Design of UAV's and MAV's - AS5213

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Group - 13

Design Report

Problem Statement

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1 Mission objective

1.1 Problem Statement

Monitoring and surveillance (MS) encompass the observation and analysis of extensive areas of interest. This broad term applies to various contexts, such as protected regions like wildlife sanctuaries and coral reefs, as well as areas prone to natural disasters, where real-time data collection enhances predictive capabilities for anticipating and responding to such occurrences.

1.2 Why this problem needs attention

Monitoring wildlife sanctuaries is crucial for several reasons, as it helps in the conservation and protection of biodiversity. Here are some key reasons why monitoring wildlife sanctuaries is important:

- **Biodiversity Conservation:** Wildlife sanctuaries are designated areas to protect and conserve the natural habitats of various species. Regular monitoring allows authorities to assess the health and diversity of the ecosystems within these sanctuaries. It helps in identifying any threats or changes in biodiversity, allowing for timely interventions to protect endangered species.
- **Illegal Activities:** Wildlife sanctuaries are often targeted by poachers, illegal loggers, and other criminal activities. Monitoring helps in detecting and preventing such illegal activities, safeguarding the flora and fauna within the sanctuary.
- **Habitat Health:** Monitoring helps in evaluating the overall health of the habitat, including factors such as water quality, vegetation cover, and soil conditions. This information is essential for managing and maintaining a balanced ecosystem.
- **Population Dynamics:** Tracking the population dynamics of various species within a sanctuary is crucial for understanding their behavior, reproductive patterns, and overall health. It aids in implementing effective conservation strategies, such as habitat restoration or reintroduction programs.
- **Climate Change Impact:** Wildlife sanctuaries are not immune to the impacts of climate change. Monitoring helps scientists and conservationists understand how climate change affects different species and ecosystems. This knowledge is vital for adapting conservation strategies to mitigate the effects of climate change.
- **Research and Education:** Monitoring provides valuable data for scientific research, helping researchers better understand ecological processes, species interactions, and the overall functioning of ecosystems. This information can also be used for educational purposes, raising awareness about

the importance of wildlife conservation.

- **Adaptive Management:** Regular monitoring allows for adaptive management, where conservation strategies can be adjusted based on the changing conditions within the sanctuary. This flexibility is essential for addressing emerging threats and challenges.
- **Policy and Planning:** Monitoring data contributes to evidence-based decision-making in the development of policies and management plans for wildlife sanctuaries. It helps authorities allocate resources effectively and implement measures that are grounded in scientific understanding.

In summary, monitoring wildlife sanctuaries is essential for maintaining the health and balance of ecosystems, protecting endangered species, and ensuring the long-term sustainability of biodiversity. It plays a vital role in conservation efforts and supports the broader goals of preserving natural habitats and promoting ecological integrity.

1.3 Mission Statement

To tackle this issue, we propose a lightweight monitoring/surveillance UAV with rapid turnaround times. The vehicle would fly around and over a designated area of interest and acquire important data - primarily in the form of pictures and terrain information - over long spans of time.

1.4 Requirements

- One of the most important aspects that will drive the design of such an aircraft will be endurance. We wish to fly for uninterrupted periods of time.
- Rapid turnaround time aiding in quick re-deployment.
- House good quality instruments for image capture and terrain estimation.
- Lightweight.

The following section details about a prospective mission profile for our aircraft.

2 Mission profile

2.1 Mission phases

- **Take-off** - Accelerating on the runway until liftoff and subsequently retracting the landing gear.
- **Climb** - Rise to the desired altitude required for the mission.
- **Cruise** - Level flight till the area of interest.
- **Loiter** - It is the most important aspect of our mission and most of the UAV's flight time is spent in loiter mode.
- **Descent** - Dropping altitude to ground level.

- **Landing** - Deployment of landing gear and deceleration to a halt.

2.2 Mission info-graphics

Given figures try to depict trajectory of mission of a UAV in a scenario that is according to the mission profile.

