

Future Advances of Aviation

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We know birds and insects can fly. Gliders, hang-gliders, kites and boomerangs fly as well. For thousands of years people also have wanted to fly. Humans and animals are unable to fly because they do not have wings and a power source strong enough to keep the wings moving through the air to sustain the lift necessary for a flight.

On December 17, 1903, Wilbur and Orville Wright brothers piloted the first powered airplane at a height of 20 feet above a wind-swept beach in North Carolina. The flight lasted 12 seconds and covered 120 feet. According to the International Air Transport Association (IATA), in 2016 there had been a staggering 3.8 billion air travellers, and predicted that it will increase to 7.2 billion passengers by 2035, a near doubling of current levels. Most of this boost in traffic is expected to come from the Asia-Pacific region (which includes Asia, Australia, and New Zealand). U.S. airplane manufacturer Boeing, forecasts (projects) that worldwide demand for aircraft will top 39,000 planes in the next 20 years, of which over 15,000 will be headed

to Asian markets.

Three factors are inducing more passengers in planes. “The first is the expansion of economies and the rise in incomes in Asia and Africa. Cheaper airfares, with more efficient planes and competition, are also making air travel more accessible.

However despite economic benefits, these passengers will also bring concerns about noise and air pollution, terrorism as well as the spread of diseases. This paper discusses the principles of flight, history of flight timeline, current challenges as well as the impact of aviation, and future development of aviation.

2. Principles of Flight :

Flights and birds are both affected by the same forces in flying. Four main forces which affect the flight abilities are weight, lift, thrust and drag.

Gravity is a force that pulls everything towards the Earth’s surface, which is known as the weight force. Planes must be able to provide enough lift force to oppose the weight force. Lift is a force that acts upwards against weight, and is caused by the air moving over and under the wings.

Thrust is provided by muscles for birds and other flying animals.

Thrust is provided by the engine

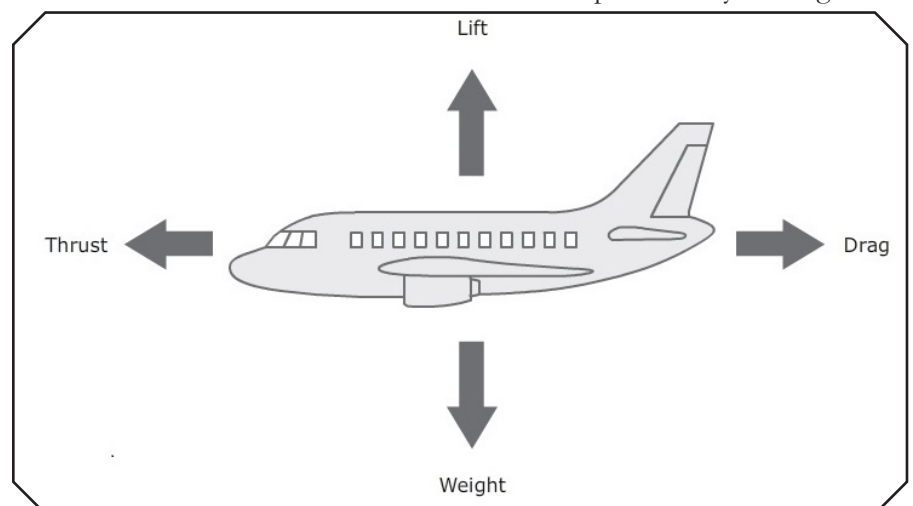


Fig : Forces affecting flight



Fig : Pre 1700s



Fig : 1800s



Fig : 1920s

for flying machines. The force working against the thrust is called drag. It is caused by air resistance, and acts in the opposite direction to the motion.

The amount of drag depends on the shape of the object, the density of the air and the speed of the object. Thrust can overcome or counteract the force of drag. An object in flight is constantly engaged in the opposing forces of lift against weight (gravity), and the thrust against drag.

