Quantitative Analysis of Lift, Drag and Energy in Air India AI171 Accident

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Abstract - Aviation accidents, though statistically rare, remain a critical focus area in safety engineering and aerodynamics research. The study investigates the causes, trends, and mitigation strategies related to aviation accidents, emphasizing aerodynamic failures such as stall, loss of lift, drag imbalance, and structural fatigue. By analyzing historical accident data from 2000–2025, the paper quantifies the fatality rate per million population and correlates it with aerodynamic factors influencing aircraft stability and control. A mathematical model is proposed to estimate the *fatality rate (F)* as a function of total fatalities, population exposure, and flight frequency. The findings indicate that improvements in aerodynamic design, such as enhanced laminar flow control and adaptive wing structures, have significantly reduced accident rates. However, pilot error and weather-induced aerodynamic anomalies continue to pose challenges. The study concludes with recommendations for integrating real-time aerodynamic monitoring and AI-based control systems to minimize risks in future aviation operations.

1. Introduction:

Aviation safety is a complex issue determined by technological, aerodynamic, and human factors. Although one of the safest transport modes, aviation accidents may produce disastrous effects. Most accidents are directly or indirectly connected to aerodynamic irregularities — such as stall conditions, boundary layer separation, degradation of lift, and turbulence-induced instability. Aerodynamics thus is the center of accident prevention and aircraft performance optimization.

Aerodynamic design evolution — from fixed-wing optimization to active flow control — has been instrumental in improving flight safety. Yet, the intricacy of real-environment phenomena like wind shear, icing, and compressibility effects close to transonic speeds can still cause loss-of-control (LOC) modes. Knowledge of these aerodynamic phenomena informs accident mechanisms and underlies predictive safety models.

For the evaluation of the social impact of aviation accidents, quantitative risk models are needed. The fatality rate per million population offers a normalized measure of the safety performance of aviation in different regions and over different time periods. This research combines aerodynamic theory with statistical analysis of accidents to offer an overall appreciation of aviation risk.

Aviation accidents are unforeseen and frequently disastrous occurrences of aircraft in flight, takeoff, or landing that cause extensive damage, harm, or loss of lives. Even though aviation is one of the safest means of transportation, accidents still take place because they are caused by a mixture of human, technical, mechanical, environmental, and aerodynamic factors. Accidents must be understood in order to enhance aircraft design, flight operations, and general aviation security systems.

The majority of aviation crashes result from a series of events instead of one single cause. Aerodynamic problems including stall, loss of lift, instability due to turbulence, and malfunction of control surfaces are some of the prime contributors. For example, when wind flow above the wings is disrupted by too high an angle of attack or bad weather, lift reduces precipitously, leading to a stall — one of the most common reasons for loss-of-control (LOC) crashes. Sophisticated aircraft have been built with automated systems to warn of and avoid such scenarios, but sensor malfunctions or improper pilot responses can still be disastrous.

Aside from aerodynamics, pilot mistake, mechanical failure, inappropriate maintenance, miscommunication of air traffic, and poor weather can also play a role. As an illustration, malfunctioning Angle of Attack (AoA) sensors on new planes like the Boeing 737 MAX resulted in faulty inputs to the control system, leading to fatal crashes in Indonesia (2018) and Ethiopia (2019). Aerodynamic overloads and structural failures in or during illegal maneuvers or turbulence have also brought about crashes in past decades.

Current research in aviation safety targets aerodynamic optimization, flight control redundancy, real-time measurement of aerodynamic parameters, and pilot training through flight simulators. These initiatives are intended to reduce risk factors and increase the robustness of aircraft against aerodynamic and environmental uncertainties. Every accident, although tragic, yields valuable information that enables regulators and engineers to further secure air travel for generations to come.

Significant air accidents in the past have been caused by various factors, ranging from aerodynamic failure to mechanical failure, pilot mistake, weather conditions, and external factors. Each of these categories has brought lessons that have contributed to today's aviation security standards.

The majority of accidents resulting from aerodynamic failure entail loss of lift, stall, or instability at critical stages of flight. For example, Air France Flight 447 (2009) had crashed into the Atlantic Ocean after the pitot tubes of the aircraft froze, providing erroneous airspeed measurements and resulting in an aerodynamic stall from which the pilots were unable to recover. In the same vein, the Lion Air Flight 610 (2018) and Ethiopian Airlines Flight 302 (2019) tragedies were attributed to defective Angle of Attack (AoA) sensors and automated systems that incorrectly diagnosed stall conditions and compelled the planes into uncontrollable plunges. The crashes exposed the risks of inaccurate aerodynamic feed and dependency on automation.

Mechanical and structural failures have also been the cause of some dismal accidents. Japan Airlines Flight 123 (1985), which was one of the most fatal single-aircraft crashes, was caused by rear pressure bulkhead failure leading to decompression and loss of control. United Airlines Flight 232 (1989) too experienced total hydraulic system failure, where pilots did not have any conventional flight controls; though passengers were largely saved, it underlined the need for control system redundancy.

Pilot error accidents continue to be one of the most common causes. The deadliest aviation accident in history, Tenerife Airport Disaster (1977), was when two Boeing 747s crashed on the runway because of a communication breakdown and visibility. Incorrect landing approaches, spatial disorientation, and procedural failures have also been major factors in other accidents.

Weather conditions like wind shear, lightning, and icing have also resulted in crash fatalities. American Airlines Flight 191 (1979) and AirAsia Flight 8501 (2014) experienced severe weather and aerodynamic issues that resulted in loss of control.

