

INNOVATION IN AVIATION





In the beginning there was desire, which
was the first seed of mind...

-Hymn of Creation, The Rig Veda



SINCE GENESIS, MANKIND HAS ALWAYS BEEN OBSESSED WITH THE DESIRE OF FLIGHT. THE REASON FOR THIS OBSESSION CAN BE RELATED TO THE MINDSET OF PEOPLE, FOR WHOM FLIGHT WAS SYNONYMOUS WITH POWER, FREEDOM AND DIVINITY THAT PROVIDED AN INDIVIDUAL, EUPHORIA OF BEING SUPERHUMAN. THE OBSESSION THAT WOULD ALLOW THEM TO SHUN THE TROUBLES OF THE WORLD, MAKE THEM AS FREE AS A BIRD AND BE CLOSER TO THE GODS THAT REIGNED ABOVE THE CLOUDS.

This obsession and passion to fly can be found in many mythological reproductions too. There are various instances where the means and methods of flying have been described in mythological scripts. We find references of Ravana's flying chariot "Pushpaka" and "mechanical bird" being mentioned in Rig Veda (verses 1.164.47-48) of Indian mythology. Similarly, other mythologies like Greek's, mention the winged divine stallion "Pegasus" and "Icarus" who wore the wings made from feathers and wax for the flight of freedom. These and many other such abstracts played an important role in refueling the desire of successful and prolonged flight.

The desire of successful and prolonged flight could only be satiated by inventing a machine that could take off under its own power, provide sustain prolonged flight and could be controlled during flight. In the modern world, although the attempts were repetitive, the first eureka moment was December 17, 1903 when Wright Brothers finally made an aircraft that completed four successful flights, and became the first aircraft to take off under its own power. Since then, there have been thousands of aircrafts with advanced technologies in all possible aspects to conquer the sky and make flying a safe and pleasurable experience.



INDUSTRY OVERVIEW

The Indian aviation industry is on its way to explore new growth avenues. India has a vision of becoming the third largest aviation market by 2020. With such a vision, the Aviation Industry has implemented several changes to augment development; such measures include Foreign Direct Investments (FDI), launching Low Cost Carriers (LCC), Modernizing airports with latest technologies and establishing new routes to improve regional connectivity.

The aviation sector contributes annually INR 330 billion (0.5%) to Indian GDP. This in total comprises: INR 147 billion directly contributed through the output of the aviation sector (airlines, airports and ground services); INR 107 billion indirectly contributed through the aviation sector's supply chain; and INR 77 billion contributed through the spending by the employees of the aviation sector and its supply chain. In addition there is INR 582 billion in “catalytic” benefits through tourism, which raises the overall contribution to INR 912 billion i.e. 1.5% of GDP.

The aviation sector supports 1.7 million jobs in India. This total comprises: 276,000 jobs directly supported by the aviation sector; 841,000 jobs indirectly supported through the aviation sector's supply chain; and 605,000 jobs supported through the spending by the employees of the aviation sector and its supply chain.

INR 7.1 billion through taxation of activities supported by the spending of employees of both the aviation sector and its supply chain.

As per the market size, the Indian civil aviation industry is amongst the top 10 in the world a size around USD 16 billion. However, in order to achieve the vision of becoming the third largest aviation market by 2020, a lot more needs to be done.

Facts about Indian Aviation Industry

- 9th largest aviation market in the world;
- Aiming to be 3rd largest by 2020;
- Operating via 450 airlines and expected to add another 800 by 2020;
- 85 international and approximately 12 domestic airlines currently operating ;
- Connecting 40 countries across the globe;
- Permitting 100% FDI for green field airport projects;
- Allowing 100% foreign equity in airport development;
- Expecting growth in domestic and international passenger traffic at an average annual rate of 12% , and 8% in next five years; and
- Supporting 1.7 million jobs in India.

Contribution to public finances, the aviation sector pays over INR 87.5 billion in tax including income tax receipts from employees, social security contributions and corporate tax levied on profits. It is estimated that an additional INR 9.8 billion of government revenue is raised via aviation sector's supply chain and another

Major Players

The Indian aviation industry is largely dominated by global players, especially relating to the matters of design and introducing new technologies. The Indian companies are tattering when it comes to global competition and need -to revolutionize their efforts in the sectors of research and development, to reach the benchmark in global aviation market.

Indian Players

The Indian players those are largely involved in aircraft manufacturing do not engage in technologies related to aerodynamics, engine, alternative fuel formulation, air traffic system, and air port development. The main aircraft manufacturing companies in India are:

1. **Aeronautical Development Agency-** It is the nodal agency for design and development of Light Combat Aircrafts. Its working centers are spread across the Country.
2. **Aequis Aerospace-** It focuses mainly on AeroStructures and AeroSystems. It specializes in precision machining and houses several interrelated capabilities that are either unavailable in India or are difficult to assemble in one location. This is the first company in India to ship Airbus A-380 Wing Assemblies. The main clientele include Airbus, Eaton Aerospace and UTAS.
3. **Bharat Heavy Electricals Ltd. (BHEL)** – It is an integrated power plant equipment manufacturer and one of the largest engineering and manufacturing company in India. It is also engaged in designing, engineering, manufacturing, constructing, testing, commissioning and servicing a wide range of products and services when it comes to aircraft manufacturing for the economy liners.
4. **CSIR- National Aerospace Laboratories (CSIR-NAL)** – It's mandate is to develop aerospace technologies in designing and building, small and medium –sized civil aircrafts like HANSA-3, SARAS, C-NM5 in association with M/s. Mahindra Aerospace Pvt. Ltd., Bangalore, and support all national aerospace programs. CSIR-NAL marks the first public-private partnership in aircraft development. It has been made the lead agency by the Government of India for carrying out feasibility study for the development of a National Civil Aircraft (70 & 90 seater for regional connectivity) proposed to be developed during 12th FYP (Five Year Plan) and beyond.
5. **Hindustan Aeronautics Ltd., Bangalore-** It is wholly owned by Government of India, which under the

current program is involved in the production of SU-30 MKI, Hawk- AJT, Light Combat Aircraft (LCA), DO-228 Aircraft, Dhruv- ALH and Cheetal Helicopters, Repair Overhaul of Jaguar, Kiran, Mirage, HS-748, AN-32, MiG 21 etc. The Company provides maintenance and overhauling services. In addition, facilities exist for repair/ overhaul of various accessories and avionics fitted on aircraft of Russian, Western and Indigenous designs.

