08 - SustAIn

One of the largest obstacles in worldwide vaccination programs is including people in remote areas, that are often nearly impossible to reach while keeping the vaccines at their required temperature. The WHO estimates that about 50% of the vaccines are wasted each year due to these so-called breaks in the cold chain. On top of that, there may be a sudden outbreak that requires there to be as little physical contact as possible between remote populations and the outside world. The SustAIn project seeks to solve these problems by designing a small, autonomous glider that can deliver vaccines on a large scale.

Mission Objective

From the use case, it is clear that the glider should be high-performance and high precision. This translates to a glide range of at least $125km$ from a maximum launch altitude of $5km$ with a maximum take of weight of $25kg$. Keeping in mind the remoteness of the target areas and the possibility of highly contagious situations, the glider is single-use. However, a goal is to keep the life cycle impact on the environment as small as possible. Combining this with the irretrievability, it means that the glider is designed for biodegradability while all steps in its life-cycle should be as sustainable as possible, from manufacturing to materials, to operations. The glider is designed around a payload of 200 vaccinations in a cooling box and all equipment needed for administration. For now, the landing locations that are being considered are Timbuktu in Mali, Fukushima in Japan, and Trondheim in Norway.

System Design

The glider is based on a flying wing design, as can be seen in the figure. The payload and electronics are situated in the middle section. The thin wings deliver the right lift over drag and combine to a wingspan of $6m$. This glider is brought to $5km$ altitude by a helicopter drone, after which the glider can reach its range in 70% of all wind conditions due to its maximum glide ratio of 32.

Longitudinal stability is achieved through a combination of the reflex of the payload section, and extra ballast in the form of sand near the leading edge, which moves the centre of gravity forward. Lateral stability, on the other hand, is taken care of by the winglets. To turn and trim, elevons are integrated into the wings. The skin of the thin wings is made of paper pulp, which is easily biodegradable and makes the manufacturing of complex aerodynamic shapes viable. A PLA film coating is applied to make the skin waterproof and aerodynamically smooth. The load bearing structure is quasi-isotropic spruce plywood in both the thin wings and the payload section.

To reach the required accuracy, a pathfinder program was made. Using a camera, the landing procedure can be started from a height of 100m. Just before touchdown, the glider goes into a quick stall to ensure near-vertical landing and thus minimise the necessary landing area. A crash structure around the payload ensures it stays intact.

After landing, the vaccines can be accessed using the instructions printed on the skin. When continuing to follow these instructions, the electronics can be retrieved for reuse, and the glider parts are more exposed to decrease the degradation time. To further help this, biodegradation enhancing mechanisms are implemented. Bacteria, fungi and plant seeds play a large role in this.

The last steps of the design include performing a Life Cycle Assessment to ensure a minimal environmental impact, and to identify possible critical elements of the design's sustainability.