

TDP: DronKab (Mexico), Outdoors Category

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ABSTRACT

This Technical Description Paper presents the solutions proposed by the DronKab team for outdoor missions in the 2025 International Micro Air Vehicle (IMAV) Competition. The competition focuses on autonomous drones for search and rescue in post-disaster environments., where unstable structures and limited human access pose challenge.

Key contributions include a Gazebo-based simulation environment, structural adaptations of commercial MAV frames for mission-specific tasks such as mapping, person identification and load and release of water, and the design and implementation of a VTOL vehicle, focused on the surveillance challenge, seeking the best balance between the design and the flight time.

The motivation for this work lies in the growing relevance of autonomous aerial systems for outdoor applications such as search-and-rescue over wide areas, infrastructure inspection and response in disaster scenarios. Outdoor setting introduces challenges not typically present indoors: wind and gusts, changing illumination, variable terrain and vegetation, sparse or dynamic obstacles, and the need for extended endurance. Competitions like IMAV stimulate advances that address these challenges by fostering innovation in autonomy, perception, guidance and safety.

The main contributions of this work include: the design of dual-platform architecture sharing common avionics and software stack for both the UAV and the VTOL; the development of a simulation environment for validating planning and control algorithms; structural adaptations for outdoor missions and implementation and testing of algorithms for navigation with route planning. Furthermore, perception capabilities were enhanced using deep neural networks and visual markers detection.

1 INTRODUCTION

This Technical Description Paper presents the proposed solutions for the execution of the outdoor missions of the International Micro Air Vehicle (IMAV) Competition and Conference 2025. The competition is centered on the development of innovative autonomous drones that operate reliably in real-world environments. In this work we employ two complementary platforms: an UAV (quadcopter) for agile, close-range operations and a Vertical Take Off and Landing (VTOL) aircraft for long-range missions. Both platforms classified as Micro Air Vehicles, are used to detail the hardware architecture, software and mission strategies proposed for the competition.

The work presented in this paper corresponds to the current progress of the DronKab team. Some developments remain constrained by ongoing hardware integration and prototype refinement; nevertheless, the solutions described here establish the foundation for the strategies to be executed during the competition.

2 BACKGROUND

The official PX4 guide [1] in its Assembly section was used as a reference to define the main components required for a VTOL drone. This guide specifies that such aircraft need a flight controller capable of managing the transition between vertical and horizontal flight, a GPS system for autonomous navigation, an external compass for accurate orientation, as well as an airspeed sensor that contributes to stability during cruise flight. It also highlights the importance of including a manual controller or telemetry radio system for ground station communication, motors and control actuators to ensure safe maneuvers, along with potential payloads and a reliable power system to supply all subsystems.

Based on these recommendations, the components selected for this project were chosen by prioritizing those that provide a balance between performance, compatibility with PX4, and market availability, which allowed establishing an appropriate initial configuration for the VTOL drone design.

Previous studies have shown that the generation of accurate orthomaps can be achieved using low-cost unmanned aerial vehicles in combination with open-source photogrammetric software. For instance, G. Vacca concludes that the use of open-source photogrammetric software with a sufficiently large and well-curated image dataset can produce point clouds with an average deviation of only 4 cm, achieving geometric descriptions comparable to those generated by commercial solutions. These results demonstrate the feasibility and reliability of using accessible, low-cost tools for photogrammetric surveying and orthomap production [2].

Works such as those by J. Martínez have demonstrated that photogrammetric workflows based on open-source software are suitable for processing aerial photographs, even in scenarios with complex topography. The digital surface models (DSMs) and orthomosaics obtained in these studies showed good agreement with reference data, validating their applicability in cartography and geospatial analysis projects [3].

Regarding outdoor navigation, studies by T. Hutsul et al. have found that offline path planning methods do not guarantee reliability in the presence of model uncertainty, while online methods may not provide optimal solutions under time or distance constraints. Consequently, the development of hybrid algorithms that combine the advantages of both offline and online approaches has been proposed, aiming to optimize the efficiency and safety of aerial missions [4].

