Crosswind Kite Power Systems (CKPSs), a specific type of airborne wind energy systems, will operate at higher altitudes than conventional wind turbines. CKPSs will fly through a significant portion of the atmospheric boundary layer, and therefore encounter a wide range of incident wind profiles corresponding to wide ranging atmospheric stability conditions resulting from synoptic and diurnal weather conditions. This study aims to demonstrate an approach to considering realistic wind speed profiles for a lift mode (a.k.a. pumping mode) CKPS. The focus is on a time-domain simulation of tethered flight to follow optimal trajectories solved for both simple and realistic wind speed profiles. The pre-computed trajectories may not be optimal, or even achievable, when considering forward-marching flight dynamics compared to the necessarily simplified optimization flight model. In particular, ground-station tether reel-in/out speed and torque envelopes and control directly affect the power harvesting performance, longevity and robustness of the system. An approach is being developed to support ground station control coupled with tether and flight dynamics, to explore controller synthesis solutions that do not excite the coupled kite–tether–ground-station system dynamics, especially during transitions between harvesting and retraction flight phases.

In the proposed approach, the wind speed profiles from the mesoscale Weather Research and Forecasting (WRF) model [1] are first implemented in the open source AWEbox [2] which is then used to determine optimal flight paths for a range of wind profiles. A flight controller is implemented in a Matlab's Simulink model to follow the pre-computed optimal trajectories generated with the AWEbox in a time-marching dynamic simulation. Dynamic tether tension, structural loads and energy harvesting performance are estimated and compared with the offline, idealized control actions obtained with AWEbox.

The ultimate goal is to integrate both the base-station and flight controllers in the combined system dynamic model in Simulink, assess the ability and robustness of the control system to follow those optimal paths, and evaluate the differences between optimal idealized performance and that achievable dynamically in the presence of wind disturbances. This evaluation will also form the basis for assessing lifetime structural fatigue loads and sizing requirements.

References: