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Publication date
2024

Document Version
Final published version

Citation (APA)
Eijkelhof, D., Rossi, N., & Schmehl, R. (2024). *Optimal Flight Pattern Debate: Circular vs. Figure-Of-Eight*. Abstract from 10th International Airborne Wind Energy Conference (AWEC 2024), Madrid, Spain.
http://resolver.tudelft.nl/uuid:f96928e5-c0c2-4de4-b957-2216c791680c

Optimal Flight Pattern Debate: Circular vs. Figure-Of-Eight

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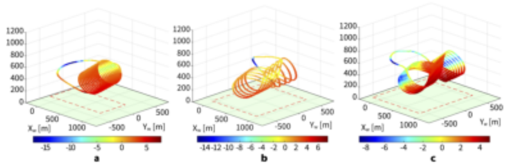
The debate about the optimal flight pattern for AWE dates back to the beginning of the technology development in the late 2000s. The industry appears undecided, with circular and figure-of-eight patterns both being prevalent. Tether winding seems to be the key reason for the latter, but other factors could influence the choice.

This work attempts to provide a better understanding of the effect of each pattern on the system's performance when using a simple flight control strategy. The performance is studied using three criteria: average cycle power, power quality (oscillations) and projected ground surface area. Three patterns are considered: the circular path; the figure-of-eight with down loops(DL) at the outer edge; and the figure-of-eight with up loops(UL).

The MegAWES reference kite (150 m^2 fixed-wing) [1] is used in conjuction with a new improved and modified flight controller developed in [2], based on [3]. The navigation strategy, based on a variation of the widely used L_1 logic [4], is proposed, tuned and tested in conjunction with a cascaded PID control loop for the attitude control of the kite. Furthermore, the winch design and controller is implemented as developed in [5]. The new flight controller is simple and robust under diverse wind conditions, and highly satisfactory path tracking capabilities.

Early results highlighted that circular paths are comparable, if not superior, with higher average power (1.175 MW) than both figure-of-eight paths (DL: 0.998 MW, UL: 0.847 MW). Even though the figure-of-eight up loop is most commonly used, it proved to be less advantageous for this type of airborne wind energy system.

Finally, the flight path is projected on the ground and the produced average cycle power per square meter of land surface area is compared. The results show a higher power density per land surface area for the circular path compared to the others.



Mechanical power (colorbar, [MW]) and ground coverage for three patterns at 15ms^{-1} and 36^o elevation: (a) Circular, (b) Down loop and (c) Up loop.

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This work was supported by the Dutch Research Council (NWO) and Kitepower B.V. under grant number 17628.