AEROTHON 2025

UNCREWED AIRCRAFT SYSTEM (UAS) DESIGN, BUILD AND FLY CONTEST

PHASE 1: DESIGN REPORT

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Introduction

1.1 Overview

In the face of natural and man-made disasters, rapid response and situational awareness are critical. Drones have emerged as powerful tools in disaster management, offering real-time aerial insights, access to hard-to-reach areas, and faster deployment compared to traditional methods. Whether locating survivors, assessing damage, or delivering essential supplies, drone technology enhances the efficiency and safety of relief operations. As disasters grow more complex and unpredictable, integrating drones into emergency response systems is no longer a luxury—it's a necessity.

Through Aerothon, Team UDSAV (*Uncrewed Disaster Surveillance Aerial Vehicle*) is not just competing—we are contributing to the evolution of drone-assisted disaster response, pushing the boundaries of what UAVs can achieve in life-saving missions.

1.2 Problem Statement and Mission Requirements

This year's AEROTHON is themed on ***Surveillance and Disaster Management.*** The problem statement is to build an ***Uncrewed Aircraft System (UAS)*** to be able to perform the mission requirements as per the rulebook. The mission requirements at a glance are as follows:

Mission - 1: *Advanced Obstacle Navigation & Fragile Payload Delivery with Precision Placement – Manual Operation*

Mission - 2: *Autonomous Object Classification, Disaster Situation Identification & Payload Drop – Autonomous Operation*

1.3 Scope of Report

The scope of this report is to provide a comprehensive understanding of the design rationale we have used while building this project. We have tried to provide the relevant calculations, figures, and analysis models to justify the materials/design/framework we've chosen to work with for our structural and system architectures.

Apart from that, this report is intended to also serve as an accessible guide catering to neophytes in UAV/UAS systems. We have tried our best to aim at providing clear context and insight that sort of demystifies drone development.

1.4 System Requirements & Design Objectives

1.4.1 Mission Profile

1. **Mission 1:** *Advanced Obstacle Navigation & Fragile Payload Delivery with Precision Placement*
   This is a ***Manual Operation.*** In this mission, the drone must transport a fragile payload through a challenging course filled with static obstacles such as walls, barriers, and narrow passages. The primary objective is to navigate these obstacles with high precision while ensuring the payload remains undamaged.

   Upon reaching the target zone, the drone must land carefully and place the fragile payload on the ground without causing any damage. After the successful placement, the drone must then return to the takeoff point or designated home base, ensuring safe and efficient navigation back through the course. The mission is complete once the payload is placed securely, and the drone successfully returns to the home base.

2. **Mission 2:** *Autonomous Object Classification, Disaster Situation Identification & Payload Drop*
   This is an ***Autonomous Operation.*** In this mission, the drone will autonomously scan, classify, and assess objects within a predefined area using onboard sensors and algorithms. The objects will vary in shape, size, color, and structure, and may be partially obscured, presenting challenges for detection and classification. Once the objects are classified, the drone will identify potential disaster scenarios, such as flooding, fire, or damaged infrastructure, within the same area.

1.4.2 Key Performance Indicators & Constraints

According to the above defined mission profiles, we have a few KPIs (*Key Performance Index*) to keep in mind.

1. Flight Endurance and Range
2. Payload Handling
3. Autonomous Capabilites
4. System Reliability
5. Design and Innovation

The design and development of the UAV is subjected to several constraints as per the guidelines mentioned in the rulebook AEROTHON 2025. These include dimensional constraints, payload restrictions and strict autonomy requirements. The drone must perform all missions bound by these constraints and we have taken great time and care to articulate them down to ensure nothing is amiss.

1. **Dimensional Constraints**
   - Maximum Wingspan: **1.5 metres** - the UAV must fit inside a ***1.5m x 1.5m x 1.5m bounding box*** in assembled condition.
   - Maximum Takeoff Weight: **3.5kg** including battery and payload.
2. **Payload Constraints**
   - Payload: One fragile payload cube of ***10cm x 10cm x 10cm*** weighing ***150 200g***.
   - Payload must be released within a ***3m x 3m*** target zone.
3. **Flight Environment Constraints**
   - Missions are conducted in ***open outdoor airspace***.
   - Expect wind speeds upto ***5m/s***
4. **Autonomy and Mission Constraints**
   - **Mission 1:** Manual flight only (no GPS or autopilot usage).
   - **Mission 2:** Fully autonomous flight (no pilot intervention or RC use).