Lastly. External or intentional causes like terrorism and war have led to some of the most devastating accidents. Malaysia Airlines Flight 17 (2014) was downed over Ukraine, and Pan Am Flight 103 (1988) was blown up by a bomb over Lockerbie, Scotland.

Together, these crashes highlight the interconnectedness of aviation safety, wherein aerodynamic performance, engineering dependability, human capabilities, and environmental factors all come together. Each has been adding vital data that keeps going forward to improve aircraft design, pilot training, air traffic control, and safety technology.

2. Aerodynamics of Aviation:

The aerodynamics of flight is the science that accounts for how forces behave on an airplane moving through the air. It defines how airplanes lift, become stable, and control themselves while in flight. Four basic aerodynamic forces act on all airplanes — lift, weight, thrust, and drag — and their equilibrium directs the plane's performance, speed, and efficiency.

Lift is the upward force that opposes gravity and allows an airplane to stay in the air. It is generated primarily by the wings due to their airfoil shape, which causes air to move faster over the curved upper surface than below, creating a pressure difference. According to Bernoulli's principle and Newton's third law, this pressure difference produces lift. The magnitude of lift can be expressed mathematically as:

$$L = \frac{1}{2}\rho V^2 S C_L$$

Where,

$L = Lift\ Force$

$\rho = Air\ Density\ \left(\frac{kg}{m^3}\right)$

$V = Air\ Speed\ (\frac{m}{s^2})$

$V = Wing\ Area\ (m^2)$

$C_L = Lift\ coefficient$

Weight acts downward due to gravity and must be balanced by lift for level flight. When lift is less than weight, the airplane descends; when greater, it climbs.

Thrust is the forward force generated by the aircraft's engines — either propellers or jet turbines — that propels the airplane through the air. The amount of thrust determines how fast the airplane moves. It must overcome **drag**, which is the aerodynamic resistance opposing motion. Drag is influenced by airspeed, air density, and the airplane's shape, and is given by:

$$D = \frac{1}{2}\rho V^2 S C_D$$

where As an airplane's **speed increases**, lift and drag both rise with the square of velocity. At low speeds, the pilot must increase the **angle of attack** to generate sufficient lift, but if the angle becomes too steep, airflow separation occurs, leading to a **stall** — a major aerodynamic hazard. Conversely, at high speeds, compressibility effects and **shock waves** appear, especially near the speed of sound, affecting drag and control response.

The ratio of **thrust to drag** and **lift to weight** defines an aircraft's aerodynamic efficiency. Modern aircraft use streamlined designs, swept wings, and materials that reduce drag while maintaining lift. Understanding the relationship between **speed, thrust, lift, and drag** is fundamental to safe and efficient flight operations and is the cornerstone of aerodynamic design and performance analysis in aviation.

3. Major aviation accidents in 21st century:

1. Concorde Air France Flight 4590 (2000):

The Air France Flight 4590 crash on July 25, 2000, ended the Concorde years in a tragic manner. Minutes after takeoff from Paris Charles de Gaulle Airport, the plane drove over a strip of metallic rubbish on the runway that damaged a tire. The burst tire threw the debris into the fuel tank, initiating an enormous blaze that caused loss of thrust and subsequent crash into a hotel in Gonesse, France. A total of 109 people on board and four on the ground were killed. The accident exposed the substantial weaknesses in the Concorde's fuel system design and culminated in its eventual retirement in 2003, marking the end of supersonic passenger flight.

2. American Airlines Flight 587 (2001):

On November 12, 2001, American Airlines Flight 587, an Airbus A300 that took off from New York's JFK Airport, crashed into a Queens residential area after taking off. The source was traced back to extreme rudder motion by the first officer because of wake turbulence, which caused the vertical stabilizer to structurally fail. The accident resulted in 265 fatalities, including five individuals on the ground. It is the second-deadliest American air disaster and has led to changes in flight training to cope with wake turbulence and rudder sensitivity better.

3. China Airlines Flight 611 (2002):

China Airlines Flight 611 broke apart in the air over the Taiwan Strait on May 25, 2002. The Boeing 747-200 had experienced a tailstrike 22 years before, which was been inadequately repaired using a doubler plate that did not conform to manufacturer specifications. In time, metal fatigue at the repair location resulted in structural failure and in-flight breakup. There were 225 fatalities. The disaster emphasized the need for proper maintenance of aircraft, long-term inspection routines, and historical damage recordkeeping.

4. Helios Airways Flight 522 (2005):

On August 14, 2005, Helios Airways Flight 522, a Boeing 737, crashed at Grammatiko, Greece, after a failure in the pressurization system rendered the crew and passengers unconscious through hypoxia. The crew remained unconscious while the plane flew on autopilot until fuel was exhausted and crashed, killing all 121 people on board. The investigation found that the pressurization switch had been left on manual after maintenance, and the crew did not acknowledge warning alarms. This accident resulted in enhanced pilot training in pressurization problems and again emphasized the value of preflight system checks.

5. Gol Transportes Aéreos Flight 1907 (2006):

On September 29, 2006, Gol Flight 1907, a Boeing 737-800, crashed midair with an Embraer Legacy 600 business plane in the Amazon rainforest in Brazil. The 737 plummeted into the ground, killing all 154 on board, while the Legacy plane landed safely with heavy damage. Investigations determined the transponder and collision-avoidance system of the business jet were accidentally turned off, failing to prompt an automatic warning. The tragedy uncovered the susceptibility of Brazilian air traffic control coordination and prompted worldwide reforms in transponder and communication standards.