6. **Indian Air Force, Aircraft Manufacturing Depot, Kanpur-** The only Base Repair Depot of the Indian Air Force exists at Kanpur, along with a Repair and Manufacturing Depot (RMD). A unit called Aircraft Manufacturing Depot (AMD) was subsequently added to undertake manufacture of the AVRO aircraft. This Maintenance Command was set up to provide maintenance support to operating bases by undertaking overhauling and repair function for aircraft, aero engines, ground equipment, radar and missiles and warehousing of stores required during peace and war.
7. **Mahindra Aerospace Pvt. Ltd. -** Mahindra Aerospace is dedicated to the production and innovation of the utility aircraft and aero structures that meet the varied needs of the global market.
8. **Taneja Aerospace & Aviation Ltd. –** It is the First private sector Company in the country manufacturing general aviation aircraft i.e. non military aircraft. The company's mission is to boost up the affordable general aviation in the country. Therefore, the company is into manufacturing Light Transport and Trainer Aircraft and is having a significant presence in many segments of the aviation and aeronautical industries in India.



Global Players

Majorly, 10 companies dominate the world in aviation sector. Indian aviation sector is also controlled by these global players:

1. Boeing - \$42.5bn

The Boeing's revenue was \$42.5bn in the first half of 2014, while its net profit during the same period was \$2.61bn. Headquartered in Chicago, Boeing is the biggest combined manufacturer of commercial jets and military aircraft. Its business segments include Defense, Space & Security; Commercial Airplanes; Boeing Capital; and Shared Services Group. The company's product line passenger aircraft are such as the 737, 747, 767, 777 and 787.

2. Airbus Group - \$36bn

The Airbus Group's (formerly EADS) revenue in the first half of 2014 was \$36bn, while net income was \$1.52bn. The European aerospace and defence conglomerate includes Airbus, Airbus Defense and Space, and Airbus Helicopters, and has a strong employee base of 140,000 people all across the globe. The Group's diverse product portfolio includes commercial and military fixed-wing aircraft and helicopters such as Eurofighter Typhoon, A380, A350 XWB, A330 MRTT and A400M.

3. Lockheed Martin - \$21.95bn

The Lockheed Martin reported net sales of \$21.95bn for the first half of 2014. Net earnings of the company stood at \$1.82bn for the same period. It develops and produces Aircrafts, Land Vehicles, Unmanned Systems, Missiles and Guided Weapons, Missile Defense Systems, Sensors and Radars, Naval Systems, Satellites, Launch Vehicles and Spacecraft, IT Systems and emerging technologies.

4. United Technologies Corporation (UTC) - \$17.3bn

The United Technologies recorded net sales of \$17.3bn from its aerospace and defense businesses, which accounted for over 50% of its net sales in the first half of 2014. UTC's diverse product base constitutes of commercial and military helicopters, aircraft engines and propulsion systems, aircraft systems and components.

5. General Dynamics Corporation - \$14.73bn

General Dynamics Corporation earned revenues of \$14.73bn in the first half of 2014. The net earnings for the same period stood at \$1.13bn. The four core business groups of General Dynamics are Aerospace Systems, Combat Systems, Information Systems and Technology, and Marine Systems.

6. BAE Systems - \$12.91bn

BAE Systems is an International defense, aerospace and security company BAE Systems, headquartered in London, reported sales of \$12.91bn and net profit of \$736m in the first half of 2014. BAE delivers products and services in areas of defense, security, electronics and systems integration, cyber and intelligence, military, IT and information systems.

7. Northrop Grumman - \$11.88bn

Northrop Grumman recorded \$11.88bn revenue in 2014. Northrop Grumman offers systems, products and services for defense and commercial customers in sectors such as unmanned systems, cyber security, C4ISR, and logistics. E-2D Advanced Hawkeye, Global Hawk, and MQ-8 Fire Scout are some of the manned and unmanned aircraft offered by Northrop Grumman.

8. Raytheon - \$11.2bn

Raytheon reported net sales of \$11.2bn for the first half of 2014. Income attributable to the company for the same period was \$1.14bn. Raytheon is an international aerospace and defense company offering products for defense and commercial customers.

9. Safran Group - \$9.65bn

Safran Group's revenues in the first half of 2014 accounted for \$9.65bn. Safran is an international (high-technology group) and a top class component provider to the aerospace, defense and security industries. Safran operates three major businesses including aerospace, defense and security.

10. Rolls-Royce Holdings-\$9.15bn

In the first half of 2014, Rolls-Royce net profit amounted to \$652m. Rolls-Royce is the second biggest supplier of aero-engine products and services for defence sector. Rolls-Royce is the major supplier of engines for wide-body airliners and corporate jets markets. The company offers engines for transport aircraft, combat aircraft, patrol aircraft, trainers, helicopters and unmanned aerial vehicles.





Major Segments

The aviation sector produces a comprehensive range of components which includes:

Airframe: Airframe is the mechanical structure of an aircraft. It combines aerodynamics, composites and light materials, on-board systems, and new frame designs for aircrafts.

Fuselage: Fuselage includes that portion of the aircraft that usually contains the crew and payload, either passenger, cargo, or weapons. Most fuselages are long, cylindrical tubes or sometimes rectangular box shapes. All of the other major components of the aircraft are attached to the fuselage.

Wing: The wing is the most important part of an aircraft since it produces the lift that allows a plane to fly. The wing is made up of two halves, left and right, when viewed from behind. These halves are connected to each other by means of the fuselage.

Air Engine: Engine is the key component of an aircraft. Aircraft uses several kinds of engines, but they can all be classified in two major categories viz. propeller driven piston engines and a form of jet engine.

Aircraft controller: Aircraft controller comprises of horizontal and vertical stabilizer, elevator, rudder, aileron, flap, cabin and cockpit.

