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# Review Paper on Aircraft Wake Turbulance: Prediction and Avoidance

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***Abstract:* *Every aircraft produces wake turbulence during flight. This process arises from the production of lift, resulting in the formation of two counter-rotating vortices trailing behind the aircraft. The vortices can significantly impact encountering aircraft due to their stability, direction duration and strength.***

## I. INTRODUCTION

Aircraft wake turbulence refers to the disturbed air left behind an aircraft after take-off or landing, which can pose a hazard to other aircraft. Predicting and avoiding wake turbulence is crucial for ensuring aviation safety.

## II. TYPES OF WAKE TURBULENCE

1) Vortex wake: Rotating air masses that trail behind the wings.
2) Jet wake: Turbulent air behind the engines of aircraft and airplanes.
3) Wingtip vortices: swirling air at the wingtips.

## III. WAKE TURBULENCE CATEGORIES

1) Light(L): Aircraft types of 7000 kg or less.
2) Medium(M): Aircraft types more than 7000 kg but less than 13000 kg.
3) Heavy(H): All the aircraft types of 13000 kg or more, with the exception of aircraft types in super(J) category.
4) Super(J): Aircraft types specified as such in ICAO Doc 8643, Aircraft types designators.

## IV. FACTORS AFFECTING WAKE TURBULENCE

1) Aircraft size and weight categories: The larger and heavier, like jumbo jets, create stronger wake vortices compared to smaller planes. These vortices are essentially swirling air masses that form behind an aircraft as it moves through the air. (John H. Olsen A. G., 2012)
2) Wing configuration and shape: wing configuration and shape have a significant impact on wake turbulence. The design of an aircraft's wing influences the formation and strength of wake turbulence.
3) Speed and altitude: speed and altitude also play a crucial role in how wake turbulence behaves. When aircraft fly at higher speeds, the intensity of the wake vortices increases. This means that faster-moving planes create stronger wake turbulence.
4) Similarly, altitude affects wake turbulence because vortices of sink as they move away from the aircraft. So, at higher altitudes, the vortices from an aircraft will descend more slowly, potentially affecting aircraft flying at lower altitudes.
5) Wind and Weather conditions: Wind and weather conditions can indeed impact wake turbulence. When there are strong crosswinds, the vortices created by an aircraft can be carried off course, affecting other planes flying nearby. Additionally, turbulent weather conditions like thunderstorms or strong gusts can further disrupt and disperse wake vortices, potentially making them less predictable and more challenging to navigate around.

## V. EFFECTS ON AIRCRAFT

1) Loss of control
2) Reduce lift force
3) Structural damage
4) Increases drag force
5) Loss of height
6) Loss of rate of climb

7) Increased Instability
8) Reduce speed of aircraft
9) Increase the chance of stall
10) Loss of rolling movement

## VI. PREDICTION

Aircraft wake turbulence prediction involves using different system to predict the behavior of wake turbulence produced by an aircraft.

1) Empirical Models: Use historical data and statistical analysis to forecast wake turbulence.
2) Large Eddy Simulation (LES): Simulate turbulent flows using LES.
3) Reynolds-Averaged Navier-Stokes (RANS): Solve RANS equations to forecast wake turbulence.
4) Wake Turbulence Models: Use simplified models, such as the Blade-Element Model.
5) Artificial Intelligence (AI) and Machine Learning (ML): Train AI/ML algorithms on historical data to forecast wake turbulence.
6) Weather prediction: Incorporate weather conditions into wake turbulence predictions.
7) Aircraft Performance Data: Use aircraft performance data, such as airspeed and weight, to forecast wake turbulence.
8) 8.Wake Turbulence Detection Systems: Utilize real-time data from sensors and radar to predict wake turbulence.

## VII. AVOIDANCE

Aircraft wake turbulence is a hazardous phenomenon that can affect aircraft flight safety.

1) Maintain safe separation: Keep a safe distance from the preceding aircraft, especially during take-off, landing, and taxiing.
2) Use standardized separation minima: Adhere to established separation guidelines based on aircraft weight and type.
3) Be aware of wind conditions: Wind can dissipate or displace wake turbulence, affecting its behavior.
4) Monitor ATC instructions: Follow Air Traffic Control (ATC)guidance on wake turbulence avoidance.
5) Use wake turbulence detection systems: Utilize available detection systems, like radar, to identify the potential of wake turbulence.
6) Adjust flight paths: Alter your flight path to avoid the wake turbulence zone, typically below and behind the preceding aircraft.
7) Climb or descend early: When possible, climb or descend early to avoid flying through another aircraft's wake turbulence.
8) Stay informed: Stay updated on weather conditions, air traffic, and any reported wake turbulence incidents.
9) Separation Distances: Air traffic controllers maintain safe separation between aircraft to prevent wake turbulence encounters.
10) Pilot Awareness: Pilots receive training on wake turbulence avoidance. They adjust their flight paths to avoid flying directly behind another aircraft’s wake.

## VIII. CONCLUSION

Aircraft wake turbulence prediction and avoidance are crucial for ensuring aviation safety.