The development of the neural network for the person detection mission was based on three key studies that guided its design. First, we used YOLOv8, presented by Ultralytics [5], as a reference. This model represents the most recent version of the YOLO family and is characterized by its optimized backbone, an SPPF-type neck, and a decoupled head, enabling an effective balance between accuracy and inference speed. We selected this architecture as the foundation for training a model capable of real-time operation, which is essential for the mission.

Second, we considered the work of Krizhevsky, A. [6], which introduced deep convolutional neural networks for large-scale image recognition. This research provided the foundations of modern computer vision architectures and demonstrated how they can be leveraged to build efficient and accurate models such as YOLOv8.

Finally, we examined the study by Feng, T. [7], which proposed methods to prevent catastrophic forgetting in incremental learning through elastic response distillation.

This approach was highly relevant to our incremental training strategy, where new classes were gradually introduced without losing the knowledge acquired in previous stages.

3 METHODOLOGY

First, the mission scenarios were defined based on the identified needs for study and development: mapping of affected areas, surveillance of critical zones, and the identification of objects and persons through aerial imagery. Each scenario was characterized by operational parameters such as flight altitude, velocity, trajectory patterns, and endurance requirements, which were evaluated to maximize UAV performance.

The VTOL aircraft wing was manufactured with a structure both lightweight and strong. Balsa wood was used for the ribs, leading edge, trailing edge, and ailerons, all fixed onto a 1.2 m main spar. In the central portion, albizia wood was employed for its superior mechanical strength. Once the structure was completed, it was covered with Monokote, forming a smooth aerodynamic “skin.”

Computational and experimental analyses validated the aerodynamic performance of the wing and optimized control surface configuration. ANSYS Fluent was used to simulate the flow field and estimate lift under different conditions, while XFLR5 defined the optimal position of the horizontal and vertical tail surfaces. This design combined the high strength-to-weight ratio of balsa wood with the robustness of albizia in critical areas, achieving a strong and lightweight structure for the VTOL.

The VTOL development followed a structured workflow. First, components were selected using the official PX4 [1] documentation as reference, which specifies requirements such as a flight controller capable of transition management, GPS for navigation, compass for orientation, airspeed sensor for cruise stability, and communication systems. Components were chosen balancing PX4 compatibility, performance, and market availability.

Additionally, the ecalc.ch tool was employed to simulate drone performance based on motors, propellers, ESCs, battery, and weight. This allowed preliminary verification of energy consumption, estimated flight time, and thrust, refining component selection and ensuring feasibility prior to integration.

For the UAV, hardware selection was based on the Pixhawk 6C Holybro guide [8], a high-performance flight controller with an STM32H743 processor (ARM Cortex-M7 at 480 MHz), redundant IMUs, and vibration isolation.

It was accompanied by a 220 mm carbon fiber frame, a PDB with XT60 connector, four 40 A ESCs, an MTF-01 optical sensor, a GPS module, and a Raspberry Pi 4 Model B. These components were selected for both technical suitability and market availability, ensuring acquisition and maintenance feasibility. Ecalc.ch was again used to validate thrust, energy consumption, and flight time.

For the mapping mission, an automated trajectory planning method was implemented to minimize preparation time. The scheme generated coverage patterns from bounding coordinates, including reference system conversion and geometric transformations for orientation. This ensured adaptability to different regions, with preparation times of 5–10 minutes and guaranteed sufficient overlap to produce high-quality orthomosaics.

An operational safety framework was incorporated, including automatic return procedures, geofencing, and emergency landing strategies to ensure aircraft integrity during contingencies.

Two implementation strategies were considered for mission execution: generating flight plans compatible with ground control software for pre-flight verification and developing a ROS2-based architecture that distributes trajectory management across nodes for greater autonomy.

The system development also included data preparation, model training, optimization, and evaluation. A dataset of training, validation, and test images containing the target categories for person and object detection was built. The YOLOv8s model was trained on an NVIDIA RTX 3060 GPU, applying learning rate scheduling, data augmentation, early stopping, and checkpointing. Once trained, the model was exported to ONNX and converted to OpenVINO IR for deployment on the OAK-D S2 camera, enabling real-time operation.