Propulsion & Fuel: Propulsion & Fuel includes aircraft fuel technologies, Electric motors, fuel storage and supply system, jet/turbofan engines, piston, international combustion engine and turboprop engines.

Air traffic system: Air traffic system includes new electronic and operational data, signaling management, navigation technology, radar, surveillance, data recorders, defense system and performance systems.

Airport development: Airport development includes technology for aircraft route development, aircraft runway development, airport infrastructure development, aircraft parking and passenger's security and management tools.

Aircraft Manufacturing: Aircraft Manufacturing includes design, engineering, manufacturing, construction, testing, maintaining, commissioning and servicing of aircraft.





SUCCESS MANTRA: INTELLECTUAL PROPERTY RIGHTS

To sustain in long run and in competitive business environment, acquiring IP Rights is the best success mantra known to all. However, during foundation period many organizations forget this mantra and in long run they fail to survive due to sudden technological drift in the market.

Innovation is the key ingredient for the development of any technological field or industry. The same goes with aviation industry too. The innovations and findings by various scientists prior to Wright Brothers gained nothing monetarily but they are the one who gave Wright Brothers the power in terms of knowledge to take off and to conquer the everlasting human desire of flight. Galileo Galilei, Christiaan Huygens, and Sir Issac Newton simplified the understanding between resistance and surface area of an object exposed to the stream and the density of a fluid. Further, research on relationship between pressure and velocity by Swiss mathematicians Daniel Bernoulli, Leonhard Euler and British engineer John Smeaton laid the seed of mind to abridge the gap between physical theory, engineering research, and the age-old dream of flight by George Cayley which resulted into a successful flight by Wright Brothers in year 1903.

It took 413 years to launch the first flying machine under its own power after a clear representation of a flying machine depicted by Leonardo Da Vinci in year 1490.

Although, the history never denied the contribution of Galileo Galilei, Christiaan Huygens, Issac Newton and many more, but the credit for a successful flight is always given to the Wright Brothers.

Since this breakthrough, in another 112 years mankind has subsequently developed small airbuses to MiG's to Superjet's, and travelled further from moon to mars. This breakthrough invention has resulted into a series of innovation and created a healthy competition amongst the innovators to innovate and further reap the benefits of true intellect. Intellectual Property Rights have played an important role in keeping the right pace of development and proliferation of this technical field; and in return has provided a successful business tool to the innovators and creators of the technology.

Improvement and innovation are the key factors for the success and survival of any business. Intellectual Property Rights and associated strategies have always been a success mantra for any organization whether it's an old and big organization or a new and small organization or an upcoming organization. The most common ingredient of success of all business giants is their Intellectual Property (IP) and its proper & strategic protection followed by enforcement and commercialization. IP has become an integral and essential part of business plans and budgets of aviation business houses.

“Now, Business development and Intellectual Property Rights can be interlinked in many ways”

Development in terms of intellectual capital of an enterprise;

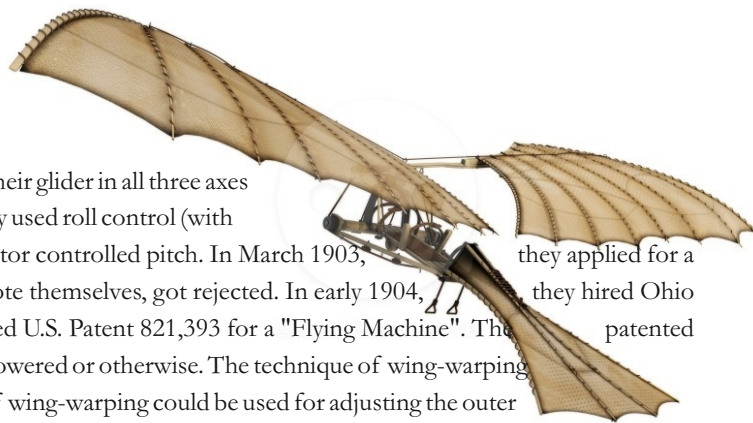
Overall business strategy means Intellectual property and Innovation strategies as the main part of the agenda;

Vision regarding the implementation of Intellectual property rights;

Investment in terms of intellectual property management, product development, and innovation; and

Market hold in terms of new products, competitive edge, and international expansion of IP

History of Aviation Patents: A Lot to Learn



During their experiments in 1902 the Wrights succeeded in controlling their glider in all three axes of flight: pitch, roll and yaw. This breakthrough discovery simultaneously used roll control (with wing-warping) and yaw control (with a rear rudder) and a forward elevator controlled pitch. In March 1903, they applied for a patent on their method of controlling. The application, which they wrote themselves, got rejected. In early 1904, they hired Ohio patent attorney Henry Toulmin, and on May 22, 1906, they were granted U.S. Patent 821,393 for a "Flying Machine". The patented claim was of a new and useful method of controlling a flying machine, powered or otherwise. The technique of wing-warping is described, but the patent explicitly states that other methods instead of wing-warping could be used for adjusting the outer portions of a machine's wings to different angles on the right and left sides to achieve lateral roll control. The Wright's patent was well drafted and broadly claimed many features in a single patent which enabled them to successfully control the aviation market and easily win the patent infringement lawsuits against Glenn Curtiss, their largest competitor.

Interesting Facts

Before Wright brothers gave us the power to take off, there were about 179 inventors and visionaries on the trail. The patents granted were initially on balloons but soon shifted to flying machines. Some of the early patents are listed here that laid foundation for the modern aircraft:

1. October 16, 1844	M Muzzi	Flying Machine
2. March 26, 1850	Hugh Bell	Balloon
3. July 11, 1854	J W Brewer	Balloon
4. May 12, 1868	Zaphna Stone	Aerial Navigator
5. July 21, 1868	Onofrio Abruzzo	Aerial Car
6. November 23, 1869	Frederick Marriott	Aerial Steam Car
7. February 8, 1870	Martin Braun	Improved Aerial Ships
8. October 5, 1886	Augustin H Hamon	Dirigible Aerostat
9. November 9, 1886	Moses S Cole	Aerial Vessel
10. November 9, 1886	Moses S Cole	Propelling Wheel
11. May 5, 1903	Otto A Kæhler	Flying Machine
12. May 26, 1903	L A Boswell	Steering for Dirigible
13. June 2, 1903	Geo D Shultz	Aerial Vessel
14. June 2, 1903	Theodor Gibon	Aeroplane
15. June 9, 1903	A F Godefroy	Means for Propelling Vessels
16. September 1, 1903	Isaac I Morris	Aerial Navigation Machine

“The Wright Brother's patent was a breakthrough invention in many ways and ahead of all inventions at that time.”

