Development and Automation of Fixed Wing UAV for Reconnaissance Mission with FPV Capability

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Abstract: *Today's military missions require pre-emptive knowledge of hostile activities in and around the conflict zone. Using a multi rotor UAV for Reconnaissance has many disadvantages, such as cost, range, reduced maneuverability and much more. The main objective is to make the UAV completely autonomous, with the transmitter on standby. By entering the flight plan into the Ground Control System, the UAV will complete the assigned mission autonomously and will be guided by an operational flight plan wherein active waypoints are plotted in the GCS. The GCS can be linked to the Telemetry and the Global Positioning System to have a complete knowledge of the UAV location.*

Key Words: *Fixed wing/ UAV, Autonomous operation, Reconnaissance, Integrated Ground Control System*

1. INTRODUCTION

An unmanned aerial vehicle (UAV) is an aircraft without any human pilot, crew or passengers on board. UAVs are a part of unmanned aircraft systems (UAS), which also comprise a ground-based controller and a communications system with the UAV. UAVs' flight can be remotely controlled by a human operator, as remotely-piloted aircraft (RPA), or with various degrees of autonomy, such as autopilot assistance, up to fully autonomous aircraft that have no provision for human intervention. Today’s military mission require pre-emptive knowledge of hostile activities in and around the conflict zone. Several researches are being carried out by the defense research and development organization (DRDO) to develop an UAV for reconnaissance mission near a hostile environment. Gaining pre-emptive intelligence is the most hectic and confidential task especially in the defense sector. For the past 3 decades, the troop actions were compromised due to the limitations in UAV flying and control which led to inadequate gain of intelligence. In the current scenario, there are some UAVs which can perform reconnaissance missions but there are certain limitations due to which the UAVs were unable to satisfy the mission requirements. The main objective behind our paper is to design, develop and fully automate a fixed wing UAV for reconnaissance mission and increase the range and the endurance to deploy and implement in real life environment. The specialization of this UAV is to gain hostile intelligence beforehand without the needs of human intervention.

1.1 Problem identification

Military organizations depend heavily on pre-emptive measures to know enemy's actions by using RPA. Back in 2017, multiple reconnaissance UAVs were shot down during the war of ISIS in Iraq and Syria and did not complete their expected reconnaissance missions because of their range and endurance. The goal is to overcome this challenge and increase the range and endurance in an efficient manner and implementing automation by using a fixed wing UAV.

1.2 Objective

The intended objective is to develop and fully automate a fixed wing UAV for Reconnaissance mission and increase Range and Endurance to deploy and implement in real life environment and to establish communication between sub-systems.

