense as it can be judged but the number of airline in operation in the US after 1978.

From 1979 to 1981, the entering airlines were not required to demonstrate that its entry was required by "public convenience and necessity" as it was prior to 1978. Instead, the opposing party was required to demonstrate that the entry were not "consistent with public convenience and interest". After 1982, entry has been granted to all new carriers that were "fit, willing and able." On January 1st 1983, all regulations on fare were eliminated. Quickly, entrepreneurs took advantage of the deregulation. In the 5 years following the deregulation, as many as 20 airlines were

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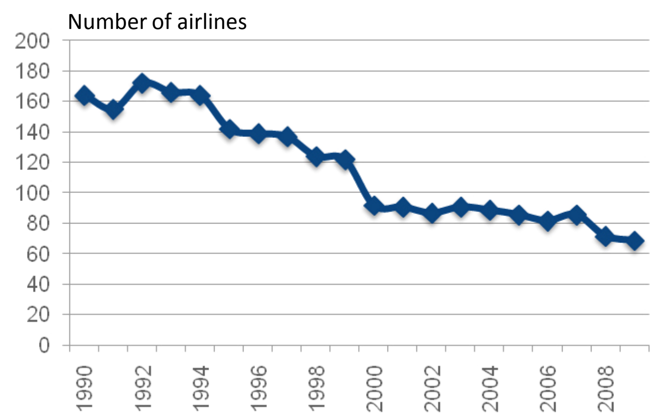
[17] Schumpeter J.A (1934), The theory of Economic Development, Harvard University Press, Boston

created in the US. From a few dozen of airlines in 1978, the US counted 45 airlines in 1983 and as many as 160 in 1990. In the 1990s, a wave of consolidation reduced the number of airlines, some big brand name such as TWA and Pan Am disappeared.

Figure 13: Airline consolidation in the US after 1990



Source : OAG, Laurent Rouaud

Morrison and Winston (1989) showed that the short terms welfare effect on the merger between competitors was negative, and that the production efficiently that the merger may have permitted did not seems to have been reflected in price. The merger did provide market power.[18] Howard (1988)[19] indicated that the top 10 airlines in the US had a market share of 93% prior to deregulation. Deregulation had some short terms effect in reducing the concentration to 85% in 1984, but the mergers brought it back to 95%; higher level than prior to deregulation.

[18] Morrisson Steven and Winston Clifford,(1989), Enhancing the performance of the deregulated air transport system, Brooking papers on Economics Activity: Microeconomics, page 61-112
[19] Howard, L. (1988). 'The Changing US Airline Picture in Transport Research', Washington, The Future of Aviation, circular no. 329

The effects of airline deregulation in the US

The deregulation effect on the US air transport system has been extensively researched. Generally, it is recognized that the US liberalization has led to (1) traveler welfare through lower fare and more flight frequencies, (2) greater airline profitability, (3) greater efficiency of labor and equipment and (4) more convenient service[20] and (5) increase of entrepreneurship that introduced low-frills , low-fares service in the short to medium haul market of the US.

Traveler welfare

Among the most valuable post deregulation studies that measure the benefits of deregulation, the work from Morrisson and Winston (1986) is probably the most thorough of all. Their study, published in a book called The Economic Effects of the Airline Deregulation, shows that travelers on every market experience a net welfare gain from deregulation on average through lower fares and higher service through additional flight frequency. However, the benefit is subject to a large variability by route. The welfare gain seems to be the highest in large markets from hub to hub and the lowest in small secondary city to secondary city type of routes. The loss in small markets, though, was generally compensated for by a gain from an increase in flight departure available to the travelers and therefore more convenience. This tends to contradict some pre-deregulation research and general consensus that deregulation would bring lower fares but will translate into lower quality of service. Business travelers seem to have gained in all markets with a decrease of fares in most markets and the benefit of better departure choice from the development of hubs and spoke network that is directly attributable to the effect of deregulation. Morrisson and Winston (1989) demonstrated that the traveler net gain in terms of travelers welfare was on average $10.6 per trip and distributed by a fare decrease that counted for 30%, a better travel time that contributed to 8% and the value of

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[20] Morrisson Steven and Winston Clifford,(1986) The economics effects of airline deregulation, The Brookings Institution

having better frequency contributing to 62%. On the total network, it was estimated that the gain in welfare was 5.7 billion of USD, or 35% of the actual 1977 US airline revenues.

Greater airline profitability

Morrisson and Winston (1989) measure the efficiency that deregulation brought to airline by looking at the financial performance of carriers before and after deregulation. They estimated the gain in airline operating profit to be $2.5 billion for 1977 alone, on total revenue of $16.3 billion. The higher profit margin were the result of airlines being able to (i) increase load factors through the use of yield management in establishing fares and (ii) to increase the productivity of their aircraft from the efficiency of the hub and spoke system.

Greater efficiency of airlines' equipment

The adoption of the hub and spoke system by the major US carriers have resulted in significant better utilization of their most expensive assets which are (i) the aircraft fleet and (ii) their flight crews.[21]

Hub and spoke network was developed extensively after deregulation since airlines were free to start any routes and because it was a way to maximize profit by lowering cost through economy of scope.[22]

To illustrate the economy created by a hub-and-spoke route network vs. a pure point-to-point network, let's consider an airline network with 2 hub airports and 5 secondary airports. To link all airports together, a hub-and-spoke network will only require 11 flights, where the pure-to-point network will require as many as 66 flights.

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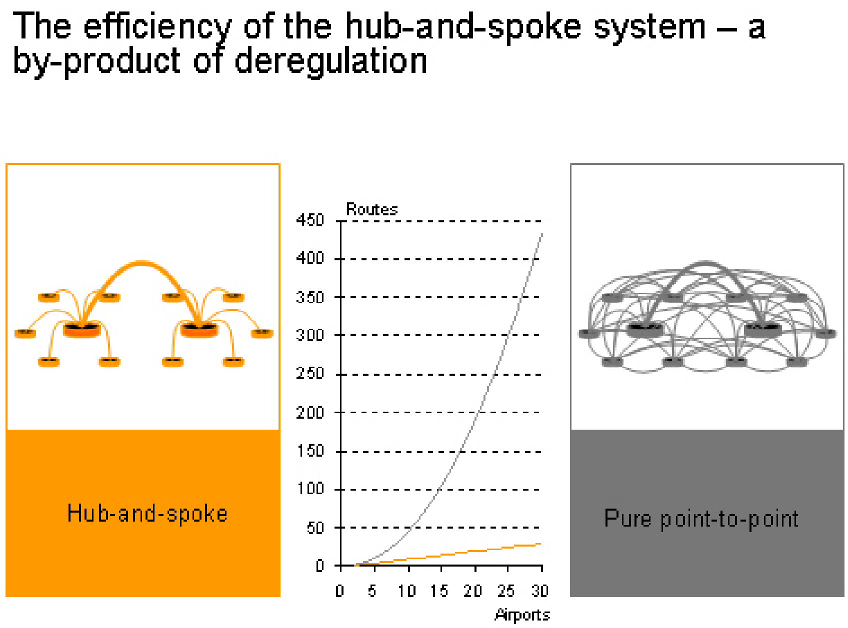
[21] Abramowitz A, and Brown M, (1990), The effects of hubs dominance and barriers to entry on airline competition and fares, US General Accounting Office, October

[22] Levine M, (1987), Airline competition in deregulated markets; Theory, firm, strategy and public policy, Yale Journal of Regulation, Volume 4, Number 2,

Figure 14: Hub and spoke system



The benefit of hub-spoke network from an economy of scope standpoint comes from the use of larger more efficient aircraft in term of operating cost.[23] To satisfy the demand of travelers and regulatory authorities for minimal service in the pre-deregulation, airlines had to dispatch small aircraft with often little load factors between secondary cities. One of the effects was that the non-stop route did not grow as fast as traffic grew. Gordon (1992)[24] showed that although non-stop service has increased on the top 500 routes, the number of non-stop routes have not kept up with traffic growth.

The hub and spoke system had an effect on aircraft size. Small aircraft are much less efficient in carrying the same output than a larger aircraft. A typical 50 eater jet such as the Bombardier CRJ for example will typically cost 8 cents per available seat miles (ASM) to operate, vs. 5.8 cents for a typical 100 seater such as the MD80 and less than 5 cents per ASM for a 150 seater such as the 737-700 or A320. By linking secondary cities to a hub with larger aircraft while carrying the same demand

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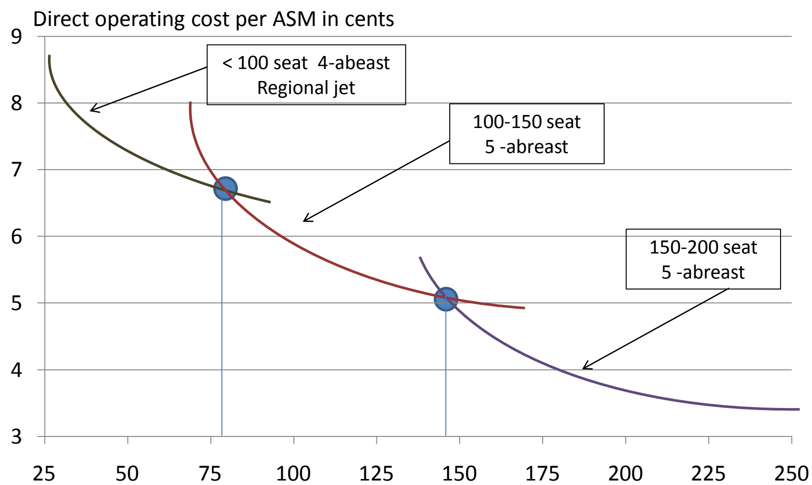
[23] Steven B, (1990), Airport presence as product differentiation, Yale University, discussion paper
[24] Gordon Robert (1992), Productivity in the transportation sector, University of Chicago, 1992

overall, airline were able to derive substantial cost reduction.[25] Brown [1991][26] showed the clear relationship between fleet composition and route structure in both the pre- and post-deregulation periods. Douglas and Miller's also showed that deregulation resulted in larger aircraft at the hubs. [27]

Figure 15: Economy of size of using larger jet on hub



Source: Laurent Rouaud

The hub and spoke system was made possible by deregulation. It brought efficiency in term of quality of service and airline profitability.[28] It also re-enforced the incumbent carriers position at their natural hubs by increasing the economy of scale and prevent potential entrant to start operation. Francis McGowan and Paul

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[25] Douglas, George W. and Miller, James C. (1974) *Economic Regulation of Domestic Air Transport: Theory and Policy,* Washington, D . C : The Brookings Institute

[26] Brown, John Howard (1993) 'Relative fleet composition under regulation and deregulation', International Journal of Transport Economics

[27] Douglas, George W. and Miller, James C. (1974) Economic Regulation of Domestic Air Transport:Theory and Policy, Washington, D . C : The Brookings Institute

[28] Gillen, David W., Oum, Tae H., and Tretheway, Michael W. (1985) Airline Cost and Performance: Implications for Public and Industry Policy, Vancouver, Canada: Centre for Transportation Studies, University of British Columbia

Seabright (1989) commented that the mergers in the US following deregulation created economy of scale from economies of aircraft size and route density.[29]

In summary, both travelers and airlines have gain substantial welfare benefits with deregulation. If those gains are certain, it has not come as a result of increase competition as the idea of deregulation. The following chapter examine why the idea of contestability and the argument that potential competition affect incumbent behavior , although attractive at the time, has (1) failed to occurred and (2) that free entry and free exit in the airline industry is a myth.

I-1-5 Is the airline market a contestable market?

The notion of contestable[30] market is one of the pillars of the justification for deregulation.[31] It suggests that the potential threat of market entry of new entrants is sufficient to keep the incumbents behave. To be perfectly contestable, the market must satisfy several conditions: (1) absence of entry barriers[32], (2) no sunk cost at the exit, (3) the potential entrant should be able to enter and exit before the incumbent could react in decreasing fares and (4) the number of actual competitors on a particular route does not affect prices.

Entry barrier

The hub-spoke network described below resulting from deregulation provided a efficiency gain for the installed airlines and will generally lead to a dominant carrier at a particular hub.[33]

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[29] McGowan Francis and Seabright Paul (1989), University of Sussex and University of Cambridge Deregulating European airlines, Economic Policy October

[30] Baumol William Panzar Jonh and Willig Robert (1982), Contestable markets and the theory of industry structure, Harcourt Brace Jovanovich Publishers, Orlando Florida

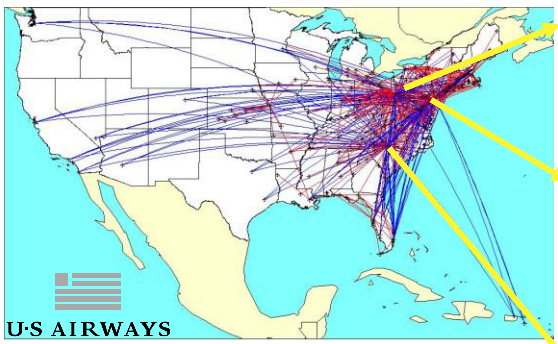
[31] Borenstein Severin, (1989), Hubs and high fares: airport dominance and market power in the US airline industry, Rand Journal of economics, Autumn, 20; 344-365

[32] Tirole Jean (1988), The theory of industrial organization, The MIT Press, Cambridge

[33] Brueckner J Dyer N and Spiller P, (1990), Fare determination in airline hub-and-spoke networks, University of Illinois Working paper, June

Figure 16: Market power at the hub

USAirways hub advantage before merger with AWE



Pittsburg	Pax share
USAirways	88.9%
Delta	2.8%
Airtran	2.1%

Philadelphia	Pax share
USAirways	69.0%
American	7.1%
Delta	6.6%
United	4.8%

Charlotte	Pax share
USAirw ays	92.2%
American	1.9%
Delta	1.7%

Source: Laurent Rouaud

Brueckner and Spiller (1992) [34] showed that there is a strong link between marginal cost and fares to traffic densities on the spoke of an airline network. They confirm the existence of economies of density identified first by Cave [35](1984) They succeeded in showing that the gains from density are partially passed on to the passengers in lower fares, and therefore highlighted the potential benefit of deregulation. As the airlines organize their route structures to increase traffic density, they also lower their costs and possibly their fares. They also show that carriers with large networks have a significant cost advantage over their smaller competitor unable to achieve significant density.

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[34] Bruekner J and Spiller P (1992), University of Illinois, Fares network 'Feed': Estimating economies of traffic Density in airline hub and spoke systems
[35] Caves, D;W, L. R Christensen, and M.W Trethway, "Economy of density versus economy of scale: why trunk and local Service airline costs differ", Rand Journal of Economics, 15, 471-489 (1984)

Eight out of the ten major US cities are largely dominated by 1 or 2 carriers. United for example, controls 48% of the total traffic from and to Chicago, 54% from San Franscisco and 63% from Denver. The only 2 major hub cities where the concentration is much lower than the average are New York JFK and Los Angeles. The concentration of airline at their hubs confers a significant market power. The hub dominant airline is able to provide more frequencies to other hubs and spokes of its network and therefore is able to provide a more convenient schedule for its customers and charge higher price.

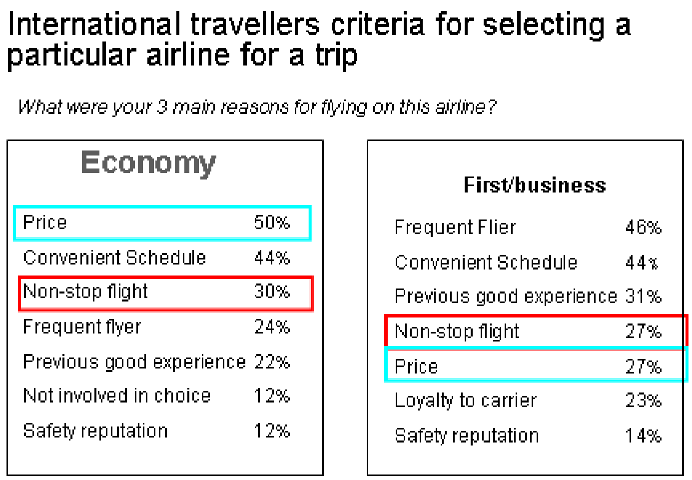
It is only in the late 1990 that the barrier of entry proved to be more elusive with the entree of jetBlue, Airtran, Frontier, Spirit, and other successful low cost airlines. As seen earlier, their business model avoided the head to head competition at the hub by flying from and to secondary airports. These airlines are operating in a low cost culture across their operation, some 50% lower than their legacy competitors.

Just after deregulation, the extensive route network of airlines allow their customers to take advantage of the dominant airline frequent flyer program and use its rewards throughout the larger dominant airline network of routes. This alone is a powerful tool to keep its customers captive. It is even more so for the business traveler from which the dominant airline will be able to retain and capture the high yield revenues that an entrant would not be able to capture.

The US Department of Commerce Survey of International air travelers [36] shows that the first criteria for selecting an airline is pricing for both tourists and business passengers , convenient schedules and frequent flyer programs are also very important in the selection of airline for a particular trip.

[36] International Tourism Administration's Survey of International Air Travel

Figure 17: Airline criteria of choice



An airline frequent flyer program is an efficient tool to make the passenger living around the airline home hub captive. Frequent mileage passenger will prefer to take their local hub airlines as their offer more connection at their home city hub.[37] The local airline will control a majority of slots at its hubs would sometimes lease contract that would allow the dominant airline to prevent additional gate construction. Banerjee and Summers (1987) showed that frequent flyer programs lower the cross eleasticity of demand between products reducing the incentive for competitive price cutting.[38]

No sunk cost at exit

Peteraf [39] argued that there are little evidence of sunk cost influencing monopoly pricing behavior in the airlines. She shows that price costs margins drop an additional 6% to 13% in the presence of price cutting potential entrant. She

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37 United States General Accounting Office, (1990), Airline Competition:industry operating and marketing practices limit market entry, Washington, GAO/RCED 90-147

38 Banerjee Abhijit and Summers Lawrence, (1987), On frequent flyer programs and other loyalty inducing economics arrangement, Harvard Institute of Economic Research, Discussion paper, 1337, September

39 Peteraf,Margaret (1995), Sunk costs, contestability and airline monopoly behavior, Review of Industrial organization, 10: 289-306,

suggests that sunk costs in monopoly airlines are not low enough to constrain prices. Furthermore, Morrisson and Winston (1987) [40]showed that a potential competitor in a market has from one tenth to one third competitive impact on incumbents. It appears that if the sunk costs are small then an incumbent can respond in price and quantity as quickly as a competitor can enter. The incumbent will have therefore no incentive to respond ahead of time of the start-up airline entry [41] and enjoy full incumbency rents without fear of hit-and-run entry. [42]

Large incumbent airlines established prior to deregulation had established a complex computer reservation system that allowed them to optimize their fare and share fare information with the travel agents in real time. In 1984, Delta Air Lines employed 150 people in their reservation system that would adjust price daily to maximize the airline profitability to adapt in real time its fare to its other competitor that share their fare in the system. Before deregulation each carrier had its own reservation system. The development of the reservation system led to 3 giant of the CRS: Sabre, Apollo and System One that controlled 80% of ticket sales. The CRS accelerated the concentration of the airline post deregulation. The CRS has also led to another management of the airline bottom line. CRS allowed yield management that seeks to maximize revenues on each flight rather than the total traffic of an airline. The airlines that were member of a CRS had the possibility to do yield management The yield management optimizes the fare class distribution to maximize the high contribution passengers. In the case of potential competition, the technique of yield management allows the carriers that master them to attract more high contribution passenger through its CRS. The new entrant, with no access to the CRS will therefore be doomed to access the low contribution passengers. The carrier strongly present at a particular hub, controlling the CRS, can protect himself against

[40] Morrisson Steven and Winston Clifford (1987), Empirical implications and tests of the contestability hypothesis, Journal of Law and Economics, April, volume 30, page 53-66
[41] Stiglitz Joseph (1987), Technological change, sunk costs, and competiton, Brooking paper on Economic Activity: Microeconomics, volume 3, page 883-937
[42] Schwartz M and Reynolds R (1983), Contestable markets: an uprising in the theory of industry structure, American Economic Review

entrant even if the potential competitor is more efficient. Although United Airlines' costs were 33% higher than its new entrant and competitor People Express with 17% higher revenues per mile, it succeeded in protecting itself against more productive competitor. It will be therefore not possible for a potential entrant to enter and exit before the incumbent could react by decreasing its fare. Because of the CRS, the incumbent can answer almost immediately. The CRS system of the 1980s and 1990s made collusion among airline possible. The system could show on the CRS that it was planning to increase its price sometime in the future. If the other airlines implemented the same price then the airline will implement the price change. If none of the airlines followed, then the first airline that proposed the price increase will not implement it. Evans and Kessides (1991) showed that CRS, with its multimarket contact had a significant effect on price. They find that it raised a round trip ticket price on domestic route by more than 20$. [43]

Because of the CRS barriers, the post deregulation has not been kind to the start up carriers in the US. Many went out of business within a few years they started operations. Western Pacific, Jet train, Air South, Nation Air Sunjet and Air 21 are a few example.

In Europe, McGowan and Seabright (1989)[44] showed that the airlines prior to the European deregulation faced the same issue regarding CRS. Some 80% of all European airline booking were made at that time through travel agent, and 80% of all travel agents' booking were made through CRSs. Levine (1987)[45] showed that the asymmetric information in combination with market power at the hub was very costly to startup airline prior to deregulation.

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[43] Evans Williams and Kessides Ioannis (1991), Living in the golden rules: multimarket contact in the US airline industry", University of Maryland, Working paper, January

[44] McGowan Paul and Seabright Paul (1989), Deregulating European airlines, Economic Policy, October, page 284-344

[45] Levine Michael (1987), Airline competition in deregulated markets: theory, firm strategy and public policy, Yale Journal on Regulation

Start up carriers faced many other costs disadvantages. The major airlines have lower costs for fuel, insurance, capital and airport facilities in addition to the economy of scale associated with the fixed overhead needed to run an airline. The only advantage the start ups had at that time was that the cost of labor was significantly lower than established carrier whose salaries and benefits have increased steadily over the years as more employees achieved higher level of seniority. In addition established carriers were burdened by unproductive union contracts that have carried from the pre-deregulation era.

The most basic problem preventing start up carriers from operating efficiently was their lack of significant capital. Even though the airline business is capital extensive, new carriers typically were beginning operations with only about $10 – 25 million in initial capital. As a result, the start ups were forced to take very short term approach in making business decisions. Their primary goal were to preserve their limited cash rather than making the long term investments necessary to create an efficient, low cost operation for the long term. The short term focus led to higher costs, poor customer service, low branding and marketing position. The new entrant will have typically started operation with older equipments acquired through the use of operating leases. This was usually the only possible option because of their low capital. Over the long run, this type of leasing is a more expensive option, because leasing companies charged higher lease rental to cover the greater credit risk of start ups. In addition, leasing companies generally required start up carriers to make security deposit and pay engine and airframe maintenance reserves well in excess of the actual amounts that will be required for maintenance. The additional maintenance reserve would be an additional monthly cash burden while the security deposits further tie up the airline's already limited capital. The initial capital constraint that led to lease older equipment will also burden the airline in higher fuel costs, noise charges, and especially poor reliability that will result in flight delays and low customer satisfaction. Furthermore, the limited use and investment in technology resulted in considerable computer downtime in the start up reservation center and airport check-in counters.

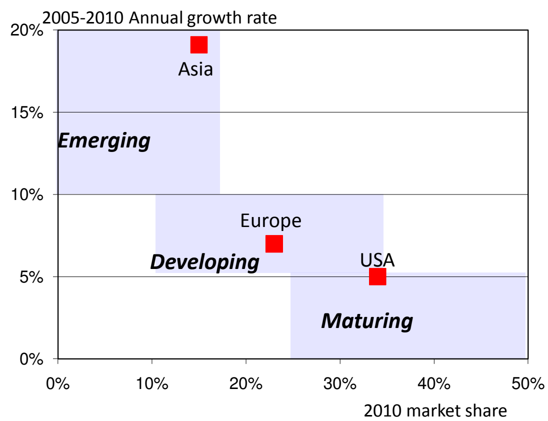
As a result, immediately after the deregulation and up until the late 1990, the idea of the airline industry as a contestable market proved to be false.

In the late 1990s and the early 2000s, however, the airline industry re-invented itself through the successful entry of many start up low cost carriers. Finally, the great idea of contestability at the base of the deregulation finally verified itself. It succeeded then, essentially because of the new available technology that overcame the CRS barrier and because of a radically different business model. At the core of the new business model was the high initial capital that the new entrant will be able to raise. It would further confirm that the sunk costs are high but do not constitute a barrier to entry.

I-1-6 The fifth major development: the Low Cost Carriers emergence

All low cost airlines (LCC) emergence are the result of markets deregulation. However, as the previous chapter indicated, deregulation alone was not a sufficient condition to make them successful. It is only 10 years after deregulation that the internet, the secondary airport strategy, the access to capital, and the new aircraft fleet made the entry of LCC successful. Technology made it possible. The first low cost airline were Southwest that started as a small regional and evolved after the US deregulation to become an airline offering extensive network all over the US. In fact, Southwest Airlines is today the largest airline in term of aircraft demand In Europe, the first LCC was Ryanair. Today, with Europe open sky, Ryanair network extends over Western and Eastern Europe In the 1990, LCC expanded rapidly throughout Europe as the European market were deregulating. The final stage of global LCC development is currently happening in Asia/Pacific. The domestic Australian market is already 60% LCC. Airlines such as Air Asia in Malaysia are rapidly expanding beyond its country border, but at the pace of bilateral country deregulation. Other low cost airlines in Asia include the Singapore highly competitive segment. The LCC airline model is still in its developing phase in Asia with about 12% of the total market. However, the pace of its development will stay steady as more market deregulate especially in the very dynamic 12 countries of the ASEAN[46] association.

Figure 18: LCC in different stage of maturation



Source: Laurent Rouaud

There is not a unique LLC business model across the globe or even across a market. In the US, there are mostly 3 models of LCCs. The oldest one is the Southwest model that flies almost exclusively to secondary airports of main cities. Southwest network is made of mini-hubs. Their entire enterprise culture is based on low cost principle throughout their operation and focuses on the leisure market. The second US model of LCC focuses on short haul traffic from one or a few strong hub. Airtran based in Atlanta is an example of this type of model. These LCCs will typically have a 2 class cabin with a business class of up to 12 seats. It selects its route opening based on pricing and type of demand on a particular city-pair. It will particularly choose city-pairs that have a high price business or leisure traffic. The third LCC model in the US

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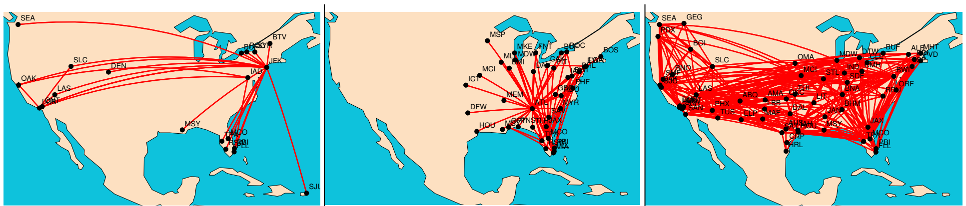
[46] ASEAN countries include Indonesia, Malaysia, the Philippines, Singapore , Thailand, Brunei, Burma (Myanmar), Cambodia, Laos, and Vietnam

will typically be the jetBlue model. Such a model, focuses on a few secondary hubs, but fly longer distances across the US. Its branding is generally very strong, well financed and with 2-class of service.

Figure 19: LCC business model in the US



- Focused on 1 or a few hubs
- Point to point
- Long haul
- Product amenities
- Strong branding
- Strong franchise
- 1-class of service
- Well financed

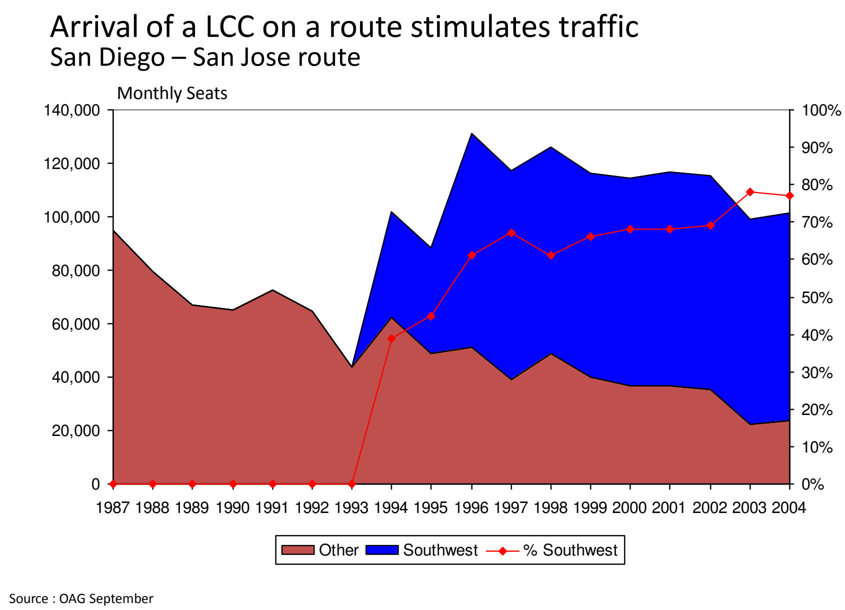
- Short haul
- 1 strong hub
- Mix class (up to 12 bus. class seats)
- Primary and secondary airports
- Enter large business center suffering from high business fare
- Strong low cost culture (a lot of 1person dpt)
- mostly booking through internet

- Multi mini hubs
- Point to point
- Short & long haul
- Focus on high density route to secondary airport
- Strong low cost culture
- Focus on leisure traffic

Source: Laurent Rouaud

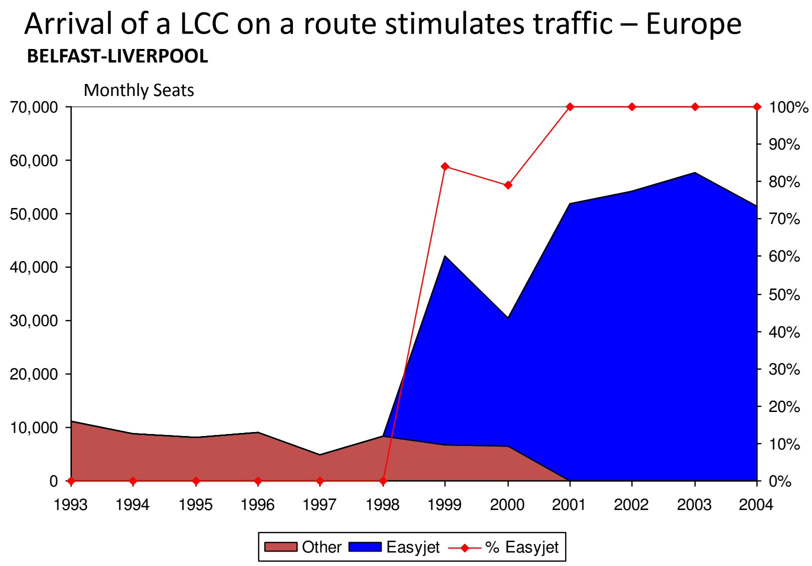
These three models will be able to propose low fare to their markets because of their very low cost culture. They will fly one single type of aircraft to minimize their training and reduce their maintenance costs. They will generally fly shorter segments than their legacy airline competitors. They will operate from secondary airport to drive airport costs to a minimum. They will have a very engaged and productive staff. Finally, they will grow quickly in their first 5 to 8 years of operation to establish critical mass as soon as possible.

Figure 20: Effect of entry of a start-up airline -US



As it can be expected from a contestable market such as the airline business, the low entry cost, and the better offering stimulates traffic and increases the public choice for service. The example above shows Southwest airline penetration of the San Diego to San Jose route in 1993. At that time there was one incumbent airline on this route that was not compelled to offer additional service as it enjoyed a monopolistic market price. The traffic was relatively stable, even decreasing as alternative routing using a multistep route became available and cheaper. The incumbent airlines were offering 60,000 seats per month in 1992. One year after entering the route, Southwest stimulated the traffic by a factor of 2, grew its market share to 76% while offering more service and better price. It has been established that in Europe, the LCCs are also stimulating the traffic.

Figure 21: Effect of entry of a start-up airline – Europe

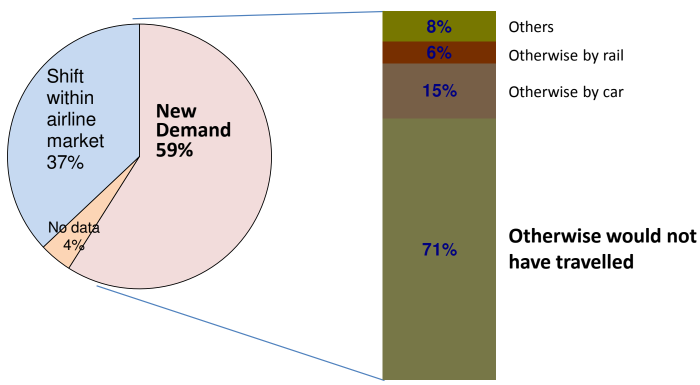


Source : OAG September

The Easyjet example on the Belfast to Liverpool route is even more dramatic. The incumbent airline traffic had been fairly constant offering 10,000 seats per month at premium price. In 1998, Easyjet decided to enter the under supply, over priced Belfast market with a very competitive pricing of 50$ per trip. Shortly after, Ryanair steadily increased its market share to 100% by 2001 and stimulated the traffic, multiplying the volume by six times over the 1997 level.

Figure 22: New entrant created new demand by lowering fares

Source of demand stimulation (European LCCs)



Source: NFO infratest, 2002, Monitor Group Analysis, Laurent Rouaud

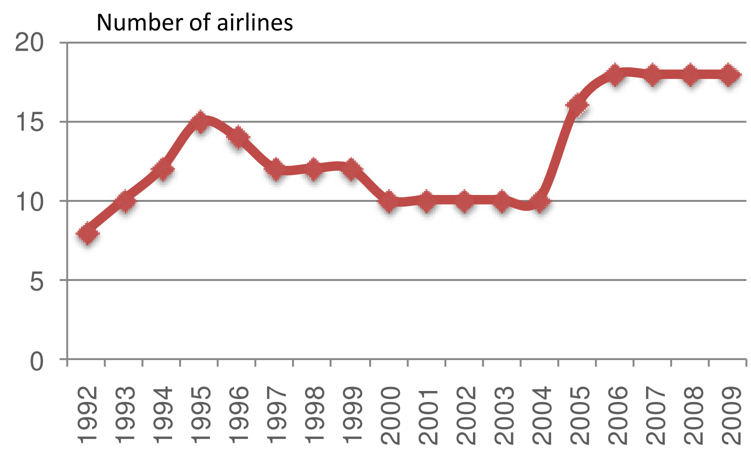
Market stimulation has been the source of numerous studies and models in the airline world. NFO infratest, in its Monitor Group Analysis has shown that as much as 59% of the LCC traffic is created by new demand or travelers that would not have flown if there were no offer from LCC. In fact as much as 71% of it would have not travelled at all, and the other 29% would have drove or taken the train.

In emerging countries, the stimulation of traffic has come from a transport mode shift to air. In Mexico, the vast bus long distance network has been the source of traveler capture of air travel. In India, the extensive railway network throughout the country has been the source of stimulation of traffic of air travel by transferring from rail to air. Often, the air alternative is the same of slightly higher priced that the other mode while cutting time door to door by an average of 5 hours.

For example, it would have taken a typical Chinese factory worker from the urban coastal town of Wenzhou to his home town Nanchang, about 3 days by bus to come home in an uncomfortable and overcrowded bus . The bus ticket price was 120$.

Today, the same worker could take a direct flight with Sichuan Airline and be in his hometown in about 2 hours and 30mn in a comfortable aircraft for 95$, or 30% less than the bus ride.

Figure 23: Number of airlines in India

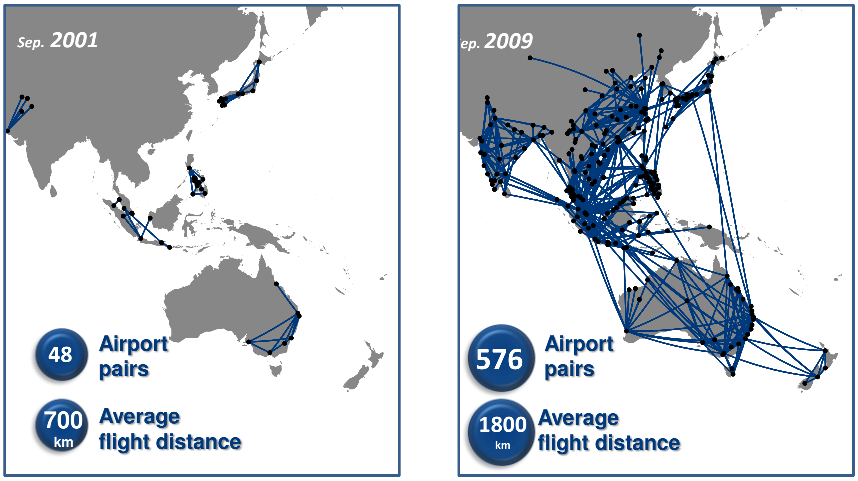


Source Laurent Rouaud

In India, the entry of the LCC changed air travel of the masses. Before 2004, the 1700 kms trip between the mega cities of Delhi and Mumbai would have had to be either with a very uncomfortable train ride for 23 hours or with an expensive airline. At that time, the first class ticket on the train would have cost 3750 Rupees, a the second class train 1775 rupees, while the legacy airline fare was 8475 rupees. In 2004, Air Deccan and other LCCs entered the market and prices on the Dehli-Mumbai air route dropped from 8475 to 2900 rupees. The travel time was reduced from 23hrs to less than 90mns. Here, deregulation brought competition, better access, cheaper fare, more services, faster journey, convenience and comfort. It changes radically the way people travel in the country. Long time considered a mode of transportation for the elite or business travelers', air travel is now affordable for the medium income Chinese or Indian. This phenomenon is spreading fast throughout Asia.

Figure 24: Low cost carriers spread their wing over Asia

Intra Asian LCC network, 09/2001 vs. 09/2009

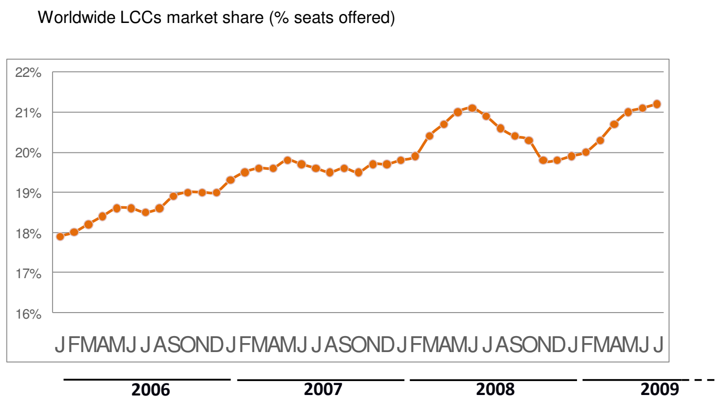


Source: OAG, Airbus

Over the last 10 year the number of route served by Asian LCC has grown from 48 to 576 for the Intra Asia market (excluding the domestic market). As the ASEAN countries deregulate their market towards an open sky, the market share of LCC will continue to increase to reach 50% share within the current decade. Sometime in the process, China will possibly fully or partially deregulate its domestic market, creating another stimulus to air travel in the region. Today, the world LCC airlines represent 21% of the total air travel market.

Figure 25: Low cost airlines entry in the market

World LCCs have 21% of the total air travel market



Sources: Airbus, Laurent Rouaud

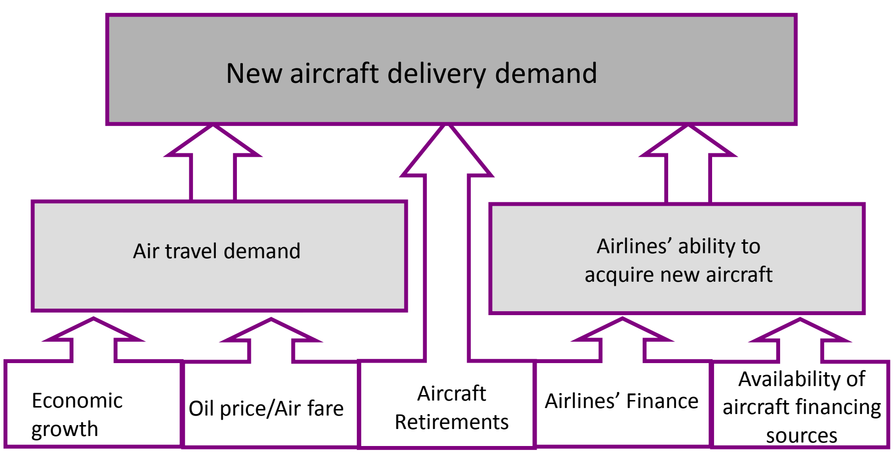
I-2 The market for commercial aircraft

I-2-1 The drivers of aircraft demand

The demand for commercial aircraft is essentially driven by air travel demand, the airlines' aircraft retirement plan and the airlines' ability to acquire new aircraft.

Air travel demand growth is largely dependent on economic growth. For developing market such as Asia, the typical elasticity for GDP to air traffic demand is between 2 and 2.5, meaning that 1% increase in GDP will translate into 2 to 2.5% increases in air traffic. In mature markets such as the US , Europe, Japan or Korea, the elasticity is only about 1. These markets will be more sensitive to air fare. A 1% increase in air fares will typically induce a 1% decrease in air traffic demand. Oil price will have some effect on demand, but the elasticity is very low until it reaches a price per barrel in excess of 150$.

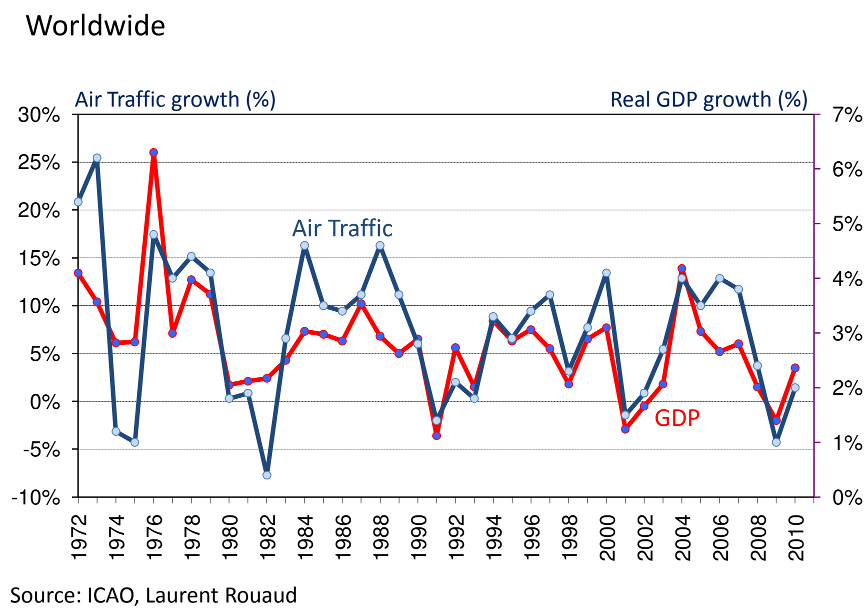
Figure 26: Main drivers of new aircraft delivery demand



Source: Laurent Rouaud

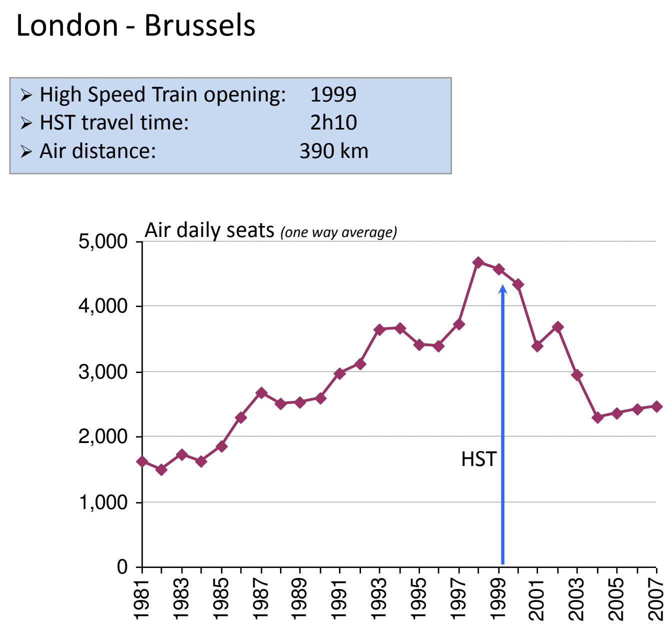
The correlation between GDP and traffic growth is actually very high. On a worldwide basis, as much as 90% of the traffic variation can be explained by the variation of GDP. The remaining 10% is mostly explained by air fares.

Figure 27: Economic growth tightly link to air traffic



Air travel demand will also depend on external factors to the airlines such as the competition with the high speed train network, the regulatory environment such as the degree of liberalization, the environmental taxes levied by airports or countries, or the number of new routes remaining to be opened on a profitable basis. Airport development, especially in emerging countries is an important factor for the development of air transport. India in particular, with its lacking road infrastructure and its congested hub airports has accelerated the construction of new state of the art airports throughout the countries. State airports strategic planning packages unveiled by the Indian government in late 2008 and early 2009 have made funds directly available for projects that will help the country air transport infrastructure that have struggled to keep pace with the 20% increasing demand for transportation. The government has also relaxed regulation to make it easier for those that are involved in airport infrastructure projects to gain access to foreign funds and expertise. This in turn is accelerating the airline supply for air transportation throughout the country.

Figure 28: Impact of High Speed Train on airlines



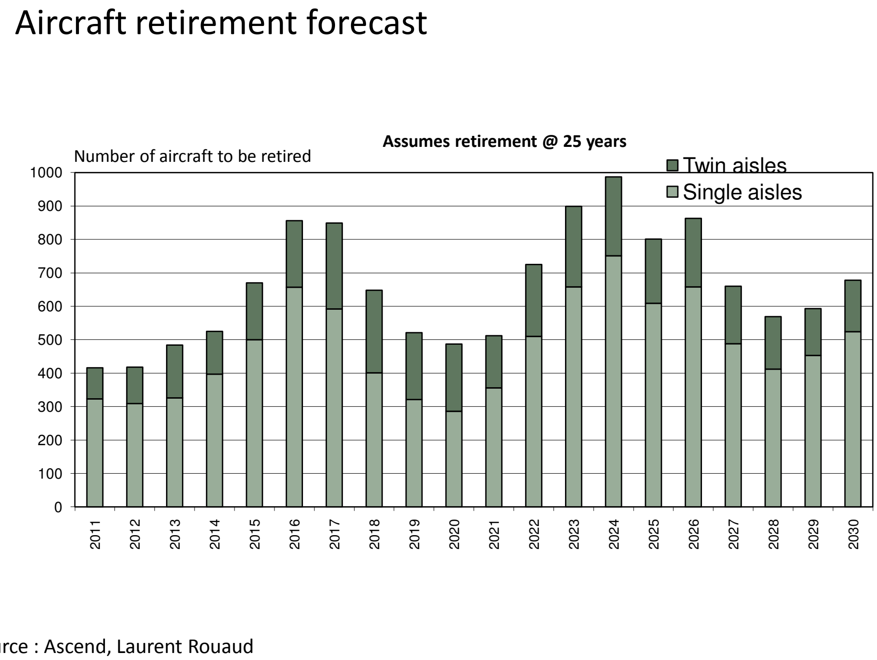
Source: OAG, Airbus, Laurent Rouaud

The High Speed Train (HST) has affected Europe air travel development since the introduction of the French TGV throughout France. Some domestic city pair have seen almost their entire air traffic transferred to rail. This is the case for Lyon – Paris. In other parts of the world, HST is developing fast. HST has been established in Japan, Korea, and is starting in China and Brazil. China has a very ambitious HST network currently in construction that will certainly challenge the aviation development. It is estimated that China will have some 4,000km of HST tracks by the turn of the century. Generally, any route that is 2 hours away by HST will switch all his traffic to HST from air. Above 300 km, the market share diminishes. Over 700km, air travel is generally preferred. The London Brussels' HST was introduced in 1999 and has gained 50% of the travel between the 2-cities.

China's Beijing-Shanghai HST line is anticipated to open service in 2013. The two cities are separated by 1100km, a 5hrs journey with an HST. Although, the value of time might be different for a Chinese than for a European, the HST will eventually capture some of China's air traffic. However, the distance, time and more importantly the planned location of the HST in the 7th ring of Beijing, far from the center, will not help the development.

Aircraft retirement is an important driver of the demand. Airline demand for aircraft is 35% to replace their older equipment and 65% to fuel growth on a worldwide average basis. Retirement is influenced by fuel price and the availability of more fuel efficient equipment developed by manufacturers. However, it will always be an airline management decision The relative operating cost of new versus older types is generally the trigger point in the management decision to retire a particular aircraft type Part of the large order in 2006 through 2008 was largely explained by an oil price above 100$ per barrel According to Airbus, with an oil price of 4$ per gallon, an airline can save about $1 million per year and per aircraft with a new A320 compared with an older generation aircraft such as MD80 that was delivered some 30 years ago. For a long range aircraft, Airbus estimate that the saving is about $4.5 million per year and per aircraft. Today there are about 50 airlines which have individually an annual fuel bill in excess of $1 billion. American airline for example, has still a fleet of 300 older generation aircraft. The saving associated with retiring its older fleet could translate into a half a billion $ better bottom line.

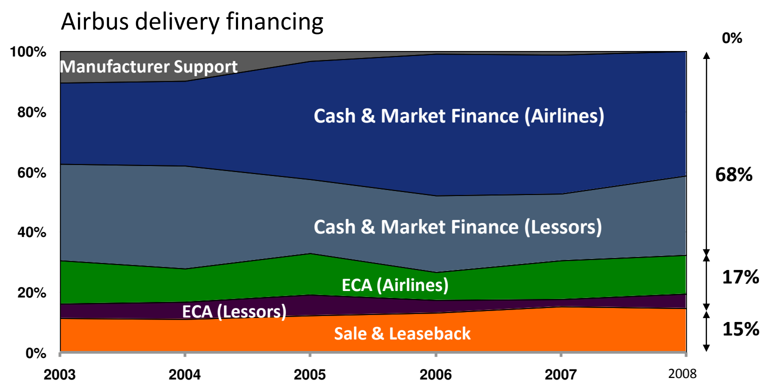
Figure 29: Aircraft retirement timing



Today there are more than 14,000 aircraft above 100 seats in operation with the world's airlines. Among the active fleet, 5000 units are anticipated to retire within the next 12 years. If in the past, the relatively low fuel price were not really influencing aircraft retirement, it seems that the current high fuel price environment is changing that dynamic. With relative low fuel price, aircraft maintenance cost was the most influencing factor in deciding the retirement of a particular aircraft. Aircraft were usually withdrawn from passenger service to be either scrapped of converted into freighters after 25 years of age. Today retirements largely depend on the supply of more efficient aircraft form the manufactures and the fuel price. With the recovery, it is expected that fuel price pass the 100$ mark in a couple of years. This in turn is encouraging the aircraft manufactures such as Airbus and Boeing to develop new re-engined derivative of their current smaller aircraft products.

Manufactures are contemplating the launch of an Airbus A320Neo or a new generation of Boeing 737 for entry into service in 2014 or 2015. Their choice is also driven by the new Canadian Bombardier entrant in the Airbus and Boeing size of aircraft that promised to be 15% more efficient than the current A320 or 737.

Figure 30: Airline financing sources



Source : Airbus

Finally, airlines will acquire aircraft depending on their financial outlook and ease of financing. Despite the crisis, airlines have been able to finance the deliveries of the aircraft on order. Airbus and Boeing had very little back stop financing activities even in the middle of the crisis. Financing for aircraft comes from 6 sources:

- Manufacturing back stop financing
- Cash and market financing from airlines
- Cash and market financing from lessors
- Export Credit Agencies (Eximbank, COFACE) from airlines
- Export Credit Agencies from lessors
- Sale and lease back from lessors

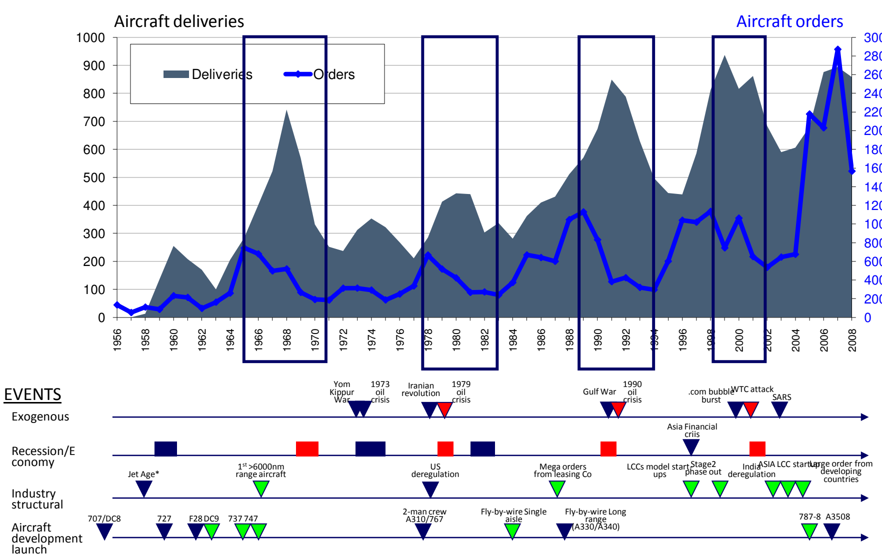
In the tough environment of 2008 and 2009, the ECAs in the US, Canada and Europe have stepped up to provide up to 60% of the aircraft delivery financing.

I-2-2 The cyclical nature of the commercial aircraft demand

Because the all factors described above (the economy, the fuel prices, the retirement of aircraft, the airline profits and the financing availability) are cyclical in nature, the aircraft demand is therefore highly cyclical. In addition, the air travel is greatly influenced by external event such as war (Gulf war, Iraqi war), terrorism attack (9/11) , natural events (volcanic ash) that deeply affect the demand or operation of air transport and create shocks in the demand for commercial aircraft.

This cyclicality in aircraft delivery can be observed in the chart below. Since the jet age, the industry went through 4 major cycles.

Figure 31: Reason for past cycles



Source: Laurent Rouaud

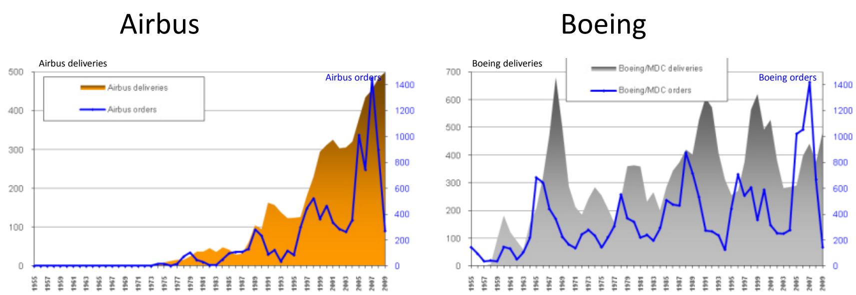
* Comet was the 1st jet airliner to fly schedule service(launched in Feb. 1947, 707 is considered the 1st successful airliner that started service in 1958

For all 4 down cycle in deliveries, the industry was hit by an exogenous event which source was either a war or some crisis that cause a recession. The timing was further exacerbated by the end of a retirement cycle following the introduction of a significant aircraft program. In the 1960, the down cycle in deliveries was the result of the end of the DC9 and 727 first jet introduction. There were not replacing anything but it was a debut of the jet age. The 1980 crisis was the result of the Iranian crisis and the oil shock that resulted from it. In the 1990, the Gulf War created another recession and coincided also with the end of the major wave of deliveries for the A320s and 737NG. The last down turn in the early 2000s was the direct consequence of September 11 that hit the air travel industry hard. It took three years to recover. In 2005, aircraft orders came back and continued to build a strong momentum up to 2007 when it hits the best level of order ever in the history of commercial aviation, with some 2872 ordered aircraft. Airbus, Boeing and Embraer delivered 859 large civil aircraft in 2007. Strong of its backlog, the industry delivered 979 units in 2009, the best year ever in term of deliveries.

The financial crisis has not hit the aircraft demand as hard as other industries. The 3 main reasons are :

- The high oil prices
- The high pace of growth in the new aviation markets of China, India, Latin America, Middle East and other fast growing countries in Asia (Vietnam, Indonesia, Malaysia)
- The anticipation of higher oil price when the recovery finally take off
- The anticipated slots scarcity coming with the re-ordering of Asia, and large airlines in North America

Figure 32: Airbus vs Boeing deliveries



Source: Ascend, Laurent Rouaud

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Airbus has not experienced the same peak and trough of the Boeing deliveries over the last cycles. Although, Airbus deliveries hit 2 steps along the way, its deliveries continued steady. This was mostly due to (1) its lower backlog in North America compared with Boeing exclusive customers reliance on North American customers, (2) the success of Airbus in penetrating earlier than its competitor the Low Cost airline market, (3) its more geographically balanced backlog and (4) Airbus success in emerging countries such as India and the rest of Asia.

I-2-3 The market demand by region and market segment

According to the Boeing Commercial Market Outlook, a yearly publication that gives Boeing's view, air travel will grow at an average yearly rate of 5.3%. There will be a great disparity in the growth of air travel

Figure 33: Air travel demand 2010-2029[47]

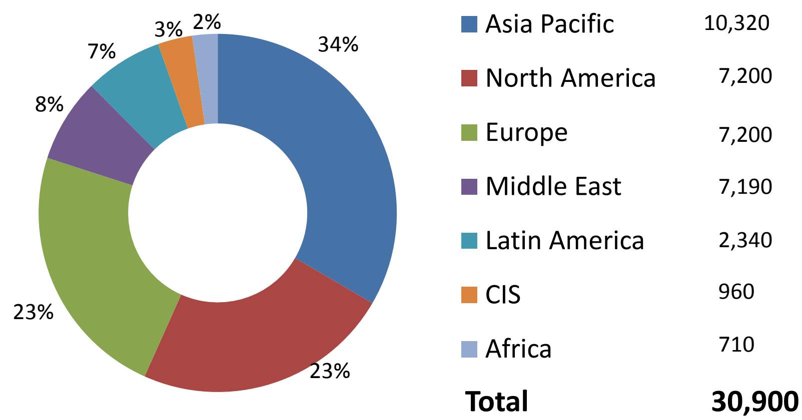
	Africa	Latin America	Middle East	Europe	North America	Asia Pacific
Asia Pacific	8.7%	6.3%	7.5%	5.6%	4.8%	7.1%
North America	7.3%	5.3%	7.2%	4.8%	2.8%	
Europe	4.6%	4.6%	6.0%	4.1%		
Middle East	6.5%	-	6.0%			
Latin America	5.5%	7.1%	-			
Africa	5.7%					

Source: Boeing CMO

The mature travel market of North America is anticipated to only grow at 2.8% per year. Since 2000 this market has been growing at moderate but steady pace because of the LLC were still expanding and adapting their business model. However, the numbers of route the LCC can expand have been almost exhausted. As a result the growth is anticipated to be limited in the next 2 decades to an average of 2.8% per year. Similarly Europe is anticipated to grow at 4.1%. per year. Despite the revised economic outlook of Europe in light of the debt crisis in the Greece, Spain and Portugal, air travel is anticipated to grow faster than GDP due to the continuing expansion of low cost airlines in the region.

[47] Boeing (2010), Current market outlook, Seattle

Figure 34: New aircraft deliveries 2010-2029 per region



Source: Boeing CMO

Boeing[48] anticipates a demand for 30,900 aircraft above 30 seats. Over the next 20 years According to Boeing, air traffic concentration in North America and Europe reached 72% in 1990. Today North America represents some 58% of the traffic. In 2029, China, Asia, India, the Middle East combined would have surpassed North America

Demand is shifting from the west to the eastern region of the Middle East and Asia. Latin America, fueled by its emerging mega country Brazil, its natural resources and dynamism is growing at a steady pace. Africa is slowly emerging from its lethargic post colonial and dictatorship period to become an economic force. For aviation, Africa is “an India in the making “

[48] Boeing (2010), Current market outlook, Seattle

Figure 35: Aircraft demand in Africa

Africa
Key indicators and new airplane markets

Growth measures	
Economy (GDP)	4.4%
Traffic (RPK)	5.5%
Cargo (RTK)	6.1%
Airplane fleet	2.7%
Ratio	
RPK / GDP	1.3
Market size	
Deliveries	710
Market value	$80B
Average value	$110M

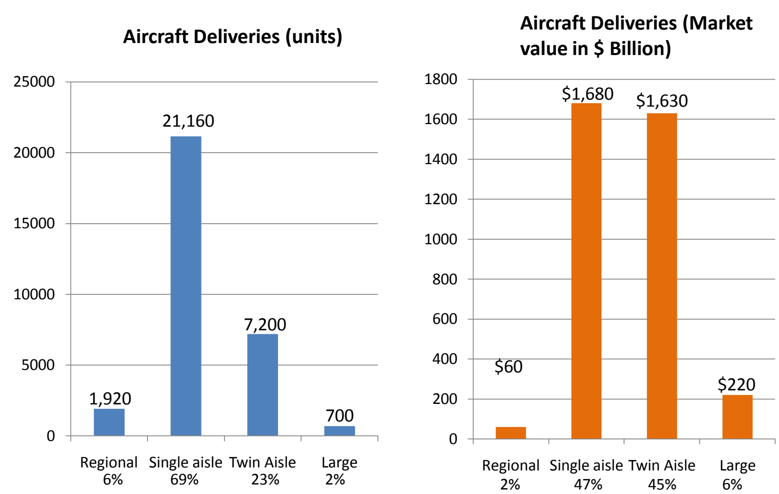
	New airplanes	Share by size
Large	10	1%
Twin aisle	230	32%
Single aisle	420	60%
Regional jets	50	7%
Total	710	

	2009 Fleet	2029 Fleet
Large	20	10
Twin aisle	140	310
Single aisle	400	700
Regional jets	100	110
Total	660	1,130

Source: Boeing

Africa population will reach the 1 billion mark within the decade, and is the second most populous continent after Asia. Aviation is playing a key role in the development of the region. Africa countries telephone networks have not developed like in the western world with land lines first and personal mobile phone later. It develops its mobile personal communication capability first and will unlikely go to develop extensively its land lines. Aviation is to transportation what the cell phone is to communication in Africa. Road infrastructures will develop but at a slow pace Air travel will be the development enabler of Africa. Africa has not been affected by the financial crisis as its neighbors. The momentum of the continent will continue through its exports of natural resources, the rapid pace of its foreign direct investment essentially coming from China, its better productivity of its agriculture and its small but emerging industry base, and the rebirth of its tourism. The impact of the better position of Africa has been apparent in air travel as passenger traffic doubled over the last 10 years. The pace of air travel growth will continue at 5.5% rate. There will be a need for 710 new aircraft over the next 20 year.

Figure 36: Demand for aircraft by market segment[49]



Source: Boeing

<u>I-2-4 The incumbents and new entrants by market segment</u>

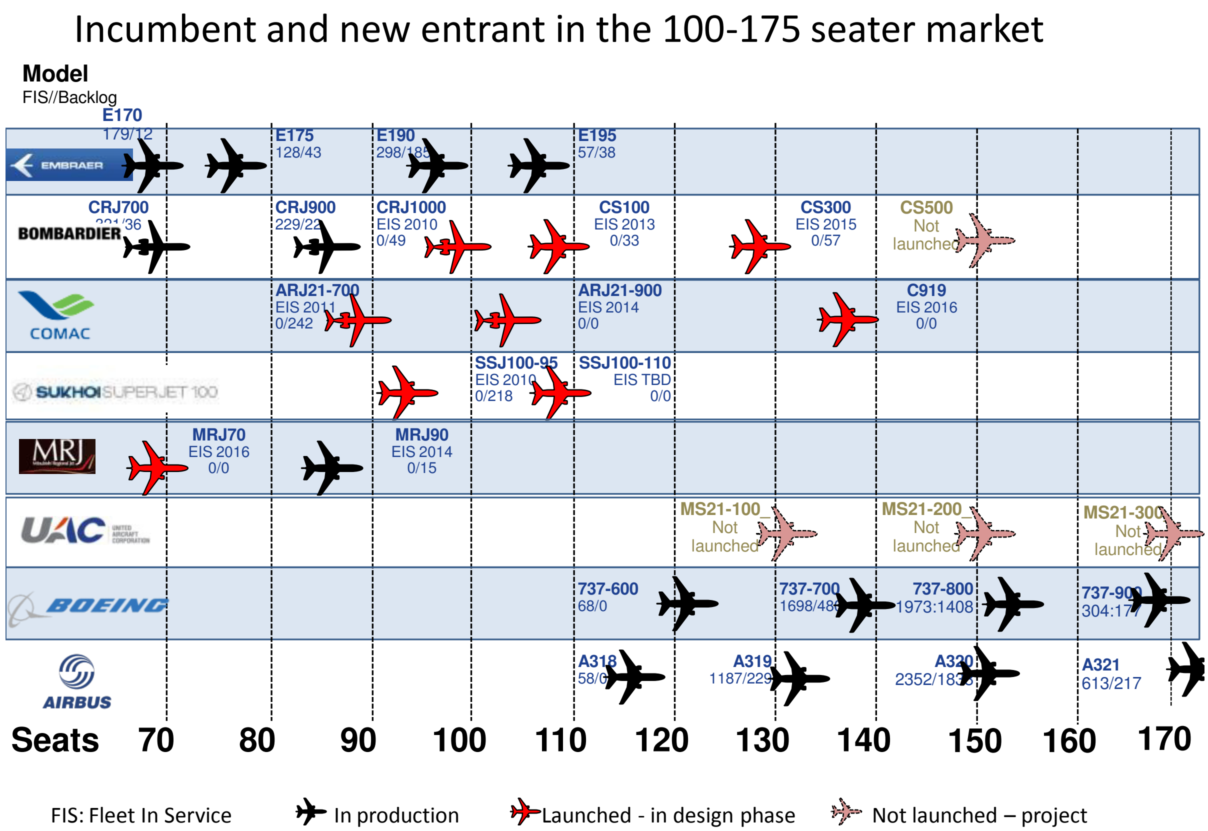
As stated earlier, over the next 20 years, world airlines will require 30,900 aircraft from the 30 seat regional jet to the 550 seat A380. Regional jet demand is anticipated to be 1,920 units for a total value of $60 billion. This market is a duopoly with two major players with competitive products developed in the 1990s. There are two new entrants from Asia: COMAC from China and MRJ from Japan. Both products are in development and will be introducing new technology such as carbon wing and new more efficient engine from Pratt and Whitney and General Electric. The Regional jet will become a very competitive market with well established incumbent. The four competitors will be competing for a relative low market in

[49] Boeing (2010), Current market outlook, Seattle

terms of units and $ value (respectively 6% and 2%). We will see in the following chapters that the main incentives for new player to enter this small and competitive market are other than return on investment or commercial success. The single aisle market is by far the largest market in terms of units. A total of 21,160 aircraft will be needed in that segment representing a market value of 1.6 trillion dollars over the next 20 years. This market of 100 to 175 seater aircraft is made of two rather distinct sub-segments. The large single aisles are the working horses of airlines and include two very successful programs that are the A320 and the Boeing 737s. Today as many as 6,681 A320 family have be sold to 226 customers. There are 2,318 A320s on backlog, some 4.5 years of production. On Boeing side, the 150 seater family 737NG has sold 5,434 units with 2,093 still to be delivered as of August 2010.

Today only Airbus and Boeing have product in the upper sub segment. The incumbency is strong for each of them. The new entrants are the Canadian Bombardier, the Russian UAC, and the Chinese COMAC. The new entrant are planning to introduce their product in 2014/2015 when the new more efficient engine will become available and when the retirement of previous generation aircraft will peak (Figure 29: Aircraft retirement timing). Although the Bombardier C series is positioned in the lower sub-segment, adjacent to its traditional segment of 70 to 100 seater, Bombardier is likely to complement its family with a third member in the 150 market that will be eventually competing with Airbus and Boeing. So far Bombardier has received three orders from Lufthansa, Republic (US carrier) and the Italian leasing company LCI. The Russian UAC has chosen to compete head to head with Airbus and Boeing in the core of 150 seater segment. The lower sub segment concerns the 100 to 125 seater. The aircraft of these segment are mostly large regional feeder of airline hubs and right sizing aircraft for smaller and shorter city pairs. They include the Embraer 195, the CRJ1000 from Bombardier, and the Sukhoi Super jet 100. Airbus and Boeing compete in this segment from the lower part of their family. Their A319 and 737-700 are mostly sold to A320 customers that need a smaller module and rarely on their own. The A318 and 737-600 are positioned in the core of this particular market but have never be launched to compete with the strong aircraft in the segment (Embraer and Bombardier) but rather to avoid giving a 100 seater price to a A319 or 737-700 customer.

Figure 37: Potential new entrant in the narrow body markets



II The strategic Importance of aerospace

II-1 The reasons for the strategic importance of aerospace

Worldwide, aerospace companies generated €274 billion of turnover and employed directly 1.3 million people in 2009.

Almost all large industrial developments are strongly linked to a political driven and complex national economic and trade development agenda. This was true from the early US transcontinental railroad development of the late 1800s to the internet development in the 1980s. The political roots are often historical and not necessarily linked together. The LCA industry is the perfect example of this. From the time of Kitty Hawk in the US to the creation of Airbus in Europe, or the creation of an aerospace industry in the Middle East, aviation has been built by industry-government partnership.

The main reason of the industry-government partnership in commercial aerospace is its strategic importance in terms of:

- National economy
- Export
- Employment
- Technology expertise
- Innovation

> *"The Union has set itself a new strategic goal for the next decade: to become the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion*
> *Lisbon European Council, 2000"*

Moreover, at this particular time, Aerospace/Defense is also an important provider of means to tackle the most pressing global problems such as monitoring of climate change, mitigation of natural disasters, search-and-rescue operations, surveillance of migration flows, global mobility, space telecommunications, fight against terrorism, protection of critical infrastructures, and peacemaking operations In short, aerospace brings economic growth, competitiveness and social values. More generally, the US congress and the US administration have recently stressed the importance of science and technology in improving America's economy, but also moving to sustainable forms of energy, and protecting national and global security[50].

According to the Aerospace Industries Association[51] (AIA) aerospace sales reached $214.1 billion in 2009, up more than 4 percent from 2008. As of 2008, aerospace manufacturing by sales accounted for 1.4% of U.S. gross domestic product (GDP) [52]. Most of the growth in 2009 took place in the military sector. Sales of military aircraft are higher in 2009 at $61.7 billion, a year-over-year increase of more than 8 percent with fighters and military rotorcraft driving that growth. Despite the recession, military aircraft R&D increased more than 15 percent in 2009. Military sales have smoothed out the effect of the recession on aerospace commercial sales.

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[50] United States Government Accountability Office (June 2009), Report to Congressional Committees on Technology Transfer June 2009 GAO-09--548

[51] The Aerospace Industries Association is an US association that represent more than 100 companies

[52] "Aerospace Summary," in *Aerospace Facts & Figures*, 56th ed. (Washington, DC: Aerospace Industries Association, 2009), p. 14.

Figure 38 Importance of aerospace in the US Economy

Civilian aircraft first US export by far

US Exports of Goods by End-Use Category and Commodity

Good Category	2009 export in $ million
Civilian aircraft + engine-civilian aircraft + part Civilian aircraft	74,728
Pharmaceutical preparations	46,140
Semiconductors	37,453
Industrial machines, other	30,862
Telecommunications equipment	28,714
Medicinal equipment	26,893
Electric apparatus	26,052
Plastic materials	25,525
Computer accessories	25,407
Chemicals-organic	24,382

Source: US Census Bureau, Laurent Rouaud

According to Kravis (1992)[53], over the last twenty years, the overall US industry share has declined by one third while the share of multinational has been virtually constant. Higher innovation, spending in R&D, and human capital intensities in the US multinationals are often associated with high share of exports.

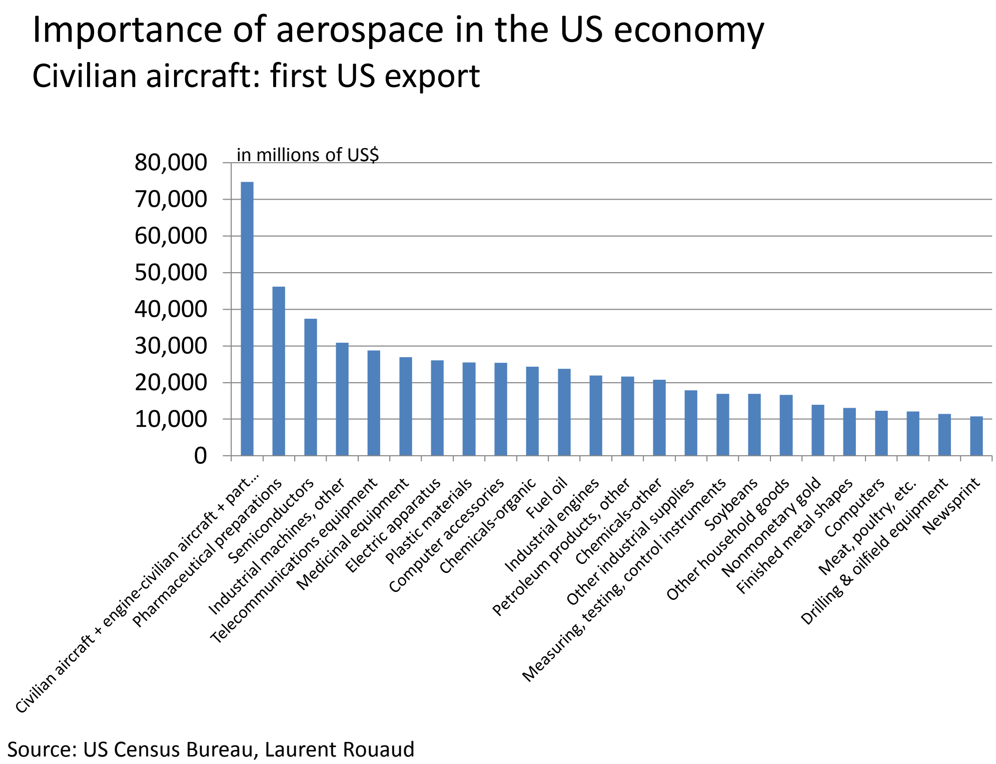
In term of exports, the US civil aircraft, engine and civil aircraft parts exported $74.7 billion worth of goods[54]. Civilian aircraft has been consistently the top American export well ahead of other any other goods. For comparison, the 2009 second and third exported goods were pharmaceutical preparation and semiconductor with respectively $46.1 billion and $37.4 billion.