First Scheduled Airline Service

The first scheduled air service began in Florida on January 1, 1914. Glenn Curtiss had designed a plane that could take off and land on water and thus could build larger than any plane to date. Thomas Benoist, an auto parts maker, decided to build such a flying boat, or seaplane, for a service across Tampa Bay called the St. Petersburg - Tampa Air Boat Line. His first passenger was ex-St. Petersburg Mayor A.C. Pheil, who made the 18-mile trip in 23 minutes, a considerable improvement over the two-hour trip by boat. The single seated plane service accommodated one passenger at a time, and the company charged a one-way fare of \$5. After operating two flights a day for four months, the company folded with the end of the winter tourist season.

Patent Troll in Aviation

In 1917, the two major aircraft patent holders, the Wright Company and the Curtiss Company, had effectively blocked the building and development of new airplanes, which were desperately needed as the United States was entering World War I.

The U.S. government, as a result of recommendation of a committee formed by Franklin D. Roosevelt, then Assistant Secretary of the Navy, pressured the industry to form a cross-licensing organization (in other terms a Patent pool), the Manufacturer's Aircraft Association.

Beacons

In 1921, the Army deployed rotating beacons in a line, between Columbus and Dayton, Ohio, a distance of about 80 miles. The beacons, visible to pilots at 10-second intervals, made it possible to fly the route at night.

The Post Office took over the operation of the guidance system the following year, and by the end of 1923, constructed similar beacons between Chicago and Cheyenne, Wyoming, a line later extended coast-to-coast at a cost of \$550,000. Mail then could be delivered across the continent in 29 hours eastbound and 34 hours westbound which was at least two days less than it took by train.

Golden Period of Aircraft Innovations

1930's, as many believe, was the most innovative period in aviation history. There were 139 different models of aircraft developed during this period. Air-cooled engines replaced water-cooled engines, reducing weight therefore allowing construction of larger and faster planes. Cockpit instruments also improved, with better altimeters, airspeed indicators, rate-of-climb indicators, compasses, and the introduction of artificial horizon. Initiation of World War II also played a major role for such innovations which resulted from modern passenger airliner to ultimate fighter planes.

First Modern Airliners

Boeing built what is generally considered as the first modern passenger airliner, the Boeing 247. It was unveiled in 1933, and United Air Lines promptly bought 60 of them. Based on a low-wing, twin-engine bomber with retractable landing gear built for the military, the 247 accommodated 10 passengers and cruised at 155 miles per hour. Its cabin was insulated, to reduce

engine noise, and it featured amenities such as upholstered seats and a hot water heater to make flying more comfortable to passengers. Eventually, Boeing also gave the 247 variable-pitch propellers that reduced takeoff distances, increased the rate of climb, and thus boosted cruising speeds.

The Jet Engine

Sir Isaac Newton was the first to theorize, in the 18th century, that a rearward-channeled explosion could propel a machine forward at a great rate of speed. However, no one found a practical application for the theory until Frank Whittle, a British pilot, designed the first jet engine in 1930. Even then, widespread skepticism about the commercial viability of a jet propelled engine prevented Whittle's design from being tested for several years. Whittle first incepted the idea of the jet engine as a 22 year old officer in the Royal Air Force. He was awarded a patent for his innovation in 1932 and published his findings widely, but his ideas received little attention. Undeterred, Whittle went to work for a

research company called Power Jets in 1936 and proceeded to develop a working model of his engine for possible military applications. After tackling and solving many technical problems, Whittle finally began receiving support from the British government in 1939 and Britain's first fighter jet used the engine invented by Whittle in April 1937.

However, Germans were the first to build and test a jet aircraft. Based on a design by Hans von Ohain, a student whose work was independent of Whittle's, it flew in 1939, although not as well as the Germans had hoped, that's why it could not create an impact on the war. It took another five years for German scientists to perfect the design, by the time it was, fortunately, too late to affect the outcome of the war.

Whittle also improved his jet engine during the war, and in 1942 he shipped an engine prototype to General Electric in the United States. America's first jet plane - the Bell P-59 - was built the following year.

Radar

Another technological development which has a huge impact on the war's outcome (and later on commercial aviation) was radar. British scientists had been working on a device that could give them early warning of approaching enemy aircraft even before the war began, and by 1940 Britain had a line of radar transceivers along its east coast that could detect German aircraft, from the moment they took off from the Continent. British scientists also perfected the cathode ray oscilloscope, which produced map-type outlines of surrounding countryside and showed aircraft as a pulsing light. Americans, meanwhile, found a way to distinguish between enemy aircraft and allied aircraft by installing transponders thereby signaling their identity to radar operators. Radar was patented (British patent) in April, 1935 by Sir Robert Alexander Watson-Watt.





FIGHTER PLANES

First Generation Fighters [1945-1955]

The first generation of fighters probably consisted of those that appeared at the beginning of the Jet Age, starting late in World War II up through the Korean War. These planes were the first to be powered by turbojet engines, but were otherwise largely similar in capability to the old piston engine fighter they replaced. These early jet engines were limited in thrust such that the fighters could not typically operate above the speed of sound. Perhaps the most apt representatives of the jet fighters of that era are the F86 Sabre and MiG15, the two planes that fought most fiercely over the skies of Korea.

Second Generation Fighters [1955-1960]

The factors that epitomized fighters of the second generation were speed, radar, and use of the first guided air to air missiles. Many of these aircrafts incorporated lessons learned in Korea to improve the overall performance and combat effectiveness. These aircrafts were the first fighters capable of maintaining supersonic speeds in level flight. Their designs also incorporated advantages of new technologies making radar small enough to be carried aboard. Similarly, advances in guided missile technology allowed this new weapon to replace the fighter gun as the primary offensive weapon for the first time. Best representing this class of fighters is the American "Century Serie" and Sukhoi Su-9.

