09 - Airborne Minesweeper

It is estimated that when the war in Ukraine is over, up to 1/3 of the country will be potentially contaminated by landmines. Being able to quickly determine which areas are safe and which actually contain minefields will prevent civilian casualties, let people return to their regular lives, and help economic recovery from the war. Currently, the non-technical survey methods, used to determine where minefields are found within a potentially contaminated area, depend mostly on local knowledge gathered by interviews. We believe that this first stage of demining can be done faster and more accurately.

Mission Objective

The objective of the Airborne Minesweeper project is designing a humanitarian unmanned aerial vehicle (UAV) to aid in clearing minefields in post-conflict zones around the world. By speeding up the first stage of demining, the so-called non-technical survey, where locations and boundaries of minefields are identified, the project aims to increase the speed and efficiency of demining efforts. The intended outcome of this DSE project is a detailed design of an autonomous fixed-wing UAV able to detect minefields in Ukraine and other post-conflict areas.

System Design

While the design of the minefield-detecting payload is deemed out of scope of the current design phase, preliminary research into possible sensors resulted in the primary requirements of the UAV: a payload mass of $10\,\mathrm{kg}$, cruise speed between $15-40\,\mathrm{m/s}$, and minimum endurance of 4 hours. These enable the UAV to scan a sufficiently large area during a single mission. Additionally, as minefields are typically found in rural areas, another key requirement is for the UAV to be able to use a 500 m stretch of unpaved road as a runway.

Based on the determined requirements, a conventional fixed-wing aircraft configuration was chosen through a series of technical trade-offs. For the tail configuration, a H-tail is used. An internal combustion engine using standard gasoline was chosen to provide thrust, as the UAV is designed for use in remote post-conflict areas where availability of more specialized fuels cannot be guaranteed. Electric propulsion was rejected, as the required endurance would be more difficult to achieve without the mass snowballing. Additionally, electricity would likely have to be produced locally with a generator due to a lack of infrastructure, ultimately making electric propulsion no more sustainable than gasoline. The engine is mounted on top of the body in a pusher configuration, to reduce the risk of debris damaging the engine during take-off and landing in rough terrain.

After the trade-offs, the design advanced to preliminary sizing. The maximum take-off weight was estimated to be approximately $40\,\mathrm{kg}$ according to early weight estimates, with later estimates putting the final weight at approximately $55.3\,\mathrm{kg}$. A suitable airfoil and wing characteristics were chosen, and initial subsystem placement and interfacing was planned.

In the detailed design phase, the subsystems chosen and initially sized have been considered in finer detail. Many components have already been chosen from among commercially available options, namely the engine, avionics, and the landing gears. Sizing of the components and subsystems that are to be designed, as opposed to bought, has advanced to a more detailed level. This includes material selection, design of the main structures, and sizing of the wing and control surfaces based on updated stability and aerodynamic requirements. In the last weeks of the project, the sizing of the various components and subsystems will be finalized, and any further necessary iterations will be performed to let the design converge into a suitable one.