Vertical Takeoff, Transition and Landing for Airborne Wind Energy Systems

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July 25, 2019

One of the challenges of Airborne Wind Energy is launching and retrieving of the airborne system in a reliable, scalable and cost-efficient manner [1]. Moreover, launch and retrieve should be fully autonomous to render AWE viable [2]. According to Fagiano [3] the takeoff and landing challenge is most pronounced for ground-gen, fixed-wing concepts. Different mechanisms are being investigated by research institutions and companies. These mechanisms include a winch launch, the rotating arm, assisted take-off, and vertical take-off and landing (VTOL). In the latter approach, rotors are attached the tethered aircraft and bring it to operational altitude in a multicopter mode.

All launch and retrieve mechanisms have their advantages and disadvantages. There is no clear trend in literature which is most likely to be successful. This is also clear from the approaches taken by companies as they vary from company to company (e.g. Ampyx Power, Enerkite, Kitemill). In contrary to the rotating arm and assisted take-off, which has been studied in the literature, such detailed studies are not found for vertical take-off. Nevertheless, as stated before, this approach has been pursued by several companies. It will be the goal of the research, to fill this gap by providing a detailed study on the VTOL approach. More specifically, the opportunities and limitations of a VTOL system as launching and retrieving mechanism for a ground-gen, rigid kite system will be investigated. This will be done by designing and simulating a VTOL system for the AP2 prototype of Ampyx Power B.V. (Figure 1).

Compared to the current state of the art in VTOL design for AWE, a more extensive design method will be developed including the aerodynamic effects and sizing of the component parameters such as thrust-to-weight ratio, rotor efficiency, rotor area, energy density and power density of battery and motor. In the literature on hybrid UAV these aspects have been taken into account. A Hybrid UAV takes off using VTOL system or multicopter mode and can fly like a fixed-wing aircraft. Because of the striking resemblance with VTOL AWES, a lot can be learned from this technology and applied to VTOL AWES. Therefore, a lot of literature has been gathered on hybrid UAV and multicopter design and reviewed to apply on the VTOL system design for AWE.

Low fidelity models will be programmed in Matlab to reach the research objective and answer the research questions. To perform a design optimization study, an optimization tool will have to be used or build. Built-in optimization tools in Matlab will be used for that. For the simulation, use of Simulink in Matlab will be made since the existing simulation environment of the AP2 is in Simulink.
References