Third Generation Fighters [1960-1970]

Many of the third generation fighters were those served in the Vietnam War, particularly in the latter stages of the conflict. Most of these planes were first designed specifically as multipurpose fighters capable of performing both air

defense and ground attack missions. Perhaps the best representative of this generation of fighters is the F4 Phantom II and Sukhoi Su-15/17/20/22.

Fourth Generation Fighters [1970-1990]

The next generation continued the trend towards multirole fighters equipped with increasingly sophisticated avionics and weapon systems. These fighters also had enhanced maneuvering capabilities rather than speed to succeed in air to air combat. Good representatives of this generation of fighters include the American F16, Soviet MiG29 and Indian HINDUSTAN [LCA].

4.5 Generation Fighters [1990-2000]

The term "4.5 generation" is seen referring to more recent fourth generation fighters. These aircrafts are generally seen as retaining the basic characteristics of fourth generation planes but with enhanced capabilities that might be seen in fifth generation fighters. Good examples are the F18 Super Hornet, Eurofighter Typhoon, and Dassault Rafale. All three use advanced avionics to improve mission capability and exhibited limited stealth when compared to older fourth generation aircraft. However, none is considered advanced enough to be classified as a fifth generation fighter.

Fifth Generation Fighters [2000-till Now]

The technologies that best epitomize fifth generation fighters are advanced integrated avionics systems that provide the pilot with a complete picture of the battle space and allowed the use of low observable "stealth" techniques. The F22 and F35 are the only fifth generation fighters developed to date, but Russia hopes that technologies being created by the Mikoyan Gurevich MFI and Sukhoi Su47 shall allow them to stand toe to toe with these fifth generation fighters.

Indian Efforts on Fighters

After its commencement in the Light Combat Aircraft (LCA) project in 1983 it took 14 years to develop a lightweight aircraft. The LCA was developed as a lightweight and low-cost replacement for India's aging fleet of MiG-21 fighters, later named as Tejas (Sanskrit for radiance) in 2003. Under the direction of India's Aeronautical Development Agency (ADA), the prime contractor Hindustan was given responsibility for most LCA design and fabrication work. HAL is also responsible for integrating the efforts of several government laboratories, educational institutes, and sub-contractors.

The Tejas uses a delta wing design featuring many advanced modern technologies, including a digital fly-by-wire control system, integrated avionics, extensive use of composite materials, and glass cockpit displays. Other sophisticated features include the aircraft's multi-mode radar, laser designator pod and FLIR system, ring laser gyro inertial navigation system, comprehensive electronic warfare suite, and jam-resistant communications systems. Tejas requires a very short runway and "takes off the runway and into the air in a mere 500 metres". Tejas is 65% Indian innovation and the full operational clearance for the LCA is still pending and is now expected by December 2015.

RULER OF THE DECADE



Year	Models
1901-1910	Wright Flyer I, British Army Aeroplane No 1 (Cody 1), Bleriot XI, Coanda-1910
1911-1920	Curtiss A-1 Triad (Model E), Royal Aircraft Factory B.E.2, Albatros B.II, Bristol Scout, Nieuport 12, Curtiss H-16, Martin MB-2 / NBS-1
1921-1930	Avro Bison, Fairey Flycatcher, Aero A.12, Boeing PW-9 (Model 15), Curtiss F6C HAWK, Boeing F2B (Model 69)
1931-1940	Hawker Fury (I & II), Curtiss F9C Sparrowhawk, Avions Fairey Fox, Douglas DC-2, Sikorsky S-43, Heinkel He 112, Curtiss SOC Seagull, North American T-6 Texan, Brewster F2A Buffalo, Mitsubishi A5M (Claude), Boeing Y1B-20, Lockheed P-38 Lightning, Sukhoi Su-1 / Su-3, Bristol Beaufighter
1941-1950	Douglas A-20 Havoc / Boston, Focke-Wulf Fw 190 (Wurger), Martin PBM-3 / PBM-5 Mariner, Hawker Sea Hurricane, Curtiss XP-46, Sukhoi Su-2, Lockheed L-133 Starjet, North American XB-28 (Dragon), Boeing B-17 F, Douglas P-70 Nighthawk, North American F-86 Sabre, Republic XF-91 Thunderceptor, Lockheed XP-90 / XF-90
1951-1960	Supermarine Attacker, Boeing B-47 Stratojet, Bell X-5, Grumman C-1A / TF-1 Trader, Mikoyan-Gurevich MiG-17 (Fresco), Sikorsky H-34 / CH-34 Choctaw, Lockheed Martin U-2 Dragon Lady, Lockheed C-130 Hercules, Aerospatiale Alouette II, Grumman WF-2 / E-1 Tracer, Republic F-105 Thunderchief, Boeing 707, Mikoyan-Gurevich MiG-21 (Fishbed), Sukhoi Su-7 (Fitter-A), Sukhoi Su-9 (Fishpot), McDonnell Douglas F-4 Phantom II, English Electric / BAC Lightning
1961-1970	Dassault Mirage III, Douglas B-26K/A-26B Counter Invader, Lockheed Martin KC-130 Hercules / Super Hercules, Boeing CH-47 Chinook, Boeing 727, Sukhoi Su-11 (Fishpot-C), Lockheed L-100 Hercules, Mil Mi-8 (Hip), HAL HF-24 Marut, HAL HJT-16 Kiran (Ray of Light), Boeing 747 (Jumbo Jet)
1971-1980	Sukhoi Su-20 (Fitter-C), Boeing T-43 (Gator), SEPECAT Jaguar, Sukhoi Su-24 (Fencer), Airbus A300, Mikoyan MiG-27 (Flogger), Boeing E-4 Advanced Airborne Command Post, AgustaWestland AW109, Boeing / McDonnell Douglas F-15 Eagle, Boeing / Hughes AH-6 / MH-6 Little Bird
1981-1990	Sukhoi Su-25 (Frogfoot), Boeing 767, Lockheed EC-130H Compass Call, Northrop F-20 Tigershark, Airbus A310, Sukhoi Su-27 (Flanker), Boeing / McDonnell Douglas F-15E Strike Eagle, Airbus A320, Boeing E-6 Mercury, AgustaWestland A129 Mangusta (Mongoose), Boeing VC-25 (Air Force One)
1991-2000	McDonnell Douglas / Boeing T-45 Goshawk, Airbus A340, Dornier 328, Boeing 777 (Triple Seven), Airbus A300-600ST (Beluga), Sukhoi Su-30 (Flanker-C), Boeing / McDonnell Douglas X-36, Bell Eagle Eye (Model 918), Airbus Helicopters H155 (EC155), Aero L-159 ALCA (Advanced Light Combat Aircraft)
2001-2010	Northrop Grumman RQ-4 Global Hawk, HAL Dhruv, Boeing X-45, Airbus A318, Eurocopter Tiger (EC665), Lockheed Martin Polecat (P-175), Boeing X-48, Airbus A380, Boeing 747 Dreamliner, Mikoyan MiG-35 (Fulcrum-F), Mil Mi-28 (Havoc), Mil AH-2 Sabre (Mi-35M)
2011-2015	Lockheed Martin F-35 Lightning II, Sukhoi Superjet 100 (SSJ 100), Airbus A330 MRTT, Boeing 787 (Dreamliner), Sukhoi Su-35 (Flanker-E / Super Flanker), Boeing MQ-18 Hummingbird (A160), DRDO Nishant, Airbus Military A400M Atlas, Boeing 737 MAX 8, Airbus A350, HAL HJT-36 Sitara (Star), Boeing Phantom Eye, Lockheed F-35 Lightning II