3. History of Flight Timeline

Around 400 BC Chinese discovered the kite that could fly in the air. Kites were used by the Chinese in religious ceremonies. They built many colourful kites for fun. More sophisticated kites were used to test weather conditions. Kites have been important to the invention of flight as they were the forerunner to balloons and gliders. It is generally recognized that Wilbur and Orville Wright brothers were credited with the first real flight, which took place on 17 December 1903.



Fig : 1950s



Fig : 1980s

2010s

running in a safe, efficient and orderly fashion, including air traffic control, airport operations, airline management, maintenance and piloting an aircraft. The field of aviation has blossomed into a rich industry in which new breakthroughs happen almost daily.

5. Benefits of Aviation

Aviation is one of the most “global” industries which connects people, cultures and businesses across continents. Aviation provides the only rapid worldwide transportation network, which makes it essential for global business. It generates economic growth, creates jobs, and facilitates international trade and tourism. The air transport industry has also supported a total of 62.4 million

British inventor Frank Whittle invented the jet engine in 1930. First human lunar landing took place on July 20, 1969, when astronauts Neil Armstrong and “Buzz” Aldrin landed on the lunar surface. Today’s aerospace revolution starting from the earliest dreams of flying in an atmosphere, to reach the planet through a rocket, is indicated in following figure.

Manufacturer Terrafugia introduced a roadable aircraft in 2011, when an aeroplane that can take off and land at any airport, can with the push of a button, fold up its wings and drive down the road.

4. What is Aviation Science?

Aviation science is the study of basic components required for a career in this industry. Aviation science includes all the support systems that keep airlines



Fig : Roadable aircraft

jobs globally. It has provided 9.6 million direct jobs. Airlines, air navigation service providers and airports directly have employed over 3 million people. The civil aerospace sector (the manufacture of aircraft, systems and engines) employed 1.1 million people. A further 5.5 million work in airports at different positions. About 52.8 million indirect employment, such as tourism-related jobs have been generated through aviation. The indirect impacts include employment and economic activity generated by suppliers to the aviation industry which include aviation fuel suppliers, construction companies that build airport facilities, suppliers of sub-components used in aircraft, manufacturers of goods sold in airport retail outlets, and a wide variety of other activities in the business services sector (such as call centres, information technology and accountancy).

Aviation continuously expands. It has weathered crises and demonstrated long-term resilience, becoming an indispensable means of transport. Historically it has been found that air transport had doubled in size every fifteen years, and has grown faster than most other industries. In 2016, airlines worldwide carried around 3.8 billion passengers, and 53 million tons of freight.

One of the industries that rely most heavily on aviation is tourism. By facilitating tourism, air transport helps to generate economic growth, consequently of poverty alleviation. Currently, approximately 1.2 billion tourists are crossing borders every year, over half of whom travelled to their destinations by air.

Aviation creates unique possibilities for empowering nations and peoples, regardless of their geographic location. It is a means of allowing people to access what they need: improved livelihoods, food, healthcare, education, safe communities and spaces, etc.

6. Current Challenges and Impact of Aviation

Aviation is one of the main drivers behind globalization, and the driving force towards development of the modern world. The air travel industry has played a major role in global development. Worldwide, there are more than 2,000 airlines with over 23,000 aircrafts serving 3,700 airports. Air travel has grown continuously. The industry is expected to continue to grow at the same rate with the possibility of doubling total air travel in the next 15 years. Air travel has gone through extreme changes; from innovating technological advancements to security requirements.