1) Various methods are used to predict wake turbulence, including empirical models, CFD, LES, RANS, and AI/ML algorithms.
2) Accurate predictions rely on considering factors like aircraft characteristics, weather conditions, and air traffic control procedures.
3) Separation distances and wake turbulence categories help maintain safe distances between aircraft.
4) Air traffic control guidance and pilot training are essential for wake turbulence avoidance.
5) Detection systems and real-time data aid in identifying and avoiding wake turbulence.

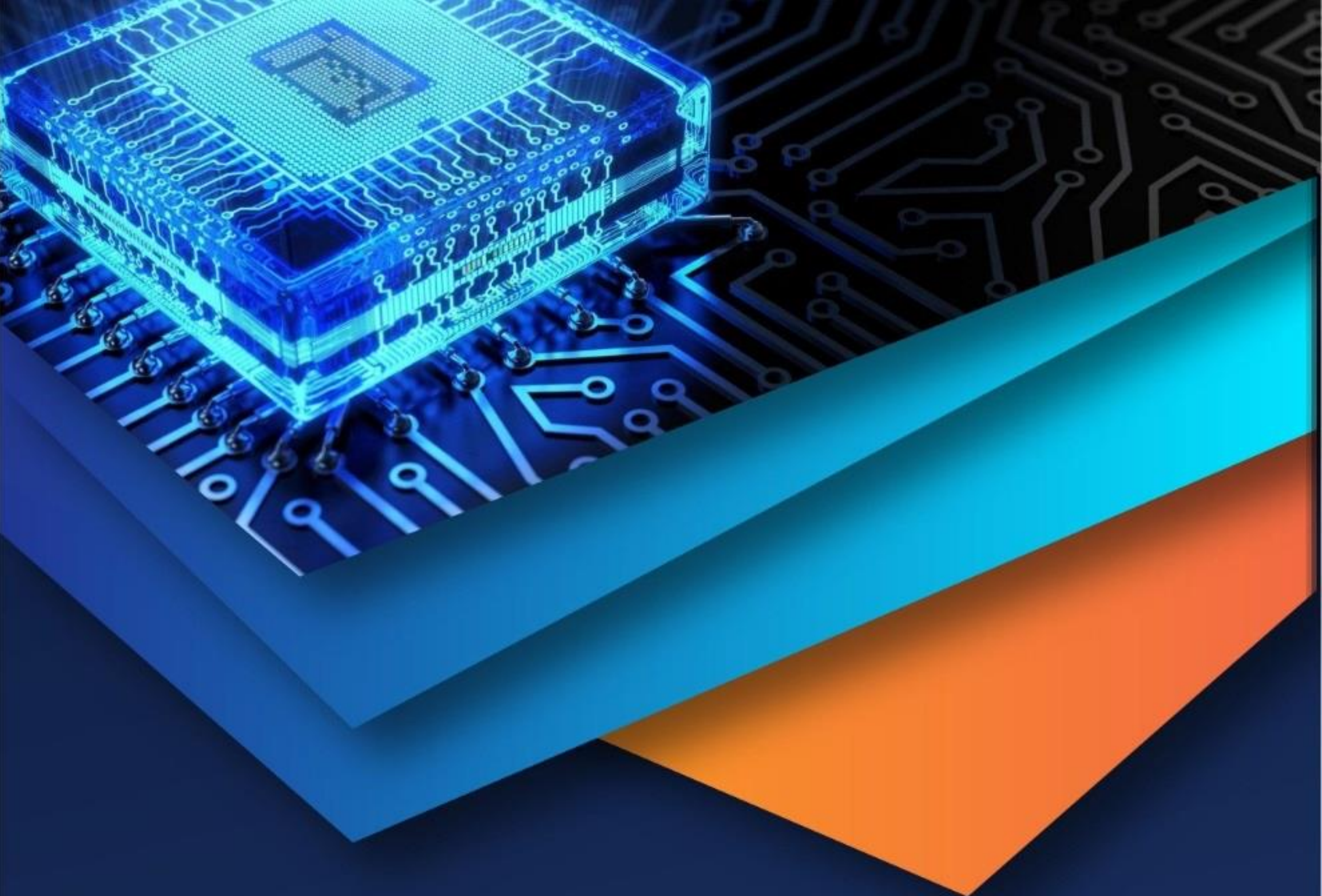
## IX. FUTURE DIRECTIONS

1) Continued research and development in wake turbulence modeling and detection.
2) Improved understanding of wake turbulence behavior in various weather conditions.
3) Enhanced air traffic control procedures and pilot training programs.
4) Integration of AI/ML algorithms into wake turbulence prediction and avoidance systems.

By advancing wake turbulence prediction and avoidance capabilities, the aviation industry can reduce the risk of wake turbulence encounters, ensuring safer skies for all aircraft operations.

## REFERENCES

[1] Academies, N. R. (2008). Wake Turbulance - An Obsactle to Invreased Air Traffic Capacity. Washington , D.C. : The National Academies Press.
[2] John H. Olsen, A. G. (2012). Aircraft wake turbulance and its detection. New York: Springer New York , NY.



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