[53] Kravis Irving and Lipsey Robert (1992), Sources of competitiveness of the United States and of multinational firms, Review of Economics and Statistics, Volume 74

[54] US Census Bureau http://www.census.gov/foreign-trade/data/index.html

As Gregory Hooks wrote: " the US Air Force could not rely on market forces to maintain the world's largest and most technologically advanced aircraft industry. National security has become equated with industrial policy".[55]

Figure 39 Top 25 US exported Goods 2009

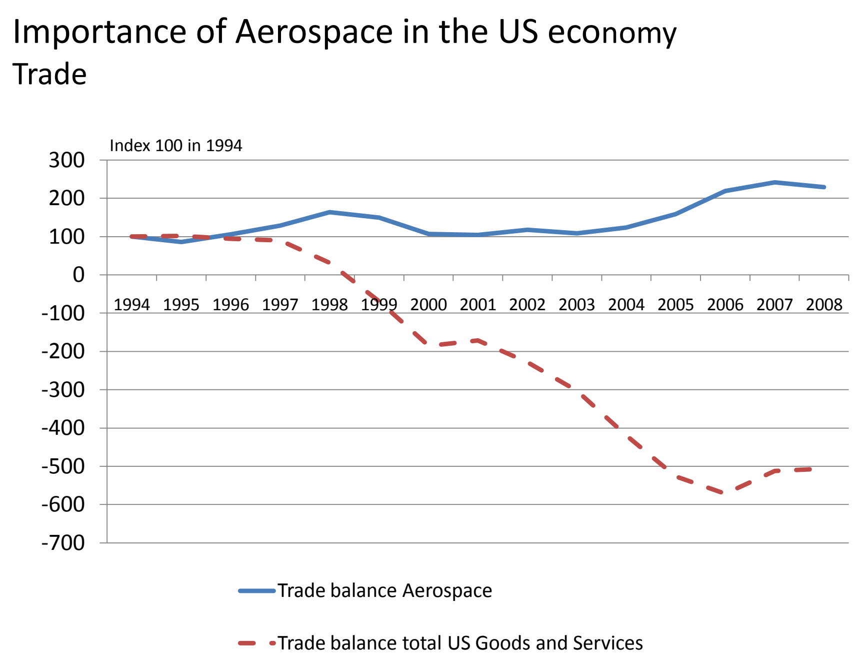


In 2009, the overall U.S. trade deficit was $514.3 billion. However, with aerospace exports representing 7.2 percent of total U.S. exports, the industry's trade surplus makes a significant positive impact on the nation's trade balance. Aerospace is one of the very few goods that are positive on the trade balance. The US Census bureau trade statistics show that America has comparative advantages with its trade partners in civilian aircraft and semiconductor trade during 2009 and 2008. In 2008

[55] Hooks G (1991), Forging the military industrial complex, University of Illinois Press, Urbana

for example, America exported $74 billion worth of civilian aircraft to other countries around the globe while importing $35.4 million worth of foreign-made civilian aircraft engines and parts as well as complete aircraft. America also sold $50.6 billion worth of semi-conductors to the world while importing $25.7 billion worth of semi-conductors from other nations. It is interesting to note that from 2003 through 2008, Japan was the top purchaser of U.S. aerospace export products, accounting for an annual average of 10 percent. For the first three quarters of 2009 France moved into the lead at 10 percent[56]. Aerospace import is anticipated to reach $25 billion in 2009, a 34% decrease over 2008. The aerospace import to the US is concentrated on 2 countries: Canada and France that account for 50%.

Figure 40 Aerospace trade balance growth vs total trade balance

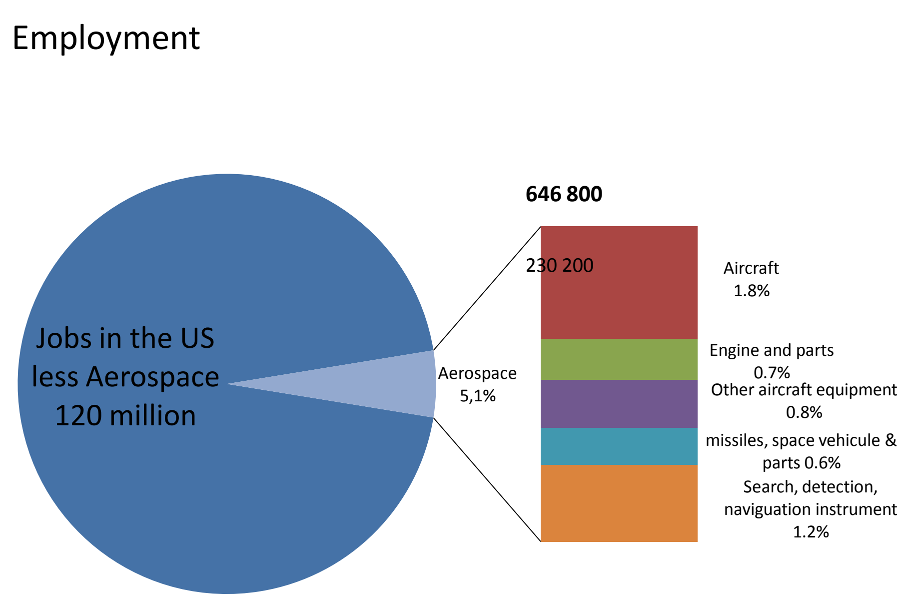


Source: Aerospace Industries Association, US Census Bureau, Laurent Rouaud

[56] US Census Bureau http://www.census.gov/foreign-trade/data/index.html

Aerospace trade balance has also continued to rise, doubling over the last 10 years, while the US overall trade balances decrease significantly. The main reason is that while aerospace has internationalized its sourcing as the other industries, the final assembly of its products still remains in the US and is therefore shipped from the US. Aerospace is also strategic in term of employment, job creation, and wealth. In 2009, aerospace employed 646,800 people or 5.1% of the total US workforce. The average annual wage of an aerospace worker is about $50,000, well above the average US annual salary of approximately $39,000. Despite the financial crisis of 2007, aerospace is doing better than most other industries. Employment for all manufacturing in the US fell by 3.2 percent and employment at durable goods manufacturers fell by 3.8 percent, while aerospace employment increased by 1.5 percent.

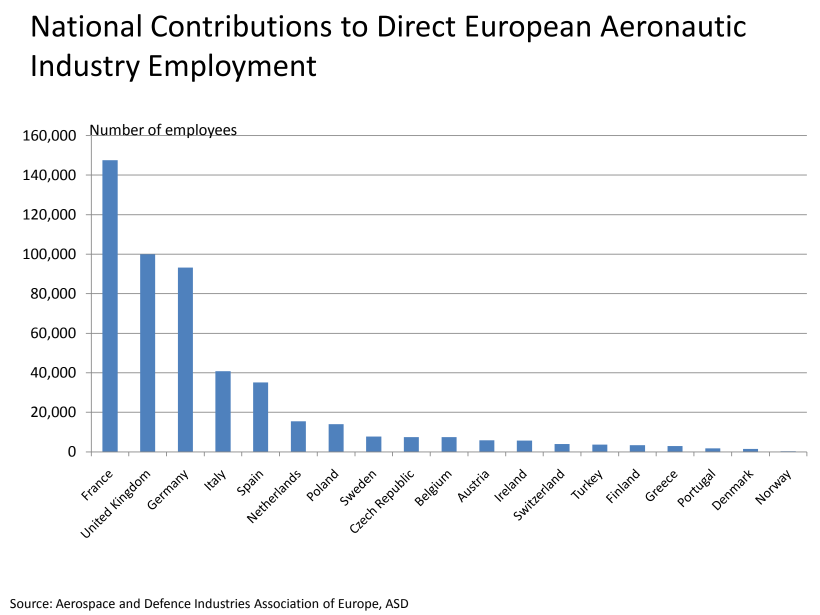
Figure 41 Importance of aerospace in terms of jobs



Source: Aerospace Industries Association, US Census Bureau, Laurent Rouaud

In Europe, the aerospace and defense industry generated € 137 billion of turnover, directly employed 676,000 highly skilled people and invested € 11.3 billion in R&D in the year 2008. The European aerospace sector employs 497,000 people of whom 70% are based in France, the UK and Germany.

Figure 42 Aerospace jobs in Europe by country



The European aerospace export more than its output and provide €1.9 billion of positive trade balance. It impact thousands of small and medium companies throughout 15 countries of the European Union.

In 2002, Europe has established its Strategic Aerospace Review for the 21st century, four governing principles for Europe's aerospace industry[57] are as follows:

[57] OECD (2002), Strategic Aerospace Review for the 21st century, Creating a coherent market and policy framework for a vital European industry, July 2002

I. Aerospace is vital to meeting Europe's objectives for economic growth, security and quality of life. It is directly associated with, and influenced by a broad range of European policies such as trade, transport, environment and security and defense.

II. A strong, globally competitive industrial base is essential to provide the necessary choices and options for Europe in its decisions as regards its presence and influence on the world stage.

III. European aerospace must maintain a strong competitive position if it is to play a full role as an industrial partner in the global aerospace marketplace.

IV. Europe must remain at the forefront of key technologies if it is to have an innovative and competitive aerospace industry.

II-2 Are the reasons for the strategic Importance of aerospace the same for the US and Europe?

Some academics have advanced the idea that the focus of Europe and the US to maintain a strong innovative and independent aerospace industry might have different drivers. They argue that the US drivers are essentially economic. Their meaning of national security is to provide good jobs with high wages and maintain technology leadership. Europe might have been driven by the desire to emancipate geo-strategically from the US. Europe might have been less concerned with economics but more with political sovereignty and to develop a success story for Europe. Some academics even suggested that the Europeans are much less concerned with the profitability or the economic rationale of undertaking a project such as Airbus or Galileo but are more driven by what those projects do to represent Europe success story and to re-enforce the political sovereignty of Europe. For those academics, Airbus or Galileo are seen as geo-strategic instruments advocated by the Europeans to respond to the challenges provided by the Americans[58]. What those

[58] Annemarie M. Spadafore, Transatlantic Misunderstandings on the Importance of Aerospace for the United States and Europe and Their Role In the Boeing/Airbus Subsidies Dispute, Miami University

academics failed to mention however is that Airbus in particular had much more chance to fail that it had to succeed in its early stage of development. Airbus could have been Europe's failure story if Airbus engineers had failed to develop differentiating products that met market needs, failed to sell those products to worldwide customers and failed to derive profits to give them the possibility to further develop a full family of products. Those aspects will be covered in the next 2 chapters concerning the entrée of Boeing and Airbus in the market of the civil jet aircraft.

II-3 Strategic importance of aerospace innovation

The following chapter highlights (1) the national strategic importance of innovation as a driver of economic growth, and social responsibility, (2) the importance of authorities, institution and legislators as key players in innovation development, diffusion, and leverage and (3) the importance of aerospace innovation for its spin-off and spillover effect within aerospace and across industry.

In times of increasing reliance on services to fuel the economy of developed nations, aerospace innovation is one of the very few domains in which the US and Europe can count to maintain technological leadership in manufacturing, accumulate knowledge and most importantly spillover aerospace innovations to others industries. Aerospace innovation is therefore strategic for Europe and the US as a driver of economic growth. [59]

I have always been surprised how difficult it is to obtain a clear answer and a consensus on the definition of innovation, even in the most innovating circles of the aerospace industry. The best definition I have found is in the OECD's Frascati

[59] Pinelli T (1997), Knowledge diffusion in the US aerospace industry: Managing knowledge for competitive advantage, Ablex Publishing Corporation,London,

Manual[60]. According to the manual, innovation involves the transformation of an idea into a marketable product or service, a new or improved manufacturing or distribution process, or a new method of social service. The term refers both to the process and to the resulting new or improved product. In the innovation process sense, the focus is on the different stages of the creative process during which the innovation is designed and produced, from pure creativity, marketing research, development, design, and production to the distribution. The process involves interactions between different functions within the firm bringing the innovation to market but also with its environment such as its main suppliers, the research laboratories, universities, government and institution support.

As a 1995 OECD document put it:

"Knowledge in all its forms plays today a crucial role in economic processes. Intangible investment is growing much more rapidly than physical investment. Firms with more knowledge are winners on markets. Nations endowed with more knowledge are more competitive. Individuals with more knowledge get better paid jobs. This strategic role is at the root of increasing investments by individuals, firms and nations in all forms of knowledge." [61]

The slowdown of economic growth in the 1970s in the developed and industrialized countries, the rise of Japan as a major technology power, and later the rise of newly industrialized countries such as Korea and Taiwan have highlighted the importance of the knowledge base economy in a nation economy at that time. Forty years later, the rise of China as an industrial power and now clearly with the

[60] OECD (2002), *The Measurement of Scientific and Technological Activities* Technology, Proposed Standard Practice for Surveys on Research and Experimental Development, Frascati Manual 2002 OECD Publishing, Paris, OECD.

[61] OECD (1995), Technology, Productivity and Job Creation, Vol. I and II, The OECD Job Strategy, Paris, OECD.

ambition of becoming an innovation power has brought the subject of innovation , once again, in the front burner of developed nations to as one of the very last drivers of economic growth.

In addition, the emergence of newly competing countries bringing innovation to market, the growing internationalization of the productive system and of the research and innovation activities, the steep rise in the cost of research, the increasing importance of social responsibility (health, environment, governance, …) are all factors that have changed the way innovations are processed. Those factors make, more than ever, authorities' fundamental players in the process of innovation dissemination.

Innovation and the concept of knowledge creation as a driver of economic growth have been researched since the late eighteen century with classical economists such as Karl Marx to Joseph Schumpeter[62]. Joseph Schumpeter had two different approaches of the innovative process (1) "creative destruction" and (2) "creative accumulation". Creative destruction emphasizes the role of new entrepreneurs entering markets by introducing new ideas and by innovating, these entrepreneurs challenged existing firms through a process of, which was regarded as the engine behind economic progress. (Schumpeter, 1912). In the creative accumulation, Schumpeter stresses the key role of large firms as engines for economic growth by accumulating non-transferable knowledge in specific technological areas and markets. Those economists have stressed the importance of innovation and knowledge accumulation for long-term growth. They have been the source of the new theories of growth known as endogenous, stressing that the development of technological progress, rather than the accumulation of capital are the driving forces behind lasting growth. Economists have also recognized that knowledge accumulation can be analyzed like the accumulation of any other capital good. In the New Theory of Growth (NTG), the authorities influence the foundation of economic

[62] Aghion, P. and P. Howitt (1998), Endogenous Growth Theory, Cambridge MA, MIT Press.

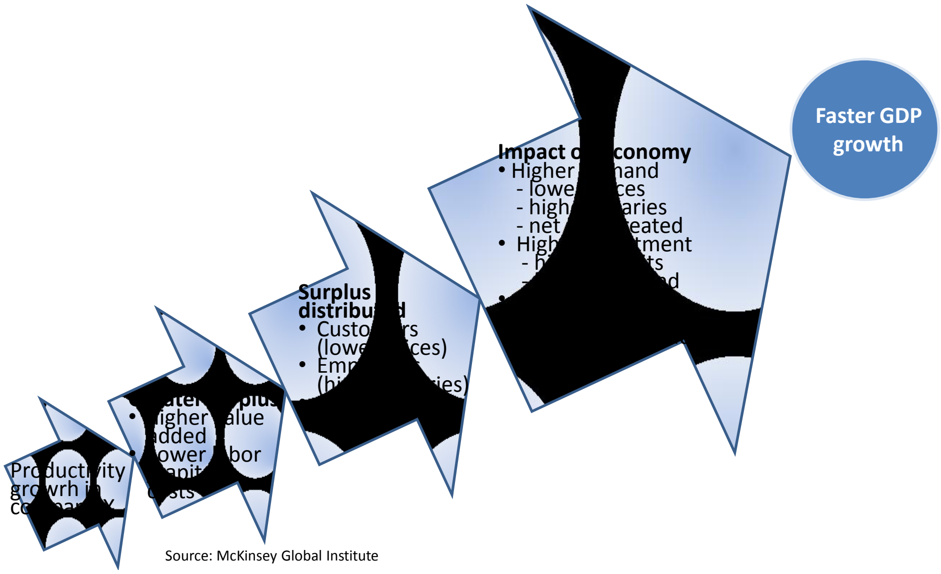
growth in the development of the know-how and through the distribution of skills throughout the whole of the economy and society. The ability of an economy to obtain competitive advantages from its innovation depends on the dynamic efficiency with which companies, authorities and institutions can disseminate, adapt, and apply knowledge. Johnson and Gregersen (1995)[63] define European integration as *"a process towards a coherent institutional setup for production, trade and innovation within Europe."* They identify four interrelated types of economic integration: (i) formal and (ii) informal institutional arrangements between political actors, and (iii) formal and (iv) informal institutional arrangements between economic actors.

The relationship between economic growth and employment is essentially the fact that product innovations lead to an increase in demand which itself drive an increase in investment and employment. Process innovations contribute to an increase in productivity by increasing production or lowering production costs. Both product and process innovation result in an increase in purchasing power, which itself increases once again demand and employment.

Innovation will be also crucial in improving productivity in Europe, a major source of growth. Europe has devoted a lot of efforts in increasing productivity in the 1990 as it was lagging compared with its competitors in the US and Japan. As Europe demographics shift towards an older population and a much smaller working population, greater productivity gain will be required from those who do work. In Germany for example, the 25-59 age group will decrease from 56% to 48% of the total German population[64].

[63] Johnson, B. and B. Gregersen (1995), Systems of Innovation and Economic Integration, Journal of Industry Studies, 2, pp. 1-18.
[64] Statistisches Bundesamt

Figure 43 Productive growth is the engine of economic growth



McKinsey research [65] on productivity across Europe and across industries indicated that the key to productivity gains is the successful development, diffusion and leverage of business and technology innovation.

The European demographics constraints in the future give innovation an even more important role to increase productivity and therefore growth in Europe. For example, in both France and Germany telecommunication industry, productivity increased by respectively 17.7% and 19.4% per year with technology related improvement accounted for about 90% of the total productivity gain. Those improvements came from major technology innovative products in operational support systems, digital technology in mobile services and IT innovation such as the introduction of improved order handling or fault management. In other industries,

[65] McKinsey Global Institute, Improving European Competitiveness, July 2003

such as banking, productivity improvement came from process innovations such as back office automation and business innovations in call centers and internet banking.

Diffusion or dissemination of innovations is as important as its development. Without adequate diffusion, innovation would only concern limited number of firm and therefore lessen the effect on economic growth. The French automotive for example have been successful in adopting best process practices developed in Japan such as lean manufacturing, improved supplier purchasing system, and simplified design process. The adoption of these innovations allowed the French automotive industry to realize productivity gain of 15% per year between 1996 and 1999. Similarly, the UK automotive industry was lagging by as much as 50% in productivity vs their Japanese competitors in the early 1990. After adopting best practice from the Japanese manufacturers, the UK car manufacturer succeeded in closing the gap in productivity vs. their Japanese competitors.

According to Mckinsey, leveraging innovations to obtain their application to an optimal scale is often critical to productivity performance. The German retail banking business has a poor performance compared with its neighbor countries. Most of the difference in productivity comes from the fact that the German banking is scattered among a great number of small banks. The German bank ownership structure restricts their consolidation. The small banks are not in a position to leverage the innovation in IT that brought major productivity gain to other European banking system such as France. Another example where leveraging innovation could bring tremendous productivity gains is the road freight in France and Germany. The road freight industry is very little concentrated. The top 6 companies account for up to 9% of the revenue. German and France road freight productivity lag behind the US , with productivity at 80% of the US model. There are thousands of small operators. Consolidation will be the only mean to leverage innovation in bar coding, network optimization, and dispatch technology.

Authorities, legislations, institutions are key actors for the development, diffusion and leverage of innovations. For the examples above, the improved French telecommunication process was encourage by the decision of the government to create a competitive mobile phone market. The improvement of the automobile productivity adopting was also trigger by the opening of the domestic market to highly productive foreign competitor from Japan and Korea. The German automobile market did not have to face the same pressure and had less incentive to increase their productivity.

Authority's involvement can also be justified since without its intervention, the innovating firms may not get the benefits of their hard search to innovate due to the possible spillover effects. In fact, in most cases, the total potential benefits to society and to the innovator firm's competitors are greater than the return for the firm that came up with the innovative idea. As knowledge cannot be owned or licensed, the private firms might be therefore less incentivized to pursue innovation (market failure).

II-4 Innovation is strategic in enabling social responsibility

Innovation is strategic for government because it is above all a social phenomenon. With innovation or technological progress, individual, society, corporations express their creativity, their needs and desires for their future and the future of their children. Innovation in a way creates a social condition and helps create the condition of change for society. It brings a response to the important societal problems of the present such as improving living conditions after national disasters such as in Asia or in Haiti, treating illness such as H1N1 or any pandemic, , or for example, helping to treat environmental disasters after a oil spill. It can improve safety or working conditions, improve transportation, it save energy, reduce pollutants, help integrate handicapped people or make everybody work from their remote home locations, giving them an equal chance in rural area. It can help reduce the difficulties of most developed countries in dealing with aging demographics and social protection. It can help solve issues of underdevelopment, malnutrition and health. For this, any sectors that bring innovation will be strategic for government to help achieve social value. Aerospace as a major innovation enabler in general is a major contributor to social progress through its innovation. The private sector, social sector and public services within their national boundaries need innovations. By its nature, innovation is a collective process that requires commitment from all the players in its value chain, from educators to private researchers, from corporations to governments.

Consumer's behavior is always evolving over time depending on the products offered but also because of societal reasons. The 2007-2008 recession has accelerated the change to a new sets of behaviors. First, we save more. A McKinsey survey shows that US respondents said that their households had reduced spending as a result of the recession, 33% of them "significantly" so. The survey, which included 600 households in three consumer segments comprising about 40 percent of all US homes, found that 45 percent of those who reduced spending did so by necessity and 55 percent by choice. Will the behavior switch back to the previous overspending on the early 2000, when household were actually spending more than they earned? Probably not, since the spending at that time was abnormal. The same survey shows that consumers will stay frugal in their spending after the recession. Secondly, consumers do not believe in large brands nor rely on the brand to make the choice for them. Brand does not translate necessarily in value. Consumers will not count on Mercedes to deliver great product because they are Mercedes anymore. Third, consumers are looking for simplicity in general and simpler products. They look for a way to combine entertainment and communication for example. They do not want to carry multiple devices, a phone, a blackberry, a computer, an ipod. They want a single product that can do all and more. Fourth, they want a healthier lifestyle. That trend is very visible in supermarket with the increase interest of consumers for organic food and products. Fifth, they want a greener lifestyle and are starting to introduce greener behavior in their everyday task. Sixth, they are expecting institutions, legislators, authorities to encourage or even force better governance in corporations and governments. The healthier and greener lifestyles, the wish for better governance are part of a bigger societal behavior that seeks more social responsibilities. Corporations such as Starbucks, Gap, Wal-Mart, and General Electric have well understood this and are engaged in reporting their action and “score cards” to the public. Corporations are facing an increased pressure from the public, the governments, their employees and their competition to play a leading role in addressing a wide array of environmental, social and governance issues ranging from climate change to obesity and human rights: that is social responsibility.

Innovation is proving to be strategic as a mean to reach a new level of social responsibility for institutions and corporations. Some international corporations have been quicker than others in adopting these values and are succeeding in creating financial value from their socially responsible focus. Corporations are taking a long term view in environmental, social and governance activities to anticipate risks from emerging issues and turn those risks into opportunities. Novo Nordisk for example manages itself with a performance dashboard that go well above their financial bottom line. They actually have a triple bottom line goal: financial viable business, environmental sound and socially responsible business. Nova Nordisk invested in technology and time in researching ways to prevent, diagnose and treat diabetes and build up a related health care infrastructure. They have used their investments to strengthen its position in mature markets and develop its business in new ones. Verizon, a telephone and communication firm in the US, sponsored research on the way information and communication technology promote energy efficiency. Verizon sponsored a multi-industry research called “Smart 2020”. The report of the research explains that with broadband internet connection, it can help the US to reduce its CO2 emission by 22% and reliance on foreign oil by 36% as early as 2020. IBM in partnership with the World Bank, and with banks in India and Brazil provide free web based resources on business management to small and mid size enterprise in developing economy through its small and medium enterprise tool kits. For IBM, it is a useful way to improve its reputation, relation with its partners and potential future customers. Telefonica has been developing new product and services specifically aimed at the over 60 age group, such as helping them to communicate with their grandchild abroad. It meets a social need by helping people while developing a new market base. The initiative of General Electric in two major programs: "ecomagination" and "healthymagination" are an interesting example on how the firm creates financial value for themselves while improving the environment, the social governance for the society with innovation. Closer from the Aerospace industry, ACARE is another European example of innovation helping competitiveness and the environment by involving firms, research centers, regulators and institutions.

GE Ecomagination

Ecomagination is a General Electric (GE) company wide business initiative to help meet customers' demand for cleaner and more energy-efficient products and to drive reliable growth for GE. "Green is Green." GE Ecomagination also reflects GE's commitment to invest in a future that creates innovative solutions to environmental challenges and delivers valuable products and services to customers while generating profitable growth for the company. GE's target is to grow revenues from ecomagination products with an annual goal of $25 billion in 2010. GE is clearly on the path to achieve that goal since as of May 2009 the ecomagination portfolio includes 80 products and the has generated more than $17 billion in revenue in 2008. GE has progressively invested in their ecomagination initiative from $750 million in 2005 to a planned $1.5 billion in 2010. GE internal Green House Gas (GHG) and energy efficiency plan is to reduce GHGworlwide by 1%, reduce the entensity of GHG emissions 30% by 2008 and improve energy efficiency 30% by the end of 2012 vs 2004 level. It has already surpassed its goal of reducing GHG intensity of GHG by 30% in 2008. GE has also committed to reduce its water consumption by 20% by 2012 from a 2006 baseline. GE goal in ecomagination is also to keep the public informed of its ecomagination actions and results through its website, global conference, advisory board or public-policy engagement. Its ecomagination products or services must significantly and measurably improve customers operating performance or value proposition and environment performance. In terms of public policy, GE was a founding member of the United States Climate Action Partnership (USCAP) which is a group of business and leading environmental organization that have come together to call on the federal government to quickly enact strong national legislation to require significant reductions of GHG emissions.

GE Aviation business for example has introduced in 2008 a improved Flight Management System (FMS) that optimizes aircraft descent profile to lower fuel consumption, CO2 emissions while lowering airlines costs. The GE's FMS enables pilots to determine while maintaining a highly efficient cruise altitude, the exact point where the throttle can be reduced to flight idle while allowing the aircraft to arrive precisely at the required runway approach point without the need for throttle increase. Scandinavian Airlines (SAS) has 36,000 descents yearly into Stockholm alone, annual benefits could reach $6 million in cost savings and an additional $4 million in cost avoidance due to increase efficiently.

Another ecomagination initiative GE's wind turbine. GE is one of the world's leading wind turbine suppliers. With over 11,600 worldwide wind turbine installations comprising more than 18,000 MW of capacity, GE has established knowledge, expertise and recognition over a period spanning more than two decades. A 100MW wind farm, over the course of its 20-year lifetime, has the capacity to generate an amount of electricity that would require about 2.9 million tonnes of coal. GE's installed base of over 11600 1.5MW turbines has the capacity to produce 52 million MWH of electricity, which could be equivalent to avoiding the emission of over 31 million metric tons of CO2, or the equivalent of CO2 emissions of 6 million cars per year. Worldwide, about 85% of wind generation capacity is split between Europe (70%) and the US (15%). In the US, although the cost of wind energy is becoming competitive with other source such as coal or gas, it has penetrated less than 1% of the US generated electricity. However, the US government has plans to bring wind generation up to 20% share in the future. In Europe, the target for wind power is much more ambitious. Wind is projected to deliver 33% of all new electricity generation capacity and provide electricity for 86 million Europeans by the end of 2010.

In Abu Dhabi, GE and a local development company are constructing the first ever ecomagination center. Upon completion Masdar City will be the first carbon neutral, zero waste city completely powered by renewable energy.

The United Climate Action Partnership (USCAP) of which GE s a founding member is calling on the US government to enact strong national legislation to require significant reductions of GHG emissions. In 2009, the group created a proposal which calls for reductions between 14 and 20% of 2005 GHG levels by 2020 and an 80% reduction by 2050 through an economy-wide trade program.

This project exemplifies the fact that technological progress and innovations in our developed society is a interactive process that requires not only economic but also social factors and a multitude of stakeholders either individual, institutions and firms to participate.

GE's ecomagination Advisory board include leaders from Climate Change Capital, Pew Center on Global Climate Change, a former CEO of Shell International Renewables, and leaders from various institutions such as the World Resources Institute, the University College London, MIT and Google.

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GE Healthymagination

From the experience and success of ecomagination, GE showed practically that technical innovation can drive solutions and value for customers, investor's employees and the public. Strong from his experience, GE decided to invest in a similar project in health. Healthcare in the US but also worldwide is challenged by rising costs, inequality of access and persistent quality issues. GE plans is to provide new solution with innovation in smarter process and technologies that help doctors and hospitals to deliver better healthcare to more people at lower costs. Launched in May 2009, GE's healthymagination initiative is aimed at four critical needs: low-cost technology; healthcare IT; innovation accessible to all; and consumer-driven healthcare. GE has committed that by 2015 it will invest $3 billion in research and development to launch at least 100 innovations that will help deliver better care to more people at lower cost. GE intends to provide $2 billion in financing and $1 billion in technology to bring healthcare information technology to rural and underserved areas. It plans to reduce the cost of procedures that use GE technologies and services by 15 percent and develop products tailored to underserved regions of the world. More importantly GE intends to reach 100 million more people every year with services and technologies essential to health. As in his ecomagination, where "Green is Green", GE intend to derive significant revenues from their initiatives. Here they consider that "Health is Wealth". Below are a couple of examples of GE healthymagination products.

Morsel is an ipod application that GE develops to promote health and wellness. The free application help people to get healthier by suggesting simple daily tasks that anyone can do. Its main goal is to make healthier lifestyle accessible to everybody.

Another GE healthymagination project is to expand access of state-of-the-art medical imaging to underdeveloped regions around the world. The US National Institute of Health awarded a contract to GE to develop new magnet technology that will make MRI systems less costly.

The development of a lower-cost mobile MRI platform would help support GE's healthymagination vision by expanding MRI use into underserved communities worldwide.

GE created an advisory board that will advise GE on its health efforts, investments and policy and will participate in regular reporting on GE's performance. The board includes regulators, institutions' leaders, doctors, and business leaders such as Dr. Devi Prasad Shetty, chairman of Narayana, a cardiac care hospital in Bangalore, or former US senator Bill Frist and Tom Daschle. Tom Daschle said "we can only find real solutions in health care when business, government and their partners work together. The commitment GE made on access, cost and quality are a great start toward demonstrating GE leadership in this debate. I look forward to working with GE".

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ACARE
ACARE is an other example of the strategic importance of innovation for Europe in the area of aerospace that will crucial on the competiveness of European aerospace in the future. ACARE stands for Advisory Council for Aeronautics in Europe. Its original aspirations are for better technology linked to social aspiration such as cleaner environment, safer travel and more security as well as the benefits of a more competitive Europe.

In January 2001 a group of European personalities in aerospace and institutions chaired by an EU commissioner established a report called the "European Aeronautics: a vision for 2020". The group established a number of recommendations for fulfilling the European Aeronautics ambition to better serve society's needs and strengthen its quest for global leadership. The Group recommended developing a long-term commitment by all stakeholders of the aeronautics industry, airlines, airports, air traffic control service providers, governments and regulators, research institutes and academia to work in closer partnership and on the basis of consensus with the aim of strengthening and reorganizing research and development efforts in Europe. Among its conclusions, the Group stressed the need for a new Advisory Council for Aeronautics Research in Europe (ACARE) whose aim would be to develop and maintain a Strategic Research Agenda (SRA) for aeronautics in Europe. The ACARE advisory board is tripartite in composition to include a representation of Member States, the Commission and stakeholders. It includes:

- Member States with significant public funding for aeronautics research (23members) - The other Member States are invited to be represented as observers
- European Commission (2 members)
- Manufacturing industry - airframe, engine, equipment and supply chain, including ATM - (10 members)
- Research establishments (3 members) EREA
- Airlines (2 members) AEA, IATA
- Airports (1 member) ACI
- Regulators (2 members) JAA , EASA
- EUROCONTROL (1 member)
- Academia and other relevant expertise (1 member).

ACARE Vision 2020 took into account the challenge of meeting continually rising demand while demonstrating sensitivity to society's needs by reducing the environmental impact of manufacturing, operating, maintaining and disposing aircraft and associated systems. ACARE Strategic Research Agenda set some environmental goals that require significant breakthroughs, both in technology and in concepts of operation. SRA environmental objectives
include:

- Reduce CO2 by 50% per passenger kilometer (assuming kerosene remains the main fuel in use)
  - -Airframe contribution: 20 to 25%
  - -Engine contribution: 15 to 20%
  - -Air Traffic Management 5 to 10
- Reduce perceived noise level to one half of current average level
- Reduce NOx emissions by 80%
- Reduce other emissions: soot, CO, UHC, Sox particulates, etc
- minimize the industry impact on the global environment including substantial progress toward Green-MDD (Manufacturing, Maintenance and Disposal).

ACARE has also set 2 large joint projects : **Clean Sky Joint Technology initiative**, a project devoted to technologies that will improve the impact aviation has on the environment, and **SESAR**, a comprehensive project aimed at modernizing the European Air Traffic Management.

The Clean Sky JTI will be one of the largest European research projects ever, with a budget estimated at €1.6 billion, equally shared between the European Commission and industry, over the period 2008 - 2013. This public-private partnership will speed up technological breakthrough developments and shorten the time to market for new solutions tested on Full Scale Demonstrators. Clean Sky will encourage the participation of Small and Medium Enterprises to ensure their full involvement in the program, therefore offering opportunities to the entire aeronautic supply chain from all EU Member States and Associated countries. Clean Sky will demonstrate and validate the technology breakthroughs that are necessary to make major steps towards the environmental objective sets by ACARE. The Clean Sky JTI is made up of 6 Integrated Technology Demonstrators : (1) the SMART Fixed Wing Aircraft will deliver active wing technologies and new aircraft configuration for breakthrough, news products; (2**)** Green Regional Aircraft will deliver low-weight aircraft using smart strutures, as well as low external noise configurations and the integration of technology developed in other ITDs, such as engines, energy management and new system architectures; (3) Green Rotorcraft will deliver innovative rotor blades and engine installation for noise reduction, lower airframe drag, integration of diesel engine technology and advanced electrical systems for elimination of noxious hydraulic fluids and fuel consumption reduction; (4) Sustainable and Green Engines will design and build five engine demonstrators to integrate technologies for low noise and lightweight low pressure systems, high efficiency, low NOx and low weight cores and novel configurations such as open rotors and intercoolers; (5) Systems for Green Operations will focus on all-electrical aircraft equipment and systems architectures, thermal management, capabilities for "green" trajectories and mission and improved ground operations to give any aircraft the capability to fully exploit the benefits of Single European Sky; and (6) Eco-Design will focus on green design and production, withdrawal, and recycling of aircraft, by optimal use of raw materials and energies thus improving the environmental impact of the whole products life cycle and accelerating compliance with the REACH directive.

The **SESAR** (Single European Sky ATM Research) program is one of the most ambitious research and development projects ever launched by the European Community aimed at developing a modernized air traffic management system for Europe. The program is the technological and operational dimension of the Single European Sky initiative to meet future capacity and air safety needs. The EU Single European Sky initiative was launched by the European Commission in 2004 to reform the architecture of European air traffic management. It proposes a legislative approach to meet future capacity and safety needs at a European rather than a local level. SESAR will help create a "paradigm shift", supported by state-of-the-art and innovative technology. The SESAR program will give Europe a high-performance air traffic control infrastructure which will ensure the safety and fluidity of air transport over the next thirty years, will make flying more environmentally friendly and reduce the costs of air traffic management. SESAR is bringing ATM into the information age, making accurate information available as quickly as possible to all who need it, right across the spectrum to help all the players make better decisions for their operations with a focus on optimizing the aircraft trajectory, as part of the overall network. It will also help us increase the level of automation, so leaving humans to do what they do best taking difficult decisions in unusual situations and leave a number of routine tasks to machines.

Given the complexity of the program, a legal entity was founded by the European Commission and Eurocontrol, to coordinate and concentrate all relevant research and development efforts in the Community. The total estimated cost of the development phase of SESAR is € 2.1 billion, to be equally shared among the Community, Eurocontrol and the industry (€700 million Community, €700 million Eurocontrol, €700 million industry).

The key SESAR objective are:

- Restructure European airspace as a function of air traffic flows
- Create additional capacity;
- Increase the overall efficiency of the air traffic management system

Airspace users want primarily to be able to optimize and implement trajectories which suit them best: reduce delays, reduce travel time, reduce costs and provide maximum flexibility. Any new ATM system must retain safety as being centrally important, while reducing their environmental footprint is another expectation of airspace users.

SESAR stakeholders include airspace users (civilian and military), airports, air navigation service providers, the manufacturing industry, aviation associations and organizations, regulators, the scientific world, regulators and administrations as well as the general public.

The SESAR projects, with its numerous work packages distributed among European aerospace firms is a catalyst for innovation and competiveness. SESAR is developing a system of systems: components that have never talked together before will work together and be interoperable, a sort of very complex technical puzzle. The Federal Aviation Administration in the US is pursuing a similar project called NextGen. In the US, a single authority regulates the whole geographical area and there are a limited number of ATM canters. In Europe, however, there are multiple national authorities and many ATM centers with different cultures and languages. Furthermore, European airspace is among the busiest in the world with over 33,000 flights on busy days and high airport density. This makes air traffic control even more complex. SESAR focuses on air traffic management, NextGen takes what is called a "curb-to-curb" approach, including not only air traffic control, but also airports, airport operations, security, and passenger management. The operational capabilities are similar, differing mostly in terminology, though SESAR seems to place greater emphasis on capabilities of the ATM system than on the aircraft and its avionics, especially during the period up to 2013.The SESAR program targets an in-depth modernization and harmonization of the existing ATM systems in Europe. NextGen is very much a "can-do" project, where a number of key new technology projects are identified and these are pushed through. NextGen is more heavily dependent on aircraft and avionics capabilities, policy changes and an emphasis on greater use of Area Navigation (RNAV), Required Navigation Performance (RNP) and Vertical Navigation (VNAV)-based flight profiles. The U.S. enroute airspace is largely conventional, using ground-based navigation aids to define the routes, while the European enroute airspace structure is completely RNAV-based (RNAV-5). SESAR is slightly more intellectual approach, where Europe have sat back and developed an "overall systems" approach, a concept of operations blueprint which Europe is now working toward. Some of the more notable differences between SESAR and the NextGen include the fact that SESAR's scope is larger than that of NextGen, reaching much deeper into the areas of research, airspace management, institutional issues, safety management, environmental and human factors, among others.

Considering the comparable nature of these two initiatives, airlines users (most of whom fly in the US and Europe) have been requesting interoperability between SESAR and NextGen to avoid costly duplication of airborne equipment. As a result, the US FAA and Europe Eurocontrol are currently working on a Memorandum of Cooperation that will come as a pragmatic response to airspace users' request. It will guarantee interoperability between both future ATM systems and promote the development of international standards through the International Civil Aviation Organization (ICAO), the Memorandum is aimed at establishing a binding framework for fruitful technical cooperation relating to their development. The cooperation should ensure that the same aircraft can fly in Europe and the US air space using one system, that common standard are available in time, the cooperation minimize the cost and share information, but also enable manufacturers of both systems to compete and supply both markets. The FAA &

Eurocontrol have always had a good relationship when sharing R&D but there is also benefit in competition and alternatives in ideas and implementation.

Nevertheless, they remain two distinct and parallel projects inspired by a sort of intellectual emulation, if not also by competition. SESAR could bring enormous added value to Asian air traffic which is seeing the highest growth in traffic and the greatest need for ATM reorganization. At some stage in the future, countries that cannot respond technologically will see a need to upgrade their technology. Strong of its unique multi-country European experience in interoperability, the European SESAR system might be the preferred solution to the Asian multi-country. Emulation between the two approaches is also important in a way that it will incite manufacturers on both sides to innovate and bring solution to the deployment phase sooner to the benefit of the users.

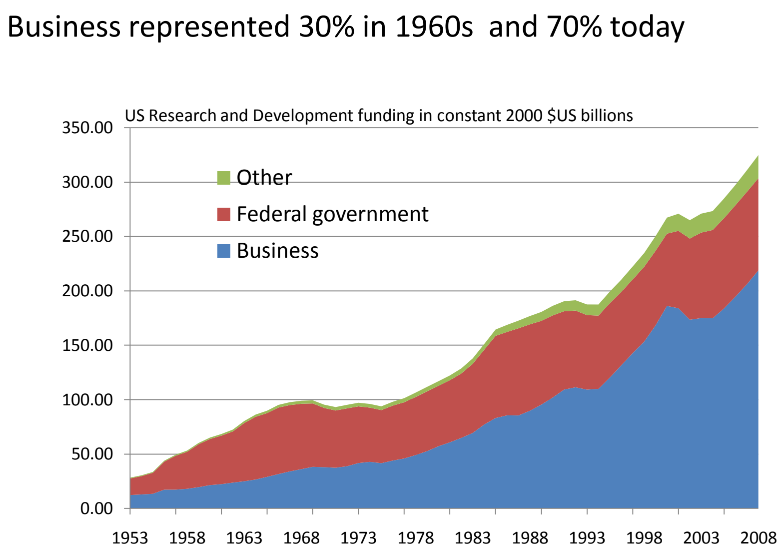
II-5 Importance of aerospace as innovation spillover

The strategic importance of aerospace also resides in the spinoff and spillover of aerospace innovation that can be realized across the aerospace value chain but also to other sectors of the manufacturing industry, and emulate research into research centers. In the case of spin-off[66], two types must be differentiated: government spin-off and research spin-off. Spinoffs are products which have undergone a technology transfer process from research to public use. These uses may be direct or indirect. Research spin-off concern a company founded on the findings of a member or by members of a research group at a university. This is a classical example of innovation leading to economic growth. In the case of government spin-off, this is typically the dual military-commercial use of technology. For example the microchip that is used in guiding missiles can possibly be used for automobiles, or for bike computers. In the government spinoff model, the scientist working on a major defense project would make discovery that in turn make some new product or service possible Scientists and engineers working in commercial firms would learn of the discovery, develop and bring to market a product or process from it. The innovation would in that case "spin-off" from the defense sector to the commercial

[66] Alic John, Branscomb Lewis, Brooks Harvey, Carter Ashton, Epstein Gerald (1992),beyond the spinoff, Military and commercial technologies in a changing world, Harvard Business School, Boston, MA

sector. In the case of government spinoff, most government R&D focuses on national defense, space exploration or health innovation. Those innovations however are not ruled by normal economics and market prices. Although they yield a real new product or service, those technological products or services are sold to a single customer: the government. The price of these products and services do not reflect its market value, e.i the value to society but are based on costs. Therefore, one can argue that the only way government R&D drive net economic growth is through spillover of innovation rather than spinoff. On the other end, privately funded R&D brings a direct return to the investors and generate a spillover net effect to another industry and therefore to another part of the economy. The real value of government spinoff is through the creation of a competitive advantage. Without the defense involvement, key technology such as semiconductors, computer communication satellite would have taken years or decades more to be developed and might have changed the leadership position of the US in these sectors. Moreover, given the fact that government usually pay premium price for new technology, they finance a large portion of the learning curve until the commercial market takes over. Generous defense procurement was just as important as R&D in influencing the leadership or competitiveness of the national aerospace or health industry. Private R&D spillovers are becoming much more prevalent in generating economic growth as the sheer volume of government R&D has never cease to decrease since the end of the cold war. Government spinoff will be studied in detail in the next section when the entry of Boeing into the market for jet aircraft. Today, private sourced R&D represent about 70% of the total US R&D , compared to 30% in 1960s at the golden age of defense spinoff and military-commercial dual use of technology.

Figure 44: US R&D funding by sector



Source: National Science Foundation, Division of Science Resources Statistics, *National Patterns of R&D Resources* (annual series).
Laurent Rouaud

For comparison, the worldwide R&D expenditures totaled an estimated $1.107 trillion in 2007 (the latest year for which data are available)[67]. The United States accounted for about 33% of this total. Japan, the second-largest performer, accounted for about 13%. China was third, at about 9%. Germany and France, respectively, fourth and fifth (and the largest performers in Europe), accounted for 6% and 4%. The top 10 countries (also including South Korea, the United Kingdom, the Russian Federation, Canada, and Italy) account for almost 80% of current global R&D performance. The 27 nations of the European Union (EU-27) accounted for about 24% of global R&D. R&D by the EU-27 grew at an average annual constant dollar rate of 3.3% between 1997 and 2007. By comparison, the U.S. pace of growth, on the same basis, averaged 3.3%.

[67] US National Science Foundation

In today's environment of reduced defense budgets, the dual use of technology interaction has changed significantly from the time of Boeing enter in the commercial aircraft. The commercial sector is focusing in getting other means of government support for innovation as the share of defense contribution shrink and the military planner on the other hand has to recognize the defense increasing dependence on the technology from the commercial sector. As a results (1) commercial aerospace has become not only a matter of economic security but also a matter of national security and (2) the spillover of commercial innovation to other industries has become the real driver of economic growth.

II-6 The benefits of innovation spillover – example of successful spillover and survey of economic literature on innovation spillover

Innovation is the main pillar of future success and competitiveness of the firms involved in aerospace or in any other industry. The challenge of the airlines to reduce their costs, reduce their impact on the environment, simplify their operation while increasing safety and reducing manufacturing costs are the main drivers of innovation of the aircraft manufacturers.

The following chapter investigates (1) the mechanism of innovation spillover or technology transfer in the UK and the US; (2) gives a few examples of actual innovation spillovers to different industries to highlight that these mechanisms actually work, and (3) it shows that Asia is becoming a formidable force in driving innovation. How important innovation is to economic growth as the "race to innovation" goes on in the US, Europe and now Asia.

According to an OECD study[68], innovation contributes to the three main drivers of economic growth: capital , labor and productivity. The study suggest that countries experiencing above-average growth performance in the 1990s were the one that

[68] OECD 2004 Understanding Economic Growth

had more people employed; accumulated more capital; improved the quality of their workforces; and improved the multi-factor productivity (MFP). Innovation drives a greater efficiency in the use of labor and capital, improves management practices, organizational changes and ways of producing the good of service to the benefit of the customers. The study indicated that the countries that had an above average rate of growth in productivity in the last 20 years (Australia, Canada, Denmark, Finland, Ireland, New Zealand, Norway, Sweden, the United States) had an above average rate of growth in patenting. It has been estimated that a 0.1 percentage point increase in R&D could boost output per capita growth by some 0.2%.

It is rather intuitive to believe that innovation spillover must occur often and meaningfully from aerospace to automobile in the field of material, structure and aerodynamic. However, there are very few documented examples of such spillovers in Europe. The most likely reason is that spillovers are difficult to estimate since they are a combination of measurable and non-measurable effects. For example, the UK has a strong aerospace industry and has long been the world's center of excellence for motorsport at its highest level, boasting championship winning F1 teams like Lotus, McLaren and Williams. The UK government even set up a structure which sole purpose was to transfer technology from aerospace to motorsports in 2002. The actual innovation development in aerospace that made its way to motorsports is actually small but the knowledge base has been tremendous through the transfer of aerospace engineers in the field of aerodynamics and structures. The experience that these engineers took with them cannot possibly be quantified but its value is certainly important to motorsports. For example, the current managing director of TAG McLaren International was originally a mechanical engineer that started his career at British Aerospace as a structural engineer. Similarly, Mike Gascoyne (graduated from Cambridge in fluid dynamic) graduated in aerodynamic and started his career at Westland Helicopters, before joining the motorsport industry as an aerodynamic engineer. Today, he is one of the most successful chief engineers in motorsport working for Lotus.

The UK is one of the very few countries in Europe that has been concerned about the policy on technology transfer for decades. Both in the UK and in the US, the use of government funded technology research, in defense, emerged as key topic for economic and policy research in the 1980s. Very early on, the attention of policy makers focused on whether the UK's defense research were contributing to the national wealth creation. The debate culminated when a report showed in the mid 1980s, that one of the best examples of a successful innovation transfer from the defense field to the civilian field concerned the liquid crystal displays, a technology that was exploited commercially by the Japanese and not a UK company[69]. In the early 1990, researches laid the ground for the establishment of a UK mechanism to better capture technology transfer and create innovation spillover. Shama in 1992[70] identified 4 different level of strategy leading to innovation spillover from passive strategy to the most active called "national competitiveness":

I. a *passive strategy*: the research laboratories limit themselves to publishing their technologies hoping for clients to come forward. The laboratories provide information and respond to inquiries.
II. an *active strategy*: in addition to the passive strategy, , the laboratories try to acquire rights to the technologies they developed and seeks to obtain revenue streams through licensing;
III. an *entrepreneurial approach strategy:* try to set up of joint venture to exploit the technology developed by the laboratory;
IV. *a national competitiveness strategy:* laboratories focuses their technology transfer activity on technology that contribute to the social and economic well being of its country

[69] Barnes, J. and Holeman, B. (1987), The transfer of defence research on electronic materials to the civil field. Technology in the 1990s: the promise of advanced materials: proceedings of a Royal Society discussion meeting held on 4 and 5 June 1986. The Royal Society,London, 27-38.
[70] Shama, A., 1992. Guns to butter: technology transfer strategies in the national laboratories. *The Journal of Technology Transfer,* 17 (1), 18-24.

Following the debate in the UK, a number of institutions were created to encourage technology transfer. Most proved to be ineffective and were abandoned. Among them the Defense Technology Enterprises Ltd. (DTE) created in 1984, organized as a large innovation database, failed because most technology innovation concerned defense at that time and the dual use of innovation was already in place by long established relationship. Another initiative was launched with the Civil Industrial Access Scheme (CIAS) and later the Dual Use Technology Center (DUTC). All failed to commercialize innovation in the public sectors; those initiatives however have contributed to established a great experience base on technology transfer. At the same time, the background of budgetary constraint of the mid 1990s encouraged to obtain more value from the UK government research laboratories. This incited technology transfer to be focused on the end result of commercializing a final product or service and commercial orientated management practices were put in place. The creation of the Defense Evaluation and Research Agency (DERA) in 1995 and the Defense Diversification Agency (DDA) in 1998 was based on this concept.

Unlike other European countries, an example of successful commercial technology transfer can clearly be observed on the UK technology transfer bodies of the UK government, such as the Defense Science and Technology Laboratory (DSTL). The Dstl is an agency of the Ministry of Defense (MOD) whose purpose is to supply scientific and technical research and advice to the MOD. In particular, the UK government has tasked Dstl with ensuring that its innovative ideas and technologies are translated into "wealth-creating enterprises that benefit the economy and wider society and bring useful income to Ministry of Defense." As a result, Dstl launched Ploughshare Innovations Ltd, as its technology management company. Ploughshare Innovations, is a wholly-owned company of Dstl whose job is to exploit selected Dstl Intellectual Property in non-MOD markets. In short, Ploughshare only job is to bring innovation made for the UK defense to commercial use by finding the best investment partners and make license deals.

As a recent example of spillover, Ploughshare brought to commercial use an innovation that originated from Dstl to make soldiers' protective clothing more effective against chemical attack.

<u>**Example 1:**</u>

Original laboratory: *UK Defense laboratory*

Original purpose: *make soldiers' protective clothing more effective against chemical attack*

Original industry: *military*

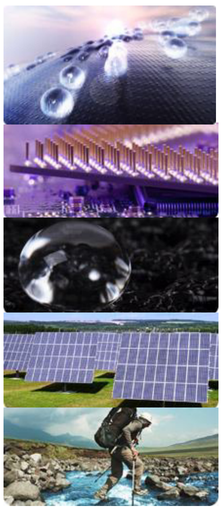
Spillover industry: *sportswear, energy, electronic, health*

Spillover usage: *shoes, water filtration, solar energy, textile, glass and ceramic, bio-consumable*

Spillover potential:: *multi $ million market*

This technology reduces the surface energy of a material so that liquids are repelled and resist to being absorbed. The technology has already found an application with the leading US sportswear equipment company Nike to repel water on sport shoes, and with Energy Launch Partners, a US company specialized in the high growth market of renewable energy. In the case of Nike, multi-patented liquid repellent technology employs a special pulsed ionized gas (plasma), created within a vacuum chamber, to attach a nanometer-thin polymer layer over the entire surface of the shoes . Nike launched its first shoe product using that particular technology on December 2009. The potential application of the technology is rather extensive from the performance textile (water repellency, stain resistance or better breathability), eyewears (effective water shedding from lenses for active sports), consumer electronics (protection against both water and oil, increase reliability), bio-consumable (avoid cross contamination), filtration (increased performance of filtration components) or glass and ceramics (prevents water, frost and dirt from forming on optical surfaces. The six markets or fields in which this innovation could be introduced are multi-billion euro in volume of business.

Figure 45 Example of spillover from the battle field to water filtration



Original laboratory:	*UK Defense laboratory*
Original purpose:	
Original industry:	*military*
Spillover industry:	*sportswear, energy, electronic, health*
Spillover usage:	*shoes, water filtration, solar energy, textile, glass and ceramic, bio-consumable*
Spillover potential:	*multi billion market*

Source: UK Defense Laboratory, Center, Laurent Rouaud

In the US, the 1980 Stevenson-Wydler Technology Innovation Act included technology transfer among the missions of all national laboratories, including those with a defense role. A number of legislation establishing technology transfer tools and procedures was put in place shortly after[71]. Following is a list of legislation and mechanisms that was enacted by the US congress to encourage the dissemination of innovation and the commercialization of those innovations.[72]

[71] Shama, A., 1992. Guns to butter: technology transfer strategies in the national laboratories. The Journal of Technology Transfer, 17 (1), 18-24.
[72] Science and Engineering Indicators 2004, National Science Foundation

The Stevenson Wydler Technology Innovation Act (1980)

The act required offices of technology transfer in Federal agencies and established budgeting and reporting requirements.

The Bayh-Dole University and Small Business Patent Act (1980)

Permitted government grantees and contractors to retain title to federally funded inventions and encouraged universities to license inventions to industry. The act is designed to foster interactions between academia and the business community.

The Small Business Innovation Act (1982)

Established the Small Business Innovation Research (SBIR) program within the major Federal R&D agencies to increase government funding of research that has commercialization potential within small high-technology companies.

The national Cooperative research Act (1984)

Encouraged U.S. firms to collaborate on generic, precompetitive research by establishing a rule of reason for evaluating the antitrust implications of research joint ventures. The act was amended in 1993 by the National Cooperative Research and Production Act (NCRPA), which let companies collaborate on production activities as well as research activities.

The Federal Technology Transfer Act (1986)

amended the Stevenson-Wydler Technology Innovation Act to authorize cooperative research and development agreements (CRADAs) between Federal laboratories and other entities, including state agencies.

The Omnibus Trade and Competitiveness Act

established the Competitiveness Policy Council to develop recommendations for national strategies and specific policies to enhance industrial competitiveness. The act created the Advanced Technology Program and the Manufacturing Technology Centers within the National Institute for Standards and Technology to help U.S. companies become more competitive.

The National Competitiveness Technology Transfer Act (1989)

amended the Stevenson-Wydler Act to allow government-owned, contractor-operated laboratories to enter into CRADAs (see below for an explanation on CRADA)

The National Cooperative Research and Production Act (1993)

Relaxed restrictions on cooperative production activities, enabling research joint venture participants to work together in the application of technologies they jointly acquire.

The Technology Transfer Commercialization Act (2000)

amended the Stevenson-Wydler Act and the Bayh-Dole Act to improve the ability of government agencies to monitor and license federally owned inventions.

The America Competes Act and the American Recovery and Reinvestment Act followed in 2009 to specifically address the importance of the U.S. innovation system for national economic growth.

Organized in 1974 and formally launched by the Federal Technology Transfer Act of 1986, the Federal Laboratory Consortium for Technology Transfer (FLC) objective is to promote and strengthen technology transfer nationwide. More than 250 federal laboratories and centers and their parent departments and agencies are FLC members. The consortium is the US nationwide network of federal laboratories that provides the forum to develop strategies and opportunities for linking laboratory mission technologies and expertise within the marketplace.

There are usually 4 ways of transferring technology from a government research lab:

(1) **A cooperative research and development agreements** (CRADA): Under these agreements, the government laboratory employees collaborate with the private partners on research projects that will directly benefit the government research program mission and the partners' research. The laboratory may contribute

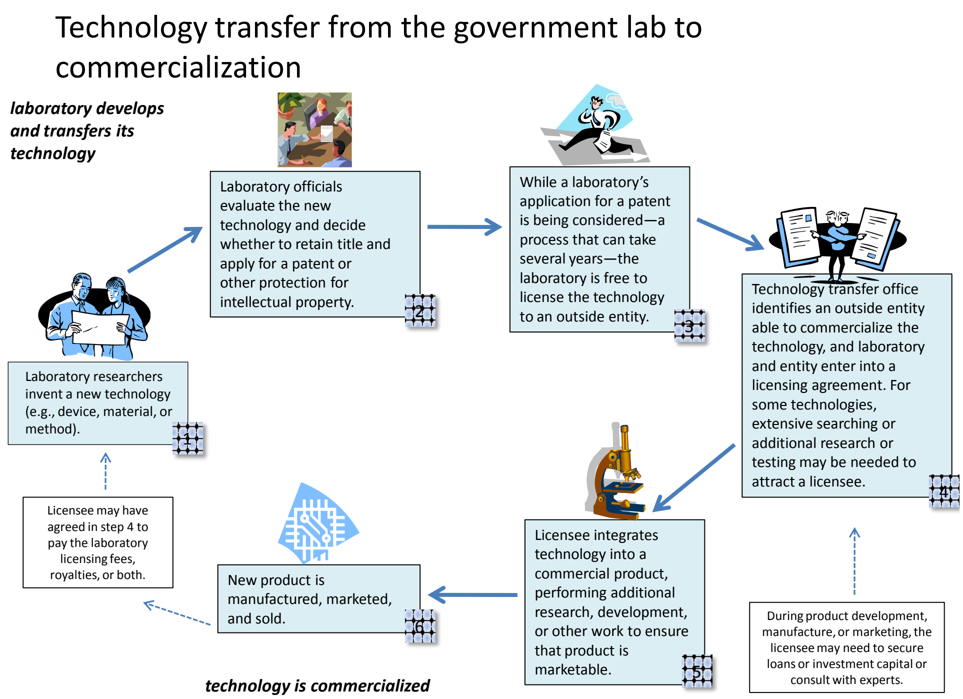
personnel, equipment, or other in-kind resources to a project, the private CRADA partner must contribute funds, in-kind resources, or both. The CRADA idea came about in 1986 to encourage the transfer of technology between the government and the private sector, and enhance U.S. competitiveness. Congress passed legislation under the Federal Technology Transfer Act of 1986 that promotes technology transfer by introducing the CRADA as a mechanism to increase federal laboratories' interaction with industry. The CRADA is a flexible contract. Both parties enter into the contract with the intention to complete the tasks defined. However, if either party finds that the tasks are impossible to complete because of technical difficulties or diminished resources, that they may not be completed per expectation, or that there is no longer the interest in the technology transfer, the contract can be amended or cancelled. In fiscal year 2008 alone, the GAO estimated that the 17 laboratories of the Department of Energy generated 698 CRADAS agreement 90% of which were with private industry partners. These agreements generated some $69 million of funding from private companies in fiscal 2008.

(2) **Nonfederal work-for-others agreements:** Under a Nonfederal work-for-others agreement, a government laboratory agrees to conduct research on behalf of a private sponsor. The research must be consistent with the laboratory's missions and rely on the laboratory's unique capabilities. This type of agreement differs from CRADAs in that the research does not directly benefit DOE's programs. The private sponsor must pay the full cost of the project. In fiscal year 2008 alone, the 17 laboratories of the Department of Energy participated in over 2,600 work-for-others agreements with nonfederal sponsors. As much as 65% of this agreement had a private sponsor and 35% a university, state or local non-federal sponsor. These agreement generated 373$ million in revenues for the Department of Energy.

(3) **Licensing agreement**: the research laboratories share its technology by licensing their patented discovery, copyrighted software programs, or other intellectual property to a private, state, university or local authority to use or commercialize that technology. The licensee may agree to pay a fees or royalties

to the laboratory for the use or commercialization of the technology. The chart below summarizes the technology transfer in a licensing setting.

Figure 46 Technology transfer stages



The different action from the innovation done in the government lab or university to the commercialization follows in general 6 typical stages. A government technology transfer office is generally responsible for coordinating a grouping or all national laboratories efforts to identify technologies and obtain patents or other legal protections for those technologies. The technology office with the laboratory is usually responsible for promoting the laboratory's technologies to potential users, and negotiating the license agreement. The Licensees are responsible for commercializing the licensed technologies by integrating the technologies and come up with the products from the development, manufacture, and marketing of those products. The licensee may require the financing of venture capitalists or other financing to launch the product. The licensee may or may not pay fees or royalties to the laboratory in exchange of permission to use the technology. In the US, the national laboratories of the Department of Energy derived fees and royalties from their patents for a total amount of $44 million in revenue for 2008.

4. **User-facility agreements:** Under a user-facility agreement, scientists from outside the government lab can use the scientific equipment for their own research. The users who wish to keep their results private, however, must reimburse DOE for the cost of using the government laboratory facilities. The Department of Energy, for example, had more than 2,800 user-facility agreements for user facilities at 8 of their 17 laboratories of which 783 were with private entities in 2008. The user-facility agreement generated 6.5$ million in revenue for the Department of Energy.

Here are four other examples of innovation spillover from a government lab to an industry for which the innovation was not at all intended and have found or has the potential to find a significant market.

Example 2:

Original laboratory: *Langley Research Center*

Original purpose: *Research study on forces of pressure and viscous drag*

Original industry: *military aerospace*

Spillover industry: *sportswear equipment*

Spillover usage: *swim suit*

Spillover potential: market: *750$ million approximately*

NASA's Aeronautics Research main objective is to research ways improve flight efficiency such as understanding the forces of pressure and viscous drag that slows down an aircraft or space vehicle. NASA uses their wind tunnels to study the forces of friction in gasses and liquids. The pressure forces are use to optimize the shape and performance of an airplane. In high speed or low speed, the thin boundary layer around a moving object in the air or in water reduces the velocity of the fluid surrounds the moving object. This layer is about 2 centimeters thick for a swimmer. Speedo, the manufacture of swimwear products, asked NASA to help design a swimsuit that will reduce drag, shortly after the 2004 Olympics. Research determined that the viscous drag on a swimmer is about 25 percent of the total drag. Researchers began testing of fabrics in a small wind tunnel developed for low-speed viscous drag reduction. They came up with a fabric called the LZR Racer. The LZR Racer reduces skin friction drag by 24 percent more than previous Speedo racing suit fabric, while the compression helps the swimmers maintain a good body form enabling them to swim longer and faster since they are using less energy to maintain form. The research seems to have paid off; in March 2008, athletes wearing the LZR Racer broke 13 world records. It paid off so much that the speed suit will be illegal to use in competition in 2010.

Figure 47 Example of spillover aerospace to swimwear

Original laboratory:	*Langley Research Center*
Original purpose:	*Research study on forces of pressure and viscous drag*
Original industry:	*military aerospace*
Spillover industry:	*sportswear equipment*
Spillover usage:	*swim suit*
Spillover potential:	*market: 750$ million approx.*

Source: Langley Research Center, Laurent Rouaud

Example 3:

Original laboratory: *Kennedy Space Center*

Original purpose: *keep space shuttle fuel ultra cold while minimizing ice build up*

Original industry: *Space*

Spillover industry: *construction*

Spillover usage: *home insulation*

Spillover potential: market: *1-2$ billion approximately*

NASA Space Shuttle needs to keep its fuel at ultra cold temperature while minimizing ice buildup that could endanger the mission. The temperatures of the shuttle's engines climb to more than 6,000 °F . The fuel used is liquid hydrogen that is maintained at -423 °F. Mixed with liquid oxygen (kept below -297 °F) it creates an explosive mixture that is combined to powdered aluminum-fueled solid rocket boosters. The final mixture makes the shuttle escape Earth's gravity. The cryogenic temperature of the liquid fuel can create ice and cause safety issues at launch. NASA started to explore innovative solutions for providing superior thermal insulation to the fuel tanks of the shuttle. It develops an aerogel derived silica, aluminum oxide, or carbon gels using a supercritical drying process. The aerogel, the lightest solid on earth, can withstand extremely hot temperature. Acoustiblok, the industry leader in acoustical insulation, has developed with NASA a spillover of the aerogel to be applied in construction. The commercialized product consists of narrow strip of flexible aerogel to be applied to wall wooden studs in buildings for thermal insulation. The commercialized product is called: Thermablok. It is a thin strip of flexible aerogel in a plastic casing with an adhesive in the back. The Thermablok is 100-percent recyclable, include more than 30-percent recycled material, and allow low-cost, low-emissions shipping due to their virtually weightless composition. According to tests conducted U.S. Department of Energy, a strip of Thermablok applied to wall studs before the installation of drywall increases the wall's insulation factor by 30. Acoustiblok believe that for a typical home,Thermablok would save over $700 annually in energy costs with an accompanying 3.9-ton reduction in carbon dioxide emissions. The market of the product is worldwide and should be commercialized to the major home improvement stores in the world in 2010.

Figure 48 Example of spillover from space to home construction

Original laboratory:	*Kennedy Space Center*
Original purpose:	*Keep Space Shuttle fuel ultra cold*
Original industry:	*space*
Spillover industry:	*home construction*
Spillover usage:	*home thermal insulation*
Spillover potential:	*market: 1B-2B$ approx.*

Source: Kennedy Space Center, Laurent Rouaud

Example 4

Original laboratory: *Ames Research Center, Johnson Space Center, Jet Propulsion Laboratory*

Original purpose: *Assist human operations in space with remote controlled robot*

Original industry: *Space*

Spillover industry: *health*

Spillover usage: *software to improve people health*

Spillover potential: market: *0.5 billion approximately*

In the 1990s, NASA developed a small robot that landed in July 1997 on the surface of Mars to take samples and photographs. The robot was called Sojourner and was the first successful rover mission on Mars. The program was one of the most successful programs of NASA. Unpredictably, the technological innovation originally for space found its way to the table of consumers; as it is today influencing the way people eat. The program led to another research to produce a free-flying robot capable of assisting astronauts with tasks such as structural repairs, assembly, and on-orbit refueling, and the Ranger Neutral Buoyancy Vehicle (NBV) was developed. The main engineer on the program founded a online nutrition company and used the same computer algorithm in the NBV to resolve a problem of disconnect between the vast amount of nutritional data available to the public and how the data is actually used. He realized that the challenge was similar to the NBV's challenges of combining 20 different computers. The solution for the robot was to create intelligent software to mediate between the operator and the robotics data. The nutrition software issue was resolved using the same technology. The result is a user friendly on-line software on which the user set health goals and then the software using a food nutrition database generate and plan balanced meals with indication on vitamin, calories, fat and minerals. The product called Vitabot has more than 1,000 company clients such as HBO, Warner Bros. and health clubs such as Gold's Gym.

Figure 49 Example of spillover from space to the kitchen

Original laboratory:	*Ames Research Center, Johnson Space Center, Jet Propulsion Laboratory*
Original purpose:	*Assist human operations in space with remote controlled robot*
Original industry:	*space*
Spillover industry:	*Health*
Spillover usage:	*Nutrition*
Spillover potential:	*market of 0.5$ billion approx.*

Source: Ames Research Center, Laurent Rouaud,

<u>Example 5</u>

Original laboratory: *Los Alamos National Laboratory's*

Original purpose: *Ultra sound research*

Original industry: *Aeronautics*

Spillover industry: *Energy*

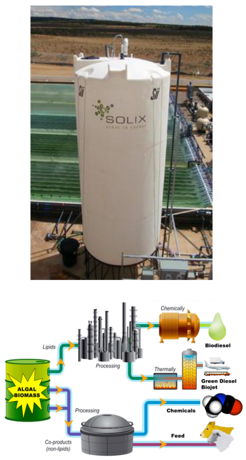
Spillover usage: *Extract oil from algae cell*

Spillover potential: *multibillion industry*

This example is probably in the field of the most promising field of energy the future. Driven by a decreasing fossil oil reserve, an increasing price and the more stringent environmental regulations clean or cleaner alternative fuel is ripe for a successful introduction, particularly in transportation. One of the most promising cleaner alternative fuels is algae, which has the critical advantage of not competing with food. Algae are also a very promising source of alternative fuel for airlines with the potential to change the business model in term of the fuel value chain distribution.

The Los Alamos National Laboratory (LANL) has been working on innovative acoustic technologies. They patented a technology that use sound wave to concentrate the harvested algae mixture and extract oil from algae cell. Solix Biofuels, Inc entered a license agreement with LANL to large scale commercialization of micro-algae based fuel. The technology not only facilitates the extracting but also eliminates the need to use chemical solvents in the extraction process. Solix is planning to bring the process forward very soon and start commercializing the algae base fuel as an alternative to petroleum base fuel in the very next future.

Figure 50 Example of spillover from aerospace to energy



Original laboratory:	*Los Alamos National Laboratory*
Original purpose:	Ultrasound research
Original industry:	*Aeronautics*
Spillover industry:	*Energy*
Spillover usage:	alternative fuel - *extract oil from algae*
Spillover potential:	*multibillion billion – new market*

Source: Los Alamos National Laboratory, Laurent Rouaud,

In both the case of the US and the UK, the successful spillover of innovation can be attributed to:

- A single national system of technology transfer,
- A solid experience on what works and doesn't,
- Strong defense sector leading the way,
- Success breeding success,
- the successful commercialization of a product or service.

III The historical leadership of the United States LCA industry

All industrial development follows a complex economic policy framework whose historical roots are often long and intricate, linking events that at first glance appear unrelated Commercial and military aerospace is certainly one of the highest strategic markets for a developed nation if not the highest. The US has for a long time dominated the aerospace market. Why did Europe, the birth place of aviation and full of innovative ideas through the history of aviation, fall behind the US until the 1990s? This question brings us back to the signature of the Yalta treaty on February 11th 1945.

If Yalta treaty main goal was to accelerate the end of the war and prepare peace, the issue of the territorial influence between the US and the Soviet Union was certainly high on the agenda. The two states can organize as they wish the economic dependence of occidental countries strained by four years of occupation and combat. The two superpowers recognized that the technical knowledge and technology was critical in maintaining their dominant position. This drove the two superpowers to invest heavily in nuclear power and aeronautics. In this new industrial strategy, aeronautic technology was at the forefront of the political agenda. This era marked the beginning of the US dominance in this field. As a result, the US and the URSS started to subsidize heavily the development of the military aerospace industry. The following comment at that time testifies of the importance given to military aerospace technology:

"The congress must prepare itself to invest and give the necessary effort to maintain our dominance in aerospace that we have successful kept since the World War II. We must fight relentlessly to maintain this dominance"
John F. Kennedy

On the other hand, the war has had catastrophic consequence on European industries and in particular to its aerospace industry. The previous German science and technology capabilities had been totally destroyed. The United Kingdom is the only European nation that has kept a strong aerospace position thanks to the military aircraft it had produced during the war.

The US commercial aircraft is a small part of the much larger US aerospace sector at that time. All US commercial aircraft manufacturers are heavily engaged in the manufacturing of military aircraft. The links are vital to the growth and profitability of the aerospace industry as the stability of the military revenues was the main driver for the development of civil aircraft. The stability of the revenue proved to be especially vital in regards to the already very cyclical nature of the commercial aircraft business. Moreover, the US manufacturers of commercial aircraft had the opportunity to obtain some government subsidies to develop their civil aircraft business. The main reason for the US government support of its aerospace industry was essentially:

- the need to insure a strong military defense;
- continue and development of the dominance on key technologies;
- continue to derive important export revenues from the sales of military aircraft;
- the development of the national prestige from the participation in key industries.

There were five different ways for the US government to intervene in the market:

- massive technology transfers from military to civil in the area of R&D, flight test and technical evaluation;
- production assistance from military contracts on R&Ds , equipments, tools, and government facilities to develop commercial programs;
- Financial assistance with progressive payments and fiscal assistance;
- Market stimulation with special financial assistance to airlines;

- Special assistance to insure federal funding available.

The US has used two instruments to support the development of its aircraft industry: the support for aeronautics R&D, and the procurement of military aircraft. These instruments have been remarkably successful. Well before the beginning of World War I, the US aviation industry was concerned that the US was lagging relative to the major European countries in institutionalizing aircraft R&D capacity. In addition, the eminent US participation in World War I precipitated the decision to establish an Advisory Committee for Aeronautics that later became the National Committee on Aeronautics (NACA). NACA developed the US research facilities and staff and especially the construction of state of the art wind tunnels to test propeller and airfoil design. As early as the mid 1920's research at Langley Field and at Stanford University were operating and producing results. In 1931 a wind tunnel was constructed that was able to test the performance of an entire aircraft. Even during the late 1920's and 1930's NACA performed some important technical innovations, such as the NACA cowling (aerodynamic fairing streamlining radial engine). In 1939 the 60 percent reduction in drag and the 14 percent increase in speed predicted by NACA wind tunnel tests were confirmed by a transcontinental speed record by a Lockheed Air Express equipped with a NACA cowling.

After NACA, came the NASA era. The Sputnik satellite program of the USSR in the mid 1950s precipitated the creation of the National Aeronautic and Space Administration (NASA). NACA research facilities and personnel were absorbed by the NASA or transferred to the Air Force. The transition from NACA to NASA was accompanied by a new focus on space rather than on aeronautic and especially from an R&D performed in-house NACA research lab to contracting the research to large aerospace contractors.

Throughout the 1960's and 1970's defense procurement accounted for a minimum of two-thirds of R&D directed to advancing aircraft performance. Between 1920 and 1970, US government funding through NASA, the Department of Defense and the other federal agencies contributed to 45 of the 51 innovations in the civil aerospace industry. The table below gives the list of some of the most important innovations between 1920 and 1964. This period was the most important period in the entry of Boeing into the civil jet aircraft era. If the subsidies of the different programs are attributed to the government (third column) it means that it comes either from a public research centers or from a government contract. If the innovation is attributed to the private sector, it means that none of the financing for the innovation considered comes from the government. For example, the star-engine cooled by air was developed in cooperation with the army and the navy following a government contract established in 1920. Civil application started in 1922 and its introduction into commercial transportation started in 1925.

Table 5 Important aerospace innovation 1920 - 1960 - Funding sources

Innovation	Year	Funded/subsidy	First year of operation	
			Military	Civil
Star-engine	1920	Federal/military	1922	1925
Retractable landing gear	1921	Federal/military	1931	1930
Hypersustantation	1927	Civil	1932	1933
Surpercharging	1927	Federal/military	1930	1930
NACA cowling nacelle	1928	Federal/civil	1932	1929
De-icing	1928	Federal/civil	1935	1935
2-way radio	1928	Federal/military	1928	1929
Molded Structures	1930	civil	1930	1930
Aluminium alloy	1931	Civil	1935	1935
Pitch mechanism for propeller	1932	Federal/military	1933	1933
Autopilot	1933	Civil	1936	1935
Kerosene with high octane	1936	Federal/military	1936	1946
Pressurized cabin	1937	Federal/military	1937	1938
Helicopter	1941	Civil	1942	1946
Adhesive bonding	1941	Federal/military	1942	1958
Turbojet	1941	Federal/military	1942	1954
ILS	1941	Federal	1943	1947
Arrow wing	1945	Federal/civil	1947	1954
Delta wing	1945	Federal/civil	1948	_
Fatigue test	1946	Federal/military	1948	1947
Thrust reversors	1946	Federal/military	1963	1954
Titanium	1947	Federal/military	1952	1954
Supersonic flight	1947	Federal/military	1953	_
Ground weather radar	1948	Federal/military	1948	1950s
Doppler radar	1949	Federal/military	1954	1955
Numerical command computing	1951	Federal/military	1956	1956
Inertial navigation	1953	Federal/military	1963	1967
Ultrasound fatigue testing	1955	Federal/military	1956	1957
Turbofan engine	1956	Federal/military	1961	1960
Digital onboard computer	1957	Federal/military	1957	1967
Communication satellite	1958	Federal/military	1966	1962
Digital flight plan	1959	Federal/military	1959	1961
Flight simulator computer	1960	Federal/military	1960	1963
Weather satellite	1960	Federal/civil	1960	1960
Composite material	1961	Federal/military	1969	_
Fog dispersor	1963	Civil	1967	1963
Navigation satellite	1964	Federal/military	1964	1970

The table above includes a few important examples of technology transfer or government contract that helped the US aerospace industry to enter into the military and civil aircraft business. All these innovation has been applied to commercial aviation by Boeing.