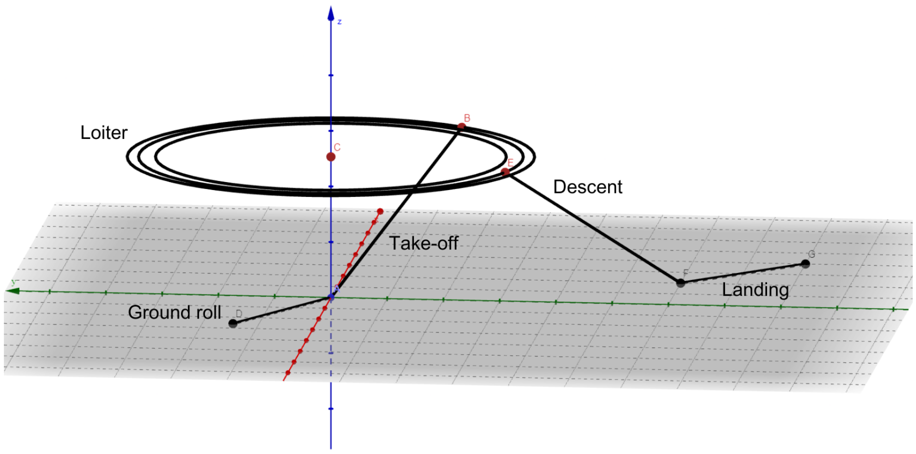

Figure 1 – Geometric view

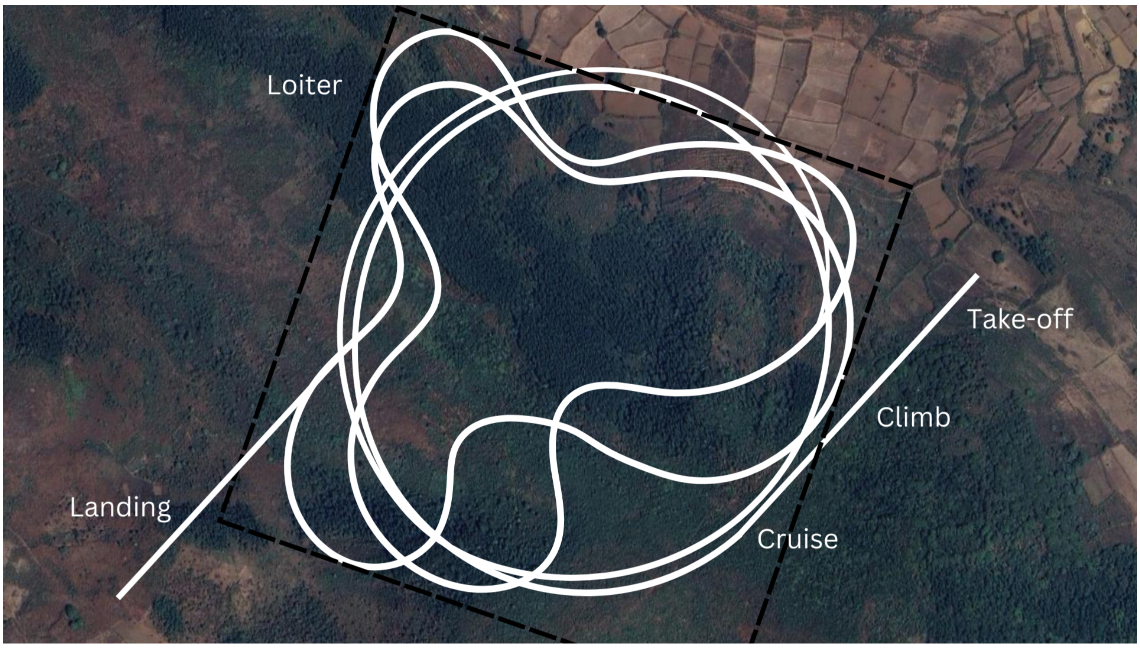

Figure 2 – Terrain / Geographic view

3 Estimation of parameters:

A general estimate of desired flight parameters (Range, approximate cruise speed, endurance was estimated as follows:
Average area of a forest in India is 1 million hectares, which is 10^4 km^2. Let us approximate a forest to be of an approximate square geometry of 100 km x 100 km.

Considering a solution for surveillance of forests using a UAV as per our mission statement, we plan a model where 15 UAV's in the skies for a duration can suffice for the surveillance of the entire forest.

Now considering forest to be an approximate square geometry of 100 km x 100 km, field of vision of each UAV spanning about 3 km of ground, the forest can be classified to 33 strips each of 100 km length and 3.3 km width. The 15 UAV's in the model would be monitoring about 2 strips each.