Air travel is associated with several environmental, economic, and social benefits, as well as damages. Flying is a major contributor to air pollution, greenhouse gases, climate change, and noise pollution. The best solution to improve environmental, economic, and social components of the aviation industry is to transit towards fuel-efficient systems. More fuel-efficient airplanes will decrease greenhouse gas emissions, as well as decrease costs for both airlines and customers in the long run, and improve the social experience for passengers and airline workers. Though growth is enormous, there are yet some challenges in

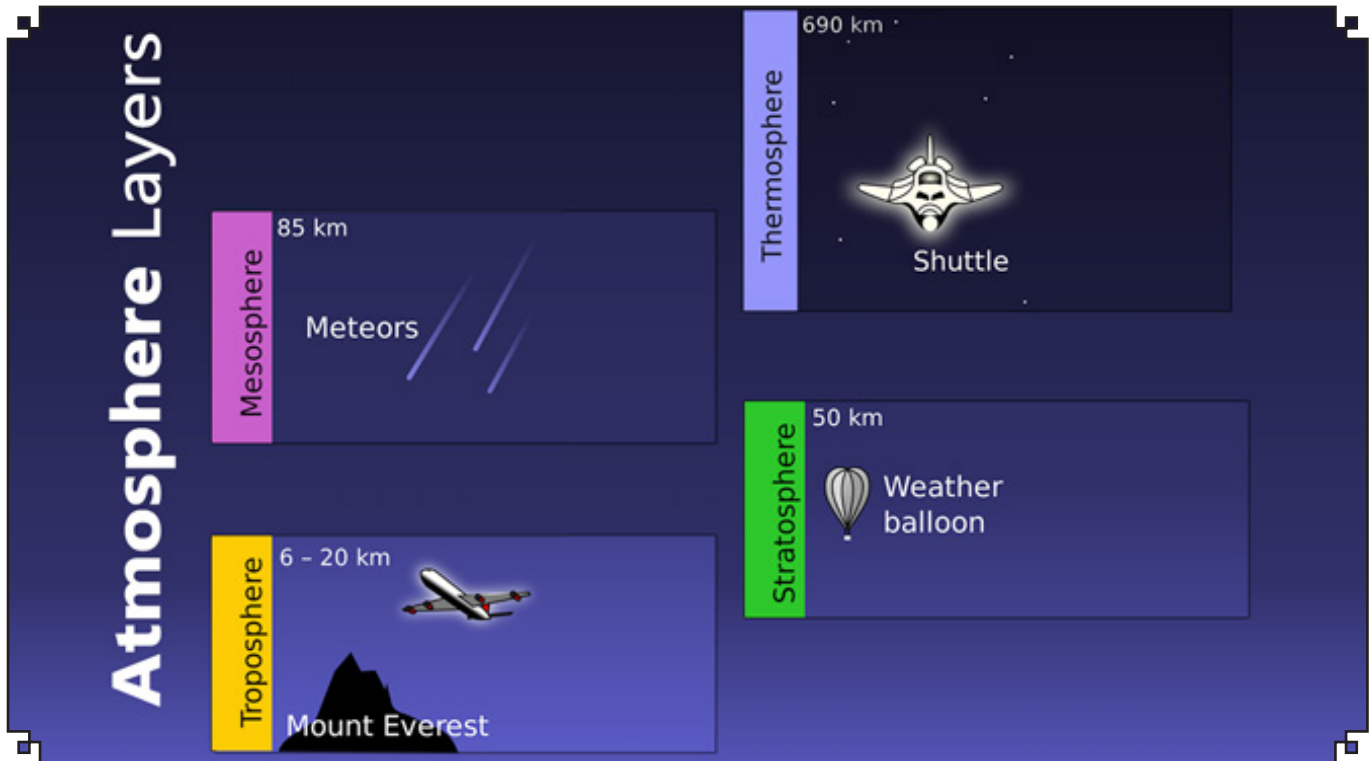
the aviation sector that airlines are facing. The current challenges or issues in the airline industries are:

(a) Security in the sky: Safety and security are the greatest challenges that this industry is facing. Airports, governments and airlines need to find out new and innovative ways, so that they can enhance their security, without compromising their service and overall comfort of the passengers.

According to IATA, in 2017 the estimated number of commercial flights was 36.8 million, excluding private, business and military aviation. In 2013 there were some 36.4 million flights and 16 fatal accidents.