In 1941, the aerospace industry built more than 19,000 fighter aircraft from the United Kingdom. The production increase significantly after Pearl Harbor to 48,000 and doubled again in 1944. At the end of the war, the aerospace industry in the US is operating at full capacity. Once the war was over, some military transport was converted to civilian use to carry passengers. The competition within the US and with the enemy aerospace capability greatly motivated the government and the private research labs to innovate. That effort led to considerable technology progress. In particular, Boeing developed and produced long range bombers whose basic design was used to develop the first transport aircraft. The US aerospace has largely benefitted from the experience gained during the war as well as the significant subvention and contracts as the table above shows.

The most important technology to date in commercial aviation, the jet engine, was developed during the last few years of the war under federal and military funding. France, still under occupation, could neither participate nor benefit from those technological advances.

III-1 European responses to the US dominance

After the war, the US prosperity contrasted with the destruction of the European aerospace. The industry faced the added difficulties of tight frontiers within Europe as a result of the war. This situation is followed by a long restructuration of the European aerospace industry. The process will be covered in 3 stages (1) the reconstruction phase from 1945 to 1958, (2) the strong growth resulting from the integration of Europe and the creation of the European market (1958-1973), and (3) the internationalization of the industry accelerated by the oil crisis.

Despite the reconstruction period, the aerospace industry in Europe faced some deep structural problems in the 1960s. Advanced aerospace requires integrating research from various fields of science and technology. The research costs more and requires large market application to be profitable. Europe had sufficient financial and industrial resources to produce the aircraft its market needed but its collective resources were dispersed into national program. The national market are too small to support an aerospace industry in each of the main European countries and be commercially successful. The Caravelle, developed by Sud Aviation, and later Mercure, developed by Dassault, are good examples of great technology and performance aircraft that failed commercially. Not only was the national market small but sometime two similar products competed for the same market (Caravelle and Mercure). The Europe aerospace industry had limited funds available compared to the US. In 1966, the US invested $1.5 billion compared with $470 million for the UK, $270 million for France and $30 million for Germany. More importantly, the US market is by far the largest market in the world, 3.5 time larger than Europe's. It is clear that at this time, European had enough financial resources to equip its airlines and air force. However, these resources were used at the individual national level. The aircraft manufactures in Europe could only rely on their small domestic market. Furthermore, US aircraft manufacturers had already a strong position in Europe as well. The competition was fierce. This situation resulted in the decreasing influence and presence of Europe in the aerospace industry. It made Europe dependant on the US to provide civil and military aircraft. More generally, Europe became dependant vis a vis the USA not only technology wise but also politically, economically and financially . National cooperation and especially international cooperation appeared as a necessary condition to have a prosperous European aerospace industry. The creation of Aerospatiale in France was clearly a result of the USA dominance in aerospace at that time.

Below is the analysis of the creation and structure of Aerospatiale. It details the cooperative system of the group.

III-2 The rise of the European aerospace industry

III-2-1 Creation of Aerospatiale and structure of its cooperative system

Introduction

Aerospatiale was created in 1970 from the merger of Sud Aviation, Nord Aviation and the SEREB. However, if the group Aerospatiale was only created in 1970, its cooperation trajectory really started in the 1950s. Aerospatiale was an aerospace group covering 4 activities: the production of civil and military aircraft, helicopters, tactical vehicles, and the strategic systems such as the vector of the nuclear bomb. The shares of Aerospatiale were owned by:

- CINDUS (Credit Lyonnais Industrie): 20%
- French State : 60%
- SOGEPA (Societe de Gestion et Participation Aeronautique) : 20%

CINDUS's share was owned by Credit Lyonnais. SOGEPA owned 20% of Dassault Aviation. Aerospatiale were at 90% owned by the French state. The only private ownership comes from the private ownership within Credit Lyonnais (13.68% of the Credit Lyonnais share were private) and from Thomson CSF (39.90% of Thomson share were private.). Thompson owned 8.85% of Credit Lyonnais. A total of 3.4% of Aerospatiale share were held privately at that time (20%x13.68%x8.5%x20% = 3.4%). The entry of Credit Lyonnais in the capital of Aerospatiale was announced in July 1992, and was part of the strategic plan to reinforce internal funding of the large French industrial groups through partnerships with financial groups. For Aerospatiale, the venue of Credit Lyonnais reduced its debt level. For Credit Lyonnais, it followed its 1989 strategic decision to develop partnership bank-industry that reinforced links with its major customers (supplier-customer alliances).

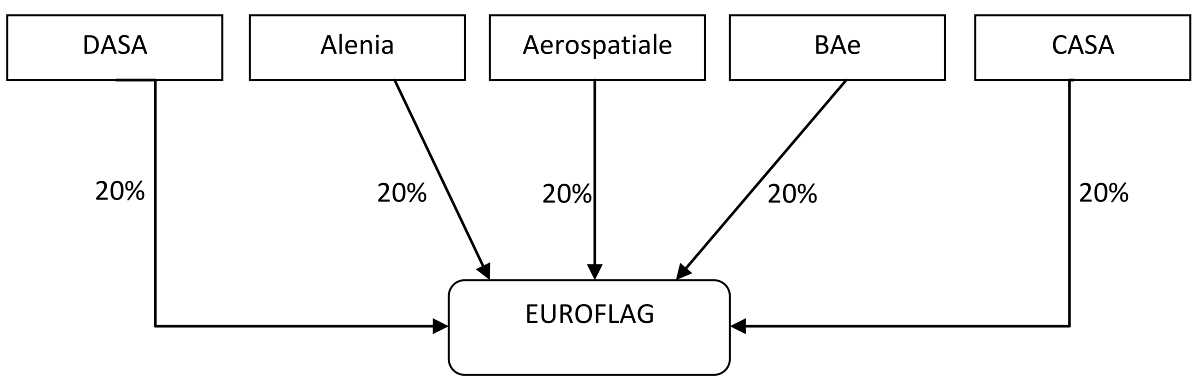
III-2-2 Evolution and motivations of the cooperative trajectory of Aerospatiale

The alliances and partnerships of Aerospatiale that started shortly after its creation showed how dynamic the group was in terms of cooperation and how determined it was to grow within Europe and worldwide. The concept of cooperation is at the base of Aerospatiale strategy throughout its life. It realized very early that a strategy based on product development was no longer sufficient to insure growth and profitability in a very competitive market. In the technology sector that requires the combination of various sciences and technologies, a single company, no matter how big, cannot invest in all areas of research. The firm must cooperate with the supplier that have the best technology and with financial institutions to provide financing for its research and development. The cooperative structure of Aerospatiale was established with this logic in mind. Historically, the direct sales of its products have slowly evolved towards more complex contracts, most often including economic compensation in the form of offset agreement. Later, cooperation product by product was developed, then by area of responsibilities by specialization (wing, cockpit, …). The cooperative system evolved toward the Airbus Industrie sytem of cooperation based on the associative structure of Groupement d'Interets Economiques (GIE) and later joint venture such as Eurocopter. The industrial resources can stay within each partner such as in Airbus Industrie, or can be placed in the structure resulting from the fusion in the case of Eurocopter. The goal is to share the enormous and long terms investment required and its risk while preserving the identity of each participant.

III-2-3 Cooperative structure of the Aerospatiale group

The cooperation structure of Aerospatiale started in the 1960 with the launch of the C-160 Transall by Nord Aviation and the German firm MBB. The Transall replacement gave birth to another more extensive cooperation of the 5 most important European aerospace firms: DASA of Germany, Alenia of Italy, BAe of the

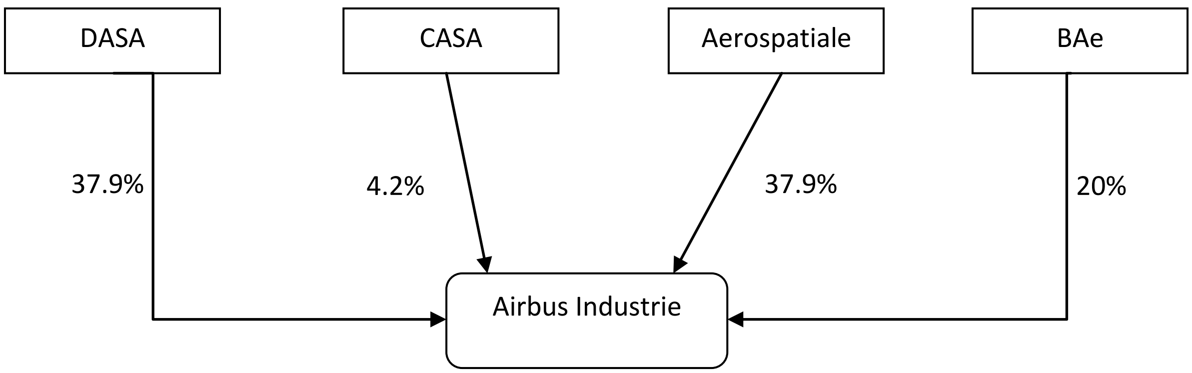
UK, CASA of Spain and Aerospatiale. This cooperative objective was to develop a military transport aircraft (today Airbus A400M) that prove to be necessary in the new conflict such as the Golf war. This horizontal cooperative agreement was a capitalistic agreement that created a joint venture called the **Euro**pean **f**uture **l**arge **a**ircraft **g**roup (EUROFLAG.) Today, this joint program is conducted by Airbus military. Originally the project began as the Future International Military Airlifter (FIMA) set up in 1982 with Aerospatiale, BAe, MBB and Lockheed to develop a replacement to the Transall but also to the C-130 Hercules. Due to conflicting requirement for the aircraft and the added difficulties of European politics, Lockheed left FIMA in 1989 to develop its own replacement to the C-130, the C-130J Super Hercules. This cooperative agreement is a strategic alliance since it follows a central decision of the 5 Europeans firms to develop a common tactical transport aircraft that will become the A400M. The resources committed to the project are substantial in the sense that they are financial, technological and human and strategic because they bring all the resources from the different partners into one exclusive structure.



III-2-4 Aerospatiale cooperation structure in Civil Aircraft: Airbus Industrie

As early as 1965, manufactures and governments in Germany, France, and the UK start discussions with the idea to develop a commercial aircraft capable of transporting 250 passengers. Recognizing their past commercial failure to bring a commercial aircraft to market, they were determined that the project must be European to avoid unfruitful competition and offer the largest possible market to the new product within its European market. The agreement protocol of September 16th 1967 opened the definition of the 250 seater Airbus A300. The final cooperative agreement that sealed the government agreement was signed in July 1968. The firms designated by the government agreement included Sud Aviation (later Aerospatiale), Hawker Siddley (later British Aerospace), MBB (later DASA) for the airframe and Rolls Royce, SNECMA and MAN for the engine. However, in February 1969, the British reversed their decision on participating in to the cooperation. They insisted that the A300 project be replaced by its competing program the BAC311, prepared in secrecy by British Aircraft Corporation (BAC). If the BAC311 were to be selected, Hawker Siddley would have become the leader of the project. The goal of the British is to stop Sud aviation from having the lead role on the project. The British are worried of the dynamism , investment, and drive of the French aircraft manufactures in the project. On April 10th 1969, the UK department of technology announced its intention to withdraw from the Airbus project. This episode, almost anecdotal, stressed the difficulty of setting up cooperation between competing firms and the disadvantage of specialization of tasks. On May 29th 1969, an cooperative agreement was signed between the French and German government. Shortly after, on July 24th 1969, Hawker Siddley joined the program in a limited way as supplier. This cooperative trajectory eventually led in 1970 to the Groupement d'Interet Economique (GIE) with the creation of a joint company: Airbus Industrie. In 1971, the Spanish firm CASA joined the consortium with a 4.2% share.

This strategic alliance was based on a GIE agreement in the framework of an additive integration. Generally, GIE has been legally set up to allow groups of company to develop industrial projects with a limited timeframe. The Airbus Industrie GIE differs in the sense that the an aircraft manufacture can only be competitive if it develop a family of aircraft covering a large spectrum of the airlines needs from the 100 seater to the 400 seater designated for transcontinental flights Developing a family of aircraft requires the commitment of the partnership on several decades given the level of investment and the human resources required. As a result, the A300 was followed by other member of the family, the 150 seater A320, the 230 seater A330s, the 300 seater A340 and later the A350 and the 500+ seater, the A380.



III-2-5 Aerospatiale cooperation in the regional aircraft

The cooperation between Aerospatiale and Alenia for the production of regional aircraft (ATR42 and 72) relied on a GIE type of agreement. This cooperation allowed Aerospatiale to avoid the specialization limited to the cockpit, central wing box, pylons and final assembly in the Airbus GIE by developing the wing for the GIE ATR. The wing design, manufacturing and assembly is a critical know how in the civil aircraft business, especially strategic in the aerodynamic R&D. Aerospatiale recovered with ATR, the expertise over the full design of civil aircraft. The chart below illustrates that point.

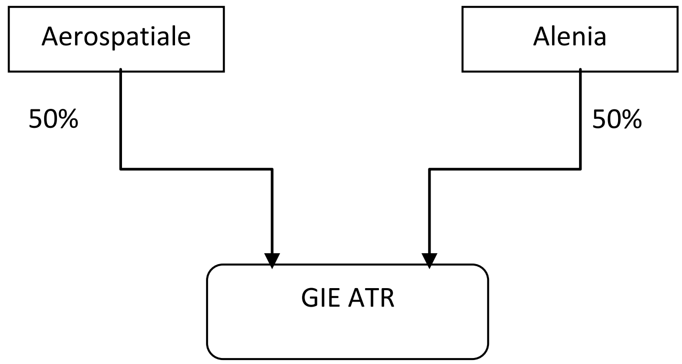
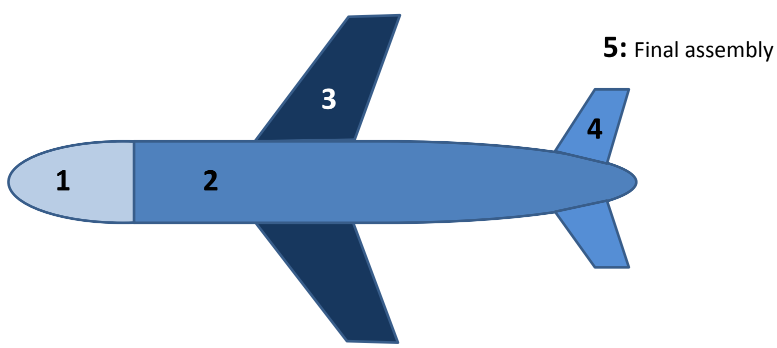


Figure 51: Specialization in ATR and Airbus GIE

Aerospatiale involved in all components

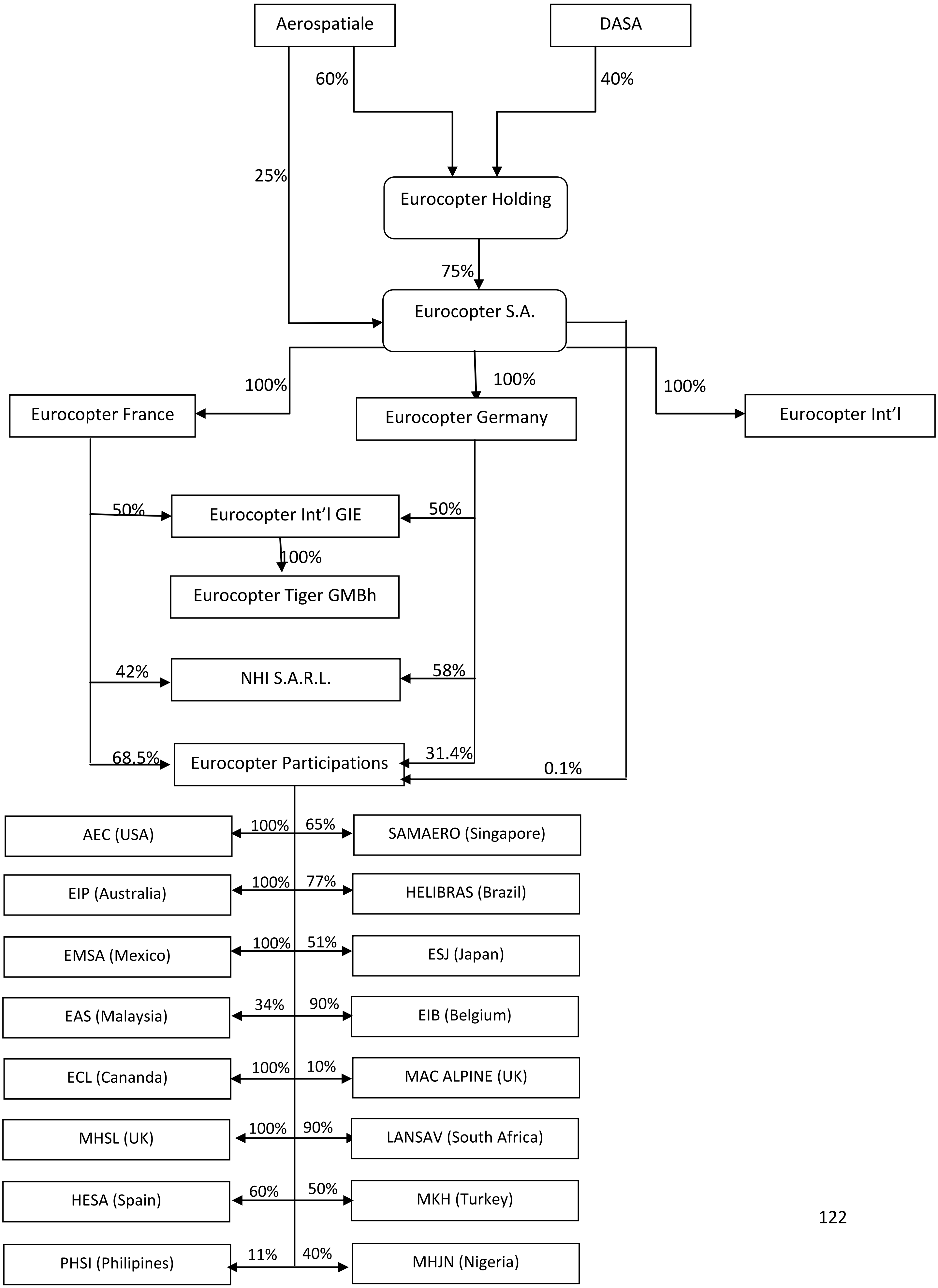


Company	GIE AIRBUS	GIE ATR
Aerospatiale	1+2+5	1+3+5
British Aerospace	3	
DASA	2	
CASA	4	
Alenia		2+4

Source: Laurent Rouaud

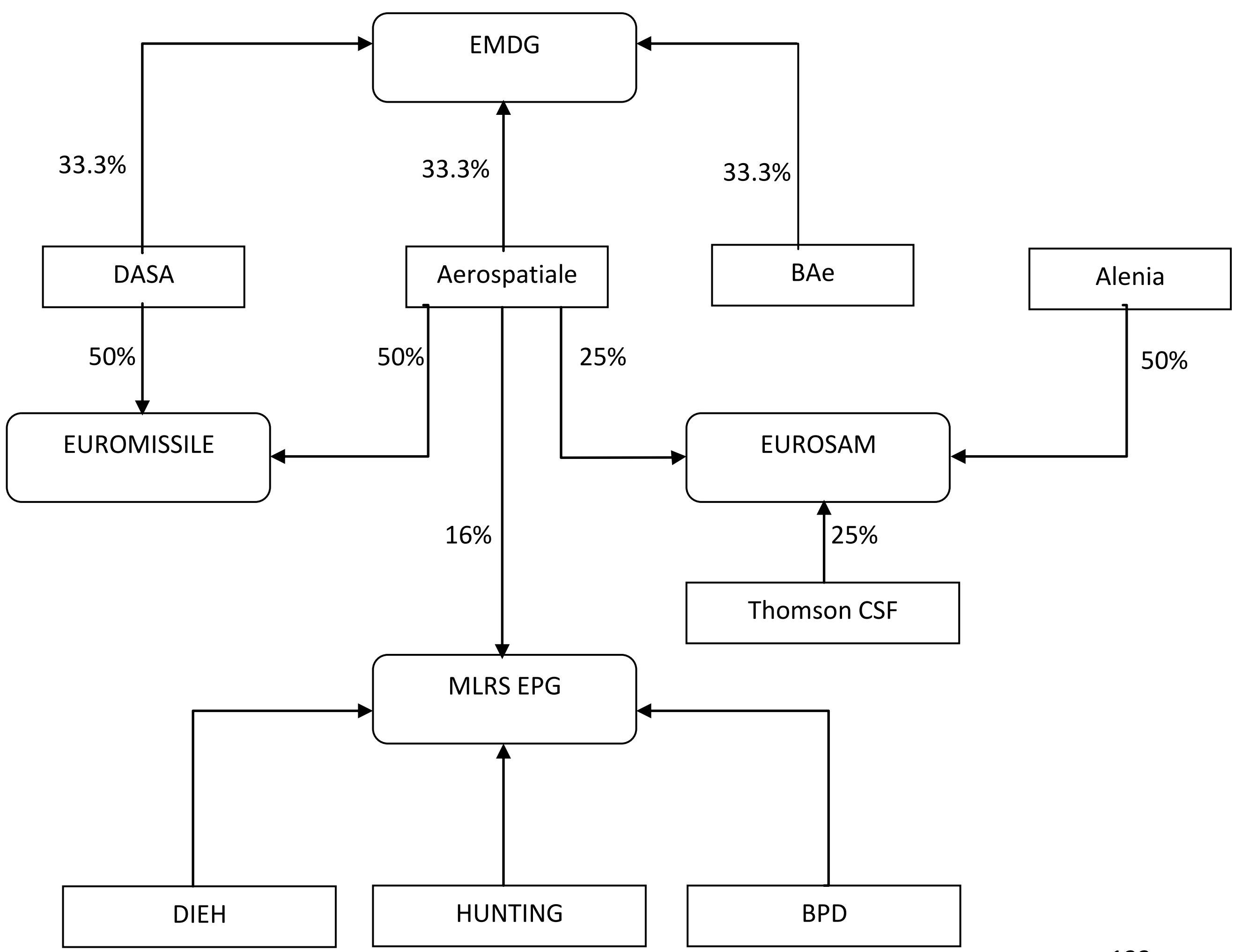
III-2-6 Aerospatiale cooperation in helicopters

With the same strategic logic of increasing the home market potential to amortize the initial investment on a longer and bigger production volume and to adapt to increasing development costs, Aerospatiale and DASA decided to merge their helicopter activities in 1991. This strategic alliance is much stronger than the GIE Airbus and ATR alliance since it is based on a completed integration of the activities of the two partners without any differentiation or compensation of any kind: commercial resources, R&D labs, existing and future product lines, production and final assembly. The advantage of this type of cooperation is that it avoid duplication and is in theory without time limit. In this cooperation, the task sharing is not done solely in terms of competence. The competitive and political tension of the GIE is here non-existent as it is a truly single entity. After the creation of the helicopter division within each of the two firms, a holding company was created, Eurocpter Holding S.A headquarterd in Marignane , France whose ownership structure is 60% Aerospatiale, 40% DASA. Eurocopter has succeeded in creating a solid network of alliance within the aerospace industry (see below). The main objective of the network is to develop or produce product(s) and to use resources that Eurocopter cannot assume on its own. For example, Eurocopter is associated with Augusta (Italy) and Fokker (Netherland) in the form NHI SARL for the production of the NH90 helicopter. Its alliance network makes Eurocopter a strong European center for helicopter production and second largest helicopter manufactured in the world (behind Sikorski). Eurocopter is therefore the result of a strategic alliance in the context of a strong capitalistic agreement. Within the alliance, Aerospatiale assumed the lead role.


Aerospatiale
DASA
60%
40%
25%
Eurocopter Holding
75%
Eurocopter S.A.
100%
100%
100%
Eurocopter France
Eurocopter Germany
Eurocopter Int'l
50%
Eurocopter Int'l GIE
50%
100%
Eurocopter Tiger GMBh
42%
NHI S.A.R.L.
58%
68.5%
Eurocopter Participations
31.4%
0.1%
AEC (USA)
100%
65%
SAMAERO (Singapore)
EIP (Australia)
100%
77%
HELIBRAS (Brazil)
EMSA (Mexico)
100%
51%
ESJ (Japan)
EAS (Malaysia)
34%
90%
EIB (Belgium)
ECL (Cananda)
100%
10%
MAC ALPINE (UK)
MHSL (UK)
100%
90%
LANSAV (South Africa)
HESA (Spain)
60%
50%
MKH (Turkey)
PHSI (Philipines)
11%
40%
MHJN (Nigeria)

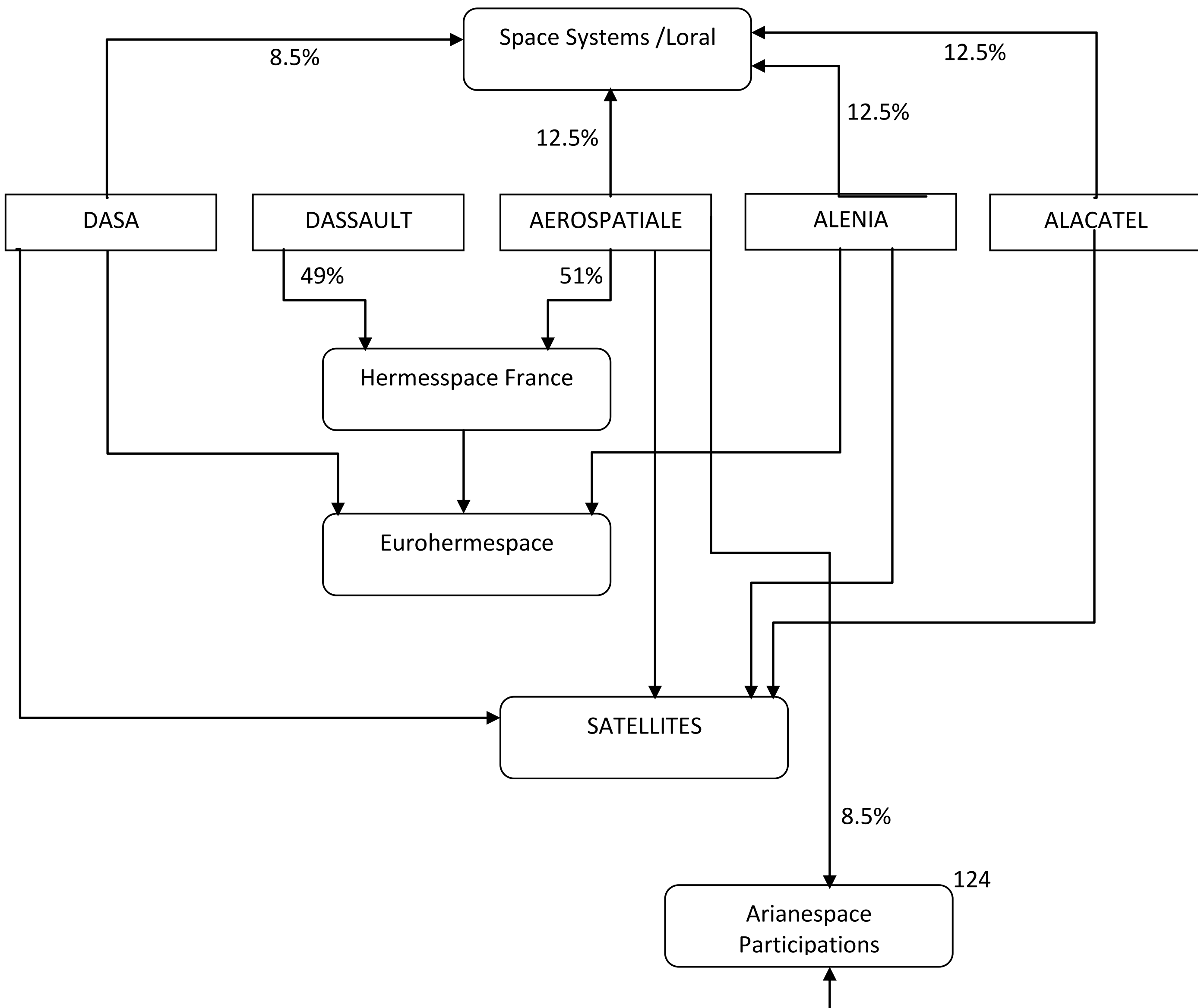
III-2-7 Aerospatiale cooperation in tactical vehicle and missiles

Aerospatiale is the first missile company in the world in terms of revenues and product line. Aerospatiale cooperation in missiles is extensive and to the scale of Europe. Strategic alliances have been negotiated with Thompson, DASA, BAe, and Alenia. They have been established by the respective governments, most often at launch in an effort to organize a common weapon program. This was the case for Euromissille, the French – German program, EMDG a tripartite cooperation between Aerospatiale , DASA and BAe, and Eurosam a Franco- Italian program involving Aerospatiale, Thompson and Alenia. These three cooperations are based on a GIE structure.



III-2-8 Aerospatiale's cooperation in strategic systems and space

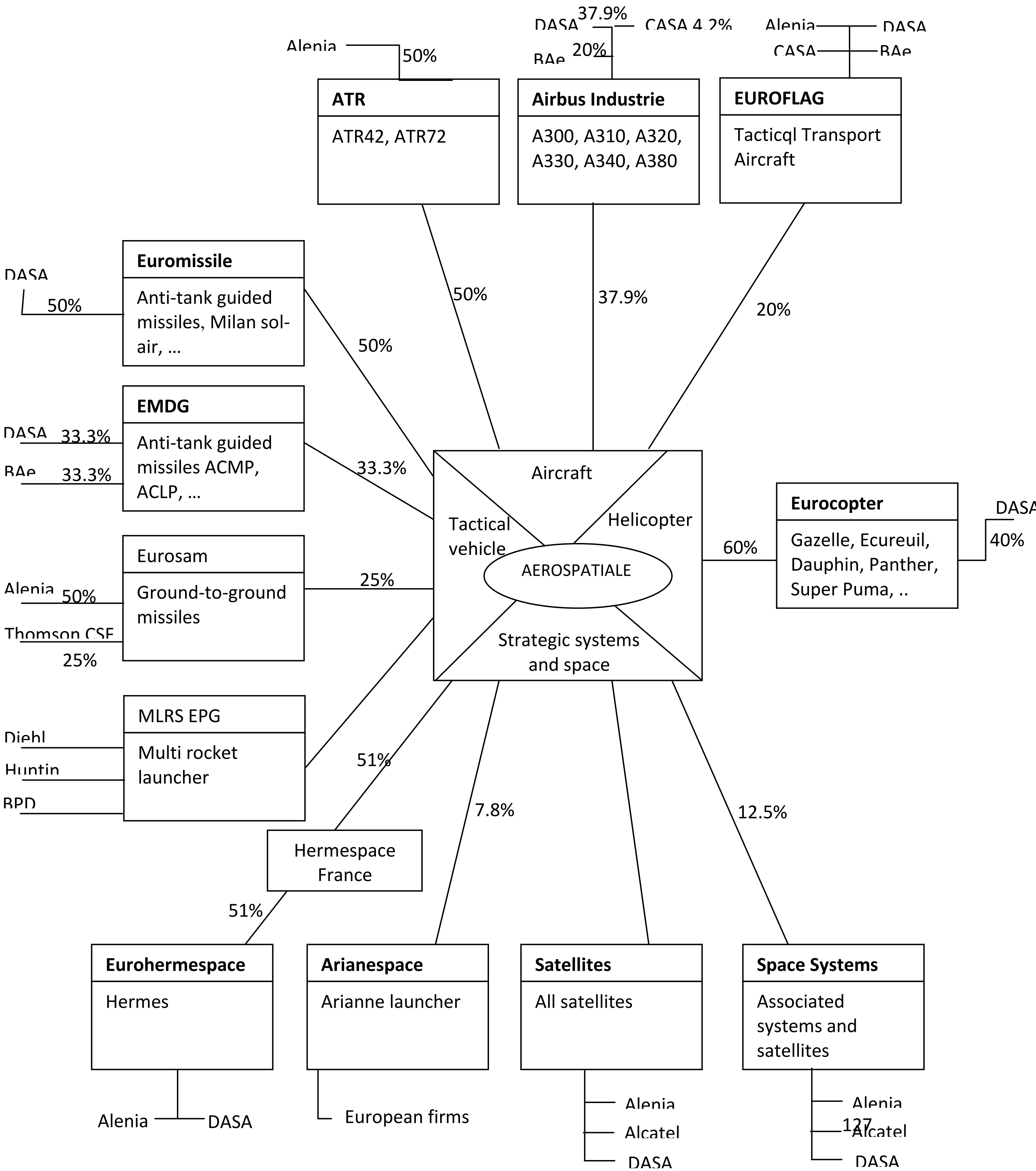
All activities of the group in the space field were done in a international partnership. This is the case in particular with Ariane. In the satellite area, Aerospatiale partnered with DASA, Alcatel, Alenia and Space System/Loral in the US. This structure is a important worldwide player in the space field. In theis partnership, Aerospatiale is the lead contractor in the final assembly of the Intersat satellites. The agreement concerns technical and commercial cooperation for satellites and associated space systems. In addition, Aerospatiales cooperated with Dassault in Hermespace France. Hermesspace France itself is in partnership with DASA and Alenia in Eurohermesspace.



III-2-9 Summary of Aerospatiale partnerships

The chart below summarizes the partnership system of Aerospatiale in the 1990s. It shows that Aerospatiale have had a long experience in building European and international partnerships in all activities. Most of these partnerships are still in place today within EADS. Over the years Aerospatiale has succeded in consistantly building a vast network of partnerships. Aerospatiale partnerships have not been the result of opprtunistic behaviour but the result of a focus strategy on building alliances in aircraft, missiles and space to become a real international player. Over the last few decades, Aerospatiale alliances strategy has allowed the firm to quickly overcome the gap in technology, commercial position and product portfolio with its US competitors. The alliance network have given Aerospatiale a strong market presence in four different areas of aerospace: helocopters, missiles, space, and aircraft. Alliances with Germany's DASA was clearly the preferred route in all 4 sectors. In fact, throughout the 1990's, more than 60% of Aerospaiale's revenues were done in partnership with DASA. As always, the fundamental reason of these alliances are to share the investment and the risks given the massive resources needed in R&D and the obtained the benefits of scale and scope. Aerospatiale built partnership networks at two different levels in accordance to: the products and the sector. At the product level, the alliances concerned the Airbus, ATR, Eurocopter and Euromissile GIEs. This type of partnership allows coordination between the different participants, reduce tension and the risks of internal conflicts. In the sector level, Aerospatiale alliances were made with major four European aerospace groups. The cooperation resulted from the larger consensual political will to reach common long term objective right from the end of the war and the dominence of the US in the aerospace field. The efficiency of these partnership relied on a common objective and common adversaries or competitors. It assumed that the partnership would bring higher market penetration and market share than each of the individual firm would have gained by itself. Two elements helped the efficiency of

Aerosaptiale partnerships: the accumulation of experience in managing the coordination between the partners and the better understanding of the different partners (their operations , governance, management, …). The accumulated experience in working together as partners improved over time from partnership to partnership, especially in the case of DASA. The partnership structure of Aerospatiale was similar to quasi-concentration (because of its symetric and almost anti-competitive nature) around a system of stable alliances. The network of partnership started decades ago and has evolved from a program by program approach to a larger structural industrial approach. The paroxysm of this strategy was reached when EADS was created functioning to a great extend as a holding company managing centrally its alliance network.



Alenia
50%
DASA
37.9%
CASA 4.2%
BAe
20%
Alenia
DASA
CASA
BAe
ATR
ATR42, ATR72
Airbus Industrie
A300, A310, A320, A330, A340, A380
EUROFLAG
Tacticql Transport Aircraft
50%
37.9%
20%
DASA
50%
Euromissile
Anti-tank guided missiles, Milan sol-air, ...
50%
EMDG
DASA 33.3%
BAe 33.3%
Anti-tank guided missiles ACMP, ACLP, ...
33.3%
Eurosam
Alenia 50%
Thomson CSF
25%
Ground-to-ground missiles
25%
MLRS EPG
Diehl
Huntin
BPD
Multi rocket launcher
Aircraft
Tactical vehicle
Helicopter
AEROSPATIALE
Strategic systems and space
60%
Eurocopter
Gazelle, Ecureuil, Dauphin, Panther, Super Puma, ..
DASA
40%
51%
7.8%
12.5%
Hermespace France
51%
Eurohermespace
Hermes
Arianespace
Arianne launcher
Satellites
All satellites
Space Systems
Associated systems and satellites
Alenia
DASA
European firms
Alenia
Alcatel
DASA
Alenia
Alcatel
DASA

IV Market entry of the current incumbent competitors

IV-1 Boeing's market entry in the LCA market

The Boeing Company, created in 1916 in Seattle, Washington State is now the second largest commercial aircraft manufactured in the world and the largest US exporter. Its successes throughout its history can be traced back to the transfer of technology from military programs such as the KC135 to the Boeing 707 in the 1950S. The first US commercial jetliner, the 707, was delivered to Pan American Airlines in July of 1954 and initiated transatlantic service in October 1957.[73]

The 707 illustrated the relationship between military procurement and commercial aircraft. Boeing engineers began to consider the possibility of developing a commercial jet airliner after World War II. The project did not go ahead at the time because the potential market could not justify the huge development costs and especially the risks. Shortly after, the Air Force contract to build a military jet tanker designed for the in flight refueling of the B-52 bomber resolved the financing of the 707. The main factor in the decision of launching the 707 was the opportunity of a civil application of its KC-135, entirely funded by the government. It started Boeing policy of using military contracts to fund the development work that fed into the design of commercial airliners. The dual development of a civil and military product was critical in establishing Boeing as the leader in commercial aircraft. According to the US Congressional Office of Technology Assessment in 1991:

> *"The single greatest means by which U.S government policy has affected the competitiveness of the commercial aircraft industry is in the procurement of military aircraft funding of the related R&D. In some cases whole systems developed for the military have been spun-off to commercial applications, reducing development costs and risks to the commercial users.*
> *Congressional Office for Technology Assessment, 1991*

[73] Rodgers, E, (1996), Flying high: the story of Boeing and the rise of the jetliner industry, the Atlantic Monthly Press, New York

In addition, between 1951 and 1955, Boeing increasingly relied on government owned facilities (56% increase over the previous period). Boeing profitability reached $20 million in 1951 and $53.6 million in 1953. The profitability of the early 1950s played a major role in Boeing decision to launch the 707. The simultaneous development of the KC-135 and the 707 provided important economy of scale. The prototype having been developed for flight test of the KC-135, the Air Force accepted to cover the entire flight test costs.[74] The results of the KC-135 flight test were used for both applications. The details developments of the KC-135 done with the Air Force were crucial for the quality, reliability, and time to market of the 707. The total 707 development costs was $16 million compared to $300 million for an aircraft developed as a commercial transport aircraft on its own such as the DC8 of Douglas Aircraft. The large order for the KC-135 from the Air Force was also a great help for the development of the 707. The Air Force understood the value of developing the civil application in parallel and accepted that all equipment used for the KC-135 be also used for the 707. As much as 80°% of the joint KC-135/707 program costs were paid by the Air Force. In return, Boeing accepted to reimbursed the Air Force $110000 per 707 sold for the first 100, and $60000 for the following 100 units. It was estimated that Boeing saved about 30% of the development cost by running the 707 and KC-135 simultaneously vs the DC8. Boeing market entry in the large commercial aircraft (LCA) was largely attributed to the KC-135. [75]

In the critical years of the beginning of the jet age in commercial airline of the 1950s, Boeing was contracted to produce a total of 4,422 aircraft by the Pentagon. The period marked the foundation of Boeing supremacy in commercial aircraft. Shortly after the 707, Boeing developed the 727, a tri-jet with 120 to 160 seat aircraft capable of flying transcontinental US. The 727 utilized the same fuselage of the 707 to reduce design and production costs. The 727 began the creation of a full family of

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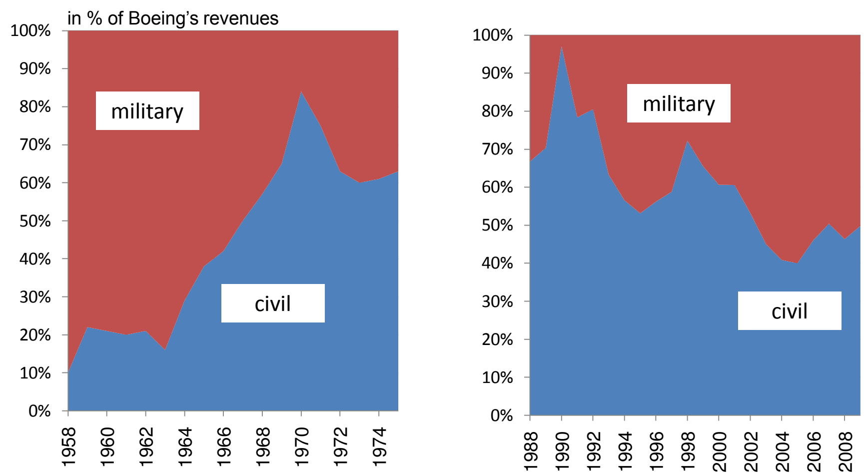
[74] Newhouse John,(1982), The sporty game, Alfred Knopf, New York
[75] Heppenheimer, T (1995), The turbulent skies, Wiley, New York

products. By the mid 1960s, the 727 sales exceeded the military sales for the first time. The 747 and 737 followed the 707 and 727 that made Boeing the only manufactured to propose a full family of product from the short range 130 seater 737 to the 400 seater intercontinental 747.[76]

Figure 52: Boeing's revenues share military/civil 1958 to 2009

Growing importance of civil in the late 60s, parity since 9/11



Source: Boeing's annual reports, Laurent Rouaud

From the 1960s, Boeing progressively reduced its dependence on military programs as its civil aircraft business started to prosper with the commercial jet transport era. Throughout the 90s, military revenues increased to reach the 50% level in an effort to counteract the effect of the very cyclical nature of the civil aircraft market. Following the September 2001 terrorist attack, the military business became, once again, the primary source of Boeing's revenues because of the triple effect of the war in Iraq and subsequent operations in the Middle East that boosted military spending, the effect of the post 9/11 on airlines and the recession, and the financial

[76] Rodgers, E, (1996), Flying high: the story of Boeing and the rise of the jetliner industry, the Atlantic Monthly Press, New York

crisis of 2007. Given the depth and length of the recession and the complex Middle East situation, the source of Boeing's revenues is likely to remain evenly distributed between military and civil for the next 2 to 5 years.

Boeing historical dominant position has allowed them to time their products to ensure that their life cycles are conveniently distinct. The profits from previous programs are financing the development cost of new programs. As an example, the estimated profit of the 747-400 in the mid 1990s (only aircraft in the 400 seat long range market at that time) was approximated to be around $25 million dollars, about 2/3 of an A320's price.

Table: 6 BOEING product launch and delivery time table

Aircraft	**Launch date**	**First Customer**	**First delivery**	**Customer**	**Last delivery**	**Total delivered**
367-80	20.05.52	-	-	-	-	0
KC135	05.10.54	USAF	28.06.57	USAF	12.01.65	820
707	13.10.55	Pan Am	15.08.58	Pan Am	28.04.94	856
720	22.11.57	United	30.04.60	United	20.09.67	154
727-100	05.12.60	Eastern/United	29.10.63	United	03.11.71	571
727-200	10.08.65	Northeast	11.12.67	Northeast	27.05.72	310
727-200ADV			20.04.72	Iberia	18.09.84	950
737-100	19.02.65	Lufthansa	28.12.67	Lufthansa	26.07.73	30
737-200	05.04.65	United	29.12.67	United	21.08.88	1114
737-300	05.03.81	Southwest	28.11.84	US Air	13.12.99	1113
737-400	04.06.86	Piedmont	15.09.88	Piedmont	25.02.00	486
737-500	20.05.87	Southwest & others*	28.02.90	Southwest	21.07.99	389
737-600	14.03.95	SAS	18.09.98	SAS	14.09.06	69
737-700	17.11.93	Southwest	17.12.97	Southwest		
737-700BBJ	02.07.96	General Electric	23.11.98*	General Electric		
737-700ER	31.01.06	All Nippon	16.02.07	All Nippon		
737-700QC		US Navy	29.09.00	US Navy		
737-800	05.09.94	Hapag Lloyd	22.04.98	Hapag Lloyd		
737-800BBJ	11.10.99	Boeing Business Jet	28.02.01*	Saudi-Oger		
737-900	10.11.97	Alaska	15.05.01	Alaska		
737-900BBJ	16.10.06	Boeing Business Jet	31.12.08			
737-900ER	18.07.05	Lion Air	27.04.07	Lion Air		
747-100	13.04.66	Pan Am	13.12.69	Pan Am	09.09.86	205

747-200	19.12.68	KLM	15.01.71	KLM	19.11.91	393
747SP	03.09.73	Pan Am	05.03.76	Pan Am	09.12.89	45
747-300	12.06.80	Swissair	01.03.83	UTA	25.09.90	81
747-400	22.10.85	Northwest	26.01.89	Northwest	26.04.05	442
747-400BCF(conv)	07.01.04		19.12.05	Cathay Pacific		
747-400D		Japan Airlines	10.10.91	Japan Airlines	11.12.95	19
747-400ER	28.11.00	Qantas	31.10.02	Qantas	30.07.03	6
747-400ERF	30.04.01	ILFC	17.10.02	ILFC/Air France		
747-400F	13.09.89	Air France	17.11.93	Cargolux		
747-400LCF(conv)	09.04	Boeing	01.07	Boeing		
747-400M		KLM	01.09.89	KLM	10.04.02	61
747-8	14.11.05	Boeing Business Jet	*04.11*	Lufthansa		
747-8F	14.11.05	Cargolux	*09.10*	Cargolux		
757-200	31.08.78	British AWs/Eastern	22.12.82	Eastern	26.04.05	914
757-200PF	31.12.85	United Parcel Service	17.09.87	United Parcel Service	12.08.99	80
757-300	02.09.96	Condor	10.03.99	Condor	27.04.04	39
757-300		Northwest	20.07.02	Northwest	21.10.03	16
767-200	14.07.78	United	19.08.82	United	24.02.94	128
767-200ER	01.83	Ethiopian	26.03.84	El Al	31.03.08	117
767-200AWACS		JASDF	01.12.94"	JASDF	01.01.97	4
767-300	02.83	Japan Airlines	25.09.86	Japan Airlines	23.08.01	104
767-300ER	01.85	American	19.02.88	American		
767-300F	15.01.93	United Parcel Service	12.10.95	United Parcel Service		
767-400ER	28.04.97	Delta	11.08.00	Delta	27.01.09	38
767-400ERX	13.09.00	Kenya Airways	-	-		0
777-200	15.10.90	United	15.05.95	United	17.05.07	63
	15.10.90	British Airways	11.11.95	British Airways	05.12.96	9
	15.10.90	Thai International	31.03.96	Thai International	06.12.00	16
777-200ER	14.06.91	Euralair	06.02.97	British Airways		
	14.06.91	United	07.03.97	United		
	14.06.91	Emirates	11.04.97	Emirates		
777-200LR	29.02.00	EVA Airways	24.02.06	Pakistan International		
777-200F	24.05.05	Air France	*02.09*	Air France		
777-300	26.06.95	All Nippon	30.06.98	All Nippon	13.11.03	18
	26.06.95	Cathay Pacific	22.05.98	Cathay Pacific	27.07.06	42
777-300ER	29.02.00	Japan Airlines	29.04.04	ILFC/Air France		
787-3	26.04.04	All Nippon	*04.13?*	All Nippon		
787-8	26.04.04	First Choice	*02.10*	China Eastern		
787-8	26.04.04	All Nippon	*02.10*	All Nippon		
787-9	26.04.04	Lcal	*02.13*	Air New Zealand		

Boeing was also the first aircraft manufacture to recognize the value of a global strategy. Its objective was to become the leader in every commercial aircraft market from the 100 seater short range aircraft to the 400 seater intercontinental range aircraft market. To achieve its objective, Boeing invested 4 to 6% of its revenues in R&D. Secondly; it focused its development effort to develop a full range of aircraft family covering the entire market. Thirdly, Boeing built a strong, coordinated and global marketing and sales organization. Fourth, it insisted in building a global customer services and after-sales organization centrally coordinated to maintain the best possible quality standard. Finally, Boeing concentrated its effort in reducing production costs through efficient manufacturing process and controlling centrally its spending on R&D. The cash generated by the successful 707 and 727 programs have allowed Boeing to implement this strategy in the early 1980s. As a result of this strategy, Boeing succeeded in building a very strong market base with 5,200 aircraft delivered to a global base of 420 customers. From the early 1980 to the first delivery of the A380, Boeing was the only aircraft manufacturer to have a family of product covering the entire market segments. This dominant position was to be challenged by the entrée of Airbus in the late 1970s with the A300, a 250 twin aisle, two-engine wide body aircraft. Boeing responded with the 757 and 767 aircraft in the early 1980s. Boeing will be once again challenged with the A320 development. It tried to convince Airbus to delay the launch of the A320 by pointing out the great financial risk of such a program. Boeing threatened Airbus to launch the 7J7, a revolutionary aircraft with a flight computer and an open rotor engine. Although the 7J7 program never took off, it sets an important milestone in starting cooperation agreements with the Japanese aerospace industry. The cooperation with Japan will continue to grow steadily to become a pillar of Boeing aircraft development. The strength of the relationship is clearly demonstrated by the Japanese participation in 787 program.

IV-2 Airbus' market entry in the LCA market

IV-2-1 From infancy to world leader

In the late 1960s and early 1970s 90% of the world's large passenger jets were produced in the US. Europe has always been aerospace pioneers, designing[77] and developing[78] the first turbojet, producing the first commercials jet transport [79], and the first supersonic commercial aircraft[80]. These innovations failed to result in any long lasting competitive advantage as they lagged behind their American counterparts as they gained 90% of the market for jet airliners in the 1960sAs previously stated, the US dominance started shortly after the war and lasted until the mid 1990s. Europeans have been nonetheless very active in developing new airliners throughout the 1960s. The Comet was introduced in passenger service in 1952. Although it was a great success in terms of passenger appeal, the aircraft had a number of fatal accidents in late 1952, 1953 and a major disaster in Rome that grounded the entire fleet of Comet 1.The accident were attributed to a design flow on the square window that developed a fatigue crack growth from a rivet hole. Redesigned, the Comet 4 was re-introduced in 1958. However, with the bad press and more importantly as Boeing 707 and Douglas DC-8 were faster and cheaper to operate, the redesigned Comet 4 failed to reach commercial success and production stopped in 1964. A total of 112 Comet had been sold. Other attempts by European manufacturers also failed to reach commercial success despite their technology innovations. All these commercial failures were attributed to the difficulty in gaining market acceptance in the largest market for air travel at the time: the United States. The other reason for the failure was that each European country with a national

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[77] The first patent for using a gas turbine to power an aircraft was filed in 1921 by Frenchman Maxime Guillaume

[78] Frank Whittle in the UK and Hans von Ohain in Germany developed the concept independently into practical engines during the late 1930s

[79] The de Havilland Comet was the world's first commercial jet aircraft to be manufactured

[80] TheConcord was the first turbojet supersonic passenger aircraft. It was developed by Azerospatiale of France and British Aircraft Corporation of the UK. It flew for the first time in 1969 and entered into service in 1976 until 2003

aerospace manufacturer was launching their own program, often competing with each other and with a home market too small to be successful. The table below summarizes the different European programs prior to the success of Airbus.

Table 7: European commercial jet aircraft program 1950s - 1980s

Aircraft	Launch	First Customer	First Flight	First Delivery	Customer	Last Delivery	Total Deliveries
DH 106 Comet	1945	BOAC/BSAA	1949	1952	BOAC	1964	112
SE210 Caravelle	1953	Air France	1955	1959	Air France	1973	279
DH 121 Trident	1957	BEA	1962	1963	BEA	1975	116
Vickers VC10	1957	BOAC	1962	1964	BOAC	1970	54
BAC/Romaero 111	1961	BUA	1963	1965	BUA	1991	241
VFW614	1961	Cimber Air	1971	1975	Cimber Air	1986	14
F28	1962	LTU	1967	1969	LTU	1987	241
Concorde	1962	Air France / BOAC	1969	1975	Air France/British Airways	1980	14
Mercure	1968	Air Inter	1971	1974	Air Inter	1985	11
F100	1983	Swissair	1986	1988	Swissair	1996	278
F70	1993	Pelita/Sempati	1993	1994	Ford Motor Co.	1997	47

None of the 1950 to 1980 aircraft program launch in Europe exceeded 300 orders from customers, insufficient to even break even. The Caravelle which was very similar to the DC-9 in all aspects, including design, technology level, fuel economy and operating cost, sold 279 units while the DC-9/MD80 sold 2167 units. The Caravelle represented a first tentative at European collaboration, utilizing the nose and flight deck of the de Havilland Comet, which led to a wider relationship between the French and British industries on the supersonic Concorde. The emerging mass travel called for another type of aircraft defined loosely at that time by a short range high capacity aircraft, a wide body concept. The basic specifications and requirements was first developed in the UK by the Lighthill committee and by a working party set up by the major European airlines of that time. A number of projects surfaced at the same time. Hawker Siddeley in the UK worked toward a high capacity version of the Trident with 2 different sizes, an 160 seater HS132 and a larger 204 seater named HS134. Breguet in France proposed a double deck Br124 powered by four Rolls Royce Spey engines in pairs. Alternative twin engine layout was also considered using RR or PW's JT9D turbofan engines. Nord Aviation in France were planning to do a high wing four Spey engines with a double bubble fuselage and 12 abreast seating for 250 passengers. The two side by side cabins was separated by a central bulkhead. Sud Aviation was working on the Gallion, a single deck 200 seats 6 abreast, and a double deck alternative for up to 250 seats. Even Avions Marcel Dassault had a 220 seat double deck design with engines mounted under a low wing. A total of 5 different programs serving the same market was considered at that time by 5 different European manufacturers.

The creation of Airbus brought to an end the competition among the European manufactures. In order to counter the strong US position held by Boeing, Lockheed, and McDonnell Douglas in the commercial aircraft market during the 1960 and 1970s, and to avoid any bankruptcy of the European manufacturers, the government of France, Britain and Germany discussed a strategic alliance, and in 1967 helped organize a multinational effort to build an aircraft consolidating the resources of European aerospace. The governments of the United Kingdom, France, and Germany quickly realized the redundant enormous financial and technical needs to build such an aircraft and urged their aircraft manufacturers to enter into partnerships. It is interesting to note that the UK government in particular has been driving cooperation as early as 1964 with a white paper entitled ''An outline requirement for an Ultra high capacity short range aircraft.'' The irony reside in the fact that the UK government changed its mind at the last hour of the Airbus negotiation and chose not to joined the consortium. Serious discussions started in 1964 between the UK and France. France also initiated high level discussions with the German industry. Germany in particular saw the collaboration as essential for the future of its aerospace industry, hampered at the end of the Second World War. Germany becomes soon the driving force of the cooperation. In July 1964, the German federal government set up an Airbus Study Group in Munich with Dornier, Flugzeugbau, Messerschitt, Siebelwerke and Vereinigte Flugtechnishe Werke. The main issue for Germany was to create a structure allowing the participation of its five aerospace companies with a single point of contact with the potential other

European partners. Hawker Siddeley entered discussions with Breguet and Nord Aviation of France, while British Aircraft Corporation initiated talks with Sud-Aviation and Dassault on cooperation on the Gallion. The European consortium idea was still a high challenge to say the least. It appear that the most attractive proposition in term of product came from the Hawker, Breguet Nord Aviation discussions to develop a conventional 200-250 seater, a circular fuselage, two efficient high by-pass ratio engine mounted under a low wing with a 30 degree sweep. However, disagreement still subsisted among airlines and manufacturers on the specific design requirements such as capacity and range. In October 1966, the aircraft manufacturers presented a joint concept document to their government. The concept was approved in May 1967 by the governments and the definition phase began. It was then that the aircraft was referred as the A300. The concept had grown to 267 seats in a circular 21ft fuselage diameter, and powered by two Rolls-Royce RB207 of 47,500lb of thrust.

In the meantime, with the talks on the Gallion between British Aircraft Corporation (BAC) , Sud-Aviation and Dassault going nowhere, and following British Airways concern that Airbus will propose a successor to the smaller BAC1-11, BAC firmed up its design of an 208 seater 1300 nm range aircraft on its own called the BAC2-11, a sort of A320 size aircraft before its time. However, the UK government having committed to the Airbus program, refused to fund the BAC2-11. At that time, many British airlines and industry experts questioned the government logic to support the Airbus project. A memorandum of Understanding (MOU) was signed in September 1967 authorizing continued studis and project definition. The agreement nominated Sud Aviation, Hawker Siddeley and Deutsche Airbus (founded in September 1967) as the aircraft partners. The agreement discarded the earlier plan of having the French as leader while the other partners acting as subcontractor towards an joint owner-supplier relationship structure. It was agreed that Sud Aviation would have the design leadership for the airframe, in exchange of Rolls-Royce leadership for the engine. Britain and France were to contribute to 37.5% of the first phase development costs and Germany providing the balance. Britain was also responsible for 75% of the engine development costs while Germany and France shared the reminder. RR was supposed to work with Snecma of France and MTU of Germany. In addition to the design leadership, Sud Aviation was given the responsibility of the flight deck, nose and fuselage center section, engine installation, most of the systems definition and final assembly. Hawker Siddeley was to be responsible for the t design and manufacturing of the wing. Deutsche Airbus was responsible for the remainder of the fuselage, empennage development, as well as the passenger cabin, cargo holds and installation of the APU.

The cooperation had some rocky start. The French decided to cancel the Airbus program in favor of the Dassault Mercure, a 150 seater aircraft, before to reverse to the original Airbus plan some only three days later. Air France and Lufthansa pushed the A300 toward a bigger size of 300 seats which resulted in higher engine thrust requirement. Rolls-Royce was also changing interest towards the US competitor tri-jet longer range DC10 and L1011 programs, anticipated to be a larger market and more adapted to their smaller engine. Rolls-Royce also felt that in addition to addressing to the long range market requirement, the US programs would also encroach in the shorter range A300 market. Except Air France and Lufthansa, most airlines wanted a smaller twin aisle in the 220 to 250 seat category. In December 1968, Hawker Siddeley and Sud Aviation release a smaller A300, briefly call the A250. The new 250 seater brought the 50,000 lb thrust engine CF6-50 of GE in contention being developed for the DC10. The airline responded favorably to the smaller A300. The use of an existing engine was to reduce the A300 launching costs by 30%. With Britain hesitation to commit and Rolls-Royce decision to pursue the US L1011 program with the RB211, Airbus became confident to go with the GE CF6. British Airways (at that time British European Airways) were still pursuing with BAC the BAC3-11, a slightly larger aircraft with similar characteristics that the A300. Similarly Air France, anticipating an increase in passenger demand within Europe, was pressing Airbus for 24 more seats. Another 2 frame were added to provide an additional three row of seats. The GE CF6 engine turbofan engine had already grown more powerful to suit the heavier aircraft. The length of the aircraft was finalized at 175 feet providing up to 281 seats in 8 abreast configuration, and up to 345 seats in nine abreast. At the end, British Airways got neither their preferred BAC3-11 nor the A300. This marked the first episode of difficult relationship between Airbus and British Airways that ended three decade later with the A320 orders. With the new option of taking an off-the-shelf US engine, the British withdrew from the Airbus project in April 1969. France and Germany signed the final development contract (covering the prototype phase and extended over a period of one year after the certification of the basic type. France and Germany decided to retain Hawker Siddeley as a privileged subcontractor to avoid unacceptable delays to the program given the competitive US program. The withdrawal of the British government and Rolls-Royce from the program did not stop France and Germany commitments to the program. The organization of the Airbus partnership was set up in December 1970 by the creation of Airbus Industrie as a Groupement d'interet Econmique (GIE) under French law. The structure allows operational flexibility and enables third parties (customers, suppliers) to deal with a single entity. The GIE establishes Airbus Industrie as the central authority for technical , financial and marketing. A number of restructuring of the aerospace industry in Europe took place in the late 1960s and early 1970s. Sud Aviation and Nord Aviation merged in 1970 to form Aerospatiale. Dornier withdrew from Deutsche Airbus. The restructuring of the German aerospace industry took place through the combination of the manufacturing capability of HFB, Messerschitt , and Siebel under the MBB name (Messserschit-Bolkow-Blohm.) The strong presence of France and Germany in the program brought credibility in the industry for Airbus. [81]

At the end of 1970, the Dutch government decided to join Airbus Industrie and an agreement was signed but Fokker-VFW, the company designated to be the Dutch participant, elected not to become a full member. . In 1972, CASA of Spain joined the consortium with a 4.2% share, reducing the German and French shares to 47.9% each. Britain rejoined the consortium on January 1979.

[81] Yoshino M, (1986), Global Competition in a salient industry: the case of civil aircraft in Porter M, The Competition in Global Industries, Harvard Business School Press, Boston

Three factors were essential in the success of the alliance: (1) the product definition, (2) the establishment of the governing rules, (3) the clear definition of the industrial and management structures. It is after having assess the market and identify a niche , where none of the incumbent were present, that Airbus decided on developing a 300 seater twin wide body aircraft. Partly due to the structure of the market and partly because of the traditional thinking that 3 or 4 engine was required to fly over long distance over water, there were either aircraft serving the domestic market at 100 to 160 seat and the large 3 to 4 engine 300 seater intercontinental aircraft such as the 747 and DC10. Airbus breakthrough was to offer a twin engine aircraft positioned between the domestic and larger multi-engine aircraft, a market left alone by other manufacturer. The Airbus aircraft was also capable to fly over the Atlantic from smaller cities while offering substantial economic advantages over the ' engines DC8 and 3 engine DC10. The A300 was also attractive for short/medium distance city pairs on domestic or intra regional markets (US, France, intra Europe) with high density demand or longer transcontinental routes between the US and Europe. The A300 were not intended to address the longer range market such as Europe to Asia or US to Asia like the DC10 and 747. It was the first twin engine medium range aircraft in commercial aviation, and a real potential game changer at the time. Air France became the first customer with an order for a disappointing six aircraft in November 1971. Early on, most of the sales of the A300 came from Europe. The agreement included a commitment from the governments that the national carriers would order the A300. Iberia became the second airline customer ordering 4 A300B4. Lufthansa ordered 3 A300B2 at the end of 1972. The Iberia's B4 was an extended range version of the original B1/B2 1750nm range to 2000nm with an additional center wing tank of 28,000lbs.

It is interesting to note that at the time of the A300, the Concord program was running into some headwinds with major cost overruns, schedule delay, and very few orders. Most engineers and program management human resources for the A300 came from the Concord program. The A300 would have an airframe launch cost of 190 million pounds in 1974 £.

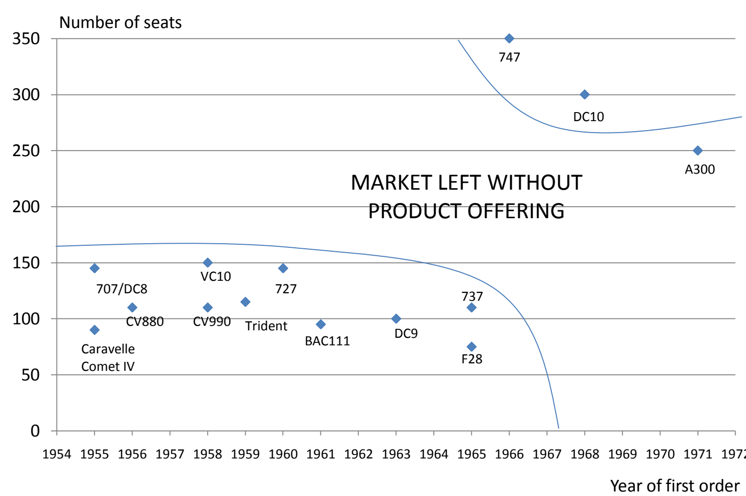
A300 production was allocated across three different countries:

- Wing assembly in Britain
- Fuselage and tail assembly in Germany
- Nose and center wing box in France.

The first flight of the A300 was in October 1972, only 3 years after the launch and 33 days ahead of schedule. This was a real performance considering the 787 and 380 2 to 3 year delays. The A300 closest competitor product was the DC10 from Douglas Aircraft and the L1011 from Lockheed. The A300 was lighter, more efficient but with less range than its competing products and was sold for 24$ million, some 6$ million cheaper than the DC10 and L1011. In 1970, Air France was the launch customer, even before the consortium was formally formed. Lufthansa placed an order for the A300, but the British and Spanish national airline did not follow. The first non-consortium buyer was Korean Airlines, which ordered in 1974. In 1975, Airbus obtained for the full year a market share of 10% of aircraft above 100 seat sales. The 1974 to 1977 were difficult in term of new sales and it looked at time than Airbus would failed and turn into bankruptcy. Between 1974 and 1979 Airbus market share remained at about 5%. While Airbus was selling to second-tier airlines such as Western Airlines, the US market was inaccessible until a major breakthrough came in May 1977, when Eastern Airlines leased 4 A300B4. At that time, the US market represented 70% of the world demand and was considered a US aircraft manufacturers market fortress. No aircraft program would have been considered a success without launching customers in the US market. Today, the US market represents only 30% of the demand for aircraft. Airbus redoubled its effort to penetrate one of the four major US airlines at that time. Eastern Airlines needed a modern aircraft to fit in size between its L1011 and its 727 and capable of operating economically on its shorter sector on the US East coast. The airline was in financial disarray at that time and in no position to acquire aircraft. Driven by Airbus eagerness to penetrate the US major airline market and Eastern to grow its business, Airbus proposed Eastern to make the A300 available to Eastern for a trial period of 6 months at no charge, except for the furnishings. At the end of the period, the agreement was that Eastern could either purchase the aircraft or return them if they felt inappropriate. The A300 performed extremely well and Eastern decided to order 23 firm and 9 options in June 1978.

It is only in the 1980s that Airbus became successful internationally reaching 17% market share between 1980 and 1985.

Figure 53 Airbus market entry into the 250 seater market niche



Source: Laurent Rouaud

With Douglas abandoning its project of a twin engine DC10 and Boeing plan for a 7X7 twin mid range aircraft, Airbus decided to pursue its strategy of entering into markets left opened by its US competition. According to Muller (1989)[82], it was the German that pressed hard “in putting the accent on further establishing the place of

[82] Muller P (1989), L ambition Europeenne, L’Harmattan, Paris

Airbus in its original niche". In 1978, it launched a derivative of the A300 with longer range and smaller capacity: the A310-200. In 1984, Airbus decided to extend the life of the program by developing a derivative to the A300-B4 which introduced advanced technologies such as a 2-crew cockpit with CRT displays.

In addition, as the A300 was entering the market in an open niche, the three US manufactures ,Douglas, Lockheed and Boeing, had begun disastrous competition in the same upper market segment. [83]

The A300/A310 was not a great commercial success with total orders for 566 and 255 units, but it allowed Airbus to enter into the market, develop its supply chain, and most importantly build a customer support organization critical to its future success. In 1975, Airbus had two goals: create a family of aircraft and target a 30% share of the market. The supervisory board of Airbus outlined the building of a new small and two larger jets which eventually became the A320 and A330/A340 programs.

Besides entering in the market in a ''white space'' and developing a worldwide customer support organization, Airbus' strategy third pillar was to differentiate its products through technology innovation over an entire family of product from a 100 seater domestic to a 400+ seater long range intercontinental. The major technology differentiator came from the fly-by-wire innovation, not new to the military world, Airbus succeeded in introducing for the first time in a commercial aircraft program with the A320. Differentiated technology was a critical factor of success in an industry that values long term relationships and strong established incumbency. The reasons for the strong incumbency are essentially related to the importance of optimizing the productive time of an aircraft from an operation point of view which comes from a reliable proven product and a top class customer support organization. It is also driven by the increased cost of switching product from new tooling, infrastructure, process, spare pool, disposition of older equipment, and

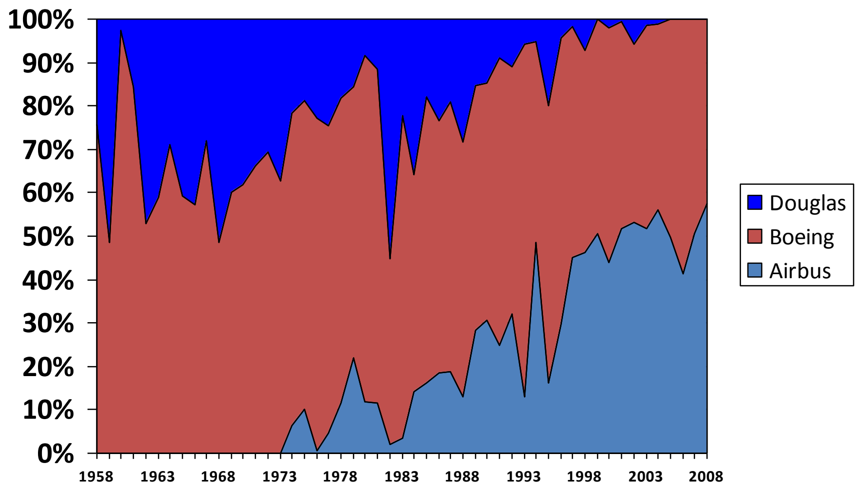
[83] Newhouse John, (1982), The sporty game, Alfred Knopf, New York

training . Launched in 1984, the A320 evolved to include a full family of product from the original 150 seater A320 to the 200 seater A321, the 125 seater A319 and the 100 seater A318. The Airbus business case at the time of the launch predicted a market capture of 900 units over the A320 program life. Although it looked very ambitious at that time to reach 900 sales given the experience of the Caravelle and Mercure, Airbus today sold more than 6,000 A320 family aircraft and is still counting. The fly-by-wire family was later extended to include the A340 and A330 in 1988. The fly-by-wire (FBW) technology not only reduced weight on the aircraft and simplified the architecture of control surfaces of the aircraft it also help airline customers to reduce their operating costs and improve productivity and therefore their bottom line through the commonality of the FBW applied to the full family of aircraft. The FBW technology helped reduce airline costs through:

- Increasing productivity of the pilots from less down time spent on transition training from one aircraft type to another;
- Reducing the training time/costs and cost for crews, mechanics, pilots;
- Sharing a common spares within each sub-family.

Thanks to its innovative technologies such as the FBW, Airbus succeeded in offering a differentiated alternative to the US aircraft suppliers . Within a few years after its launched, Airbus FBW family of aircraft increased its worldwide market penetration from 7% in 1979 to 20% in late 80s. Shortly after, the fly-by-wire 150 seater A320 aircraft developed into a 4 member family of aircraft with the launch of the 100 seater A318 , the 125 seater A319, and the 220 seater A321 . The success of the Airbus strategy came about when it consistently obtained 50% of the net orders of aircraft above 100 seats.

Figure 54: Airbus order market share



Source: Ascend, Laurent Rouaud

In December 2000, Airbus formally launched the A380 555 seat aircraft, completing Airbus 1970 original goal to develop a full family of aircraft from 100 seat to 400+ seats. As of August 2010, the A380 has received 250 orders from 20 customers. Some 40 years later, Airbus has succeeded in gaining 50% market share, sold nearly 10,000 aircraft to more than 320 customers and hold a backlog of 3,500 units or 5 years of production at current level.

Table 8: Airbus aircraft launch

Aircraft	Engine	Launch	Customer	First service	Last delivery	Total delivered
A300B1/B2/B4/C4/F	GE/PW	1969	Air France	1974	1987	249
A300-600/R/F/ST	GE/PW	1980	Saudia	1984	2007	300
A310-200/200F/300	GE/PW	1978	Swissair	1983	1998	255
A318-100	PW/CFM	1999	LAN Airlines*	2003		
A319-100	CFM/IAE	1993	ILFC	*1996*		

A320-100/200	CFM/IAE	1984	B.Cal	1988		
A330-200	GE/PW/RR	1995	ILFC	1998		
A330-200F	PW/RR	2007	Guggenheim	*2010*		
A330-200MRTT	GE	2008	Australian Defence Force	*2009*		
A330-300	GE/PW/RR	1987	ILFC	1994		
A340-200/300	CFM	1987	Qatar	1993	1997	245
A340-500/600	RR	1997	Air Canada	2003		
A350-800XWB	RR	2006	Pegasus Aviation Finance	09/2014		
A350-900XWB	RR	2006	Finnair	06/2013		
A350-1000XWB	RR	2006	Qatar Airways	11/2015		
A380-800	RR/EA	2000	Qantas	2007		

Source: Laurent Rouaud

IV-2-2 Transformation of Airbus into an integrated company

As a G.I.E , Airbus Industrie has acted as a conduit for sales with its four partners/suppliers sharing the responsibility for producing airplanes as well as sharing in the profits from the sale of the airplane. Although the system worked well for decades, by the early 1990s, it was clear to Airbus that the G.I.E structure was no longer a sufficient vehicle for Airbus to remain competitive in the world market. More importantly the fixed price negotiated with the partners as supplier for every program was a strain that Airbus could not sustain to remain competitive. In January 1997 (six months before the Boeing/McDonnell Douglas merger was announced) the Airbus partners entered into an agreement to form a new consolidated company. However, implementing that decision required several years of negotiation during which the contemplated structure changed several times.

The integrated process started in late 1999, when Aerospatiale Matra, Daimler Chrysler Aerospace AG and CASA signed agreement for the creation of the European Aeronautic, Defense and Space Company (EADS). EADS is currently Europe's premier aerospace company and third worldwide, behind Boeing and Lockheed Martin.

In June 2000, BAE Systems plc (BAeS), EADS and CASA entered into an agreement relating to the creation of a joint company with respect to their Airbus assets and activities. The three companies integrated their assets and activities, including their respective interests in Airbus G.I.E into a single company. The new company, Airbus Integrated Company S.A.S was incorporated under French law and constituted a restructuring and rationalization of the existing legal structure. BAe Systems held 20%. Both EADS and BAe Systems were publicly traded companies listed in London, Paris, Frankfurt and Madrid stock exchanges. Prior to the integration, 60% of Airbus was already fully owned by publicly held companies.

The new structure allowed the large civil aircraft activities to be integrated under a single management, permitted the centralization of essential functions, streamlined the management decision making, and provided wider access to financial markets.

The transition from partnership to an integrated company was a far more complex process than the simple merging of existing corporate assets that has characterized the consolidation in the US aerospace industry. The German and British shareholders were “spinning-off” their civil aircraft business units into arms lengths subsidiaries. The French and Spanish shareholders were spinning-off and privatizing their civil aviation business units at the same time. A multinational cross border spin-off, privatization and merger process of this scale was without precedent in corporate history on either side of the Atlantic.

The objectives of the Airbus restructuring were the following:

- to integrate the civil aviation activities under a single management fully accountable to its shareholder;
- to centralize key functions such as design, production, management, after sales support, and purchasing in order to further improve efficiency;
- to streamline management decision making in order to react more quickly to market demands;
- to remove conflicts of interest between ex partners/suppliers by imposing corporate governance monitoring;

- to provide increase financial transparency, thereby permitting wider access to financial markets and foreign partnerships.

Given the events that unfolded after the integration such as the increase competition, the GATT dispute on the 1992 agreement, and the internationalization of the supply chain, the integration was definitely the right decision.