6. Air France Flight 447 (2009):

Air France Flight 447 lost contact on June 1, 2009, over the Atlantic Ocean while flying from Paris to Rio de Janeiro. The Airbus A330 was hit by intense turbulence and icing that caused its airspeed sensors to become incapacitated, resulting in autopilot disconnection. The pilots were confused and made inappropriate control inputs, causing a high-altitude aerodynamic stall. All 228 individuals on board died. The wreckage was finally recovered two years later, and the disaster spurred global revisions to pilot training in flying manually under unreliable airspeed conditions as well as in flight data transmission technology.

7. Smolensk Air Disaster (2010):

A Tupolev Tu-154 operated by the Polish Air Force carrying President Lech Kaczyński, his wife, and several senior officials crashed on April 10, 2010, near Smolensk, Russia. The plane tried to land in heavy fog despite warnings of poor visibility. Controlled flight into terrain (CFIT) took place after going below the glide path. Everyone of the 96 on board perished. The accident created a national disaster in Poland, resulted in tense relations with Russia, and highlighted the perils of political pressure on pilot judgment while flying under bad weather.

8. Malaysia Airlines Flight MH370 (2014):

Malaysia Airlines Flight MH370 disappeared on March 8, 2014, while flying from Kuala Lumpur to Beijing. The Boeing 777 went off course and lost communication with air traffic control and is thought to have strayed far off course into the southern Indian Ocean. Although the international search operation extended extensively, the primary wreckage was never discovered, but some debris floated to remote shores. All 239 on board are considered dead. The enigmatic disappearance set the world talking about flight tracking, communication faults, and security technology, triggering changes calling for real-time tracking of aircraft.

9. Malaysia Airlines Flight MH17 (2014):

Only months following the disappearance of MH370, Malaysia Airlines Flight MH17 was downed on July 17, 2014, over eastern Ukraine. The Boeing 777 flight was traveling from Amsterdam to Kuala Lumpur when it was hit by a Russian-made surface-to-air missile while in the midst of regional tensions. All 298 on board died. The disaster increased global tensions and created new International Civil Aviation Organization (ICAO) rules barring commercial flights over war zones. It is still one of the most politicized aviation accidents in history.

10. Germanwings Flight 9525 (2015):

Germanwings Flight 9525 crashed in the French Alps on March 24, 2015, after the co-pilot intentionally locked the captain out of the cockpit and engaged a controlled descent toward mountainous terrain. The Airbus A320 was obliterated, and every one of the 150 aboard was murdered. The investigation showed that the co-pilot had a depression history and hid his mental illness from the airline. The disaster led to broad mental health evaluation reforms for pilots and the "two-person cockpit rule" to avoid unauthorized cockpit seclusion.

11. Lion Air Flight 610 (2018):

Lion Air Flight 610 plunged into the Java Sea on October 29, 2018, just minutes after departure from Jakarta. The Boeing 737 MAX 8 was repeatedly pitched forward by a malfunction in the plane's new Maneuvering Characteristics Augmentation System (MCAS) due to erroneous sensor data. The pilots were unable to take control back, and the aircraft went into the sea, killing all 189 passengers and crew. The tragedy revealed the failures of regulation and design at Boeing and the FAA, which triggered investigations that transformed worldwide aviation certification standards.

12. Ethiopian Airlines Flight 302 (2019):

On March 10, 2019, Ethiopian Airlines Flight 302, another Boeing 737 MAX 8, crashed just a few minutes after takeoff from Addis Ababa, Ethiopia, under conditions very similar to Lion Air 610. The MCAS software once again compelled the plane into a fatal nose-dive. All 157 passengers and crew members perished. The consecutive 737 MAX crashes precipitated a global grounding of the MAX fleet for almost two years. The incident became a turning point in aviation safety, highlighting corporate responsibility, pilot training honesty, and the moral obligation of aircraft manufacturers.

13. Pakistan International Airlines Flight 8303 (2020):

Pakistan International Airlines Flight 8303 crashed in Karachi on May 22, 2020, following an initial abortive landing when both engines hit the runway. The pilots tried to make a go-around, but both engines failed shortly later, resulting in a crash in a residential district close to the airport. Of the 99 passengers on board, 97 died, along with a single civilian on the ground. Investigation showed lapses in pilot attention and communication, while subsequent scrutiny revealed anomalies in pilot licensing, leading to changes in Pakistan's aviation industry.

14. China Eastern Airlines Flight MU5735 (2022):

On March 21, 2022, China Eastern Airlines Flight MU5735, a Boeing 737-800, abruptly dropped from cruising altitude into a steep descent and crashed into mountainous country in Guangxi, China. All 132 passengers and crew members on board died. Flight data from the aircraft revealed a near-vertical flight path, prompting investigators to consider whether pilot input, mechanical failure, or outside interference was possible. Although the final report has yet to be made public, the accident was China's worst air disaster in decades and brought renewed attention to pilot behavior monitoring and flight data disclosure.

15. Yeti Airlines Flight 691 (2023):

Yeti Airlines Flight 691 on January 15, 2023, crashed while approaching Pokhara International Airport in Nepal. The ATR 72 plane suddenly went out of altitude and crashed into a river gorge, and all 72 individuals on board were killed. Initial findings determined that the propellers were accidentally feathered (reduced to low thrust) during final approach, resulting in loss of lift. The crash was Nepal's worst in 30 years and highlighted ongoing challenges in pilot training, aircraft maintenance, and safety oversight in mountainous regions.