(b) Aircraft Noise: Noise has historically been the principal environmental issue for aviation. It remains high on the agenda of public concern. Noise disturbance is a difficult issue to evaluate as it is open to subjective reactions. Its impact is not a lasting one on the actual environment, but it can have significant adverse effects on people living close to an airport, including: interference with communication, sleep disturbance, annoyance responses, learning acquisition, performance effects and cardiovascular and psychophysiological effects.

(c) Customer satisfaction: Customers are the key to the growth of any business, and aviation industry is also trying to appease their customers. Nowadays, everyone owns a Smartphone with a stable internet connection which will help them to stay connected with the rest of the world. If the customers are not happy or satisfied with Airline services or offers, they



will certainly tend to give a negative feedback about the airline and will circulate it on various social media platforms. If this happens it will certainly tarnish the brand image and businesses. So, aviation people try to make more personalised interaction with their customers, and would try to improve their customer service score.

Technology: Advances in technology is another big challenge in the aviation industry. Like any other sector, the aviation industry has been impacted by the move for digitalization.

(d) New technology aircraft: As technology has penetrated to every sphere of life, new aircraft are being launched in the market. And the number of variants introduced by manufacturers has made the situation more complicated. Modern aircraft entering into airline fleets today bring with them fuel efficiency gains of 20-30% over their predecessors.

Today's aerospace and aircraft manufacturing industry seeks to produce more efficient aircraft. Modern aircraft produced today are about 80 per cent more fuel efficient per passenger kilometre than in the 1960s, and each new generation of aircraft continues this downward trend.

There are three significant regions of the atmosphere which concerns aircraft engine emissions and their impact on the environment: the free troposphere, the stratosphere, and the planetary boundary layer. The troposphere is where almost all weather related activities take place (clouds, precipitation, etc.), and extends from the ground level to about 15 km at the equator, and about 8 km at the poles. Because there is significant mixing in the troposphere due to weather systems, pollutants travel relatively freely once they are out of the layer of the atmosphere in contact with the ground (the planetary

boundary layer, which is the part of the troposphere closest to the ground). Most ground emissions of air pollutants stay in the boundary layer for several hours or days, and are restricted to local or regional impacts. The troposphere above the boundary layer is the free troposphere. The stratosphere has much less mixing than the troposphere. Therefore when pollutants enter the stratosphere, they generally remain there for long periods.

The significance of aircraft emissions is that these emissions alone are directly injected into the free troposphere, and even to the stratosphere, as well as the planetary boundary layer. The main emissions of concern for climate issues are:

- Carbon dioxide (CO₂) - this has a long lifetime in the atmosphere and is the principal culprit of global warming.
- Nitrogen oxides (NO_x) - almost



Fig : Credit: NASA Credit: NASA/Boeing Credit: NASA/Lockheed Martin Credit: NASA/Cal Poly

any combustion process in the atmosphere (which is 79% nitrogen) creates NOx. NOx is involved in atmospheric chemistry with ozone, and supports “acid rain” processes. Through the creation of ozone (O₃) in the troposphere NOx contributes to global warming. In the stratosphere, NOx is involved in chemistry which damages the ozone layer.

- Water vapour - Recent work has highlighted the potential climatic impact of clouds formed (partly) from the water vapour emissions (e.g. contrails) which is a normal by-product of fuel combustion. High thin cloud has an important role in climate issues, and changes to its amount and geographical distribution may be significant.
- Smoke and other particulates - Smoke and other particles and some sulphur compounds emitted by engines form effective nuclei for cloud droplets. At low altitudes, smoke contributes to local air pollution while higher in the atmosphere it may be involved in cloud formation, and thus in climate.