V - Key determinants of competitiveness in the large civil aircraft business

The key determinant of competiveness can be divided into those that are internal to the firm and those that are external to the firm. Internal factors are by definition controlled or controllable by the aircraft manufacturers such as the firm's R&D spending, its strategy, the internationalization of its production, or its funding sources. Manufacturers in Europe and in the United States face the same circumstances with respect to market conditions. How well manufacturers do vis-à-vis each other is primarily a function of the choices made by the management of each company in response to these market conditions. The internal factors could be also characterized as the supply side factor of competitiveness. The key determinants are the management strategic choices and decision-making on the product strategy, its product differentiation and value proposition to the customers, or its manufacturing process, its supplier base strategy, or outsourcing strategy to lower its costs. Guenther (1986) found that there are four key determinants of competitiveness across all industries: cost structures, quality, exchange rate and government policy. [84]

External factors affecting competitiveness of the firm are by definition beyond the direct influence of the firm. There are for example, the macroeconomic factors, such as exchange rate, fuel prices, inflation, and availability of capital and government policy. The external factors also include the demand factors that come from the airlines. The government policy external factors have a major impact on the aircraft industry through direct or indirect support of their national aerospace companies. As seen in the previous chapter, aerospace is of strategic importance for Europe and the US.

[84] Guenther Garry (1986), Industrial competitiveness: definitions, measures, and key determinants, Congressional Research Service, Washington D.C

V-1 Internal determinants of competitiveness

V-1-1 Corporate Structure

Corporate structure influence competitiveness as it determines how and how much a company pays taxes on its profits, reports its revenues or whether or not it reports to its shareholders or board the strategic decisions the firm might take for its future. It also influences its local, states and federal funding in its home base countries and in its outsourcing countries.

At the time of its creation, Airbus was organized in a groupement d'interet economique (GIE) under French law. Airbus main objective at the time of the GIE was to create the condition necessary for long term profitable participation in the supply of large jetliners to the world. Its goal was to:

- Develop a base product;
- Create an appropriate financial/industrial structure;
- Establish a market base and global support system;
- Develop a full range product family;
- Achieve a sufficient share of the total.

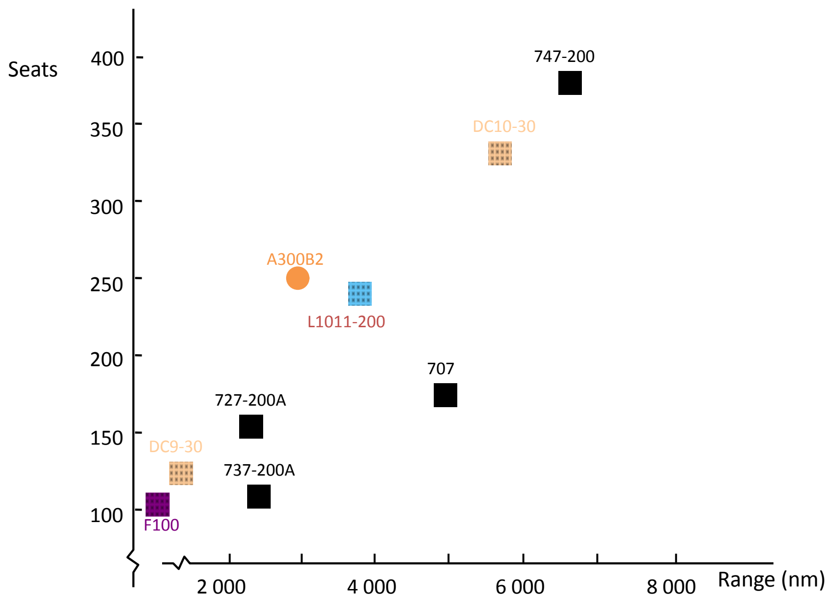
The GIE was the right structure to develop this ambitious goal. It was a grouping of mutual economic interest to oversee cooperation between Europe's major aeronautical concerns involved in the Airbus project. The GIE was a type of joint venture that had a legal identity separate from its members and which had no formation requirement of fixed capital contribution. Similar to a partnership in the US, the GIE was not required to report financial results. The members of the GIE were jointly and separately liable for the GIE debts and obligations. Airbus member companies needed not to share information about their costs. The companies as well as the GIE knew the actual cost of manufacturing Airbus planes. The lack of transparency decreased the oversight and control the partners could exert on the GIE Airbus. A GIE is a unique European structure that allows members of a joint venture to collaborate on a particular project without merging or forming a true partnership. The benefits from a GIE structure are essentially:

- Enables cooperation on full partnership basis;
- Merges the technical strength of the participant;
- Receives new members easily;
- Enables partners to vary participation program by program;
- Avoid locking up large sum of capital;
- Allow to deal directly to customer as a single entity.

The GIE major assets were attached to the manufacturing base, therefore in the hands of the members. It enabled merging of common interest without the merger of assets and avoiding major equity participation. All contractual relationship between Airbus and partners were based on fixed price contracts for the life of the program in US$ subject to US escalation.

The GIE structure of Airbus allowed the entity to distribute among its member companies the risks, including losses, associated with the high cost of research and development, manufacturing and marketing a new commercial aircraft. Without the GIE structure it is unlikely that Airbus would have survived pass the A300.

Figure 55: 1975 product offering



Source: Laurent Rouaud

Figure 56: Airbus launch aid by program

Aircraft	Launch Date	Aid
A300	1969	100%
A310	1978	90%
A300-600	1980	90%
A320	1989	75%
A330/A340	1987	60%
A321	1989	0%
A319	1993	0%

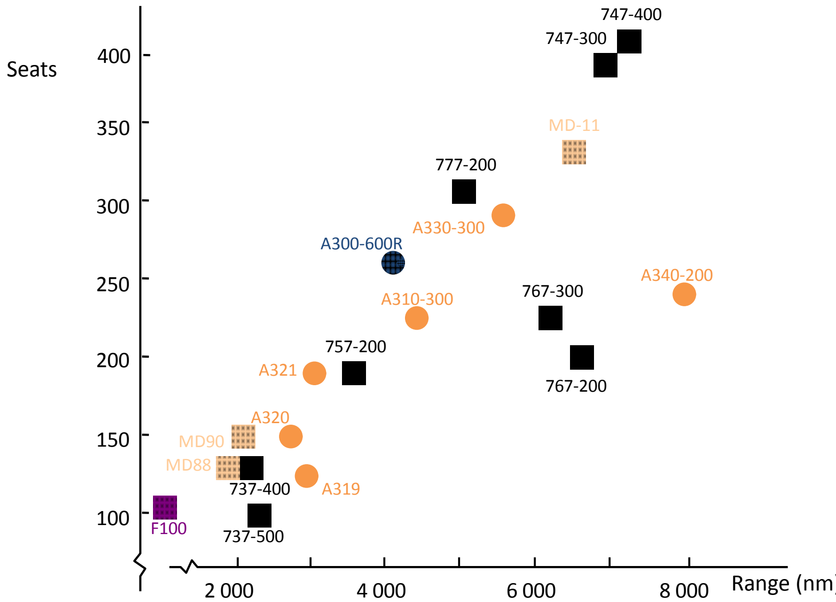
The subsidy issue has been the source of many discussion and debates across the Atlantic. Per definition, a subsidy is a grant or gift of money by a government to a private person or company to assist an enterprise deemed advantageous to the public. The Airbus so called subsidies are repayable through a levy on aircraft sales at a real rate of return. Therefore, it is more a refundable launch aid than a subsidy. The grey area is that the repayment is not mandatory if the program fails and the interest rates are very low. In the case of Airbus, all programs had been successful and the government investment has been paid many times over.

The refundable launch aid was given to AI partners for a program-specific R&D, and not for a generic technology development or not for a production subsidy. The government loans were repay repayable on royalty basis. The repayment continued for the life of programs even if loan is fully repaid. The A320 family since its introduction into airline service some 22 years ago has generated about 10 times the original investment made by the government of Germany, France Spain and France. It was definitely a good investment. The risk at the time of launch was too high to have an interest in the financing of the program.

In comparison, US manufacturers are obligated to make business decision with the approval of their shareholders which are most commonly driven by short term interests in a 20 year aircraft product cycle industry. US corporations are also taxable.

The main disadvantage of the GIE structure is that it decision process is more complex and slower than for a single entity. Another disadvantage is that each of the Airbus partners has the dual role of being owners and subcontractors. As a result, the behavior of the partner might be guided by the best interest as of the subcontractor rather than the best interest to Airbus. The dual role brings tension between the owner/supplier partners of the GIE on a regular basis. The location of the final assembly line was always a passionate negotiation with some heated debate within the GIE. In contrast, US manufacturer's decisions are solely based on the best interest of the company

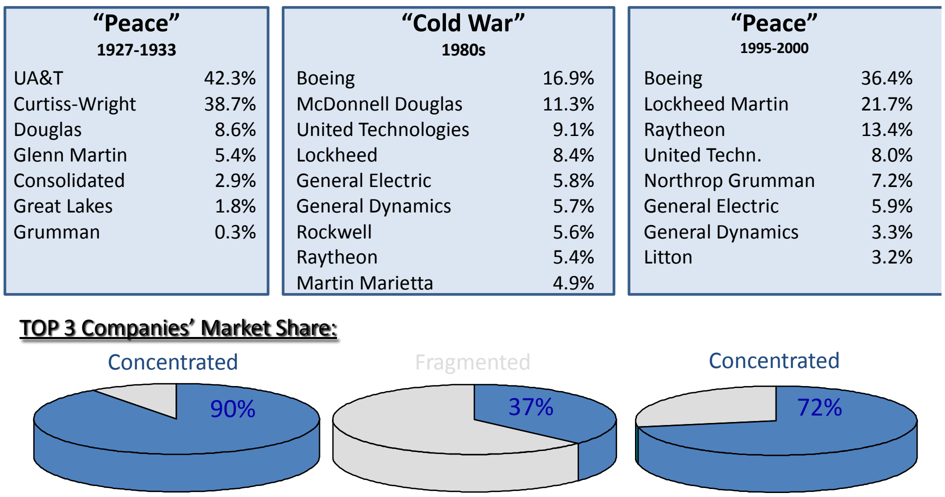
Figure 57: 1990 product offering



Source: Laurent Rouaud

While Airbus GIE were developing its family of aircraft the large US aerospace were consolidating. Three main groups emerged from the first round of consolidation. Boeing main goal was to increase its military revenue to balance its portfolio of product equally between defense and commercial aerospace. At the end of the consolidation, the top 3 firms had 72% of the business vs. only 37% during the 1980s.

Figure 58: consolidation of the large US defense firms



Source: Aerostrategy, Laurent Rouaud

Figure 59: Consolidation of the US aerospace

Source: Laurent Rouaud

V-1-2 Firm Strategy

Firm strategy is a critical component in the ability to develop a sizable business to finance future program and insure the viability of the firm. This is critical considering the long program life of an aircraft program. On average, a successful program will last 25 years. Some program are upgraded with a newer and more efficient engine, or equipped with the latest systems. All aircraft manufactures have the same overall goals:

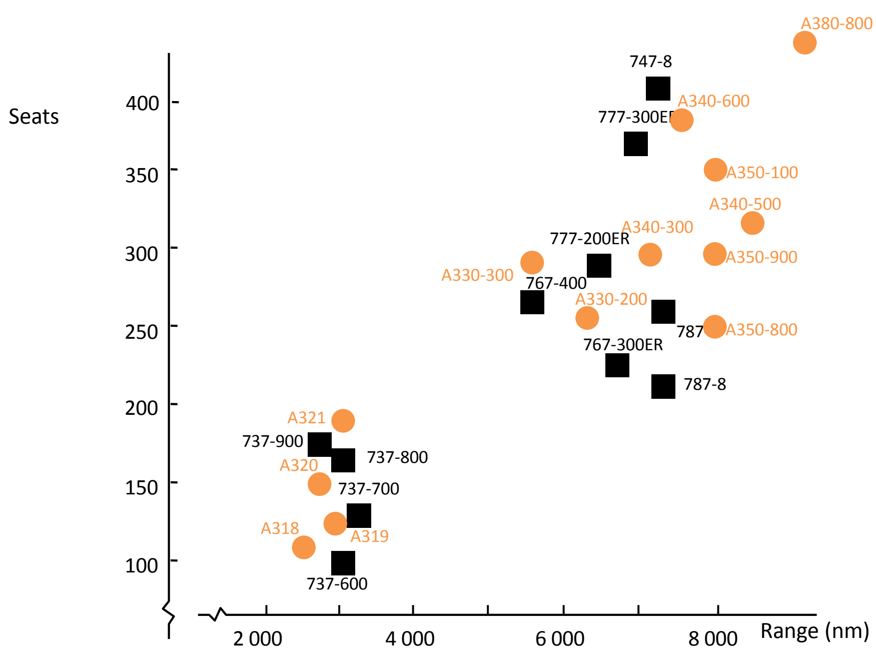
- Offer new aircraft with the best possible technology that will differentiate and give competitive operating costs for their airline customers;
- Maximize commonality across their product portfolio;
- Develop a worldwide customer support organization;
- Obtain the lowest possible cost structure.

V-1-3 Develop a family of products

Offering a wide product range that covers the full requirement of an airline customer brings not only economy of scale and economy in the operation of the airline but also some significant economy of scale, scope and experience to the manufacture of civil aircraft. The family concept also provide allow the incumbent to react to new entrant by developing a derivative to its product portfolio at a much lower cost than a potential entrant by using the same tooling, supplier base. The derivative could be as simple as to stretch the current aircraft by adding a few frames to the fuselage or shrinking the fuselage by a few frames. The A318 was a shrink of the A319, itself a shrink of the A320. The A318 allowed Airbus to compete in the 100 seater against Embraer 100 seater E-195. The A321 is a stretch of the A320 that compete with the 757. The demise of Douglas as a supplier of large civil aircraft was partly due to the lack of a wide product range within their product offering, covering less than 30% of the market.

Airbus and Boeing have both employed a product strategy that has focused on developing a family of product in tune with the market requirements. Airbus, because of its later entrance with no legacy products, has relentlessly used commonality throughout its product as a differentiating technology. This strategy has been very effective in persuading airline customer to switch supplier from Boeing/Douglas to Airbus despite the high cost of transitioning from a fleet to another. Te enabler of the commonality throughout the Airbus product line resided in the fly-by-wire innovation that Airbus introduced in its A320.

Figure 60: 2010 product offering



Source: Laurent Rouaud

The A330/A340 family was launched in 1987 to respond to the increasingly deregulated market environment that has led to the growth of point to point services and greater efficiency by matching capacity to market size. This market requirement led Airbus to develop the A330/A340 family of aircraft for medium and long range routes, with the continued policy of pursuing maximum commonality of powerplant, fuselage, components, and systems through the product range.

The A330/A340 complemented the A320 family and the A310/A300 family. From 1993, Airbus has been in a position to build from its common base of products, adding incremental developments to enhance its product line and giving choice to airlines. The first of these was the A319, a smaller version of the A320, which was launched in the depths of the recession in June 1993. The decision reflected a focus on the long-term nature of the civil aircraft business and the anticipation that the market would have recovered by the entry into service scheduled at the time in 1996. While the timing of the decision was considered bold in the prevailing economic conditions in 1993, the subsequent orders and the economic upturn proved that it was the right strategic decision.

The development of a full product offering was completed in the year 2000 for Airbus with the launch of the A380. The A380 allowed Airbus to offer a family of common product from the 100 seater A318 to the 600 seater A380.

In 2006, Airbus launched the A350 family that will cover the long range market in the 250 to 375 seater market. The A350 three member family has been extremely strategically well positioned as a replacement of the 767-300ER, and the 777 and responded to the threat cause by the Boeing's product developments in the long range middle of the market. The A350 response was also addressing the success of the 777 and the airlines lack of enthusiasm on the 4-engine A340 from the airlines because of the higher fuel consumption of quad engine and the ability of twin engine to fly longer distance over water.

Boeing has used the same strategy of product development except that it had to start from a legacy family of products. Its 737 family has 4 members spanning from the 100 seater 737-600 to the 175 seater 737-900ER. In 1990, Boeing launched its 777, a 300 to 375 seater capable of flying up to 8000 nm at full payload. In 2004, it launched the game changing, 787 family that spans from a 225 seater to a 300 seater in response to the point to point long haul airline requirements. In the A380 market segment, Boeing launched the 747-8, the successor to the older version of the 747 with a new wing and new engines. So far, the aircraft has been very well received by the cargo operators but with less enthusiasm by the passenger airlines. Both Boeing and Airbus have a complete family of products.

It is interesting to note that the segment covering the medium range 250 seater market has been left uncovered by the incumbents since the A300/A310 and 767 The A300/A310 has been discontinued in the early 2000s while the 767 is slowly ramping down at the end of its product economic life. Why did the potential entrants decide not to enter the market space left open, the same market in which Airbus decided to enter some 40 years ago? Why are they entering in the most competitive market of the 125-175 seater?

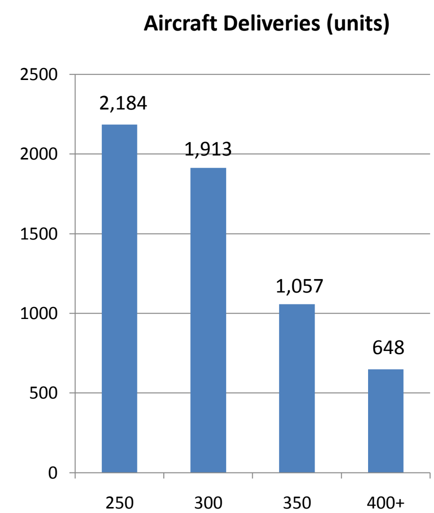
The reasons for not entering the 200-250 medium range is essentially:

- ✈ The 250 twin aisle medium range market demand is small;
- ✈ The demand 250 seater market seat in a grey zone between the short range and long range market;
- ✈ The 250 seater market can be addressed by the incumbents from the 210 short range and by the 300 long range markets;
- ✈ A true 250 medium range seater will require a brand new program that would cost a minimum of 7 to 8 billion dollars;

- ✈ The market for short range 150 seater is crowded (Airbus , Boeing, Bombardier CSeries, COMAC C919) but with a demand for 15,000 aircraft;
- ✈ The incumbent products (A320 and 737) are arriving at the end of their product life cycle.

Figure 61: Demand for new aircraft deliveries 2010-2029 Middle of the market

Middle of the market



Source: Airbus

Over the next 20 years, Airbus[85] estimates that the market for the 250 seater segment is about 2,200 units. This market is made of long range aircraft requiring a range of more than 6,000nautical miles for the Europe to Asia and Transpacific markets. These two fast growing markets will be actually captured by the adjacent market segment of 300 seater aircraft since most of the demand for twin aisle will come from higher capacity aircraft. Few of the airlines will went to add another type to cover the 250 segment. Similarly, the demand for 250 seater on shorter distance such as the Europe to North America and Europe to Africa market are shorter range

[85] Airbus, (2009), Global market forecast, Toulouse, France

(3,000 to 5,000nm) but can easily be covered by 300 seater longer range aircraft such as the 787, A330, 777 or A350s. Some of the 250 seater could actually be filled from the 210 seater single aisle aircraft such as the A321 or 737s. Therefore, of the 2,200 aircraft demand market only about 800 to 900 units are truly medium range aircraft. With development costs of about $7B to $8B, the market is too small to allow any return on investment at any rate. It worked for Airbus in the 1970s because the 250 seater aircraft ,at that stage of air travel development, was used on short range domestic Europe and US markets and because most of the international markets were concentrated on the North America to Europe route. Today, with the development of international travel, the Atlantic market is small in comparison to the others. The250 seater aircraft that were used extensively on the domestic markets in the 1970s and 1980s have been replaced by much smaller models such as the A320s and 737. The smaller models have become the preferred airline tool on the domestic markets as the competition on these markets has increased and as the passengers started to value frequency and price rather than only price in the earlier stage of air travel maturity.

V-1-4 Commonality as a market barrier

The fly by wire technology that was introduced by Airbus in the mid 1980s on the A320 enabled to use the concept of commonality as a valuable differentiator for airlines. The common flight deck and common systems which came from the use of flight by wire reduced significantly the training costs of flight, cabin and maintenance crews within the family. Pilots, for example, could cut the training time required for transitioning from one aircraft type to another larger aircraft type from three weeks to a few days of computer base simulation. The fly by wire technology provides similar handling characteristics and procedures within a same family. Airbus applied the fly by wire technology to the larger and longer range products as it develop its product line in the 1990s and 2000s. As a result, the 100 seater A318 and the 555 seater A380 have similar handling characteristics. Not only would a pilot be able to transition quicker within the same family such as the A320 family for example, but he could also transition from one family to another (A320 to A330 for example) in a matter of days instead of weeks. The shorter training time of pilots, crews and mechanics translate in significant labor cost savings for the airlines. In addition, because the pilots down time is reduced, they can also be more productive and bring more revenues The commonality brings also productivity through a quicker turnaround time on the ground and a more efficient use of the aircraft itself. Because, the pilot and crew is qualified to fly the full family of aircraft size, the airline operation dispatch can adapt the passenger demand with the right aircraft size on a short time basis. The load factor will be optimized and the fuel cost be reduced as a result. Another economic advantage of fleet commonality is in spare parts inventory. The cost of parts inventory decreases with the number of common planes, since demand for unique parts and maintenance equipment is minimized. It is estimated that the commonality between the A320 and A330, for an airline that possesses both aircraft in its fleet, is about $1 million per additional aircraft per year. It is estimated that to get an airline to break with commonality, all other things being equal, the new manufacturer's price would have to be 10% below that of the common competing aircraft. It also means that an incumbent with a complete family of aircraft can justify a price 10% higher than the new entrant that either has one product family or compete to introduce one product into the airline in which the incumbent has already at least one product. *this provides the airline with the incentive to choose products from other families by the same manufacture.

Commonality tends to discourage entry of new players in the LCA industry. Russia has stated that to sell in the western markets of Europe and North America, they must use Western engines and avionics not just because of quality considerations but also because of commonality.

Not only does an incumbent manufacturer benefit from developing a commonality strategy through the marketing of their products, they also reap benefits from development cost efficiencies by using common features and parts on different aircraft, manufactures spread development costs across more products. The cost of developing a derivative with common features is about 10 times cheaper than that of developing a new aircraft program. Common parts and manufacturing requirements permit for a more efficient assembly of different aircraft on the same production line, providing increase productivity through the use of common production processes, tools and human resources. The MS21 or the CSeries is likely to cost between $9 billion to $12 billion to develop. The new aircraft to be delivered in 2014 is anticipated to bring a 15% fuel burn and a 5% operating cost advantage over the current A319 or 737-700. Airbus and Boeing have public ally stated that they are working on re-engineering their A320 and 737 series of aircraft with new generation engines and some slight aerodynamic clean up that will yield the same economic improvement. The cost of developing a re-engine program is likely to be in the neighborhood of $1 billion to $1.5 billion As Airbus and Boeing have already manufactured several thousands of their aircraft. Their recurrent costs are very low compared to the early program recurring costs of a potential entrant, while the benefits to the airline in terms of operating costs are the same.

The commonality has some trade off and limits for incumbents. It works best over an entire product range that is developed over a decade or two. As the technology evolves, manufactures must decide between maintaining a level of commonality and introducing a new technology on a new program that cannot be retrofitted on previous programs. As the product line ages and develops, manufactures are confronted with the dilemma between preserving commonality and introducing a step change innovation. A potential entrant can use the commonality to its advantage if the incumbent are still developing products on a previous commonality cycle and if the new entrant innovation provides a significant step in operating cost advantage.

V-1-5 Product innovations

Product innovation is a key determinant of competitiveness as it improves the product and services in the area of product performance, economics, environmental impact, productivity, safety, or operational flexibility. Technology for the sake of technology has absolutely no value in the competitive airline environment. The changes in technology are driven by the market, competition and regulatory forces regarding safety and environmental standards. Innovation enable to improve operating cost for airlines (fuel consumption, maintenance, training …), aircraft performance (take off field length, payload, reliability, productivity, CO2 emission, noise emission, turn around time …), or passenger appeal (comfort, internal noise level, flight entertainment, interior appearance, humidity of cabin …). Different airline segments can value innovation in a different way. A Low Cost Airline will be as attentive to operating cost as a legacy airline, but will value aircraft boarding and de-boarding more than a legacy airline. Airbus, for example, has brought a number of key innovations over the last decades. Aircraft delivered today use technology developed in the 1990. Among the innovation that Airbus brought to the market in the 1990s are:

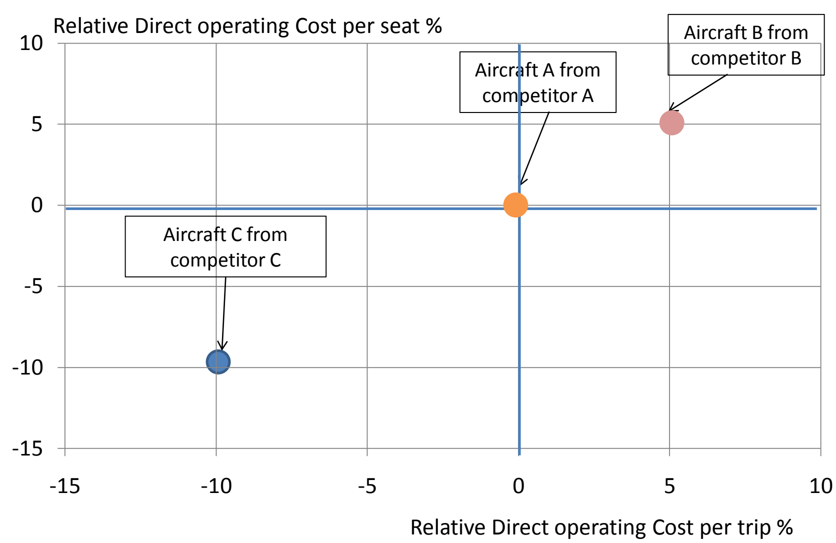
- Advanced aluminum alloys on the A310
- Composite in primary structures
- Trim tank/center of gravity control
- Carbon brakes
- Sidestick controller
- Fly-by-wire
- Extensive use of composites and advance aluminum alloys on A320s
- Cross Crew Qualification and Mix Fleet Flying
- Carbon Fiber Reinforce Plastic on the A380
- GLARE on upper fuselage panel
- Laser welded lower fuselage

The development of larger aircraft that travel longer distances more efficiently created the need for material which are lighter, stronger, and last longer. Aircraft manufactures have introduced composite material to satisfy that need.

V-1-6 How do airlines evaluate the value proposition of competing product

Airlines are sophisticated buyers. The aircraft fleet planning decision can significantly affect the viability of the airline over the entire life of the aircraft selected. As a result, airlines tend to be analytical and exhaustive in their review of the available competing products. Their evaluation is always conducted by analyzing the performance and economics of the competing aircraft and how those factors impact costs and revenue generating over an aircraft's economic life of approximately 25 years.

Figure 62: Evaluation of competitive aircraft



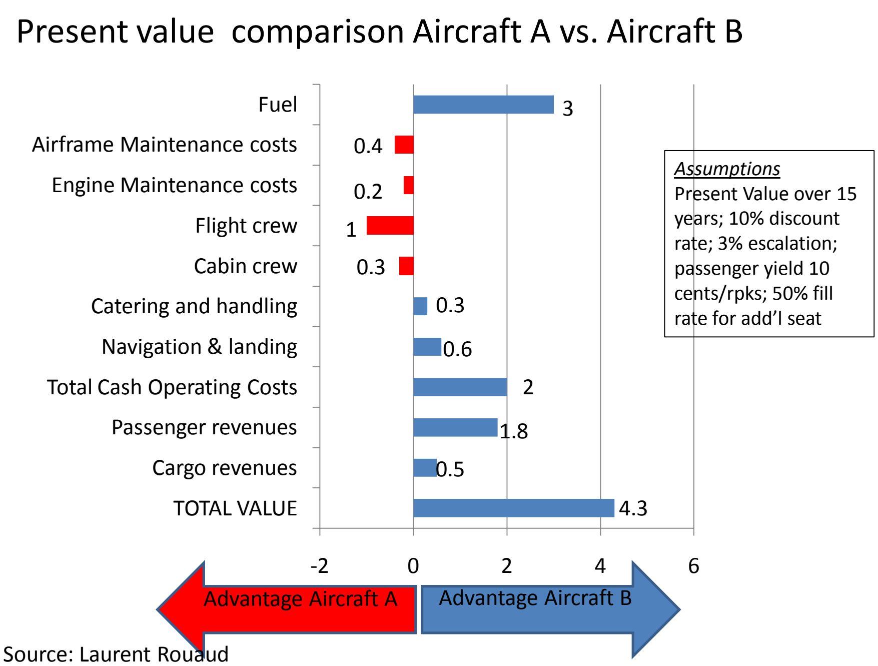
Source: Laurent Rouaud

The first part of the evaluation is the life cycle costs and revenues of an aircraft type, including such elements as fuel burn, maintenance, crew costs and ownership on the cost side, and passenger and cargo loads on the revenue side. Competing aircraft are evaluated over a specific mission defined as a given number of passengers over a specific distance and particular season to include the effect of wind on the particular routes.

The second part of an aircraft evaluation most commonly consists of assessing the different competing aircraft ability to be economically redeployed on different routes and still generate profits. This can be characterized as aircraft type flexibility and is of increasing importance to airlines as they attempt to manage future uncertainty due to both external macroeconomic shocks and competitive move within its industry. A major element driving this flexibility is type commonality. Other attributes considered can include the effect of a wider and more spacious cross section on a passenger preference or the branding associated with the aircraft family.

Airlines typically quantify the attribute and characteristics of competing aircraft by using discounted cash flow analysis, projecting twenty years or more into the revenue future. The method allows airlines to simulate the effect of their aircraft decision on their bottom line. Ownership cost represents a small fraction of the overall cost and is only one parameter of the evaluation equation. For example, an average wide body aircraft can consume its own cost in fuel over its economic life span. Moreover, the discount cash flow methods provides a result that can be related back to the aircraft price For example, if an aircraft consumes $340,000 worth of fuel less than the competing aircraft, one can calculate a resulting discounted cash flow of $3 million., commanding a price premium of the same amount. Fuel saving can be achieved through innovation. As an example, the saving in structural weight due to the use of composite material is 1,600 lbs. A 1,600 lbs saving is equivalent to adding 8 passengers with their luggage on every flight, which translates into over $2 million to an airline.

Figure 63: Airline evaluation of competing aircraft



Source: Laurent Rouaud

In the example above, aircraft B has a present value advantage of the discounted cash flow of about $3 million for aircraft B. Its value proposition come from a better fuel consumption, and better passenger and cargo revenues. The $3 million advantage means that aircraft B can justify a $3 million price premium over aircraft A.

By developing aircraft using innovative and advanced technology and commonality benefits throughout its product families, an aircraft manufacture can succeed in differentiating its products from its competition and offering airlines a very competitive asset in terms of their ability to generate profits and minimize costs.

V-1-7 Entry barriers

A new entrant must choose a market segment or niche and develop differentiating innovative technologies to attract key potential customers away from the incumbent firms. In addition, a new entrant must be able to commit and have access to billions of dollars to design, develop, test, certified and produce a civil aircraft program.

Boeing, for example, in 1966s, incurred a development cost estimated at $1.2 billion in 1966 dollars for its 747 program. It was more than three time the total capitalization of Boeing at that time. It almost pushed Boeing into bankruptcy. Once the investment is made, the funds cannot be recovered by selling the assets, they are sunk costs. Incumbents producers have capital available from their current program and have access to financing as they have an history of previous successful program and better credit rating that an entrant. The following costs are the sunk costs or the non-recurring costs that constitute the major entrée barriers to the large civil aircraft business:

Table 9: Entry barriers for large commercial aircraft

Non-recurring costs	Description
Design	human resources, IT, design bureau work in the area of structural tests, wind tunnel testing, flight test, aircraft certification
Wind tunnel	Design and production of model for wind tunnel testing
Structural test	Prototypes production, tools, test equipment, installation of test equipments
Simulators	Design of flight simulators
Equipment development	Development of all systems: air conditioning, communications, automatic pilot, FMS, electric power, hydraulic …
Calibration and tooling	Design the manufacturing processes
Development aircraft	First aircraft for test flight
Flight tests	Test equipment, IT, ground support
Modifications	changes in the aircraft conception, tooling, documentations
Ground support	storage, maintenance of flight test aircraft, equipment, tooling, …
Documentation	Develop the documentation for maintenance, operability, training, …
Others	Supplier integration, contract negotiation with suppliers, travel, Customer focus group, advertisement, promotion, …
Sales and marketing organization	Build a strong global marketing and sales organization

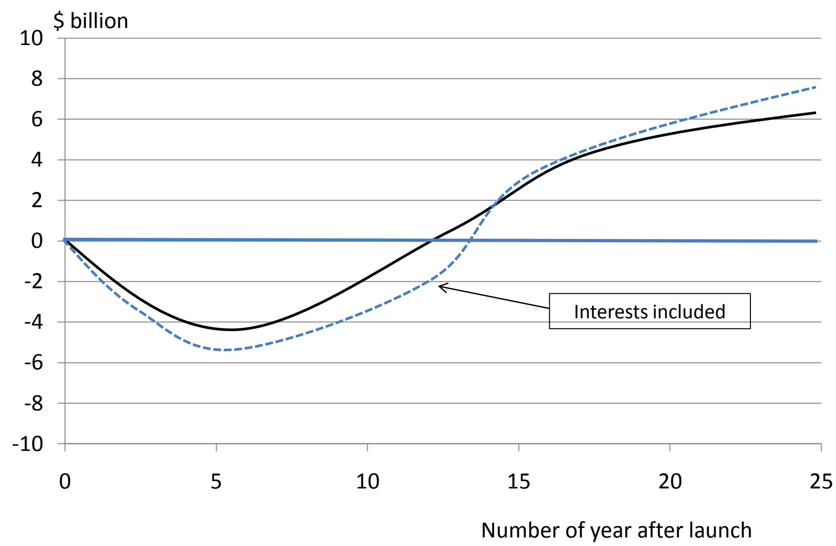
Source: Laurent Rouaud

Incumbent's relationship with customers

The new entrant would have to establish the credibility in the very concentrated airline market. There are about 400 airlines in the world with a fleet ranging from a few turboprop aircraft to network airlines with a fleet of 500 or more aircraft. The credibility of the entrant would have to be established with a few of the airline trend setters such as Air France, Lufthansa, Easyjet, or Ryanair in Europe, Singapore, Qantas, Korea Air in Asia, TAM, Lan, or Gol in Latin America, Emirates, or Qatar in the Middle East. The trend setters and incumbent manufactures have established long term relationship throughout their management structures and are continuously engaged in Voice of Customer dialogue to help shaping the next generation aircraft with the manufactures. The incumbents have already proven their technical capabilities. The entrant will have to heavily invest in building a strong marketing and sales force, but more importantly will have to establish a global and credible customer support organization in which the customers will trust. The costs incurred by a manufactures of providing a after sales support to its airline customers declines significantly as the installed fleet of aircraft increases. The upfront cost of establishing a customer support network that is global and satisfactory to the customer is substantial. A long established airline-manufacture relationship cannot be built easily by new entrants.

In addition, because an aircraft is a working asset that last up to 30 years, airlines decision to acquire an aircraft is influenced by their assessment of whether the manufacture will stay business for the long term to continue supporting the aircraft in upgrade, spare parts, and service bulletin.

Figure 64: Cumulative cash flow profile of a large civil aircraft



Source: Laurent Rouaud

Economy of scale and learning curve and economy of scope

The long term presence of incumbent firms provides important cost advantage. First, cost efficiencies in the large civil aircraft business is derived through the lengthy production runs, which allows manufactures to spread the high development costs over more aircraft and provide a learning curve effect that makes unit production costs to decline as output increases.

Baldwin and Krugman (1988)[86] showed , using a Cournot Nash[87] game subsidy to model the welfare effect of industrial trade policies in the LCA, that the substantial learning economies caused the negative impact of Airbus entry in the market for the industry and the European tax payers but brought consumer gains. Klepper (1990)[88], using a Cournot-Nash game in production capacity confirmed that the

86 Baldwin R and Krugman (1988), Industrial policy and international competition in wide-body jet aircraft, Trade Policy Issues and Empirical Analysis, University of Chicago Press, Chicago
87 Fudenberg Drew and Tirole Jean (1993), Game theory, The MIT Press, Cambridge
88 Klepper Gernot (1994), Entry in the market for large transport aircraft, European Economic Review, volume 34, page 775-803

competitive benefits of Airbus were diluted because of the steep learning curve in LCA manufacturing by transferring learning economies from Boeing to Airbus with an overall loss of value. Because of the learning economies, Neven and Seabright (1995)[89] showed with their competition model that the absence of Airbus would have discouraged Douglas Aircraft from producing the MD-11 (300 seater long range aircraft). Counter intuitively, it is because Boeing can obtained higher economy of scale from the absence of Airbus and therefore price the 777 at a level which Douglas cannot compete. Given the fact that the 777 is 25% cheaper to operate than the MD-11, Boeing can obtain higher value pricing for the 777, while enjoying significant higher economies of scales. The model suggests that Airbus entry made life easier for Douglas because its sales reduced Boeing's economies of scales and therefore increased its pricing relative to the MD-11. Benkard (2000) [90]even argued that restrained antitrust policy could be justified based on the fact that concentrating learning is socially optimal [91].

It is recognized that civil aircraft manufacturing is characterized by a learning curve with an elasticity of 0.2, i.e. a doubling of the output brings a 20% lower production costs. Secondly, fixed costs can be also spread by using components, systems, and production facilities from previous programs. Manufactures' experience from previous programs enables them to design, develop, test, certify and produce much faster than its smaller new entrant. This is particularly true for Airbus since its strategy is based on developing common product. A third advantage comes from the optimum utilization of the production resources. Not only does the number of aircraft produced in critical, the length of the program, is as important.

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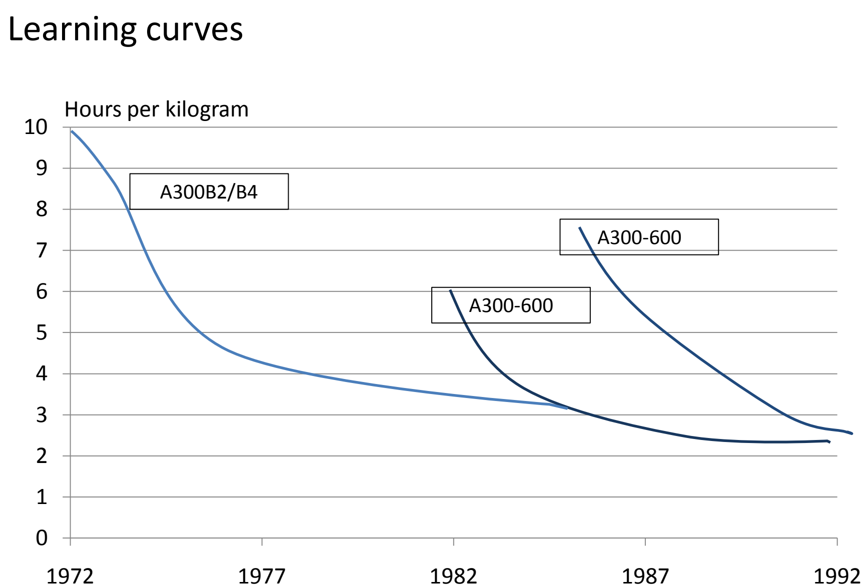
[89] Neven Damien and Seabright Paul (1995), European industrial policy, the Airbus case, Economic Policy Volume 21, October

[90] Benkard Lanier (2000), Learning and forgetting: the dynamics of aircraft production, The American Economic Review, volume 90, number 4, September

[91] Dasgupta Partha and Stiglitz Joseph (1988),Learning by doing, market structure and industrial trade policy, Oxford Economic Papers, June, volume 40, number 2, page 246-268

Figure 65: Learning curves of large civil aircraft



V-1-8 Flexibility of the production

The flexibility of the production is a key element of competitiveness because it maintains the position of the incumbents. In case of a sharp increase of demand from the market (as in 1988-1989, or 2005-2008), a low production output will delay the availability of aircraft and will discourage airlines to place an order to fill air travel demand growth. Similarly, a sharp drop of demand for air travel (as in 1992, 2001, 2010) followed by a long reaction time in adjusting production output will drive inventory up, and create "white tail" aircraft, the worst nightmare for manufactures. Airbus and Boeing have a 6month lead time in building an aircraft, from the first cut of metal to the actual delivery. They also need six months to reduce the manufacturing output. Both manufactures can produce a maximum of 42 to 44 A320 and 40-42 737 per month. In comparison, the CSeries production line will only be able to produce about 20 to 25 per month. Continuous improvement in manufacturing cycle time introduces benefits in flexibility in order to respond to changes in market demand, an ability that was absent in the previous cycles of the 1980s. Lead time reduction is also a major factor in driving inventory performance, which is vital for the industry in releasing cash previously tied-up in working capital. The choice of the right level of aircraft production level is a compromise between:

- the additional costs from the under utilization of the production facilities;
- the potential delivery delays and the loss of potential sales from lack of open aircraft positions;
- the buildup of unsold inventory that would drive price down and incur;
- the social regulations in Europe which tend to avoid large hiring and layoff of production personnel.

It is the interest of the manufacture to manage carefully its workforce since labor represents 25% of the cost of building an aircraft. In 1970, Boeing laid off 60,000 people (55% of its workforce) following the cancellation of orders on its 747s. Shortly after, Boeing had difficulties in hiring back as demand for aircraft increased and lost experienced workforce that resulted into quality issues in the production line.

Benkard (2000) suggested that learning economies can be achieved by the accumulation of human capital. The flexibility of the production system paid off for Airbus during the economic recovery following the event of September 11, 2001. Airbus production flexibility comes from the high level of automation throughout the Airbus factories, the manufacturing workforce, and the efficient work processes. The flexibility of the work force is built with short term sub-contracting (retractable within 6 months), working time enhancement (such as forced temporary unpaid leave), overtime management, and temporary labor, time limited contracted labor and voluntary early retirement. Before 9/11, this built-in production system flexibility accounted for 20% of the total capacity. In 2002, through reduction of overtime, reduction of weekly work time, flex time, Airbus achieved significant labor cost reductions without layoff.

This was achieved with constant dialogue between management and the work force representatives throughout the Airbus production system. The built in flexibility proved to be very effective in managing the downturn while preserving and growing the valuable skills and experience of the workforce. It also succeeded in keeping its experienced workforce to rapidly ramp up production when the recovery of the demand for air travel happened.

In contrast, Boeing laid off 30,000 people in 2002. The production rates increased in the mid 1990s resulted in the increase of its workforce from a low of 90,000 to a high in 1995 of 122,000. Drastic lay off are costly. For example, Boeing's Form 8K filing to the Securities Exchange Commission for Q3 1997, reported a $1.6 billion pretax charge representing the financial impact of unplanned and abnormal production inefficiencies and late delivery cost.

During the recovery years of 2005 through 2008, because of its production flexibility, Airbus was able to resume its production ramp up at a much faster pace than that of its competitor.

V-1-9 Internationalization of the supply chain

In the 1990s there was little if any breakthrough in technology or structure of the aerospace industry except for the consolidation of the industry into major firms. The development of the next generation of aircraft (787 and A350) and the next single aisles is precipitating a supply chain breakthrough leading to an extensive globalization of the productive system of the incumbents The capacity of manufactures to simplify a complex supply chain from thousand of suppliers to a few reliable and cost efficient tier 1 suppliers is becoming a key determinant of competiveness.

The first internationalization of the productive system started with offset obligation in aircraft sales contract in the 1970 and 1980.Many of these offset has been triggered to the economic development or industrial diversification plans of foreign governments that control the purchasing decisions of their national airlines[92]. At that time there were still a number of government own airlines whose government wanted to share the production of the aircraft they were buying. This has resulted in the emergence of offset agreement (initiated by McDonnell Douglas and Yugoslavia in 1972). The offset agreements increased steadily throughout the 1980 and 1990s. These offsets were also the beginning of Asia's emerging economies plan to transfer technologies through co-operation with established western industries. The offset agreement delivered especially new production methods to foreign manufactures, or an international transfer of production skills from one nation to another.[93] Most studies of internationalization of the production have focus on labor such as Schoenburger (1988) [94]and some on product life cycle Markusen (1985)[95]. Most studies however failed to list the manufactures' own actions to drive these offsets as a way to access new customers as a market strategy. Eriksson (1995)[96] provided a comprehensive survey of the aircraft manufacture reasons for the internationalization of their production. According to Smith (2001), faced with the increasing threat of Airbus, Boeing responded with joint ventures, mergers, and international subcontracting arrangement.[97] In the mid 1990s, offset contracts multiplied [98]quickly. The timing coincided with Boeing exclusive contract with the

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[92] Dixon M, (1999), State, strategy, firm strategy and strategic alliance: evidence from United States – Asian collaboration in commercial aircraft, Doctoral thesis, University of Pittsburg

[93] Markusen Ann, (2001), Offsets and US export controls. Statement of Commission members Ann Markusen reagarding offsets and US export controls, Statement Report of the Presidential Commission on offsets in international trade, Washington, D.C, January

[94] Schoenburger E (1988), Multinational corporations and the new internationalization of labor: a critical appraisal, International Regional Science Review, volume 11, page 105-119

[95] Markusen Ann, (1985), Profit cycles, oligopoly and regional development, Cambridge, MA, MIT Press

[96] Eriksson S, (1995), Global shift in the aircraft industry: a study of airframe manufacturing with special reference to the Asian NIEs, Doctoral thesis, University of Gothenburg

[97] Smith D (2001), European retrospective: the European aerospace industry 1970-2000, International Journal of Aerospace Management, Volume 1, page 237-251

[98] Krugman P (1986), Strategic trade policy and the new international economics, MIT Press, Cambridge, MA

three major airlines in the US. For example, Boeing offset contract with Korea involved building a wing for the 717 in 1995. Hyundai received the engineering and technical drawing and were able to produce wing as early as 1997. According to Mowery (1987)[99] , offsets did not have a negative impact on the US employment of highly skilled labor as it increased sales and therefore production of the final assembly and component made in the US. Airbus has evolved from being focused on the four main industrialized nations of Europe to 35% of today's spend is spread among nearly 80 countries, the largest (33%) being the US where €6 billion is spent per year. In China Airbus has source $70 million worth of industrial goods in 2007, a figure that is expected to almost quadruple by 2012. China is to become a major partner for the A350 with 5% of the aerostructure manufacture there. Airbus' India co-operation dates back 30 years. Airbus has established co-operation on R&T, IT services, MRO, training and manufacturing agreements. Hindustan Aeronautics Limited (HAL) now produces almost half of all A320 forward passenger doors worldwide. Airbus Engineering Centre India (AECI) is expected to employ 300 people in the next few years Airbus Training India partnership with Canadian training company CAE will be capable soon to train up to 1,000 pilots per year and will offer maintenance courses. In Russia a wide co-operation program will generate more than $2 billion turnover for Russia over ten years ($800 million for Airbus) covering R&T, material procurement and design, manufacturing and certification work. The ECAR, (Engineering Centre Airbus Russia) was set up in 2003 with Kaskol. About 150 ECAR Russian engineers and scientists have been involved in the A350 XWB. Under offset agreements, Russia will supply $200million of components over the 10 years to Airbus and more than half of Airbus titanium will come from the Verkhnaya Salda Metallurgical Production Association in Russia. Airbus stated that the two major reasons for internationalization are (1) financial: to achieve market growth, while remaining competitive and integrating natural hedging and (2) tap into resources: to access the best resources in order to reduce costs.

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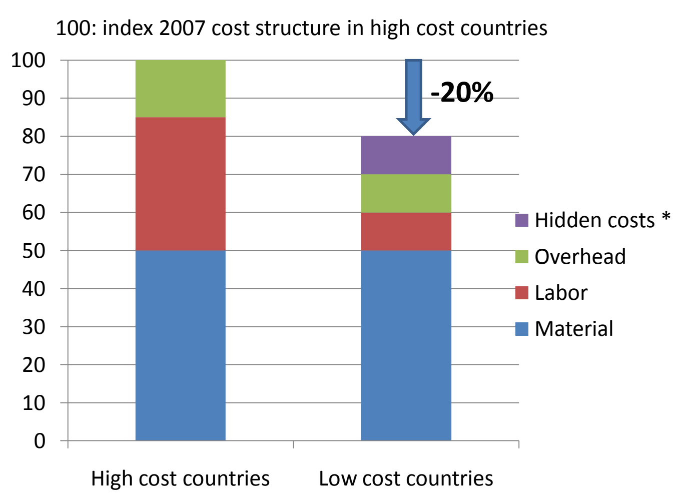
[99] Mowery D (1987), Alliance politics and economics: multinational joint venture in the commercial aircraft, Cambridge, Ballinger Publishing Company

Airbus CEO, Tom Enders, stated in February 2010 that internationalization is driven by finding engineering resources in emerging countries as the European and US pool of qualified engineers diminishes. According to Airbus, the aging populations as the baby boomer generation approaches retirement, and the changes in graduate output are driving them to seek outside the west for engineering talents. For example, in the US, the steady decline in engineering undergraduates (down 1,500 to 75,000 since 2004) is set to continue for another three or four years, echoed by drops in the number of graduate students (down nearly 4,000 to 37,000). As up to 40% of those graduates go on to work in other professions, there are even fewer available for the industry. As a result Airbus believes that is difficult to ignore several hundred thousand engineering graduates in China and India. For Airbus, tapping into new resources can complement existing R&T teams to accelerate the application of step-change solutions, freeing them up to focus on higher value-added activities.

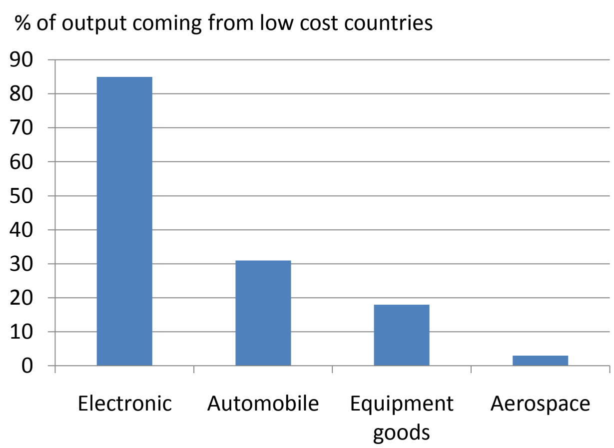
Figure 66: Costs structure in high vs. low cost countries



(*): management complexity, risk, transportation, tariffs
Source: McKinsey

In other words, leveraging large international network of highly skilled people and experienced suppliers is supposed to add more brainpower onto projects, speed up product launches and upgrade quality as well as freeing OEMs to focus on high value added items.

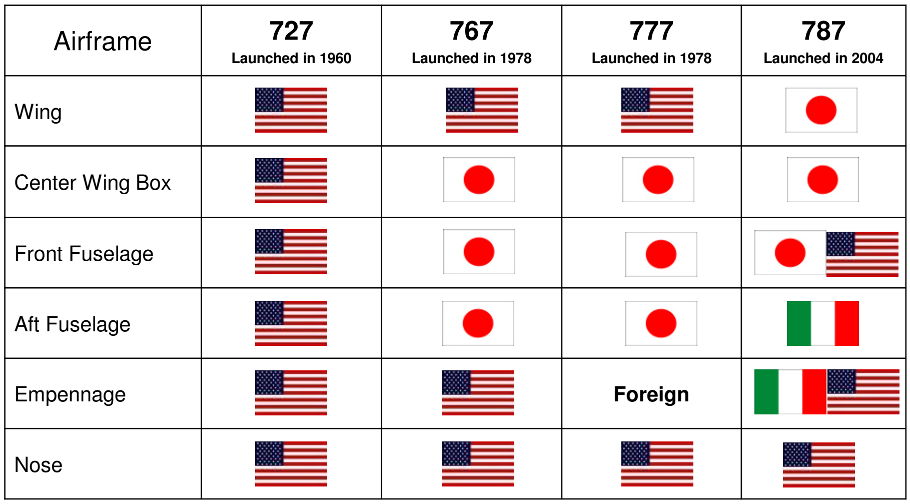
Figure 67: Output from low cost countries across industries



Source: McKinsey

However, the transformation of the supply chain of Airbus and Boeing towards more internationalization is not only a matter of talents is more about reducing manufacturing costs to stay competitive as the new technology breakthroughs required for the next new generation necessitate massive R&D resources. It all about leveraging the innovative resources of the supplier base and sharing the burden of development costs.

Figure 68: Boeing global decentralization of the production

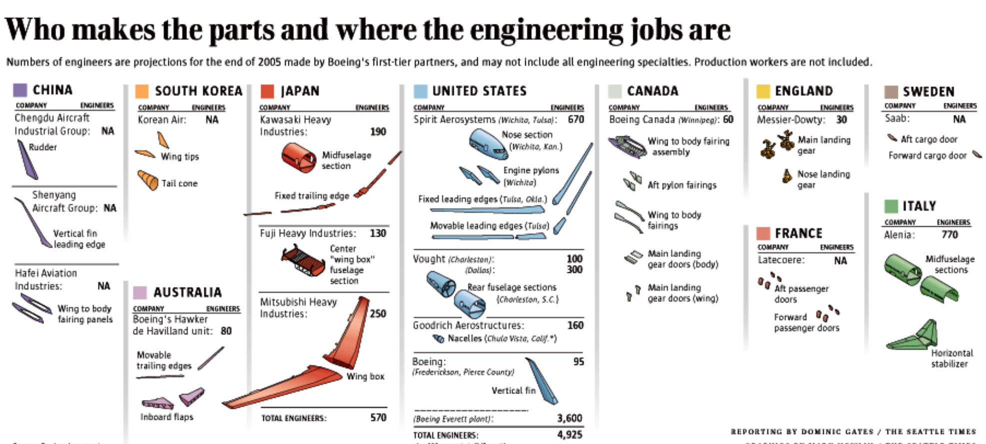


Source: Boeing, Laurent Rouaud

The analysis of the foreign content of Boeing aircraft shows that in the 1960s, every major airframe sub assembly for the 727 was produced inside the US. Only 2% of the content in terms of value was produced outside the US on the 727. By 1990, 5 of the 7 critical airframe components for the 777 were produced abroad. As much as 30% of the value of the 777 was produced outside the US.

However, all aircraft that fly today were designed, manufactured and their parts supplied under the organization that prevailed in the 1960s and 1970s when the B737C and A300 were developed. Technology on the new programs, to the exception of the fly by wire, was evolutionary. The same suppliers were selected program after program. Most suppliers had limited engineering and innovation capabilities, the conflicting transactional relationships prevailed rather than partnership, the supplier size was limited by the role given by the manufactures, 1000s of suppliers had direct access to the aircraft manufactures, often located around their engineering base and often family owned. That supply chain system led to a limited improvement potential to lower manufacturing costs, a complex supply chain with limited agility, a limited re-engineering or innovation in current products, and long development and lead time and a lack of integration. The 787, currently under test flight, brought the globalization to an entire new level both in terms of content but also in terms of production and assembly to such an extent that it is considered a supply chain breakthrough. Given the high cost of labor in Japan, the decision to outsource 35% of the 787 to Japan could be questioned. However Boeing will be receiving about $1.4 billion of Japanese government subsidy. In addition All Nippon Airways and Japan Airlines are both launching customers of the 787. According to MacPherson and Prichard (2004), the real drivers is the political relationship as the platform for Japan sales and government subsidies. [100]

Figure 69: Boeing 787 outsourcing engineering



Source: Boeing

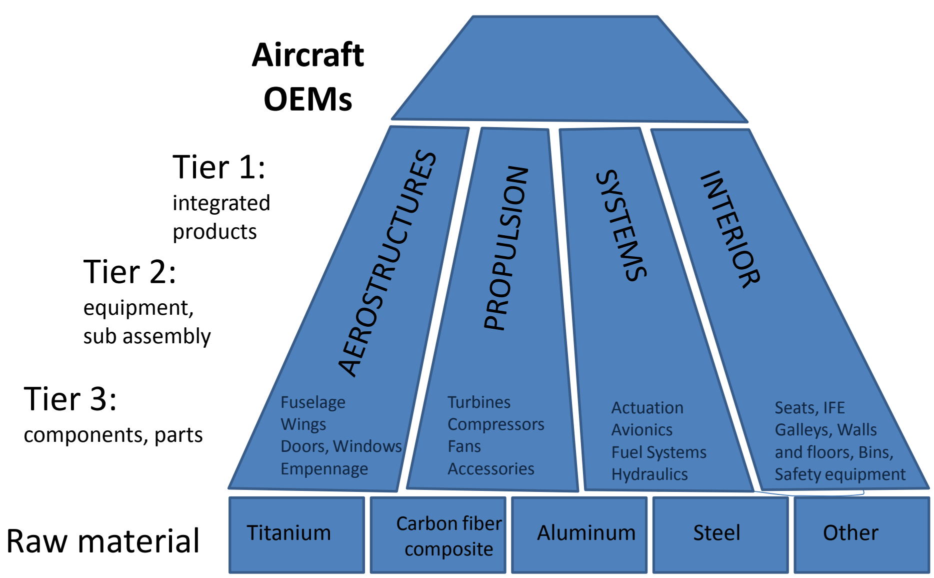
[100] MacPherson A and Pritchard D,(2004), Outsourcing US commercial aircraft technology and innovation: implication for the industry's long term design and build capability, Canada-United States Trade Centre Occasional paper, State University of Buffalo, New York

The 787 breakthrough were driven by the ambitious strategy of

- develop faster
- Buy more integrated packages
- Flow down higher share of risk to suppliers
- Become more global

It means transferring engineering roles to the suppliers, selecting suppliers much earlier than before on basis of high level specifications, reduce the number of suppliers at tier-1 suppliers level which implies a new structure of the supply chain and new relationship with suppliers. As a result, tier1 led suppliers consolidated and now develop their portfolio of technologies and better control their supply chain to retain direct market access to OEMs and airlines. At the subassembly level, the tier-2 suppliers also consolidated.

Figure 70: Suppliers consolidation to a few tier-1



The ultimate goal of the airframers was to develop faster which implied giving suppliers more responsibility; transferring detail design and buying integrated systems. The required capabilities to become and remain a tier-1 supplier include design, technologies development and product support.

For Airbus it means that the suppliers were selected much earlier in the development of the A350 compared to the A330. Landing gears, APU, hydraulic systems for example were selected at the authorization to offer (ATO) the product instead of 18 months later at the design freeze It also translate in much fewer work packages to suppliers, from 150 on the A330 to about 90 on the A350.

If the ambitious new outsourcing model leading to more globalization and less tier-1 suppliers will expand in the future, it has been interrupted or temporary revised to become more conservative. Following the well publicized major setback of 787, Boeing is taking a more conservative approach for the time being. Production delays on the 787 will result in almost 3 years delay in aircraft delivery to airlines. The delays has benefited Airbus because it had (1) the best product currently in production in the 787 segment with the A330, and (2) Airbus had aircraft position available to offer to unsatisfied 787 customers. An estimated 150 to 200 A330s was sold because of the 787 delays. In addition to the loss of business, the delays represent significant added development costs for Boeing because of the additional work to be done, the rework on 787s already in the production pipeline, and the contractual obligations made to airlines as they will not receive their aircraft as anticipated in their fleet growth plan. The difficulties of the new model implementation at the supplier level were underestimated. Key suppliers were not ready for the changes and the new technologies, such as the carbon barrel, were not as mature as it had been anticipated. Their own supply chain was not mature enough to deliver on spec and on time. To reach their committed cost goals, the tier-1 suppliers embarked themselves in the globalization of their supply chain. For example, from 2000 to 2009, some 125 major aerospace companies elected to move some of their lower value added manufacturing to Mexico, from 25 in 2000 to more than 150 suppliers in 2009.

Nevertheless, the new supply chain model will continue in the future and will become a key determinant of competitiveness in the large civil aircraft business. It also means that the tier-1 suppliers get access the lucrative aftermarket and that the consolidation extended capabilities of tier-1 suppliers led to raising the entry barrier for aspiring tier-2. However, it also means that the tier-1 suppliers will be in a position to offer the same packages to new potential entrants that they offer to their large incumbent customers and make it easier for the potential entrant to design, develop and bring to market a new product. The only risk for entrants is that large OEMs develop exclusivity agreement with the tier-1, and that pricing might be higher due to the larger volume of Tier-1 production for the main OEM. The capacity of production might also be an issue as Tier-1 dedicated more production capacity to their high volume, lower risk incumbent customers.

V-2 External determinants of competitiveness

The external factors of competitiveness include fuel price, regulations, macroeconomics, business cycles, availability of capital and government policies. The following chapter assessed the importance of government policies affecting the large civil aircraft industry. The debates does not centered on the fact of government support but rather on the form and amount of the support.

The United States has chosen to support its aeronautical industry through broadly based research that is directed and funded by government agencies such as NASA, the Department Commerce and the Department of Defense. The research consists of applied and development research by industry contractors, as well as basic research within the university and private research centers. Often, research programs have direct applications by industry contractors as well as basic research within university and private research center.

The issue of government support for the large civil aircraft business has long been a source of transatlantic debate. Given the large investment required to develop an aircraft, there would be no commercial aircraft without the support of their government. Brander and Spencer (1985) [101]highlighted a prisoner's dilemma in export subsidies. Both the US and Europe could be better off by reducing subsidy on each side, but would be worst off if there were to unilaterally reduce subsidy. Therefore is likely that both will continue to seek subsidy or launch aid in the future likely through international procurement source. Tyson and Chin (1992)[102] suggested that the US industry issues vis a vis Airbus are not due to errors of trade policy, but to errors of domestic industrial policy.

The US government acknowledged this fact when it entered the 1979 GATT agreement. Often, research program have direct applications which by consequence benefit the industry contractor, thereby converting the contract into a subsidy. Specifically, through the life of the program grant and beyond, the technology and know-how remain with the company and no repayment to the US government is required. For example, when the NASA High Speed Commercial Transport program was cancelled, none of the $1.8 billion expended by the US government was recouped from the companies that performed and benefited from the research. The US National Research Council identified some examples:

> *"…Some aeronautics R&T programs have produced "breakthrough" that are immediately usable. NASA's low drag cowl for radial engines and "coke-bottle fuselage" to reduce transonic drag rise are examples from the past. In the Department of Defense, aeronautics breakthroughs include shaping for stealth,*

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[101] Brander James and Spencer Barbara (1983), International R&D rivalry and industrial strategy, Review of Economic Studies, Volume 50, page 707-722

[102] Tyson Laura and Chin Pei-Hsiung (1992), Industrial Policy and trade management in the commercial aircraft industry, Trade conflict in high technology industries, Institute for international economics, Washington DC

multi-axis thrust vectoring exhaust nozzles integrated with airflight control systems, fly-by-wire flight control technologies, high strength high stiffness fiber composite structures, and tilt wing rotorcraft technology. Many of these advances have been achieved in partnership with NASA R&T programs and are finding widespread use in both military and commercial aircraft …"[103]

Unable to match the US support in this sector, Europe has taken a different approach that focuses its research on certain important technologies and directly funding its program through grant or contracts, but rather through repayable loans for specific high yield project. This form of support can be profitable for the government involved. In the case of the A320 program for example, Airbus fully repaid the associated loans with interest and continues to make royalty payments to the European governments.

The US government argues that Europeans loans are not made on commercial conditions while the Europeans governments, in response, argue that the billions of dollars of research grants by the US government constitute subsidies and should be subject to international disciplines.

In addition to the forms of government support, Europeans note that there are other means of subsidization employed by the US. The foreign Sales Corporations (FSC) tax rules allow a company to receive large tax benefits on income earned from export. By avoiding federal taxation, US exporters with FSCs enjoy lower costs than their competitors. The financial benefits can be passed to the customers in the form of price reductions, thus giving a competitive advantage against other manufactures.

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[103] National Research Council, Recent Trends in US Aeronautics Research and Technology, National Academy Press 1999

PART 2: Threats to the Large Commercial Aircraft Duopoly

VI-A new era of innovation development: the entrance of emerging countries as innovation powerhouses

Governments in emerging parts of the world are planning and acting on increasing their knowledge base economy as they realize that it will generate well-paying jobs, contribute to higher value products and ensure competitiveness when their economy matures. As stated by Fisher (2006)[104], innovation is increasingly seen not only as a critical driver in national and regional economic development but as the most important component in the future. As a result, many national and regional governments as well as academics have become focused on the policies promoting innovation[105]. As early as the 1990s, the Chinese State Council identified innovation as a critical objective for their future, and a series of effective reforms were put in motion. Worldwide, knowledge intensive services industries and high technology manufacturing industries have grown more rapidly than any other segments of economic activity. In 2007, these knowledge and technology intensive industries combined contributed about $16 trillion to the global economic or 30% of world GDP. The top 5 high technology industries were: communications and semiconductors ($445 billion), pharmaceuticals ($319 billion), scientific instruments ($189 billion), aerospace ($153billion), and computers and office machinery ($114 billion).

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[104] Fisher Manfred, (2006), Innovation networks and knowledge spillover, Selected Essays, Springer, Berlin

[105] Storey J (2004), The management of innovation, Volume 1, Edward Elga Cheltenham

In 1990, the US and Europe represented as much as 90% of the total worldwide R&D spending. Today, Asian countries represent more than 30% of the world R&D. The emerging Asian economies are investing heavily in technology in order to bring more added value to their export but more importantly to continue the high level of growth their economy is used to and is based on. It follows a logic of growth that was first based on export of lower added value items such as textile to higher valued items such as complete computers. Export will continue to strengthen for some time, fueling their economy. Soon, a new force or source of growth will take the relay: their formidable number of growing middle class consumers whose consumption will accelerate in the present decade. Finally, in the next decade, while the domestic consumer will still be providing a formidable level of growth, technological innovation on high value products and services will take the relay to continue their high rate of economic growth. As in the US and the UK, the advantage over Europe is that China will only have to deal with one system. The second even greater advantage is the power of their market size in the next decade. Therefore, not only the manufacturing center of the world and the biggest market of the world will become Chinese, but the innovation center of the world might also become Chinese. This put additional pressure on the US and especially on Europe to strengthen and unify their technology transfer mechanisms to a more commercial output driven.

This chapter highlights the importance placed by emerging nations on innovation. In particular, it focuses on understanding the innovation system in China. The analysis is important in determining if China might enter the commercial aircraft business successfully. Will they enter the market with a "me too" aircraft or will they have the capability to bring a differentiated product with major innovations, and if yes when could it happened? In the next chapter, the different components of the National Innovation System will be reviewed and analyzed through an OECD document guideline[106].

[106] OECD (1996) The measurement of scientific and technological activities proposed guidelines for collecting and interpreting technological innovation data, Oslo Manual

VI-1 Metric to measure China ability to innovate and become an LCA leader

To do so, it is important to not only analyze China's R&D evolution and the deployment of its advanced education system that will foster their innovative propensity in the next decade, but it is also important to understand the innovative environment of the firms, which is itself greatly dependent on the national policy towards innovation development.

The pursuit of modernization in China through sciences and technology science and technology has been central to its economic reforms to modernize its economy and its society in the context of greater social, ecological and environmental sustainability. [107]

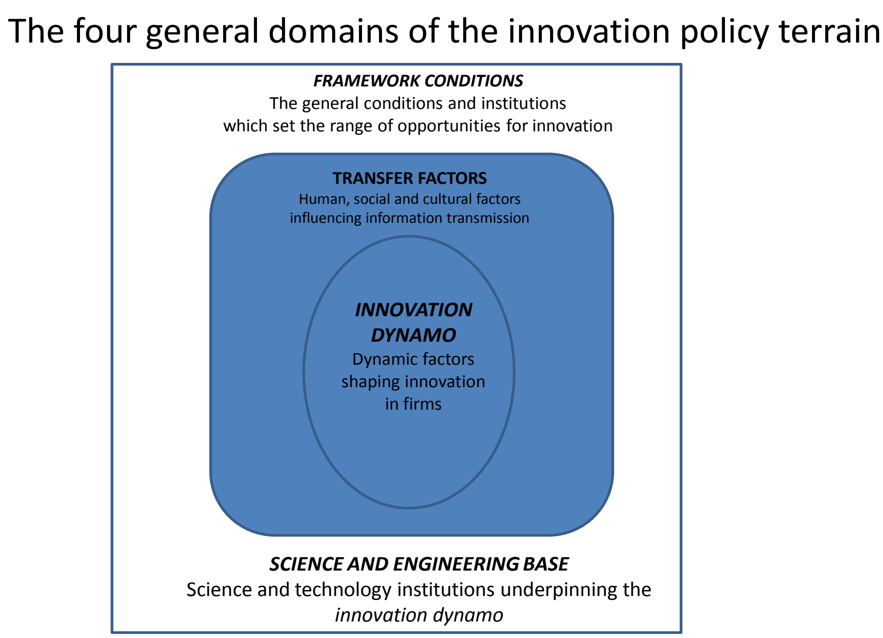
There are three main actors in the Chinese innovation system: the government research institutes, the higher education sector and the business sector. The effectiveness of the innovation system will depend on the performance of each of them, the coordination between them in the environment created by the government policies but also to a larger extent nowadays the interactions with the international innovation scenes. The government is not directly involved in the performance of R&D, but it plays a key role in (1) providing direct support through funding and tax incentives and (2) in setting the coordination environment. Since the early 1990s, similar to the developed countries, the Chinese government has put in place a number of programs to foster coordination among the three actors.

The OECD's document called *"The Measurement of scientific and technological activities – Proposed guidelines for collecting and interpreting technological innovation data* (referred as the Oslo Manual) is an interesting document in the sense that it gives an appropriate map of the elements of a good national innovation

[107] Mengkui, W. *et al*. (2004), *China's Economy.* China Intercontinental Press.

policy or a set of conditions that makes the firm environment conducive to innovation. This document has been used to evaluate the innovation environment of firms in emerging countries at this point in time. The purpose of using this map is to give a framework to our analysis. It helps in collecting the data (qualitative and quantitative) that will base our judgment on the degree of readiness that the emerging countries have reached in shaping their innovation system. According to the OECD, there are four categories or domains of factors relating to innovation: (1) the business enterprises ("firms"), (2) the science and technology institutions, (3) the transfer and absorption of technology, knowledge and skills and (4) the surrounding environment. The fourth domain is of particular importance for emerging countries as it drives the range of opportunities for innovation through its institutions, its legal arrangement, its macroeconomic settings, and other conditions that exist regardless of any considerations of innovation. Those four domains are mapped in the following fashion:

Figure 71: The four general domains of the innovation policy



Source: Department of Industry, Science and Technology (1996), *Australian Business Innovation: A Strategic Analysis – Measures of Science and Innovation 5, Australian Government Publishing Service, Canberra.*

VI-2 The framework conditions to innovation

The framework conditions set the rules and range of opportunities for innovation. The framework conditions include the institutions set-up, the basic educational system for the general population, which determine the minimum educational standards and the domestic market. It also includes the communications infrastructures (roads, telephone, and electronic communication), the financial institutions (ease of access to venture capital) and the market access (such as size and ease of access).

VI-2-1 The Chinese institutions influencing innovation

The highest level of China's institution for R&D governance includes six main actors[108]:

1. the State Council (top level of China central government) Steering Group of Science & Technology (S&T) and Education which main role is to provides top-level leadership and co-ordination;

2. the Ministry of Science and Technology (MOST) is at the center of the innovation system in China. It designs and implements China's S&T and innovation policies. Its key missions include: formulating strategies, policies, laws and regulations for S&T development; setting priorities, promoting the building of the national S&T innovation system; conducting research on major S&T issues related to economic and social development; guiding the reform of the S&T system; designing, organizing and implementing funding programs for basic and applied R&D; inducing firms and especially SMEs to

[108] A Quick Overview of the Science and Technology System in China swissnex Shanghai, October 2009

innovate; creating science parks and incubators, etc.; and promoting international S&T co-operation and exchanges;

3. the Chinese Academy of Sciences (CAS) occupy a strong position in the S&T and innovation system since it depends directly from the central government within the State Council. Most of the government R&D is done within the CAS. CAS responsibility is to conduct research, to undertake nationwide surveys on natural resources, to provide scientific data and advice to the government for decision making, to undertake national R&D programs, to train personnel and provide advanced graduate education, and to promote high-technology companies. CAS has 91 research institutions and received the majority of the government funds for innovation. It is CAS that undertook the reform of the R&D system that started in the early 1990s. It greatly influences MOST in establishing S&T policies. CAS is also responsible for the transfer and commercialization of R&D output;
4. The National Development and Reform Commission (NDRC) is responsible for the allocation of public funding for innovation and the technological upgrading of all economic sectors. It is a powerful institution with responsibility across the full horizontal chain of the economy and of the S&T in particular. Within NDRC, the department of High Technology is responsible for monitoring the progress of the high tech development.
5. The Ministry of Education (MOE) is responsible for setting policies for human resources through higher education, for university research and for the commercialization of research;
6. The National Natural Science Foundation originally created as a funding agency for basic research. It has played an important role in implementing China's basic research policies in general. The NNSFC promotes and supports basic research and identifies and fosters scientific talent. It mainly funds research projects carried out by universities on the basis of evaluation and peer review of proposals. It has grown into the role of advising the government on major issues related to the development of basic research. NNSFC develops international cooperation and exchanges with scientific

organizations in foreign countries. Funds mainly come from the government with marginal donations from individuals as well as national and international institutions.

The framework is also characterized by the absence of any coordination body among those institutions concerning S&T. The coordination is done on a case by case, program by program.

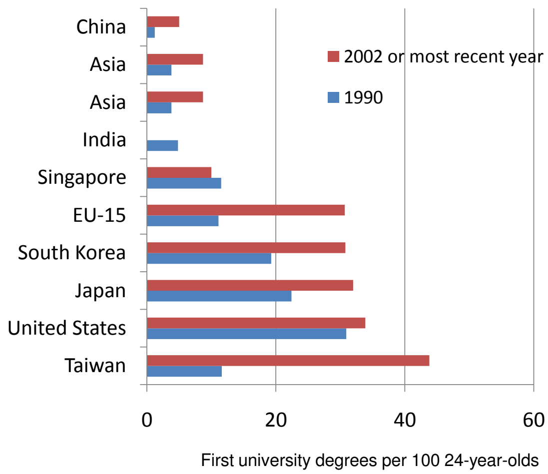
VI-2-2 Education set-up and basic education system

Concerning the educational system, China is still behind the US and Europe per population but is catching up at impressive rate. The number of first bachelor degrees per 100 of 24 year-old might be low in percentage of the population but given the sheer size of the population of China, it is rather impressive. Although the Chinese first degree rate has increased almost fivefold over the last 12 years while it stagnated in the developed countries, still only 5 out of 100 24-year old Chinese has a bachelor degree. This compares to 33 in the US.

However, in term of volume, China has produced in 2002 (last data available) six time more engineers than in the US. The 2010 figure should well exceed this ratio. The higher education sector's role in supplying human resources for technology will be a key factor in the performance of the R&D underway in China. Such a rapid growth can only be explained by strong financial support from the government to invest in a higher education in order to become a world leader in terms of innovation by the next decade. The Chinese government seems to concentrate their support in the field of science and engineering, certainly in order to create a world-class research environment and performance. The top 50 Chinese universities received two third of the total R&D expenditure. R&D activities are focused on a few key disciplines in natural sciences and engineering. In 2005, 66% of total R&D

expenditure by the top 50 universities concerned engineering, natural science being the distant with 16% of the total expenditure.

