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Comparing Aircraft Wake Turbulence with Induced Power Calculations

NEW WAKE TURBULENCE CATEGORIES (WTC) COMPARED WITH THOSE FROM EUROCONTROL, FAA and ICAO

Every aircraft produces wake turbulence during flight. The strength of wake turbulence depends on various factors, for example aircraft mass, wingspan, speed or wing geometry. However, FAA, EUROCONTROL and ICAO consider only aircraft mass and wingspan for categorization of aircraft wake turbulence. In this approach, other variables related to flight mechanics and aircraft design are used to calculate induced power. Based on these calculations, new aircraft wake turbulence categories are presented and compared to FAA, EUROCONTROL and ICAO categories.

What is wake turbulence?

Wake turbulence is defined as turbulence which is generated by the passage of an aircraft in flight. This turbulence in the wake of an aircraft in flight is principally caused by wing tip vortices. Wing tip vortices decay gradually and can produce a significant rotational influence on an aircraft encountering them for several minutes after they have been generated.

The formation of wing tip vortices is a direct and natural consequence of the generation of lift by a wing. Lift is generated by air being deflected by the wing and accelerated downward. This creates the vortex sheet with the downwash. The wake vortex rolls up at the wing tip and forms the wing tip vortex, resulting in swirling air masses that trail behind the wingtips.

Figure 1: The vortex wake behind lifting wings descending through a thin cloud layer (Source: Airliners.net)

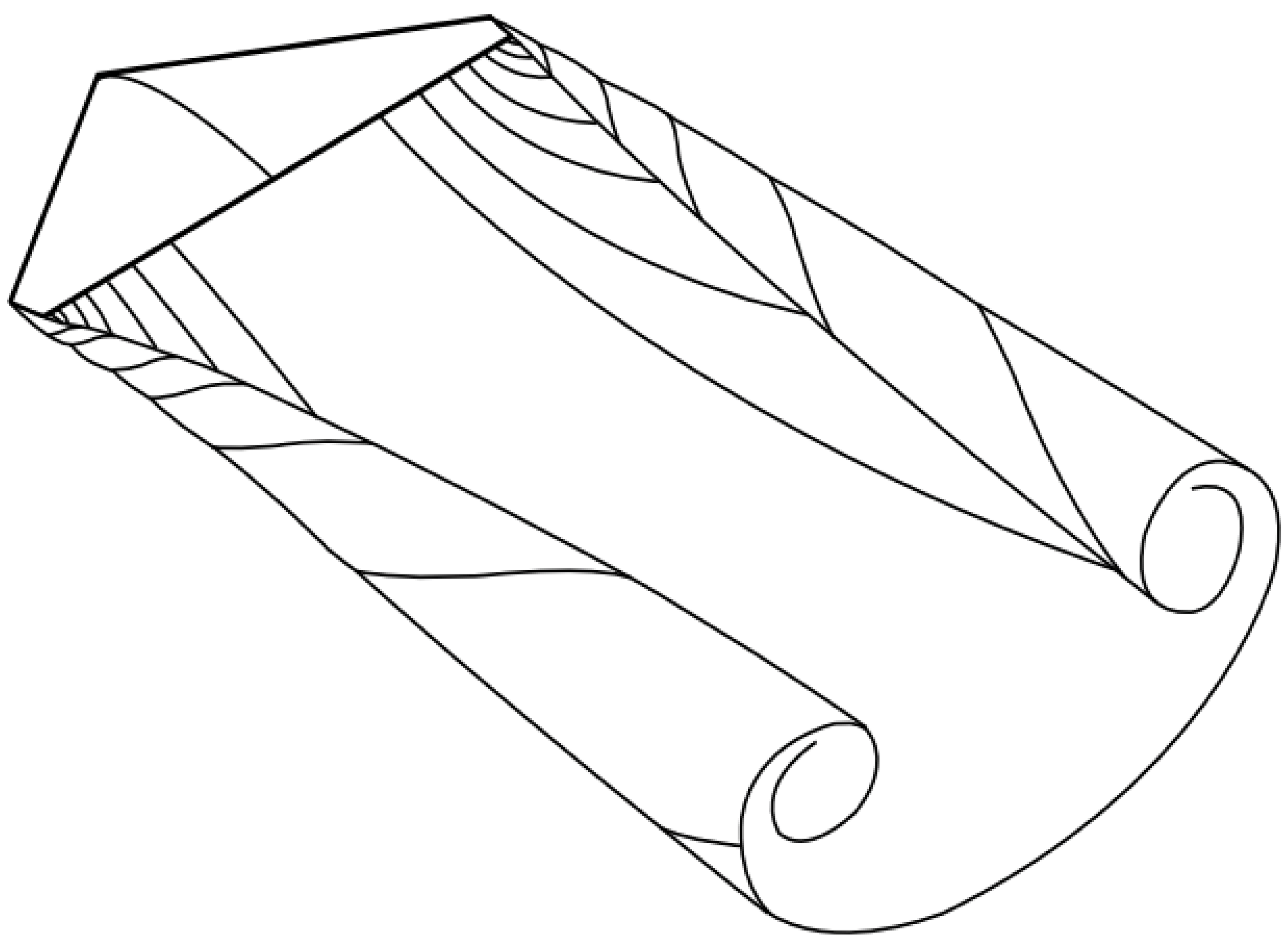

Figure 2: The vortex wake behind a lifting wing (Source: Boeing)