Model performance was assessed with standard object detection metrics: Precision, Recall, mAP@50, and mAP@50–95, complemented by classification and localization losses. These results confirmed the model's accuracy and efficiency.

For the water collection mission, lightweight mechanisms were designed to collect and deposit water efficiently without adding unnecessary mass. A neural network was implemented to identify the water container, enabling autonomous collection.

Finally, a simulation environment was developed using Gazebo 7 (Garden). A world was defined in SDF, including UAV initial positioning, objects such as mannequins and

water tanks, lighting points, and physical properties like gravity and air density. This environment serves as a testbed for evaluating algorithms while avoiding unsafe physical trials.

4 DEVELOPMENT AND IMPLEMENTATION OF AUTONOMOUS DRONES

4.1 Functional Description of the Drones

4.1.1 Mechanical Design and Structure

The ZD550 is a commercial quad-copter frame designed for robustness and versatility. Its structure is primarily composed of carbon fiber, providing a high strength-to-weight ratio and effective vibration damping. The frame measures 550 mm diagonally (motor-to-motor), with a weight of ~580 g and a central plate thickness of 1.5 mm, the design remains lightweight while ensuring structural integrity. The landing gear (260 mm height) allows integration of diverse payloads, such as cameras or sensors. The arms, made of 20 mm carbon fiber tubes reinforced with metal connectors, feature a foldable design that simplifies transport without compromising rigidity. It supports payloads up to ~1.3 kg making it suitable for a wide range of autonomous drone applications.



Figure 1: ZD550 Frame

A dedicated mounting base was designed and installed to accommodate the OAK-D depth camera, ensuring a rigid and vibration-isolated position for optimal visual perception.

Furthermore, the frame integrates a custom mechanism for water collection. The mechanism consists of a lightweight container suspended by a 2 m tether. At the center of the container, a small orifice is sealed by a sphere acting as a plug under the effect of gravity during flight. The sphere is attached to an additional cord that provides extra travel

distance. When the container reaches the water surface and begins to float, the sphere is displaced downward, unsealing the orifice and allowing the container to fill with water. Once the MAV takes off, the sphere is pulled back into position by gravity, effectively resealing the orifice and preventing water leakage.

The VTOL prototype is based on an UAV quadcopter frame with dimensions of 600 mm in length and 550 mm motor-to-motor spacing along the horizontal axis. The frame is constructed from 3 mm carbon fiber plates, providing high structural rigidity with minimal weight.

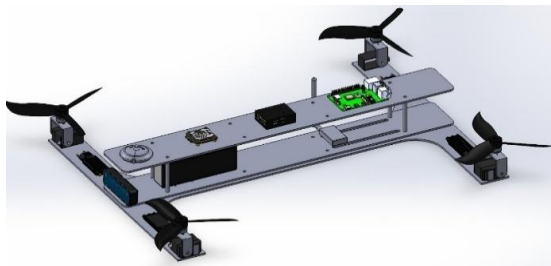


Figure 2: VTOL's frame with hardware elements

A detachable fixed wing with a 1.2 m wingspan is integrated at the center of the frame, attached between the upper and lower plates. The wing structure consists of MDF airfoils with carbon fiber spars, covered in Monokote film, offering a balance between strength, low weight, and aerodynamic performance.

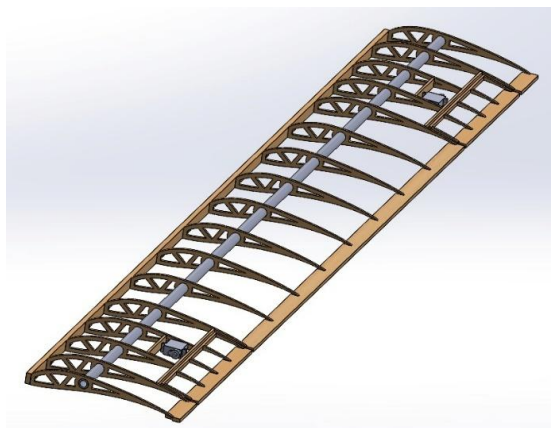


Figure 3: Wing design with albizia's airfoils

The transition between flight modes is achieved through vertical take-off (VTOL), followed by motor rotation into the horizontal position, enabling sustained wing-borne flight. The wing incorporates ailerons, while the tail section includes rudder and elevator control surfaces, ensuring maneuverability and stability during cruise flight.