Breakthrough Inventions in Aviation

Some of the great innovations that realized the Leonardo Da Vinci imagination into the modern aircraft are listed below:

Patent No.	Applicant	Date	Purpose
US821,393	Wright, Orville & Wilbur Dayton	May 22, 1905	Flying-machine
US856,838	Bell, Alexander G & Hector P. McNeil	June 11, 1907	Connection device for the frames of aerial vehicles and other structures
US868,039	Uherkocz, Julius U. de	Oct 15, 1907	Steering-gear for winged flying-machines or air-ships
US 1019078	C.M. Olmsted	March 5, 1912	An aerial propeller and was used in a famous flying boat produced and flown by Glenn Curtiss
1027242	Glenn H. Curtiss	May 21, 1912	Means for launching flying machines
1085575	Glenn H. Curtiss	Jan 27, 1914	Control mechanism for flying machines and the like
1195142	Henry Kleckler	Aug 15, 1916	Fuselage for aeroplanes
US 1210379	Henry Kleckler	Dec 26, 1916	Aileron systems
US 1223317	Glenn H. Curtiss	April 17, 1917	Folding wing aeroplanes
US 1285021	William Starling Burgess	Nov 19, 1918	Aeroplane wing construction
US 1296770	Glenn H. Curtiss	Nov 3, 1919	Airplane landing gears
US 1296773	Nelson W. Dalton,	Nov 3, 1919	Convertible control systems
US 1316277	Glenn H. Curtiss	Sep 16, 1919	Cruising hydroaeroplanes
US 1329038	Glenn H. Curtiss,	Jan 27, 1920	Lubricating systems for traveling motors,
US 1358603	Albert F. Zahm,	Sep 11, 1920	Hovering aeroplanes
US 1386841	Joseph G. Coffin,	Aug 9, 1921	Methods and apparatus for making aero foils and the like
US 1394726	William L. Gilmore,	Oct 25, 1921	Airplane fuselage
US 1398315	Ernest Hallewell Cawthra	Nov 29 1921	Fuel supply and regulating systems for aircraft engines
US 1435139	Harvey C. Mummert	Nov 7, 1922	Retractable landing gears for aircraft
US 1454505	John A. Christen	May 8, 1923	Multiple control systems for multi-motored aircraft
US 1785339	Elliot Daland,	Dec 16, 1930	Shock absorbers for landing gears of airplanes
US 1789483	William Wait, Jr.,	Jan 20, 1931	Operating mechanism for aircraft control surfaces
US 1874523	Knut Henrichsen,	Aug 30, 1932	Aircraft cowling for tandem motors
US 1892914	Clem G. Trimbach,	Jan 3, 1933	Machine gun mounts for aircraft
US 1934399	Maitland B. Blecker,	Nov 7, 1933	Methods and apparatus for cooling internal combustion engines
US 1950970	Roland Chilton,	March 13, 1934	Two cycle engines
US 2092639	Roland Chilton,	Sep 7, 1937	Gear means for eliminating a master connecting rod
US2168726	Frank Whittle	8 Aug 1939	Propulsion of aircraft and gas turbines
USD139438	Howard R. Hughes	16 Aug 1943	Hercules
USD206035	The Boeing Company	22 Jun 1965	Boeing 737-100
USD212564	The Boeing Company	20 Dec 1966	Boeing 747-100
US5,984,231	Northrop Grumman Corporation	19 Jun 1998	Forward Swept Wing Aircraft
USD365,545	Northrop Grumman Corporation	9 Sep 1994	Advanced Manned or Unmanned Concept



Players	Patents in native country	Worldwide Patents
The Boeing Company	13,706	23,209
Airbus Group	2,382	18,350
Lockheed Martin	4,848	6,843
United Technologies Corporation	9,154	13,570
General Dynamics Corporation	722	794
BAE Systems	1392	5842
Northrop Grumman	2516	5288
Raytheon Company	6131	10298
Safran Group	121	253
Rolls-Royce Holdings	2914	12145

Technology Segment	No. of Patents
Airframe	94
Fuselage	1100
Wing	832
Jet Engine	902
Aileron	130
Rudder	402
Cockpit, windows and doors	1356
Control and transmitting system	2000
Vertical takeoff system	598
Blade	490
Aerodynamic Structure	130
Helicopter Technology	860
Aircraft Fuel	345
Radar	2067
Runway and its management	975
Aircraft parking	140

Players	Patents in Native Country	Worldwide Patents
Aeronautical Development Agency	0	0
Aequis Aerospace	0	0
Bharat Heavy Electricals Ltd.	1470	26
CSIR	7649	3967
Hindustan Aeronautics Ltd.	77	0
Aircraft Manufacturing Depot	0	0
Mahindra Aerospace	0	0

Source: WIPO Database from year 2000-2015.