7. Future development of Aviation

Faster and more fuel-efficient aircrafts, planes that run on solar power, bigger windows, and fancier interior are the endless possibilities. As technology continues to improve, so will be the advancements in aviation. Aviation sector must make a genuine commitment to achieve Sustainable Development Goals (SDGs) with safe, affordable, accessible, efficient, and resilient aircrafts while minimizing carbon and other emissions that cause environmental impacts in future. Aviation is one of the most innovative industries in the world. The manufacturing sector is continually developing new technology, creating significant urban infrastructure development through the construction of airports and navigational infrastructure.

i. The future is Green

It’s a well-known fact that many of the technologies used in aviation today are environmentally unsustainable. Flight emissions

comprise one of the many culprits that contribute to this problem. Current market trend is towards more environmentally friendly flight technologies, with one of the most promising developments being the production of electric aircraft that do not emit harmful carbon dioxide and nitrogen dioxide gases.

According to the most recent figures from the Intergovernmental Panel on Climate Change (IPCC), aviation (domestic and international) accounts for approximately 2 % of global CO₂ emissions produced by human activity. International aviation is responsible for approximately 1.3 % of global CO₂ emissions. Electric ultra-light aircraft passenger planes are a real possibility in the near future.

In the future, NASA expects flights that will burn 50 % less fuel than aircraft that entered service in 1998; release 75 % fewer harmful emissions; and minimize the radius of airport noise pollution by 83 %.

One of Boeing’s advanced vehicle

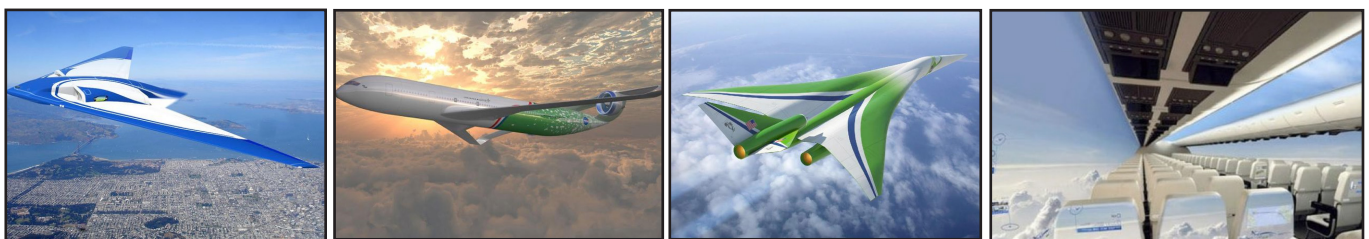


Fig : NASA/Northrop Grumman / NASA/Lockheed Martin / Plans to build planes with virtual windows

concept designs aims for better aerodynamic efficiency, creating as little drag as possible. Two vertical tails have been designed to shield engine noise. This design has been built using additional technologies to reduce noise and drag, along with long-span wings to improve fuel efficiency, and could potentially go into production by 2025. This box wing design was made possible by the use of advanced lightweight composite (non-metallic) materials. A Rolls Royce Liberty Works Ultra Fan Engine uses advanced turbofan technology to maximize efficiency, achieving a bypass ratio (the flow of air around engine compared to through the engine) nearly five times greater than that of current engines.

This is the hybrid wing body-type subsonic vehicle AMELIA (Advanced Model for Extreme Lift and Improved Aeroacoustics), able to handle steeper and shorter take-offs and landings. AMELIA can potentially have a great impact on noise produced by airport traffic.

This is a cargo carrying aircraft which has been designed to be very efficient and ultra-quiet.

This is a possible future subsonic aircraft using a boxed or joined wing configuration to reduce drag and to increase the fuel efficiency. The ability to fly at supersonic speeds over land in civil aircraft depends on the ability to reduce the level of sonic booms, says NASA, which has been exploring options



for quietening the boom, starting with design concepts and moving through wind tunnel tests to flight tests of new technologies. The sleek, pointed shape of this design concept would reduce the sonic shockwave signature and also reduce drag, resulting in increased efficiency. Imagine boarding a flight to discover that all the windows within the cabin have been removed and replaced by projected digital images on the walls. According to the Centre for Process Innovation (CPI), this will become a reality sooner, calculating the first plane to take to the skies within the next ten years.