Figure 72: First university education - China vs other countries



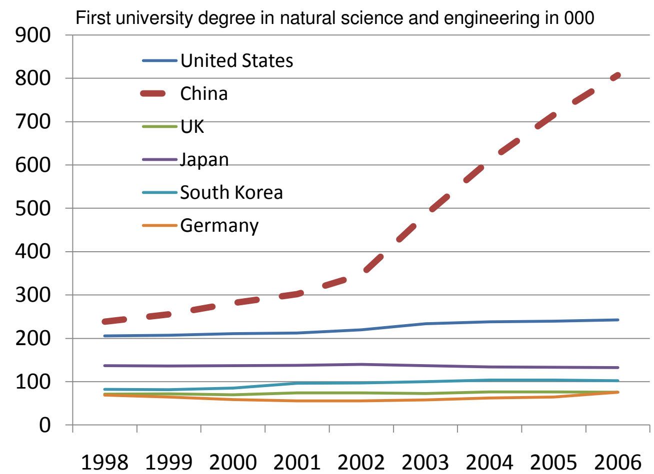
Source: National Science Foundation, Laurent Rouaud

Figure 73 Science and engineering bachelor degree comparison

Region and country/economy	1990		2002 most recent year	
	S&E	Engineering	S&E	Engineering
Asia	898,000	311,400	1,209,200	590,800
China	268,400	115,900	533,600	351,500
India	205,000	29,000	NA	NA
Indonesia	30,700	9,800	97,100	20,600
Japan	187,900	81,400	351,300	98,400
Malaysia	3,400	900	4,800	900
Philippines	71,100	29,400	NA	NA
Singapore	3,700	1,200	5,600	1,700
South Korea	79,300	28,100	113,100	64,900
Taiwan	24,400	9,000	72,500	41,900
Thailand	24,200	6,800	31,200	10,900
EU-15	284,300	92,700	506,100	198,300
United States	329,100	64,700	415,600	60,600

Sources: United Nations Educational, Scientific and Cultural Organization (UNESCO), *UNESCO Statistical Yearbook* (various years); UNESCO Institute for Statistics database, http://www.unesco.org, accessed 14 December 2006, special tabulations; Organisation for Economic Co-operation and Development (OECD), *Education at a Glance* (various years); OECD Education Database, http://www1.oecd.org/scripts/cde/members/EDU_UOEAuthenticate.asp, accessed 14 December 2006; China—National Bureau of Statistics of China, *China Statistical Yearbook* (2004); India—Department of Science and Technology, *Research and Development Statistics 1996–97* (1999); Japan—Ministry of Education, Science, and Culture, *Monbusho Survey of Education* (various years); Taiwan—Ministry of Education, *Educational Statistics of the Republic of China* (various years); and United States—National Science Foundation, Division of Science Resources Statistics, Integrated Science and Engineering Resources Data System (WebCASPAR), http://webcaspar.nsf.gov, accessed 14 December 2006.

Figure 74: First university natural science and engineering degrees by countries



Source: National Science Foundation, Laurent Rouaud

Doctoral education typically prepares a new generation of faculty and researchers in academia, as well as a high-skilled workforce for other sectors of the economy. It also generates new knowledge important for the society as a whole and its competitiveness. Here again, the number are showing a definitive focus on engineering and on building a strong knowledge base economy for the future.

VI-2-3 Communication infrastructure facilitating innovation

The framework conditions also include the communications infrastructures (roads, telephone, and electronic communication), the financial institutions (ease of access to venture capital) and the market access (such as size and ease of access). These three factors are well covered in the literature but also in the press. Communication access has been the focus of the Chinese government for over two decades and the aviation; high speed train planning and road network developments have been impressive. Concerning the financial institutions, there was the one that bailed out some of the depressed financial institutions in the US and Europe.

VI-2-4 Financial institutions facilitating innovation and market access

They also have since the early 2000s been very active in financing major US and European projects from aircraft acquisition to large construction projects. Finally, with a potential 500 million middle class citizen by 2015, China is ripe to become the number one market in the world for consumer goods to industrial goods.

Figure 75: Top financial institutions by market capitalization

4 Chinese banks in the top 10 in 2010

2000	2005	2010
Citigroup (US)	Citigroup (US)	**ICBC (China)**
HSBC (UK)	Bank of America (US)	**CCB (China)**
Bank of America (US)	HSBC (UK)	**Bank of China (China)**
Morgan Stanley Dean Witter (US)	JP Morgan Chase (US)	HSBC (UK)
Lloyds TSB (UK)	Wells Fargo (US)	JP Morgan Chase (US)
Bank of Tokyo-Mitsubishi (Japan)	RBS (UK)	Mitsubishi UFJ Financial (Japan)
Wells Fargo (US)	UBS (Switzerland)	Banco Santander (Spain)
Fannie Mae (US)	Wachovia (US)	Goldman Sachs (US)
Chase Manhattan (US)	Banco Santander (Spain)	Wells Fargo (US)
UBS (Switzerland)	Barclays (UK)	**Bank of Communications (China)**

Source: Financial Tmes, Laurent Rouaud

However, China financial system is made of large banks that are typically loaning money large state owned Chinese companies that have generally not been very profitable or have been losing money. According to the Chinese Banking Regulatory Commission, there was RMB 1,268 billion in non-performing loans in the commercial banking sector at the end of 2007. The banking system is not set up to efficiently serve small and medium size enterprise especially start up stemming from the innovation spin-off .Given the risk and the long payback, very few domestic or foreign venture capitalists are willing to step up to investing in innovation spin-off. The Chinese government has rightfully identified the lack of venture capitalists as a major impediment to the innovation transfer in China. As a result, it turned to regional authorities whose responsibility is to establish venture capital companies. These companies are essentially publically funded and staffed with civil servant who lack the technical, commercial and managerial skills . This system has failed to deliver venture capital to the right project is subject to partial distribution of funds. The Chinese government have also created in 1999 the Innovation Fund for Technology-based SMEs (Innofund), whose responsibility is to fund early-stage commercialization projects with innovative technology and good market potential. It provides grants and loans to high-technology firms in six fields: information technology (IT) and electronics, biotechnology and medicine, advanced materials, automation, new environmental resources and energy. Between 1999 and 2004, Innofund gave grants worth RMB 4.3 billion to 6 400 projects. So, the venture capital is still in development but show some early sign of improvement from the central government initiative with Innofund. However, a large scale venture capital will take some time to develop.

A recent private initiative that promises to deliver venture capital is Innovation Works, a private firm, launched in September 2009. Innovation Work was founded by Dr. Kai-Fu Lee, the former President of Google Greater China. Innovation Work could create a new paradigm in the Chinese innovation system that will facilitate the start-up of technology firms in China.

According to Dr Lee: *"The Chinese entrepreneurial environment is still in its formative stage, with significant barriers for the early-stage entrepreneur: the lack of management experience and coaching, the reluctance of venture capitalists to invest in companies in the formation stage, and the lack of networking and experience to pull a company together. These barriers contribute to have a very few high-tech start-ups in China."*

Dr Lee have created Innovation Works as a business creation platform focused on establishing high-technology companies and mentoring the next-generation of

Chinese entrepreneurs. Innovation Works concentrates on internet, mobile internet and cloud computing technology advancement. Innovation Works plans to collect, analyze prioritize and execute the most promising innovations. More importantly it plans to match entrepreneurs, engineers, and capital to improve the success rate of start up companies and accelerate time-to-market of products. Innovation Works plan to provide mentoring and support to the next-generation of Chinese entrepreneurs that today are faced with lack of resources, management experience, and especially lack of venture capitalists network to launch their technological innovation. Innovation Work start-up itself was financed by world renown venture capitalists and investors such as Steve Chen Co-Founder of YouTube), Foxconn Technology Group, Legend Group and New Oriental Education & Technology Group, while WI Harper Group is the lead venture capital investor.

Focus on one of the very few Chinese venture capital firm: the WI Harper Group

WI Harper Group was founded in 1993 and is one of the founding venture capital franchises in China. The firm specialized in investing in early and expansion stage companies with significant operations in China and aspirations to become a global leader. Wi Harper Group has already invested in over 100 technology companies worldwide with a particular focus on China. They focus on technology, clean technology and Healthcare. The typical investment size is between $5M to $10M. Below are a list of China companies in which WI Harper has invested:

Company	Activity/market position	Location
21Vianet	leading chinese carrier neutral internet data center and content delivery network provider	Beijing
Cwill Telecom	Provider of technology related to China's 3G wireless standard	Beijing
Pollex Mobile	A leading mobile software company focusing on providing mobile application platform and applications products for mobile devices.	Beijing
Sungy Data Ltd	3G.net is the first and largest independent WAP portal in China	Guangzhou
Daqi	Leading BBS aggregation website and offline PR events management provider	Beijing
Maxthon Holdings	Maxthon is one of the most popular Internet browsers in China, second only to IE.	Beijing
Troodon Entertainment	Provider of Massive Mobile Multi-player Networking Games	Beijing
PayEase	Customer Loyalty Programs	Beijing
New Dynamic Institute	Online and offline English training programs in tier two cities of China	Wuhan
Focus Media Holding Ltd	operates a nation-wide segmented media network to enable targeted advertising in China.	Shanghai
VeriSilicon Holdings	fabless and chipless ASIC Design Foundry, which provides ASIC design services and turnkey solutions.	Shanghai
China Diagnostic	Provider of diagnostic medical equipment and supplies	Beijing
Edan Instruments	Provider of fetal monitoring and ultrasound systems to both Chinese and international markets	Shanghai
ShanhhaiMed Healthcare	leading provider of healthcare management services in China.	Beijing
Medical System	Leading Chinese clinical information system provider	Shanghai
Cnano Technology	Developer of Carbon Nanotube and related advanced applications	Beijing

In the area **of Clean technology**, WI Harper Group is active in sub-sectors including advanced materials, energy efficiency, and pollution control. They believe that advanced materials is a tremendous key enabler of sustainable industrial growth. WI Harper experience in China allow them to identify and commercialize opportunities in advanced materials through their established relationships with Chinese universities, governments and industry leaders. A good example is their investment in Cnano. In **healthcare**, they consider that although the US is the largest market, China offers great opportunity. They intend to bring Western technology, executives and business practices into China to build the next generation of global health care companies. They particularly focus on health IT, medical devices, services, and diagnostics. Their investment in Edan and Medical System in China is an example on their focus. In technology, WI Harper Group focuses in investing in Internet and wireless, digital media, electronics, technology-enabled services, and semiconductors. Their investment in Focus Media is an example in the technology field..

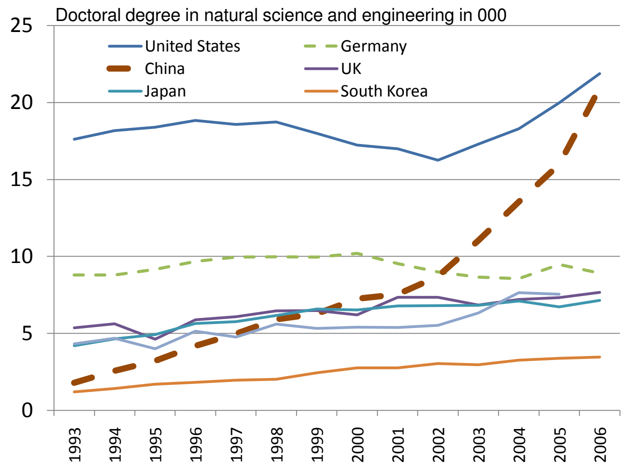
VI-3 The dynamo to innovation: the science and engineering base.

The Science and engineering base brings the theoretical understanding base for business innovation. It comprises the technical training system and the university system. It also includes basic research. Basic research might not yield a direct and short term benefit to firm innovation but brings a wealth of knowledge in terms of advanced equipment use and specialization that helps in the long terms. The Science and engineering base is also fed by the government funding of the public goods R&D activities (such as health, environment and defense), the strategic R&D activities (pre-competitive and generic technologies), and the non-appropriable innovative support in some fields where the firms cannot expect to gain an appreciable return in the short to medium term from their in-house research.

VI-3-1 The technical training and university system

In 2006, some 174,000 Science and Engineering (S&E) doctoral degrees were awarded worldwide. The United States gave the largest number of S&E doctoral degrees of any country (about 30,000), followed by China (about 23,000), Russia (almost 20,000), and Germany and the United Kingdom (about 10,000 each). More than 52,000 S&E doctoral degrees were earned in the European Union.

Figure 76 Natural science and engineering doctoral degree by countries



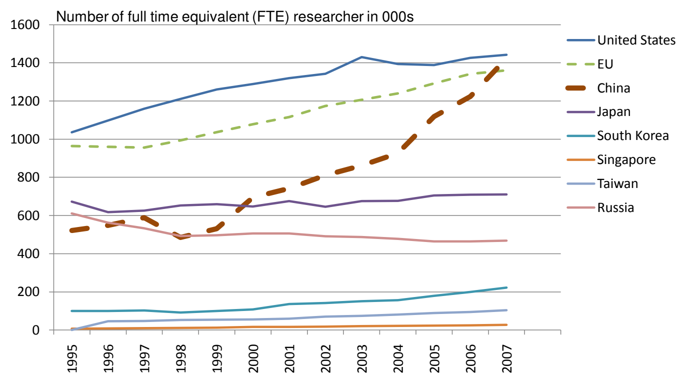
Source: China—National Bureau of Statistics of China; Japan—Government of Japan, Ministry of Education, Culture, Sports, Science and Technology, Higher Education Bureau, Monbusho Survey of Education; South Korea—Organisation for Economic Co-operation and Development, OECD. Stat Extracts, http://stats.oecd.org/WBOS/index.aspx/; United Kingdom—Higher Education Statistics Agency; and Germany—Federal Statistical Office, Prüfungen an Hochschulen, and Organisation for Economic Co-operation and Development, OECD. Stat Extracts, http://stats.oecd.org/WBOS/index.aspx/; and United States—National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey; and National Science Foundation, Division of Science Resources Statistics, Integrated Science and Enginee ring Resources Data System (WebCASPAR), http://webcaspar.nsf.gov. See appendix tables 2-40 and 2-41.

In the field of natural sciences and engineering[109] , China has quickly caught up with the US. Although in 2006, the United States awarded 23,000 doctoral degrees in those fields vs. 21,000 for China, it had probably surpassed the US in 2009. As a result, China's researcher have more than doubled over the last decade from about 500,000 in 1995 to more than 1.4 million in 2007, increasing its world share from 13% to 25%. The US and the EU 27 members have also 1.4 million researchers.

[109] Natural sciences and engineering include physical, biological, earth, atmospheric, ocean, and agricultural sciences; computer sciences; mathematics; and engineering.

Figure 77: Number of researchers in selected countries 1995-2007

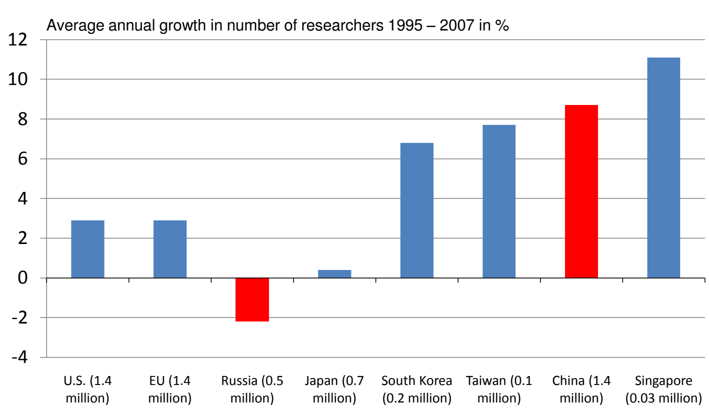
China matching the US and Europe from 2007



Source: OECD, *Main Science and Technology Indicators Science and Engineering Indicators 2010*, Laurent Rouaud

Since 2000 China has doubled its number of researchers, expanding at twice the rate of the EU, US and Japan. Russia, on the other hand, have been reducing the number of its researchers by an alarming 2.2% per year on average over the 1995-2007 period as they consider the compensations in other professional opportunities and because of the decrease focus of the government on basic research.

Figure 78: Number of researcher by countries 1995-2007



As the number of researchers increase in China, so have the number of scientific articles in scientific publications. If the US and Europe have been the most prolific in terms of research article production, their share have steadily decreased from 69% in 1995 to 59% in 2008. In the meantime Asia increased its share from 14% to 23%. Here, once again, the Asia's increase reflects China's productivity in generating article at a rate of 14% per year. China is now responsible for producing about 8% of the world scientific article (from 1% a decade ago). Moreover, for the field of engineering alone, the US share of article production decreased from 36% to 20% over the last 2 decades. Europe succeeded in maintaining its share, while Asia's share (without Japan) grew from 7% to 30% over the same period, with China producing nearly half (14%). Between 2000 and 2006, the total number of scientific publications produced in China each year grew by 178% while it only grew by about 18% both in Europe and the US and by only 5 % in Japan. As a result, the Chinese share of world scientific publications has more than doubled within six years and has now well surpassed Japan. Robert N. Kostoff and others [110] showed by studying the Chinese scientific articles in scientific journals from 1980 to 2005 that China's publication of Social Science Citation (SCI) research articles has had an annual exponential growth rate of 20% over the last 25 years. The top 10 research institutions listed below published 1,607 , 6,235 and 35,759 respectively in 1985, 1995 and 2005. Among the most prolific in 2005 was the Chinese Academy of Science that is well connected to most research institutions throughout China and appear to be a central core of the Chinese institutional research network. The main reason for its prominent position in the Chinese research establishment is largely explained by the fact that 81% of the total funding granted to the Chinese government research institutes are given to the China Academy of Sciences.

[110] Robert N. Kostoff, Michael B. Briggs, Robert L. Rushenberg, Christine A. Bowles, Alan S. Icenhour, Kimberley F. Nikodym, Ryan B. Barth and Michael Pecht (2007), "Chinese science and technology — Structure and infrastructure", Technological Forecasting and Social Changes Volume 74, Issue 9, November 2007, Pages 1539-1573

Figure 79: Top 10 Chinese article publishing institutions

1985	1995	2005
Chinese Acad Sci (870)	Acad Sinica (1808)	Chinese Acad Sci (14051)
Acad Sinica (175)	Chinese Acad Sci (1524°	Tsing Hua Univ (3650)
Beijing Univ (126)	Nanjiing Univ (617)	Zhejiang Univ (3268)
Chinese Acad Med Sci (99)	Beijing Univ (488)	Beijing Univ (2710)
Univ Sci & Tech China (83)	Univ Sci & Tech China (358)	Shanghai Univ (2435)
Nanjing Univ (72)	Fudan Univ (353)	Univ Hong Kong (2109)
Fudan Univ (66)	Tsing Hua Univ (346)	Nanjing Univ (2031)
Beijing Med Coll (42)	Julin Univ (259)	Univ Sci & Tech China (1992)
Nankai Univ (40)	Nankai Univ(243)	Fudan Univ (1770)
State Seismol Bur (34)	Lanzhou Univ (239)	Chinese U Hong Kong (1743)
1607 articles	6235 articles	35759 articles

Source: N. Kostoff Michael B.Briggs , Robert L.Rushenberg, Christine A. Bowles, Alan S. Icenhour, Kimberley F. Nikodym, Ryan B. Barth and MichaelPecht (2007), “Chinese science and technology — Structure and infrastructure”, Technological Forecasting and Social Changes Volume 74, Issue 9, November 2007, Pages 1539-1573

Ronald N. Kostoff and others shows that there is a clear evolution of the type of articles Chinese institution have been focusing from multidisciplinary science, medicine, and life science in 1980 to more specific articles on materials, chemistry, and physics in 2005. The second trend in their analysis is that there is now a large difference in the subject of article between the US and China, and that difference is also widening. China emphasis is now on physical and engineering sciences that drive defense and commercial needs. The USA seems to emphasize research areas focused on medical, psychological, and social problems.

Chemistry and physics represent almost one-half of China's research articles production in 2007. This compares with 17% in the US and 25% in Europe. In particular China seems to direct their focus on Computer Sciences (especially in Cybernetics & Systems Engineering and Signal Processing) and Physical Sciences (especially in Materials Science, Chemistry and Nanotechnology.) Within those disciplines, Systems Theory, Structural Mechanics, Materials, Applied Measurement, Power/Energy Market Enterprises, and Organic Chemistry are particularly cited. According to Robert N. Kostoff and others, the China scientific research publication is indicative of a society growing to sustain itself and become technologically competitive on a global scale. They also surveyed the abstracts of China scientific article to show that the most cited disciplines in the scientific literatures are:

- Energy/Power Generation,
- Mining,
- Materials & Structural Mechanics,
- Signal Processing,
- Systems Engineering,
- Transportation & Traffic flow,
- Robotics, Sensors & Diagnostics,
- Advanced Communications,
- Nanotechnology,
- Assessment Methods,
- Mathematics,
- Environmental & Ecological,
- Modeling & Simulation,
- Control Theory.

All of these areas have applications that can be of military significance and is important to aeronautics.

Figure 80: Difference in scientific publication China vs USA

(ranked by highest differences in favor of China)

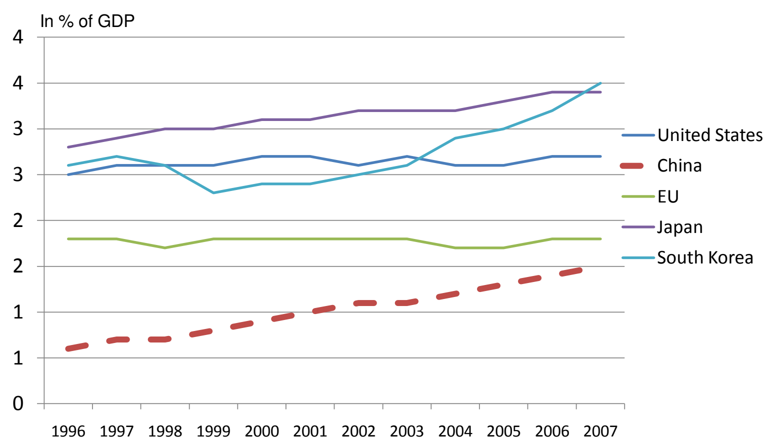
	China (1)	**USA** (1)	**Ratio China/USA** (2)
Bearing capacity	145	12	12.08
XRD	2213	237	9.34
Microhardness	174	22	7.91
Photoelectric	86	13	6.62
Diesel Engine	152	23	6.61
Wavelet transform	338	54	6.26
Fiber Bragg grating	115	19	6.05
Wear resistance	213	37	5.76
Annealing temperature	214	39	5.49
Impact strength	92	19	4.84
Magnetron	285	60	4.75
Countermeasures	57	13	4.38
Intrusion detection	100	23	4.35
Missile	100	24	4.17

(1) Number of citations; (2) ratio of citation on that discipline in China / US

Source: N. Kostoff Michael B.Briggs , Robert L.Rushenberg, Christine A. Bowles, Alan S. Icenhour, Kimberley F. Nikodym, Ryan B. Barth and MichaelPecht (2007), "Chinese science and technology — Structure and infrastructure", Technological Forecasting and Social Changes Volume 74, Issue 9, November 2007, Pages 1539-1573

In terms of R&D, Asian developing economies have also focused in increasing their level of investments. Over the past decade, while the R&D/GDP ratios of developed countries held steady, China R&D doubled from a very low base. The R&D intensity of China, measured by the ratio of GERD to gross domestic product (GDP) reached 1.43% of GDP in 2006, up from 0.6% in 1995. China has increased its R&D investment steadily at an average yearly rate above 18%. This compares to 2% per year growth for Europe between 2000 and 2005. If the ratio is still relatively low compared to other OECD economies, the level reached over the last 10 years is particularly impressive since it had to chase a double digit GDP growth rate.

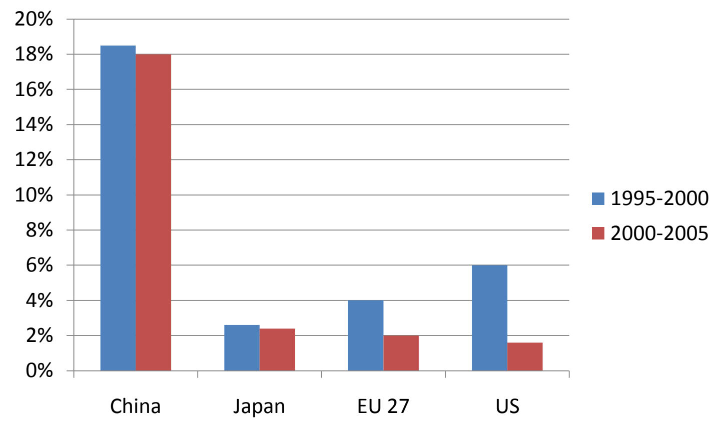
Figure 81: R&D expenditure as share of GDP



Source: OECD, Main Science and Technology Indicators Science and Engineering Indicators 2010, Laurent Rouaud

With a $86.8 billion Gross domestic expenditure on R&D (GERD) at purchasing power parity (PPPs), China's GERD was the third largest worldwide in 2007, after the United States and Japan.

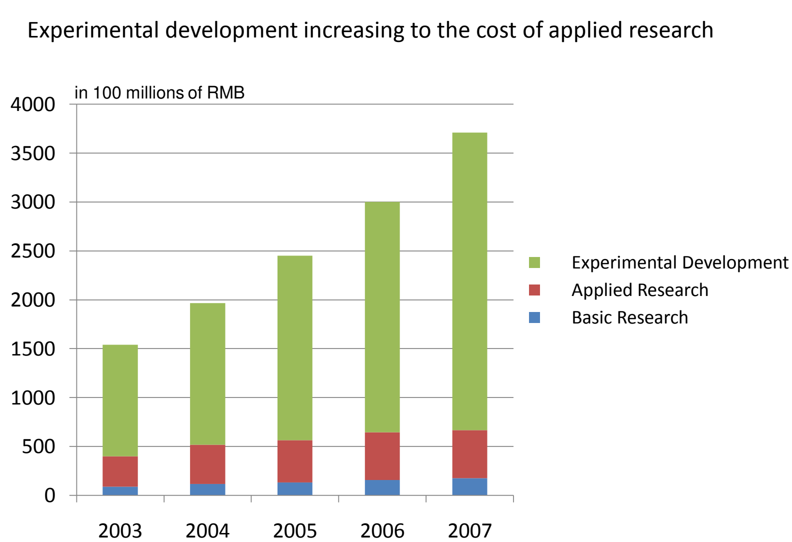
Figure 82: R&D investment growth - China vs others



Source: OECD, Main Science and Technology Indicators Science and Engineering Indicators 2010, Laurent Rouaud

These impressive rates hide one important qualitative characteristic of the China R&D spending that is lagging compared with all other developed OECD countries: the absolute amount and share of R&D invested in basic research.

Figure 83: China R&D by type of activity

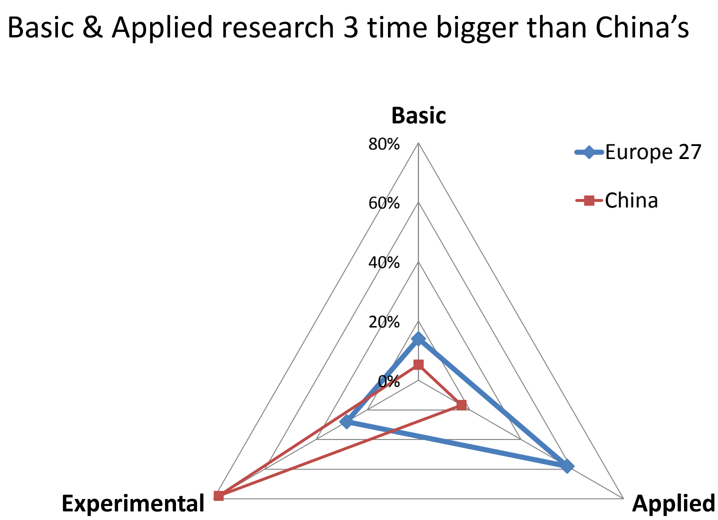


Source: China yearly statistical yearbook 2008, Laurent Rouaud

VI-3-2 Basic Research

Most of the growth in R&D over the last 20 years has been directed towards experimental development rather than to the longer term basic research and applied research. In fact, the share of total R&D on basic research has stagnated since 1990 at 5.2%. OECD countries invest on average 10 to 20% of their R&D money into basic research. More worrisome is the fact that the applied research has even decreased in importance from 26.4% in 1995 to 16.8% in 2006. OECD countries invest on average 50% of their R&D money into applied research.

Figure 84: China vs Europe R&D by type



Source: OECD, Main Science and Technology Indicators Science and Engineering Indicators 2007, Laurent Rouaud

The low Chinese basic research is explained by the fact the business sector R&D has quickly become the most important contributor to China R&D efforts and about 80% of its total R&D effort on experimental research. Their renowned expertise in this field is actually accelerating this growth, as international firms tend to outsource more of their experimental research to China because of its much lower cost than in their home country.

A recent development of this takes place in the field of biotechnology. The market for pharmaceutical biotechnology is expanding rapidly worldwide as a result of consumer demand for a healthier lifestyle. In China, in particular, this market has grown 21.4% per year over the past 4 years. Because of China health care reform and the government choice of pushing this field of science, the market in China is anticipated to grow above 30% in the coming years. The research and clinical trial in biotechnology is risky, costly and has long lead time. As a result, Pharmaceutical companies in developed region are tapping into the human and financial resources of China, obliged to outsource if they want to continue growing profitably. China is particularly attractive as it has a large patient subject pool, great research centers, a large market for biotechnology and a supportive government.

In particular, the central government support of applied research has encouraged Chinese business to develop new therapies in pioneering field of gene therapy and stem cells. Examples include genetically modified (GM) crops, and vaccines. In stem cell or GM crops, an added difficulty for research and clinical trial in developed countries are the stringent regulations and controversial ethical issues. Although the US and Europe are leading stem cell research, China, with its looser R&D regulation environment is anticipated to emerge as the leading research and product development in the applied area of stem cell.

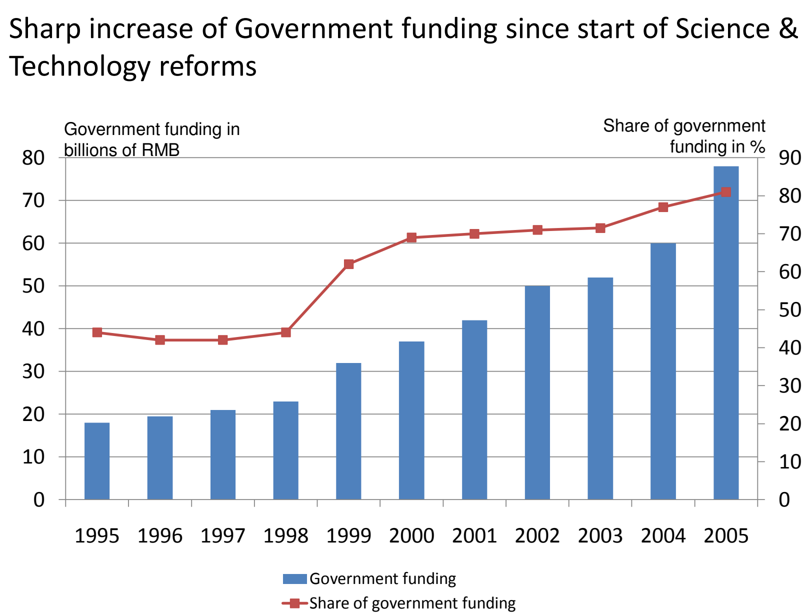
The business sector increased its R&D expenditure by an average of 20% per year since the beginning of the 1990s. As table 1 shows, most of the business sector R&D is self funded (87% in 2006). Another negative sign of the Chinese R&D beside its extraordinary growth is the fact that the number of R&D units has actually decreased within the business sector over the last 20 years. Over the same period, the government funding became the most important funding source for the government research institutes. The government objective was to focus on basic research and applied research in the field of public goods, such as agriculture and defense that requires more government funding. However, in absolute terms, the magnitude of the business sector growth R&D growth focused on experimental research has underpinned the government effort at increasing basic research in its research institutes.

Table 10: R&D Participation of China's government research, higher education and business sector

	Government research institute	Higher education	Business sector
Number of units	3901 institutes	1792 university and colleges	28567 Large+middle firm 6775 have S&T units 248813 small firms 22307 have S&T activities
Share of R&D personnel (FTE)	18.10%	16.10%	65.70%
Share of government funding	66.50%	20.40%	13%
Share of R&D expenditure	19.70%	9.20%	71.10%
Share of R&D expenditure in basic research	46.40%	44.90%	8.70%
Share of R&D expenditure in applied research	40.70%	26.90%	32.40%
Share of R&D expenditure in experimental development	13.30%	3%	83.70%

Source: China Statistical Yearbook on Science and Technology, 2006, Laurent Rouaud

Figure 85: Government funding of institution R&D



Source: China Statistical Yearbook on Science and Technology, Table 2-1, 2005 and China Statistical Yearbook on Science and Technology 2006 (NBS, 2005a and 2006a)., Laurent Rouaud

VI-4 The transfer factor for innovation, or the links between participants

The transfer factors help the innovation system to be effective by linking the participants (the government research institutions, the higher education and the business sectors) , ensure the effectiveness of the information flows and the development of skills. The OECD Oslo Report identifies 8 transfer agents:

- formal and informal ***linkages between firms***, but also the link within the small firms, the relationships among users and suppliers, relationships between firms, regulatory agencies and research institutions, and the competition stimuli within an industry "clusters" .
- the ***presence of expert, technological "gatekeepers"*** *or receptors* – individuals who, through many means, keep abreast of new developments within a firm;
  International links are networks through which information is channeled by international experts transmitting up-to-date scientific understanding and leading-edge technological developments;
- the degree of ***mobility*** of expert technologists or scientists will affect the speed at which new developments can spread;
- the *ease of industry* ***access to public R&D*** *capabilities*;
- ***spin-off company formation***
- ***ethics, community value-systems, trust and openness***
- ***codified knowledge*** in patents, the specialized press and scientific journals.

VI-4-1 The linkage between innovative firms

Central to the transfer links are China's S&T and innovation policies. Since the late 1980s, the policies have focused on the same following 5 elements:

- the promotion of basic research in selected scientific fields which have significant potential impact on social progress and economic development;
- the research and development of new technologies in selected high-technology areas of national priority, such as biotechnology, information technology, space technology, energy technology, new materials; …
- the technology innovation and commercialization;
- the support for the construction of infrastructure for scientific research and
- The development of human resource in S&T and rewards for S&T excellence.

Since there is no formal institutionalized coordination mechanism between the policy makers and the main actors (higher education research labs and the business enterprises), the only real effective transfer mechanism is the different programs that involves the different actors for a particular objective.

As in developed countries of the OECD, the preferred and most effective way to link and coordinate the higher education, business and research institutions is through specific programs. ACARE is an example of this. In China the 5 policies described above has been supported by a number of programs that gave started as early as the mid 1980s. The Chinese S&T program was part of the policy and ran by the central government major entities such as MOST. They were conceived to overcome mostly the co-ordination failure. Below are the most important of those programs.

Table 11: Chinese S&T programs

Program name	Year of launch	description	comments
National Key Technologies R&D Program	1984	Foster key technologies to upgrade traditional industries and create new ones - focuses also on the sustainable development of Chinese society and the enhancement of the national innovation capacity	first R&D program implemented in China by the 6th 5-year plan – run by MOST
The National High-technology R&D Program (863 Program)	1997	foster innovation capacity in key high-technology - to develop breakthrough technologies and improve the international competitiveness of major Chinese industries	Priority projects in six high-technology fields: IT; biotechnology and advanced agricultural technology; advanced materials; advanced manufacturing and automation technology; energy and environment technology– run by MOST
National Program on Key Basic Research Projects (973 Program)	1997	Support basic research - mobilize China's scientific talent to conduct research in agriculture, energy, information science , environment , human health, materials science, synthesis and forefront of major science and related areas	supports cross-disciplinary research to develop new ideas – run by MOST

Spark Program	1986	promotes rural development and supports technology transfer in agriculture	
Torch Program	1988	Support development of high technology sectors by setting up S&T industrials parks and incubators	According to MOST, In 2005,succeded in setting up 53 national Science and Technology Industrial Parks and 534 technology business Incubators – run by MOST
International S&T Cooperation Plan	1997	use global S&T resources to solve bottleneck problems in some critical technologies, to provide a platform for international S&T exchange and cooperation, to improve indigenous innovation	According to MOST, in 2000-05, China and its foreign partners financed 631 projects for a total RMB 424 million RMB. 229 patents granted ; 3 623 papers published – run by MOST
Innovation Fund for Small and Medium Technology-based Firms (Innofunds)	1999	supports Small and Medium business innovation	Funding in the form of loan-interest refunds, capital investment
Knowledge Innovation Program	1997	restructure the research institutes of CAS, revitalize and train highly qualified personnel, create new high-technology companies via incubators, and become a major national S&T and int'l actor in innovation	Extensive transformation on quality – younger scientist 77% of researchers under 45 - average age of institute leaders is 47 vs 56 in 1991 – run by CAS

The Government Support for basic research are the Natural Science Foundation programs and 973 program, but also some human resource scientific and technology programs such as the Yangtze River Scholars Program, the CAS Hundred Talents Program, and the NSFC National Distinguished Young Scholars Program all aimed to academic excellence.

The largest Government support for high technology R&D are the High Technology R&D Program (863 Program), and the National Key Technology R&D Program.

The Government support for technology innovation and commercialization includes programs for the development of new products, such as the National New Product

Program, and the Torch , the Spark , the S&T Achievement Dissemination program, as well as the Action Plan for Thriving Trade through S&T.

What is the effectiveness of those programs to foster research, innovation and commercialization? Why is basic research still decreasing in share of R&D?

As the survey on R&D cooperation shows [111], that beside the program cited above, cooperation among Chinese's business enterprises with other enterprises and with the higher education sector or research institutes is very limited. Of the few Chinese's large and medium-sized business enterprises that have their own R&D capabilities (less than a third of them) carry out R&D projects on their own. The surveyed business enterprise had 39 072 R&D projects in 2005 or which only 4.4% were done in cooperation with the higher education sector and 9.7% with the government research institutions. Similarly, of these projects only 3.6% were carried out in cooperation with other Chinese domestic enterprise or foreign wholly-owned units. This clearly shows that the program government program has not succeeded in bringing research institutions, universities and business enterprises to cooperate effectively as those programs intended.

Table 12: R&D projects in business sectors by co-operation type

R&D projects in the business sectors	**2005**
operation with overseas institutions	1.9%
Co-operation with higher education	4.4%
Cooperation with government research institute	9.7%
Cooperation with foreign wholly-owned enterprises	0.1%
Cooperation with other enterprises	3.5%
Independent implementation	77.7%
Other	2.8%
Total number of R&D projects	39072

Source: China Statistical yearbook, 2007, Laurent Rouaud

[111] China Statistical Yearbook on Science and Technology 2006

One reason the programs are not as effective is that the decision making is centralized, with a top-down approach by the Central Government and MOST, particularly in program initiation and design. Another reason is that there is still little transparency on the evaluation of the programs. Unlike in the US there is no accountability office like the GAO in China. There is no legislation that makes the evaluation of the R&D programs a legal requirement. In fact, the original purpose of the evaluation was mainly to draw lessons for the sake of internal management and not for the sake of accountability. The evaluation results of the different programs are mostly kept internal. As a result, there is a lack of information on the program and little accountability to deliver results, and most importantly a lack of an evaluation culture throughout the innovation system from the lab researchers to the policy makers.

The system is in place though with institution such as The National Centre for Science and Technology Evaluation (NCSTE) created in 1997, but there is no obligation to evaluate or to give the evaluation to the public. For example according to his website , the NCSTE aims at “providing an objective and impartial basis for government departments, enterprises and investment organizations to make better decisions, to offer consulting service in a wide range of sectors, and to promote dialogue between government, industries and academies”.[112] The NCSTE is staffed with 25 to 30 specialists in management consulting, public policy research, technology-economy analysis and system engineering. They are in charge of designing evaluations, organizing activities, performing research and reporting and communicating. the result It can also draw from a group of 40 or so senior or retired senior evaluators and advisors (about 40 people),and a vast pool of a pool of more than 2000 experts providing resources in research , economics and organization. The NCSTE has been very active in evaluating R&D project having evaluated more than 1 000 projects such as National Key Science and Technology Industrial Projects

[112] www.ncste.org/ncste/english

and the Key Projects of the National New Products Program. In particular, the NCSTE has evaluated three times the 863 program, the largest of MOST's R&D program. The evaluation was intended to judge to what extent the program had narrowed the technological gaps between China and the leading S&T nations. The evaluation was based the typical evaluation criteria of any projects: relevance, effectiveness, efficiency and impact. The evaluation concluded that the 863 Program had played a decisive role in narrowing the gap within the strong S&T advanced countries in some fields but that gaps still existed in terms of innovation capacity, invention patenting and supporting conditions. However, a major lesson of the study was the lack of fully relevant indicators and methodology. This raised the question of setting "closing the gaps" as a relevant operational objective of such large programs. The NCSTE has also formulated a set of guidelines for project evaluation in line with international standards. It includes the description of procedures and recommendations for evaluation methodologies and tools as well as rules of behavior for evaluators and their relations with evaluated bodies.

Despite the progress that has been made to date, there is still a concern about the lack of openness, fairness and transparency in the selection process, program management and evaluation. The evaluation system or system of the different programs exists and is well in place. Its methodology, measurement, human resources seems to be adequate to assess the efficiency and results of the program. The only issues is that so far the evaluation purpose is up to now mainly to draw lessons for the sake of internal management. However, changes are slowly being implemented. According to Fang (2005), the purpose of evaluation is shifting towards the question of public accountability. [113]

Considering the openness of these programs, one of the main criticism of the programs is that it is concentrated on a few large programs. In fact the twenty

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[113] Fang Yan (2005), "National Evaluation System for Public R&D Programmes in China", KISTEP/WERN International Workshop, Korea, 31 May-1 June.
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largest program receive 50% of the funding, with the 973 and 863 programs being the 2 largest. The government was often criticized as to concentrate funding on a narrow circle of privileged beneficiaries, either firms or main research institutes. Some of the firms or research institutes were actually created for the sole purpose of the project. This process creates entities that unfairly compete during the selection process. For Fang (2005), the evaluations were mostly aimed at measuring the effectiveness of Science and technology programs in order to accelerate the technological catch-up process and were used as an input for R&D program managers and decision makers. However, Fang anticipate that as the reform of the Chinese S&T continues, evaluation will shift towards ensuring equitable resource allocation and the fairness of selection processes as opposed to the more hierarchical and closed environment with little external consultation. The evaluation of the 863 Program has been instrumental in helping shaping those changes. For instance, whereas earlier evaluations of the gap with foreign countries was a key focus, firms' participation is now crucial (notably in patenting, definitely a new focus for officials and scientists).

The Chinese government keenly aware of the requirement for better co-ordination of their S&T program and the need for openness has already incorporated a number of policy improvements in their 11th Five-year S&T Plan summarized below. Will the initiative of the government to have more coordination between the research institute, the higher education and the business enterprise be successful? It is hard to say. However, the right measures seem to slowly be put in place to improve co-ordination, accountability and more openness.

Improvement for better co-ordination of S&T programs, accountability and openness in China 11th Five-year S&T Plan:

<u>Ensuring fairness, openness and greater transparency in programme management</u> requires transparent project evaluation. To this end several measures are being implemented. First, a sound expert consultation mechanism will be used to evaluate the scientific rationale of the projects proposed. Concrete measures include the establishment of a unified information management platform and the implementation of online project application. Applications for projects under the 863 and 973 Programs are subject to online evaluation and appraisal by experts who are selected and assigned assessment missions randomly. Second, 98% of the projects of the National Key Technology R&D Program and 87% of the major projects of the 863 Program will be awarded on the basis of publicly published information and guidelines and competitive bidding. At the same time, information on all projects under all three programs, except classified projects, will be made public through e-government information channels. Third, a database of scientific experts will be established and the expert pool for project evaluation will be expanded to avoid repeated reliance on certain experts and risks of conflicts of interest (for example, the involvement of an expert from a given institute in project assessment and funding decisions relating to his institute).

<u>Science-industry (S-I) link/coordination:</u> *will be an important criterion in evaluating project proposals*, and priority will be given to institutions with well-established S-I relations when awarding publicly funded projects. The government will actively explore new mechanisms for fostering S-I relations and the formation of consortia of research, university and enterprises for major industrialization projects.

<u>Accountability and improvement of program management</u> *through closer monitoring and build an independent yet mutually controlled management system*, the government will rely on various means, including rules and regulations, the Internet and process management. The government has issued a number of related documents, including “Some Opinions on the Reform of Management of National S&T Plans”, “Some Opinions on Strengthening Planning Management at the Ministry of Science and Technology, and Perfecting the Supervisory Mechanism” and “Opinions on the Implementation of the Reform Requirements on the Budget Management, and Strengthening the Management and Supervision of Science and Technology Funding at the MOST”. It also aims to establish a system of mutual dependence and control between government decision making, expert consultation, process management by implementation agencies, and third-party monitoring.
Source: OECD, MOST

VI-4-2 Ethics in R&D

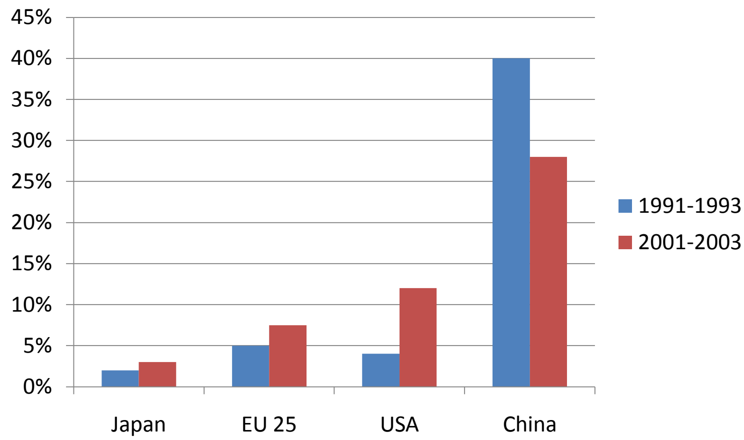
On ethics in R&D, China appears to be more relax on certain rules. For example, the central government support of applied research has encouraged Chinese business to develop new therapies in the pioneering field of gene therapy and stem cells research Examples include genetically modified (GM) crops, and vaccines. In stem cell or GM crops, an added difficulty for research and clinical trial in developed countries are the stringent regulations and controversial ethical issues. Although the US and Europe are leading in stem cell research, because of its looser R&D regulation environment; China is anticipated to emerge as the leading research and product development in the applied area of stem cell.

VI-4-3 International links

Concerning, international links which are important conduit of innovation transfer, China has done some significant achievement over the last 5 years and is set for even greater international links in the future. The patents and the number of technical articles co-authored by Chinese and foreign researchers are good examples of the increasing international links. The number of foreign business enterprises setting research centers in China and even the small but growing number of Chinese firms setting research centers in the US and Europe are another example of the increasing international links without China's innovation system.

China domestic co-invention by one or several Chinese researcher(s) and one or several foreign co-author(s) is a great measure of the international nature of research in China. It gives a pragmatic indicator of R&D international co-operation between inventors from different countries. Worldwide, domestic co-authored invention with foreign researchers represents only 7% of all inventions. In China, because of the increasing number of foreign research centers and the increasing number foreign firm that outsource part of their R&D to Chinese research centers, the number of international co-authorship is much greater. In fact, international co-invention in China is about 30% of the total domestic invention. This figure is to be compared to 7% in Europe and 12% in the US.

Figure 86: Domestic patent with foreign co-inventors

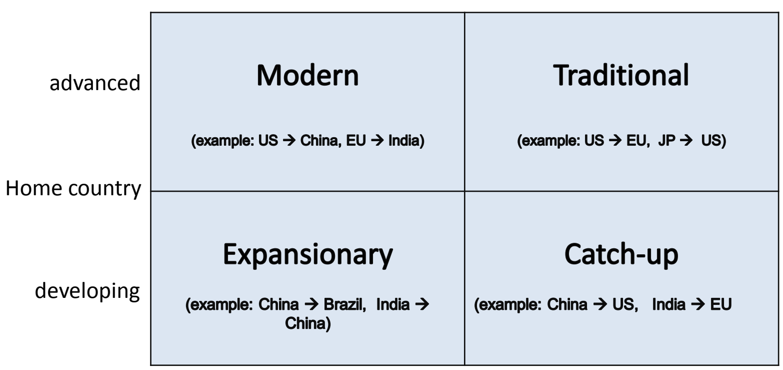


Source: OECD, Main Science and Technology Indicators 2007, Laurent Rouaud

International alliances and partnerships give China an opportunity to catch up quicker with their global competitors in high value added technology products. The size of the Chinese domestic market is a great leverage for China to attract foreign firm into investing in China and build in partnerships or strategic technology alliances. Chinese firms bring the knowledge of the market and legal environment while the foreign firm brings the technological solutions. The Chinese firm might decide later to acquire a technology foreign firm which operates in a country with safer and more transparent patent regulations than in China. The Chinese computer industry, now world leader, has been built in this fashion.

Another way to increase China international links is through the internationalization of its R&D The internationalization of developed countries R&D to emerging countries make sense as it lowers its costs and tap into a vast reservoir of research resources. It may be counter-intuitive that a Chinese firm might decide to set a research lab in a high cost R&D intensive developed countries but the benefits are interesting in the sense that it helps to catch up quicker with the US and Europe on the technology front . Companies such as Haier are great example of this trend. Haier has three industrial parks in the US, Jordan, and Pakistan, ten “listening posts” in Seoul, Sydney, Tokyo, Montreal, Los Angeles, the Silicon Valley, Amsterdam, Vienna, Taiwan and Hong Kong, and design network that include Lyon, Los Angeles, Tokyo, Amsterdam, and India.

Figure 87: Four phases or type of research on R&D internationalization



Source: Maximilian von Zedtwitz (2005) International R&D Strategies in Companies from Developing Countries – the Case of China,, Research Center for Global R&D Management, Tsinghua University, Beijing PR China

According to von Zedtwitz (2005) [114], there are 4 types of R&D internationalization. The traditional is the oldest type where typically a country of the triad, US – Europe – Japan will set up research center within each other. The rise of China and India has resulted in a second type called the modern type of R&D internationalization, where a firm in an advanced economy conducts R&D in developing countries. This type was the prevalent type in the 1990S. Examples of the modern R&D internationalization are IBM who has establishing its R&D in India or Microsoft's Research lab in China. The large foreign firms are either (1) starting their own research center, or (2) building an R&D partnership with a Chinese firm, or (3) entering in a co-operation agreement with a Chinese government research lab or a university. Does this internationalization help fostering the innovation capability of China? On the positive side, it trains local researchers, improves their language skills that are clearly a barrier to internationalization, trains Science and Technology future manager and increases the number of patent with possible spillovers. However, it also has some negative impact. China researcher prefer to work for international companies and usually prefer to stay in the international company over the long term, thus preventing talent to enter the Chinese national innovation system. Finally, the foreign firm with a Chinese R&D lab provides little funding to the university less than 1% of university funding). So, in general the foreign firms R&D lab in China do contribute to raise Chinese researcher level of expertise and china S&T in general but in China innovation system must rely on its own action to bring step changes in their S&T capabilities.

One way of doing so is to set up their international R&D capabilities. Recently, a new type of R&D internationalization concerning, this time the developing countries, has started to emerge. This type consists of a firm in a developing country investing in R&D in a developed country. Von Zedwitz calls this type the "catch-up" as it was

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[114] Maximilian von Zedtwitz (2005) International R&D Strategies in Companies from Developing Countries – the Case of China,, Research Center for Global R&D Management, Tsinghua University, Beijing PR China

intended to close the gap between technology capacity with the advanced country. The rationale for doing so is also to escape the competitive market of China to expand the developing market reach to the developed regions. In some cases, they respond to the request of their international customers to set up an R&D lab in their country. Example of this type are Haier , ZTE, Huaweu, and 3NOD which have established a real network of international R&D labs. ZTE established its first three foreign R&D centers in the US and Chile as early as 1998, and founded more R&D labs in Korea and Sweden. The last type of von Zedtwitz's international R&D concerns emerging countries firms that set R&D capability in other emerging countries, that he calls the ”expansionary” type. The rational for doing so is to expand the market to a similar environment or to seek a second generation innovation application that brings the innovation already exploited in the original emerging country to an even less developed country. An examples of the expansionary type is Huawei's R&D center in Bangalore, India. Huawei has established a strong international R&D base. It was the first Chinese company to set up an R&D center in Bangalore in 2000, which it expects to serve its targeted strategic markets of Indian subcontinent, the Middle East, and Africa as strategic markets. Huawei has recently decided to set up a basic research center in Cergy-Pontoise, in the French district of Val-d'Oise. The table below give a few other examples of China's "catch-up" and "expansionary" international R&D initiatives.

Table 13: Example of Chinese firms with R&D centers in developed countries

Chinese firm	Activity	International R&D location
Huawei	Telecom	Stockolm, Dallas, Silicon Valley, Bangalore,Moscow, Cergy-Pontoise
ZTE	Telecom	Stockolm, Bangaolore
Glanz Group	Electronics	Silicon Valley
Konka	Electronics	Silicon Valley
Haier	Electronics	Germany, South Carolina, India, Boston
Foton	Automotive	Japan, Germany
Chongqing Changan	Automotive	Turin, Tokyo
Kingdee	Software	Singapore

Source: survey Laurent Rouaud

The 11th Five-year Plan targets the internationalization of China R&D. In particular the plan focuses on international co-operation in the field of clean energy development, environmental protection, HIV treatment and other health issues, nano-science and aeronautic technologies. To do so the key national R&D programs and funds will be open to overseas partners. Universities and government research institutes are encouraged to expand Manassastheir co-operation and exchanges with foreign counterparts. To motivate them, the government will help business enterprises to set up overseas antennas to benefit from international S&T resources. It will encourage Chinese scientists to work in international organizations and to participate in international scientific projects.

However, there are still barriers to overcome to have a truly global Chinese R&D. Among them is the fact that Chinese firm are generally still much smaller compared to the major advanced countries' firms. The Chinese companies' procurement is still local or regional base. Setting R&D in advanced countries is costly to set up and costly to operate. Chinese researchers have limited management experience in working and managing in an international environment. The market in China is still strong and companies have less incentive to go international.

VI-4-4 Spin-off company formation

The spin-off process is one important means of transferring and commercializing technological innovations. Spin-off companies as shown in II-6 contribute to the technology transfer process that in turn leads to new economic growth and more generally wealth creation. According to Rogers (1986) [115], a spin-off is a mechanism of technology transfer because it is usually formed in order to commercialize a technology which originated in a government R&D laboratory, a university, or a

[115] Rogers, E. M. (1986a) The role of the research universityin the spin-off of high-technology companies.*Technovation* **4**, 169–181.

private company. Military spin-offs have been studied earlier and examples have been given. University spin-offs are as important. According to Carayannis et al [116] two factors are almost always involved in each spin-off: (1) an entrepreneur,who, according to the usual definition, usually transfers from a parent organization, and (2) a *technology* on which the new venture is based, and which also, by the usual definition, comes from a parent organization. Some universities such as MIT, Harvard, Stanford or Cambridge are the most known in terms of spin-off. Spin-off concerns all universities that have center of competence in a particular technology or any research institution. In the case of MIT, an analysis by the Bank of Boston (1997) indentified 4000 spin-offs from MIT. According to this analysis, these 4000 spin-off created 1.1 million people and generated $232 billion in annual sales in the mid 1990s. It estimated that on average, MIT generated some 150 spin-off per year throughout the 1990s. Some universities have even created technopolies, Stanford University with the Silicon Valley, the University of Texas in Austin, and Cambridge University in Cambridge. Sun Microsystems originated from research at the University of California Berkeley. Cisco Systems grew from research on operating system in Stanford University.

In China, the best example of a spin-off on the scale of Sun Microsystem, was Lenovo who has become the world largest producer of computers. Before it bought IBM's personal computer division, Lenovo was formed by a few researchers from China Academy of Science. Although the Chinese government is encouraging spin-off in all discipline of S&T, the most promising sector in China for spin-off are the biotechnology and nanotechnology fields. In both these field China is becoming the world research leader from basic to development research.

[116] Elias G. Carayannis, Everett M. Rogers Kazuo Kurihara, Marcel M. Allbritton (1998), High-Technology spin-offs from government R&D laboratories and research universities, Technovation, 18(1) (1998) 1–11

The spin-offs system is not new to China. As previously stated, the Torch program was created especially to bring innovation to commercialization through the creation of spin-off business. There are three types of spin-off in China: the incubators, the technology parks and the university-run enterprises.

The technology incubators were the target of the Torch program as a facilitator of technology base start up enterprise China originally borrowed the idea of incubators from the United States. They were expected to create convenient and efficient environments for start-up companies, as well as in providing financing, taxation and land-lease incentives. According to MOST, there are 548 incubators throughout China that have had helped raise about 20,000 high technology companies, with about 600 of them having an annual revenues of more than 100 million Yuan (13.7 million U.S. dollars). The initial funding provided is governmental either from the local S&T commission, or the local government of the Torch administration. The incubators are usually focusing on a particular issue or sector of the technology field. Some focus in attracting Chinese researchers back to China, others focus on the deployment of international networks, or a particular sector of technology such as biotechnology, internet or software. Established in 2000, the Tianjin Women's Business Incubator is a non-profit business incubator based in Tianjin dedicated to promote the development of women-owned businesses of all types in Tianjin. While there are over 400 business incubators in China, TWBI is China's only women's mixed business incubator. The incubator has currently 48 on-site tenants and 10 off-site tenants and to date has graduated 4 companies and employ directly and indirectly about 2,000 people. They also are diverse in terms of operational models: some are government based, other business based, or multi-investor base. . A business incubator is an organization that devotes itself to nurturing entrepreneurial companies by offering them various resources and services from physical space, capital and investment, administrative services, to networking connections and providing financial help for the day to day operation. These incubators are not supposed to derive a profit. A director is often appointed by the government to supervise and manage the incubator. Private business enterprises are responsible to set up the business-based incubators. They have a board of directors, which takes all decisions and appoint a director to run the operations. The multi-investor co-operative models are financed by two or more investors and are governed by a shareholder model. According to Yan (2003) the incubation period is usually three to five years and survival rate is an impressive 85%.

The reason for this high rate of survival is the requirement needed to become an incubate candidate. To be accepted in an incubator, the candidates have to develop an advanced technology with a feasible commercialization, to complete a business plan with some initial investment, have a good market prospect, and a competent team in the area of technology, management, and marketing.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Incubators	80	77	110	164	324	378	431	464	534	548
Number of incubated firms	2670	4138	5293	8653	14270	20993	27285	33213	39491	41434
Number of employees	45600	68975	91600	143811	28551	363419	482545	552411	717281	792590
Number of graduated firm	825	1316	1934	2790	4281	6207	8981	11718	15815	20000

Over the 1997 to 2006 period, the number of incubators are increased seven-fold while the number of graduated firm from the incubated has been multiplied by almost 20. MOST planned to have 1,000 incubators by 2010, harboring more than 50,000 companies and helping create over one million job opportunities. There is very little information made available though on the actual results of the graduated firm in terms of products generated or actual performance in attracting oversees Chinese researchers. However, according to Zhanglian Chen [117], previousl vice president of Peking University and now President of the China Agricultural

[117] http://nabc.cals.cornell.edu/pubs/nabc_18/NABC18_Chen2.pdf

University, the 4,500 companies belonging to Chinese universities generated some US$12 billion annual revenue in 2004.

VI-4-5 Presence of expert

One of the challenges is the lack of experience in management of the incubates leaders. In the 90s the government have encourage university professors to become CEO. Furthermore, the Chinese culture place a higher value on scientific education rather than business and the entrepreneurship spirit is still at its infancy in the Chinese society. The most important challenge though remains the lack of appropriate financing in the traditional risk adverse and debt adverse Chinese society . According to Chandra et al (2007) [118] who have interviewed 12 incubators managers, financing was the key bottleneck for the successful development of Chinese incubates. In fact most incubators managers job is to find a financial backer through the financial network. Although the capital markets in China are relatively underdeveloped, the primary job of the incubators managers is to introduce their incubatees to banks (mostly state owned) , venture capitalists (limited), loan guarantors (from the incubator), Angel funds (small size investors who invests in a venture that holds high potential) or soft loans. The financial service business is relatively young in China. Capital markets are still limited. Furthermore, the banking system in China is composed by mega-state owned banks that are use to loan money to large Chinese state own firms. The private sector, although more profitable and with better prospect than the large state owned firms have little chance to get adequate bank financing from the large state owned banks. The primary private venture capital investors belonged to both the major international investment banks and the Chinese diasporas from the United States, Taiwan, Hong Kong and other countries or regions. China has a long way to go before catching up with the US venture capital capability.

[118] Aruna Chandra, Wei He, Tim Fealey, Business Incubators in China:A Financial Services Perspective, 2007, Asia Pacific Business Review, Vol. 13, No. 1, 79–94, January 2007

Other challenges faced by incubates are their inexperience in building business plan, and marketing their products. They receive very little advice from incubators as they are public servants with limited business and market experience. Another challenge comes from the government support of the incubators and the conflicting roles they play as investor and regulator. A free market driven environment is likely to better encourage the creation of a technology network and financing availability from private sources without the invisible hand of the government.

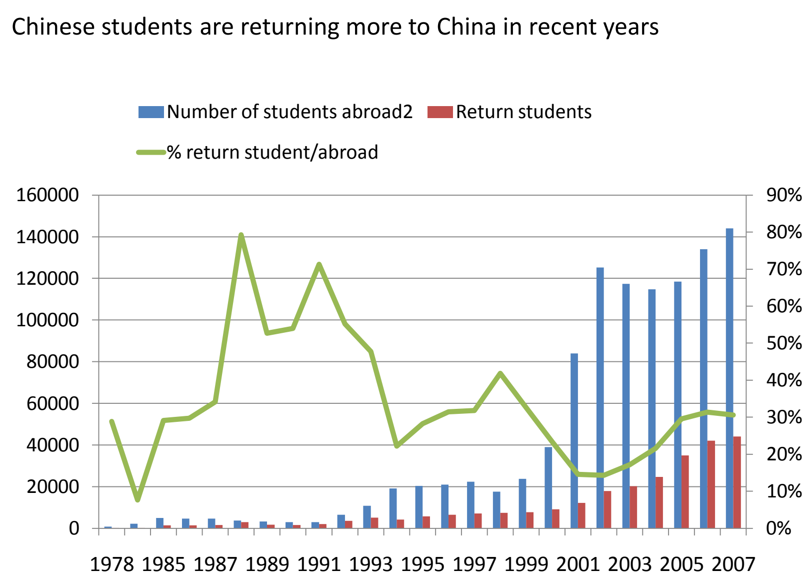
Over the next future though, changes will likely occur to make venture capital more available to small business enterprises. Among these changes are the slow but forthcoming reforms of the Chinese banking system which is prompted by the WTO membership of China. In addition, if the Chinese states banks have been focused on financing large state enterprises, they cannot continue to ignore the formidable opportunities to finance small and medium size businesses and be part of this consumer market. If not, foreign banks will definitely seize the opportunity and grab a significant market position. Furthermore, the foreign venture capitalists have started to show sign of interest in the Chinese technology market. An example is Japan's Softbank's US$20 million investment in Alibaba, an online Business-to-Business marketplace that helps small- and mid-sized businesses trade goods globally. It seems that for U.S. or European venture capital, to invest in China is no longer so far away. Soon, foreign banks and foreign venture capitalists will push Chinese bank to no longer ignore the start-up technology firms. In a way, it is a contestable market. There are signs that the domestic venture capitalists are slowly emerging (see Wi Harper Group box above). Finally, initiative such as the Innovation Work should be able to bring trust and transparency in the Chinese technology system to facilitate more and more venture capitalists of the west invest in the next future.

VI-4-6 Mobility

The mobility of expert technologists or scientists plays a role in the transfer of technology in the sense that it affects the transfer of technology and speed up its development. The mobility of scientists can be measured by (1) the number of Chinese students and graduates in high education graduate in foreign countries such as the US or Europe, (2) the return rate of the graduate student , (3) the Chinese expatriates return to China, (4) the cooperation between Chinese university and foreign universities and research institutions (5) the employment of Chinese citizen outside of China,(6) the Chinese scientists and engineers employed in joint venture companies involving an foreign firm , or (7) the internationalization of the Chinese firm that will send their scientists and engineers in their international offices.

The number of students in foreign universities are covered in following chapters . There was a large increase of postgraduate students studying abroad in the year 2000. Surprisingly, the number has stayed relatively stable over the last few years with about 130,000 students enrolled in postgraduate education abroad. It has been estimated that the number of Chinese undergraduate and postgraduate student studying abroad was about 450,000. The number of postgraduate student abroad represents about 12% of the total enrollment of student in postgraduate education in China (1195047 in 2007). This figure is particularly high compared with Europe or the US. The internet bubble of the late 1990 with the much higher paying job in the US and Europe have encourage Chinese students to stay abroad after their graduation in that period. Since the end of the bubble in 2000, the numbers of return graduate students to China have steadily increased. In 2007, 1 out of 3 Chinese students return back home after their degree. The incubator specialized in getting the Chinese international student back to China is bearing its fruit. The return rate is anticipated to show a substantial increase in 2008-2009 in the aftermath of the US financial crisis.

Figure 88: Mobility of Chinese postgraduate students



Source: China Statistical Yearbook on Science and Technology, 2008, Laurent Rouaud

There is no statistic on the return of Chinese expatriates to China, but only anecdotal evidence. The most striking piece of evidence comes from the Government initiative to make Shanghai one of the world financial centers by 2020. As in other instances, the Chinese central and local government shows imagination and effectiveness in pursuing their plans. In particular, Shanghai official have in 2009 teamed up with 17 major financial institutions to recruit in the US, Canada and Singapore financial talent to bring them to Shanghai to help build the government's vision. The Shanghai Financial Development Services Office organized job fairs in the three targeted countries. In New Jersey they posted 117 and attracted 700 candidates. In addition to the attractive salary proposed, a 1million RMB bonus is given to the high profile of high talent candidates. This initiative is part of the government's 1,000 People Plan, a project announced in 2009 to facilitate the recruitment of overseas Chinese talent in various fields. In 2008, Shanghai has attracted 66 talents of which 6 were recognized as high profile talent under the 1,000 People Plan. Most applicants are Chinese expatriates that want to return home. The foreigners represent a very small proportion of the applicant (10 out of 700 total applicants in 2009.) This particular initiative promise to be not only helpful in facilitating the transfer of technology but will also help in increasing managerial skills, business skills, entrepreneurial spirit and venture capital investment experience and network. All these attributes are critical to China future in commercializing innovation successfully.

Another initiative to attract returning Chinese talent was launched in 2008 by the authorities in the Beijing suburb of Yizhuang to work for companies established by the Beijing Economic-Technological Development Area (BDA). Under the program, qualified Chinese recruits returning from overseas are entitled to an award of 100,000 RMB housing subsidies, free medical checkup, and education subsidies for their children. In addition, BDA companies that will recruit returning talents could receive an award of up to 500,000 RMB. Already the program succeeded in attracting some 300 talents from oversees. Xie Liangzhi, one of the returned talents working in BDA, said: *"I graduated from Massachusetts Institute of Technology and I quit my job in a US company to establish my own company. But the incentives offered by BDA attracted me to create my own business here. I am sure that there will be more people like me coming back from overseas seeking job opportunity in the current economic downturn."*

Kai-Fu Lee is a great example of a successful return and its influence on the technology transfer dynamics could be instrumental to the next phase of the Chinese innovation system. Lee started Innovation Works, a company based in China whose goal is to bring innovative ideas, engineers, entrepreneurs and venture capitalists together. He was raised in the US, studied in the US and return to China to head Google China before starting Innovation Works. At a conference Lee argued that the Chinese American might lose their elite status in China due to local people's continuous effort to catch-up. *"If you want to go back, go back soon. Your advantage is about to run out"* said Lee.

The foreign firms that invest in R&D in China contribute to improving the science & technology knowledge of Chinese scientists. Most of the foreign firms that have set up a R&D center are in partnership with a local research organization that provides a significant portion of the staff. According to Blomstrom and Kokko (1998) [119] the most important conduit of knowledge spillover from foreign R&D centers is the mobility of people. Not only will the foreign R&D train and develop the local researchers but it will push other domestic firm or research center in the same industry or field to innovate if they want to survive in their market. If the foreign R&D is generally considered as a positive on the mobility of Chinese researchers and on its influence on China innovation, however, there are drawbacks. The China researchers that do join the foreign R&D center tend to stay in the foreign lab. In addition, the foreign lab usually conduct development research rather than basic or applied research. Finally, the foreign center might focus on a fraction of the total research required for the final product. For example, a chemical compound might require hundred of reactions, with different speed and timing. The China lab might focus on a very few reactions or operations in isolation where each Chinese scientist might only see a small element. The total process of the chemical compound will be kept under the responsibility of the home base R&D. Finally, the recent ease of regulations permit foreign firm to set up wholly owned R&D lab in China instead of forming a partnership with a local R&D facility in the past which limits the possibility of hiring local researchers and therefore their mobility. As mentioned earlier, the new trend for Chinese firm to implant R&D lab in advanced countries might become the best way to develop mobility for Chinese scientist and subsequently build experience, technical knowledge, language skills and managerial experience. All those attributes are in dire needs for China's researchers.

VI-5 The innovation dynamo: the business enterprise

The factors shaping the firm innovation is referred to as the "innovation dynamo". It occupies a central place in the OECD's framework map as the firm innovation is

[119] Blomström, M. and A. Kokko (1998), "Multinational Corporations and Spillovers", *Journal of Economic Surveys*, Vol. 12, No. 2, pp.1-31.

conditioned by its policy environment but most of all, it is driven by the firm itself. Regardless of its location, a firm bringing innovations to a successful commercialization will depend on its ability to create technological opportunities, to exploit them, to understand the market in general and estimate the market demand for the particular innovation considered. If the market is worthwhile in terms of demand and profit potential, then the firm will need to be able to set up a relevant strategy, carry the strategy, and transform these inputs into a real innovation that will be commercialized. Finally, the firm will also need to be able to time the innovation to market earlier than the competition or better than the competition. Along the way from the innovative idea to the commercialization, the firm will have a lot of options and directions to choose. It will have to strategically choose on the market to enter, or seek to create the type of innovation they might commercialize, or/and vice versa. In its R&D effort, the firm might prefer to invest more for the medium to long term by focusing on basic research, or might want to focus on a more strategic research approach (no specific application) geared towards broadening the range of applied projects that are open to it. The firm could also select a more applied research route to specific innovations or modifications of existing techniques. The firm's R&D approach might be to develop product concepts to judge if they are viable by designing a prototype and testing it, then develop and modify the prototype to the final design solution. The firm might also want to engage in non-R&D activities that could also bring innovations. For example, a firm with an extensive product experience and marketing experience might engage in discussions with its customers through its market development team within the marketing department to position the product and draw its top product objectives (TPO). It can also simply buy a license for a product or royalties. The firm that would know its competitors might follow and copy an innovative product from its competitor by doing reverse engineering.

To do so, the firm will need to have the right caliber of people in place to put all this together. It includes an engaged and skilled workforce that does not consider innovation as a fringe activity but the main activity of a firm that want to stay or become competitive. It needs researchers and engineers that can design the actual product or service and organize the production. It needs a procurement team that will source internationally. It needs a strong marketing and sales department. It needs a strong financial team that will carry the business plan and attract venture capitalists. Furthermore, it needs good managers that will put it all together. The Chinese innovative firm today excel in research and engineering, in production capabilities but lack in market research outside their domestic market, lacks in financial capabilities to attract funding outside the government support, lack in management of projects. Today a significant number of firms come from the conversion of some public research institutes into business enterprise. From 1998 to the end of 2003, 1,149 public research institutes were converted into business entities. This explains why the firms are still lacking the marketing, financial, and managerial skills. In addition, the governance of these companies did not encourage manager to take risk or to propose innovation. However, framework conditions are being improved. Strong of their benchmarking, the government has develop policies that addressed some of the issues in the innovation system. The framework has moved business into a more market driven environment. A steady number of successful market driven companies have been developed. Among these successes, the list below was the most impressive. Most were born in China's 540 incubators.

Table 14: Top innovative companies in China

2010 ranking	Company	Activity	Comments
1	**Huawei Technologies**	Telecom	2nd largest telecom equipment in the world
2	**BYD**	Batteries	use cutting edge technology in lithium-ion ferrous phosphate battery; plan to mass market electric car
3	**Alibaba**	Internet on line buying	more than 145 million users
4	**Huayi Brothers**	Media	First film ad TV to be list o the stock exchange
5	**Tencent**	Internet	450 million members
6	**Suntech Power**	Alternative energy	revolutionary technology to decrease reflectivity of cell
7	**Sohu**	Internet search engine	specificto chinese market
8	**Eno**	Retail - clothes	target young population
9	**Ctrip**	Travel - on line	caters rapidly expanding middle class + executives of foreign companies
10	**Baidu**	Internet search engine	largest search engine in China

Source: Fast company http://www.fastcompany.com/mic/2010/industry/most-innovative-china-companies

Some Chinese firms have already mastered all the skills required of an innovating firm. According to the respected 2010 Fast Company 's ranking of innovative companies, five of the Top 50 most innovative firms in the world are based in China: Huawei (No. 5), BYD (No. 16), Alibaba (No. 29), HTC (No. 31), and Huayi Brothers (No. 42). In China, the innovator dynamos are starting to increase in numbers and significance. The top innovative dynamos are listed above according to Fast Company ranking. Huawei, TCL and Lenovo, Haier are in high-technology sectors that have gained a significant global market presence to become the top firm worldwide in their industry. Most of them have been nurtured by Chinese incubators or in government research institute.

VI-6 Conclusion: does China have what it will take to design and commercialize successfully the next game changing single aisle aircraft?

The OECD framework map to evaluate the innovative capability of a nation has been extremely useful to systematically assess China's innovation system. These elements have been assessed in detail in the section above. The table below summarizes the finding and highlight the main challenges of the current Chinese's innovative system. It also compares China to the US and Europe and give a qualitative assessment of the Brazilian, Russian and Indian innovation system. The most challenging issues for the China's firms are:

- basic research
- linkage between firm
- presence of experts
- venture capital for technology start-up firms
- management skills and experience for researchers
- marketing research, market development skills
- ease of industry access to public R&D capabilities
- strategic research capabilities of the firms
- capacity of combining all innovation dynamo factors of the innovative firm

Table 15: Evaluation of the innovative environment of the firm in emerging countries based on OECD framework

	Brazil	Russia	India	China	US	Europe
Framework						
basic educational system	Y	Y	Y	Y	Y	Y
communications infrastructure	Y	Y	N	Y	Y	Y
financial institutions	Y	-	-	Y	Y	Y
legislative and macro-economic settings	Y	-	Y	Y	Y	Y
market accessibility	Y	-	Y	Y	Y	
industry structure	Y	-	N	Y	Y	Y
Science and engineering base						
specialised technical training	Y	Y	Y	Y	Y	Y
university system	Y	Y	Y	Y	Y	Y
basic research	-	Y	Y	N	Y	Y
Public good R&D activities	Y	Y	Y	Y	Y	Y
Strategic R&D activities	Y	-	-	Y	Y	Y
Non-appropriable innovation support	Y	Y	-	Y	Y	Y
Transfer factors						
linkages between firms	-	-	-	N	Y	Y
presence of expert technological "gatekeepers"	-	-	-	N	Y	Y
international links	-	-	Y	Y	Y	Y
degree of mobility of expert technologists or scientists	Y	-	Y	Y	Y	Y
ease of industry access to public R&D capabilities	-	Y	-	N	Y	Y
spin-off company formation	-	-	N	-	Y	-
ethics, community value-systems, trust and openness	-	-	Y	-	Y	Y
codified knowledge	Y	-	N	Y	Y	Y
Innovation dynamo (the firm capacity to innovate)						
skill employee in the firm						
researcher and engineers	Y	Y	Y	Y	Y	Y
sales and marketing	Y	N	Y	N	Y	Y
general managers	Y	-	Y	Y	Y	Y
Strategic capabilities of the firm						
understanding the market	Y	-	Y	-	Y	Y
understanding the competition	Y	Y	Y	-	Y	Y
ability to recognize and exploit technological opportunities	Y	-	Y	-	Y	Y
capability to bring innovation to market	Y	-	Y	-	Y	Y
time to market vs competion	Y	-	Y	Y	Y	Y
Strategic research	Y	-	-	N	Y	Y
Capacity of combining all above dynamo factors efficiently	Y	-	Y	N	Y	Y

Source: Laurent Rouaud

To be able to develop a game changing aircraft, China would have to master all these skills. China has already launched a 150 seater commercial aircraft with the ambition to enter the market in 2015. Under this timing, and because of the 6 year lead time between the end of the design phase to first delivery, it will be impossible for COMAC to be able to include game changing technologies. However, the development of this "transition aircraft" will be critical even if it fails commercially to build experience in linking Chinese aerospace and international suppliers, to generate experts, to develop management skills and experience and build marketing expertise in an international environment. Boeing and Airbus anticipate delivering their game changing aircraft in the 2023-2025 time frame. To be able to deliver a game changing commercial aircraft "timed to market" earlier or at the same time that its competitors, China would need to finish preliminary design of their game changing aircraft by 2017 or 2018. Possible to Chinese speed of execution but challenging especially in the area of basic research, management skill and experience and combining the skills for innovation or be a sort of architect that integrate all the technology and discipline together.   It will all depend on how the Chinese commercial aerospace organizes itself to reap the maximum benefit from the experience that will develop in the "transition aircraft" launched last year.

