Mechanical aspects of Mothership Plane with Sensing Drones system

MichalModzelewski[1], *GrzegorzMuchla*[2], *AleksandraPakula*[3], *BartoszZalecki*[4]
Warsaw University of Technology[1−4]

With Unmanned Aerial Vehicles (UAVs) becoming more cost-efficient and reliable, the potential for sensing broad, otherwise inaccessible areas, arises. This emerging technology has enormous possible to enable new military and civilian application. Many of them require whole unmanned aerial system (UAS) including ground station, air vehicles, associated equipment and communication between its elements [2].

The systems that combine a larger copter as the Mothership to carry multiple smaller drones equipped with sensors have been recently studied for the advantages and new brands of usage [3]. However, they are facing the problem of low battery capacity, small due to practical copter constrains which significantly limits the area of research. Taking from experience gathered during constructing UAVs for Society of Automobile Engineering (SAE) Aero Design Competition, we focused on potential benefits of using plane as a delivering platform [1].

This year mission for Advanced Class aircraft required designing Mars Colonizing system that can deliver habitats as static payload and Colonist Delivery Aircrafts (CADs) to specific target. As the growing potential for the system in the field of research have been noticed, we decided to develop parts of our project for wider application such as 3D mapping and deal with matters of similar design limitations.

This paper is aimed to present potential solutions and benefits in regard to UAS consists of high endurance Mothership Plane, Sensing Drones and Ground Control Station (GCS). It will also presents mechanical improvements that have been implemented to the original design in order to increase the scope of applications. Using the plane, as a Mothership, instead of a copter is expected to have significant impact on expanding mapping areas. It would benefit from superior range of the Mothership as it would have much higher endurance. Although the competition rules required gliders as Colonist Delivery Aircrafts, we chose to use copters to provide increased maneuverability over sensing area. The capacity of plane allows to supply greater number of Sensing Drones which could eventually enhance the accuracy of mapping process. The idea is to place the copters in the main aircraft's cargo bay that was previously created for carrying large volume payload (Figure 1). Due to space and masses limitation, we decided to design new Sensing Copters that would met our conditions rather than use commercial ones. The key assumption was to arrange drones in cargo bay in two vertical columns that determinate their overall dimensions. After analyzing the restrictions, the „X" shape frame has been settled that allowed us to eventually design the UAS for 6 drones.

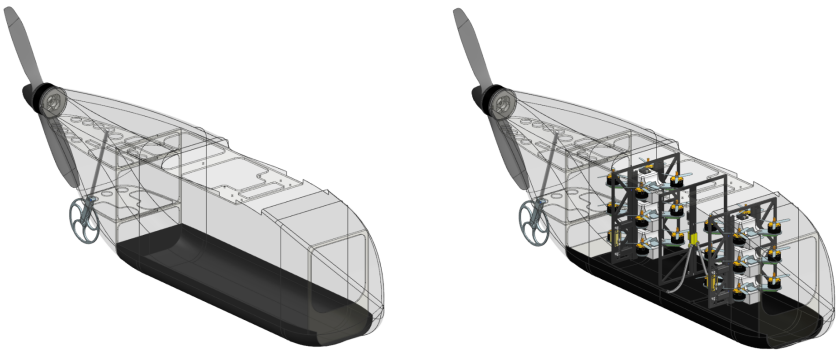

Figure 1: Left - Original fuselage. Right - Redesign fuselage

In order to introduce safe storage compartment for sensing drones, fuselage and release system had to be redesigned. The stack alignment would be guaranteed by two rails holding drones one over the other. Each drone has two sets of rollers matched to the rails, which constrain the rotation in respect to the vertical axis meanwhile allow for movement along it. Wanting to keep the system simple but effective, the release mechanism consists of a single servo motor equipped with double-sided lever and two pivots - one holding stacked drones and other securing next-to-release drones from unintended drop (Figure 2).

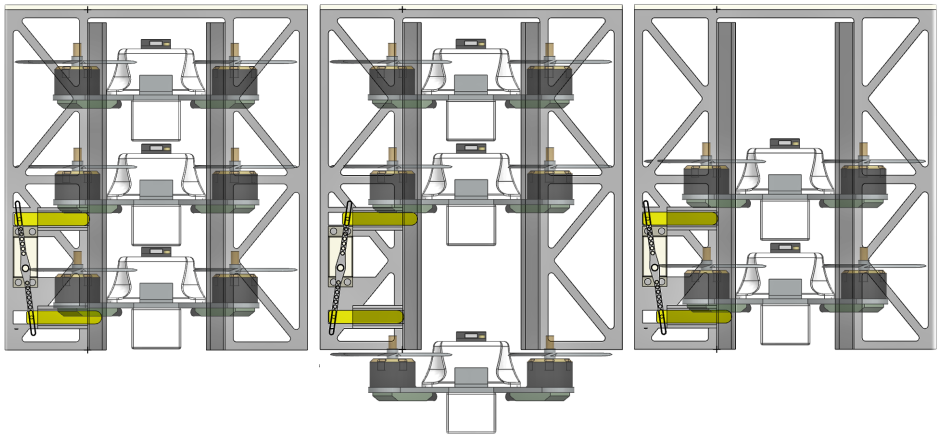

Figure 2: Drone release sequence

The main idea of the project is to use previously designed heavy lift aircraft as the Mothership plane for the Sensing Drones develop it for further applications. Described UAS may be used in hard-to-access or inaccessible areas. The sensors that can be placed on the Sensing Drones provide data necessary to create 3D models of measured parameters: temperature, air quality etc. They also may be modified to collect multiple samples from the ground to be used in agriculture.

References

[1] Piotr Pacuszka and Tomasz Sadowy-Sadowski. Design report for sae west 2019 competition. 06.

[2] Anam Tahir, Jari Böling, Mohammad-Hashem Haghbayan, Hannu Toivonen, and Juha Plosila. Swarms of unmanned aerial vehicles – a survey. 10 2019.

[3] Gervasio Varela, Pilar Caamaño, Felix Orjales, Alvaro Diaz, Fernando López Peña, and Richard Duro. Swarm intelligence based approach for real time uav team coordination in search operations. pages 365–370, 10 2011.