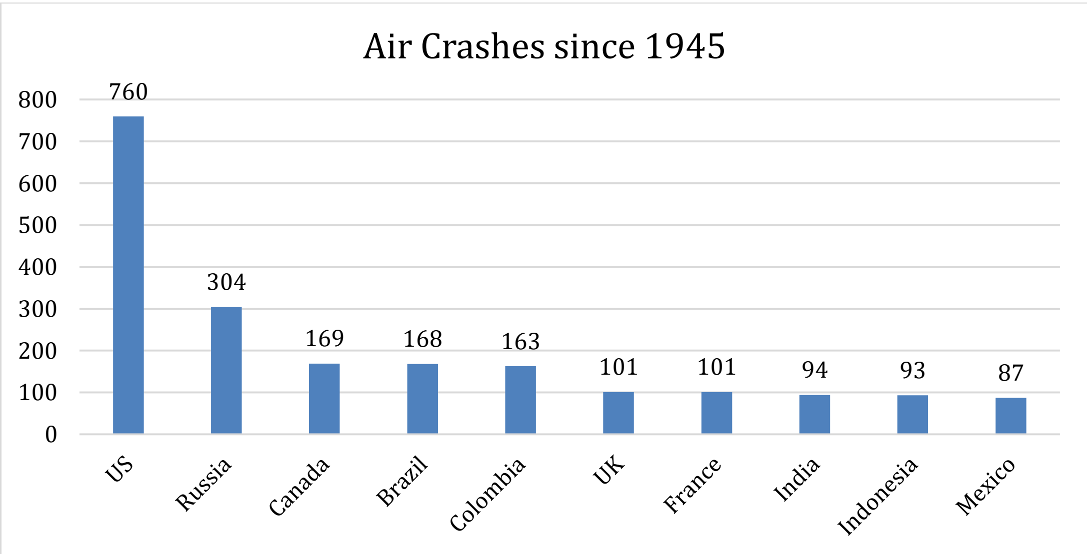

Chart 1: Air crashes since 1945

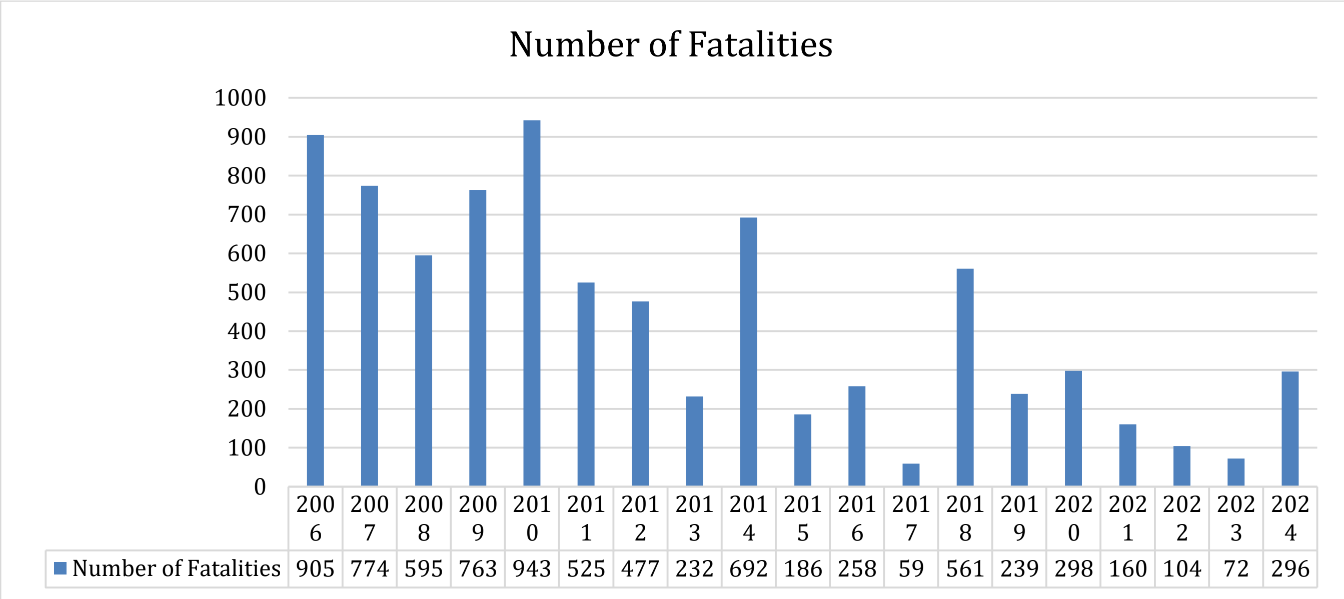

Chart 2: Number of Fatalities

4. Major Aircraft Manufacturers:

1. <u>Boeing:</u>

Boeing is one of the world's biggest aerospace and defence makers, and it is best known for making commercial jets like the 737, 777, and 787 Dreamliner series. Established in 1916, it also makes defence jets (F/A-18 Super Hornet, KC-46 Pegasus) and spacecrafts (Starliner). Boeing's biggest competitor in civilian aviation is Airbus. Even though it has encountered reverse due to the 737 MAX accidents, it is still a world leader in aviation with huge factories in the U.S. and global partnerships.