A motor rotation mechanism has already been designed and implemented, allowing reliable transition from hover to forward flight. This hybrid configuration combines the versatility of multirotor operation with the efficiency of fixed-wing flight, making the system suitable for extended missions and variable operational requirements.

For the construction of the VTOL aircraft wing, each component was carefully crafted from balsa wood. These included wing ribs, leading and trailing edges, and ailerons, all of which were cut to fit and assembled into position on the main 1.2 m spar to form the overall structural assembly. The main section of the wing, to be fitted onto the drone's frame, was built from albizia wood due to its greater mechanical strength and load-carrying capacity. The pieces were assembled by accurate alignment techniques to ensure structure and maintain the required aerodynamic form.

Once the skeleton was assembled, the entire wing was treated with Monokote, forming a tensioned, smooth-finished aerodynamic skin which is extremely lightweight. This wrapping not only provides for an aerodynamic finish but also contributes to the overall stiffness of the wing. The careful combination of balsa for light areas and albizia for solid points of attachment resulted in a lightweight yet mechanically robust wing structure that was suitable for an experimental VTOL aircraft's demand.

4.1.2 Hardware Selection and Analysis

For the development of the VTOL, four SUNNYSKY X2212 motors were selected, each coupled with propellers measuring 7 inches in diameter and a 4.2-inch pitch. The propulsion system is supported by four 40A ESCs and a Pixhawk 2.4.8 flight controller, fully compatible with PX4. In addition, the aircraft is equipped with a GPS module for autonomous navigation and an LR900-F telemetry module to ensure reliable communication.

To preliminarily assess performance, the online tool eCalc was used. By inputting the drone's components and specifications, the system generated performance graphs. As shown in the results, increasing speed slightly reduces flight time, while range grows steadily, leading to an estimated endurance of approximately 12.2 minutes.

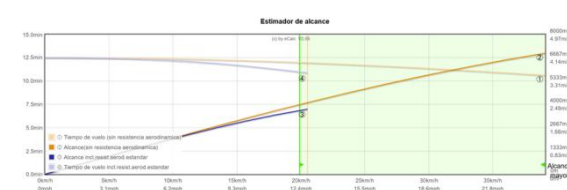


Figure 4: VTOL Range Estimation

A second UAV (quadcopter) was also developed, featuring a 220 mm X-configuration carbon fiber frame. Its core components include a Pixhawk 6C flight controller, a Power Distribution Board (PDB) with XT60 connector, four 40 A ESCs, an MTF-01 Optical Flow sensor, a GPS module, and a Raspberry Pi 4 Model B serving as an auxiliary processing unit.

4.1.3 Software Architecture

The system is composed of three main functional modules. The first module focuses on area mapping, the second on person identification based on description, and the third on detecting containers for water loading and unloading. These core modules are implemented using ROS 2 through node programming, and the overall architecture is described below.

For the mapping mission, two nodes and three primary topics are employed. One node generates the waypoints to traverse the area, while the other node controls the UAV's velocity to navigate toward each waypoint. The same architecture (Figure 5) is used to generate the UAV trajectory for the competition challenge; however, the trajectory itself differs.

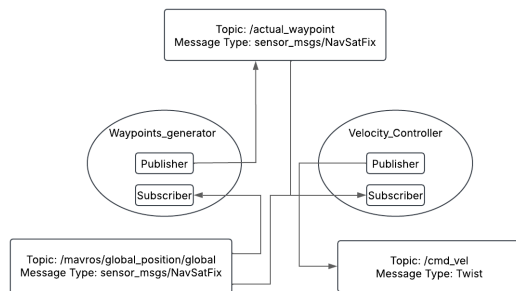


Figure 5: ROS2 nodes and topics to execute mission 1 and challenge

For the person search mission, architecture shown in Figure 6 is proposed. In this case, the OAK device executes neural network inferences and publishes detection results, which are then used by the “go-to-person” node to maneuver the UAV toward the detected individual.