- All autonomous missions must avoid obstacles and make decisions based on ***onboard computation.***

5. **Power and Communication Constraints**
    - Must operate on battery only
    - No cellular or internet-based comms allowed
    - Only 2.4 GHz or 5.8 GHz RF modules permitted
6. **Safety and Compliance**
    - Must have a failsafe mode (e.g., return-to-home or emergency land)
    - Must pass technical inspection before flying
    - Compliance with DGCA drone guidelines (if relevant in test zones)
7. **Operational Constraints**
    - The team must complete the flight within a ***15-minute slot.***
    - Payload must be dropped in an area of ***3m x 3m.***

Conceptual Design Approach

2.1 Design Methodology

2.2 Product Benchmark & Trade-off Analysis

Detailed Design Breakdown

3.1 Preliminary Weight Estimation

We've begun by

3.2 Thrust Requirement & Propulsion System Selection

3.2.1 Motor, ESC & Propellor

Motor: DYS D2836-7 1120KV Brushless Motor

The DYS D2836-7 1120KV Brushless Motor is our go-to motor for this project because of the following leverages it offers:

- ***KV Rating: 1120KV*** - KV generally means RPM per volt. In layman terms, in one volt, how many rotations does it make per minute = KV. In this case, 1120KV is mid-range, which means good thrust at moderate RPMs, and it works decently with larger propellors (*9" - 11"*) which improves lift and efficiency, *especially* at low speeds. This is perfect for surveillance drones that require loitering and stability. A lower KV would force us to use bulky propellors, and a higher KV would drain the battery faster. 1120KV is a sweet spot between the two.
- ***Power & Efficiency:*** - With a 3S or 4S LiPo, this motor produces 800g to 1100g of thrust, depending on the propeller used. It can pull 20–25A max, so it's efficient for mid-weight UAVs (*in our case, it is around **1.5 2kg AUW** (All Up Weight.)*), so it's ideal for our choice.

Figure 3.1: DYS D2836-7 1120kV BLDC

Table 3.1: Motor Characteristics (DYS D2836-7 1120kV BLDC)

Parameter	**Value**
Motor KV (RPM/V)	1120
Motor Type	Brushless Motor
Compatible LiPO Batteries	2S to 4S
Weight (g)	70
Shaft Diameter (mm)	Φ4.0×49mm
Max. Power (W)	336
Maximum Thrust (gm)	1130
Compatible Prop (inch)	11×7 / 7×3
Required ESC (A)	40
Shipping Weight	0.089 kg
Shipping Dimensions	10 × 6 × 5 cm

ESC: ReadytoSky 40A 2-4S ESC

The ReadytoSky 40A 2-4S ESC is a good choice for surveillance drones, and our use case for the following reasons:

- ***Sufficient Current Handling*** - Our DYS D2836 motor draws about 20 – 25A at max. The ESC we're using can supply upto 40A, which is comfortably safe for our use case.
- ***2-4s LiPo Compatiility*** - This works best with common drone battery setups like 3S – 4S. Another reason for this choice is that it matches our motor's voltage tolerance (D2836 runs fine upto 4S).
- ***BLHeli Firmware*** - Comes pre-flashed with BLHeli, and this offers a smooth throttle response; brake support (for fixed wing or quad hybrid designs).
- ***Thermal Performance and Build*** - The ESC is rating to suport 40A, which means it can take bursty loads without frying good for maneuvers, sudden wind corrections, or takeoffs.

Figure 3.2: ReadytoSky 40A 2-4S ESC

Propellor:

3.2.2 Powertrain Efficiency Calculations

3.3 Aircraft Sizing

Rotor Arm

Hub

Wheelbase

Propellor Clearance

Landing Gear

3.4 Aircraft Performance

3.4.1 Power Estimation

3.4.2 Battery Selection and Endurance

Battery: Orange Pro-Range 11.1V 5200mAh (3S)

The Orange Pro-Range 11.1V 5200mAh battery is the best for our use case for the following reasons:

The 3S variant provides 11.1V, and has a **discharge-rate** of 40C. According to the official rated specifications, the maximum continuous discharge current is **208.0A** (*40C*). It also has a max.

burst discharge of **416.0A** (*80C*). Let us assume that each motor draws 24A current at full-throttle, total current draw would be $\boldsymbol{24 \times 4 = 96A}$ then

$$\text{Theoretical Flight Time (hrs)} = \frac{\text{Capacity (Ah)}}{\text{Current Draw (A)}} = \frac{5.2}{96} \approx 0.0542hrs = 3.25mins$$

But in real world applications, we dont use 100% of the battery, we use about 60%, so that would make the flight time around 5.2mins.

Table 3.2: Battery and Flight Characteristics Summary (Orange 11.1V 5200mAh 3S)

Parameter	**Value**
Voltage	11.1V (3S)
Capacity	5.2Ah
C-Rating (Continuous)	35C
Theoretical Max Discharge Current	$35 \times 5.2 = \mathbf{182A}$
Stated Max Discharge Current (datasheet)	156A
System Current Draw (4 motors @ 24A)	$4 \times 24 = \mathbf{96A}$
Flight Time @ Full Throttle (96A)	$\frac{5.2}{96} = \mathbf{3.25}$ minutes
Flight Time @ Moderate Throttle (60A)	$\frac{5.2}{60} = \mathbf{5.2}$ minutes
Energy Capacity	$11.1 \times 5.2 = \mathbf{57.72\ Wh}$

3.5 Material Selection

3.5.1 Structural Frame, Airframe Components

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Innovations and Future Scope

Bill of Materials