2. <u>Airbus:</u>

Toulouse-based Airbus SE is the industry's leading competitor to Boeing in commercial aviation. It makes some of the most popular planes in the world, including the A320neo, A330, A350, and A380 (the largest passenger aircraft on the planet). Airbus has a defense and space business as well, making planes such as the A400M Atlas and helicopters through Airbus Helicopters. It is a consortium of several European countries including France, Germany, Spain, and the UK.

3. <u>Lockheed Martin:</u>

Lockheed Martin is mainly involved in defense and military aviation. It manufactures some of the most advanced combat aircraft in the world like the F-16 Fighting Falcon, F-22 Raptor, and F-35 Lightning II. The organization also works on aerospace research, unmanned aerial vehicles or drones, and defense systems. It is very important for U.S. military aviation and cutting-edge aeronautics.

4. <u>Northrop Grumman :</u>

Northrop Grumman is a major American defense and aerospace firm that specializes in strategic bombers, surveillance aircraft, and stealth technology. Northrop Grumman built the legendary B-2 Spirit stealth bomber and is constructing the next-generation B-21 Raider. Northrop Grumman also operates in unmanned systems and space technology.

5. <u>Embraer:</u>

Embraer is the biggest aircraft company in South America that produces regional jets like the E-Jet and E2 series. Its regional and low-cost carriers favor its aircraft for their reliability and efficiency. Military aircraft like the KC-390 Millennium and business aircraft are also manufactured by Embraer under Embraer Executive Jets

6. Bombardier:

Bombardier was formerly a dominant force in commercial and business aviation. It built the CRJ regional jet line and the C Series, which Airbus bought out and rebranded as A220. Bombardier now concentrates on upscale business aircraft such as the Global 7500 and Challenger 3500 lines.

7. Dassault Aviation:

Dassault Aviation is a French aerospace manufacturer that specializes in military and business jets. Its products include the Rafale multirole jet fighter and its Falcon line of business aircraft. Dassault is credited with its innovative aerodynamics and technological advancements, making it a major defense supplier to the French Air Force and overseas buyers.

8. Commercial Aircraft Corporation of China (COMAC):

The Commercial Aircraft Corporation of China (COMAC) is China's state-owned aircraft maker that strives to cut the country's reliance on Boeing and Airbus. Its showpiece programs are the ARJ21 regional jet and the C919 narrow-body jet, which compete head-to-head with the Boeing 737 and Airbus A320 families. COMAC symbolizes China's strategic expansion into global commercial aviation.

9. Mitsubishi Aircraft Corporation:

A subsidiary of Mitsubishi Heavy Industries, the Japanese company created the Mitsubishi SpaceJet (previously MRJ), a regional jet for efficiency and comfort. Despite rapid production issues and the pandemic slowing its introduction, Mitsubishi is still a significant aerospace player through engineering contributions to Boeing and other projects.

10. Sukhoi / United Aircraft Corporation:

Sukhoi, which is owned by Russia's United Aircraft Corporation (UAC), manufactures civil and military aircraft. Its civilian product is the Sukhoi Superjet 100, used for regional flights, while the military product portfolio consists of the Su-35 and Su-57 fighter aircraft. UAC also oversees other Russian aviation brands like Tupolev, Ilyushin, and Mikoyan (MiG), all key to Russia's aviation sector.

Manufacturer	**Market Value (Billion USD)**	**Country**
Airbus	114.97	Netherlands
Boeing	113.82	USA
Lockheed Martin	110.98	USA
Hindustan Aeronautics Limited (HAL)	42.8	India
Textron	16.35	USA
Dassault Aviation	14.18	France
Bombardier	6.26	Canada
Embraer	4.82	Brazil
Joby Aviation	3.51	USA
Korea Aerospace Industries (KAI)	3.45	South Korea