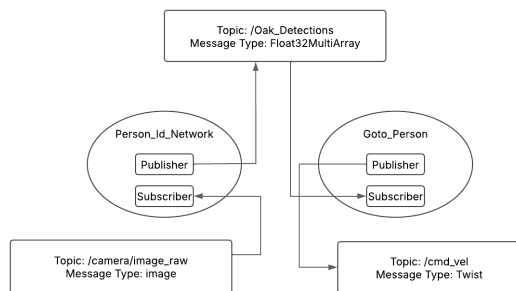


Figure 6: ROS2 nodes and topics to execute mission 2

Finally, a similar architecture is proposed for the Load-and-Release mission (Figure 7). Here, a neural network identifies containers, and the UAV is directed to these containers to pick up water and subsequently release it at the designated locations.

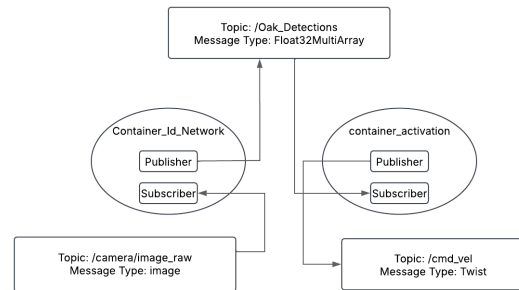


Figure 7: ROS2 nodes and topics to execute mission 4

4.2 Design Approach

In the following subsections, the development of the solutions for the different missions is defined, describing the specific requirements of each mission as well as the tools employed for their execution. Likewise, the main algorithms developed for this purpose are presented, along with the mechanisms integrated into the vehicle to successfully accomplish the missions.

4.2.1 Mapping

For the disaster area mapping mission, and in accordance with previous research on photogrammetric techniques, a lawnmower flight pattern will be employed at an altitude of 50 meters above ground level. This pattern is repeated twice with a rotation angle between 15° and 20° to increase the number of images captured over the region of interest. The operation will be conducted at an average velocity of approximately 12 to 15 m/s, balancing rapid coverage of the UAV's trajectory with the preservation of image quality required for accurate mapping.

In developing the solution for this mission, the focus was placed on automating the mapping process as much as possible, without relying on manual flight plan generation in tools such as QGroundControl or MissionPlanner. The traditional approach of defining each waypoint individually can be time-consuming; therefore, an alternative methodology is proposed to accelerate the creation of the flight plan. The objective is to enable deployment of this solution across different geographic locations with short preparation times, ideally between 5 and 10 minutes.

The proposed solution is based on obtaining the bounding coordinates (latitude/longitude, WGS84) of the target area. From these, a quadrilateral delimiting the region of interest is constructed and subsequently converted into UTM coordinates (x , y in meters) for easier manipulation and rotation. The area is then divided into sections to generate a lawnmower coverage pattern. This trajectory is also defined in reverse (starting from the waypoint farthest from the takeoff location) by applying a 2D rotation to all waypoints using a rotation matrix. Finally, the UTM coordinates are converted back into WGS84 latitude and longitude.

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \cos \theta & -\sin \theta \\ \sin \theta & \cos \theta \end{bmatrix} * \begin{bmatrix} x - c_x \\ y - c_y \end{bmatrix} + \begin{bmatrix} c_x \\ c_y \end{bmatrix} \quad (1)$$

Where:

- x' , y' represent the rotated waypoint coordinates,
- x , y are the current waypoint coordinates before rotation,
- θ is the rotation angle applied to the flight pattern, and
- c_x , c_y are the coordinates of the quadrilateral's centroid.