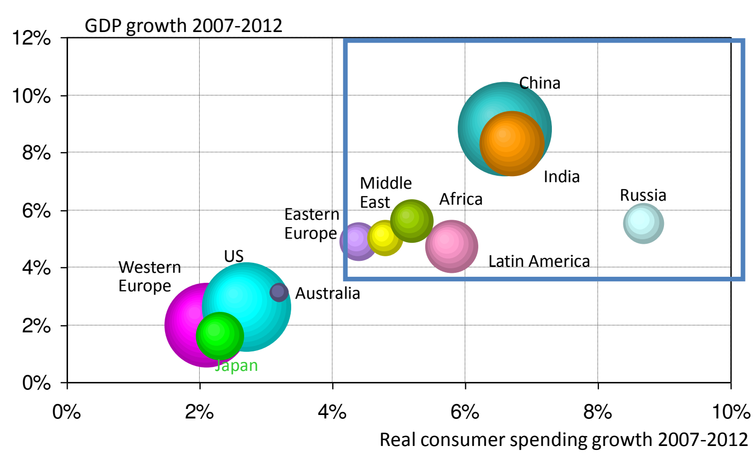
VII The large commercial aircraft industry in China

VII-1 Demand for aircraft in Mainland China

Air travel largely depends on GDP growth and consumer spending. The elasticity for air travel of GDP to air traffic is usually 1.2 worldwide. In developed countries, as the market is mature the elasticity will be much lower. Traffic volume will be very sensitive to change in ticket price. In emerging countries the elasticity of traffic to economic growth will be typically between 2.2 to 2.5, i.e. very sensitive to economic growth. The second driver of air traffic is consumer disposable income.

Against these 2 criteria, China and India are definitely without equal even in the rest of the emerging world. China GDP is anticipated to grow close to 10% yearly on average between 2007 and 2012 while its consumer spending at about 6.5% per year.

Figure 89: Emerging countries driving the world economy



Bubble size proportional to real GDP at PPP (Purchasing Power Parity) in US$billions in 2012
Source: Global Insight, Airbus

Figure 90: China's growing economy on its way to number 1

China passed Japan in 2009 in terms of real GDP

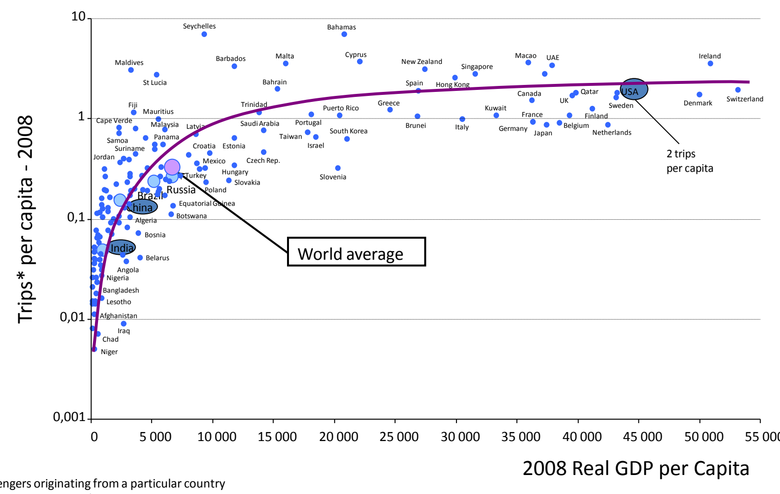
1986	2006	2026
1- US	1- US	1- US
2- Japan	2- Japan	2- China
3- Germany	3- China	3- Japan
4- UK	4- Germany	4- Germany
5- France	5- UK	5- India
6- Italy	6- France	6- UK
7- Brazil	7- Italy	7- France
8- Canada	8- Canada	8- Brazil
9- Mexico	9- Brazil	9- Italy
10- Spain	10- India	10- Russia
11- China	11- Spain	11- Mexico
12- Netherlands	12- South Korea	12- South Korea

Ranking by real GDP

Source: Global Insight, Airbus

Over the last 20 years China has successively passed nine countries in terms of real GDP volume. Today, the Chinese economy is only second to the US. Some anticipate the Chinese economy to become the first world economy shortly after 2030. In terms of air travel, Chinese propensity to travel is still at very low level. On average, a European or US citizen will travel twice a year in comparison to a Chinese who will travel 0.1 time per year, or 1 Chinese out of 10 will travel once a year.

Figure 91: propensity to travel



Passengers originating from a particular country
Note: GDP in 2005 US$

However, China is the fastest growing air traffic market.. The growth is fueled by the domestic Chinese leisure market discovering the benefits of air transport. The international market is mostly made of foreign tourists visiting China and an abundant business traffic. So far, the Chinese international travel have been relatively small in comparison to the domestic traffic. This is however supposed to change progressively over the next decade. One of the most important impediments to the development of the Chinese international traffic is the lack of “Chinese” infrastructure to receive the typical Chinese travelers who expect to find some of the Chinese products when they travel abroad. When it comes to international travel, the Chinese have proven to be less adventurous than the European or US traveler. Australia has understood this and has succeeded in attracting the first wave of Chinese international travelers by developing the right infrastructure to respond to the particular need of the Chinese international tourists. That market will be a real force going forward and will keep the Chinese traffic growing at double digit for a long while.

Figure 92: Chinese tourists' destination

100 million Chinese tourist by 2020

World Top 10 outbound tourism countries by 2020

	1995 Outbound tourist (million)	2020 Outbound tourist (million)	AAGR* (%)
Germany	75	153	2.9
Japan	23	142	7.5
United States	63	123	2.7
China	5	100	12.7
United Kingdom	42	95	3.3
France	21	55	3.9
Netherlands	22	46	3.0
Italy	16	35	3.1
Canada	19	31	2.0
Russia	12	31	4.0

Source: World Tourism Organisation

* Average Annual Growth Rate

By 2020, it expected that the Chinese outbound tourists will reach 100 million people in China. It will then surpassed the United Kingdom air travel volume and be close to the US level.

Figure 93: Mainland China air travel demand

World fleet forecast	2006	2026	Change
RPKs (billion)	226	1,053	+366%
Passenger aircraft (≥100 seats)	874	2,870	+228%
New passenger aircraft delivered (≥100 seats)	-	2,669	-
Dedicated freighters	43	471	+995%
Freighters delivered new	-	128	-
Total new deliveries	-	2,797	-

New aircraft deliveries valued at $329 billion

Airbus anticipates the Chinese air traffic to increase fourfold over the next 20 years and the fleet to increase threefold. The fastest growing market segment in China in terms of aircraft demand will be the dedicated freight aircraft. Freight will grow the fastest under the driving influence of a fast domestic and international demand but also because the freight aircraft market is still underdeveloped in China. The large and fast growing economy, coupled with impressive domestic demand for air travel and the expected global economic recovery, has led the major aircraft producers to conclude that China is their most important future market. Boeing is more bullish than Airbus on the China aircraft market. Boeing forecasts that China will need to more than triple its aircraft fleet by 2028, requiring 3,770 new aircraft valued at over $400 billion. Single-aisle aircraft serving the domestic air travel market are expected to account for 70% of the new deliveries. AVIC forecasts that China will need to increase its commercial aircraft fleet to 4,233 by the end of 2028. This equates to 3,796 new aircraft deliveries over the next 20 years. In 2010, the Chinese airlines are expected to take delivery of 243 new aircraft, more than any other country worldwide.

Figure 94: Aircraft demand by country

New passenger and freighter aircraft deliveries
Top ten countries (2007-2026)

	Aircraft new deliveries		By US$ value (billions)	
1.	United States	6.057	United States	540.9
2.	China Mainland	2,797	China Mainland	329.5
3.	United Kingdom	1,118	United Kingdom	144.4
4.	India	983	Japan	120.5
5.	Germany	914	India	117.7
6.	Japan	618	Germany	109
7.	Mexico	490	UAE	98.2
8.	Ireland	473	Australia	58.6
9.	Russia	466	Singapore	57.4
10.	Canada	427	France	55.9

New passenger (≥100 seats) and freighter aircraft
Source: Airbus

The major aircraft OEMS have long recognized the strategic significance of China's market. Airbus rolled out its first A320 assembled at its final assembly line in Tianjin. Airbus Tianjin FAL is planning to deliver 26 A320 family aircraft and up to 40 by 2012. In July 2009 Airbus started the construction of a $350million facility in Harbin for the manufacturing of composite parts for A320 and the new A350XWB. This is part of a commitment that Airbus have with the Chinese government to manufacture 5% of the airframe of the A350XWB in China. It is reported that Airbus already procures around $100million from China, with the plan to reach $500million by 2015. Similarly, Boeing is thought to have $600million in supplier contract partnerships with China. AVIC Shenyang Aircraft Corporation builds the 787 vertical fin. It is estimated that Rolls-Royce already has more than $1billion of business with China and it is expected to grow its sourcing of materials from $200million in 2009 to $800million within three years, and to $1billion by 2015.

It is evident that all the aerospace OEMS have reflected the emergence and importance of China's aviation in their own manufacturing strategies. This has, and will continue, to influence their purchasing policies and, as a consequence, there will continue to be a profound effect on their supply chains. However, it is not only the existing major OEMS that are increasing their investment and purchasing spends in China. China has ambitions to establish its own civil aerospace development and manufacturing capability.

VII-2 The Current Situation of the Aviation Industry in China

In May 2008, a new company, the China Commercial Aircraft Company (COMAC) was set up by the Chinese Government with the aim of developing China's own indigenous large aircraft producer to rival Airbus and Boeing. This is part of a wider government initiative to develop the aerospace sector in China. A year earlier, the State Council, the highest executive organ of the state, approved a new large aircraft project alongside plans for lunar exploration and manned space flight. This demonstrates the priority the Government has placed in aerospace in its overall economic development agenda. The project is known as the C919 and the objective is to produce a single-aisle, 150 seat aircraft by 2016 to compete with the B737 and A320.

According to Goldstein (2006)[120], China strategy to build an indigenous LCA industry is based on two pillars: (1) leverage the interest that foreign manufactures have in accessing China domestic market by entering in various partnerships, (2) develop competencies across the full supply chain from aerostructures , systems, and propulsion, as well as their integration and the final assembly. China recognized it needed to learn from western LCA manufactures in technology, managerial and commercial skills, crucial to the successful development of a commercial aircraft that will be credible in the Europe and North America as well as with the domestic airlines. COMAC will be responsible for the overall C919 program. The Government has also merged the country's two biggest aerospace industrial conglomerates - AVIC I & II - into a single state-owned enterprise. They were originally a single entity, but were divided in 1999 in order to break the monopoly and foster fair competition.

AVIC has over 420,000 employees, about four times more than Airbus and Boeing Commercial aircraft combined, spread across more than 200 subsidiaries and 20 listed companies. The operation covers manufacturing plants and research institutes with capabilities across all aspects of the aerospace supply chain from airframe, aero-engine and airborne systems, through to the production of military fighter and transport aircraft, and the civil regional turbo-props. In 2009 AVIC entered the Fortune 500 Global companies, with revenue of $21.7 billion and profits of $568 million. It ranks 11th in largest Aerospace & Defense Company, ahead of Bombardier. The restructuring and the launch of the C919 program has resulted in the acceleration of foreign engagement in China's aerospace sector which had already some momentum. Overseas aerospace OEMs and Tier 1 suppliers have

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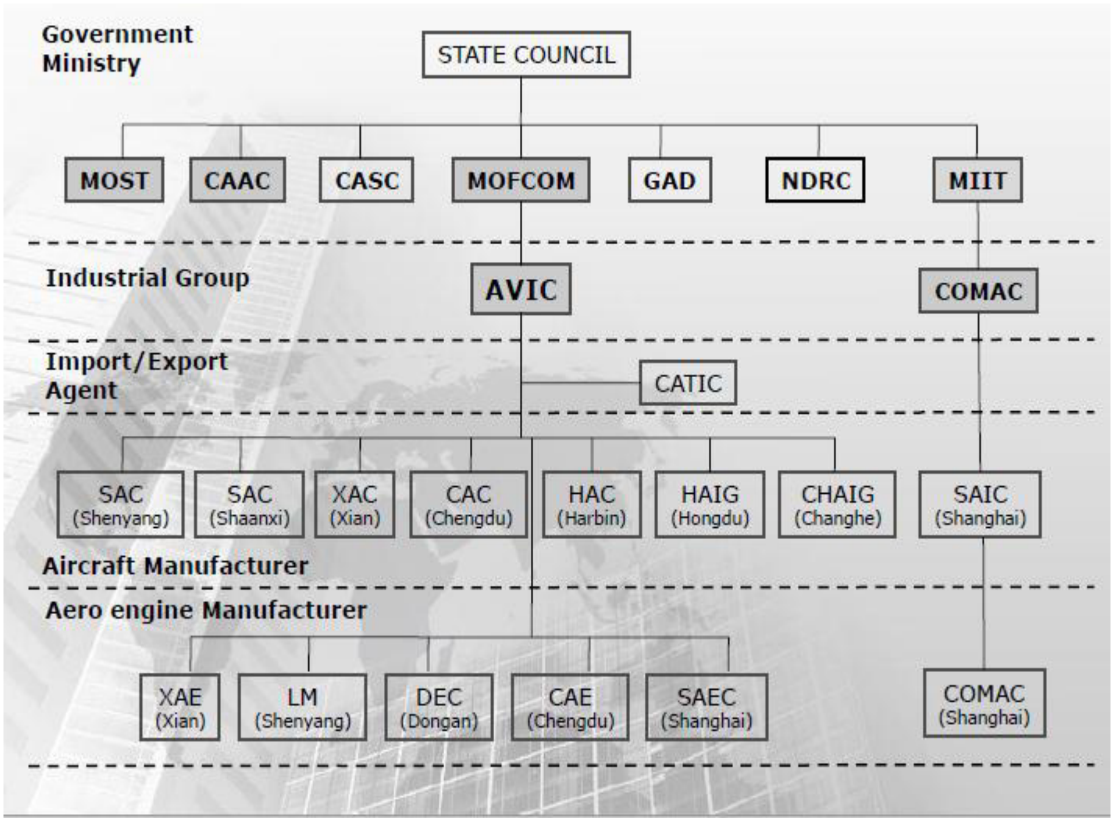
[120] Goldstein Andrea (2006), The political economy of industrial policy in China : the case of aircraft manufacturing, Journal of Chinese Economic and Business Studies, volume 4, number 3 page 259-273, November

recognized the opportunities that the market presents and have been expanding their relationships with the aerospace supply chain in China.

Recently General Electric formed a 50:50 joint venture with AVIC to develop a new avionic company that will market worldwide its product and will compete with Rockwell and Hamilton Sundstrand. The JV will supply the core processing system, display system and on-board maintenance system for the newly launched the C919. Under the terms of agreement, the JV will also integrate the airplane's entire avionics system. The integrated avionics systems that GE AVIC has agreed to provide for the Comac C919 include an open-architecture, integrated modular avionics core processing system, a large-area display system, an on-board maintenance system and the flight recording system. The JV intends to market the avionic system to other new programs after the C919 is completed. Similarly in August 2010, Goodrich and AVIC Xi'an Aircraft International signed agreements to form two joint ventures to produce landing gear and components for the C919.

China has also reached a new milestone in its international partnerships goals as it is now looking at oversea investments and acquisitions in order to boost its capabilities. As recently as December 2009, AVIC Xi'an Aircraft Company concluded the purchase of a 91% stake in Austria's Fischer Advanced Composite Components (FACC), a $393 million turnover enterprise which supplies Boeing, Airbus, Bombardier, Embraer and Gulfstream. Back in 2007 AVIC also made enquiries regarding the Airbus facilities in Europe that were being sold at the time. There were also reports that AVIC also bid last year for the experienced German composite aircraft manufacturer, Grob Aerospace, and has looked at Piper Aircraft in the US. It is clear that AVIC is proving an attractive partner to major foreign aerospace companies looking to exploit the market opportunities in China. It is also evident that AVIC also has the desire, and importantly the financial resource to acquire the expertise and technology it needs to become a truly global player in the sector. Its stated strategic corporate goal of 22% revenue growth to reach sales of one trillion Yuan (USD 147billion) by 2017 is a measure of its bold ambition.

Table 16: Government structure of the aerospace in China



<u>VII-3 The entry of China in civil aviation</u>

In the early 1980, China started its first reverse engineering aircraft program, the Y10, based on the 1950s Boeing 707[121]. The Chinese civil aviation developed itself from the military capabilities and from China long partnership history with western manufacturers. The knowledge gained over the last 20 years history of partnerships has given the Chinese full capability for producing their own civil aircraft programs

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121 Nolan P and Zhang J (2003), Globalization challenge for large firms from developing countries: China's oil and aerospace industries, European Management Journal, Volume 21, number 3, page 285-299

that can meet FAA and JAA certification standards. The oldest partnership was established with the Soviet Union on both military and civil programs.[122] The military partnership with the Soviet Union can be traced back to the Mig models. The latest partnership concerned the co-production with the Sukhoi design bureau on the Su-30s in 2000. On the commercial aircraft side, the cooperation started with the co-production of the YAK-10 that originated form a Russian design.

Since the early 1980s, the Chinese airlines through their government have purchased western built aircraft. China's central government retains the ultimate approval regarding civil aircraft purchase. There are two entities within the government structure that control the purchase of aircraft:

- the National Development and Reform Commission (NDRC);
- the Civil Aviation Administration of China (CAAC).

The NDRC needs to approve any aircraft purchase and supervise the aircraft acquisition negotiations with the manufacturers. The CAAC because of its responsibility over Air Traffic Control and Safety is the second body to approve the purchase. The airlines of China need to obtain CAAC approval before any type of fleet expansion. If neither NDRC nor the CAAC can oblige an airline to take a particular type of aircraft, their power reside in their ability to withhold the allocation of aircraft needed by the airlines. Over the last 15 years, the NDRC and the CAAC have balanced the orders of aircraft equally between Airbus and Boeing. However, given the level of investment of Airbus in the Tianjin final assembly of A320 and the fact that Airbus has only 35% of the installed fleet in China vs Boeing, it is likely that the China authorities order more Airbus aircraft for the for foreseeable future.

Historically, all large aircraft contracts with western aircraft manufactures included some type of offset program to manufacture some of the aircraft component in

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[122] Frankeistein J (1999), China's defense industry : a new course ? in James Mulvenon and Richard Yang (Eds), The people's liberation army in the information age, Rand Corporation, Santa Monica

China. The Chinese firms involved in the offset had to comply with FAA and JAA standard that was often taught to them by the FAA and JAA directly in China.

For every offset, western firms had to detach their employees on site at the Chinese manufacture to oversee and train their Chinese counterpart. The FAA and the JAA also develop oversight in the Chinese factories doing parts not only for the Chinese delivered aircraft but for deliveries of the aircraft globally. The most successful offset agreement so far is the A320 door agreement between *airbus and AVIC's subsidiary Shenyang Aircraft. Shenyang has delivered its 8,000th door in April 2009.

Table 17 Offset agreement with western aircraft manufactures

Western aircraft program	Type of aircraft	Western Manufactures	type of offset
MD-82	125 seater Narrow Body	Douglas Aircraft	Final Assembly
MD-82	125 seater Narrow Body	Douglas Aircraft	Nose section
737	125 seater Narrow Body	Boeing	Fuselage panels for section 48
MD90	130 seater Narrow Body	Douglas/Boeing	Fuselage panels
737	130 seater Narrow Body	Boeing	Horizontal stabilizer
757	175 seater standard body	Boeing	Empennage
757 Freighter	small freighter	Boeing	Cargo door
A300 freighter	medium freighter	Airbus	Cargo door
737	130 seater Narrow Body	Boeing	Vertical fin & tail
ATR42	70 seats	ATR	Center Wing box
ATR72	90 seats	ATR	Rear fuselage
A320	150 seater Narrow body	Airbus	Door and FAL

Source: survey, Laurent Rouaud

VII-3-1 China Aviation Industry Corp. (AVIC)

AVIC is a fully state owned company that was created in 2008 by the merger of China AVIC 1 and AVIC 2 which at its peak employed jointly about 520,000 people. The main objective of the merger was to create a state owned company that will manage aircraft manufacturing for all China aircraft program from turboprop to aircraft in the size and range of the Airbus and Boeing product portfolio[123]. The large aircraft above 100 seats are the responsibility of COMAC, a separate company under government control, partly owned by AVIC (see next chapter). AVIC is responsible for designing and manufacturing large and medium size military transport, bomber and special military purpose aircraft. The restructuring has ended the separation between the military and civil parts of AVIC I and II. Western companies were more comfortable dealing with the civil side knowing that there was a firewall between the two. In reality, it seems that this firewall was just a perception. In any case, since the merger, western companies have notably increased their partnership and presence in AVIC.

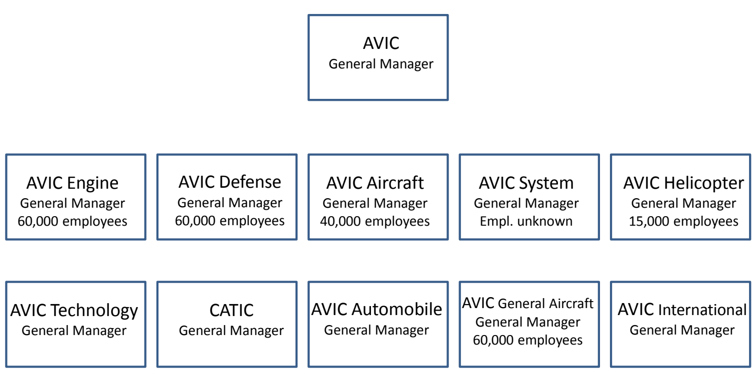
Over the last 10 years, AVIC I and II have developed an international partnership and collaboration with the main aerospace groups in Europe and the Americas. AVIC has also expanding its presence across China, has changed its company structure reflecting the structure of western firms. In order to improve its capital structure and access to private capital, AVIC has integrated its listed companies to its structure.

Immediately after the merger, AVIC has restructured by different specialties in order to integrate more than 200 subsidiaries of the merged companies and eliminate cost overlap between the subsidiaries of the two AVICs. The specialty Divisions are financially independent in the sense that they manage their own Profit and Loss statement. AVIC is located in 19 provinces shown below.

[123] Goldstein A (2005) The political economy of industrial policy in China/ the case of aircraft manufacturing, William Davidson Institute, Working paper number 779

Figure 95: AVIC restructuring

AVIC restructuring in Division by speciality



Source: Aviation Week, Laurent Rouaud

Although AVIC announced in 2009 that it will hire overseas talent for management role within the 10 division of AVIC, all General Manager are Chinese. The reason invoked was the confidential information that the GM would have access. The divisions are not located in a central location such as Beijing but throughout China, in the main aerospace clusters. AVIC Aircraft is based in the aerospace cluster of Xi'an, while AVIC Helicopter is based in the cluster of Tianjin. The establishment of the Division was the result of a careful selection of site by the central government and follow the strategy to industrialized different and provide high tech jobs in different areas of china other than the 3 major cities of Beijing, Shanghai, and Shenzhen.

AVIC continues to develop partnerships with leading western aircraft manufactures and tier-1 suppliers. In 2009, AVIC signed agreement with Bombardier to for its CSeries aircraft. AVIC has been a partner of Airbus since the mid 1980s. In 2009, AVIC and Airbus signed another agreement to build a composite manufacturing centre in Harbin to produce as a joint venture composite parts and component for the A350 as well as for the equipment of the A320 wings.

Table 18 AVIC recent partnerships and mergers

Partnership/merged company	Detail of agreement/contract
Airbus	JV with Airbus to build a manufacturing center in Harbin for composite material parts and components for the A350. AVIC to hold 80% and Airbus 20%
Airbus	FAL, Tianjin municipal government JV with Airbus. Airbus control 51%, remaining 49% split between Tianjin Free Trade Zone Investment (represents Tianjin) holds 60% and AVIC 40%
Airbus	Airbus and Xian Aircraft Industry signed a cooperation to equip A320 wings for the A320 to be assemble in China. A new facility will be built in Tianjin next to the FAL. A new subsidiary was created Xian Aircraft Industry Company
AVIC I and AVIC II	Merger into AVIC to form the biggest aircraft manufacturer in China
COMAC	Formation of COMAC to take the responsability in building Chinese large civil aircraft (ARJ and C919) . AVIC take 26% of COMAC

COMAC	Strategic cooperation agreement. AVIC to support COMAC by providing R&D capability to COMAC and marketing. Stated goal is to "increase market share of China made civil aircraft"
Boeing	Boeing expanded capacity of composite facilities JV Boeing Tianjin Composite Co. Ltd, 88% Boeing, 22% AVIC
Bombardier	AVIC and Bombardier entered a strategic cooperation agreement in 2007.
Bombardier	Agreement with Shenyang Aircraft to become Bombardier partner for its 130 seater Cseries aircraft and the Research and manufacturing of short to medium haul aircraft

Source: Aviation Daily, Laurent Rouaud

In recent years, AVIC has been very active in building its portfolio of product. AVIC opened a Defense branch in Beijing as part of its plan to become a global company in the defense business such as the fighter aircraft J-10. AVIC is diversifying its offering by entering into the electric vehicle market. AVIC signed an agreement with the Central China's Henan province to build a manufacturing facility of electric cars. AVIC tried to enter in the airline industry by tempting to acquire the troubled East Star Airline. However, the airline did not accept the low price offer from AVIC and liquidated. This was the first airline bankruptcy in the history of China airline.

AVIC decided in 2008 to enter the market of commercial aero engine. In 2008, it signed an agreement with the municipality of Shanghai to establish a commercial aero engine company. In 2009, AVIC unveiled a turbofan engine at the Zhuhai Air Show, by its subsidiary Aviation Engine Industry Corp. The engine introduces a number of current technologies. The engine consists of a high by pass fan, a three stage combustor, a single stage HP turbine a three stage low pressure turbine, and a simple convergent nozzle. The technology that have been selected and successfully integrated have surprised all western engine manufacturers. The difficulties though now will consist of testing the engine for its reliability, safety, performance, maintenance and economics for an airline operation. AVIC Engine Co Ltd own 20 member companies including the Shenyang Aero-engine group and Chengdu Engine Co. Ltd and 3 listed companies at the stock exchange. Most of its engines are dedicated to military applications. It possesses R&D facilities, engine test and inspection capabilities for the military engine.

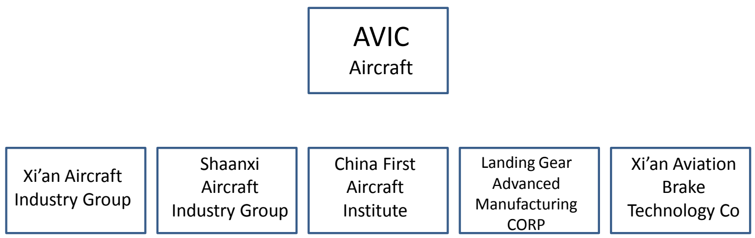
AVIC Aircraft Corporation includes 5 member companies. AVIC Aircraft objective is to develop medium and large military and civil aircraft. The State owned company responsibilities include:

- Pre-study
- Design
- Development
- Production
- Marketing
- Customer support

for medium and large transport aircraft, civil passenger aircraft, and landing gear systems. It is also a major part contractor and component design and production for domestic and western aircraft manufactures.

AVIC had made public is intention to list 80% of its business by 2010 and become a public company by 2015. However, the financial crisis has postponed the plan.

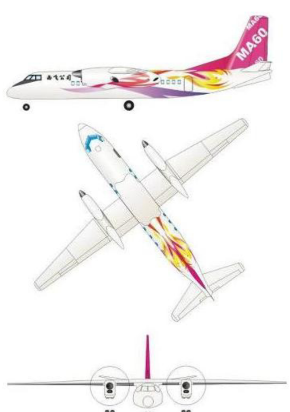
Figure 96: AVIC aircraft division structure



Source: Aviation Week, Aviation Daily Laurent Rouaud

VII-3-2 The MA600 & MA700 Regional Transport Aircraft

The MA60 is an advanced regional turboprop aircraft developed by AVIC Xi'an Aircraft Company. The MA60 is suitable for short and medium-haul commuter operations as well as multi-role applications.



According to forecasts of Bombardier and China Aviation Industry Development Research Center, the next 20 years the total global demand for regional aircraft will be 5,300-5,500, of which 1,900 will be turboprop regional aircraft. Currently there are three major turboprop regional aircraft manufacturers in the world: ATR, Bombardier and Embraer, with AVIC XAIC hoping to join them.

The MA60 is part of AVIC XAIC Xinzhou series of aircraft. The first MA600 (Xinzhou 600) was delivered in 2009 and the MA700 (Xinzhou 700) is undergoing development.

The major customers of MA60 are in Africa, Asia and Latin American, including Zimbabwe, Congo, Zambia, Laos, Indonesia, and Bolivia. Africa is expected to be a priority market where there is a projected need for about 500 new aircraft in the next decade.

The MA600 is an upgrade of MA60. Compared with MA60, the MA600 has improved structure and integrated avionics systems and enhanced comfort and improved economy through better energy efficiency. The price of MA600 is expected between 100 to 120 million RMB is significantly lower that similar foreign aircraft which sell at $18-20 million (about 124 to 138 million RMB). In terms of the operating costs, MA600 is expected to be 40 per cent lower than that of the jet aircraft.The MA700 is a new generation of turboprop and in the early stages of development. It is being designed for EU and U.S. markets and hopes to become a mainstay regional aircraft in the world market.

VII-3-3- Commercial Aircraft Corporation of China (COMAC)

Created in 2008, COMAC is a state owned company regrouping the First Aircraft Institute, Shanghai Aircraft Manufacturing and Shanghai Aviation Industrial

Corporation and its subsidiaries. These three companies have been active in the MD80/90 and ARJ21 program. The company is jointly invested by 6 state owned Assets Supervision and Administration Commission of the State Council: Shanghai Guo Sheng Co. , China Aviation Industry Corporation, Aluminium Co; of China, Baosteel Group Co. , and Sinochem Co. COMAC has a registered capital of 19B yan ($2.8B).

COMAC Strategy

COMAC has outlined its strategy plan as “1 goal, 2 product lines, ,3 centers, 4 strategies, 5 core capabilities, and 6 relationships”

One goal: To become a world – class aerospace enterprise.

Two product lines: Series aircrafts of both regional jet and trunk-liner.

Three centers: General Aircraft Research & Design Center, Final Assembly Manufacturing Center, Global Customer Service Center Global Center.

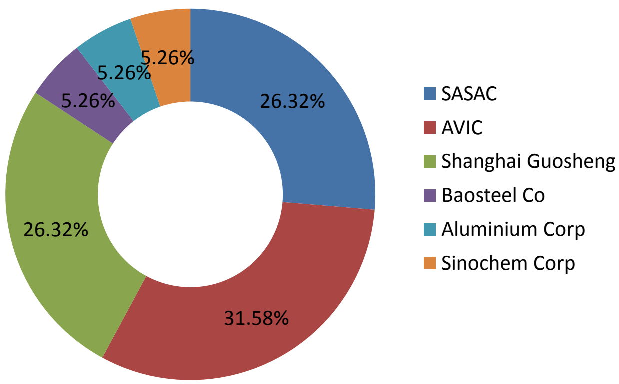
Four strategies: Corporate Culture strategy, Human Resources strategy, Brand strategy, Information strategy Information strategy.

Five core capabilities: Aircraft design and integration, final assembly and manufacturing, marketing and sales, customer service, airworthiness certification.

Six relationships: Safety and economics; independent innovation and global technology resources adoption; mechanism innovation and role of current technology and people; technological breakthrough and industrialization; government dominance and market mechanism; trunk liner and regional aircraft.

COMAC is responsible for the design, development, manufacturing, flight test, sales and marketing of all large aircraft from the regional ARJ21 aircraft. COMAC is building a large network of international cooperation starting with the ARJ21 aircraft development. COMAC is also in close partnership with its part owner AVIC. All the subassembly of the COMAC's ARJ21 are done by AVIC factories.

Figure 97: COMAC ownership structure



Source: AVIC, Laurent Rouaud

COMAC has received about 300 orders for its ARJ21 aircraft with the first deliveries anticipated at the end of 2010. The ARJ21 is the first medium and short range regional aircraft by the Chinese. It provides a solid experience base for the development of China's larger trunkliners to come

In early 2009, COMAC announced the launch of the C919 aircraft, a family of aircraft from 150 to 190 seats that will compete head to head with Airbus A320 and Boeing 737. Developing a large civil aircraft has been in the plan for decades and a core national project. The first test flight in 2014. and the first delivery of the aircraft is anticipated for 2016. The dates have been brought forward from the original 2020 date, because it is believed that China wants to exploit this market segment before Airbus & Boeing look to develop replacements for their A320 & B737 families. This accelerated timescale necessitates engagement with foreign suppliers, particularly in the areas of propulsion, avionics and materials. However, in procuring equipment in these areas China will not be content with straight forward off-the-shelf solutions;

it will want to work with suppliers to develop its own long term capability. It has already established a new aero-engine company in Shanghai with the ultimate aim of developing and producing engines for the C919. AVIC, the Shanghai Municipal Government and Shanghai Electric are its principle shareholders and it has been reported that it is open to further investment from either domestic or foreign investors, for a stake of up to 30%.

ARJ21 program

In the short term, COMAC focus is on the ARJ21 which first flight took place at the end of November. The ARJ21 is 70% build oversee by 19 major European and US suppliers. A stretch version of the ARJ21 is being developed with the support of Bombardier. Antonov collaborated with COMAC to design the ARJ's wing. Boeing is supporting the ARJ program as a consultant. GE is heavily involved on the ARJ as a system provider and an engine provider.

Table 19 Western suppliers of ARJ21

Section or components	Suppliers	Country
Engine	General Electric	US
Avionics	Rockwell Collins	US
Hydraulic Systems	Parker	UK
Electric power and APU	Hamilton Sunstrand	US
Landing Gear system	Liebherr Aerospace	Germany
Air Conditioning	Liebherr Aerospace	France
Flight control system	Honeywell	US
Fire Protection system	Kidde Aerospace	UK
Water system	Envirovac	US
Emergency evacuation	Air Cruisers	US
Oxygen system	B/E	UK
Control deck	Eaton	UK
Light system	Goodrich	US

Source: AVIC

Table 20 Domestic supplier of ARJ21

Section or components	Suppliers	Country
Nose	Chengdu Aircraft Industry group	China
Wing	Xi'an Aircraft §Industry Group	China
Fuselage	Xi'an Aircraft Industry group	China
Rear fuselage	Shenyang Aircraft Industry Group	China
Stabilizer/Elevator	Shanghai Aircraft Group	China
Radom	Research Institute for Special Structures Composite	China
Pylons	Shenyang Aircraft Industry Group	China
Vertical tail	Shenyang Aircraft Industry Group	China

The success of the ARJ21 outside of China will depend on the quality of the customer support and its global coverage. Most aircraft program in China and even in western countries that have failed was due to the lack of commitment from the customer support side of the business. Aware of this condition, AVIC has build a new 18,000 m2 customer service center located in Shanghai industrial area. The Center include training for mechanics, crew and flight crews, as well as a technical service, maintenance support, and a spare part facility. In order to overcome the difficulties to finance the ARJ21 for foreign airlines, COMAC has set up a leasing company that will enable airline to lease the asset without worrying about the likely low residual value of the aircraft. In addition of its own leasing company, GECAS, the aircraft leasing subsidiary of GE, has purchase 6 ARJ21 following the selection of GE engine of the aircraft. Despite these efforts, it is unlikely that the ARJ become successful as to reach more than 1,000 orders. The most important constraint will remain the relatively low probability that the ARJ be successful outside China, and the small market for regional jet aircraft in domestic China. In addition, the ARJ21 has already suffered some major setback. First the original planned was to have the first deliveries in 2009. Because of design and industrial challenges, the entrée into service has been pushed back by one year. The ARJ21 is the stepping stone for the emergence of China civil aircraft business in the key area of aircraft architecture and integration capabilities, customer services and aircraft marketing, sales and contract. It is the opportunity to experience in real situation the different discipline of aircraft manufacturing the way western manufactures do. The ARJ program is view as a demonstrator program in view of the ultimate China aviation goal of building a successful 150-190 seater alternative to the Airbus and Boeing products.

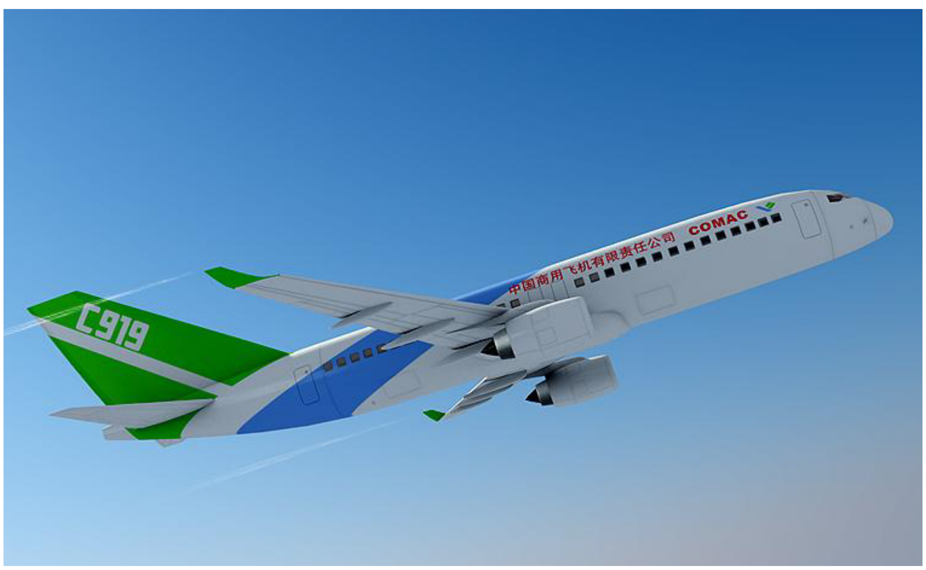
<u>The C919 program</u>

The C919 is anticipated to cost about $10 billion. The funding of the program is 100% government through the shareholder of COMAC:

- SASAC
- Shanghai Municipal Government
- AVIC
- Baosteel Group
- Chinalco
- Sinochem

The State Council approved a new large - aircraft project in February 2007 and incorporated it into the 11th Five-Year Plan alongside Lunar Exploration and Manned Space Flights. The large commercial aircraft project is named C919 and aims at the domestic and overseas single-aisle aircraft market, in competition with the Boeing B737 and Airbus A320. Premier Wen Jiabao wrote an article in "People's Daily" named "Let China's own trunk liner soar into the blue sky". This expressed how the Chinese consider the Trunk Liner Program as an important strategic decision made by the government for the development of a world class science and technology base, and for the overall modernization of China. It is seen as a landmark for establishing China as an innovative country and its implementation will promote the development of the economy, and science and technology in China.

Figure 98 artistic view of COMAC C919



The basic design of the initial C919 includes supercritical low wings, three-point type retractable landing gears, and regular empennage and powered by two wing mounted advance high bypass ratio engines. The range is 4,075km for the standard range version and 5,555km for the extended range version. Three variants are planned - 156 seats (mixed class), 168 seats (all economy), and 180 seats (high-density It will be equipped with a new generation aero-engine, more advanced than existing aircraft. It was recently announced that CFM's new LEAP-X1C engine would be the power plant. The design has been set the ambitious target of achieving a 10% less cost of ownership than B737/A320 models, and a 50% reduction in carbon emissions. In March 2007 while announcing the strategy & program, the central government clearly stated that China would seek international co-operation. As noted above the engine is being sourced internationally and it is expected that airborne systems and materials will be open to international partners and selected by competition. The C919 is planned to have its maiden flight at the end of 2014, and to be delivered to the users after achieving Airworthiness Certification in 2016. The engineering mock-up began in September 2009 and the sections of the major structure of are expected to be finalized soon. Some estimate that the development program should take about 10 years, with a budget of 30-50 billion Yuan (USD 4, 42 – 7, 36 billion). The flight test would take 3 years. Therefore, it will be a significant challenge if the first aircraft is to be operational much before 2020, let alone the planned 2016.

COMAC signed MOUs with 9 domestic fuselage suppliers, including AVIC, in May 2009. These included AVIC Xi'an Aircraft Company, AVIC Chengdu Aircraft Company, AVIC Shenyang Aircraft Company and AVIC Harbin Aircraft Company as well as AVIC Hongdu Company. CASIC is also one of the suppliers.

The 1st tier suppliers of engines and airborne systems will be foreign, in order to assist with meeting the ambitious in-service date. The RFI for this was given to overseas suppliers in late February 2009. COMAC at the moment is reviewing all the RFIs that have been submitted by foreign suppliers and a decision on the successful bids will be made by the end of 2009. Once the system suppliers are chosen, they will start to conduct joint concept design work.

Now, the procedure of suppliers select was finished and the suppliers are presented in the figure below.

Table 21: C919 suppliers

System/Equipment	Supplier	Country
Fuselage - nose section	Chengdu Aircraft Industrial	China
Fuselage - foreward & aft (barrels)	Jiangxi Hongdu Aviation Industry Corporation Ltd.	China
Empennage (Tail section)	Shenyang Aircraft Corporation	China
Fuselage mid section, wing boxes, spoilers, ailerons, flaps, and slats	Xi'an Aircraft Industry Company Ltd.	China
Turbofan Engines	CFM International Inc. (LeapX engine)	USA/France
Engine nacelles and thrust reversers	Nexcelle (GE)	USA/France
Engine exhaust systems	Nexcelle (GE)	USA/France
Auxiliary Power Unit (APU)	Honeywell (131-9(C9C) APU)	USA
Electric power generation & distribution systems	Hamilton Sundstrand Electric Systems	USA
Starter-generators	Honeywell Aerospace	USA
Fuel tanks and systems	Parker Aerospace Fluid Systems Division	USA
Hydraulic Systems & Equipment	Parker Aerospace Hydraulic Systems	USA
Fly-by-wire flight control actuation system	Parker Aerospace	USA

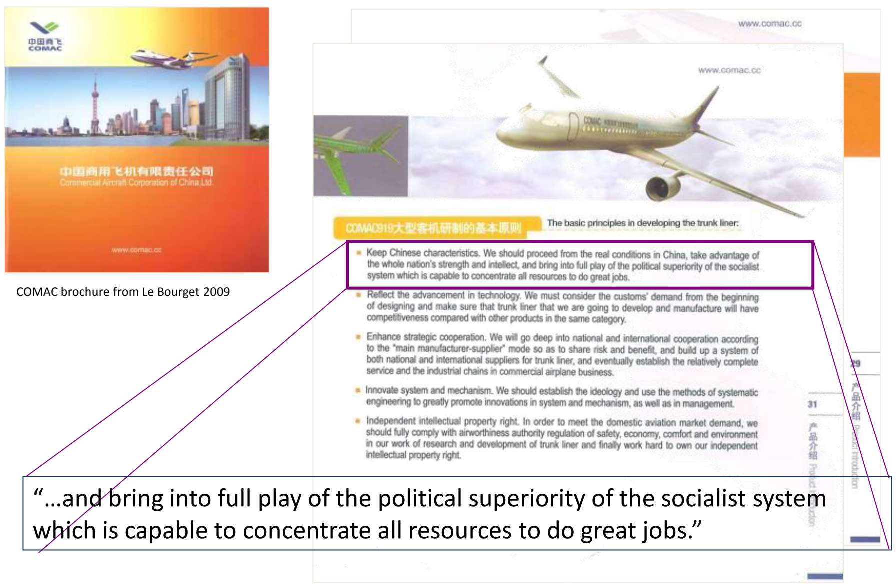
Source: COMAC, Laurent Rouaud

The C919 is anticipated to provide some benefits in terms of performance and economic compared with the current A320 and 737. The capacity of the Chinese industry to integrate an aircraft is certainly within reach. It will depend on China ability to understand global requirements, design compelling and reliable aircraft, and to develop program management, supplier integration and after market support capabilities.

Component		C919 Readiness	2025 Readiness	Experience
Metallic wing	Research: design & develop	yes	yes	military aircraft and ARJ21
	Manufacture	yes	yes	experience from A320 and ATR wing manufacturing
Composite wing	Research: design & develop	no	yes	none
	Manufacture	no	yes	Prime focus of several key research programs
Metallic fuselage	Research: design & develop	yes	yes	ARJ-21, MA-60, military programs
	Manufacture	yes	yes	MD-90, ARJ21, MA60 and military programs
Composite fuselage	Research: design & develop	no	no	none on carbon pressurized fuselage; experience to be build with Airbus Cooperation ABEC
	Manufacture	no	Very likely	On-going research programs
Metallic Empennage	Research: design & develop	yes	yes	military and commercial programs
	Manufacture	yes	yes	military and commercial program
Composite Empennage	Research: design & develop	no	yes	On-going research programs
	Manufacture	no	yes	experience from the Boeing 787
Under carriage Metallic	Research: design & develop	no	likely	Military ,ARJ, and MA
	Manufacture	yes	yes	Military ,ARJ, and MA
Under carriage Composite	Research: design & develop	yes	likely	No experience – complex part
	Manufacture	yes	yes	Experience from wing

The composite application know how for the wing, empennage, and fuselage will be critical for future aircraft development. COMAC would have to develop the capability to become a major supplier of composite structure design and manufactures. It is doubtful that the product support organization be in place for the delivery of the first aircraft. Secondly, one of the biggest challenges will be the ability of COMAC to bring together a marketing organization that will be able to succeed in placing the aircraft outside of China. The odds seem slim in view of the current activity in the market. The chart below is an extract of a marketing brochure presenting the aircraft to the western customers.

COMAC919 Marketing



COMAC brochure from Le Bourget 2009

VIII The aviation clusters in China

Seattle, Toulouse and the North-west England region are the three largest large civil aircraft clusters of the western world. According to Hickie (2006)[124], they particular location can be traced back to experienced engineers who had some strong local connections and passion for aviation. In North-west England, the origin of the LCA industry came from the creation of A.V Roe Company in 1910 by Alliot Roe in the basement of his brother's Manchester mill. In Toulouse, Emile Dewoitine set up his aircraft company in 1921 in a warehouse. He had some experience in manufacturing in World War I and started quickly by receiving military contracts. Bill Boeing set up his aircraft factory in a boatyard, to build airplane for his own amusement. According to Maoui (1999)[125], all three regions developed from small scale operation to large companies because they were competent and fortunate enough to receive a early boost from large military contract.

VIII-1 The theory of clusters

According to Niosi and Zhegu (2005) [126]clustering and dispersion of industry are submitted to two opposing forces: a centripetal force that tends to concentrate industry in a few geographical locations, and a centrifugal force that tends to disperse industry across regions and nations. A partial typology of clusters could consist of six groups: (1) industrial districts (the Marshall tradition), (2) regional poles (the Perroux model), (3) local knowledge spillover , (4) local and regional

[124] Hickie Desmond (2006), Knowledge and competitiveness in the aerospace industry: the cases of the Toulouse, Seattle and North-west England, European Planning Studies, Volume 14, number 5, June
[125] Maoui (1999), Aerospatiale, Perrin, Paris
[126] Niosi Jorge and Zhegu Majlinda (2005) Aerospace clusters: local or global knowledge spillovers?, Industry and innovation, volume 12, number 1, page 5-29, March

systems of innovation, (5) Michael Porter's diamond applied to innovative clusters and (6) anchor firm cluster.

The Marshall's district is the agglomeration of small and medium size companies in the same or related industries. Universities, vocational schools, government policies and public laboratories play a small role in the district. According to Meardon (2001)[127], they include firms that are self organized and compete in the same markets

The regional poles are based on Perroux work and consist of clusters built around industrializing industries such as transportation equipment. There are made of part manufactures and component as well as metal, glass, and producers that use this material. This type of clustering do not requires universities or local laboratories.

In the late 1980s and 1990s, academic cluster research[128] focused on the US. There were mostly local knowledge spillovers with non market scientific and technological leakages from research and public laboratories.

The local and regional systems of innovation emphasized the dynamic between several organizations and institutions such as innovative firms research universities, public research, institution and government incentives. As Cooke and Morgan (1998)[129] described, these clusters are have the full panoply of innovation organization set in an institutional environment where systematic links among the innovator actors is common.

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[127] Meardon S (2001), Modeling agglomeration and dispersion in city and country : G. Myrdal, F. Perroux and the new economic geography, American Journal of Economics and Sociology, volume 60, number 1, page 25-27

[128] Feldman M (2000), Location and innovation : the new economic geography of innovation, spillover and agglomeration, in G.L Clark, M Gertler, M.P Feldman and K Williams (Eds), The Oxford Handbook of Economic Geography, page 559-579, Oxford University Press, Oxford

[129] Cooke P and Morgan K (1998), The associative economy, Oxford University Press, Oxford

Michael Porter (1998)[130] suggested a cluster model as geographical concentration of interconnected companies and institutions in a particular field or industry.

Finally, the cluster that is anchored by a particular firm or firms has been developed by Feldman (2003)[131]. For this type, the clustering is driven by the anchor firm that attracts human capital and suppliers and provides knowledge spillover.

Niosi and Zhegu (2005) great cluster analysis concludes that the aerospace clusters of Seattle and Toulouse were originally regional poles as described in the Perroux model, but have evolved towards a district Marshall model. Suppliers were first attracted by the prospect of selling part to the large firm in the cluster (Airbus or Boeing) but progressively became more global and diverse market players. In the Toulouse and Boeing clusters, the roles of universities and government laboratories in innovation are secondary.

VIII-2 The Chinese clusters

The Chinese government, the defense industrial authorities, and AVIC have been drafting the national reforms and plans to make China a world major player in aviation within the next 10-15 years. The strategic plan includes the development of aviation clusters throughout China. The clusters location have been driven by

- the education and people resource
- the transport infrastructure
- the economic development of the area

The strategic planning involves several administration and processes:

[130] Porter M (1998), Clusters and the new economics of competition, Harvard Business Review, November-December, page 77-90

[131] Feldman M (2003), The location dynamics of the US biotechnology industry: knowledge externalities and the anchor hypothesis, Industry and Innovation, volume 10, number 3, page 311-328

- A medium and long-term civilian aviation development plan currently being finalized by the Ministry of Industry and Information Technology (MIIT)

- A long-term corporate plan done by AVIC in 2009 that sets out key priorities to 2016;

- The 12th Five Year defense industrial program drafted by the State Administration for Science, Technology and Industry for National Defense (SASTIND) that will begin in 2011;

- The civilian and defense versions of the 2006-2020 Medium and Long-Term Science and Technology Development Plan promulgated by the State Council and SASTIND's predecessor. These state-level plans help to locate the aviation industry within the overall national development priorities and also serve to promote the coordination and integration of civilian and military activities.

While some of these plans are classified, especially those related with military activities, their key elements and contours can be analyzed. First, the long-term building of a world-class civilian airliner industry is a key strategic priority for the Chinese authorities. Their process consist of a cautious step-by-step process of building more advanced and larger airliners with increasing levels of local technological content. The first two stages of this plan have already been laid out with the development of the 70-110 seat ARJ21 trunk liner, which is now undergoing flight testing, and the COMAC C919 airliner, which is scheduled to fly for the first time at the end of 2014. Only 10 percent of the ARJ21 will be local in content while the target for the C919 is 30 percent. The third stage is the development of a two aisle wide-body airliner after 2020.

A second major goal contained in these plans is the construction of a new geographical structure for the civilian aviation industry with specialized clusters concentrated in the Pearl and Yangtze River Deltas in South and East China and the

Bohai Rim centered on Tianjin. A commercial engines base will be established in Shanghai, generation aviation operations in Zhuhai, Guangdong Province, and helicopters in Tianjin. These new clusters are intended to complement the existing military-intensive aviation industrial complex that was built in the Maoist era and is concentrated in the country's interior, such as Xi'an, Chengdu, Shenyang, Guizhou, Nanchang and Harbin.

The seven China aviation clusters:

1. Xian
2. Chengdu
3. Shenyang
4. Tianjin
5. Guiyang
6. Nanchang
7. Harbin

In general, aviation industry clusters represent geographic concentration of interconnected aeronautics enterprises that share related production inputs, specialized labor pools, distribution and communication channels, and network association. They can be characterized as being networks of production of strongly interdependent firms (including specialized supplier), knowledge producing agents (universities, research institutes, engineering companies), bridging institutions (brokers, consultants) as well as distribution channels and customers, linked to each other in a value-adding production chain. The aviation cluster approach focuses on the linkages and interdependence between actors in the network of production when producing products and services. In recent years, this view has also motivated more and more policy makers and economic development practitioners to turn to cluster-based concept as new tools to strengthen regional economies.

In China, two types of aviation clusters can be identified.

<u>1. Clusters that emerged from the demand of China defense in the 1950s through 1970s.</u>

Xi'an, Chengdu, Shenyang, Guiyang, Nanchang and Harbin, were selected by the China's government in the 1950s. The construction of several aircraft factories which were to produce primarily military aircraft for the People's Liberation Army Air Force (PLAAF) and the air component of the PLA Navy. These cities are located in the inland of China, with rich natural resources, which are changing their roles and the aviation clusters have begun to take shape.

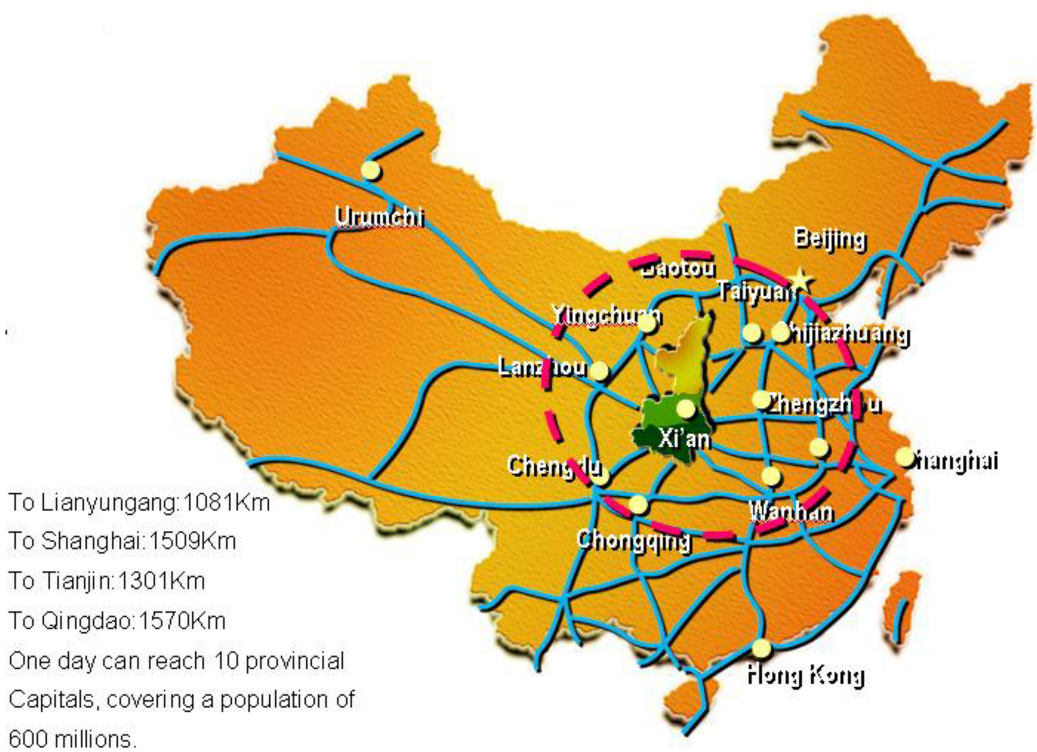
<u>2 Clusters that emerged in the 1990s following the growing demand of air travel in China</u>

Shanghai and Tianjin clusters which lie on the coasts were developed for the commercial aircraft markets.

The cluster analysis that follows presents the first systematic mapping and analysis of regional aviation clusters in China.

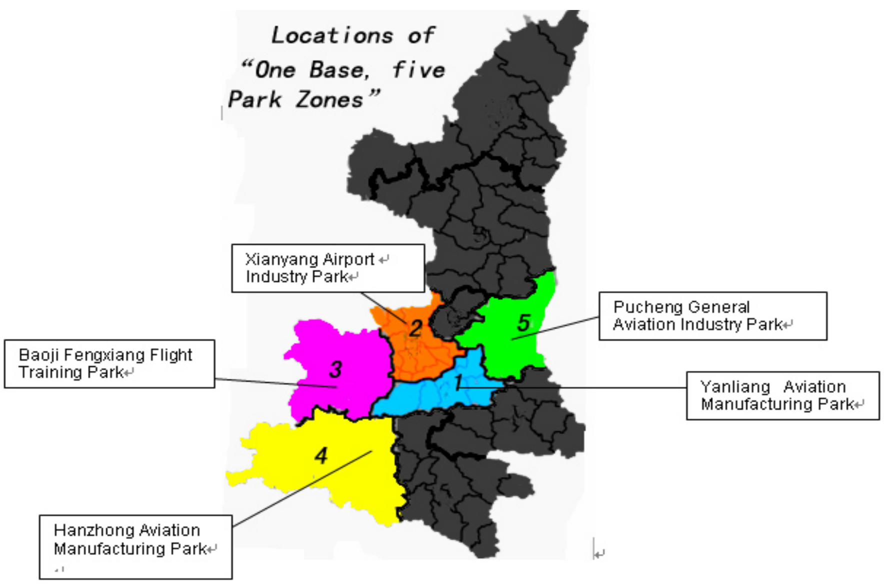
VIII-3 The Xi'an aerospace cluster

The Shaanxi Province has a population of 37.6 million people centrally located in China mainland. The province is considered as one of the most advanced industrial sectors in China in the area of aviation, aerospace, machinery, electronic, and energy. It is considered the number one Chinese province in terms of equipment manufacturing. Over the last five decades, Shaanxi has emerged as the number one aviation industry province in China.



The Shaanxi province is rich in technical and research expertise in aviation, possesses a qualified human resource, a full aerospace industrial expertise, and has had success with its dynamic international cooperation. The province has 10 colleges and universities and 4 vocational & technical colleges specialized in aviation. As many as 20,000 students graduate in aviation every year. There are 41 aviation companies and public institutions that employ approximately 150,000 people. Shaanxi has 6 states key aviation-related laboratories, 7 key laboratories for national defense, 4 state specialized laboratories, and over 20 provincial additional laboratories as well as a few national aviation technology development centers. Shaanxi is also the only province in China, which has two companies that final assemble aircraft. Over the last 20 years the province has succeeded in building a solid aviation industry with R&D capabilities, manufacturing parts, performing aircraft final assembly, doing flight test and strength test, and providing aviation training. Shaanxi also pioneered in launching the first international cooperation in the aviation industry in China. It has become a major subcontractor province for all aircraft manufactures. The subcontracts has been growing at a speed of 35% per year, representing as much as 50% of the aerospace subcontract in China.

<u>The foundation of the cluster Aviation cluster</u>



Building the national aviation industry base in Shaanxi reflects the sixteen Party's National Congress on the development of the western region. Relying on the advantageous aviation resources established over the last decade in Shaanxi Province, the China Aviation Industrial Base integrates airport resources and industry resources of the Guanzhong Region (Central Shaanxi Province) to make the "One Base, Five Park Zones" vision.

"One Base" is China Aviation Industrial Base (CAIB) while the "Five Park Zones" include (1) Yanliang Aviation Manufacturing Park, (2) Xianyang Airport Industry Park, (3) Pucheng General Aviation Industry Park, (4) Baoji Fengxiang Flight Training Park and (5) Hanzhong Aviation Manufacturing Park. These 5 parks represent the Xi'an aerospace industry cluster.

The CAIB had 253 enterprises in the cluster, of which 17 foreign enterprises, 236 domestic enterprises, and a total industrial investment of more than 30 billion Yuan (USD 4.4 billon). China aerospace companies within the Xi'an province have established contractual relations with more than 20 well-known international aviation enterprises such as Boeing, Airbus, and GE. In 2006, the aviation companies in the cluster exported 275 million USD aviation related goods.

The CAIB have decided to invest in three areas:

- OEM and major projects: focuses on main-line aircraft, regional aircraft and general aviation, promote large aircraft project such as the serial production of ARJ21 Aircraft and Xinzhou Aircraft, the manufacturing of Little Eagle series aircraft. It also focuses in establishing foreign manufacturer production lines of advanced aircraft type that fits the Chinese airline market.
- Component suppliers: focuses on supplying component for aero-engine, system, avionic, invest in R&D for central of landing gear and new material capabilities in ceramic matrix composites, carbon fiber composites.

- Support: focus on modification and maintenance of aircraft, international cooperation to expand the aviation maintenance business, forming strong aviation service capability.

In 2004, the National Development and Reform Commission officially approved the overall development plan (Fagaigaoji [2004] No.1679) of Xi'an Yanliang National Aviation Hi-tech Industries Base. Xi'an Yanliang National Aviation Hi-tech Industries Base was launched officially in March 2005. It is the only national hi-tech industry base integrating aviation R&D government labs, aviation manufacturing firms, aviation universities and vocational education, aviation equipment manufacturing and aviation services firms.

The National aviation industry base is comprised of the Core District and the Expansion District. Yanliang is in the Core District of the national aviation hi-tech industries base. The Core District is responsible for design, manufacturing, and test flight. The Expansion District is in the Guanzhong Area of Shaanxi Province, covering the aviation-based enterprises surrounding Xi'an, is responsible for R&D.

Capabilities in the area of flight test, hydraulic press, high-performance carbon fiber, flight simulators are being developed. In addition, eight key materials and techniques for large aircraft manufacturing have been identified. As a result, national, provincial and municipal engineering centers have been funded and are in operation today. These research centers include: the Manufacturing National Engineered Research Center, the Ultra-High Temperature Composites Engineering Center, the High-Performance Carbon Fiber Engineering Laboratory, the Silicon Carbide Material Engineering Center, the National Defense Science & the Technology Electric Research Center.

Major Chinese aerospace firms in Shaanxi province:

Enterprise	Scope	Activity/Products
AVIC Xi'an Aircraft industry (Group) Co., Ltd	largest manufacturing of large military and civil aircraft in China	More than 30 different types of commercial and military aircraft.. Commercial aircraft: Y7 series and Shenzhou 60 (MA600) (more than 170 orders) , MA700 entry into service in 2015. Military aircraft: Leopard, B6 series bomber
AVIC Shaanxi Aircraft Industry (Group) Co., Ltd	research & development center for large military and civil transport aircraft and special dedicated aircraft.	Aviation Manufacturing, automobile
AVIC Landing Gear advanced Manufacturing Corp Liaoyuan Aero-mech Corp	research & development center and manufacturing of aircraft landing gear	Plane landing gear, hydraulic attachment, shock absorbers, Manufacturing, machining, vacuum heat treatment, NDT, vacuum welding
AVIC Shaanxi Qianshan Aviation Electronics Co., Ltd	research & development and manufacturing of aircraft flight data management system.	Manufacturing, research and sales of systems.
Xi'an Aero-Engine (Group). , Ltd	manufactures aero-engines	turbo engine/ manufacturing
	ZEMIC is a high-tech enterprise,	26 models load cells have gained OIML certificates and 4 models

AVIC Electronic Measuring Instruments Co., Ltd	producing the electronic measurement products such as strain gages, load cells, airplane weighing systems, highway weigh pads and automobile test facilities.	load cells have gained NTEP certificates; 79 models load cells have gained the approvals in Ukraine; 52 models load cells have passed the metrology type approval in Russia; 68 models load cells gained the anti-explosion certificates, 71 models load cells gained CE certificates, 57 models load cells gained FM (for US) and CFM (for Canada) certificates, 58 models load cells gained European ATEX anti-explosion certificate.
AVIC Xi'an Aero-engine Controls Company	develop and produce aero-engine fuel control systems, aircraft hydraulic units and high-tech industrial electro-mechanical products	More than 50 models covering 150 types of fuel control systems for aero-engines
AVIC QING'AN GROUP CO., LTD.	firm established as one of 156 key projects during the first-five year plan of China. has established a state level R&D center of aeronautic and aerospace airborne equipments	Mechanical, hydraulic, pneumatic, electronic/ electric equipments and control systems.
AVIC Shaanxi Hongyuan Aero Forging & Casting Co., Ltd	specializing in forging and casting.	Aerospace, military, ship, , transportation, and electrical industry.
Shaanxi Aero Electric Co., Ltd.	Electric power supply system and engine ignition system in China.	Specializes in researching; developing and manufacturing main power supply systems, secondary power supply systems

		and engine ignition systems for all kinds of airplanes.
AVIC Huaxing Aircraft Wheel Corporation	one of the 156 major projects in "The 1st Five-year Plan", research, manufacture aircraft wheels and brake accessories	Machining, rolling, cold and hot-treating stamping, ferrous and non-ferrous forging and casting, can also produce non-standard equipment, tools, powder metallurgy products plastic and rubber products.
AVIC Baocheng General Electronic Co., Ltd.	Design, research and development of aviation and navigation gyro instruments and other products	

Source: AVIC, Chinese website, Aviation press, Laurent Rouaud

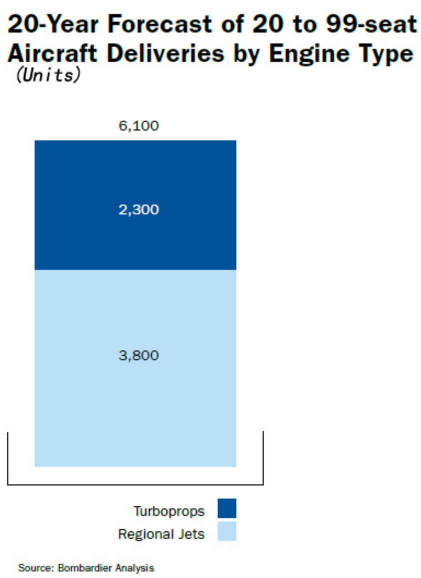
AVIC Xi'an Aircraft Industry Company Limited (XAC)

XAC is the largest aviation firm in China whose activities spans from research to aircraft production, under the leadership of AVIC Aircraft Company Limited. XAC is based in Yanliang District, employs 19,000 people with a total annual operating income of over RMB 10 billion.

From its inception in 1958, XAC primary responsibility is to develop and produce military and commercial airplanes. XAC has successively developed and manufactured more than 30 different types of commercial and military aircraft. Military aircraft include the Flying Leopard and B6 series bomber. Its current commercial aircraft include the Y7 series and turboprop regional MA series. XAC has become a high-tech industry group with products in aviation, automobile, and electronics.

XAC was the first Chinese aviation company to step into the international market in 1980, and successively cooperates with global aircraft manufacturers such as Boeing, Airbus, and Bombardier. XAC is the largest Chinese aerospace component manufacturers. XAC has successively invested and established more than 30 enterprises including the Xi'an Silver Bus Corporation, Xi'an Aircraft Industry Corporation, and XAC Import and Export Corporation whose products include large-sized luxury Silver bus, aluminum extrusion, metal architectural panel, aluminum doors and windows, and electronics.

Figure 99: Demand for small aircraft-World



Bombardier and China Aviation Industry Development Research Center forecast that 6,100 regional aircraft will be delivered over the next 20 years worldwide of which 2,300 would be turboprop aircraft. Regional aircraft account for just 12 percent of China's aircraft.

XAC has successively developed and manufactured the MA turboprop regional jet series such as MA60, MA600, and MA700. To date, the MA600 has received more than 170 orders. The 60-seat MA600, an improved version of the MA60, is 300 kilograms lighter, and 40 percent more fuel efficient than the MA60. The MA series competes with the ATRs and the Bombardier Q Series.

Main characteristics of the MA series:

	MA 60	MA 600	MA 700
General characteristics	**Crew:** 2 **Capacity:** 60 passengers **Length:** 24.31 m (81 ft 0 in) **Wingspan:** 29.20 m (95 ft 11 in) **Height:** 8.89 m (29 ft 2 in) **Wing area:** 75 m^2 (807 ft^2) **Power plant:** 2× Pratt & Whitney Canada PW127J Turboprop, 2052 kW (2750 shp) each	**Crew:** 2 **Capacity:** 60 passengers **Length:** 24.708m () **Wingspan:** 29.200m () **Height:** 8.858m () **Empty weight:** 13,730kg () **Max takeoff weight:** 21,800 kg **Power plant:** 2× Pratt & Whitney Canada PW127J turboprops, 2,148 kW (2,880 shp) each	**Crew:** 2 **Capacity:** 70-80 passengers **Length:** 30 m

Performance	**Maximum speed:** 514 km/h (278 KTAS) **Range:** 1,430 km (775 nm) **Service ceiling:** 7,622 m (25,000 ft)	**Maximum speed:** 514 km/h (278 KTAS) **Range:** 1,430Km (775 nm) **Service ceiling:** 7,622 m (25,000 ft)	**Maximum speed:** 650 km/h
Market	30 MA60 currently in service in Africa, Asia and Latin America	170 orders from Africa, Asia and Latin America	Extension of MA600 family
Delivery time	The first aircraft was delivered to Sichuan Airlines in August 2000	first delivery to the Civil Aviation Flight University of China in Sichuan Province.	Entry into service in 2014

Source: AVIC

<u>XAC main products</u>

Turboprops	MA60 turboprop airliner MA600 turboprop airliner
Bombers	Xian H-8 stealth, strategic, heavy bomber Xian JH-7 Flying Leopard twin engine fighter-bomber. NATO codename "Flounder"

	Xian H-6 twin engine bomber - Chinese-upgraded variant of the Tupolev Tu-16 Badger
Trainers	Y-7H trainer based on Y-7-100
Parts	COMAC ARJ21 Xiangfeng -wings and fuselage Boeing 737 Next Generation vertical fin Boeing 747 trailing edge ribs, floor beams, detailed parts, and subassemblies Boeing 747-8 trailing edge flaps Airbus access doors for wide-bodied aircraft , wing fixed trailing edges, medium air ducts
Military Transport Aircraft	Yun-7 (Y-7) twin-engine turboprop transport Yun-14 (Y-14) twin-engine turboprop transport Xian Y-20 four-engine turbojet transport

Source: AVIC, press, Laurent Rouaud

<u>XAC takes over Austrian manufacturing FACC</u>

XAC is the majority share holder (91.25%) of the Austrian aerospace manufacturer FACC. XAC bought FACC with another Hong Kong base firm Hong Kong ATL. At the time of the acquisition, it was the largest Chinese acquisition in Central Europe. It also marked XAC strategic goal to invest outside of China in regions that have had a long aerospace experience.

XAC international cooperation started with all the major aircraft manufacturers. The cooperation has evolved from a pure supplier relationship to a more strategic partnership relationship with Airbus and Boeing. On January 26; 2010, XAC delivered the 1,500th vertical fin for Boeing's 737 aircraft and signed an extended contract to supply another 1,500 units to the US aircraft manufacturer.

The extension of the contract showed that XAC is capable of producing large-size aircraft components in large volume for leading international aviation manufacturers. The first contract for producing 1,500 units of the 737 vertical fins was signed in 1996. XAC is currently able to produce up to 24 vertical fins per month. Since Boeing manufactures 31 B737s planes per month, nearly two-thirds of the newly delivered 737s worldwide fleet are equipped with vertical fins produced by XAC.

XAC also produces wings for Airbus A320 airplanes. The A320 wing is the largest and most complicated aircraft component a Chinese company has ever made. China is Airbus' only wing manufacturer outside Europe. XAC is also a major supplier to China's build regional jet ARJ21 and large commercial passenger aircraft C919 by manufacturing the fuselage and wings.

AVIC Shaanxi Aircraft Industry (Group) Co., Ltd

AVIC Shaanxi Aircraft Industry (Group) Co., Ltd (SAC) located in Hanzhong city of Shaanxi Province and under the leadership of AVIC Aircraft Company It is a military company founded by Chinese authorities in 1969 to manufacture transport aircraft.

SAC has over 10,000 employees including 3,600 managers and technicians, 404 senior engineers and 130 skilled workers. SAC has over 4,000 machine tools, including 60 large high precision milling machines. SAC is believed to have the largest aircraft assembly capability in China and all special equipment required to build large aircraft parts and other components.

Figure 100: Y-9

The Shaanxi Y-9 (Yun-9) aircraft is a medium sized, medium range transport aircraft produced by SAC. The aircraft was developed as a stretched version of the Shaanxi Y-8F with greater payload and range. The Y-9 is considered China's attempt to build a C-130J class transport aircraft.

Originally known as the Y-8X project, the development of Y-9 began in 2000 to produce a C-130 class transport intended to replace the older Y-8. Shaanxi Aircraft Industry showed models of the aircraft as Y-9 at the 2005 Beijing International Aviation Expo, to promote its use as a civilian transport. The development has had various technical challenges. As a result, the first flight slipped from 2006 to 2008. The Y-9 is powered by four turboprop engines, and equipped with 6-bladed composite propellers. The tail ramp is designed to handle vehicle cargo. The aircraft is capable of transporting 25 tons of cargo, or configured with about 100 troop seats in troop transport. The design was reported frozen in January 2010. No aircraft has been manufactured since then.

Y9 Specifications:

Flight crew: 4

Cargo cabin size: (length/width/height) 16.2m/3.2m/2.35m

Empty weight: 39,000kg

Maximum take-off weight: 77,000kg

Overloading take-off weight: 81,000kg

Payload: Normal 25,000kg; Maximum 30,000kg; or 132 armed paratroopers; or vehicles and weapons

Cruising speed: 600~650km/h

Cruising altitude: 9,000m

Range: Ferry range with max payload 7,800km

Flight length: 12 hours

AVIC Landing Gear Advanced Manufacturing Corp Liaoyuan Aero-mech Corp (LAMC)

Founded in 1966, as a member company of AVIC, LAMC specialize in the design and manufacturing of landing gears for large and medium sized aircraft, hydraulic accessories, and rubber and plastics products. LAMC is located in Hanzhong city, southern Shaanxi Province and employs 2,700 people. LAMC use all tooling and testing to manufacture landing gears following the strict requirements of American Military Standards (MIL), Boeing standards (BAC, DPS), French Aerospace Standards, Messier-Dowty Process Specifications, British Standards (BS), and the Russian standards.

LAMC possesses all the advanced measurement and test equipment and quality control means essential for hydraulic and pneumatic products, which can be used to carry out air tightness, strength, life cycle, performance tests and other special test at different high and low temperatures. LAMC has established and implemented effectively a rigorous quality system. It had its quality system accredited GJB/Z9001 and certified in 1996, and ISO9001 certified 1998. In 1998, LAMC became one of Messier-Dowty's Acceptable Suppliers.

Since its establishment, LAMC has produced landing gears, hydraulic accessories and spare parts for most of China's aircraft program, and has succeeded in establishing business relationships with all western landing gear manufacturers to carry out subcontracted production of parts and assemblies.

In the field of civil hydraulic products, LAMAC has successively developed and produced pumps and valves for mining, metallurgy, automotive, forklifts as well as equipment and spares parts for textile, chemical woodworking machineries.
LAMC works closely with over one hundred companies in China and abroad, on both civil and military applications.

AVIC Xi'an Aero-Engine Ltd. (XAE),

Founded in 1958, is a state-owned large scale base for the manufacture of aero-engines and one of the top 1,000 large enterprise groups in China. XAE has developed and manufactured turbojet and turbofan engines as well as turbo starters, turbo generating units, and industrial and marine gas turbine. It has also successfully completed several top scientific research and trial production programs relating to aerospace, marine and nuclear industries.

XAE has invested in innovation and possesses today a number of intellectual properties. In 2001, XAE was restructured into a limited liability company called Xi'an Aero-Engine Group, which is modeled on a parent-subsidiary system having Xi'an Aero-Engine (Group) Ltd. as its parent company AVIC Aircraft Company Limited is the majority shareholder and China Huarong Asset Management Corporation is an equity participant.

GE Aviation celebrates 25-Year Cooperation with XAE

XAE and GE have been cooperating on engines for more than 25 years. In May 2009 XAE delivered its first high pressure turbine (HPT) disk for GE's CF34 and CFM56 engine models and celebrated 25 years of cooperation between the two companies.

The cooperation between GE Aviation and Xi'an Aero Engine started back in 1984 when Xian Aero Engine received the first order from GE for a low-pressure turbine disk for a gas turbine. With the strong support from executive teams from both sides and the collaboration of the GE project team, the delivery was fulfilled with good quality. In 1998, the Xi'an Aero Engine Disk and Ring Factory were established in order to meet the requirement of the growing orders from GE. The dedicated production line provided guaranteed delivery for GE parts. Currently, Xi'an Aero Engine is producing over 100 GE part numbers, covering shaft, disk, ring, and seals that are used on multiple marine and aircraft engines. In 2008, Xi'an Aero Engine delivered $83.6 million worth of parts to GE, which represents a 35% increase from 2003. The relationship with GE has evolved from a subcontractor to a Risk Sharing Partner relationship

AVIC Xi'an Aero-engine Controls Company (AECC)

AECC developments and manufactures fuel control systems, hydraulic units and electro-mechanical products. The company has advanced digitalized precision machining, special processes, advanced metrology equipments. AECC is approved by 4 international aerospace companies' quality standards in USA and UK.

Since its establishment 50 years ago, the company has successively developed and produced more than 50 models covering 150 types of fuel control systems for aero-engines. At the same time, through the implementation of its strategy for core technology radiation, the company has successfully extended its business in some adjacent fields such as space flight, controls of combat vehicles, repair and overhaul for airlines and sub-contract production of aerospace products for international companies.

AVIC QING'AN GROUP CO., LTD.

Affiliated to the AVIC Aircraft Company, Qing'an Corporation was established in 1955 as one of 156 key projects during the first-five year plan of China. Today, Qing'an is one of 512 key state-owned enterprises supported by the government. Qing'an has established a state level R&D center engaged in the research and production of aeronautic and aerospace airborne equipments, including mechanical, hydraulic, pneumatic, electronic/electric equipments and control systems. It has strong research & development ability and modern production capacity in integrated system. Its expertise includes mechanical, electronic, hydraulic technologies, flight control system as well as in rubber seals, engineered plastics, special welding, special casting, complex mould of non-conventional shape. It has gained the ISO9001 quality certificate.

AVIC Shaanxi Hongyuan Aero Forging & Casting Co., Ltd (HYFC)

HYFC, founded in1965; specialized in forging and casting. It has a 640million Yuan capital, and employs 3,500 people with 300 aerospace. Its possess CAD capability. Its expertise covers forging and precision forging using steel, Al-alloy, copper-alloy, mg-alloy, Ti-alloy and super alloy. Its largest customers include Boeing, BF Goodrich, Rolls Royce, Airbus, Toshiba, and Siemens Its export turnover is about $6million annually.

Shaanxi Aero Electric Co., Ltd. (SAEC)

SAEC is part of AVIC and is the leading manufacturer of aviation electric power supply system and engine ignition system in China. SAEC specializes in researching, developing and manufacturing main power supply systems, secondary power supply systems and engine ignition systems for all kinds of airplanes.

Besides the aviation electric power supply system and the engine ignition system, SAEC also has invested recently in other commercial aerospace technology. It has 4 subsidiaries: Shaanxi Qinling Special Electric Co., Ltd., Shaanxi Qinling Special Motor CO., Ltd., Shaanxi Qinhang Electrical Machinery Co., Ltd., and Shaanxi Tianchou Construction Co., Ltd. These companies are responsible for manufacturing of electric products, generators and motors, rubber and plastic products, aviation standard fixing parts, road & building construction. In 1999, SAEC set up a joint venture with the US based company Hamilton Sundstrand Aerospace named Xiamen Sundstrand-Qinling Aerospace Ltd. The major activity of the JV is the overhaul of aircraft electric power supply systems.

SAEC is located in Xingping, in the Shaanxi Province and employ 1,800 people, of which more than 300 are technical staff. SAEC is capable of doing its own R&D, and manufactures aviation electric power supply systems and aviation engine ignition systems.

It test equipment are state of the art. It includes electromagnetic compatibility testing (EMC), the three stress integrated test for temperature, the humidity and vibration test, the high-speed driving test, the 30000 meters temperature-altitude simulated test, as well as advanced physics-chemistry analysis and measuring inspection equipments.

AVIC Huaxing Aircraft Wheel Corporation

Huaxing Aircraft Wheel Corporation, built as one of the 156 major projects in "The 1st Five-year Plan". It was established for the R&D and manufacturing of aircraft wheels and brake accessories It has become an important test center for aircraft wheels and tires. It also manufactures car brake parts Huaxing is one of the 500 biggest transportation manufactures in China.

Huaxing not only has capabilities of carrying out various kinds of processing like machining, rolling, cold and hot-treating stamping, ferrous and non-ferrous forging and casting, but also can produce non-standard equipment, various tools, powder metallurgy products plastic and rubber products.

Huaxing's military products QAS and civil products QAS were approved and certificated by China New-era QS Certificate Center in 1997. It was certified to the ISO 9001 accreditation in 1998.

Huaxing manufactures wheels, brakes, hydraulic and pneumatic units for various types of aircraft, automotive wheels and brake

<u>Capability of the cluster in Research, Development and Design</u>

Shaanxi is the base for the third of China talent in aerospace. At present, Shaanxi has ten colleges and universities that focus on aviation and four vocational & technical colleges. About 20,000 students graduate per year in fields related to aviation. The cluster hosts six national aviation-related key labs, seven key labs for the national defense, four national specialized labs, over twenty key labs at ministerial and provincial levels as well as a number of national aviation technological development centers and aviation-related supporting factory.

Figure 101: Main scientific institutions

Name	***Main Business Scope***	***No, of Professional Technical Personnel***
AVIC First Aircraft Design Institute	The largest design and research institute of large and medium sized and civil aircrafts in China.	2250
AVIC Flight Test Establishment	The only national research and qualification centre for flight test.	2000
AVIC Aircraft Strength Research Institute	The only base for aircraft strength research and ground strength test verification in China	1100
AVIC Xi'an Flight Automatic Control Research Institute	Flight control, and inertial navigation	1200
AVIC Xi'an Aviation Computing Technology	Aviation computer	800

Source: AVIC, press,Laurent Rouaud

AVIC First Aircraft Design Institute (FAI)

FAI was created through the merger of the Xi'an and Shanghai Aircraft Design and Research Institutes in June 2003. AVIC First Aircraft Design Institute is engaged in the development of medium and large aircraft. It is responsible for development of the Advanced Regional Jet (ARJ21) program and is a key player in China's drive to penetrate the highly competitive, commercial jet industry. AVIC First Aircraft Design

Institute aims to increase China's aircraft development capabilities and competitiveness in the global aviation marketplace. FAI headquarter is located near Xian There are about twenty design and research departments in Xi'an and 12 in Shanghai. FAI has about 2,250 employees in various aircraft projects design activities.

FAI is credited for the design of ten aircraft including the:
· Y-7, the first regional aircraft in China
· Y-10, the first large jetliner in China
· LE-500, the first light general aircraft in China.

The institute had also taken part in international co-operation in pre-development of the MPC75 and AE-100 in 1980s and 1990s, as well as the cooperation in the McDonnell Douglas MD-82 and MD-90 development. FAI was the leading design office for the Advanced Regional Jet (ARJ-21).

<u>Engineering, digital, experience</u>

FAI is capable of designing all aspect of aircraft design structure, and integrated propulsion. The institute is the pioneer user of CATIA v4-5 in 3-dimention designs, digital pre-assembly and digital mock-up in China. In aerodynamics, FAI owns CFD methods and software for analysis of structural and fluid flow problems, has capability to design and manufacture a wind tunnel test model.

<u>AVIC Flight Test Establishment</u>

The Chinese Flight Test Establishment (CFTE) is the central Chinese state testing, evaluation and certification of aircraft and helicopters. It is co-located with XAC. The CFTE is active since 1959. It does tests in flight, but also use flight simulators and other test beds, such as engine test benches or devices for testing ejection seats. Xi'an CFTE has two runways of 3400 m. The test aircraft can be instrumented for data acquisition of up to 6000 parameters. They are equipped with recorders for aircraft onboard data storage and telemetry for the monitoring in real time in ground base flight test operation center. It has also a ground resonance testing facility for all aircraft systems and on-site real-time analysis system.

AVIC Aircraft Strength Research Institute

Founded in 1965, it is the only research institute of aircraft strength and ground strength verification and testing base of Chinese aviation industry. The Institute performs structural fatigue, dynamic strength, composite materials testing, thermal strength testing, noise and comprehensive environmental testing and aircraft full-scale structural testing.

AVIC Xi'an Flight Automatic Control Research Institute

The institute established in 1960, conducts R&D on flight control and inertial navigation, aerospace vehicle control, guidance and simulation, and manufactures production of such systems. It has undertaken recent research breakthroughs in quadruple redundancy FBW systems, inertial/GPS combined navigation systems, and quadruple redundancy combined servo actuators, Fly-by-light (fiber optic) control system. R&D is also believed to be underway by the China Avionics Research Institute.

AVIC Xi'an Aviation Computing Technology (ACTRI)

ACTRI was founded in 1958, originally as the Northwest Computing Institute of the Chinese Academy of Science, and now belongs to China Aviation Industry Cooperation I (AVIC1). Historically, ACTRI was a national high performance-computing center. Today the institute is mainly engaged in the development of airborne and missile-borne computers, and aeronautical software. Currently ACTRI has 1,050 employees and host several research centers such as the Aeronautical Laboratory of Computational Fluid Dynamics (ALCFD). ALCFD has been established by AVIC1 in October 1995. From 1990 to 2000, ALCFD had acted as a developer of integrated software system for aerodynamics numerical simulations. Recently the research focus has been changed to the validation of CFD simulations, and aerodynamic database. Experience has been accumulated in development and application of software platform for aerodynamic numerical simulations.

Training

There are 672 research institutions (including 49 large-scale research institutions), and over 200 large-scale labs (including 55 national key labs). Although they employ some 410,000 scientific and technical personnel (including 150,000 in electronics and information fields), the cluster ranks only third in China, behind Beijing and Shanghai in terms of researchers. The R&D personnel of the cluster accounts for 22% of China.

Xi'an is an important base for China's electronic and information industry. Electronic City, situated in the south suburb of Xi'an City, has gathered 25 domestic top scientific research institutions and large-scale enterprises in the electronic information field with 4,000 scientific and technological personnel per km2.

Xi'an is also an important base for China's higher education. The universities and colleges are focused on engineering course. There are 129,000 graduates of higher education institutes each year in Shaanxi Province (including 42,000 graduates in electronic information) and 108,000 graduates of intermediary vocational schools (including 37,000 graduates in processing & manufacturing and information technology). There are nearly 3,500 foreign personnel in Xi'an, of which 60% are engaged in education and training in the local area. According to the investigation of Mercer Human Consulting, the turnover of talents in Xi'an is low. In 2003, the turnover rate of talents was 6%, and the turnover rate of professional technicians was 7%.

Table 22: Educational institutions

Educational Institution	Higher Educational Institution	Research Organization	Adult Higher Educational Institution	Non-governmental Higher educational Institution	Intermediary Vocational School	Adult Intermediary Vocational School	Vocational High School
Number	57	672	26	68	89	83	293

Table 23: Number of students by level of education

Educational Background And Number	Doctor's Degree	Master's Degree	Bachelor's Degree	Junior College	Adult Bachelor's Degree	Adult Junior College	Intermediary Vocational School
Students	8665	31625	295810	203928	146554	77223	378900
Graduates	3802	8159	69427	47757	45942	30744	107800

Source: China Statistical year book 2008

Aviation-related Schools

Northwest Polytechnic University, Xi'an (NPU)

The Aircraft Department of NPU was founded in 1952 by merging three Aeronautics Departments of Shanghai Jiaotong University, Nanjing University and Zhejiang University. The next big expansion occurred in 1970 when the Aircraft Department of Harbin Engineering College merged into the Department. With the approval of AVIC (Aviation Industries of China) and the CAAC (Civil Aviation Administration of China), the Civil Aviation Engineering College was jointly founded by NPU, AMECO (Aircraft Maintenance & Engineering Corporation) and CNWA (China Northwest

Airline) in 1994. In 2003, the Aircraft Department merged with the Civil Aviation Engineering College.

Table 24: Aviation education in the X'ian cluster

Name	Description	Main Research Scope
Department of Aircraft Design Engineering	33 faculty members, including 8 professors, 12 associate professors	Aircraft Design,
Department of Synthetic Technique and Control Engineering	7 associate professors and four lecturers.	Design of flight vehicle system,
Department of Hydromechanics	60 faculty members, including 12 professors and 16 associate professors. 15 wind tunnels in total in the department, including 6 scientific research wind tunnels and 9 teaching wind tunnels. Two are large ones: one is the low-speed wind tunnel, and the other is the high-speed wind tunnel.	CFD Applications, Flow control, Design of Airfoils and Wings, and Fluid-Structure Interaction.
Department of Aeronautical Structure Engineering	26 faculty members, includes one academician of the Chinese Academy of Engineering, ten full professors, one chair professor of the Cheung Kong Scholars Program, and 80 postgraduates.	Aircraft Design Engineering and Theoretical and Applied Mechanics for masters. and Ph.D. degree programs, five post-doctoral researchers each year.

Department of Civil Aviation Engineering	26 faculty members with seven professors, five doctor instructors and 10 associate professors and senior engineers. 93% of the faculty members are doctor or master degree holders. 16 of them have the experience of taking professional technical training programs abroad given by Boeing in USA and Lufthansa in Germany.	Civil engineering applied to aviation
Faculty and Students	The school has 40 full professors and 40 associate professors, including one members of the Chinese Academy of Engineering and four Cheung Kong Scholars appointed by the Ministry of Education. Two of them are the recipients of the Humboldt Foundation Sponsorship. There are over 1,300 undergraduate students, 299 postgraduate students, and 116 Ph.D. candidates at the school.	
Research	The school has one national key laboratory, one national specialized laboratory, and ten other laboratories, institutes and centers that give support to the Aircraft Design, Fluid Dynamics, Solid Mechanics and other disciplines.	

Xi'an Jiaotong University

The School of Aeronautics and Aerospace has five academic departments:

- Flight Vehicle Design,
- Aerospace Propulsion
- Theory and Engineering,
- Navigation, Guidance and Control,
- Manufacturing Engineering of Aerospace Vehicle.

The school has 80 full professors and associate professors, including over 146 undergraduate students, 45 postgraduate students.

Xidian University

Nearly 80 years since its foundation, Xidian University is a key national university under the Ministry of Education of China. It focuses primarily on electronics and information education and research, and also offers a wide range of academic subjects covering engineering, science, management, economics, arts and social sciences. It has been approved by the state to be one of the universities funded by "Project 211" and it is one of the 55 universities having a Graduate School, one of the 35 universities having a national demonstration School of Software and one of the 15 universities having an IC Talents Training Center. It is an essential base of IT talents training and high-level scientific research innovation. Xidian University has over 40,000 students including over 1,600 Ph. D. students and 7,600 Master students. Of its 1,696 academic research and teaching faculty members, there are over 900 professors and associate professors, who cover the range of specialties in electronics and information technology, in the fields of communication networks, signal and information processing, information security, microelectronics and mechatronics.

Air Force Engineering University

Air Force Engineering University is a multi-disciplinary, and it is one of the five universities prioritized by the People's Liberation Army (PLA). The university consists of Engineering, Missile Institute, and Telecommunications Engineering School and Science. The school trains the Air Force Aeronautical engineers, in surface to air missiles, electronic and other related fields.

Xi’an Aero Technical College

Xi’an Aero technical College, started in 1956. The college comprises 5 departments, offering 27 specialties, 36 laboratories and five comprehensive experimental bases. The departments are: Mechanic Engineering Department, Dynamic Engineering Department, Electronic Engineering Department, Computer Engineering Department and one Basic Course Department. There are 7000 students enrolling every year.

Xi'an Aeronautical Polytechnic Institute

Xi'an Aeronautical Polytechnic Institute, an institution approved by Ministry of Education China, was established in 1958. Designated as one of the 31 major polytechnics, its two campuses stand over 615 hectares in Xi'an.

The Institute offers five filled of studies :

- Aerospace and Aeronautical Engineering,
- Mechanical Engineering,
- Electronics/Electrical Engineering
- Information Technology
- Management.

With 21 specialty areas and more than 50 teaching laboratories, the Institute is regarded as a major training institution for Applied Electronics.

Financing

Xi’an has broad financing channels and a relatively complete financial system. At present, various types of financial institutions are focused in Xi’an and a more comprehensive financial system taking specialized banks and insurance companies The entry of foreign banks, such as Hong Kong Bank of East Asia, Bank of Nova Scotia, Canada, HSBS of Hong Kong etc. and the well- known accounting firms, such as Price Water House Cooper, highlights the position of Xi’an as a regional financial center and a capital market. In 2007, the deposit of the city's financial institutions reached $67 billion. The bond market is set to develop in the region to foster and develop key projects and capable enterprises to raise funds by issuing bonds.

China to encourage private capital to enter civil aviation market

In 2009, Xi'an National Aviation Industry Fund Investment Management Company Limited (Xi'an Company), China's first national-level aviation industry fund management enterprise, officially opened for business in Xi'an. Its stake holders include the Management Council of Aviation Bases, Bases Development Center, Xi'an International Trust Co., Ltd., Beijing Venture Capital Co., Ltd, and Shaanxi Industrial Investment Co., Ltd. This marks a major change to the tradition of China's aviation industry having to rely solely on state special funds for development. The move is seen as a major event in the history of the development of China's aviation industry. It marks the launch of China's first national level aviation industry fund. Private capital is being encouraged to enter China's civil aviation industry through market-oriented operations. This will change the current situation in which investment in China's aviation industry come solely from the state.

The Xi'an National Aviation Industry Fund, with an expected of 30 billion yuan (USD 4.42 billion) was jointly initiated and organized by a group of enterprises led by Xi'an Yanliang National Aviation Hi-tech Industrial Base. Over 60 percent of the fund will be used to promote the development of the aviation industry and invest in a number of enterprises and projects with development potential within the five national-level aviation industrial bases in Xi'an, Harbin, Shenyang, Chengdu and Anshun.

Basic Infrastructure of the Logistics in Xi'an

Xi'an is the largest transportation hub in Northwest China.

Highway: Xi'an is one of the cities where high-grade highways across China intersect densely. 2 main lines of national road, 3 large roads leading to west China and 5 national roads intersect here. 7 provincial highways radiate from Xi’an to the outside or surround around Xi’an. These lines connect with 10 central cities, forming a “one-day transportation circle”.

Railway: Double-track Lianyungang-Lanzhou Railway and Lanzhou-Urumqi Railway pass through Xi’an and connect with the Eurasian Continent. They join with five railway branch lines, such as Xi’an to Yuxia, to Tongchuan, to Houma, to Yan’an and to Ankang, forming the largest railway transportation hub in Northwest China.

Aviation: Xi’an Xianyang International Airport, one of the six regional hub-airports planned and constructed by General Administration of Civil Aviation of China, receives 25 international airlines. It has become a city with the largest amount of international airlines in China’s western regions.

- Lianyungang, 1,081km, 3-4 days by train, 1-2 days by automobile;
- Shanghai Port, 1,509km, 4-5 days by train, 2-3 days by automobile;
- Tianjin Port, 1,301km, one routine of freight train per week by scheduled train, 3-4 days;
- Qingdao Port, 1,570km, two routine of freight train per week by scheduled train, 4-5 days.

The Shaanxi’s aviation industry association

Shaanxi aviation Industry Association was established in 2009 by the air base administration committee and Xi'an Aircraft Industry (Group) Co., Ltd. and five other constitutions as co-sponsors. The association is a social group of aviation industry whose establishment was authorized by Shaanxi provincial government.
It is guided and supervised by Shaanxi National Defense Science and Technology and the office of aviation industry in the business. After its establishment, the association will assist the government departments in the management of the

aviation industry actively, and give advices to the industry development to relevant government department according to the actual needs in development. These advices will reflect the aspirations of members and maintain membership rights. The association also will introduce and promote advanced techniques and methods about management, organize trade affairs, exhibitions, seminar and discussion activities relevant to the aviation industry, and strengthen international exchange and cooperation in aviation industry to become a new platform for communication and cooperation among members. Today, the association has 70 members, covering the major state-owned the private aviation enterprises and their supporting constitutions in Shaanxi. The establishment of Shaanxi Aviation Industry Association has a significant and far-reaching significance for the integration and use of aviation resources in the province

Outlook of the cluster

As the largest aviation hi-tech industrial base in the country, the CAIB has always committed itself to building a platform that allows private capital to enter the aviation industry. Among all the 280 enterprises settled in the CAIB, over 85% of which are private or foreign-funded enterprises. The aviation industry truly deserves the name of “sunrise industry”

CAIB’s businesses cover aircraft manufacturing, aviation new materials, avionics, air testing, aviation maintenance, aviation parts, and aviation technical services Among them, 25 industrial projects have been completed and commissioned. These includes projects in the fields of :

- ultra-high temperature ceramic matrix composites,
- high-performance carbon fiber engineering,
- aircraft de-icing program
- engine blade manufacturing

Another 40 projects are in development. They include a large aviation forging hydraulic machine project, an aircraft simulator manufacturing R & D projects, and a fuel tank system development project. Some 30 specific targeted projects are planning to start in 2011.These projects, together with a large number of aviation technology business incubators operated by small and medium enterprises are accelerating China's capabilities in aerospace. The projects and incubators are further accelerated by the strategic integration of capital and human resources. In April 2008, as a result of a large aviation investment strategy, the CAIB initiated the "Xi'an National Aviation Industry Fund". The fund focuses on investment in aviation industry park infrastructures, either for major aviation enterprises, key aviation projects or major aviation center industrialization projects. The purpose of the fund is to facilitate and accelerate the development of the aviation industry in the region. In June 2009, Xi'an National Aviation Industry Fund Investment Management Co., Ltd. was formally established and registered with a capital of 300 million yuan (USD 44. 2 million). Since then the fund has been raising capital. In addition to accelerate its aviation capability through the construction of infrastructure, the development of talents and the establishment of funding sources, the cluster is also seeking international cooperation projects. Since 2007, CAIB has been organizing the "Xi'an Aero Subcontract Production and International Cooperation Forum" to facilitate the communication and cooperation between domestic and major international aerospace companies. In 2009 the Xi'an Aero Subcontract Production and International Cooperation Forum gathered 146 enterprises from aircraft manufactures, engine manufactures, tier-2 aerospace suppliers, training and maintenance firm, and aviation scientific research institutes.

In terms of cluster typology, the Xi'an cluster is an anchor firm model with XAC at the center. However, it also has a number of medium interconnected companies that seems to be connected. It is therefore a mix of anchor firm and Porter's model.

VIII-4 The Tianjin aerospace cluster

The output of the aerospace manufacturing industry in Tianjin reached 11.23 billion yuan, or 1.64 billion U.S. dollars, in 2009, a 14-fold increase over 2008. According to the Tianjin Municipal Commission of Development and Reform, the output of the city's aerospace manufacturing industry ranked fourth nationwide in 2009, after the Northwest China's Shaanxi Province, the Northeast China's Liaoning Province and the Southwest China's Sichuan Province. The top three's outputs were 27 billion yuan, 16.2 billion yuan and 15.7 billion yuan, respectively. Tianjin's aerospace manufacturing industry output is expected to reach 40 billion yuan (6 billion U.S. dollars) by 2011. The authority vision is to create a “China Seattle” in Tianjin. With the production of the Airbus A320 in Tianjin ramping up, the local authority’s "China's Seattle" dream began to take off.

The two major programs in the Tianjin cluster are the A320 and the helicopter JV. Last year, the new Airbus A320 Final Assembly Line (FAL) delivered eleven airplanes which output value was 3.85 billion yuan, or 564 million U.S. dollars. The Airbus final assembly line project in Tianjin will assemble and deliver 26 A320 aircraft in 2010.The helicopter joint venture between AVIC and the Tianjin municipal government reached an output valued at 6 billion yuan, or 879 million U.S. dollars.

Overview of Tianjin

Tianjin is a metropolis in Northeastern China established in A.D 1404. In terms of urban population, it is the sixth largest city of the People's Republic of China, and its urban land area ranks 5th in the nation, after Beijing, Shanghai, Guangzhou, and Shenzhen. Tianjin's urban area is located along the Hai He River, which connects to the Yellow and Yangtze Rivers via the Grand Canal in Tianjin. Its ports, some distance away, are located on the Bohai Gulf in the Pacific Ocean. The municipality incorporates the coastal region of Tanggu, home to the Binhai New Area and the Tianjin Economic-Technological Development Area (TEDA).

The nominal GDP for Tianjin was 750 billion yuan (USD 110 billion) in 2009, a year-on-year increase of 16.5%. The manufacturing sector was the largest sector (54.8%) and the fastest-growing (18.2%) sector of Tianjin's economy.

The aerospace industry in Tianjin

Aerospace is relatively new to Tianjin. In 2005, the aerospace development in Tianjin was only in the “white paper” stage. In June 2006, the National Development and Reform Commission and Airbus announced that an Airbus A320 FAL were to be located in the Tianjin Binhai New Area. The announcement marked the beginning of the aerospace development in the province. In March 2007, the Airbus A320 FAL started to be built and the 102 square kilometers Tianjin Binhai New Area Aviation Industry Park development plan began. The cluster referred to as “Aviation City.” As early as September 2008, the first Airbus A320 “made in China” was set to start assembling. Tianjin, Tianjin became the fourth city in the world to own a trunk-line aircraft assembly line after Seattle (US), Toulouse (France) and Hamburg (Germany). On May 18, 2009, with the first flight of the first Airbus Tianjin A320, Tianjin’s dream of "China Seattle" just started.

Rapidly, with the successful rollout of the A320, a flourishing aviation industry, centered on the Airbus A320 final assembly line took shape in Tianjin Airport Industry Aera of Tianjin Binhai New Area. Almost all of the aviation industry is concentrated in the 102 km2Airport Industrial Area. The area focuses on the development of aviation manufacturing, airport logistics, civil aviation science and technology, and trade exhibition.

Why did Airbus selected Tianjin?

The attractiveness of Tianjin for any aerospace companies resides in its:

- Location
- Transport system
- Sea port
- Educated work force

- High tech base or clusters for other industry
- Financing

Location, transport and Sea port

TBNA is located at the intersection of the Beijing-Tianjin city belt and the Bohai Bay Rim city belt, which serves as a main hub connecting China with overseas and links North China and Northwest based on North China, Northeast and Northwest China. TBNA has the largest comprehensive seaport in the North. TBNA has established trade links with over 300 harbors in 170 countries and regions. It is the nearest starting point of the continental bridge from Asian to Europe in North China. TBNA consists of nine functional zones:

- Advanced Manufacturing zone,
- Airport-based Industrial zone,
- High-tech Industrial Development zone,
- Seaport-based Industrial zone,
- Nangang Industrial zone,
- Seaport Logistics zone,
- Coastal Leisure & Tourism zone,
- Sino-Singapore Tianjin Eco-City
- Central Business District.

TBNA has a coastal line of 153 kilometers and a population of 2.02 million. TBNA has a rather favorable ecological environment. and a verified reserves of oil of over 10 billion tons and of natural gas of 194 billion cubic meters.

The area has one of the most modern and comprehensive transportation system (air, rail, road, sea) in the nation. Not only its trade port is the largest in North China in term of volume and the largest in China for containers and bulk cargo, but it also has a well developed train and road infrastructure Two new expressways have recently been opened: the Beijing-Tianjin-Tanggu Expressway and Tangshan-Tianjin Expressway Across and adjacent to TBNA are the Jing-Ha railway line and Jing-Hu railway line which cross north-south in Northeast China, North China, and East China. The Beijing-Tianjin high speed train link the 2 cities in less than an hour. Tianjin Binhai International Airport is for the time being the largest aviation freight center in China and plays the role of the second Beijing airport.

Tianjin human resources

Tianjin main interest for aerospace is its educated work force. Because of its size and importance, the city of Tianjin has many colleges and universities. There are over 40 institutes of higher learning in Tianjin, with a total of approximately 300,000 registered students. In addition, the nearly 1,000 scientific and technological research institutes which host over 600,000 technicians, expert researchers and scholars complement the universities research centers. The overall scientific and technological strength of Tianjin is among the best in China. There are six aerospace related higher education universities and colleges:

- Civil Aviation University of China
- Beijing University of Aeronautics and Astronautics
- CAAC-Rolls-Royce training centre
- AMECO Aviation College

- Tianjin Sino-Germany Vocational Technology Institute
- Tianjin Sino-Spanish Machine Tool Technology Training Center

The Civil Aviation University of China (CAUC)

CAUC is a state university in Tianjin, under the Civil Aviation Administration of China. The university was established in 1951 to provide civil aviation tertiary education and training for new pilots in China. It is next to the Tianjin Binhai International Airport. It has 11 research institutes, covering almost all the disciplines. CAUC research focuses in flight safety, aircraft and engine failure diagnosis, and air navigation systems. CAUC is well equipped with 4 test facilities, 18 labs, 4 teaching & research labs, and possesses 19 trainer aircraft and 30 types of aircraft engines. The university has strong foreign cooperation and exchanges with the International Civil Aviation Organization (ICAO, the UN body for international regulations and international standards in civil aviation), the International Air Transport Association (IATA, an airline association regrouping most international airlines), the Association Européenne des constructeurs de matériels aéronautiques (AECMA), the US Federal Aviation Administration, the Joint Aviation Authorities (JAA, representing the civil aviation regulatory authorities of a number of European States co-operating in developing and implementing common safety regulatory standards and procedures), Boeing, United Airlines, Pratt & Whitney, Roll-Royce, Airbus, as well as aviation universities and research institutes in Britain, USA, France, Russia and Australia. Many foreign experts or scholars are invited to deliver lectures. The university is composed of nine colleges, five departments or sections, seven master specialties, seventeen undergraduate specialties, fifteen high-level vocational courses as well as continuing education specialist courses in aviation. Among them are:

- College of Aeronautical Mechanics and Avionics Engineering
- College of Air Traffic Management
- College of Transportation Engineering
- College of Safety Science & Engineering

- College of Computer Science and Technology
- College of Humanities and Social Sciences
- College of Management
- College of Sciences
- College of Cabin Attendant
- Flying College
- Vocational Technical College

Beijing University of Aeronautics and Astronautics (BUAA)

BUAA was founded in 1952 from the merger of the aeronautical departments of Tsinghua University, Beiyang University, Amoy (Xiamen) University, Sichuan University, Yunnan University, Northwest Institute of Technology, College of Engineering, North China University, and Southwest Aeronautical Institute. BUAA is China's first university of aeronautical engineering. BUAA was officially listed in China's "Action Plan for the Revitalization of Education in the 21st Century." Over the past 50 years BUAA has provided about 80,000 professionals of high caliber in various aeronautical disciplines for China. Total faculty and staff number more than 3300, including 10 academicians of either the Chinese Academy of Sciences or the Chinese Academy of Engineering Sciences, over 1400 full or associate professors, and 290 supervisors of doctorate programs. BUAA has a total enrolment of over 26,000, including more than 1,300 doctorate candidates, over 5,000 master candidates, more than 14,000 in 4 or 2 year undergraduate programs, and about 300 overseas students. It has 42 research institutes or interdisciplinary research centers, 11 key disciplines of the national level, and 89 laboratories.

CAAC-Rolls-Royce training centre

CAAC and Rolls-Royce worked closely together on design, building, staffing and equipping the centre through a Joint Management Board. The centre provide education and training programs in a variety of technical and management disciplines to employees from airlines, airports and the CAAC, mostly with staff from the CAAC, but with continuing support from Rolls-Royce. Tianjin intends to offer engine type maintenance training for Rolls-Royce and International Aero Engine aircraft in operation in China. The centre will also be able to offer training to other airlines operating Rolls-Royce engines in the Asia Pacific region.

The facility at the Civil Aviation Institute of China (CAIC) builds on more than 30 years of co-operation between CAAC and Rolls-Royce. In particular, Rolls-Royce and the CAAC have been working together on joint training initiatives since 1990, covering technical training, teaching methodology and English language training, and expanding this to management training in 1992. Discussions on the creation of the training centre began in 1994, with the agreement to go ahead with the centre being signed in March 1995.

AMECO Aviation College (Ameco)

AAC is the first maintenance training organization authorized by Civil Aviation Administration of China (CAAC) and the first maintenance training organization to receive the JAR-147 approval out of Europe. Ameco Aviation College provides civil aircraft maintenance basic training, basic skill training and type rating training. Ameco Aviation College also provides customer tailored courses, such as Aircraft Structural Repair, Composite Material Repair, AMM Usage, Engine Standard Technology, Aircraft Maintenance Standard Practices, Technical English and Human Factors.

Tianjin Sino-Germany Vocational Technology Institute

Tianjin Sino-German Vocational Technology Institute was established in July 1985 by the Tianjin City Government and the Ministry of Education in Beijing. Its main focus is vocational training in the fields of electrical engineering and metal engineering for skilled workers. The center plans to establish a new system of cooperative education, based upon the German concept, Berufsakademie, and to extend its courses to new sectors such as automobile mechanics. The teaching staff includes German and Spanish experts and more than 200 qualified Chinese teachers that have followed education abroad. The institute has about 4,500 students. Majors and courses include the following disciplines:

- Processing Technology of Numerically Controlled Machine Tool
- Maintenance Technology of Numerically Controlled Machine Tool
- Mould Design and Manufacturing
- Mechanical and Electrical Integration
- Electric Automation
- Computer Controlling Technology
- Information Security Technology
- Computer Network Technology
- German and English Language

Tianjin Sino-Spanish Machine Tool Technology Training Center (CSMC)

CSMC was built in December 2003. CSMC is a vocational training center established as a result of the collaboration between the Spanish and Chinese governments and the cooperation between the Tianjin Technology Institute and the Machine Tool Spanish Promotional Group. The Spanish government provided $9.8 million USD to purchase equipment for the CSMC workshops. Located in Tianjin, CSMC main objectives is training and servicing of the Spanish Machine Tool manufacturers. In August 2005, Lantek (Spanish machine tool firm) and CSMC signed a collaboration agreement in which Tianjin CSMC agreed to provide Lantek with logistic and human support for their installations and customer support in China. The CSMC courses include:

- Distance Diagnosis Technology
- Maintenance Technology of Numerically Controlled Machine Tool
- Digital Tridimensional Measuring Technology
- Operation of Numerically Controlled Processing Center

- Numerically Controlled Grinder Operation
- Numerically Controlled Machine Tool Operation
- Electro-processing Machine Tool Operation
- Electronics
- Pneumatic Hydraulics
- Principle of Electric Drive Numerical Control
- Typical Numerical Control System
- Installation, Testing and Maintenance for Numerically Controlled Machine Tool.

High tech base of Tianjin

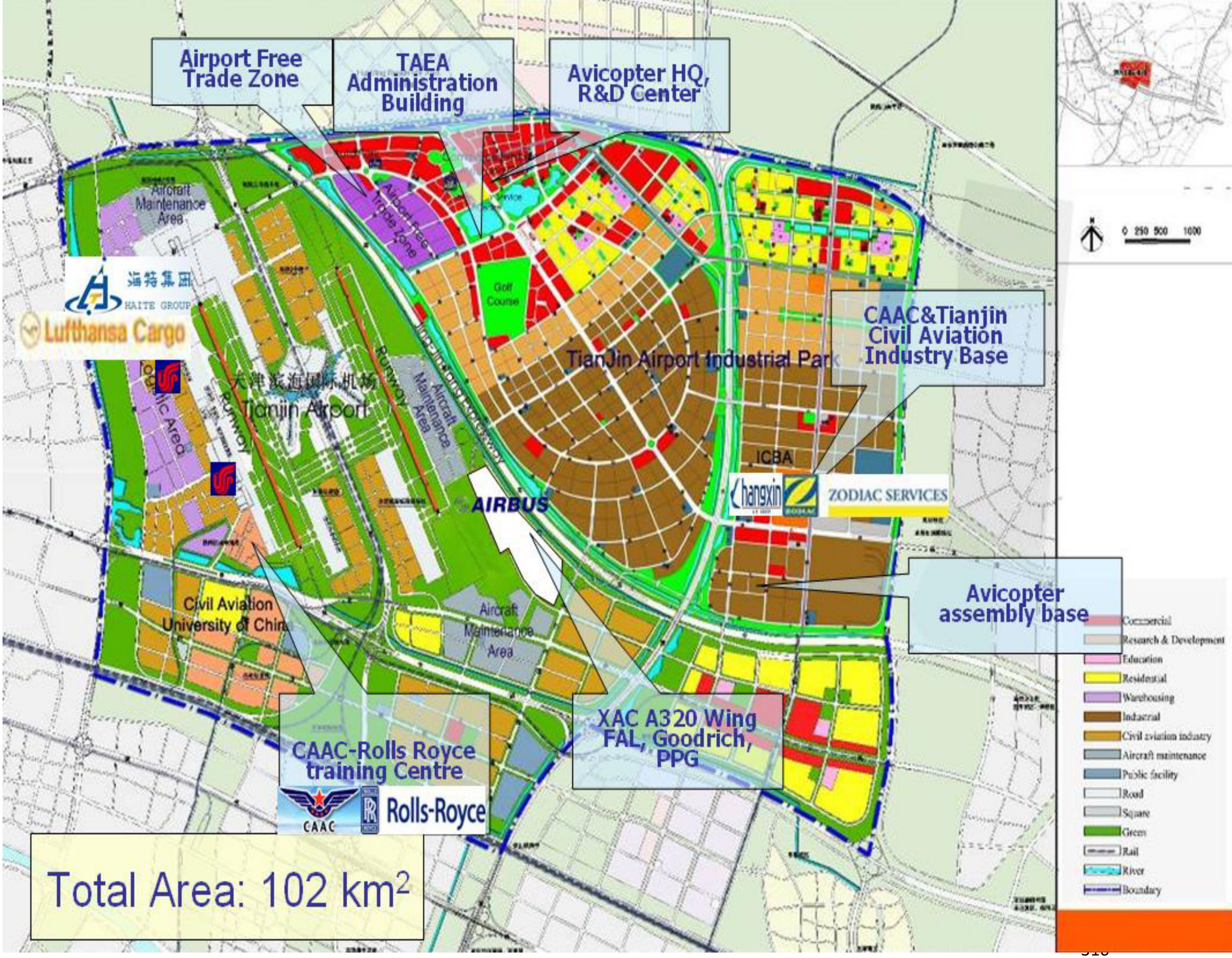
The interest of international aerospace companies in the Tianjin area is also triggered by the area high tech base. Other industries have elected to build their own cluster such as telecommunications, biotechnology, and optoelectronics. The zone has built eight major competitive industry clusters. To date, more than 450 billion Yuan ($66.3 billion) investment in fixed assets, more than 200 projects completed and commissioned and more than 7,500 registered enterprises and 122 projects funded by the World's Top 500 Enterprises. In addition to the Airbus A320 FAL and the helicopter JV, a large number of key projects have settled in the area such as the General Administration of Civil Aviation of China Technology Industry, the Tianjin Institute of Industrial Biotechnology of the Chinese Academy of Sciences. Tianjin was also an early adopter of the Green Sustainable Development as its development model focusing on low-carbon economic projects, promoting energy conservation and emission reductions, and build an eco-friendly and sustainable community.

Tianjin financing

The third criteria for Airbus to chose Tianjin was the funding offer by the Tianjin Province and Municipality that was eager to start their aerospace vision for the region. The region has dedicated important financial resources to develop its aviation cluster. It was China's first aviation industry fund. s much as 20 billion Yuan ($ 3 billion) was dedicated to fund Tianjin Binhai New Area aviation projects. Reports suggest that the fund will grow to 40 billion Yuan (USD 6 billion) in the next 2 years. The fund was co-established by Aviation Industry Corporation of China (AVIC) and China Construction Bank. In the past, most of the projects of the aviation industry were military projects and invested by the state. The establishment of AVIC Fund was aimed at attracting industrial aviation firms (civil and military), and providing convenient and effective channels to access the capital market. The aviation projects of Binhai New Area such as the Airbus 320 project and AVIC helicopter project are major beneficiary of the fund as well as for their suppliers in the cluster. At the end of the "12th Five-Year Period", the AVIC Fund is anticipated to grow beyond the border of the cluster and into possibly acquisition of foreign companies in their home market such as Europe and the US.

The fund has been allocated by the central government because of the Tianjin plan to develop a major aviation cluster but the area of Binhai have also been selected by the Chinese government as an experimental zone for comprehensive reform called "go and try beforehand". This reform is particularly set up to experiment financial market innovations and opening-up the economy to attract international firm.

The establishment of a Free Trade Zone within the cluster has also facilitated the implantation of foreign firms. It is the Tianjin Free Trade Zone and China Aviation Industry Corporation I and II that signed the framework agreement with Airbus in October 2006 to set up the A320 General Assembly Line in Tianjin.



Airport Free Trade Zone
TAEA Administration Building
Avicopter HQ, R&D Center
Aircraft Maintenance Area
海特集团
HAITE GROUP
Lufthansa Cargo
Golf Course
TianJin Airport Industrial Park
CAAC&Tianjin Civil Aviation Industry Base
天津滨海国际机场
Tianjin Airport
Runway
Aircraft Maintenance Area
ICBA
Changxin
ZODIAC SERVICES
AIRBUS
Avicopter assembly base
Civil Aviation University of China
Aircraft Maintenance Area
XAC A320 Wing FAL, Goodrich, PPG
CAAC-Rolls Royce training Centre
CAAC
Rolls-Royce
Total Area: 102 km²
Commercial
Research & Development
Education
Residential
Warehousing
Industrial
Civil aviation industry
Aircraft maintenance
Public facility
Road
Square
Green
Rail
River
Boundary
0 250 500 1000

Following the Airbus announcement, a flourishing aviation industry has developed around Airbus FAL as a number of aerospace firms of the aviation supply chain decided to open up a facility to support the Airbus FAL. Following the manufacturing implantation, aircraft leasing firms, R&D centers, logistic centers, and financial services for aviation have continued to keep the cluster momentum. In the early phase of the negotiation, Tianjin and Airbus Project had reached a common understanding that suppliers of airbus were to be brought together at Tianjin. In the process of attracting suppliers a supplier village was specially set up in Airport Economic Zone to attract the existing supporting manufacturers of Airbus.

The Aviation City is fulfilling its dream to become the largest aviation industry cluster in Asia. In addition to the A320 FAL, the city now have a cluster of aviation-related industries such AVIC's helicopter project, Goodrich's nacelles manufacturing facility, Thales' radar assembly line, STTS aircraft painting service , Canada's FTG aviation meter production and German Lufthansa and Hainan Airline's aviation leasing and Tianjin Airlines Co., Ltd. These companies cover a wide range of business such as aircraft manufacturing, R&D, parts, aviation leasing and logistics. AVIC's helicopter project will include the construction of a headquarter for AVIC's helicopter operations, R&D base, assembly line and customer service facilities. Tianjin has also become home for UAV, Satellite and other domestic aviation and aerospace firm. China Aviation Industrial Helicopter Co., Ltd. co-funded by Tianjin Port Free Trade Zone and China Aviation Industry Corporation was established in the Airport Processing Zone on February 26, 2009. Headquartered in Binhai New Area, China Aviation Industrial Helicopter Co., Ltd. has a multiple of member enterprises and specialized research institutes. It is mainly engaged in the R&D, production, sales, maintenance and service of helicopter and other aircraft and aviation components.

Tianjin Airlines Ltd., a joint venture between HNA Group, Tianjin Port Free Trade Zone and Hainan Airlines Co. was founded in June 2010. Tianjin Airlines is renamed after Grand China Express Air, the biggest regional airlines in China that accounts for 40 percent of the country's regional aircraft fleet. Grand China Express Air is formerly controlled by HNA Group. Tianjin Airlines, headquartered in Tianjin Binhai International Airport.

Table 25 Large aerospace companies in the Tianjin cluster

Name	Parent Company	Business Scope
Airbus (Tianjin) Final Assembly Co., Ltd	Airbus S.A.S	Final Assembly of Airbus A320 aircraft
Zodiac Aerospace (Tianjin) Co., Ltd	Zodiac	MRO of aero safety systems, aircraft systems and cabin interior products
Goodrich Aerostructure Service (China) Co., Ltd	Goodrich	MRO of nacelle
Avicopter Co., Ltd.	AVIC, TAEA	Civil helicopter R&D, manufacturing
Tianjin Aviation Electro-Mechanical Co., Ltd.	AVIC	Production of avionic device
Alcan (Tianjin) Co., Ltd.	Alcan	Aircraft wire production
Xi'an Aircraft International Tianjin Co., Ltd.	Xi'an Aircraft Industry Group	Assembly of A319/320 wing
Thales (Tianjin) Radar Technology Tianjin Co., Ltd.	Thales	Assembly of airport radar
Indra (Tianjin) Radar Technology Co., Ltd.	Indra	Assembly of airport radar
STTS Painting Service Tianjin Co., Ltd.	STTS (A French company)	Aircraft painting service
PPG Tianjin Co., Ltd.	PPG Industrial Corporation	Paints supply
Haite Aviation Technology Co., Ltd.	Haite Group	MRO of helicopter, business aircraft, Avionics Maintenance and Repair
Hangxin Tianjin Aviation Technology Co., Ltd.	Hangxi Technology Group	Avionics Maintenance and Repair, Mechanical Components & Accessories Maintenance
FTG Tianjin Co., Ltd.	Canadian Firan Technology Group	Mil-spec and specialty printed circuit boards for avionics
Grandstar Cargo International Airlines Co., Ltd	Korean Airlines, Sinotrans	Cargo carrier
Tianjin Airline	HNA, TAEA	Passenger carrier
JLG (Tianjin) aerial work platform Co., Ltd.	Oshkosh Group	Production of aerial work platform

Main Aeronautic & Aviation companies in Aviation city

In recent months, a number of companies have expressed the fact that that they were evaluating or planning to open a facility in the Tianjin clusters. These companies are:

Following the A320 FAL, local enterprises of Tianjin also attained rapid development. For example, Tianjin Saixiang Technology (TST) is a mechanical private company created in 1990 of Tianjin. From a general contractor providing transportation services to the Airbus FAL, it evolved into becoming a supplier to the FAL. TST have successfully completed the design and manufacturing of transport frame, and now undertake the task of transport frame manufacturing for the A350 project. Another private local enterprise that has grown with Airbus is Tianjin HYLT Aviation Science and Technology Co., Ltd, which was established in 2003. The company is specialized in design and production of aviation simulating training devices. It has become the first authorized user of Airbus A320 data package and will engage in design and R&D of simulators and exercise apparatus in China.

In terms of cluster typology, Tianjin is a regional pole (Perroux model) build around the A320 FAL. Although the cluster has a significant research and university system, there are not important to the companies in the cluster since they are mostly suppliers to the FAL.

VIII-5 The Chengdu aerospace cluster

The Chengdu province has a population of 11.2 million people. It is considered a major province in term of high tech investment in which 140 Fortune 500 companies decided to implant an office or research center. The province is the second center for aerospace in the country. In particular Chengdu has developed a competency in the design and production of fighter aircraft, and maintenance base for military and civil aircraft.

In particular, Chengdu has 33 research institutes and companies specialized in aviation and aerospace that employs 50,000 people. The largest Chinese aerospace companies include:

Chengdu Aircraft Industrial (Group) Co., Ltd.

Chengdu Aircraft Design & Research Institute

Chengdu Engine (Group) Co., Ltd.,

Chengdu Aviation Instruments Corporation,

Chengdu Jinjiang Machinery Factory,

Electronics Technology Group Corporation

Chengdu Hot Aviation Technology Co., Ltd..

Snecma,of France has a maintenance base operation called Snecma China Southwestern Airlines Maintenance. Chengdu's aviation and aerospace industry keeps on rising with an average growth 17% per year over the last 5 years in terms of revenue.

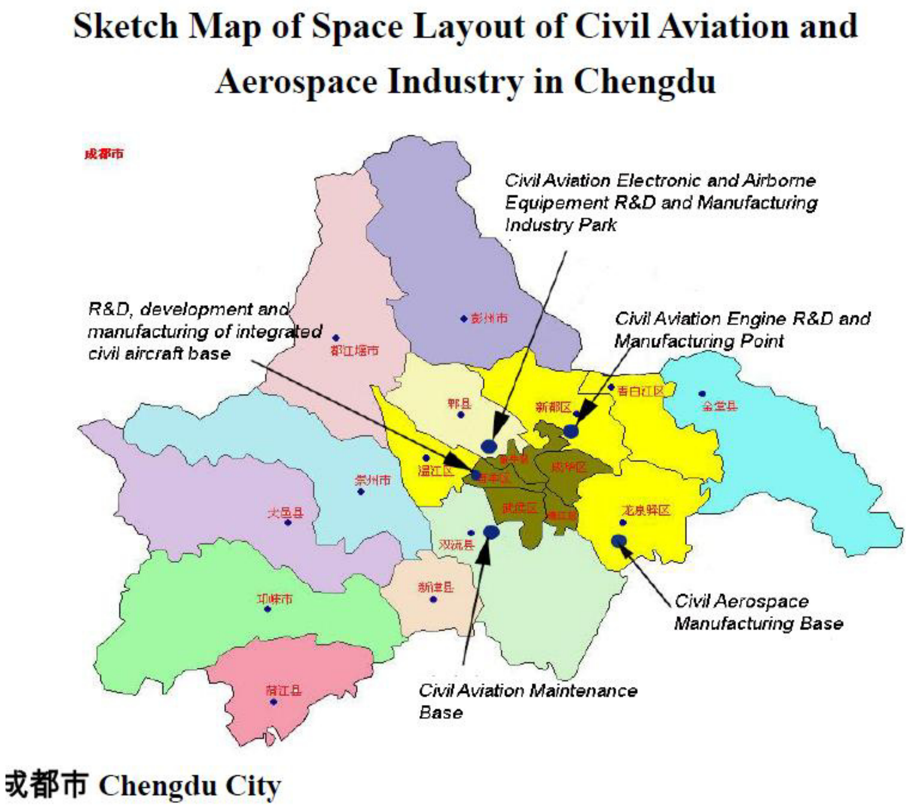
Chengdu province strategy for developing aviation

Chengdu aviation development is part of the national 10 years' development and construction plan. China's 10-year plan is very ambitious. The province ultimate goal is:

- Establish an important state's research, development and manufacturing base for small feeder aircrafts, general aircrafts, business aircrafts and helicopters.

- Develop the province into a major production and subcontract manufacturing base of domestic large aircraft parts and spare parts of international aircraft.
- Develop a strong aviation maintenance base
- Become an important research and manufacturing base of military equipment and space navigation products.

Chengdu has already successfully developed a good research capabilities and a great deal of aircraft manufacturing By 2012, Chengdu will reach the capability to produce 50 Mi-17 helicopters per year It has successfully developed a manufacturing capability in civil aerostructure and final assembly of the ARJ21. The final assembly of the ARJ21 will also reach a 50 production capacity potential by 2012. Its Airbus part manufacturing will step up to reach 50 units for the A320 nose and rear passenger door. Unlike the door, the nose section is a difficult part to manufacture and assemble since it involves the floor grid, the nose landing gear bay and frame. More importantly, its A320 wing assembly, the more technology demanding part of an aircraft structure, will reach the capacity of 3 units per year. The Chengdu province developed a manufacturing base for large civil aircraft in the 100-150 seats with the A320 and C919, in the regional jet with the ARJ21 and in the business aircraft market. It also developed the skeleton of an aviation electronic equipment, and an aviation auxiliary equipment. Its objective of becoming a prime maintenance base is already completed as the A320 and A340 maintenance facility is about to open. The facilities will be able to do heavy maintenance, but also aircraft conversion, line maintenance, and fleet technical management. The cluster is organized by district with each having a particular focus. For example, the Qingyang District focuses on research, development and manufacturing of integrated civil aircraft, the assembly of medium-sized aircraft (regional aircraft, general aviation aircraft and helicopters), and the manufacturing large parts of large aircraft. The Shuangliu County district focuses on aircraft maintenance, ground equipment, and assembly of medium size helicopter. The Xindu District mainly develops civil aircraft engine manufacturing and is a base for engine maintenance i.



Chengdu research capabilities

Research Center	Specialty or focus	Employees
Chengdu Aircraft Design & Research Institute	fluid dynamics, mechanical engineering, structure, vibration, electronics, radar, environmental control	1800 employees - 80% researchers and technicians
China Gas Turbine Research	design, experiment and test of aircraft engine	2500 employees including 1300 engineers
China Electronic Technology Group Corporation Research Institute	system integration, aviation communication system and electronic system, reconnaissance equipment	2600 employees
Sichuan Academy of Aerospace Technology	Aircraft design, navigation, guidance and control, automation, rocket/missile structure analysis, photoelectric instrument	15,000 employees

Aviation manufacturing capability

Chengdu is the second aerospace manufacturing base in the country. The companies in the cluster include:

Company	Business Scope
Chengdu Aircraft Industrial Group Co. Ltd	Fighter aircraft, supplier for Boeing 787 rudder, Boeing 757 tail piece, Airbus A320/A340 doors
Chengdu Engine Group Co. Ltd	Large and medium-sized aircraft turbojet and turbofan engines
Chengfei Civil Aircraft Co., Ltd	Project stage: Research , manufacturing, subcontractor of components for military and civil aircraft
Sichuan Lantian Helicopter Company Limited	Assembly and production of Mi-17 transport helicopter
Sichuan Haite Group	airborne equipment manufacturing (video system, dual-band antenna), manufacturing of aviation test equipment
Chengdu CAIC Electronics Co. Ltd	Aircraft air data system, aircraft instruments and sensors
Wisesoft Co., Ltd.	automatic air control system, surveillance radar simulator
Chengdu Aerospace Communication Device Limited	Communication equipment manufacturing

Aviation maintenance capability

Chengdu aviation maintenance facilities include:

Enterprise	Business Scope	Volume
Sichuan Haite Group	Maintenance of aviation auxiliary power unit (APU), airborne electronic equipment, airborne electrical equipment, airborne mechanical equipment; overhaul, retrofit of aircraft engine	Net asset 0.6 billion, uan, market value 1.4 billion Yuan
Sichuan Snecma Aero Engine Maintenance Company Ltd.	Overhaul and repair of CFM56-3 engine, engineering support, training	N/A

	and engine lease.	
5701 Factory	Helicopter maintenance	N/A
Taikoo Sichuan Aircraft Engineering Services Company Limited	Maintenance and overhaul of Airbus aircraft	Projects in progress

Chengdu Aircraft Industrial (Group) Co., Ltd.

Chengdu Aircraft Industrial (Group) CO., Ltd. Has 132 factory sites and is a subsidiary of Aviation Industry Corporation of China specialized in military aircraft manufacturing. It is also a supplier of part to western civil aircraft manufactures. It designed and now produces the Jian-10 (J-10) medium-weight multi-role fighter and the FC-1/JF-17 light-weight multi-role fighter, produced in cooperation with Pakistan. Following is a list of its main products:

Parts and components	Comac ARJ21 nose section; Chinese licensee of McDonnell Douglas MD-80 / MD-90; Parts supplier for Northrop Grumman; Empennage (horizontal stabilizer, vertical fin and tail section) for the Boeing 757; Parts and maintenance tools for Airbus Industries.
Fighters	Chengdu J-7 - Lightweight interceptor; export models designated F-7; FC-1 Xiaolong/JF-17 Thunder - Lightweight multi-role fighter; Chengdu J-10 - Medium-weight multi-role fighter; -XX - Heavy-weight fifth generation stealth fighter.
Trainers	Chengdu JJ-5 (JianJiao-5) basic jet trainer;
Facilities	Chengdu Airframe Plant Chengdu Engine Company Chengdu Aircraft Design Institute

Chengdu Aircraft Design & Research Institute

Chengdu Aircraft Design was founded in 1970, as a research institute, and later became predominantly a design office. The institute has 1800 employees, including over 1300 technical persons. Among them, 60 are research fellows, 380 are senior engineers, and 650 are engineers. Their research covers over 80 specialties, from fluid dynamics, to software development.

Sichuan Haite Group

Founded in 1992, Haite Group is the first non-state-owned aviation enterprise obtaining a repair station certificate issued by CAAC. Haite Group is an aviation maintenance enterprise Now it is mainly engaged in repairing and inspecting small engines, and developing test equipment for aviation. The headquarters of Haite Group is located in the High-tech Development Zone in Chengdu. In 2002, Haite became FAA certified repair. Besides importing the advanced international aviation test equipment, such as ATEC5000 and ATEC 60A from the EADS Test & Services, it has also developed and manufactured the the ATE7000 Series Aviation Automatic Test System with the independent intellectual property. Haite Group owns over ten subsidiaries, and established cooperation relationships with western aerospace suppliers in France, the US and Russia.

AVIC Chengdu Engine (Group) Co., Ltd.

Founded in 1958, AVIC Chengdu Engine (Group) Co., Ltd. specialized R&D and production of turbojet and turbofan engine in China. The company six manufacturing centers doing case, plating, disc shaft, blade, heat meter, and assembly of engine.

Chengfei civil aircraft project (project)

Chengfei Civil Aircraft Co., Ltd. was financed by Xi'an Aircraft International Corporation, Chengdu Aircraft Industrial (Group) Co., Ltd. and CATIC Investment Co., Ltd. respectively by 45%, 40%, and 15%. Its activity will focus on the manufacturing as subcontractor of civil aircrafts parts.

Taikoo Sichuan Aircraft Engineering Services Company Limited

The company is financed by Sichuan Airlines Group, Hong Kong Aircraft Engineering Company Limited, Taikoo (Xiamen) Aircraft Engineering Co., Ltd, and Sichuan Haite High-Tech Co., Ltd., Taikoo Sichuan Aircraft Engineering Services Company Limited (respectively 42%, 40%, 9% and 9%). Taikoo Sichuan will provide heavy maintenance, aircraft conversion, line maintenance, fleet technical management, inventory technical management and other engineering services. It will focus on Airbus aircraft. The company is building a small-sized hangar capable of accommodating one Airbus A320 for maintenance and later another hangar will be build to accommodate the maintenance of two Airbus A340s.

Aviation universities and research center

The Chengdu cluster has 6 major universities with aviation courses. Although is it unclear how many aviation courses are given in the different department, the 6 universities count more than 23,000 students with 4100 graduate and doctoral students.

Universities	Departments with aviation related training	Number of Students		
		Undergraduate	Graduate Student/ Doctoral Student	Total
University of Electronic Science and Technology of China	School of Microelectronics and Solid-state Electronics	1700	218	1918
	School of Communication and Information	2000	930	2930

	Engineering			
	School of Mechanical and Electronic Engineering	700	1200	1900
Sichuan University	School of Electrical Information	2500	451	2951
	School of Electrical Information			2500
	School of Materials Science and Engineering	1003	269	1272
Southwest Jiatong University	School of Materials Science and Engineering			1080
	School of Electrical Engineering	830	341	1171
	School of Mechanical Engineering	2993	581	3574
Chengdu University of Information Technology	Department of Communication Engineering	1700		1700
	Department of Electronic Engineering	1800		1800
Southwest University of Science and Technology	School of Information Engineering	2200	100	620

Vocational and technical colleges

There are 120 vocational and technical schools with 246,000 on-campus students with 59,000 of them graduating every year. There are 18,000 students in aviation related fields with 1,300 of them graduating per year.

Table 26: Vocational training in the Chengdu cluster

College/vocational institute	Number of on-campus students	Number of on-campus aviation students	Number of aviation students graduating per year
Chengdu Aeronautic Vocational and Technical College	4122	1898	561
Sichuan Aviation Vocational & Technical College	8417	5462	280
School of Mianyang Mechanical & Electrical Industry	524		
Sichuan Electromechanical Institute of Vocation and Technology	3700	2758	443
Deyang Electronic Science & Technology College	1087	N/A	N/A

Labor Cost

Chengdu cluster advantage is its lower labor costs compared with other industrial cluster of the Chinese coastal areas. On average, it is estimated that Chengdu labor is 2/3 of the coastal areas with a low turnover rate of less than 10%.

Table 27: Management wage in Yan per person

Management Level	Wage Guiding Indexes in Chengdu	
	L/M/H	Intermediate
Company-level	9048/27720/150668	62478
Department-level	7865/19980/56531	28125
employees	5799/12487/36774	18353

Wage of Technicians in Yuan per person per year

Management Level	Wage Guiding Indexes in Chengdu	
	L/M/H	Intermediate
Computer programmer	12117/21040/33035	22064
Mechanical engineer	11340/20445/60100	30628
Software Engineer	33795/46408/110160	63454
Software Engineer	16368/29370/61131	35623
Miscellaneous	12439/19440/71658	34512

Average Labor Cost of Representative Industries in Yuan per person per year

(Example for qualified labor in electronic manufacturing)

Cost Item	*Electronic and Communication Equipment Manufacturing*
Average labor cost of employees	17512
Average wage of employees on the job	11250
Average social insurance	3577

Average employee welfare cost	1251
Average employee education cost	151
Average employee labor protection cost	105
Average employee housing cost	882
Miscellaneous	198

Chengdu cluster infrastructure

The National Development and Reform Commission have developed Chengdu as a "national level-A" logistics hub city and is on its way to become a regional and international logistics center.

Chengdu is served by the Chengdu Shuangliu International Airport, the sixth busiest airport in China. The Chengdu Airport has constructed a second runway, capable of landing an Airbus A380. The Chengdu Government plan to improve the infrastructure of the airport and passenger traffic from 17 million today to 40 million by 2015, making Chengdu Airport the fourth international hub in China, after Beijing, Shanghai, and GuangZhou. There is also a long-term plan to build a second airport in Jintang County with five runways.

Chengdu is a railway Junction City and rail administrative center of southwestern China and the terminus Chengdu-Dujiangyan High-Speed Railway. New railways are currently under construction such as the conventional line to Lanzhou and the high-speed lines to Mianyang, Leshan and Chongqing.

Located to the northwest of Chongqing, Chengdu has no direct access to the Yangtze River, or any other larger river. However, to ensure that Chengdu's goods have access to the river efficiently, the port cities of Yibin and Luzhou -- both of which are reachable from Chengdu within hours by expressways—on the Yangtze have commenced large-scale port infrastructure development. As materials and equipment for the rebuilding of northern Sichuan are sent in from the East Coast to Sichuan, these ports are anticipated to receive significant increases in throughput.

In terms of typology, the Chengdu cluster seems to be an industrial district on the Marshall model of medium size companies with universities having a small role in the diffusion of innovation.

VIII-6 The Shenyang Aviation cluster

Shenyang is among the top ten largest cities in China and is the economic, cultural, financial and commercial center of the northeastern region of the country. Since the 1930s, Shenyang has been diversifying its industry from traditional sectors to become an important industrial base for a number of new and fast growing of key sectors of the economy. It is the gateway to Japan and Korea. It has attracted leading firms in the sectors of aerospace, heavy machinery, automotive, electronics, and software. The Shenyang area was also helped by the Chinese government's recent efforts to revitalize northeastern As a results, it has become, one of the fastest growing software and automotive sectors in the country. There are now 800 research institutes, 30 colleges and universities, 550,000 technical professionals.

Shenyang aerospace center of competence came from the early development of a military aircraft manufacturing. In fact, the first aircraft manufacturer Shenyang Aircraft Corporation, of China was founded in Shenyang. In the 1990s and 2000s, the Shenyang area expanded its expertise as to cover the civil aircraft sector. Today, Shenyang Aircraft Corporation, Shenyang Liming Aero-Engine Group Corporation, and Shenyang Aerospace Xinguang Corporation are the most important aviation companies of the cluster.

Strategic development of the Shenyang cluster

The overall strategy of the cluster is to develop its international partnerships. The strategic plan of the cluster was approved by the National Development and Reform Commission in 2008. The plan focuses on developing an advanced equipment-manufacturing industry, and intensify policy in support of local implantation of international companies The goal is for the region to become an important center for subcontractors of large aircraft and engine programs.

According to the agreement, China Aviation Industry Corporation will invest more than 10 billion yuan ($1.5 billion) within three years, to introduce twelve major projects such as the

Bombardier C Series aircraft, ARJ21 aircraft engine assembly, heavy-duty gas turbine technology into Shenyang. It will strengthen the R & D and personnel Their objective is doubling the output in five years. The agreement is the first major cooperation project after re-integration of AVICI and AVIC II.

The cluster is developing at the Shenyang Taoxian International into “3 cities”: Aviation City, Science City, and International City

Science City objective is to host the aerospace technology base with aviation design, R&D, education, training, flight training, flight demonstrations, new energy, new materials If the aerospace technology is the main driving force, Science City also include research centers in microelectronics, computers, biotechnology and optical technology.

International City focus is on finance, trade, services, administration and possesses an exhibit and conference center as well as an international school. Aviation City is the airport and its associated service and operation companies.

<u>Infrastructure of the cluster</u>

Shenyang is a major transportation hub in Northeast China, with a well-connected air, rail, and road transportation network. The Shenyang Taoxin International Airport, which can handle more than 6 million passengers each year, is the largest airport in Northeast China. Direct flights from Shenyang go to Beijing, Shanghai, Hong kong, Seoul, Cheongjiu, Tokyo, Frankfurt, Sydney, and Los Angeles. Shenyang is one of the most heavily traversed rail hubs in China. Six lines intersect in Shenyang, extending south to Beijing, north to the rest of Northeast China and Russia, and southeast to North Korea. In 2006, 8.5 million tons of goods were transported by rail through Shenyang. Shenyang is also being developed into a state- of the art container hub terminals.

Expressways cross the province and link Shenyang to key cities such as Beijing, Changchun, Dalian, Harbin and Tianjin. Within the city, two subway lines are under construction and scheduled to be completed in 2010.

AVIC Shenyang Aircraft Corporation (SAC)

The oldest aerospace company in China, SAC has been instrumental in developing other companies such as Chengdu Aircraft Industry Group and Guizhou Aircraft Industry Co. The company mainly focuses on designing and manufacturing fighter aircraft and is a subsidiary of AVIC. SAC is divided into four divisions: civilian aircraft and ancillary equipment, military aircraft, and civilian products. The civilian product is an adjacency to aerospace, mostly focusing on construction materials to passenger buses. .SAC has had a number of first development for China. Its F-5 was the first China made fighter jet, the FT-1 the first trainer, the F-6 the first Chinese supersonic fighter, the red-flag the first Chinese's ground to air guided missile, the F-7 the first double fighter jet, the F-8 the first high-altitude and high-speed fighter. SAC has build over twelve aircraft program in the last 50 years A joint venture has been established at SAC to produce the Su-27 aircraft and the associated Lyulka AL-31 turbofan engine.

Shenyang Aircraft Corporation has formed a joint production venture with Boeing for producing whole tail sections and cargo doors. Of civil aircraft. SAC in the past has done work for British Aerospace, Airbus, and Lockheed, and currently has a manufacturing sub-assembly venture with the Canadian firm Bombardier Aerospace. Boeing maintains a sizeable expatriate presence in Shenyang to support the project and has built a strong working relationship with the Chinese. SAC has been involved in manufacturing parts for Airbus aircraft as well as maintenance tools.

The last cooperation agreement with SAC was done in 2007 with Cessna to produce the Cessna 162 Light Sport aircraft. Cessna ships raw materials, engines and avionics from the US to Shenyang. Cessna provide on-site personnel to oversee assembly, quality assurance and technical support. Once test flown and disassembled, the Skycatchers is shipped to three authorized Cessna service stations in the US for reassembly and acceptance test flights. The first aircraft was delivered in 2009. However, it is Bombardier that have established the strongest cooperation with the Shenyang aerospace companies in the last decade. SAC has been manufacturing doors for Bombardier's *Q-Series* aircraft since the 1990s. In 2006, Bombardier Aerospace signed a major cooperation agreement with SAC to supply main parts for the fuselage of the Q400 aircraft.

In 2007, AVIC and Bombardier signed a framework strategic cooperation agreement to further promote the development of the commercial aircraft business of both companies and contribute to the development of the global aviation industry. The real reason for the agreement was the planned CSeries of Bombardier After the commercial launch of the CSeries in 2008, the agreement become clearer. SAC became a risk sharing partner for the CSeries and will supply the fuselage, tail cone and doors for the jetliner. What was new however is that SAC had the full technical responsibility for their work packages.

A large facility has been build to further the cooperation of SAC and Bombardier. Although no details are available as to what this facility will do, its size seems to indicate that it will be a final assembly line for the CSeries. It is clear that SAC became a key supplier in the Bombardier CSeries aircraft program. SAC delivered the first fuselage test barrel to Bombardier in 2009. The test barrel is being used to demonstrate manufacturing and engineering structural concepts before the CSeries aircraft's final design phase began. It has already been subjected to 40,000 simulated flight cycles of testing.

SAC Military aircraft program

Aircraft currently in production	Aircraft currently in development
Shenyang J-8II Shenyang J-11, Chinese variant of the Russian Sukhoi Su-27	Shenyang J-XX A fifth-generation fighter aircraft under development. Shenyang J-15 Carrier-borne aircraft based on the Sukhoi Su-33. Shenyang J-20 Another fifth-generation fighter aircraft rumoured to be under development that is separate from the J-XX program

SAC Commercial airplane programs:

Client aircraft programs	
Airbus A320	Wings - Fixed leading edges, wing interspar ribs ; Aircraft Doors - Emergency exit doors, cargo doors & skin plates
Boeing 737	Fuselage Sections - Aft fuselage section
Bombardier CSeries	Wings - Wing-to-fuselage wingbox ; Aircraft Doors ; Empennages - Tailcone structure ; Fuselage Sections - Centre fuselage
Bombardier Dash 8 Q Series	Fuselage Sections - Aft & forward fuselage ; Empennages
Cessna 162 SkyCatcher	Final Assembly
COMAC ARJ21	Empennages
COMAC C919	Empennages - Tail

AVIC Shenyang Liming Aero-Engine Group Corporation

Shenyang Liming Aero-Engine Group Corporation is another firm that date way back (1954) in the development of China military aircraft strategic plan. The firm is under the direct control of AVIC. This firm was one of the 156 important projects built in the first five-year plan period of China. It is the first aero turbine jet engine manufacturer and also the research and production base of the large and medium-sized aero jet engines in China. Over the last 50 years, Shenyang Liming Aero Engine has developed and produced more than 20 models or aero-engine. It employs more than 13,000 people.

This state-owned company with a long history of military engine development is currently in the process of transforming itself into a lean enterprise. on the model of its western future competitors. Shenyang Liming development and manufacturing processes have been the result of legacy program developed in an era of cheap labor and low production level. These legacy programs made Shenyang Liming processes obsolete They have also established specific goals within the lean initiative. These include better flow of information through the enterprise, optimized use of manufacturing resources, lower product development costs, a shorter product development cycle and improved product quality.

As SAC, Shenyang Liming Aero-Engine Group Corporation is a strategic supplier to all western engine manufacturers such as General Electric Power Supply in the United States, Rolls Royce in the United Kingdom and SNECMA in France. Shenyang Liming Aero-Engine Group Corporation became produces heat shield rings for the Roll-Royce BR700 series.

In 2007, the company signed an agreement with the US-based company General Electric to assemble and test GE's CF34-10A engine. The engine will be applied to China's regional passenger jet ARJ21-700. This is China's first foreign cooperation project in the area of passenger aircraft engines. The first CF34-10A engine is expected to roll off the production line, and be tested and certified for flying, in 2011.

In 2009, the company invested 434 million Yuan ($64 million) to construct two large aircraft parts production line in Shenyang, The production line is mainly producing components such as casing and the short axis for Airbus A350, A380, Boeing 787 and other large aircraft engine group. After the official production, the annual export value will exceed $120 million.

Research capability in the cluster

The cluster possesses three main research institute dedicated to aviation.

Shenyang Aircraft Design Institute

Founded in 1961, Shenyang Aircraft Design Institute is the oldest institute for fighter aircraft R&D in china. The research institute employs more than 2,000 people. The institute is a joint venture with SAC and the government. It has researched and designed the Shenyang J-5, J-6 and J-8.

Shenyang Aero-Engine Research Institute (SARI)

The Shenyang AeroEngine Research Institute (SARI) is responsible for military engine design. Its main partner and sponsor is Shenyang Aircraft Corporation. It has developed the PF-1 turbojet for the domestic JJ-1 trainer, the Hongqi-2 turbojet intended for the Dongfeng-fighter. SARI developed several engines for programs that were never launched either because the air force lack of interest or because the technology was already too obsolete in the design. However, it has developed a tremendous experience since the mid 50s for developing jet engines.

AVIC Aerodynamics Research Institute (ARI)

ARI is under the governance of AVIC. It was established in 2000, by merging former Harbin Aerodynamics Research Institute (founded in 1955) with Shenyang Aerodynamics Research Institute (founded in 1958). At present, the permanent staff of ARI totaled over 800 employees of which more than 600 are technicians. In 1982, it was authorized to confer the master degree of aerodynamics. In 1997, it was compliance with ISO9001 quality certification. It has developed expertise in aerodynamics , aircraft design, research and application of CFD technology. It possesses a wind tunnel testing facility.

Aviation-related Schools

Shenyang Aerospace University (SAU)

SAU is a multi-disciplinary university that has a strong aeronautics and astronautics department. Founded in 1952, the university was initially administered by the National Ministry of Aeronautical & Aerospace Industry, and later by the China General Corporation of Aeronautical Industry. Since 1999, SAU has been under the administration of the Liaoning Provincial Government, and is the only university owned by the China Industry and Information Technology Ministry and the Liaoning Provincial Government. It is the only university of aeronautical and aerospace engineering in the Liaoning Province. At present, the university comprises 17 schools, with over 900 lecturers, including 400 professors and associate professors. There are 20,000 full-time students in SAU. The university has over 50,000 graduates. A great number of graduates are now working as senior engineers or executives in China aerospace companies.

Shenyang Aeronautical Vocational and Technical College

The College has training in CNC machine tools, car clamp milling, electrical and electronic, automatic control, electrical intelligence, computer hardware and software and digital technology.

In terms of cluster typology, Shenyang is an industrial district (Perroux model) that focuses on supplying part assembly to domestic and international manufactures. Because data is not available in determining the level of communication between the 800 research institutions of the cluster, we cannot determine if the cluster is a regional system of innovation. However, given the fact that the main focus of the area is supplying part assembly, we can infer that the link is not that important.

