AI-171 Crash Analysis : A Physics-Based Hypothesis on Rearward Center of Gravity-Induced Deep Stall and Engine Power Loss

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July 10, 2025

Abstract

On June 12, 2025, Air India flight AI-171, a Boeing 787-8 Dreamliner en route from Ahmedabad to London Gatwick, crashed less than a minute after takeoff, killing 241 of 242 onboard and at least 39 on the ground. The aircraft failed to climb beyond approximately 625 feet above ground level before descending in a nose-up attitude and impacting terrain near B.J. Medical College. This paper proposes a physics-based hypothesis for the accident, suggesting that an undocumented or improperly loaded cargo in the aft fuselage may have caused a critical rearward shift in the aircraft's center of gravity (CG). This, combined with a potentially overweight takeoff condition, likely resulted in pitch instability, delayed rotation, a high angle of attack (AoA), and a subsequent aerodynamic stall at low altitude.

The aircraft's engines reportedly lost effective thrust, as indicated by the crew's "Thrust not achieved... falling... Mayday!" Mayday call, and the deployment of the Ram Air Turbine (RAT) confirms loss of engine-generated electrical power. Video footage shows the aircraft maintaining a steep nose-up attitude, with landing gear extended throughout the flight, and a survivor's report suggests mid-air structural separation in the rear fuselage. The proposed theory accounts for all major observed factors without requiring mechanical failure or bird strikes, and underscores the potential hazards of CG mismanagement and undocumented loading in large, high-bypass twin-engine aircraft.

1 Introduction

On June 12, 2025, Air India flight AI-171, a scheduled international Boeing 787-8 Dreamliner flight from Ahmedabad (India) to London Gatwick (UK), crashed less than a minute after takeoff from Runway 23 at Sardar Vallabhbhai Patel International Airport. The crash occurred within the B.J. Medical College campus perimeter, killing 241 of 242 occupants onboard, and at least 39 people on the ground. The sole survivor was seated in 11A, close to the front exit.

The aircraft struggled to climb, reaching a maximum altitude of only 625 feet above ground level, before descending nose-high and crashing in a shallow trajectory. Video footage and eyewitness reports captured the aircraft's unusually late rotation, extended landing gear, high nose attitude, and lack of visible smoke or fire prior to impact.

Roughly 30-35 seconds after liftoff, the flight crew issued a Mayday call stating "Thrust not achieved... falling... Mayday!" – a phrasing that stands out, as it implies engine response failure without explicitly declaring a dual engine failure or fire. Soon after, the aircraft's Ram Air Turbine (RAT) deployed (as seen in the video captured by a 17-year old eyewitness, Aryan Asari), which only occurs under complete electrical or engine power loss, suggesting that both engines became unresponsive shortly after takeoff.

This paper presents a physics-based technical hypothesis suggesting that the accident may have been caused by a dangerously aft-shifted center of gravity (CG), likely due to unauthorized or incorrectly-loaded cargo in the aircraft's rear hold, combined with a possible overweight condition. Such a center of gravity misconfiguration could have led to:

· A delayed and aggressive rotation
· A steep pitch angle
· An aerodynamic stall

· Airflow disruption into engines, resulting in severe inlet distortion and thrust degradation, without mechanical failure – a known condition during high-angle, low-speed flight.

This hypothesis explains the observed low climb, loss of thrust, RAT deployment, and the aircraft's inability to recover from a nose-high attitude – all without invoking bird strikes, mechanical engine failure, or sabotage.

While the official report from the DGCA and Air India Safety Board remains pending, this paper reconstructs the tragic event using available public data, flight physics, video evidence, witness statements, and system behavior specific to the Boeing 787-8 Dreamliner. The aim is not to assign blame, but to propose a plausible, technical explanation that can inform future discussions on loading safety, thrust reliability, and deep stall scenarios in large twin-engine aircraft.

2 Basic Aerodynamic Concepts Used

A pitching moment (M) is defined as -

$$M = (x_{C_P} - x_{C_G}) \times L$$

where x_{C_P} and x_{C_G} are position of center of pressure and center of gravity respectively and L is the force of lift. A rearward C_G results in the pitching moment being positive, hence reducing the pitch control authority.

The lift force L is defined as -

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

where ρ represents the air density, V represents the velocity of the airflow, S is the reference area (or in this case - the wing area) and C_l is the lift coefficient.

The Thrust Equation states -

$$T = \dot{m} \times (V_e - V_0)$$

where T is the thrust produced by the aircraft's engines, $\dot{m}$ represents the mass flow rate, V_e symbolizes the exhaust velocity and V_0 represents the inlet velocity of the aircraft.