Table 1: Market Value (Billion USD) of major manufacturers

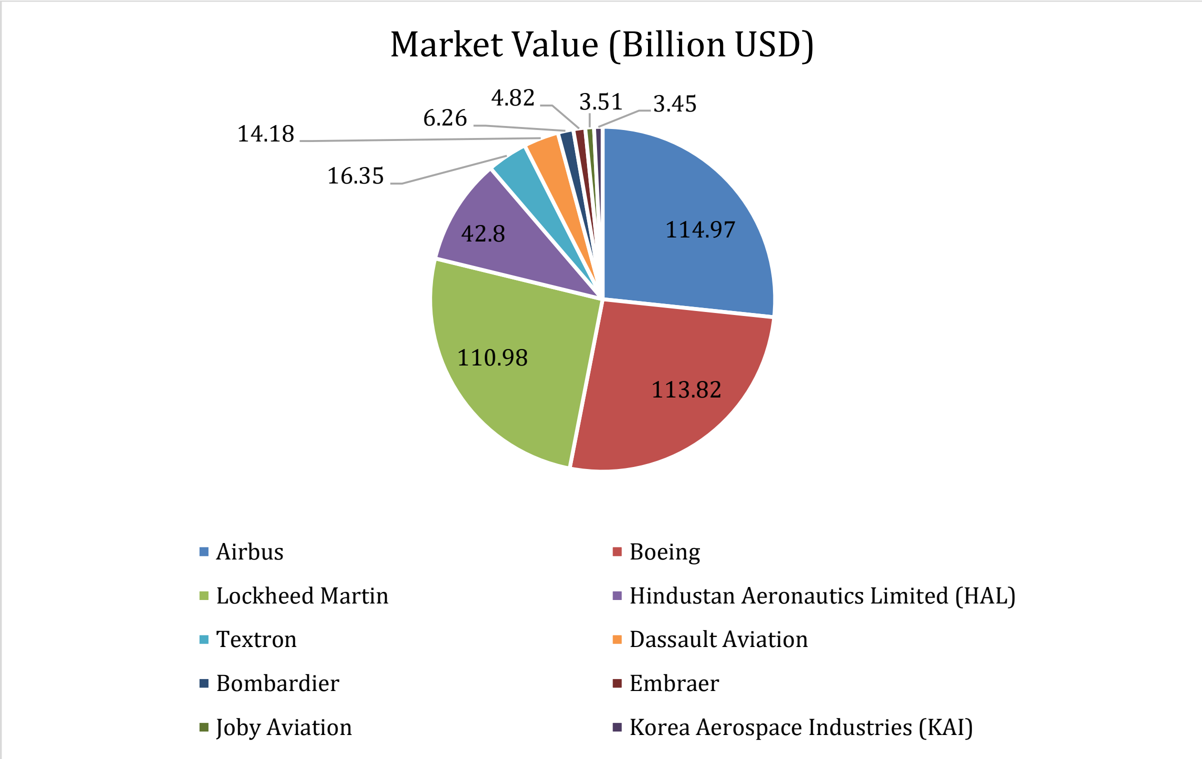

Chart 2: Market Value (Billion USD) of major manufacturers

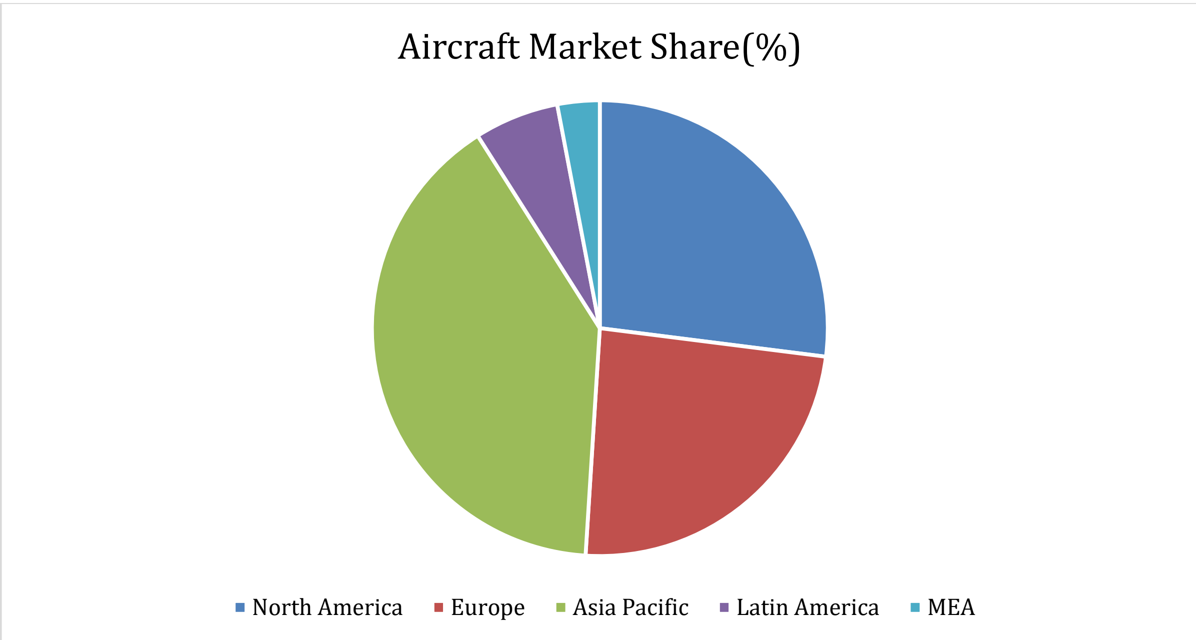

Chart 3: Aircraft Market Share (%) of different regions

5. Air India Flight AI-171:

The Air India Flight AI-171 crash in Ahmedabad was a Boeing 787-8 Dreamliner (VT-ANB) with two GE GEnx-1B engines. The plane was in good technical condition, with its right engine having been overhauled in March 2025 and the left engine checked in April 2025. Routine maintenance checks had been done on it, and it was scheduled for its next heavy D-check in December 2025. The aircraft took off from runway 23 at 13:38 IST, but barely a few seconds after liftoff, the plane suffered a sudden and simultaneous loss of power from both its engines. Data from the flight recorders later revealed that the fuel control switches for both engines were moved from “RUN” to “CUTOFF” within approximately three seconds after takeoff, cutting fuel supply and causing the engines to shut down almost instantly.

The cockpit voice recorder (CVR) captured a brief but revealing exchange between the pilots: one asked, “Why did you cut off? ", and the second one replied, "I did not so," suggesting that neither of them moved the switches on purpose. The automatic relight system for the engines tried to restart the two engines; Engine 1 indicated partial recovery, while Engine 2 would not recover at all.

The plane's Ram Air Turbine (RAT) deployed automatically, usually in the event of both engine power loss and primary electrical system failure, a clear indication of a near-total power loss. The flight data recorder (FDR) also documented inconsistencies in the physical and data positions of the thrust levers—they were discovered in idle in the wreckage despite data indicating they were at takeoff thrust when power was lost, indicative of mechanical disconnection or failure of the control system. The fuel control switches in this version are constructed with safety gates to avoid accidental travel, yet examiners detected evidence that the locking mechanism could have failed.