From this stage, two alternative approaches can be derived. The first involves automatic generation of a flight plan that can be imported into QGroundControl or MissionPlanner, where parameters such as UAV cruising speed, flight altitude, and takeoff/landing points can be refined. This provides a higher degree of control and facilitates verification of the planned route within the defined area. The second approach is based on a ROS2 implementation, where one node is responsible for generating the flight plan, and another node manages waypoint navigation dynamically by adjusting velocity and yaw angles according to the UAV's current and target positions. This second method can offer faster deployment and autonomous navigation independent of external ground control software.

During flight, the UAV is tasked with capturing images at approximately 5-second intervals, ensuring sufficient overlap between consecutive frames to optimize photogrammetric reconstruction quality. For the processing stage, open-source software such as ODM is considered for orthophoto generation. Furthermore, by transmitting images via telemetry during the mission, preliminary processing could take place concurrently with the UAV's flight, thus enabling near real-time orthomap generation.

4.2.2 Person search and Identification

For the person detection task, an object detection model based on YOLOv8s (version 8, small model) was trained, chosen for its balance between accuracy and speed to

operate in real time. The architecture includes an optimized backbone, an SPPF-type neck, and a decoupled head, which improves the separation between classification and localization [5].

The dataset consisted of 34,487 training images, 9,746 validation images, and 4,837 test images, which allowed for a reliable evaluation of the model. Training followed an incremental approach: it was first trained only with the "person" class, and then other relevant classes were gradually added—helmets, vests, pants, computers, briefcases, glasses, and umbrellas—while avoiding catastrophic forgetting.

Training was performed with CUDA on an NVIDIA RTX 3060 GPU, applying techniques such as dynamic learning rate adjustment, data augmentation, early stopping, periodic checkpointing, Elastic Weight Consolidation, and knowledge distillation [6,7]. Finally, the model was exported to ONNX and converted to OpenVINO IR for deployment on the OAK-D S2 camera, operating in real time for person and object detection.

4.2.3 Water Collection and Transportation

For the water collection and deposit mission, the UAV will be equipped with a mechanism consisting of a fixed container and a movable "plug" that allows water to enter and exit. This mission requires precise positioning of the UAV at the collection and deposit points to ensure correct operation of the mechanism.

The navigation approach builds upon the previously described waypoint-based methodology. The UAV will first navigate to the target waypoint corresponding to the water source. Upon arrival, the neural network previously implemented for object detection is reused but now configured to detect the water container. Once the container is identified, the plug mechanism is activated via a motor, allowing water to be collected efficiently.

After the collection is completed, the UAV proceeds to the deposit waypoint, where the same detection and activation procedure is applied to release the water at the designated location. The flight plan can be generated automatically for use with ground control software, or it can be implemented within a ROS2-based architecture, where one node provides the target waypoints and another dynamically adjusts velocity and yaw angles according to the UAV's current and desired positions.

During both the collection and deposit operations, sensor feedback ensures correct actuation of the plug mechanism,

preventing spillage or incomplete filling. The mission is designed to optimize efficiency by minimizing the time spent at each location, while the plug motor is controlled either via PWM outputs from the flight controller or directly from an onboard processing unit, depending on integration preferences.

This configuration enables the UAV to autonomously execute multiple water transport cycles, maximizing the amount of water delivered while maintaining safe and precise operation throughout the mission.

4.2.4 Challenge

For the surveillance challenge, a Vertical Take-Off and Landing (VTOL) unmanned aerial vehicle (UAV) was selected to optimize energy efficiency and maximize airborne operational time, which are the primary objectives of this mission. The use of this hybrid configuration combines the ability to take off and land vertically in confined areas with the efficiency of cruise flight. In the context of disaster-area surveillance, this approach is particularly advantageous, as it eliminates the need for long runways for takeoff or landing. Moreover, if a point of interest is identified, the vehicle can transition to landing at virtually any location without requiring wide operational spaces, which is crucial in scenarios where prolonged loitering over an area of interest is a priority.

With respect to flight programming, the mission plan is defined by a set of waypoints configured in either orbital or linear patrol patterns, depending on the mission requirements. These patterns can be programmed using ground control software (e.g., QGroundControl) or integrated into an autonomous system based on ROS2, where a primary node manages navigation and another ensures compliance with operational constraints. The key focus of this mission lies in the indefinite repetition of waypoints, ensuring that the flight pattern is interrupted only when battery alert thresholds are reached.