The critical angle of attack (AoA) of an aircraft is defined as the angle of attack beyond which the coefficient of lift C_l starts to drop (*refer to Fig. 1*) and the airfoil (wing, in this case) will stall -

$$For \;\; \alpha > \alpha_c, \quad C_l \downarrow,$$
$$C_l \downarrow \; results \; in \; L \downarrow$$

where α is the angle of attack of the aircraft, α_c is the critical angle of attack, C_l is the coefficient of lift and L is the lift force of the aircraft.

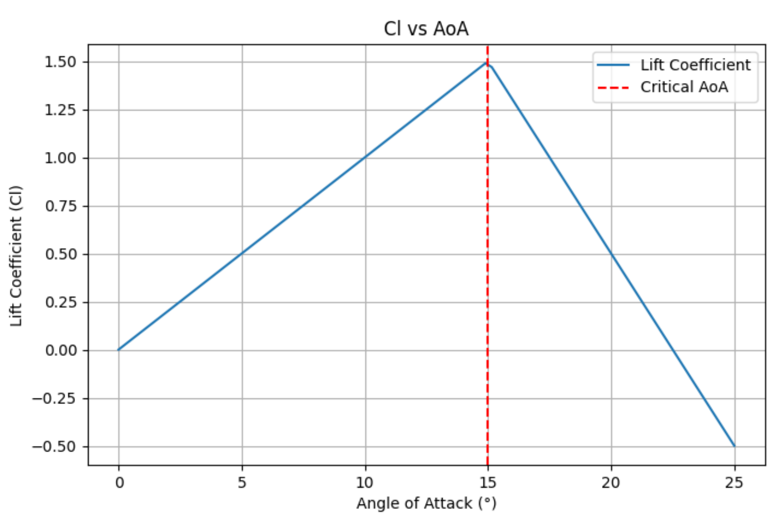

Figure 1: Lift Coefficient (C_l) vs Angle of Attack (α). Note the stall occurring after $\alpha_c \approx 15°$.

For recovering from a stall, net moment -

$$M_{available} = M_{elevator} - M_{C_G}$$

where, $M_{available}$ is the net available pitching moment for recovery, $M_{elevator}$ is the nose-down pitching moment produced by the elevator on board, and M_{C_G} is the nose-up pitching moment due to the shifted center of gravity C_G, which works against the recovery of the aircraft.

3 Discussion

The behavior of AI-171 in its final moments presents an unusual and concerning flight profile for a Boeing 787-8 Dreamliner. Based on radar data from sources like FlightRadar24, Mayday calls reported, video evidence captured, and the sole survivor's testimony, it is apparent that the aircraft experienced severe pitch instability, abrupt power loss, and ultimately unrecoverable aerodynamic stall at a very low attitude. The observed chain of events is most consistent with an improperly balanced aircraft – in particular, one with an excessively rearward center of gravity (CG).

An aft CG can dramatically increase an aircraft's pitch sensitivity (*as explained in section 2*) while reducing the elevator's authority. During takeoff, this condition often leads to delayed rotation of the aircraft, followed by abrupt nose-up movement once sufficient lift is generated. In this case, the delayed liftoff followed by an aggressive climb as seen in a video evidence from the Ahmedabad airport's CCTV camera showing the aircraft taking off (*refer to Fig. 2*) supports this. Once airborne, the combination of high angle of attack (AoA), low airspeed, and compromised longitudinal stability likely induced a stall – not from mechanical failure, but from poor aerodynamic balance.

Figure 2: Still taken from the video captured by a CCTV surveillance camera at the Ahmedabad airport showing AI-171 taking off runway 23.

Figure 3: 1. Note the nose-up attitude of the A/C while losing altitude 2. The engines show no visual cues like flame or smoke 3. The Ram Air Turbine (RAT) is deployed, indicating engine failure.

The aircraft's reported "Thrust not achieved... falling... Mayday!" Mayday call indicates that engine thrust response was lost, but without evidence of external damage such as bird ingestion or visible fire. It is therefore likely that the high AoA caused severe inlet distortion, leading to a disruption in core airflow to both engines. In such a scenario, the engines cannot generate usable thrust, even at full throttle settings, and may enter a wind milling state or low-power idle despite no mechanical failure.

