Turbulent ship air-wake with ship motion

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Helicopter landing on a naval ship is acknowledged as a dangerous marine operation. The main risk is attributed to the highly complex and unsteady flow over the flight deck, which is commonly known as the ship air-wake. Although the ship air-wake is a result of both the incoming flow interacting with the ship's superstructure and the ship motion, few studies have investigated the turbulent ship air-wake incorporating with ship motion simulation[1]. Moreover, although the importance of Atmospheric Boundary Layer simulation has been highlighted by numerous researchers[2], a turbulent boundary layer naturally developed over a water surface with a long fetch length has never been studied. Hence, in this study, we conducted a series of experiments in a $60 \times 2 \times 2$ m (length $\times$ width $\times$ height) wind-wave interaction facility located at the University of Melbourne[3] to investigate the turbulent ship air-wake for different motion cases, with an ultimate goal of predicting the helicopter landing safety based on upstream measurements. The ship model employed is a 1:200 scaled NATO Generic Destroyer (NATO-GD) model, which was recently developed for collaborative research[1]. Figure 1(a) shows the ship model mounted inside the wind-wave facility.

Planar Particle Image Velocimetry (PIV) is used to obtain the velocity fields over the deck. The results show that the turbulence characteristics are strongly affected by both the ship position and its moving direction. Figure 1(b) shows an example of the instantaneous stream-wise velocity field during sinusoidal pitching motion. In this study, we divided the motion cycle into 8 phases to assess the landing safety during different stages of ship motion. Due to the direct contribution from the deck velocity to the air-wake flow, the pilot would experience stronger down-wash as the ship deck is descending around its neutral position. Moreover, by employing a specified threshold for the standard deviation of the vertical velocity fluctuation (σ_w) from civil helicopter operations guidelines[4], it is found that the pilot is more likely to encounter extreme turbulent motions with negative pitch angle. The variation that the pilot would suffer between phases is amplified when the helicopter is closer to the deck.

a) b)

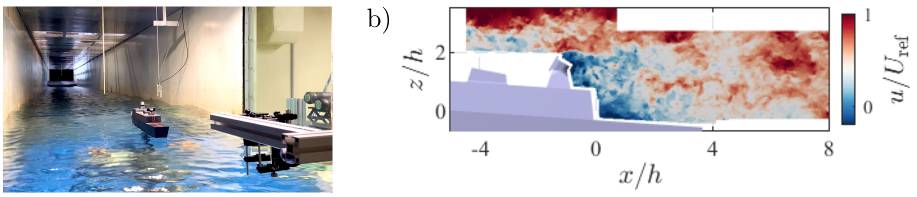

Figure 1: (a) 1:200 scaled NATO-GD model mounted inside the Wind-Wave facility. (b) One instantaneous stream-wise velocity field in Pitch motion with positive pitch angle.

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[2]Setiawan et al., *Ocean Eng.* **260**, 111931 (2022).
[3]Lee and Monty, *J. Phys. Oceanogr.* **50**, 383 (2020).
[4]CAAP 92-4 (2013).