Fig : Conception of a supersonic plane

Experts tend to assume that the potential for developing lower emission aircraft will be pursued first. As well as improvements to the efficiency of engines, the use of alternative fuels has a great deal of potential to reduce CO₂ and particulate emissions. According to NASA, non-fossil, organic fuels derived from algae or other plants, have already been added to the fuel mix of aircraft, and to test flights. The development of electric power units continue to progress. Currently, electrification of aircraft is challenging due to the high



weight and low energy density of batteries.

ii. The future is automated

The aviation industry has experienced steady growth in recent decades. Pascal Traverse, Cockpit R&T Program Leader at Airbus, estimates that “the global commercial aviation industry will need some 600,000 pilots in the next 20 years”. This poses a problem, observing the fact that there are significantly fewer pilots currently in service. Automated pilotless aircraft could provide a solution. However it is not so easy to teach a machine to take into account all that many variables. For this reason it has been suggested that a safety pilot needs to be there in case something unexpected happens.

Interim solutions may include “one-and-a-half” pilot aircraft, in which a human co-pilot assists an artificial intelligence (AI) pilot until technology reaches maturity. If the rate at which driverless vehicle technology has evolved is anything to go by, we are likely to see some significant developments in this area before long.

iii. The future is fast

Long travel times are a frustration. To reduce travelling time, new supersonic and hypersonic plane concepts are planned to be introduced. These aircraft are designed to break the sound barrier,



Fig : The e-volo Volocopter V2X may soon be revolutionising personal air travel

that is, more than twice the speed of sound.

NASA has planned to build its next experimental plane, which is designed to fly faster than the speed of sound without producing the loud sonic booms that have plagued air transportation. This plane is due to be delivered in 2021.

Because no one wants to hear that noise, the Federal Aviation Administration and similar international organizations have banned supersonic travel over land. Now, NASA believes that technology can break the sound barrier without being quite so loud about it. The secret is in the shape of the plane.

Concorde, the last remaining supersonic passenger jet, was withdrawn from service in 2003. But the romance of flying faster than the speed of sound lives on. Numerous companies are developing technology for more efficient and quieter supersonic travel. Noise reduction is the key function here, and preventing the supersonic boom from reaching the ground will be a significant achievement.

Aircraft such as Spike Aerospace's Spike S-512 craft could be in our

skies by 2020s. The company says its plane will fly at the supersonic speed of Mach 1.6, and travel from London to New York in three hours.

iv. The Future is convenient

The latest aviation technologies mean passenger experiences are becoming ever-more convenient. Wireless connectivity allows passengers to enjoy a personalized experience, with in-flight entertainment. Soon flights will be faster, greener, more convenient and more comfortable.

v. Personal air transportation in 2050

Overcrowded roads, traffic jams that extend for several kilometres, and collaborative public transport



Fig : The vision of the future by Lilium GmbH: a vertical take-off jet to relieve the overcrowded streets

systems in major cities, demand innovative approaches and solutions. Established aviation businesses and start-ups from all over the world are therefore researching an aircraft that could transform local transportation from the roads to the air. Electrically powered "air taxis" could solve two problems at once: (a) by giving up the use of fossil fuels, particulate and CO₂ emissions could be substantially reduced, and (b) shifting local transportation from the ground to the air would remove

the burden on streets.

While this might sound like a vision for the distant future, it is already technically feasible. The Karlsruhe-built Volocopter VC1 completed its maiden flight as far back as 2011, and is seen as a pioneer of electrified personal air transportation. Just a few years later now the Volocopter is on the verge of beginning its test operations as an autonomous air taxi in Dubai.

The electrically powered Lilium Jet, which has been developed in Munich, offers an impressive range of 300 km, and can take off and land vertically. By 2025, the taxi could begin operations as a five-seater, picking up passengers from the rooftop landing areas.

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