DSE Group 3 – Design of a drone swarm to measure the wind field and temperature stratification in a wind farm

To quantify and subsequently optimize the performance of an array of wind turbines, information is required about the wind conditions in the vicinity of each turbine. The design goal is to optimize the performance of an array of wind turbines through the mapping of wind and temperature fields inside of a wind farm. This is done to provide more information that can lead to better wind farm performance and control for wind farm operators. Traditionally, this is provided by meteorological masts located sparingly inside the wind farm. This has the downside that it is not possible to obtain high resolution data in space and the data may not reflect the true conditions close to individual turbines. Unmanned Aerial Vehicles (UAV) offer a platform that can host the required sensor technology. A swarm of UAVs would then have the potential to significantly increase the measurement coverage around an entire wind farm, and in turn improve operator control.

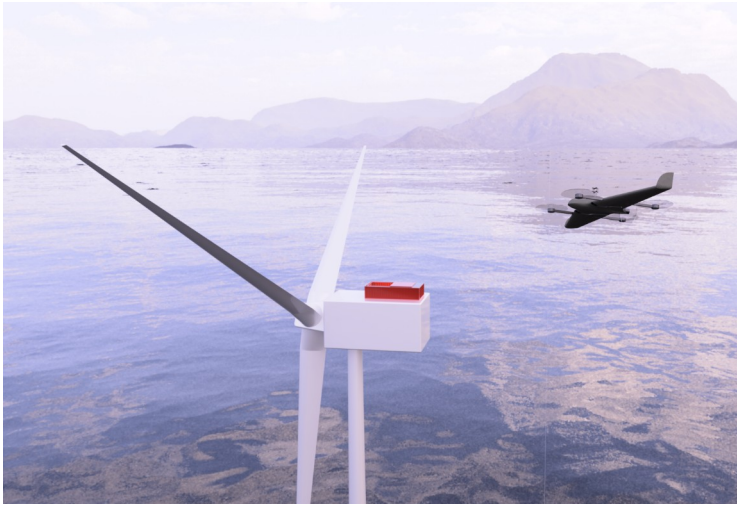
The goal of the project can then be reformatted into a mission need statement (MNS):
Measure the atmospheric conditions with full three-dimensional coverage of a wind farm to optimize its operational performance and control

To approach the finding of a solution to this problem, the project was divided into four: planning, concept definition, concept exploration and detailed design. From the first two phases came unique concepts exploring remote and local sensing options, combined with a range of UAV types including hybrid, fixed-wing and rotor. Through a detailed trade-off process and sensitivity analysis, the agreed upon final solution came to be a local sensing concept that makes use of many hybrid drones. In the fourth and final phase, where we now find ourselves, the detailed concept is unpacked and designed into a marketable system that is capable of satisfying the underlying MNS. In this stage the design was split into three design groups: UAV design, ground station design, swarm design.

The UAV department decided on an off-the-shelf UAV to ensure satisfactory resources could be allocated to the design of the autonomous operations of the system. The final choice came to be the DeltaQuad Pro UAV, as this gives good endurance and flyability in windy conditions while being able to carry the chosen sensors: Trisonica mini (from Anemoment) for the wind speed and FST600-202 4-20mA PT100 (from Hunan FirstRate) for the temperature. These were selected for their compliance with the required accuracy and weight. The hybrid configuration is useful here as it allows the UAVs to take-off and land vertically whilst still having efficient flight when measuring data.

The swarm department identified optimal flight routes with the chosen UAV, this allows the calculation of optimal number of ground stations and their placement. This was chosen to be a preset zig-zag path optimized for ground station positioning, later combined with a collision avoidance algorithm, making use of Rapidly-exploring Random Trees. This also allows the estimation of the spatial and temporal resolutions of 300metres and 29minutes respectively.

The ground station department worked to facilitate the autonomous operations of the system, to allow the UAVs to charge regularly and take shelter in non-operable conditions. To combat this, containers are designed to be constructed on the nacelle of the turbines, providing covered space for the UAVs to charge and be stored.



In the last weeks we will be finalizing all work in the final report and preparing for the final review and symposium.