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Wake Turbulence Reclassification and Separation with Induced Power Using the FAA Aircraft Characteristics Database

Induced power is induced drag multiplied by aircraft speed. It is energy per time in the wake vortex of an aircraft. The vortex can be dangerous for other aircraft when they enter the rotating flow field. So, better stay at a distance and keep aircraft separated. The FAA ACD has the information to start the calculation.

Aim is the definition of new Wake Turbulence Categories (WTC) based on the calculation of induced power of aircraft on approach. This requires the parameters aircraft mass, span, approach speed, air density, and Oswald factor (calculated from wing aspect ratio, wing sweep, wing taper ratio, winglet height, and fuselage diameter). This is considerably more detailed than other metrics (ICAO, FAA, EU) based on aircraft mass only or aircraft mass together with wingspan.

METHODOLOGY

Camilo (2022) [1,2] grouped 89 aircraft types into only four categories based on their calculated induced power. With the FAA Aircraft Characteristics Database, the necessary parameters for calculating induced power (Figure 1) are accessible for 388 aircraft, which were grouped into six categories. This broader dataset allows for a refined statistical analysis and better comparison with other classification systems, enabling the definition of new category thresholds for an own WTC (called HAW WTC) based on induced power (Figure 2). Additionally, a continuous separation formula was developed (Figure 3).

FINDINGS

WTC separation minima got proposed following EUROCONTROL, but now with physics-based WTCs from induced power. Continuous (non-classifying) separation minima can be calculated with a new equation. Its structure is conceived from non-linear regression. Input parameters are induced power of leader and follower aircraft as well as the difference of their induced power (Figure 3). Five regression parameters were optimized with Excel's Solver based on EUROCONTROL and ICAO separation minima.

RESEARCH LIMITATIONS

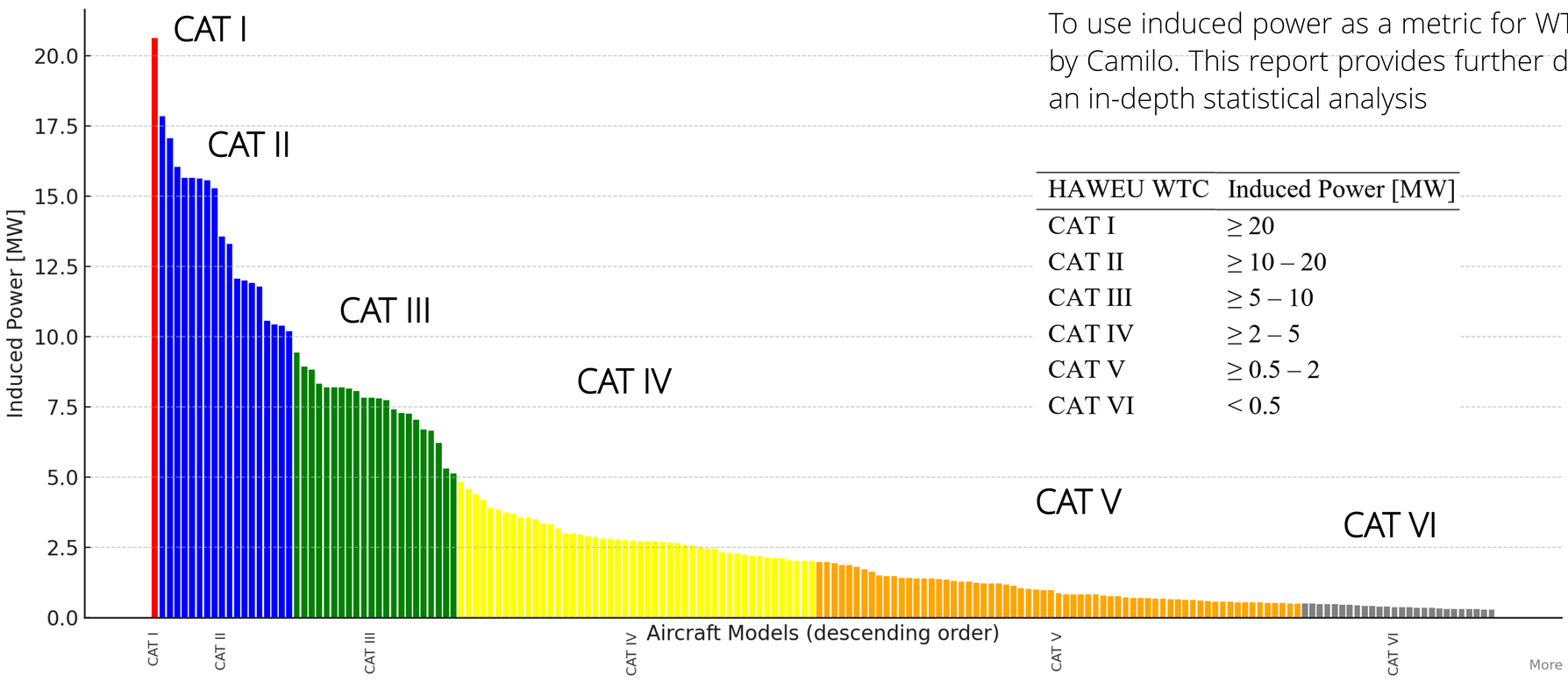
Aircraft responses of the following aircraft are only envisioned from flying behind and parallel to the leading aircraft and directly through the vortex core. It is assumed that the resistance to roll of the following aircraft is related to its induced power. This seems plausible, but no proof is given. The analysis is statistical only. Other dangers like intersecting vortices at an angle are not considered.

PRACTICAL IMPLICATIONS

Separation minima can easily be obtained from a table based on six physics-based wake turbulence categories. Pairwise separation minima for specific leader and follower aircraft can be calculated without categorization boundaries. These dedicated separation minima have the potential to improve efficiency and safety for aircraft on approach. In the next step it is necessary to discuss data handling at Air Traffic Control (ATC) units. It also needs an agreed graphical representation of the calculated pairwise separation minima suitable for controllers at work.

ORIGINALITY

To use induced power as a metric for WTC was proposed by Scholz and applied by Camilo. This report provides further details with 388 aircraft investigated and an in-depth statistical analysis



HAWEU WTC	Induced Power [MW]
CAT I	≥ 20
CAT II	≥ 10 – 20
CAT III	≥ 5 – 10
CAT IV	≥ 2 – 5
CAT V	≥ 0.5 – 2
CAT VI	< 0.5

$$P_{wake} = \frac{2\,g^2}{\pi}\,\frac{\frac{m}{S}}{Ae}\,\frac{m}{\rho\,V}$$

$$P_{wake} = \frac{2\,g^2}{\pi}\,\frac{1}{b^2 e}\,\frac{m^2}{\rho\,V}$$

Figure 1: Induced Power in the aircraft wake.

Leader / Follower	CAT I	CAT II	CAT III	CAT IV	CAT V	CAT VI
CAT I	3NM	4NM	5NM	5NM	6NM	8NM
CAT II		3NM	4NM	4NM	5NM	7NM
CAT III			3NM	3NM	4NM	6NM
CAT IV						5NM
CAT V						4NM
CAT VI						3NM

Figure 2: HAWEU WTC based on RECAT-EU with pairwise separation minima.

Optimized parameters for the RECAT-EU-based model HAWEU		
$n = 2.9661$	d:	Required separation in NM
$a = 0.5029$	ΔP:	Difference in induced power (P1 - P2) in megawatts (MW)
$u = 0.2635$	$P1$:	Induced power of the leading aircraft (MW)
$v = 0.3351$	$P2$:	Induced power of the following aircraft (MW)
$w = -0.3629$	n, a, u, v, w:	Empirical model parameters derived through optimization.

$$d = n + a\,\Delta P^{u}\,P1^{v}\,P2^{w}$$

Figure 3: Continuous separation can be calculated for the specific parameters of two aircraft.

References

[1] https://nbn-resolving.org/urn:nbn:de:gbv:18302-aero2022-12-30.011
[2] https://doi.org/10.48441/4427.558 (Poster, DLRK 2022)

All details in the Bachelor Project of Grunze (2025):

https://nbn-resolving.org/urn:nbn:de:gbv:18302-aero2025-06-30.01

Data in in Harvard Dataverse:

https://doi.org/10.7910/DVN/4YIYLN

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