2. METHODOLOGY

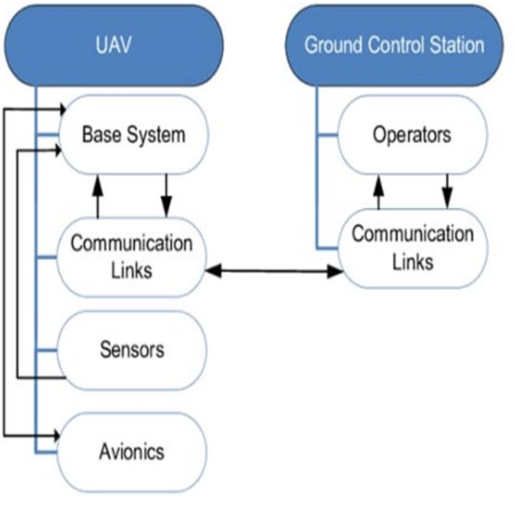

Fig. 1 – Mission Sequence

2.1 Layout and Design

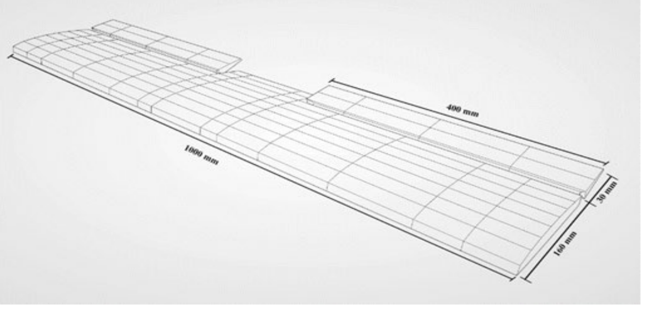

Fig. 2 – Wing

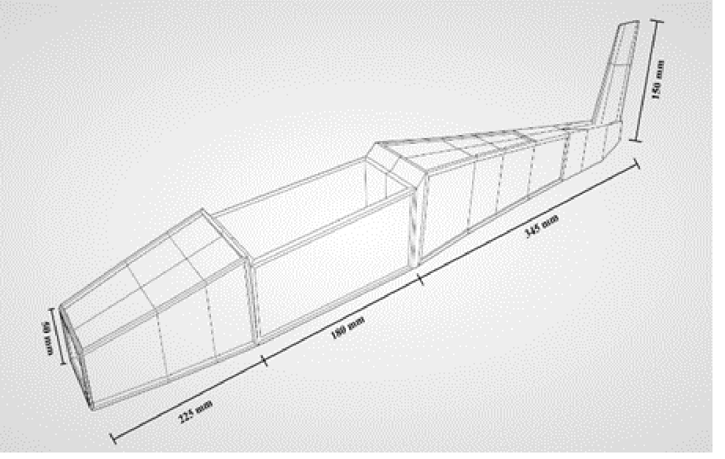

Fig. 3 – Fuselage

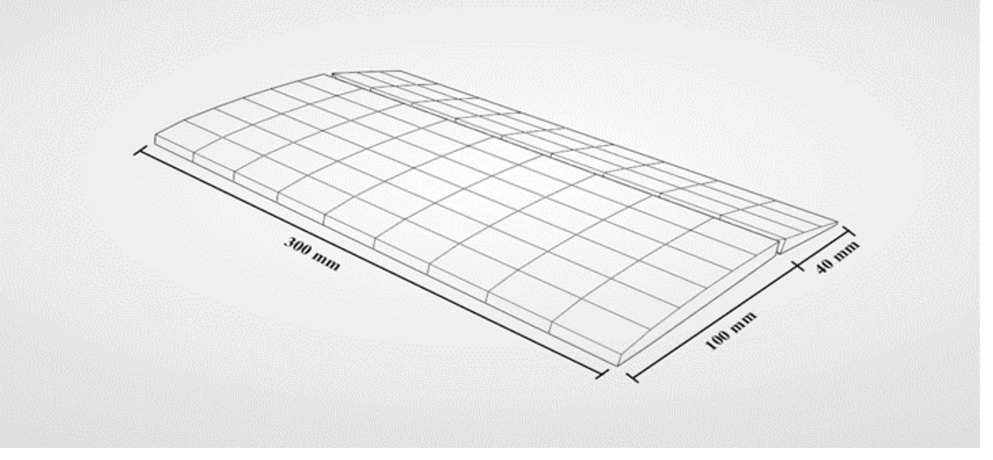

Fig. 4 – Horizontal stabilizer

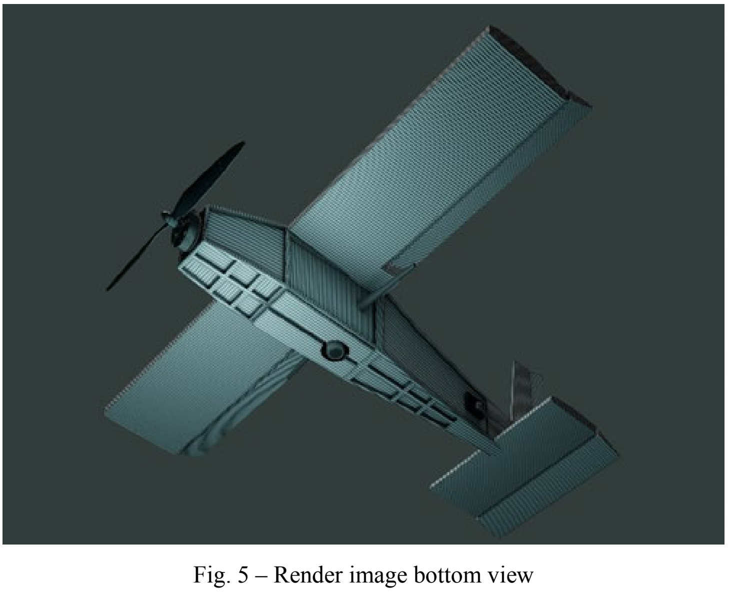

Fig. 5 – Render image bottom view

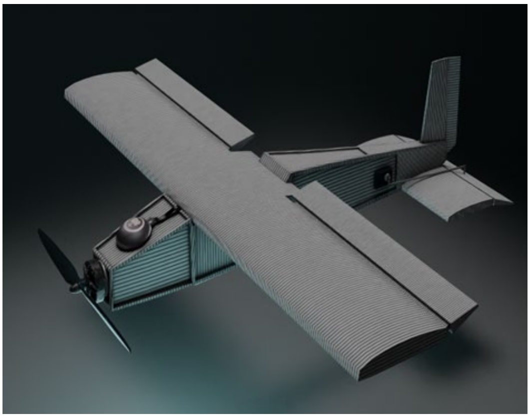

Fig. 6 – Render image isometric view

2.2 Calculation

Table 1 – Performance characteristics

Aircraft class	Hard 3D
Thrust to weight ratio	1.5: 1
Stall speed (1g, clean)	4.16 m/s
Best Range speed	13 m/s
Maximum speed	20.83 m/s
Pitch speed	25.83 m/s
Max. Propeller power	272 W
Electric power	342 W
Max. Vertical speed	0.6 m/s
Max. Angle of climb	38 degrees
Max. Rate of climb	7.3 m/s
Time to height	28 s
Endurance	19.1 minutes
Range	10 km
Optimum motor efficiency	84.1 %
Revolutions	11106 rpm
Efficiency at maximum power	82 from 84.2 %
Revolutions	10315 rpm
Optimum battery temperature	23˚C

2.3 Weight and balance

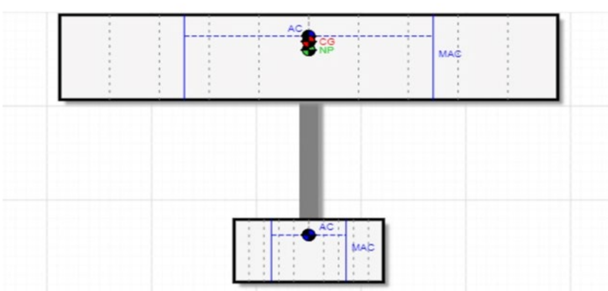

Fig. 7 – Weight and balance

Table 2 – UAV Specifications