In 2018, an FAA and GE service bulletin had previously alerted to the possibility of mechanical and microprocessor flaws in the Engine Control Unit (ECU) that might interfere with fuel control operation, and examiners are looking into whether this problem contributed to the Ahmedabad accident. The aircraft was in takeoff configuration at the time of the crash, flaps 5°, landing gear extended and no retraction signs. It flew for about 30 to 32 seconds before crashing into a residential colony along the path of the BJ Medical College hostel. The unexpected dual-engine failure, precipitated by a probable simultaneous fuel cutoff event, is currently the focal point of the Aircraft Accident Investigation Bureau (AAIB) investigation, which is considering possible causes that range from electrical or mechanical malfunctions to software or human-factor irregularities.

6. Calculations:

Year	Global Airline Traffic (in millions)	Aviation Accident	Air Passengers Traffic in India (in millions)
2015	67	33	190
2016	64	35	200
2017	46	37	228
2018	60	39	267
2019	52	41	341
2020	34	22	198
2021	30	24	160
2022	42	32	250
2023	30	39	329
2024	46	40	376

Growth:

1. Global Airline Traffic(in millions) – 7% Decrease
2. Aviation Accident – 6.3% Increase
3. Air Passengers Traffic in India (in millions) – 4.97% increase

- **Aerodynamic Factors:**

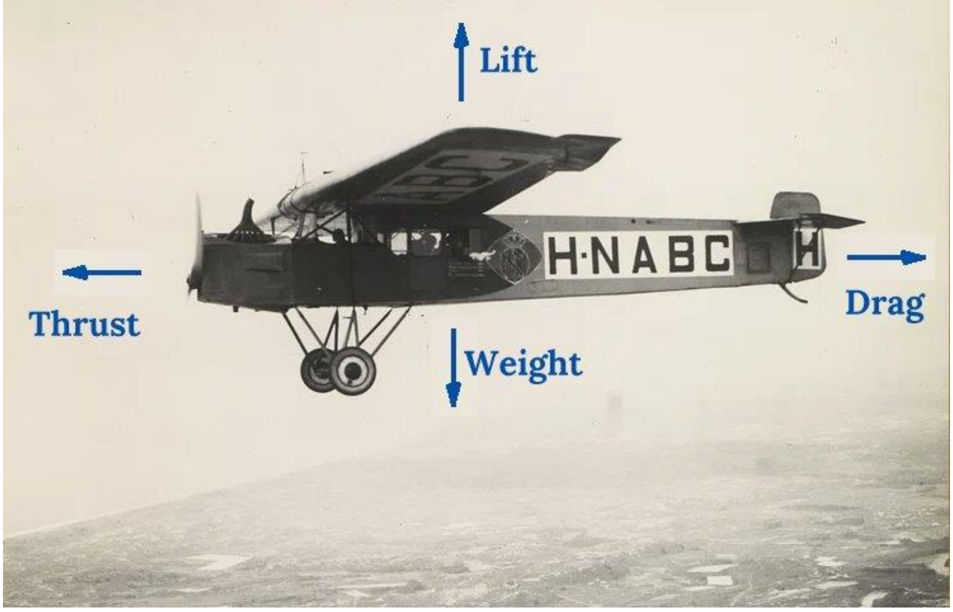

Chart 4: Aerodynamic factors in airplane

https://www.science20.com/patrick_lockerby/air_india_flight_171_accident_the_most_probable_cause-257574

Time (t)	**Airspeed (in km/hr)**
0	155
3	180
4	178
5	176
10	160
32	0 (rest)

1. Velocities:

$$\boxed{V_{mean} = \frac{V_{Final} + V_{initial}}{2}}$$

$$d = V_m \times t = 46.25 \times 31 = 1433.75\ m \approx 1480m$$

$$\boxed{v = u + at}$$

$v = 92.5 + 2.89t$ (Linear model, velocity and time)

$$Distance\ travelled = 1700m\ or\ 1.7\ km$$

2. Acceleration:

$$a = \frac{v_f - v_i}{t} = \frac{0 - 92.5}{32} = -2.89\ m/s^2$$

3. Height plane achieved:

$$h = \frac{1}{2}at^2$$

Where,

$$h = \text{height above the ground before the crash}$$

$$a = \text{deceleration}$$

$$t = \text{time taken to touch the ground (crash time)}$$

$$a = \frac{2h}{t^2}$$

$$a = \frac{2 \times 189}{31 \times 31}\ m/s^2$$

$$a = 0.393\ m/s^2$$

Lower deceleration, imply plane's inability to maintain lift hence result in air crash.

4. Change in velocity:

$$\Delta v = 330\frac{km}{hr}$$

(Or) $\Delta v = 91.67\frac{m}{s} = 92\frac{m}{s}$

5. Force and Kinetic Energy:

Approx. plane mass, m = 230 tonnes = 230000 kg

$F = ma$
$F = m \times dv/dt$

$\frac{dv}{dt} = change\ in\ velocity/change\ in\ time$

$$F = 230000 \times \frac{92}{31} = 682580.65 = 6.82 \times 10^5\ Newton$$

$$KE = \frac{1}{2}mv^2$$

$$KE = \frac{1}{2} \times 230000 \times 92 \times 92$$

$$KE = 973360000\ J$$

$$KE = 973360\ KJ$$

$$KE = 973\ MJ$$

High value of Kinetic energy results in destructive forces, resulting in crash.