The BHEL & CSIR patent numbers include patent activities in all technical fields which may or may not be related to aircraft technology. According to some media reports, HAL has filed 773 patent applications in the year 2014-15 which count total 1067 patent applications of HAL. However, the same is not published in Indian Patent Journal or WIPO database.



BIG LIKE BOEING

Boeing was founded by the American timber merchant William E. Boeing in 1916 as Aero Products Company. Mr. Boeing and U.S. Navy officer Conrad Westervelt developed a single-engine, two-seater seaplane, the B&W. He renamed Aero Products Company to Boeing Airplane Company in 1917, and built “flying boats” for the Navy during World War I. In 1920s and '30s it successfully sold its trainers, pursuit planes, observation craft, torpedo planes, and patrol bombers to the U.S. military. In late 1920s Boeing Airplane expanded into airmail services, and in 1928 William Boeing formed Boeing Airplane & Transport Corporation to encompass both manufacturing and airline operations.

Boeing is the world's largest manufacturer of commercial and military aircraft, and it controls more than half the market for jet aircrafts, military jets and helicopters, missile systems and space technologies.

The Boeing Assembly Hall is the building with the largest volume in the world, with a surface of 98 acres (400,000 m²) and a height of 115 feet (35 m). The volume is an incredible 472 million cubic feet (13 million m³). In 1997, Boeing bought its arch-rival *McDonnell Douglas Corporation* for more than 16 billion dollars, the largest merger ever in the aviation industry. Besides commercial aircraft Boeing also produces military aircrafts and helicopters, including the

famous *Apache combat helicopter*, the bogeyman of tanks around the world, and certainly a flying machine with exceptional technical qualities.

Prior to and during World War II, Boeing Airplane Company built several famous commercial aircrafts, such as the Model 247 twin-engine monoplane, the Model 314 flying boat (one of Pan American's Clipper-class aircraft), and the Model 307 Stratoliner, the first airliner with pressurized cabin. Boeing's legendary bombers, the B-17 Flying Fortress (first flown in 1935) and the B-29 Superfortress (1942), played key roles in the Allied war effort in World War II. During postwar era Boeing continued its military commitments with the six-engine B-47 Stratojet (1947) and eight-engine B-52 Stratofortress (1952) jet bombers.

In 1958 it launched the 707, which proved to be a huge commercial success, and this model subsequently succeeded by the 727, the 737 and the 747. In 1961 the company diversified operations into other technologies, and it designed the first steps of the enormous Saturn rocket that brought Apollo capsule to the moon. In 1966, Boeing decided to build the largest commercial Jet-airplane in the world, the famous 747.

The Boeing 707-120 made its mark as the world's first successful commercial jet

airliner, ushering in the era of accessible mass air travel. The four-engine plane carried 181 passengers and cruises at 600 mph for up to 5280 miles on a full tank. The first commercial jet flight took off from New York and landed in Paris.

IP protection and its management played the biggest role in making the Boeing “BIG BOEING”. THE BOEING is one of the biggest names in aviation sector around the globe. As of January 2014, Boeing has more than 7,000 active US patents and more than 13,500 active patents worldwide. It had 8,500 pending patent applications worldwide (including several hundred PCT and European Patent (EP) applications which shall multiply upon entry into the national/validation stages). In 2012, Boeing filed 145 international patent applications in PCT. Boeing filed some 1,000 patent applications on the 787 (Dreamliner) program alone. Patent filings include technologies in areas relating to avionics, structures, computing, satellites, energy, simulation and manufacturing. Each year Boeing rewards its top innovators for creating new IP.



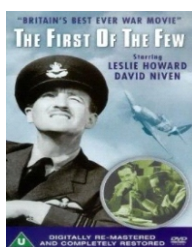
INNOVATE LIKE AIRBUS

During the A380 development phase, Airbus filed more than 380 patent applications for its new double-decker carrier. Significant breakthrough innovations were achieved in aerodynamics, cabin design, engine integration, flight controls, aircraft systems, manufacturing techniques and the extensive use of advanced lightweight composite materials.

Airbus had also filed patents for the innovative systems developed for A380. These included the avionics data communication network (ADCN) which supported the increasing inter-system communication needs with the benefit of further improving data integrity and transmission speed. Another significant breakthrough in aircraft systems is the Brake-to-Vacate function that optimises the amount of energy used for braking and reduces runway occupancy time, while ensuring high level of passenger comfort during landing. Patent applications also cover the Electrical Back-up Hydraulic Actuator (EBHA) which is part of the A380's new two energy, four-channel flight controls architecture.

Movies on Aviation and Aviators

Spitfire (1942)



A British aircraft designer R. J. Mitchell, alarmed at growing German militarism, works to perfect a defense against the German Messerschmidt at the cost of his health.

The Memphis Belle: A Story of a Flying Fortress (1944)



Memphis Belle is the nickname of a Boeing B-17F Flying Fortress during the Second World War. The aircraft was one of the first B-17 United States Army Air Forces heavy bombers to complete 25 combat missions with her crew intact.

Breaking the Sound Barrier (1952)



A story of British aerospace engineers solving the problem of supersonic flight.

The Spirit of St. Louis (1957)



Charles 'Slim' Lindbergh struggles to finance and design an airplane that will make his New York to Paris flight the first solo transatlantic crossing.

Those Magnificent Men in Their Flying Machines or How I Flew from London to Paris in 25 Hours 11 Minutes (1965)



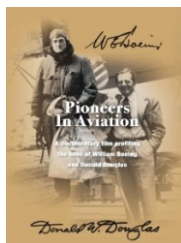
An interesting collection of early aircraft in a lighthearted comedy. Set in the early 1900s, an "international" air race, from England to France, and of course across the English Channel, was proposed, ostensibly to advance aviation. Naturally, the film presents cultural/national stereotypes

The Flight of the Phoenix (1965)



After a plane crash in the Sahara, one of the survivors says he's an airplane designer and they can make a flyable plane from the wreckage.