Based on the considerations, the operational strategy consists of orbiting a fixed point with a constant radius (in the case of a circular orbit) or at well-defined distances relative to reference foci (in the case of an elliptical orbit). The main objective is to maintain precise control over the deflection angle, to sustain a constant or slightly variable course angle, thereby ensuring aircraft stability and enabling the UAV to follow the trajectory for an extended and potentially indefinite duration.

A central element of this approach is the incorporation of safety measures that guarantee controlled operation under risk conditions. These include:

Programmed battery limit, which activates Return-to-Launch (RTL) when a critical charge threshold is reached. Tests must be conducted to ensure that the UAV can successfully return, thereby preventing loss of control and avoiding accidents.

Fail-safe stop mechanism, which halts the mission in case of prolonged communication loss or failure of essential sensors, prioritizing a controlled emergency landing in the current operating area to minimize risk.

Virtual geofences, which restrict operation to a predefined area, prevent unauthorized exit from the designated airspace, and trigger actions such as RTL or controlled emergency landing within the geofenced region.

In this way, the design of the surveillance mission not only addresses the energy performance and flight efficiency of the VTOL platform but also establishes a safety-oriented architecture that ensures the integrity of both the aircraft and its operational environment.

5 RESULTS

For the airfoil selection, considerations included aerodynamic efficiency at low speeds, ease of manufacturing, and favorable handling characteristics. Several candidate airfoils were analyzed using XFLR5, and the results indicated that the Selig S1223 airfoil provided superior aerodynamic performance, particularly in terms of lift generation at low Reynolds numbers. Based on these findings, the S1223 airfoil was selected for the wing.

A summary of the main parameters of the wing is shown in table 1,

Parameter	Description	Value
m	Mass	$2kg$
b	Wingspan	$1.2m$
ρ	Air density	$1.225 \frac{Kg}{m^3}$
C	Mean chord	$0.2m$
C_L	Lift coefficient	1.16
C_D	Drag coefficient	0.89

Table 1 Aerodynamic coefficients and characteristics

Regarding the tail design, the horizontal and vertical stabilizers were positioned 0.7 m from the wing reference point to ensure adequate stability and authority control. The elevator was designed with an area of 0.03 m² and the rudder with an area of 0.01 m². For both surfaces, a NACA 0012 airfoil was selected, as it offers a symmetric geometry suitable for control effectiveness without introducing additional lift when set at zero deflection.

The most relevant metrics of the model were: Precision: 0.90647, Recall: 0.84277, mAP@50: 0.91508, mAP@50-95: 0.75562, Box Loss (Train/Val): 0.71143 / 0.79841, Classification Loss (Train/Val): 0.48971 / 0.49450. The precision, recall, and mAP values indicate that the model correctly detects most of the objects present, with few incorrect detections. Overall, the results are consistent and suitable for real-time use with the OAK-D S2.

Figure 8 shows an example of a test batch with the trained model to detect people and objects.

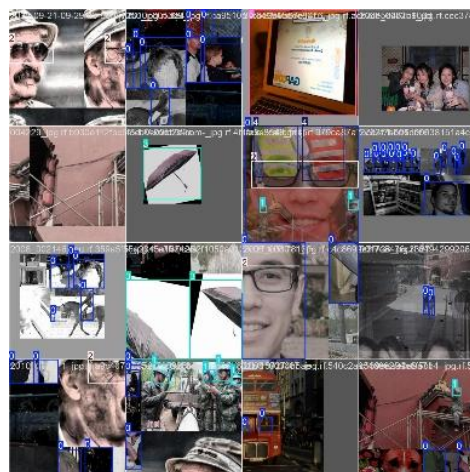


Figure 8: Detection test

Figure 9 shows the training results graphics, they specify the loss and metrics evolutions, such as precision, recall, classes and boxes losses.