6. Lift:

Lift is the force opposes weight and allow aircraft to fly.

$$\text{Lift} = K.v^2$$

$$\text{Lift} = K.(92)^2$$

But due to deceleration, velocity tends to decreases reduces to lift reduction by its square.

7. Rate of descend:

$$\text{Rate of descend} = \text{Change in height/change in time}$$

Rate of descend $= \frac{189}{31/2}$

(Total 31s, let us assume half for take-off, half for getting down)

$$\text{Rate of descend} = 12.19\frac{m}{s}$$

8. Thrust to weight ratio:

$\varphi = \text{Total thrust/total weight}$

Boeing 787 planes has thrust maximum of 700000 newtons and total weight of this particular flight

$\varphi = \text{F} \times \text{g}$

Total weight of particular flight $= 495000 \times 9.8$

$$\varphi > 1$$

means plane moves straight up, leading in low lift of plane, when thrust is lost, ratio drops to nearly 0,making flight impossible.

7. Conclusion:

International air travel has grown very quickly in the 21st century, with passenger traffic increasing from about 2.6 billion in 2010 to more than 5 billion in 2024. India's growth has been a reflection of that, with it becoming the world's third-largest domestic market for aviation, with passengers crossing over 150 million and aircraft movements crossing 2 million. Even with this spike, the overall accident rate per million flights has fallen, indicating advances in aircraft technology, pilot education, and safety equipment.

Yet the absolute number of accidents increased with increasing traffic, reminding us that vigilance is a requirement at all times. The Ahmedabad Air India Flight AI-171 crash (2025) illustrates how several system and human factors can come together to lead to disastrous results within a matter of seconds. Initial indications pointed toward an unexpected loss of engine power soon after departure, resulting in an uncontrolled fall — a grim reminder that even trivial technical or procedural mistakes can be lethal in extreme flight moments.

As the Indian and global skies become increasingly congested, this study concludes that regulatory scrutiny, human-factor engineering, and safety measures need to keep pace with traffic expansion. Ongoing innovation, openness in investigations, and intensive training are critical to sustaining the strong safety record of the aviation business during a period of record growth.

8. References:

1. Aircraft Accident Investigation Bureau (India). 2025. Preliminary Report – Accident involving Air India's B787-8 aircraft bearing registration VT-ANB at Ahmedabad on 12 June 2025. 11 July. https://i2.res.24o.it/pdf2010/Editrice/ILSOLE24ORE/ILSOLE24ORE/Online/_Oggetti_Embedded/Documenti/2025/07/12/Preliminary%20Report%20VT.pdf

2. Air Accidents Investigation Branch (UK). 2025. "AAIB Update: Preliminary report into Air India flight AI171." 13 June. https://www.gov.uk/government/news/aaib-update-preliminary-report-into-air-india-flight-ai171
3. Reuters. 2025. "Air India crash probe shows engine fuel-switch movement, no immediate action." 11 July. https://www.reuters.com/business/aerospace-defense/india-finds-engine-switch-movement-fatal-air-india-crash-no-immediate-action-2025-07-11/
4. PBS NewsHour. 2025. "India orders inspection of Boeing fuel-control switches after Air India crash report." 14 July. https://www.pbs.org/newshour/world/india-orders-inspection-of-boeing-fuel-control-switches-after-air-india-crash-report
5. The Guardian. 2025. "Engine fuel switches cut off before Air India crash that killed 260, preliminary report finds." 12 July. https://www.theguardian.com/world/2025/jul/11/engine-fuel-switches-cut-off-before-air-india-crash-that-killed-260-report-finds
6. Financial Express. 2025. "Ahmedabad plane crash: The AAIB prelim report into the June 12 AI 171 crash mentioned that engine fuel control switches transitioned from 'Run' to 'Cutoff'." 12 July. https://www.financialexpress.com/india-news/aaib-releases-prelim-report-on-ai-171-plane-crash-in-ahmedabad-air-india-pilot-asked-another-pilot-why-did-you-cut-off/3911514/
7. The New Indian Express. 2025. "Both engines shut down just after take-off: Preliminary report on Air India AI171 crash." 11 July. https://www.newindianexpress.com/nation/2025/Jul/11/both-engines-shut-down-just-after-take-off-preliminary-report-on-air-india-ai171-crash/
8. Airlineratings.com. 2025. "Air India crash explained: Key timeline and sequence of events." 12 July. https://www.airlineratings.com/articles/air-india-crash-explained-/
9. The Wire. 2025. "Unpacking the preliminary report of the Ahmedabad air crash." 12 July. https://m.thewire.in/article/government/unpacking-air-india-crash-preliminary-report
10. BusinessToday.in. 2025. ""We will defer to the AAIB to ...": Boeing reacts to preliminary findings on AI171 crash." 12 July. https://www.businesstoday.in/india/story/we-will-defer-to-the-aaib-to-boeing-reacts-to-preliminary-findings-on-ai-171-crash-484355-2025-07-12/
11. TheAirCurrent.com. 2025. "Air India crash investigation focuses on movement of engine fuel control switches." 12 July. https://theaircurrent.com/aviation-safety/ai171-investigation-fuel-control-switches/
12. IndianExpress.com. 2025. "AAIB releases initial report on Ahmedabad Air India plane crash." 12 July. https://indianexpress.com/article/india/aaib-releases-initial-report-on-air-india-plane-crash-10121167/

9. Biographies:

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- M.Sc (Mathematics) (Double gold medalist)
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- B.E Mechanical Engineering From Thapar Institute of Engineering and Technology
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