#04 - Off-shore Cargo UAV

The off-shore wind turbine industry is rapidly expanding, with more expansion expected in the coming decades. The Dutch market is one of the largest and fastest growing in Europe, with companies like Vattenfall at the forefront. These turbines have to be maintained regularly and are subject to frequent failures due to the harsh off-shore environment. This maintenance requires relevant tools, electronic components, oil, greases and replacement parts to be delivered to the wind turbine location. However, due to the inaccessibility, this has proven to be a challenge. Current operations, involving ships, helicopters and cranes are logistically complex and require a significant amount of manpower and consequently have high operational costs. This is made worse by the fact that individual payload mass, to be carried by one technician on an off-shore wind turbine, is limited to 25kg, making helicopter and ship hoisting operations highly inefficient.

Mission Objective

The mission objective therefore is to design a VTOL UAV capable of transporting a 25kg payload and delivering it to an off-shore wind turbine. The UAV should be able to hover for 30 min and shall have a minimum range of 5km in order to complete this mission. This will be done autonomously, safely and sustainably in the challenging off-shore environment, where high winds up to 6bft and wet, saline conditions are prevalent . The UAV will deliver the 25kg payload through either landing on the hoisting platform on top of a wind turbine, or hoist it to the bottom. The aim of this design is to provide a low-cost and efficient solution to off-shore cargo delivery and logistics operations.

System Design

To realise this mission objective, an engineering design and systems engineering approach was taken in order to find the most suitable system configuration. For this, a large set of requirements were derived, based on the mission objective statement, risk assessment, legislation and stakeholder needs. Following this, a large number of system design options were explored and developed, in order to make an informed choice on the most suitable option based on an engineering trade-off process. The result of this trade-off was a 4-bladed propeller, ducted quad-copter configuration, powered by electric motors and batteries, which was further developed in order to converge to the final design. The 4 blades contribute to low rotational speeds and reduce the characteristic size of the UAV, while the ducts contribute to safety and through aerodynamic design increase the efficiency of the UAV rotors. This design can hover for 37 minutes, cruise for 28 km in zero-wind conditions and 7 km in 6 bft wind conditions. It will include visual-acoustic warning signals, an integrated hoisting system and shall be able to navigate autonomously using an advanced sensor suite and positional system, while avoiding obstacles with a dedicated collision-avoidance system. The UAV also includes a camera system for direct operator control during critical mission phases such as landing and hoisting. Furthermore, the UAV incorporates additional safety features through the use of a parachute system in case of rotor failure, and a return-to-base feature in the event of signal loss, ensuring the drone remains recoverable and safe in the unlikely event of failure. Sustainability was taken into account throughout the entire design process, with a majority of the components being available off-the-shelf or easily manufacturable at a low cost.