VIII-7 The Harbin aviation cluster

The major interest of Harbin is the partnership with the Brazilian aircraft manufacturer Embraer. Harbin city is the base of heavy industries, such the automobile, electronics, food, and chemistry. There are seven manufacturing sectors with strong international partnership or cooperation. These include:

- Power Equipments,
- Measuring & Cutting Tools,
- Bearings,
- Aluminum Alloy,
- Light Aircraft & Helicopters,
- Antibiotics and
- Linen Textile.

Harbin is also developing its knowhow in bio-engineering, new materials and new energy power generation.

Strategic focus of the cluster

Harbin strategic focus in aviation is the development of the largest and most competitive cluster in China for large civil aircraft and helicopter. Harbin intends to develop its aviation service with aircraft and engine maintenance. It also plans to develop adjacent businesses for advanced composite material, and communication systems. The Civil Aviation Base of the Harbin cluster is building up fast in the South of harbin. AVIC Harbin Hafei Aircraft Industry Group, and AVIC Harbin Dongan Engine Co., Ltd are the driving force of the cluster. The first phase of the Harbin cluster development started in 2008 and was mainly dedicated to planning the development, starting implementing the programs and supporting policies, as well as planning the new construction While building the base, the goal was to reach revenues from aviation of 21.4 billion Yuan by 2010, with an average annual growth rate of 25%. By 2012 Harbin anticipates to reach 36 billion yuan (USD 5. 3 billion) with an average annual growth rate of 30% and 100 billion yuan (USD 14. 7 billion) by 2015

The Major firms in the cluster

AVIC Harbin Aircraft Industry (Group) Co., Ltd. (HAIG)

HAIG is an AVIC subsidiary founded in 1952. Over its 50 year of existence, HAIG manufactured and sold 1600 aircraft. A small number compared to western manufacture. However , HAIG has built up a multi-families and multi-types of aeronautical products including the general-purposed aircraft Y12 , the civil helicopter the H425, the military helicopters Z9., the HC120 helicopters. Harbin HAIG has developed a strong and privileged cooperation with Embraer for the final assembly of their ERJ145 regional jet airplane

Main products:

Helicopters	Harbin Z-5 - Chinese variant of the Mil Mi-4 transport helicopter Harbin Z-9 medium-weight multipurpose twin-engine helicopter - Chinese variant of the Eurocopter Dauphin Harbin Z-9W/G attack helicopter Harbin Zhi-15 medium utility helicopter HC-120 joint-developed with Eurocopter and Singapore Technologies Aerospace, Ltd.
Bombers	Harbin H-5 - Chinese variant of the Ilyushin Il-28 bomber Harbin SH-5 amphibious bomber HongDian-5 ECM version of Harbin H-5, being replaced
Patrol/Utility Aircraft	Harbin PS-5 Patrol Anti-submarine seaplane version of Harbin SH-5 Harbin Y-11 high wing twin-engine piston utility aircraft
Civil aircraft	ERJ 145,under the jointveture of Embraer by Harbin Embraer

Military Transport aircraft	Harbin Y-12 utility STOL transport and variant of the Harbin Y-11

Cooperation Projects:

Harbin Embraer Aircraft Company Ltd. (HEA)

Set up in 2002, Harbin Embraer Aircraft Company Ltd. (HEA) is a joint venture company established by the cooperation of the world fourth leading aircraft manufacturer in Brazil.

Harbin Embraer Aircraft Industry Company and HAI manufacturer and final assemble the ERJ-145 regional jet series products. The production was launched in 2003. A total of 5 ERJ-145 regional jets have been delivered to China Southern Airline, another 5 to China Eastern Airline and 5 for Wuhan Airlines.

Airbus starts Harbin plant

Airbus started construction of a $350 million component plant in this industrial city, one week after it delivered its first A320 plane assembled in China. The composite manufacturing facility, in which Airbus holds 20 percent stake, will produce components for the A350 XWB, and the A320 families.

Harbin Aircraft Industry Group Corporation Ltd, Hafei Aviation Industry Company Ltd, AviChina Industry & Technology Company and other Chinese partners hold the balance 80 percent stake. The new plant, scheduled to be operational by the end of 2010, is part of the world's second biggest aircraft maker's commitment to locally manufacture 5% of the A350 XWB airframe under an agreement reached with the Chinese government in 2007. The new plant, will be able to manufacture composite parts and assemble composite work-packages for the A350 XWB and A320 families and future Airbus programs. In 2009,
Harbin Hafei Airbus Composites Manufacturing Centre delivered the first A320 plane elevator saddlebag to a Spanish Airbus factory.

AVIC Harbin Dongan Engine (Group) Co., Ltd. (AVIC HDE)

AVIC Harbin Dongan Engine (Group) Co., Ltd., was founded in 1948 The company now has a staff of over 5,500 people, mostly engineers and technician. The Company is the high-tech enterprise group mainly engaged in producing aero-engine, aviation electromechanical products, and gas turbine generator. Over 15,000 sets of aero-engine and 9,000 sets of helicopter transmission system have been produced and repaired since the establishment of the country. Throughout its 60-year, Dongan (Group) Company has developed a family of aero-engines and helicopter transmissions system. The WJ5 series aero-engine developed and produced by Dongan is used as power plant on regional and military transportation airplane Since 2000, it produces an auxiliary power unit. At present, the transmission system on domestically made Z-8 helicopter, Z-9 series helicopters, Z-11 helicopter are all from Dongan. The group has built a strong and independent R&D capability. The Group has carried out international cooperation especially with Pratt & Whitney Canada, Eurocopter France, Honeywell USA as well as GE Aviation.

R&D capability in the cluster

There are 118 independent scientific institutes in Harbin. Such as the Welding Institute, the Veterinary Research Institute, and the Institute of Engineering Mechanics There are 176 scientific research centers and 35 R&D centers held by large & medium enterprises of which 21 are experimental centers The research center is strong in the area of air conditioning, engine, turbine, oxygen-making and biochemical

Harbin Institute of Technology

Harbin Institute of Technology or HIT, is a research university in the city of Harbin, Harbin Institute of Technology is consisted of three campuses: the main campus in Harbin, HIT in Weihai and HIT Shenzhen Graduate School. Harbin Institute of Technology is widely recognized as one of the top universities in China and consistently ranked among the best engineering schools. The school is also member of the C9 League, which was formed by nine prestigious universities in China in 2009.

The Harbin Institute of Technology is organized into 20 full-time schools, which hold 73 undergraduate degree programs, 143 master programs, and 81 doctorate programs. Most of HIT's schools are in science and

Schools of HIT (Science, Engineering, and Architecture)						
School of Astronautics	School of Mechatronics Engineering	School of Material Science and Engineering	School of Energy Science and Engineering	School of Electrical Engineering and Automation	School of Civil Engineering	School of Municipal and Environmental Engineering
School of Architecture	School of Transportation Science and Engineering	School of Computer Science and Technology	School of Software	School of Electronics and Information Technology	School of Science	Dept. of Media Technology and Art

HIT is known to have close links to the People's Liberation Army and the space program of China. HIT made great contribution to the Chinese Shenzhou spacecraft project. In 2010, the Astronautics Innovation Research Center was established at HIT in conjunction with China Aerospace Science and Technology Corporation.

<u>Human Resource</u>

Harbin city is the hub of science and education. There are 73 high level institutions and universities, represented by Harbin Institute of Technology, Harbin Engineering University. More than 400,000 professionals and technical personnel work in this city and more than 300 doctoral tutors. The total number of students enrolled in college is 800,000, of which 200,000 students graduate annually. Among these graduated students, around 6,000 students have obtained post graduate degrees, 120,000 students have acquired bachelor degrees or associated degrees; 80,000 students are graduated from vocational schools.

In terms of cluster typology, the Harbin cluster is likely to be an anchor firm model build around helicopter production with no clear link to research centers. This typology is likely to change as the cluster develops its service and aircraft maintenance competence.

VIII-8 The Nanchang aviation cluster

Nanchang is the capital of China's Jiangxi Province, the political, economic, cultural, scientific & technological center of the Province. With a total population of 5million, it is one of the 35 megacities in China.

Nanchang has a strong experience in manufacturing technology, comprehensive processing and production capacity for sheet-metal forming, digital control processing, tooling, designing and manufacturing, airplane sub assembly and final assembly. It has developed knowledge in manufacturing airplane's large parts and complex parts. Nanchang aviation industrial base mainly relies on the leading enterprises such as Jiangxi Hongdu Aviation Industry Group Ltd and Changhe Aircraft Industries Group Co., Ltd. Jiangxi Province and AVIC are planning to construct an aviation industrial city covering an area of 25 square kilometers to create Nanchang a major production base of aircraft, and an international aviation industry subcontracting production base.

Construction of Nanchang Aviation Industrial Base

In. 2009, Jiangxi Provincial Government signed a strategy alliance agreement with AVIC to build the Nanchang Aviation Industrial Base with initial investment of 30 billion Yuan ($4.4 billion).

The future cluster relies on AVIC Jiangxi Hongdu Aviation Industry Group Ltd. The cluster consists of two parks: the Jingdezhen Helicopter Industrial Base, with AVIC Changhe Aircraft Industries Group Co., Ltd and AVIC Chinese Helicopter Research & Development Institute, and Jiujiang Red Eagle Aviation Industrial Base. The cluster is anticipated to reach a total revenue of 100 billion Yuan ($14.7 billion) by the year of 2018

According to the strategic alliance agreement signed between Jiangxi Provincial Government and AVIC, both parties decided to establish three new companies to build the aviation city with distinctive features. The three new companies will be: Aviation City

Science and Technology Development Company, which is in charge of the overall plan and; the Hongdu Commercial Aircraft Corporation which will become the major domestic supplier of COMAC and the main subcontractor of international established trunk carriers; and the third company Nanchang General Aircraft Company which pay more attention to develop the high-end business aircraft.

Major firms in the Nanchang aviation cluster

AVIC Hongdu Aviation Industry Group

Hongdu Aviation Industry Group (HONGDU) is a largest firm in the cluster It was founded in 1951 and named as State-Run Hongdu Machinery-Building Factory and Nanchang Aircraft Manufacturing Company later. Hongdu has become a technology group capable of doing their own R&D, testing including flight test, manufacturing, production., marketing and sales. In addition to its aviation focus, Hongdu manufactures motorcycle and textile machinery.

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Figure 102: L15-05 Trainer

Hongdu first attempt to penetrate the aerospace market was through the development of military fighters based on the Russian programs. However its first attempts were cut short as the program was cancelled. There is no information as to why the program was cancelled. Hongdu enter the aviation market through a few niche products such as the military trainers. Today, it has gained expertise in military jet trainers, general aviation and multi purpose agricultural and forestry airplanes. Hongdu employs 20,000 people including over 3,000 engineers and technical personnel. It has also a landing gear manufacturing factory with nearly one 1,000 staff.

Hongdu products are listed below.

Table 28: AVIC Hongdu products

AVIC Hongdu Aviation Industry Group Products:	
Fighter	Q-5 "Fantan"(exported under the designation A-5) - single-seat dual-engined supersonic attack aircraft based on the Russian Mikoyan-Gurevich MiG-19; Q-6 - A variable sweep-winged attacker, similar to Su-24, cancelled
Fighter	J-12 –(1970) Chinese lightweight supersonic fighter, Development abandoned in 1977. Only prototypes built .
	CJ-5 tandem two-seat military primary trainer aircraft - variant of

Trainers	Yak-18 (1958); CJ-6 - basic and advanced trainer, similar to the Russian Yakovlev Yak-18; NAMC/PAC K-8 - two seat basic trainer; Hongdu JL-8 2 seat trainer; L-15 supersonic trainer; K8 Jet trainer; K8E trainers
General Aviation	Hongdu N-5 multi-use agriculture & forest aircraft
Transport	Yun-5 (Y-5) light utility/transport biplane
Vehicles	Chang Jiang 750cc sidecar motorcycles derived from Soviet copies of the 1938 BMW R71
Parts	C919's a quarter of the fuselage; sub-contract with Vought Aircraft Industries which allows the two companies to co-produce parts for the 48th section of Boeing 747-8 airplane.

Hongdu has two subsidiaries AVIC Hongdu Nanchang Airplane Design and Research 650 Institute was established with the State for the development of regional aircraft.
Its researchers are considered as the best in the country for aviation R&D including some known and experienced aircraft designer Hongdu Commercial Aircraft Corp was established in July 2010 with a capital of 1.2 billion yuan (USD 0, 17 billion). Hongdu Aviation is the majority shareholder with 25.5% of the shares. Seven other companies are shareholders:

- Jiangxi Investment Group subscribed
- Xi'an Aircraft Group,
- AVIC subscribed
- Jiangxi Copper Group
- Jiangxi International Trust
- Jiangxi Rare Metals Tungsten Group Holdings
- Jiangxi Tungsten Industry Group

Hongdu Commercial Aircraft Corp will be producing a quarter of the C919’s fuselage and will be producing structural parts for the new Boeing 747-8 through Vought Aircraft Industries in the US.

AVIC Changhe Aircraft Industries Corporation

The helicopter industry development in China is interesting in the sense that it started before the civil aircraft development and has developed in phase similar to the aviation sector from fail programs to reverse engineering, partnership and then “indigenous” programs.

Established in 1969, Changhe Aircraft Industries Group Co., Ltd.(Changhe Aircraft), is a subsidiary of AVIC. The company has the capability of R&D, testing and production of multi-model of helicopters and subcontracting production of aviation parts and sub-assemblies. Changhe Aircraft employs more than 4,300 people and has developed a strong testing facility and capability for avionics and flight test of helicopters.

Changhe Aircraft has a 37-year history for developing and manufacturing helicopters such as the, Z-8 and, Z-11 models currently in production. Most of its models were produced either in cooperation with the Russian or the French or resulted from a reverse engineering program.

Figure 103: Z5 Helicopter

The first program was the Z5 , which was based on the Soviet Mil Mi-4 Hound with. The development of the Z-5 began in 1958 by Harbin Aircraft Factory (now Harbin Aircraft Manufacturing Corporation, HAMC), which later became one of the two primary helicopter manufacturers in China. Through the Z-5 project, the Chinese obtained valuable knowledge and experience in helicopter design and development. Soon after the Z-5 project was completed, China began its efforts to develop an indigenous helicopter independently. In 1966, Harbin began the initial studies on the first indigenous helicopter Z-6. The Z-6 was mainly designed to carry airborne troops in the frontline, with a fuselage to accommodate twelve soldiers. The first prototype of the Z-6 was completed in 1967 for static tests. In 1968, the Z-6 project obtained officially authorization from the PLA and Chinese Government. From 1970, the Z-6 program was relocated to the newly founded Changhe Aircraft Factory (now Changhe/Jingdezhen Aircraft Industry Corporation) Jiangxi, which later became the second largest helicopter manufacturer in China. The Z-6 helicopter was type classified in 1977, with 15 helicopters already built. However, despite being a technologically successful design, the Z-6 program was later cancelled due to various reasons, including unsatisfactory performance and poor reliability. The cancellation of the Z-6 was a real setback for Changhe Aircraft. From that time, the firm changed its strategy to learn from its western competitor and engaged in several partnerships and co-operations. The cooperation was also made possible by the opening of China in the 1970s to the rest of the world. The co-operations on helicopters were intense throughout the 1980s. It included:

- The licensed production of the 50 AS 365N Dauphin with the French Manufacturer Eurocopter under the name of Z-9.
- The purchase of 13 French AS 321Ja Super Frelon naval helicopters and the following reverse engineering product Z-8.
- The bid for the PLA's next generation utility helicopter between the Bell 212 and Sikorsky S-70C Black Hawk.
- The negotiation on the purchase and possible licensed production of the Bell 47.
- The purchase of 6 AS 342 Gazelle anti-tank attack helicopters and the proposed licensed production or reverse engineering.

Figure 104: Z9 helicopter in cooperation with Eurocopter to produce 50 Dauphin

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In the late 1980, Harbin started to indigenize the production of the Z-9 In 1992 the first indigenous variant Z-9B with 71.9% Chinese-made parts flew successfully. The Z-9 were the first successful helicopter program of China. It became a multi purpose helicopter for basic army transport to search and rescue.

Figure 105: Z11 a reverse engineering of the Eurocopter AS350B Squirrel

Following the success of the Z-9, Changhe Aircraft reverse engineered the French AS 350B Squirrel light helicopter (Z-11). The Z-11 program was officially approved in 1989 and the development began in 1992. The Z-11 have a limited take off weight performance and so far only of few trainers has been ordered by the PLA.

The strategy of the two Chinese helicopter manufactures is to develop their own program, produced locally but still with the help of western manufactures as partners. Both Harbin and Changhe have increased their relationship with the European and U.S. helicopter industry.

The EC-120 lightweight helicopter program, which includes Eurocopter, Harbin/CATIC, and Singapore Aerospace Co, has been under development since the mid-1990s. Changhe in particular has become an international partner for the Sikorsky S-92 medium transport helicopter program.

Figure 106: EC-120 helicopter in partnership with Eurocopter – CATIC and Singapore Aerospace

The Chinese helicopter program is set to become a major force in the development of China's aerospace. Three programs have already started to shape the future of China helicopter industry

A baseline 5,500 kg Chinese medium helicopter tactical for transport for the PLA;
A 6,000 kg third-generation attack helicopter also for the PLA
A 5,000~6,000 kg commercial transport helicopter with potential growth

In 1997, China signed a $70~80 million contract with Eurocopter France to develop an appropriate rotor system (main/tail rotor hubs and blades) for China's next generation of helicopter. In 1999, Agusta announced it has also signed a contract with the Chinese to develop the transmission system (gear box and transmission components) for China's next generation helicopter. The S-92 Tail Rotor Pylon in cooperation with Sikorsky Aircraft Corporation is now in production. Jiangxi Changhe-Agusta Helicopter Co., Ltd. , a joint venture between Agusta and Changhe Aircraft, was unveiled in 2005

Figure 107: China Military helicopter programs

Model	Mission	Builder	Qty
Z-11	Training	Changhe	12
Mi-17/-171	Transport/ground attack	Mil	60
Mi-8	Passenger/cargo transport	Mil	n/a
S-70C	Transport	Sikorsky	24
Z-9A/B	Utility/transport	HAMC	80~100
Z-9C	ASW/SAR	HAMC	n/a
AS-565	ASW/SAR	Eurocopter	10~20
WZ-9	Anti-tank attack	HAMC	30+
SA 342	Anti-tank attack	Eurocopter	6
Ka-28	ASW	Kamov	8~12
As 332L	VIP transport	Eurocopter	4
SA 316/318	Training	Eurocopter	n/a
Mi-6	heavylift transport	Mil	2~4

Changhe Aircraft is slowly introducing advanced manufacturing technologies and is building its management experience through its partnerships.

Products:	
Helicopters	AC313, the maiden flight of China's first large civilian helicopter in March 2010 CAIC WZ-10 attack helicopter; it is scheduled to replace Wuzhuang Zhisheng WZ-9 Changhe Z-8 naval and Z-8A army heavy transport helicopter - Chinese variant of SA321Ja Super Frelon Changhe CA109 Utility Helicopter Chinese version of A109 Zhi Z-11J - military utility light helicopter Zhi Z-11 - civilian utility light helicopter
Parts	Tail rotor pylon for the Sikorsky S-92 Fuselage for the Sikorsky S-76 Wing spoiler for C919

The first result of the Chinese helicopter strategy to build their indigenous helicopter is becoming a reality with the AC313.

The AC313 is China's first locally designed transport helicopter. The AC313, made its first flight in early 2010. The AC313 is a 13 ton helicopter that can carry four tons of cargo or 27 troops. However, the AC313 show some striking resemblance with Eurocopter's Cougar EC725 program launched in 2000. China continues to be very pragmatic in developing its aviation industry The AC313 was designed for a variety of uses, including search and rescue, fighting forest fires, and even assisting in fighting fires within cities.

AVIC Chinese Helicopter Research & Development Institute (CHRDI)

Founded in 1969, under the leadership of AVIC, the institute is the China's only general scientific research Institution which mission is vertical flight research and pre-study of helicopter development. CHRDI is the overall design authority for Chinese domestic helicopter programs.

Transport infrastructure

Nanchang and Shanghai's air, rail, road and water transport is well developed It takes five hours by railways, 8 hours by highways to reach Shanghai. The Yangtze River, allows 5,000-ton ocean-going vessel to be directly shipped from Shanghai to Jiujiang ,and up to 2000-ton ship up to Nanchang.

COMAC and AVIC have publically stated their intention to develop a full family of large aircraft beyond the 150 seater C919 to a 300 to 400 seater large aircraft in the future. As the A380 and A350 in France, such a program will rely on water transportation. Nanchang in that regards is perceived as convenient location to build large structural parts.

Research and universities in the cluster

At present, there are nearly 700,000 students in 32 universities and colleges, 18 adult institutions, 131 adult vocational schools in the Nanchang cluster.

Major Aviation Schools:

Nanchang Hongkong University

Located in Nanchang, Nanchang Hangkong University (or NCHU for short) specializes in engineering, and science. It is affiliated to China Aviation Industry Bureau and now is under the supervision of the local provincial government and the Ministry of Industry and Information Technology.(formerly National Defense Science industry commission) At present, the total number of registered students is 22,000, of whom 19,000 undergraduates, 1,095 postgraduates, and over 2,200 vocational students.

Schools	Specialties
School of Aeronautic and Mechanical Engineering	Machine Design & Manufacturing and Their Automation Flight Vehicle Manufacture Engineering Material Processing and Control; Welding Technology and Engineering.
School of Aircraft Engineering	Flight Vehicle Propulsion Engineering; Flight Vehicle Design and Engineering; viation Technology.
School of Material Science and Engineering	Metallic Materials Engineering; Macromolecular Materials and Engineering
School of Information Engineering	Electronic and Information Engineering; Telecommunications Engineering; Electronic and Information Science and Technology; Automation; Computer Science and Technology; Network Engineering; Educational Technology.

In terms of typology of cluster, Nanchan is an anchor type with two companies as anchors: Hongdu and Changhe Aircraft.

VIII-9 The Guiyang aviation cluster

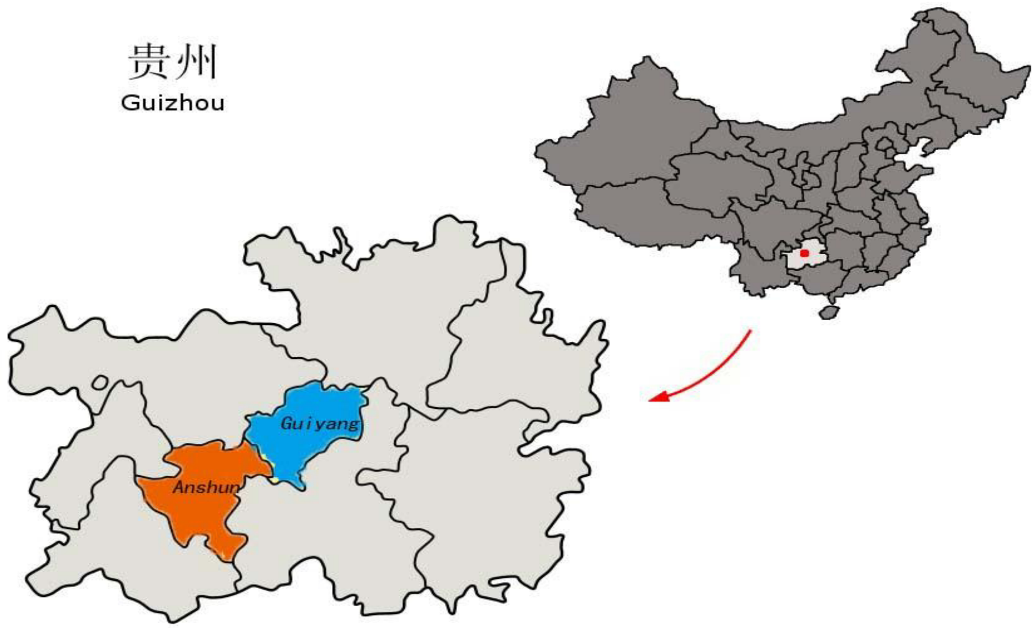
Guiyang is located in the east part of Yunnan-Guizhou plateau of southwestern China. Its industry has been mostly based on the exploitation of its natural resources. The Chinese Government made a strategic decision to bring more value base industry in the region. As a result it decided to develop Guiyang as an aviation cluster specializing in manufacturing fighters and trainers.

In the 1970s, after 46 years of development, Guizhou Province established a fairly complete aviation industry research and manufacturing driven by Guizhou Aviation Industry Corp (GAIC).

GAIC has pursued independent innovation. Recently, GAIC developed the Shanying advanced trainers and a unmanned airplanes. It also develops its civil aviation expertise through the development of small to medium size regional jets. The Guizhou Provincial Government established a company to develop the 30-seated ARJ-60 aircraft

Aircraft engines are another product of the group. GAIC considers that China has become the fifth leading aircraft engine manufacturer of the world after the United States, the United Kingdom, France and Russia.

<u>The development of the Guiyang cluster</u>



Its strategic focus is to strengthen international co-operations, and expand its sub-contracting scope to produce aircraft and aircraft engine parts.

In 2008, the National Development and Reform Commission officially approved the overall development planning of Anshun Civil Aviation Nation High-Tech Industrial Base. The base includes a modern industrial park, a logistics parks and an urban new park. The total investment dedicated to develop the cluster is expected to reach 30 billion yuan ($44. 2 billion).

According to the strategic cooperation framework agreement with Guizhou province, Guizhou Aviation Industry Corp will accelerate the extension of aviation technology to civil industry with the construction of Anshun Civil Aviation Nation High-Tech Industrial Base. The goal is to build the largest aircraft equipment manufacturing and general aviation research and production base in the Southwest region. Guizhou Aviation industry Corp signed a multibillion yuan deal with Guiyang government for building a manufacturing base in the Guiyang National Hi-Tech Industrial Development Zone. The newly launched industrial base will focus on aero-engines R&D, manufacturing and maintenance. It will also develop new energy, electric vehicles and auto parts derived from the aviation technology. According to the agreement, the first projects include engine and engine parts manufacturing and maintenance for AVIC's Liyang engine company and new energy development project.

Guizhou Aviation Industry Corp

According to the "eleven-five" plan that GAIC formulated, the group revenues is anticipated to reach 20 billion yuan (USD 3billion) in sales in 2010. Guizhou Aviation Industry Corp. belongs to AVIC, and was established in 1964. The firm includes 46 manufacturing sites. Among them are four aircraft and seven engine manufacturing sites, and ten aircraft equipment factories GAIC also has I/E. Corp a financial and investment company. The firm is nationally recognized as a "postdoctoral center", a national defense and regional computation test center. It has established long-term cooperative relationship with the best domestic and foreign universities and research institutions.

Snecma Xinyi Airfoil Castings Co. Ltd

Snecma Xinyi Airfoil Castings Co. Ltd, founded in July 2006, is a subsidiary of Snecma (85%) and its Chinese partner Guizhou Xinyi Machinery Factory. Located in Guiyang, it produces low-pressure turbine blades, nozzle guide vanes and low-pressure turbine seals for the CFM56-2, 3, -5A, -5B, -5C and -7B engines.

In terms of cluster typology, Guiyang is an anchor firm model with Guizhou Aviation as the anchor.

VIII-10 Conclusion on China aviation clusters

Although China has succeeding in developing their 7 aviation clusters, it still lacks of basic skills in the area of

- understanding market demand
- an industrial base with lean manufacturing
- a global supply chain (for both manufacturing and support),
- the ability to integrate complex structures and systems via a global network of suppliers.
- management experience
- innovation capability
- coordination between the companies in the 7 clusters that sometime compete or have adjacent programs

Type of cluster	Xian	Tianjin	Chengdu	Shenyang	Harbin	Nanchang	Guiyang
Industrial district (Marshall model)			X				
Regional pole (Perroux model)		built around A320 FAL		major subcontractor			
Local knowledge spillover							
Local and regional system of innovation							
Interconnected companies (Porter's model)	X						
Anchor firm model	AVIC XAC is the anchor				HAIG as the anchor	Hongdu as the anchor	Guizhou Aviation as the anchor

Comments	Largest cluster; a lot of aerospace companies and research center	A320 fal	design + production fighter + maintenance for civil and military, labor cost 2/3 than other clusters	first aerospace manuf in China from military, 800 research institutes, 30 colleges and universities, 550,000 technical professionals, important center for subcontractors of large aircraft and engine programs	helicopter firm started in 1952; want to develop service and MRO, composite and systems; privileged relationship with Embraer; cluster model likley to evolve towards local knowledge	based on Hongdu; started as trainer manuf.; manufactures large and complex parts; specialized in helicopters; plan to develop Business aircraft; Hongdu commercial aircraft for C919 subcontract and int'l subcont., such as 747-8 structural parts; Changhe Aircraft building its indigeneous helic.	New cluster, plan to focus on fighters and trainers, and small to medium size regional jet

The cluster analysis suggests that the clusters' productivity and innovation failed to keep pace with the United States and Europe even though the number of researchers is far beyond the one of the west. The analysis shows that the clusters often work on the same projects or technologies without differences in regional specialization patterns or cooperation.

The aviation industry has more than 130 large and medium-sized factories and research institutes employing 250,000 workers scattered across the country, especially in the deep interior, and often possessing the same manufacturing and research attributes. But intense rivalry, local protectionism, and huge geographical distances mean that there is little cooperation or coordination among these facilities, preventing the ability to reap economies of scale, engage in innovation clustering, and also hampering efforts at consolidation. For example, there are three clusters that are planning to develop civil aircraft engines. All are in the same phase of development although none seems to be co-operating in any way.

Despite these obstacles, the Chinese aviation industry is making robust progress in its quest to catch up and become a leading global player within the next two decades. The industry has managed to organize itself around its clusters and is starting to display some level of innovation within the research centers and universities To continue to develop, the firms in the clusters will need to seek to optimize their value chain through the internationalization of its supplier base for building the best product at competitive price. Today the internationalization is based on its learning benefits and is aimed at developing the indigenous products with the experience obtain in cooperation. The enterprise of the cluster should embrace innovation, seek differentiation rather than imitate successful enterprises of the west.

Once the clusters are firmly established, China might very well transition from being a technological learner and imitator to becoming an emerging innovative power even though the ability to successfully conduct radical innovative activities is still beyond China aviation reach for now. While the Chinese aviation industry will continue to close the technological gap with the world's leading aviation powers, its aspirations to join their ranks will still remain a long-term prospect. The re-organization of the clusters around center of competences would accelerate the process. The research, education, firms, manufacturing capacity is already in place to execute.

IX- Russian entry in the large commercial aircraft business

The Russian commercial aerospace has been in business for decades alongside its military business. The Russian military aerospace design offices have been extremely prolific in the cold war in developing both effective fighter and military transport and a wide variety of more exotic aircraft that never passed the prototype phase. Since the end of the cold war, the military have been less prolific but has gain credibility in the international aerospace world, with noticeable international sales of their fighters. India has recently signed a contract for the supply of 29 MiG aircraft for a total of over 1.5 billion USD.

In 2009, Russia's manufacturing companies delivered 14 aircraft and posted an 18% increase in consolidated revenues to 114 billion Rubles ($3.8 billion) over 2008. Sales of commercial aircraft accounted for only 11% of this total, 12.5 billion Rubles, 8.7% up from the previous year. Its civil aircraft divisions manufactured 17 civil aircraft, of which 14 were delivered. The Aviastar plant at Ulyanovsk delivered five Tupolev Tu-204s: two to Red Wings, and one apiece to Cubana, Air Koryo and VTB Leasing. VASO delivered four Ilyushin Il-96s, three to Polet and one to Rossiya, as well as the first two Russian-built Antonov An-148s to Rossiya. The KAPO plant in Kazan delivered two Tu-214s to Russia's presidential transport, and a third to Transaero. Three Sukhoi Superjet 100 test airframes were manufactured by the KnAAPO plant in Komsomolsk-on-Amur. First deliveries of the type have been delayed.

The Russian civil aircraft has never been recognized outside of the CIS as economic, performing and reliable. However, the talent of Russia aerospace engineers is recognized worldwide as being the best in class in design and aerodynamic The few successful domestic programs they have had in the past are ramping down. As Aeroflot aircraft became more productive with their western aircraft, the airline has reduced its fleet size. Aeroflot and the other 50 Russian airlines have been allowed for a decade to purchase western aircraft. In addition, the CIS countries have lost their allegiance to Russia and are completely free to purchase western aircraft. In fact, very few of the CIS airlines have ordered Russian built aircraft in the last decade. Therefore, even though Russia has been in the civil aircraft business for decades, its civil manufactures are need to re-invent themselves and reenter the market. The Russian government have ambitious plan for commercial aircraft. Unlike in the past, a significant amount of resources are being allocated to the plan. The extraordinary gas revenues of the last few years are certainly providing the fund to fuel Russia ambition. If 2009 and 2010 have looked great on the military internationally, the prospect for the Russian civil aircraft manufactures is rather gloom. Old technology, poor customer support, quality issues are major impediments for the international success of current civil programs.

Another necessary driver of the future success of their ambitious plan is the execution of the integration of all aerospace companies of Russia under the same structure: These companies often compete for the same domestic market. Unified Aircraft Corporation (UAC) UAC have already signed deals in 2010 with three domestic non-scheduled airlines for the supply of 18 aircraft An-148s, including 10 cargo version. The An-148 will enter into airline service in the first quarter of 2011, and in the first quarter of 2012.for the cargo version UAC's consolidated debt fell by 13% to 157 billion Rubles. It says the debt reduction is associated with the initiation of state financial support measures to aerospace companies.

The following chapter assesses the development of the Russian commercial aerospace industry, its plan for the future and its chance to succeed.

IX 1 The structure of the Russian civil aviation industry and its plan to enter the large commercial aircraft industry

The years that followed the fall of the USSR have been hard for the aviation industry in Russia and other CIS countries. The involvement of the military production sector makes it difficult to appeal to foreign capital. Civilian aircraft manufacturers have suffered the most. The financing of the Russian civil industry have become difficult. International financial institutions are reluctant when making loans to risky sectors such as this one, even if they are essential to the economic development of Russia. A declining market and an increase in the stock of old aircraft, abandoned since the Soviet Union era, followed this crisis. During the 90s, the passenger traffic in Russia declined 77% and even more in some CIS countries.

Aircraft and equipments are developed in the design bureau. After approval of the government they are distributed among different plants to be produced. The plants responsible for building commercial aircraft were not spared from the difficulty of financing new programs. The end of the Cold War seemed to provide a future for this promising sector but only 30 aircraft were delivered by the large factories in Voronezh, Kazan, Ulyanovsk, Samara and Saratov. Other large plants outside of Russia such as KhAPO in Kharkov and TAPO in Uzbekistan have a gloomier future than their Russian counterparts

Thanks to the adoption of the Federal Program "Russian Civil Aircraft Development", the country has begun to see signs of recovery in the sector. The State will ensure that economic and legal conditions are advantageous to manufacturers and to airlines.

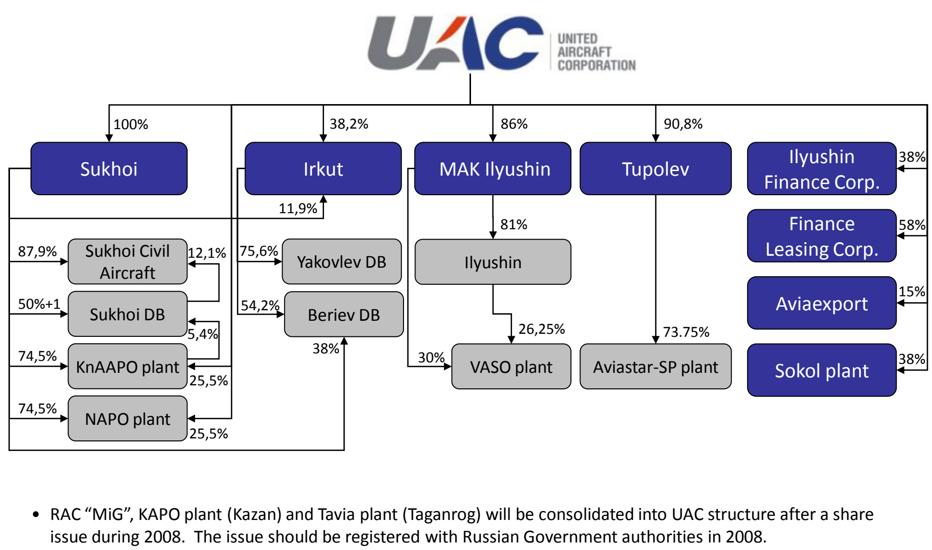
Vladimir Putin showed his interest for the civil aviation industry. In 2006, he signed the decree on the creation of the Unified Aircraft Corporation. The company was officially registered in November 2006 with chartered capital of 96.7 billion rubles ($3.7 billion.) The catalyst was the merger of the main Russian aircraft design and manufacturing companies aimed to increase Russian participation in the world aviation market. The benefit of the merger was uniting the activities of civil aircraft-makers (Tupolev, Ilyushin, Yakovlev), military aircraft-makers (Sukhoi, MiG), transport and special aviation (Ilyushin, Beriev), and UAV (IRKUT). These companies combined more than five engineering centers and ten manufacturing plants and an extraordinary pool of engineering resources and talent.

UAC strategy in the civil aircraft area is to transform the civil segment of the Russian aircraft industry into a competitive industry that will account for at least 10% of the annual world supplies of aircraft above long 50 seats. With the government support, UAC is implementing its 2008-2015 programs to create critical technologies required for developing competitive products in 2015-2025.

The merge of the Russian aerospace companies was complex and set in stages:

- the initial stage (2006-2010) proposes that 75% of merged group be controlled by Russian Government, and 25% by investment and private companies
- the second stage (after 2010) propose that no less than 51% of the merged group be controlled by Russian Government, and no more than 49% by investment and private companies

Figure 108: UAC structure



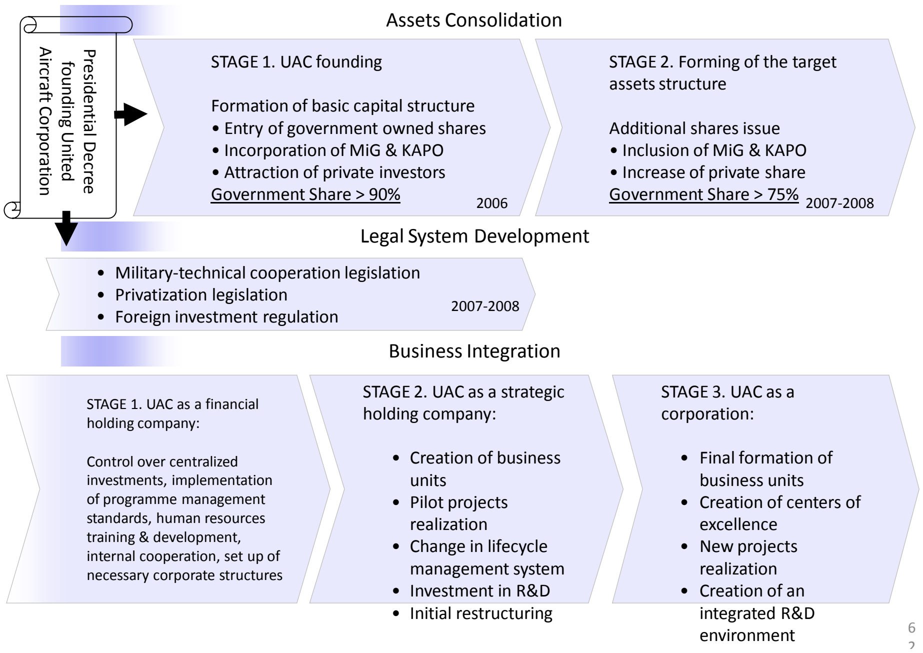
Under UAC plan to re-align responsibilities within the Russian aerospace industry Sukhoi will retain its responsibility for the Sukhoi Super Jet 100, while Irkut will take the lead for the MS-21 future program. The two other player within UAC are MIG and Iljushin. The position of the four major aerospace companies in Russia is often misaligned. Putin and Medvedev are often called to play the arbiter. Because of the strong leadership of UAC in the person of Alexey Federov, the consortium is moving ahead.

Alexey Innokentyevich Fedorov biography

Chairman President and Member of Management Committee Irkut Corporation

Alexey Innokentyevich Fedorov has been President and Chairman of the Executive Board at Joint Stock Company United Aircraft Corporation since 2006. Mr. Fedorov serves as the Deputy Head of Department at Federal Security Service (FSB). He served as President of Irkutsk Aircraft Production Association (now Irkut Corporation) from 1998 to 2005. He serves as Director General of Russian Aircraft Corporation "MiG". He served as Chief Executive Officer and President of United Aircraft Corporation, a Civil Aviation Managing Company of United Technologies Corp. and Russian Aircraft Corporation "MiG" until January 2009. He served as an Executive Officer of Russian Aircraft Corporation "MiG". He served as Chief Executive Officer - General Designer at FSUE (Federal State Unitary Enterprise) Russian Aircraft Construction Corporation MiG from 2004 to 2007. Mr. Fedorov serves as the Chairman of JSC Nizhny Novgorod Aircraft Building Plant SOKOL. He has been the Chairman of the Board of United Aircraft Corporation since August 14, 2008 and Russian Aircraft Corporation "MiG" since August 14, 2008. He served as Chairman of Irkut Corporation. He served as a Director of Aeroflot - Russian Airlines. He serves as Director at Joint Stock Company United Aircraft Corporation. Mr. Fedorov graduated from Irkutsk Polytechnic Institute with specialty - aircraft construction engineer-mechanic in 1974 and Business School of Oklahoma State University (USA) in 1989.

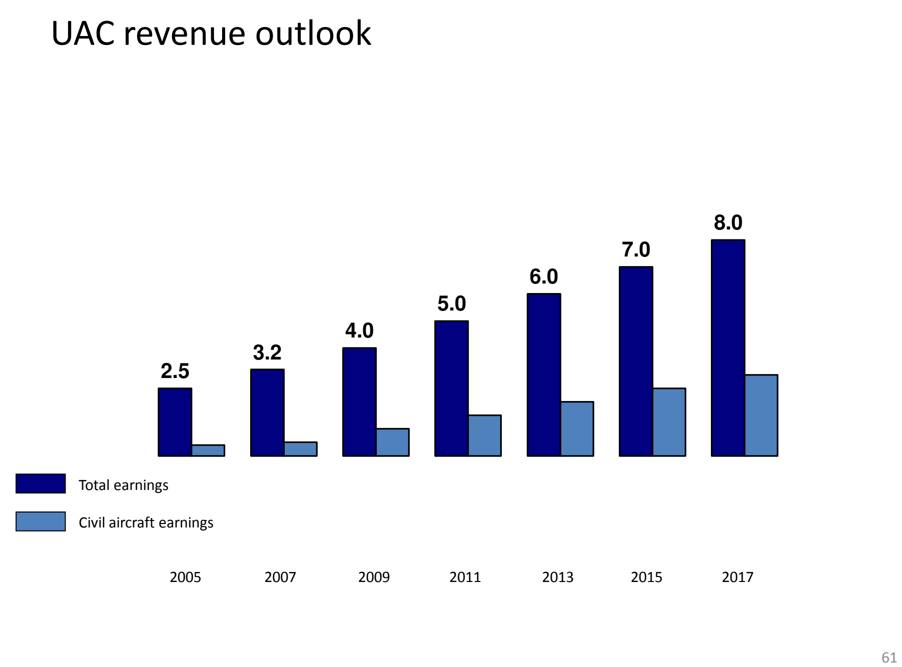
Figure 109: UAC next corporation structure - road map



UAC goals are :

- To retain Russia's position as the third centre of aircraft manufacturing in the world,
- To triple sales in 10 years ($2.5 billion to $7-8 billion),
- To become one of the top 5 aircraft companies in the world,
- To create a balanced product portfolio by increasing production of civil and cargo aircraft and to enter the international market,.
- To obtain more than 10% market share,
- To create world-standard centers of excellence in key technologies (assembly, titanium, composite structures),
- To ensure investment attractiveness of UAC by participation of private investors, publicity & transparency of the company,.

Figure 110: UAC plan to reach $8B revenue by 2017



In order to achieve its strategic objectives; UAC will have to identify market niches (product and market) for positioning the Russian civil and military aircraft, and will have to become competitive against the products of foreign aircraft manufacturers

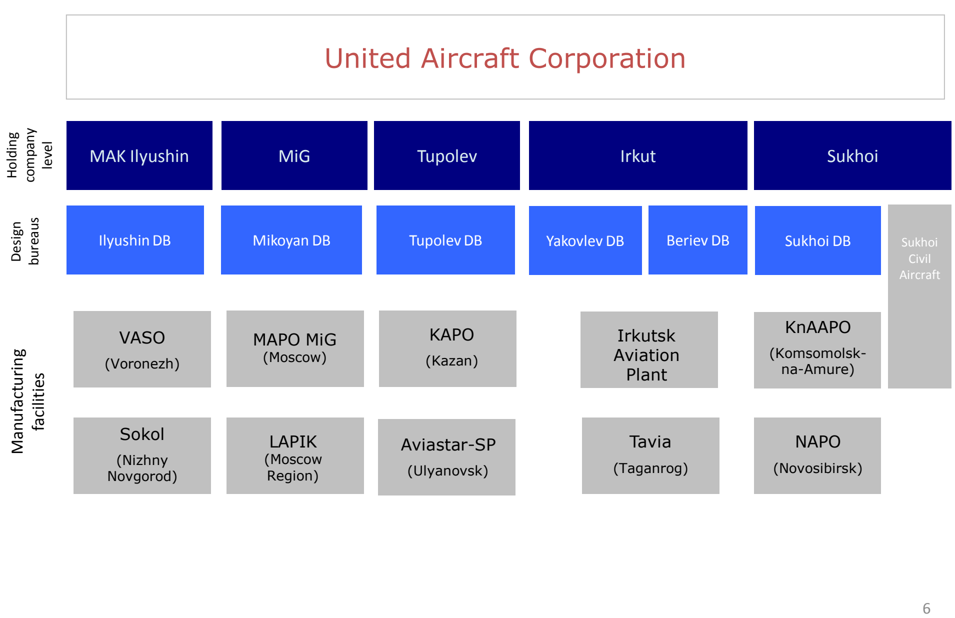
The UAC strategy has been supported by a number of decrees, resolutions and military planning:

- Decrees of the Russian Federation President, Resolutions of the Russian Federation Government and other guidelines on the development of the national aircraft industry;
- Fundamentals of the Russian Federation policy in the area of the development of the defense industrial complex for a period up to 2010 and further long-term period;
- Fundamentals of the Russian Federation military technical policy for a period up to 2015 and further long-term period;
- Key lines of the development of armaments, military and special equipment (AMSE) for a period up to 2020 and further long-term period;
- Government's armament program for 2007-2015;

- Strategy of the Aircraft Industry Development for a Period up to 2015;
- Federal target program "Russian Civil Aircraft Development for 2002-2010 and for a period up to 2015";
- Transport Strategy of the Russian Federation.

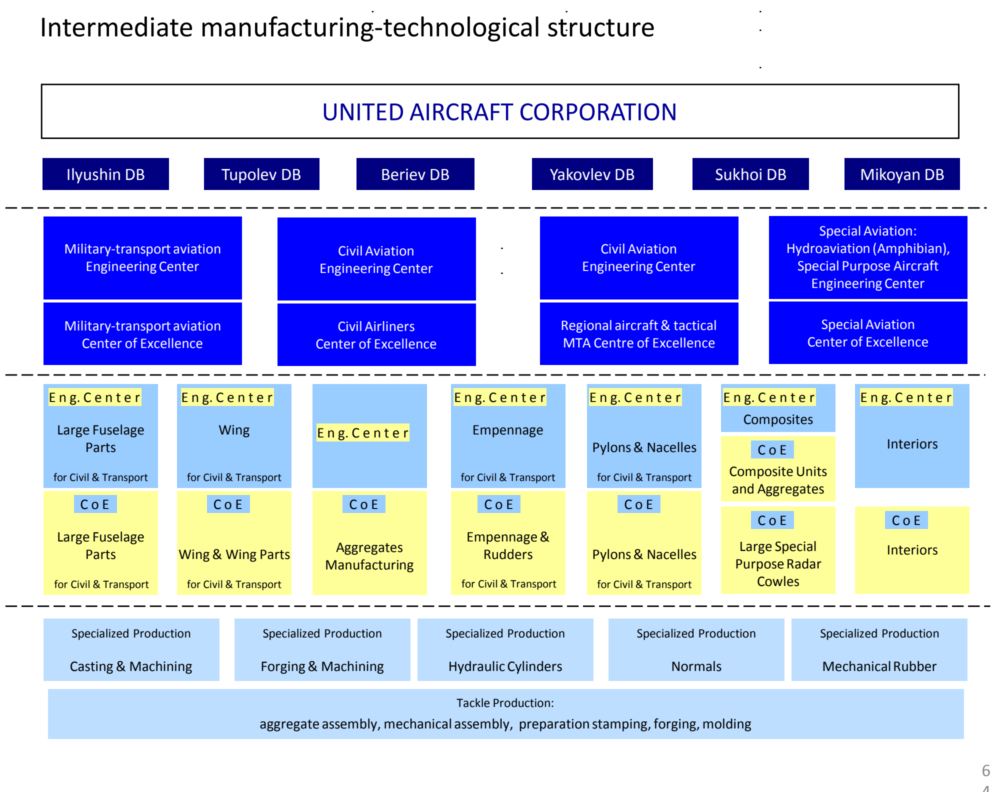
UAC plans are part of a higher strategic economic development agenda that aim to (1) diversify and balance civil and military revenues, (2) increase competitiveness, and (3) increase Russia global outreach. To diversify and reach a balance portfolio, UAC is planning to develop its business in all key aircraft industry segments, using a differentiated approach to each segment and considering available market opportunities against its own competences. In order to be competitive, UAC plan to attract foreign partners and acquire necessary technological and industrial solutions. To increase its global outreach, UAC plan to transition to an open business model on the basis of a public company that will be able to obtain additional investments from capital markets and technologies from its future partners.

Figure 111: Current technology structure



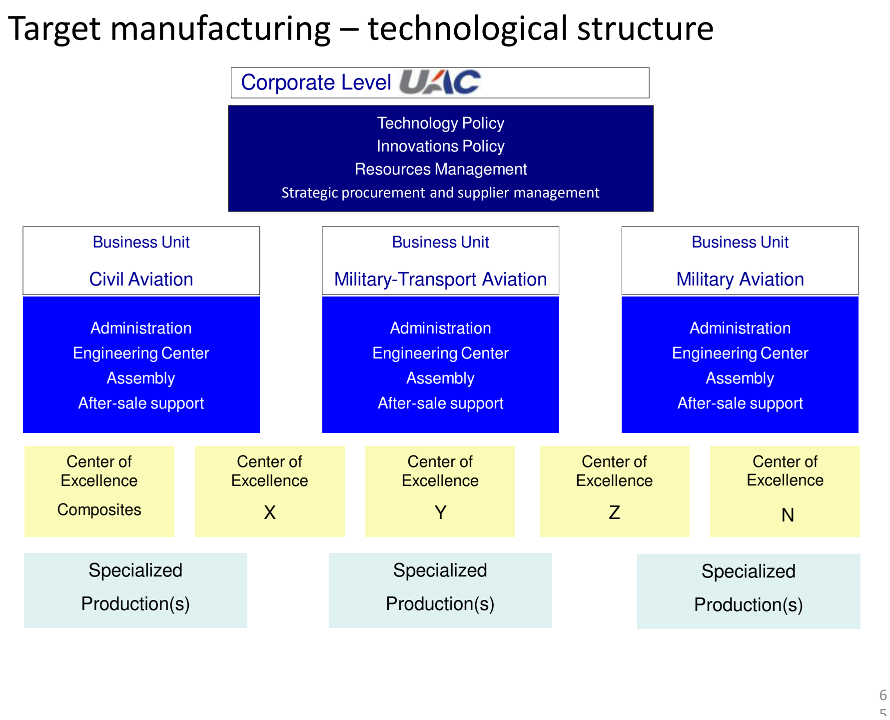
The second stage of UAC development will be to form a corporate structure and organization similar to an EADS and Airbus. In fact, UAC is referred in Russia as a Russian Airbus. The structure will pilot key projects to develop centers of excellence. At the end of stage two, UAC corporate plan to have the following structure:

Figure 112: Intermediate UAC structure



The third stage will transform UAC into an aerospace group that will manage its business units and centers of excellence. The technology, innovation and resource management as well as the procurement will be managed at the group level. The six companies will be fully merged and the group will be organized into three business units: Civil Aviation, Military transport and Military Aviation. There will be three production centers.

Figure 113: UAC Final Structure



The corporate structure is the capitalization of the parent company, where the three business units are profit centers and the parent the center of cash flow consolidation The capital structure of the company is anticipated to reach $9B by 2015 and be engaged in major partnerships with western aircraft manufacturers.

The Corporation's strategy in the civil aircraft area include the development of three groups of aircraft projects, the current, the promising and the future projects.

For the current projects, UAC is engaged in the modernization and serial production of the IL-96, Tu-204/214, IL-114, Tu-334, An-148 and Be-200 aircraft families. The modernization of these aircraft is to be performed at minimum cost-and aim at reducing the production costs At the same time UAC will upgrade its production facilities both to increase production of currently manufactured aircraft and prepare for production of next generation aircraft.

The aircraft characterized as "promising projects have already been launched. UAC is planning to facilitate the introduction into international markets. This category includes projects of SSJ (SSJ-100 and successors), and the wide body short/medium range aircraft Tu-204SM. Considering technological, financial and market barriers, the implementation of promising projects presupposes the cooperation and alliances with foreign aircraft manufactures.

For the new generation project, UAC is planning to create a solid basis for launching production of aircraft appealing to international market and develop a full family of product from 150 to 210 seats. Their actual plan is to produce the MS21. The cost of a modern civil aircraft project makes it impossible to implement, unless such project is intended to the world market. Therefore the most important element of the UAC's strategy will be attracting foreign partners to the MS21 on conditions that the Corporation reserves the role of the integrator. UAC may participate as a subcontractor in projects of foreign aircraft manufacturers.

IX-2 The large Russian aircraft manufactures

IX-2-1 Sukhoi

Sukhoi is best known for its military fighter aircraft. The Sukhoi design office was created in 1939 under the name of its founder Pavel Sukhoi. It is now the Sukhoi Company, which includes the design office based in Moscow and manufacturing facilities in Novosibirsk, Komsomolsk-on-Amur and Irkutsk. Its current CEO Mikhail Pogosian. The production of Sukhoi military aircraft was, and is primarily for the domestic market. They are currently equipped with Sukhoi 24, 25, 27, 30. Sukhoi estimates that the market for this type of aircraft could reach 2000 units including export version to countries politically linked to Russia such as Algeria, India, China, Malaysia, Iraq, Syria, Vietnam, Korea Northern Afghanistan, Yemen, Libya, Egypt, Iran, Angola, Ethiopia, Eritrea, Venezuela, and Peru. Its latest aircraft, the SU 34, a two-seater fighter bomber, is intended to replace the SU 24 fighter bomber and, in part the bomber Tupolev TU 22. The latest addition to its combat aircraft, currently being tested, is a stealth fighter of 5th generation, the SU PAK FA (T 50) which first flight took place in January 2010.

In the late 90s, Sukhoi decided to evolve towards the production of civil transport aircraft.

It had partnered with the Italian company Finmeccanica and created the company "Sukhoi Civil Aircraft" (President Vladimir Prissiajniouk) which initial goal was the creation of the new family of Russian regional planes Sukhoi Superjet 100.

The Sukhoi Company is developing three new programs:

- A civil program, the Sukhoï Superjet 100
- A military program, the Sukhoï T 50
- In a marginal way, it also participates in the project of transport aircraft of short / medium haul MS 21, whose leader, within the UAC consortium is the Irkut company.

Figure 114: Sukhoi Superjet 100

The regional transport aircraft is offered in four different versions from 75 to 98-seat. A new version of 110 passengers is under consideration. Produced by Sukhoi, and Ilyushin in Komsomolsk-on-Amur, the aircraft made its first flight in 2008.

A subsidiary of Finmeccanica, Aliena Aeronauticais is a 25% shareholder of the company. The engines are provided by a the collaboration between Russian NPO Saturn and Snecma Safran Group of France and Aircelle (France) for the nacelle.. Many other companies are participating including Thales (France) and Boeing, acting as a consultant.

<u>Main suppliers of the Superjet100</u>

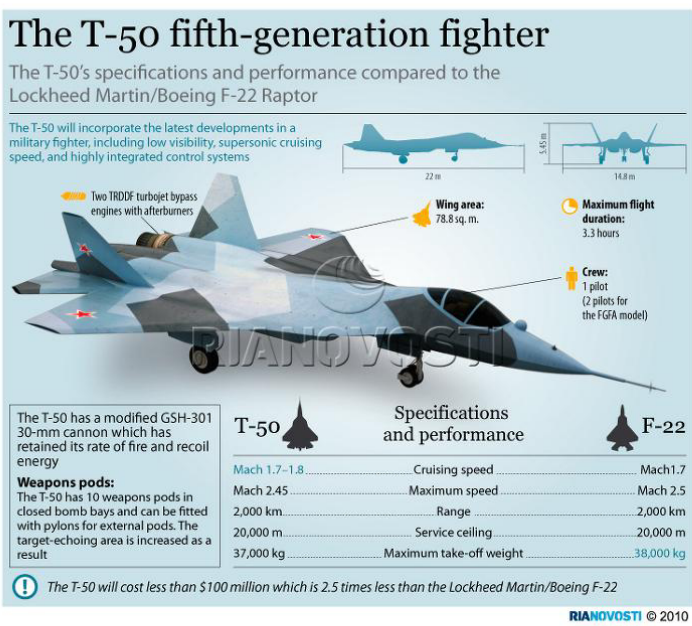
Component	Partner, supplier
Engine	Snecma
Engine Nacelle	Aircelle
Avionics	Thales
Control systems	LEIBHERR
Environmental control systems	LEIBHERR
Landing gear	MESSIER DOWTY
Fuel system	INTERTECHNIQUE (ZODIAC)
Interior	B / E AEROSPACE
Security protection againt fire	AUTRONIC (Curtiss Wright)
Oxygen system	B / E AEROSPACE
APU	HONEYWELL
Seats	IPECO
Hydraulic system	PARKER
Electric system	HAMILTON SUNDSTRAND
Motor vibration detector	VIBRO-METER
Wheel and brake	Goodrich

The Superjet International Corporation, responsible of marketing, is owned by Alenia Aeronautica (51%) and by Sukhoi (49%). It is established in Venice, Italy and in 2009 opened a branch in Washington D.C . It also has representations in Moscow and Toulouse. On October 2009, the Sukhoi Civil Aircraft Company and the airline VietJet signed a memorandum confirming the intention of the Vietnamese company to study the possibility to buy the Sukhoi Superjet 100. Great efforts are made to promote export sales. The Sukhoi Superjet 100, will compete against the Bombardier CRJ900 and the Embraer 170 and 190. It also will compete, in its larger versions, against the A318, A319 and Boeing 737-600.

Currently 200 units have been ordered: the majority is going towards Russian companies.

<u>Sukhoi T 50:</u>

The Russian multi-role stealth fighter of 5th generation developed by Sukhoi was launched in 2000. Its full name is PAK FA T 50. It is intended to replace the Mig 29 Fulcrum and SU 27 Flanker. It inherited the technology of two projects developed by the Company, the Mig (Mig 1.44) and Sukhoi (SU 47). Over 100 Russian companies are involved in the program.



Russia's company NPO Saturn produces the new generation engine. The Society of Aircraft Production Komsomolsk-on-Amur in cooperation with the Society of Aircraft Production Chkalov Novosibirsk is producing the aircraft. It made its maiden flight in January 2010 and should enter service in the Russian Air Force in 2015. Partnerships are sought for a licensed production overseas. Statements in April 2009 suggesting a possible licensed production in Brazil have not materialized. A partnership with India is being discussed and a contract could be signed in 2010. According to Sukhoi's CEO, Mikhail Pogosian, "this common realization, by its qualities and its price should not only strengthen the power of the Russian and Indian Aircraft industry but also still have a great-deserved place on the world market.”

IX-2-2 Yakovlev

The OKB (opytno konstruktorskoïé biouro - office and construction) Yakovlev was founded in 1934 by Alexander Sergeyevich Yakovlev. It became Yak by unification with the airplane factory in Smolensk in March 1992. These two entities, however, continue to be managed separately. The Yakovlev OKB has since been privatized and became the Society of Aviation Yak now part of UAC.

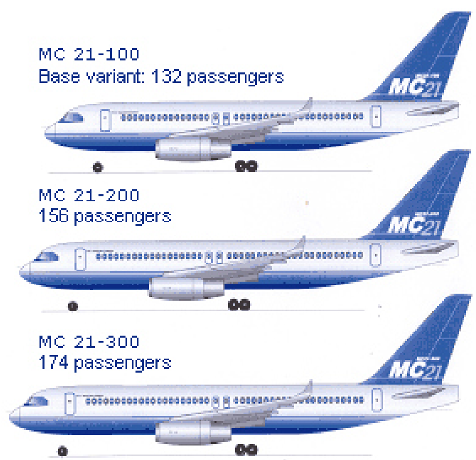
Yakovlev was primarily a manufacturer of military aircraft that had a great reputation, especially during the Second World War for building interceptors and fighter-bombers. In the 1960s, its research department demonstrated its high scientific and technological capabilities through its work in the field of fighter aircraft with short and vertical takeoff. It has also produced some helicopters and aircraft for training. Yakolev design bureau, in 70 years of existence, have produced as many as 70,000 aircraft Its production of civil transport aircraft has been limited to two models (Yak 40 and 42) and one project in the present time the future MS 21.

MC 21: (or MS21)

Figure 115: MC-21 (or MS-21)

The MS21 is in its early stage of definition. It is designed to compete directly with the CSeries, the A320 family, the 737 and the COMAC919. Yakovlev is a major participant in the project of the Irkut MS 21 designed by Irkut Corporation and the Yakovlev Research Bureau.

The MS 21 is a twin-engine for short/medium haul derived from the Yak 42.. Its first flight is expected in 2014 for an entrée into service in 2016. Originally the MS21 had a 100 seater in the family that would have competed against the Superjet 100. The 100 seater version was dropped from the MS21 program not to compete with the SSJ within the same UAC entity.



The top product objectives of the program include:

- - Uses 40% of composite materials,
- - Russian reactors for the Russian market,
- - Pratt and Whitney (Canada) and Rolls Royce for the western market,
- - Avionics: Avionika (Russia) and Rockwell Collins (USA),
- - For the control system of the aircraft: Aviapribor (Russia), Goodrich, (France) and Rockwell Collins (USA).

IX-2-3 Antonov

Antonov latest product is the AN-148 .Its production has already started. Airlines of Russia, Ukraine and Kazakhstan have stated their intention to purchase approximately 100 AN-148 aircraft. Contracts have already been signed with KrasAir, Polyot, SCAT, and Berkut airlines.

Russia, Ukraine, Kazakhstan, Georgia, Kyrgyz and Tajikistan leaders have expressed their interest in purchasing VIP-versions of the AN-148.

The AN-148 program has been launched with risk sharing partners including . SE Kyiv Aviation Plant "Aviant", Kharkov State Aircraft Manufacturing Company, IFC and Voronezh Joint Stock Aircraft Building Company .

The main suppliers of the AN-148 are mostly Russian, to the exception of a very few western suppliers:

- Ukraine: Motor Sich JSC, Juzhmach Plant, UKRNIIRA JSC, NII Buran, Aviacontrol JSC, KhADB, Ukranalit JC, STC Electroprylad JSC;
- Russia: Aviapribor Holding JSC (Moscow), UDBP JSC (Ulyanovsk), Joint Avia Teploobmennik JSC (Nizhniy Novgorod), Aerosyla-Electromash JSC (Moscow), Techpribor JSC (Saint-Peters-burg), Rubin JS;
- France: Deutch, Filotex, Thales, LIEBHERR;
- Germany: Litef, Goodrich Hella Aerospace, Hawker, PALL Corporation GmbH,

Monogram System;

- USA: Rockwell Collins, ASCC;
- England: Raychem, Dunlop Aircraft Tyres Limited.

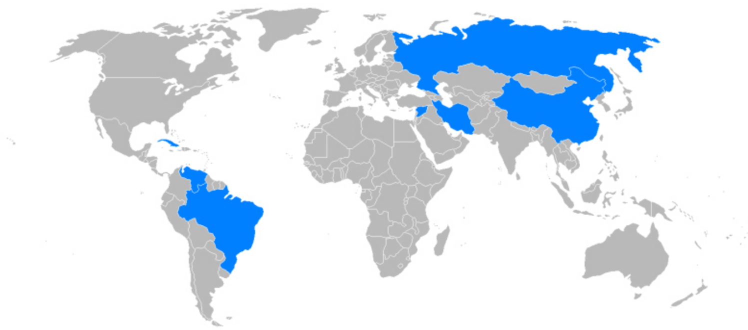
IX-2-4 Ilyushin

Figure 116: Ilyushin Il-96M

Ilyushin main civil aircraft program is the IL-96-300. The long range aircraft is shorter but similar to the Airbus A340. The Il-96M and Il-96T are propelled by Pratt & Whitney PW 2337 engines. Its avionic system comes from Collins Digital Avionics.

It was launched in 1985 and entered into service in 1993. The Il-96-300 can accommodate 262 passengers. In August 2009, Russian Minister of Industry and Trade Viktor Khristenko announced that the Russian Aviation Industry would stop manufacturing Il-96-300. A future airplane development project Il-96MK is currently under study. However, the future of the program is rather gloomy as airlines throughout the world are moving away from 4 engine 300 seater aircraft to the A330, or future 787 and A350. Moreover, the IL-96 operating cost are some 30% higher than the current western aircraft being delivered.

As of June 2009, a total of 21 Ilyushin Il-96 airliners were in service with 12 more in order. Operators include Rossiya (four in service, one on order), Ilyushin Design Bureau (one in service), KrasAir (two in service), Iran Air (six on order), Atlant-Soyuz Airlines (two on order), Aeroflot (six in service), Cubana (three in service, one on order), Clean Air (two on order), Polet (two in service, one on order), Conviasa (two on order) and another Russian airline (five in service).



IX-3 Factors influencing the success of UAC entry into the commercial aircraft industry

To achieve the ambitious plan, a number of external conditions to UAC plan would have to realize. These conditions are essentially:

- Accelerate social and economic development of the country ensuring dynamic growth of disposable earnings and, as a result, transport mobility of population;
- Government's stimulation of air freight and passenger operations in Russia,
- Development of the aviation infrastructure in order to utilize domestic market;
- Improvement of airport operations, improve or build civil aerodromes of regional and local importance;
- Upgrading military aircraft fleet of the Armed Forces of Russia;
- Maintaining favorable investment climate in the high tech and strategic areas of the economy and implementation of the government's innovation policy.

The necessary conditions, which are to be created inside the industry, are:

- Providing competitive advantages (price and quality of the products, availability of after sale maintenance service, financial instruments for sales support) for products in selected market niches (product and market);
- Providing conditions for investment attractiveness of the industry;

- Conducting flexible international cooperation combining purchase of components with their possible localization by world leading manufacturers of aircraft systems and units, participation in technological process chains of foreign aircraft manufactures, entering into strategic alliances and joint projects with such companies;
- Accelerate the development or adoption of critical aircraft manufacturing processes required for creating competitive products;
- Accelerate upgrading, the productive system by importing latest production equipment and processes.

The existing technology and positioning of the current products will not be able to achieve the stated UAC target by a long shot. UAC will have the difficult task to carry out the following projects to be successful:

- Select priority projects of strategic importance by market segments and concentrate resources on such projects;
- Accelerate formation of the scientific and technological capacity sufficient for development of competitive aircraft;
- Form an integrated design and production environment making it possible to realize the created capacity into competitive products;
- Stimulating the demand of Russian airlines by providing competitive products and for the foreign market, by getting international alliances.

In order to develop a family of aircraft that will be successful in the world market, UAC will have to identify a few market niche and perform deep concept research, which would define future aircraft features that are shaped by future business environment such as the rapid growth of fuel prices, toughening of ecological requirements and the increase competition with other types of transport. The most challenging element of the UAC's Strategy is to organize its scientific research to provide state of the art manufacturing and differentiated products through innovation and right market positioning.

Conclusion

The demand side of the large commercial aircraft is very competitive and requires products of high performance that are economical and efficient to operate as well as reliable. The demand for air travel and aircraft is shifting to Asia, but the trendsetter airlines continue to be in Europe and the US. Air travel growth is challenged by environmental sustainability factors that greatly influence innovation of the supply side. The need for technology innovation to be able to grow air travel and to maintain the incumbent leadership position through differentiation is pushing the incumbents' costs for new program introduction to new heights. At the same time, their product cash cows (A320 and 737) are reaching their economic life and are challenged by new entrants that are bringing new and more efficient aircraft to the market in the next five years. Although these new products are only step changes, the incumbent aircraft manufactures must respond by seeking new opportunities to reduce their costs through internationalization of their supply chain and product innovation.

Asia has become the world's largest market for commercial aircraft. As a result, the home market of China and India are now large enough to justify an indigenous civil aircraft in the 70 to 90 seats capacity for India and 150 seats capacity for China and to enter the market with some success. As for the entry in the market of Airbus, Boeing and Douglas, the strategic importance of the commercial aircraft business is influencing government policy of the emerging countries. The strategic importance of the commercial aircraft comes from its impact on the national economy; export, employment, technology expertise, and innovation. In particular, aerospace innovation has a proven spillover in other industries. For China, aerospace is also a matter of national security and is part of a larger strategy to shift growth from consumer goods to high-value-added industries. Governments in emerging parts of the world are planning and acting on increasing their knowledge base economy as they realize that it will generate well-paying jobs, contribute to higher value products and ensure competitiveness as their economy matures. Government support of the LCA industry has occupied many policymakers on both side of the Atlantic in the last twenty years. Given the comprehensive and aggressive plan, and the level of committed resources both in people and funds of the Chinese and Russian governments to develop their LCA industry, the debate will transfer from the Atlantic to the Pacific and within Europe at one point in time. It is actually surprising that so far, it has not been the source of much debate at the WTO.

However, it will take more than government support and their home market to make the Chinese and Russian LCA industry successful. The key determinants of competitiveness involve many factors that are beyond their influences. Among them, the most challenging for the new entrants will be the development of a coherent product development strategy, the market credibility of their products, the values proposition and differentiation of their products, the productivity, efficiency and flexibility of their productive system and the relationship with customers and suppliers.

Most of these challenges can be overcome if China and Russia focuses on one single aspect: innovation. Their ability to innovate could transform the leadership in aviation. The challenge is big. The immense financial resources of Russia will still be not enough to develop an innovation network to the scale of Russia, notwithstanding to the scale of UAC. The credibility in the market place will be long to obtain. Given the magnitude of China's engagement, the credibility they have successfully built in other domains such as automobile and computers, their ability to innovate in aviation is real. Everything will be in the execution. The metric perfected for this research to assess the degree of readiness that China have reached in shaping its innovation system is based on four categories or domains of factors relating to innovation. These four factors are: (1) the business enterprises ("firms"), (2) the science and technology institutions, (3) the transfer and absorption of technology, knowledge and skills and (4) the surrounding environment. The fourth domain is of particular importance for emerging countries as it drives the range of opportunities for innovation through its institutions, its legal arrangement, its macroeconomic settings, and other conditions that exist regardless of any considerations of innovation. The metric has allowed this research to collect data using a practical framework.

The Table 10: Evaluation of the innovative environment of the firm in emerging countries based on OECD framework give a summary of the assessment.

In essence, the most challenging issues for the China's firms to innovate are essentially:

- basic research linkage between firm
- presence of experts
- venture capital for technology start-up firms
- management skills and experience for researchers
- marketing research, market development skills
- ease of industry access to public R&D capabilities
- strategic research capabilities of the firms
- capacity of combining all innovation dynamo factors of the innovative firm

To be able to develop a game-changing aircraft, China would have to master all these skills. China has already launched a 150 seater commercial aircraft with the ambition to enter the market in 2015. Under this timing, it is expected to have a six year lead time between the end of the design phase and the first delivery. It will be impossible for COMAC to be able to include game-changing technologies. However, the development of this "transition aircraft" will be critical even if it fails commercially to build experience in linking Chinese aerospace and international suppliers, to generate experts, to develop management skills and experience and build marketing expertise in an international environment. Boeing and Airbus anticipate delivering their game changing aircraft in the 2023-2025 timeframe. To be able to deliver a game-changing commercial aircraft "timed to market" earlier or at the same time than its competitors, China would need to finish preliminary design of their game changing aircraft by 2017 or 2018. Possible to Chinese speed of execution but challenging especially in the area of basic research, management skill and experience and combining the skills for innovation or be a sort of architect that integrate all the technology and discipline together. It will all depend on how the Chinese commercial aerospace organizes itself to reap the maximum benefit from the experience that will develop in the "transition aircraft" launched last year.

The cluster analysis has been tremendously useful in showing that China has hundred of thousand of qualified engineers and technician, and a strong aeronautic base. It also shows that in the helicopter business in China has successfully evolved from being an imitator to a partner, then a component supplier and finally an endogenous helicopter designer and manufacturer. On the negative side, the cluster analysis has shown a very inefficient cluster structure, with competing or overlapping programs. The number of engineers and technician is quite impressive but the collective low output of the aerospace sector in China raises the question of their efficiency. Finally the cluster analysis indicated that China is trying to develop the entire aircraft supply chain expertise in the different clusters rather than taking the internationalization route of its western competitors. This seems to be the result of the individual clusters developing their own isolated strategy rather than a comprehensive national strategy to cover the full supply chain. In any case, it does not seem to be the right strategy especially in building the credibility in the western world.

The challenge is difficult but will most likely be overcome in making COMAC one of the top three LCA leaders. Innovation leading to unique value propositions of their product will in any case be the enabler to unlocking the credibility challenge in the global market place.

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Key words

Air travel
Aircraft manufactures
Airlines
Alliances
Barrier to entry
Clusters
Commonality
Competition
Contestable markets
Co-operation
Demand
Deregulation
Economic cycle
Emerging markets
Firm
Firm structure
Government policy
Incumbent
Innovation
Internationalization
Legacy airlines
Low cost airlines
Market
Market dominance
Market entry
Natural monopoly
New entrant
Oligopoly
Partnerships
Product differentiation
Social responsibility
Spillover
Strategy
Subsidy
Suppliers
Supply
Technology

Abstract

The incumbent firms in the large commercial aircraft industry (LCA) oligopoly are faced with many short to medium term challenges that will shape their future competitiveness. The financial crisis has accelerated the market dynamics that are driving these challenges. Among them, the sustainable growth of air travel, the increasing costs of new programs and the threat of the new contenders entering the LCA top the list. For all the players and potential players, innovation and internationalization of the supply chain are key determinants of their future competitiveness. The main objective of the thesis is to assess the capacity of emerging countries to turn into innovation powerhouses and become leaders in the large commercial aviation business.

The research integrates the supply (technology, structure of the firm, internationalization, strategy, government policy) and the demand side (effect of the airlines market and business strategy on the LCA manufacturers's strategy). Most of the research in this field have concentrated on the supply side. The thesis focuses on understanding the reasons for the strategic importance of civil aviation in government policy, defining the key determinants of competitveness in the LCA industry, and analyzing the market entry of incumbent firms. More importantly, the research proposes a metric and a cluster analysis to determine whether or not China has the ability to be innovative and to become a leader in the commercial aircraft business.