Referee Comment #2 - WES-2024-170

We thank Prof. Fontes for the thorough revision of our manuscript and his comments and suggestions.

The AWE research group at the Universidad Carlos III de Madrid, collaborating with CT Inginieros and INTA, has been working on the development of AWE systems for several years, having provided valuable contributions in theoretical modelling and control results, development of high fidelity simulators, and experimental testbeds, mainly considering systems with soft-wing (possibly with rigid frame) kites. Consequently, the article expresses the authors' mature view and expertise in the field, providing a valuable reference for the AWE community.

We are glad to know this positive opinion of Prof. Fontes about this work and the contribution of UC3M group to AWE.

The impact of parameter variations in controller performance could be further investigated. It seems to me that a significant parameter that could be further analyzed is the radius of the circles centred at the attractor points, C− and C+. This parameter should be larger than the minimum turning radius of the kite (ocurring at the maximum roll angle), and would condition the choice of the other parameters.

We fully agree with Prof. Fontes that there is still room for exploring the impact of the parameters of the controller into the kite trajectory. It is a very interesting research problem, but beyond the scope of this work that it is focussed on presenting a new ground station, a controller, and experimental results for two complete sets of parameters (see Table 3). The radius of the circle is not a parameter that we could directly impose in the controller because the guidance module is based on the kite attitude (and not on its position). Nonetheless, this suggestion encourages us to investigate in future flight campaigns the dependence between the radius of the turn with the parameters of the controller that we can directly define like the position of points C, L and R. In particular, we could try to find the flight envelope (minimum turning radius) as a function of the wind velocity by progressively changing the controller parameters to reduce the radius. Such a research activity is fully aligned with the purpose of the testbed presented in this manuscript, that is using the infrastructure to investigate basic dynamic and control phenome in AWE systems.

This important point has been now mentioned in the new paragraph at the end Sec. 4.1 (line 305).

Although the development and validation of a small-scale testbed – as well as the data collection it enables – are of great importance for the AWE community, a future commercially viable system would require some modifications that could be worth discussing in this article. These modifications would include not only a larger dimension, but also a reduction on the number of tethers. This is because the number of tethers can significantly hinder the power efficiency of the system.

We fully agree with this comment and also with the later discussion made by Prof. Fontes about 1-line and 3-line AWE systems. For this reason the UC3M testbed has been designed to be compatible with 3-line and 1-line AWE systems. The former is presented in this manuscript and, regarding the latter, we are currently working on a fly-actuated system to work with 1-line AWE systems. Our main objective when developing our testbed (and also its scaleup version, see below) was not power production but having a flexible platform in terms of system architecture and configuration to conduct research on AWE energy.

The authors could consider discussing the possibilities of using a single tether system, possibly having a single tether that splits into a variable geometry bridle, as is used in the Kitepower/ TU Delft system [ref] with a hanging control pod, or as in the University of Porto/Upwind project system [ref] with actuators for varying the bridle geometry inside the aircraft.

We fully agree with the comment. UC3M AWE research group is currently working on an on-board control system, with a single tether connecting the kite with the ground station due to the reasons pointed out by Prof. Fontes (see Ref. [01]). Such a control system is not based on a pod, but on a mechanical system integrated in the kite that varies the bridle geometry. We recently finished its integration phase and we plan to start a testing campaign next month. As explained in this manuscript, our goal is that the testbed will be a useful platform to explore different types of AWE systems (single and multi tethered machines and flexible and rigid wings).

The authors may also want to consider discussing the possibility of using other control strategies, that could be more efficient in terms of power output than the one proposed in the article, such as the ones that use optimization based methods and try to follow a trajectory that maximizes average power generated.

We agree that the original manuscript was not linked enough to the final goal of any AWE machine, which is power generation. Following this suggestion, we added a paragraph at the end of Sec. 4.1 (line 305) discussing the possibility of extending the proposed control strategy for the optimization of power output, and we added a few more sentences to the paragraph starting in line 40 of the Introduction discussing the limitations and advantages of this approach. We thank the Reviewer for this suggestion, which improved the quality of the manuscript.

The potential for scaling up the testbed and the predicted challenges associated with such modifications are also a relevant research aspect and a discussion of some of these questions would make the article even more interesting to the AWE community

We fully agree and our research group has already updated and scale-up the testbed presented in this manuscript. We added several new capabilities like for instead mechanical-to-electric power conversion, and upscaled the actuators to work with larger kites (see [02]). Nonetheless, the architecture and methods of the scaled-up testbed are very close to the ones presented in this manuscript. We have recently finished the integration phase and will perform test campaigns in the next months.

We added some sentences at the end of the Conclusions (line 386) to keep the AWE community informed about our roadmap and level of development.

[01] González-García, J., et al. An Aircraft-Integrated Control System Based on Bridle Actuation for AWE Machines. Airborne Wind Energy Conference 2024 (AWEC 2024). DOI: 10.13140/RG.2.2.19533.14569
[02] DeLosRíos-Navarrete, F., et al. A Small-Scale and Multipurpose Airborne Wind Energy Prototype. Airborne Wind Energy Conference 2024 (AWEC 2024). DOI: 10.13140/RG.2.2.15230.70729