Calculation method

The presented approach to categorize wake vortex strength considers the Induced Power contributed by the respective aircraft to its wake vortex. By using correlations and equations derived from flight physics, the following equation is used for the calculation of the Induced Power:

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

g: gravitational acceleration
b: wingspan
e: Oswald factor
m: aircraft mass
ρ: air density
V: approach speed

Result & comparison

The above-mentioned equation is used to calculate the Induced Power of 89 different aircraft that vary significantly in mass, wingspan and other characteristics. Based on the results of this calculation, the following "HAW Hamburg Wake Turbulence Categories" (HAW Hamburg WTC) are proposed in accordance with the Induced Power an aircraft contributes to its wake vortex:

CAT I : > 15 MW; CAT II: 5– 15 MW; CAT III: 1-5 MW; CAT IV: < 1 MW

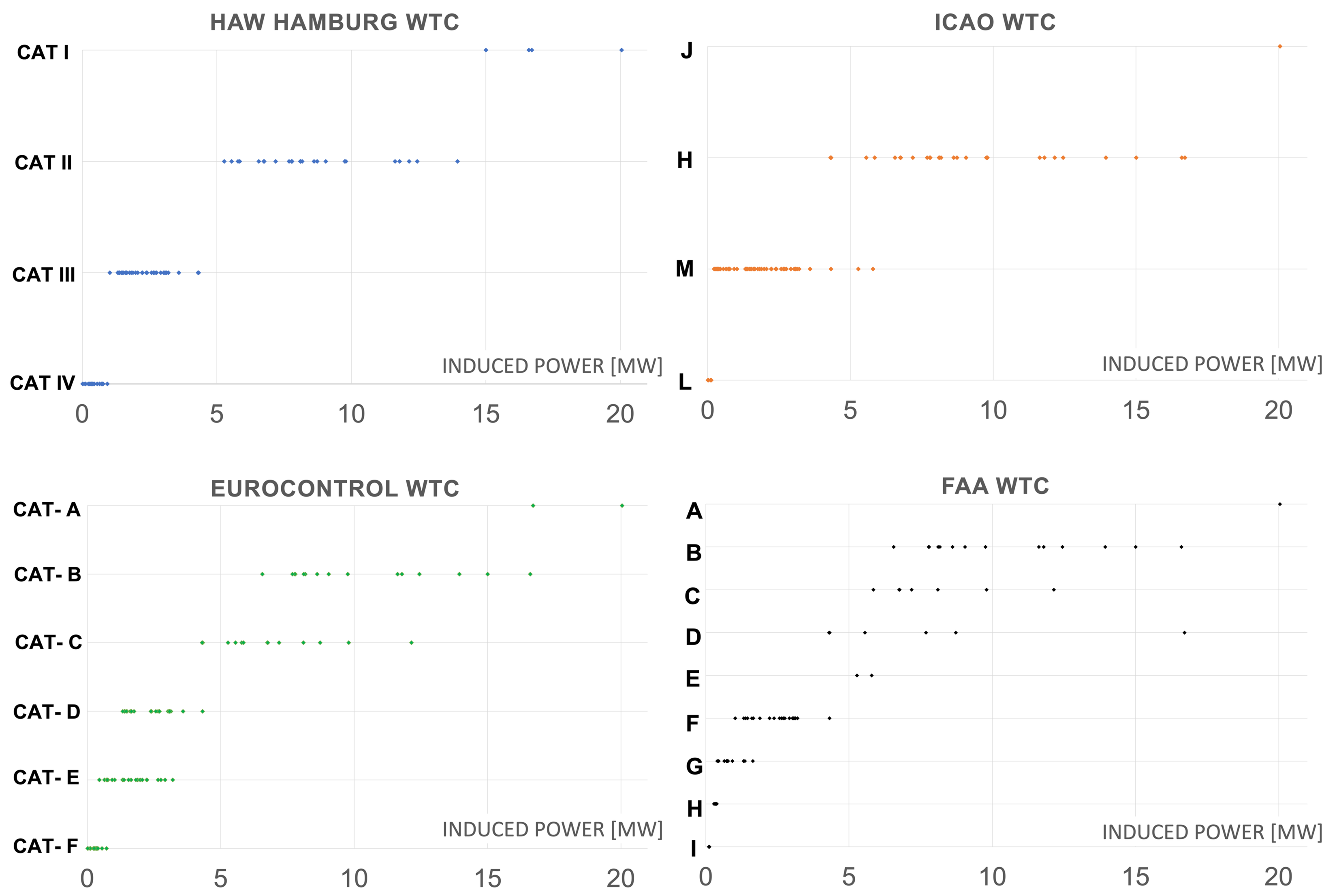

Figure 3: Comparison of Wake Turbulence Categories (WTC). HAW Hamburg WTC are clearly better than those from ICAO, EUROCONTROL and FAA.

HAW Hamburg WTC depend clearly on Induced Power. In contrast, all other WTC occasionally assign a smaller WTC to an aircraft with larger Induced Power. This is indicated by an overlap of categories when plotted versus Induced Power. FAA WTC seem especially inconsistent. EUROCONTROL WTC seem inconsistent comparing CAT-B and CAT-C.

Downwash and wing tip vortices have an impact on following aircraft. They are more dangerous, if formed by more Induced Power. Therefore, the newly proposed "HAW Hamburg Wake Turbulence Categories" (HAW Hamburg WTC) are based on Induced Power. As such HAW Hamburg WTC describe the physical effects better than established WTC and should be used instead.

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