#30 - CARGONAUT
A crew of drones searching for golden boxes

Aircraft are responsible for transporting 2% of global cargo measured by volume per annum. However, when the value of the goods being transported is considered, this figure rises to 35% due to the reduced transportation time and higher service costs associated with air freight. Despite this, its supply chain faces significant logistical challenges to ensure efficiency in enabling a global reach. Contrary to passenger transport, air cargo transport has embraced new technologies at a slower pace, which is reflected by ground handling labor remaining largely manual. This hinders productivity and leads to inefficient cargo packing schemes that may cause potential delays, forming the so-called "air cargo load planning problem".

Mission Objective

A mission need statement was derived to guide the design process in addressing this issue systematically, which is specified as follows:

"*Provide an autonomous system to stereometrically measure the volume of cargo items in a ground handling warehouse to improve the flexibility of loading operations.*"

Analysis of feasible solutions concluded that the most suitable option would be to design a fleet of autonomous drones. As such, *Cargonaut* was born, which is a dynamic and highly flexible alternative to static and case-specific existing solutions.

System Design

Aligned with the United Nations Sustainable Development Goals, this project employs value-sensitive design principles, focusing on safety, sustainability, and flexibility. Stemming from these values, each Cargonaut drone is designed to be a 50x50x12 cm quadcopter that autonomously measures cargo boxes and navigates within warehouse environments via Simultaneous Localization and Mapping (SLAM). With an individual volume measurement accuracy of 99%, the Cargonaut fleet can achieve a throughput of 1000+ cargo items per hour. This is satisfied by using the YOLOv8 Convolutional Neural Network for object detection, which allows for a point cloud volume estimation via the onboard depth camera. The optimum fleet size depends on the warehouse layout. For example, at KLM's Schiphol Cargo Hub, 9 to 12 drones would be most effective. Logistically, fleet control and task assignment are managed by a distributed local and global planner, along with a centralized auction-based task allocation system. For the communication between drones and ground stations, the UAV Low Altitude Air to Ground (U-LAAG) model is used to tune the data handling pipeline. Flight performance is optimized by analyzing propeller dynamics with OpenFOAM, and controllability is ensured through PID controllers. A highly recyclable wood-carbon fiber thermoplastic is chosen as the material for the frame, which is modeled using CATIA and validated via Finite Element Analysis (FEA). Built on a foundation of rigorous verification, validation, and sustainability, Cargonaut aims to transform the industry of warehouse logistics. Beyond the project, post-DSE development, market integration, and scalability for diverse applications are on the horizon, ensuring Cargonaut becomes integral for efficient warehousing.