The deployment of the Ram Air Turbine (RAT) (*refer to Fig. 2*) confirms that both engines lost electrical output, which is a highly abnormal event at this phase of flight. With the aircraft now in a deep stall and with insufficient elevator authority to pitch the nose down, recovery became impossible. The fact that the landing gear remained extended suggests that the aircraft never reached a stable climb profile, and the flight crew likely had no opportunity to perform standard post-liftoff actions.

Further, the survivor's testimony – describing the aircraft cracking open from the rear aligns with the structural risks posed by an aft CG during high pitch moments. Rear fuselage stress concentrations, especially in a composite aircraft like the Boeing-787 Dreamliner, can lead to catastrophic failure if subjected to conflicting forces such as nose-down elevator input versus rear-heavy inertia. If unsecured or undocumented cargo had been loaded into the rear hold without proper entry into the flight management system, it could have shifted further aft during the attempted recovery, worsening the load on the tail and causing the reported break.

Collectively, these factors support the conclusion that this was not the result of a traditional dual engine failure, sabotage, or bird strikes, but of a catastrophic aerodynamic and control failure initiated by improper loading and CG mismanagement. The possibility of undocumented cargo or intentional CG falsification introduces serious questions regarding pre-flight checks, ground handling procedures, and airline oversight that must be addressed by authorities. But it is still a possibility and not a final report, which has not been made available by the DGCA or any authorities till the date of publication of this report.

4 Conclusion

The tragic crash of Air India flight AI-171 shows a complicated series of aerodynamic and mechanical events. Using publicly available data such as flight behavior, cockpit communication, eyewitness accounts, and video footage, this paper suggests that the most likely cause of the accident was a critical shift in the aircraft's center of gravity. This shift may have been due to undocumented or improperly loaded cargo in the back hold.

This imbalance in center of gravity, along with a potential overweight condition, seems to have caused a late and unstable takeoff. The aircraft then pitched up steeply, which the pilot had to consider while keeping the aircraft's documented weight in mind. At low altitude and a high angle of attack, the aircraft likely entered an aerodynamic stall. This led to engine airflow disruption and a loss of thrust, as reflected in the flight crew's Mayday call: "Thrust not achieved... falling... Mayday!" The deployment of the Ram Air Turbine also indicates trouble. The aircraft's continued nose-up position, extended landing gear, and lack of recovery suggest that elevator control was not enough to handle the rearward center of gravity. Additionally, the report from survivors about mid-air fuselage cracking matches the structural stress on the rear section under these flight conditions.

This explanation provides a clear understanding of the crash from an aerodynamic and systems perspective without relying on mechanical failure, sabotage, or bird strike theories. If flight recorder data supports this theory, the case could reveal serious issues in loading oversight, cargo verification, and center of gravity management. These factors are crucial for the safety of large commercial aircraft, especially during demanding long-haul departures. Until the official DGCA investigation is released, this analysis offers one of the few well-grounded frameworks that considers all publicly observed details of the AI-171 disaster.

5 Observed Phenomena Explained by the Proposed Theory

To further illustrate the consistency of this hypothesis, the following phenomena are best explained by the center of gravity imbalance and stall dynamics proposed in this paper:

· No visible engine fire or smoke
· Calm Mayday call
· Ram Air Turbine (RAT) deployment
· Delayed rotation and extremely long takeoff roll
· Excessive nose-up attitude during loss of altitude
· Landing gear remained extended
· No reports or audio of bird strikes or loud bangs
· Survivor's testimony of rear cabin breakage
· Aircraft's trajectory ends with nose-high descent

6 References

1. ***Aryan Asari (witness) reported by BBC News*** – Captured footage of the AI-171 crash. [link]
2. ***The Economic Times*** – Mayday call made by the AI-171 pilots [link]
3. ***BBC News*** – Miscellaneous flight details used in constructing the hypothesis [link]
4. ***Reuters*** – Miscellaneous flight details used in constructing the hypothesis [link]
5. ***Boeing 787-8 Dreamliner Wikipedia*** – Technical/activity information [link]
6. ***Real Engineering (YouTube)*** – Mechanics of the Boeing 787-8 Dreamliner [link]

7. ***The Times of India*** – Picture attached for reference on page 2 and nose-up attitude while at a critically dangerous altitude [link]

7 Acknowledgment

The author gratefully acknowledges the mentorship and technical insights provided by **Mr. Ved Amit Takte**, **Aerospace Researcher** and member of the **AirborneX team at IIT Kharagpur**. His guidance in refining the aerodynamic hypotheses and strengthening the physics-based arguments played a critical role in shaping the direction and clarity of this paper.

The author would also like to thank all those who indirectly contributed to this research by fostering an environment of scientific curiosity and inquiry.