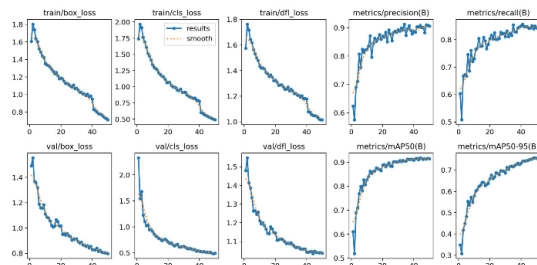


Figure 9: Training results graphics

The flight plan generator developed for this project allowed for automated creation of coverage trajectories over the target area. Using the bounding coordinates of the

region of interest, the tool generated a lawnmower pattern that ensured consistent image overlap along both the forward and return passes.

During initial testing, it was observed that image overlap and orthomosaic quality were highly sensitive to flight altitude. Adjustments to the altitude on the return pass, relative to the outbound trajectory, significantly improved image alignment and reduced gaps in the dataset. By optimizing the altitude difference between the outbound and inbound flights, the resulting orthomaps exhibited more uniform coverage and higher reconstruction fidelity.

In addition, the tool permitted rapid adaptation of flight plans for different areas, allowing operators to define new bounding coordinates and generate an updated trajectory in just a few minutes. This feature minimizes pre-flight preparation time and ensures that the UAV consistently captures images with sufficient overlap for high-quality photogrammetric processing.

Figure 10 shows a screenshot of the flight plan generator interface, illustrating the automatically generated waypoints, trajectory orientation, and planned altitude profile for the mapping mission.

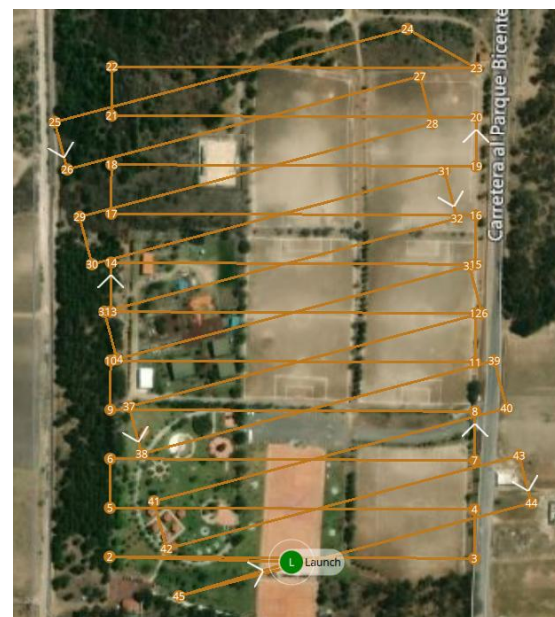


Figure 10: Flight plan generated by the algorithm with 5 sections

Finally, for algorithm validation and testing, a Gazebo Simulation Environment was developed, the following figures (11-12) show the mannequins for mission 2.



Figure 11: Find a person mannequins' zone 1



Figure 11: Find a person mannequins' zone 2

6 CONCLUSIONS

This paper reports on substantial progress toward outdoor autonomy for the IMAV 2025 missions using dual-platform strategy; an agile quadcopter for close range tasks and a VTOL airframe for long-range coverage. A unified avionics/software stack was validated through simulation and controlled tests, demonstrating end-to-end capability in perception, mapping, trajectory planning and autonomous navigation. Aerodynamics studies in XFLR5 supported the selection of the Selig S1223 wing.

Perception results show that the trained detector is suitable for real-time deployment with the OAK-D 52, reliably identifying people and objects for search-and-rescue missions. The flight plan generator automatically produced lawn-mower trajectories with consistent overlap. A Gazebo environment enabled rapid iteration and risk-reduced validation of algorithms accelerating integration across both platforms.

Overall, the results confirm that the proposed architecture provides a robust foundation for autonomous outdoor missions; the quadcopter offers precise, proximal interaction and platform landings, while the VTOL delivers range endurance and area coverage. This foundation supports complete systems integration and

expanded field validation ahead of IMAV 2025 deployment.

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