Consider the following parameters:
- Endurance of each UAV = e hr's
- Speed of each UAV corresponding to maximum time of flight = s km/h

We can thereby develop a relation:

$$e * s = 200 \tag{1}$$

Now, choosing/fixing the preferred range for one of the above parameters wihh thereby give out the range of the other. We choose the flight speed to be in the range 10 - 25 m/s (36 - 90 km/h) which implies the endurance of each UAV should be around 2.2 - 5 hours.

Thereby we proceed ahead to research on UAV's with an endurance of about 2 - 5 hours and flight speeds of about 10-25 m/s.

4 UAV Study

4.1 Data of similar UAV's

Data of UAV's which are used actively in environments with the same natural prospects as our problem statement have been collected and analysed.

4.2 Parameters for selection, Categorization and classification of UAV's

A substantially produced UAV was categorized similar to the UAV we aim to design for out problem statement based on following paramenets:

- **Weight** : UAV's with an ideal weight of 5-20 kg.
- **Endurance** : An endurance of at least 1hr is expected considering it's used for surveillance purposes. Following our estimations, UAV's with endurance in range 2-5 hours are considered.
- **Operational height / Ceiling** : UAV's with an operational height of 150 m - 1 km were considered with a maximum ceiling of around 2 km - 3 km. These parameters are considered keeping in view that the UAV would be required to perform several tasks related to imaging and detection.
- **Speed** : UAV's with operational speeds in the range 10-25 m/s, to ensure the quality and resolution of the data collected through camera and sensor modules is not compromised.

5 UAV Mission Phases

Estimated durations for each of the phases of the mission are given as follows, this is only a preliminary flight estimate based on the mission profile

UAV Mission Phases and Duration's		
S.no	Mission Phase	Duration in minutes
1	Ground-roll	30 seconds
2	Climb and cruise	3 - 5 minutes
3	Loiter	2 - 4 hours
4	Descent	3 - 5 minutes
5	Landing	30 seconds

Table 1 – UAV Mission Phases and Durations

5.1 Comparison chart

The following table has data of UAV's with similar mission profiles and with similar parameters like operational ceilings, range and endurance. All the UAV's listed are fixed wing and are manufactured on a substantial scale and are widely available for commercial purchase.

Similar mission profile UAV's data									
S.no	UAV Designation	Empty weight	Powerplant weight	Payload weight	MTOW in kg	Endurance in hr	Range in km	Speed in m/s	Ceiling in km
1	Supercam S250	4.4	-	5.1	9.5	3	180	17 - 33	0.15 - 5
2	Albatross	5.6		4.4	10	1.5 - 4	250	18.9	-
3	Bramor PPX	3.7	-	0.6-1	4.7	3.5	150	16	0.5
4	Condor 300	12	-	6	18	4	360	25	3
5	Penguin BE electric	14.9	1	6.6	21.5	1.86	145	22	6
6	RQ-20 Puma	1.95	-	-	5.9	2	15	10 - 23	0.15 - 3
7	Silent Falcon sUAS	11.5	1	3	14.5	5 -12	50	10-31	0.07 - 6
8	Chacal 2	75	-	10	85	3	700	77	1.5
9	CREXB	1.5	-	-	2.2	1.25	10	10	3.1
10	MicroFalcon	6	-	-	10	2-3	-	-	0.15 - 0.6

Table 2 – UAV Technical Specifications

In the above tabe consisting of data of different UAV's. All the data presented above has been collected from valid and reliable sources and the hyperlinks redirecting to the sources have been attached for all the UAV's.

All the weights mentioned are in kilograms. Exact data of power-plant weight of several UAV's wasn't available in the catalogues so approximations have been considered in a few cases based on the data of MTOW, Payload capacity and Empty weight.

5.2 Further information on data of similar UAV's

5.2.1 Ceiling

In certain UAV's from the above mentioned list, exact details of ceiling wasn't mentioned in catalogue, hence the data provided is the data of the suggested operational ceiling provided by the company.

5.2.2 Range

In certain UAV's their range is restricted based on the farthest for which a smooth data transmission is possible which is majorly dependent on communication modules (LoRa etc) and antennae used (Omni, Yagi, uni etc) and not on power-plant. Considering communication an important prospect, we proceeded with the available data of range.

Range of certain UAV's wasn't specified, in those scenarios, we estimated the maximum possible range based on cruise speeds, endurance, MTOW.

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