Pioneers in Aviation (2001)



Profiles of two of America's legendary aerospace pioneers: William Boeing and Donald Douglas. Interweaving the stories of the two men and the companies they founded, "PIONEERS" features rare film footage from the early decades of the century, together with historical photographs, period music, and narration. The age-old wish to defy the law of gravity found its fruition in turn-of-the-century America. William Boeing and Donald Douglas each came of age at this renaissance moment in the country's history, and their achievements are infused with the indomitable spirit of their time.

The Aviator (2004)



A biopic depicting the early years of legendary director and aviator Howard Hughes' career from the late 1920s to the mid-1940s.

One Six Right (2005)



A documentary film that celebrates the unsung hero of aviation - the local airport - by tracing the life, history, and struggles of an airport icon: Southern California's Van Nuys Airport. Featuring aerial photography and an original score, the film dispels common misconceptions and opposes criticism of General Aviation airports. Through the love story of one airport, past to present, the film shares the timeless romance of flying with all ages.

Hawaizada [2015]



Movie is about first Indian aviator Shivkar Bapuji Talpade who had constructed and flown India's first airplane in the year 1895. Talpade is supposed to have constructed Marutsakthi under the guidance of Pandit Subbarya Shastri. However, according to various report Marutsakthi' took off, fled to a height of 1500 feet and then fell down to the earth. After the experiment, Marutsakthi apparently was stored at Talpade's house until well after his death.

Scope of Developments

Necessity is the mother of all inventions. This is well depicted by the historical analysis of aviation industry. The World War I and World War II created a dire necessity which resulted in sporadic developments in aviation sector. The technology in aviation sector was on its peak after World War II. However, it is always said that improved understanding and analytical capabilities permitted continuous improvement in this sector. Henceforth, there is still demand for:

- **Improved Modern Airplanes**
- **Active Controls on air traffic**
- **New Airfoil Concepts**
- **Advance Propulsion Techniques and Alternative Air Fuels**
- **Multidisciplinary Optimization on ground and air control**
- **Runway & Airport development**

Year	Upcoming Models
2015	HAL Tejas
2016	Denel Dynamics Bateleur, HAL LCH (Light Combat Helicopter), AgustaWestland AW159 Wildcat, Dassault Falcon 8X, General Atomic's Sea Avenger, Guizhou Sparrow Hawk II, Guizhou Soar Dragon (Soar Eagle), AVIC TA-600 / AG-600
2017	IAIO Fotros (Fallen Angel), Mitsubishi Regional Jet (MRJ), Northrop Grumman MQ-4C Triton, AgustaWestland AW609 TiltRotor, Sukhoi T-50 (PAK FA), Chengdu J-20 (Black Eagle)
2018	Boeing KC-46 Pegasus, Textron AirLand Scorpion, DRDO Rustom (Warrior), Ilyushin IL-214 MTA (Multirole Transport Aircraft), Airbus Helicopters H160 (X4), Gulfstream G500
2019	COMAC C919, Sikorsky CH-53K King Stallion, DRDO AURA
2020	Bell V-280 Valor
2022	HAL Sukhoi PMF/FGFA
2025	HAL AMCA (Advanced Medium Combat Aircraft)
2030	Lockheed SR-72

WAY TO GO



Indian aviation industry is claimed of being on the verge for achieving some new landmarks especially under the drive of 'Make in India' initiative. Although these landmarks are still to be reflected in terms of numbers of patents filed, by giants of Indian aviation industry. However, it is noteworthy that "TATA" has filed 37 patent applications for its "TATA NANO" but Indian aviation industry is still looking for indigenous innovation while manufacturing a "BIG AIRCRAFT".

Nowadays, top companies in aviation are building their focus for securing their IP rights for maintaining a reputation among their consumers and to protect their innovation from other competitors. Due to high filing cost and R&D expenditures, these firms are generating funds and profiting investment in protection of IP through licensing. A lot is to be learned from these GLOBAL PLAYERS.

In such cut-throat era, IP rights can provide a great support and a cutting edge to an emerging company. When an organization owns a numbers of patents in different fields or owns other IP rights, it reflects the creativity of organization and their ability to innovate and protect their knowledge. Due to such recognition companies attract high number of customers and potential investors; this also helps them to continually enhance their capabilities by recruiting best talent or employees. Therefore, for any organization achieving the "patent podium" makes them a more attractive enterprise.

The Intellectual Property Rights, if managed and protected, always creates:

1. **competition between foreign subsidiaries and local players;**
2. **development and/or the conversion of existing technological field;**
3. **various suppliers and industry cluster;**
4. **opportunity to bargain with major players in cross-licensing and in commercialization of patents;**
5. **faster diffusion of hi-tech, innovative products or machinery in the domestic and foreign markets;**
6. **real transfer of human capital, skills and knowledge through the labour market; and**
7. **healthy competitive environment for sustainable development.**

It is always noticed that exploiting new technologies in an existing technical field can change the rules of the game.

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IPO database
French patent database

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About the Authors



Lalit Ambastha

Founder | Patent Attorney
Mobile: 9811367838
Email: lalit.ambastha@patentwire.co.in



Shruti Kaushik

Director | Patents
Mobile: 9810338816
Email: k.shruti@patentwire.co.in

Researcher: Pankaj Tyagi is a LL.B Student at IIT Kharagpur. He has researched the data related with aviation sector during his internship program at Patentwire. He can be reached at thepankajtyagi20@gmail.com.

Patentwire Consultants Pvt. Ltd.
B-10, Ground Floor
Vishwakarma Colony, M.B. Road
New Delhi-110044, India

Tel: +91-11-26360036
Fax: +91-11-26360037

Email: desk@patentwire.co.in
www.patentwire.co.in

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-Hymn of Creation, The Rig Veda

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Patentwire Consultants Pvt. Ltd.
B-10, Ground Floor, Vishwakarma Colony
M.B. Road, New Delhi-110044, India

Tel: +91-11-26360036
Mob: +91-9811367838
Fax: +91-11-26360037

Email: desk@patentwire.co.in
www.patentwire.co.in