Aircraft CG range	27.40 – 32.40 % MAC
Wing AC	25 % MAC
Wing span	1 m
Wing area	0.19 m^2
Wing Aspect Ratio	5.26
Aircraft Neutral Point	42.40 % MAC
Tail AC	25 % MAC
Tail span	0.3 m
Tail area	0.04 m^2
Tail Aspect Ratio	2.25
Stabilizer volume	0.55 m^3

2.4 Performance graph

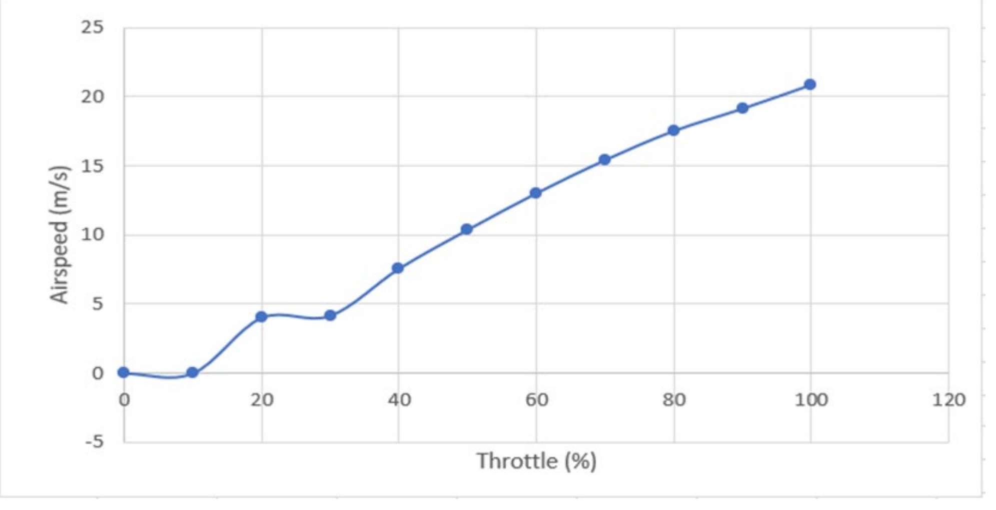

Fig. 8 – Comparison between Airspeed and Throttle

3. SIMULATION OF UAV AND FLIGHT TEST

A scaled UAV model has been developed that demonstrated greater range and endurance compared to existing rotary-wing UAVs. Communication was established between GPS, telemetry and mission planner. The mission was successfully simulated and tested using Mission Planner. The transmitter was assigned 3 different flight modes to enhance safety. The autonomous mission was successfully accomplished and the UAV was safely retrieved.

3.1 Return to Launch Mode

The Return to Launch mode is set during an unfortunate event of an emergency. The following are the events when RTL mode can be set:

- Loss of Communication
- Loss of GPS signal
- Battery issues
- Other systems malfunction

All the systems and their gauges can be monitored in the Mission Planner.

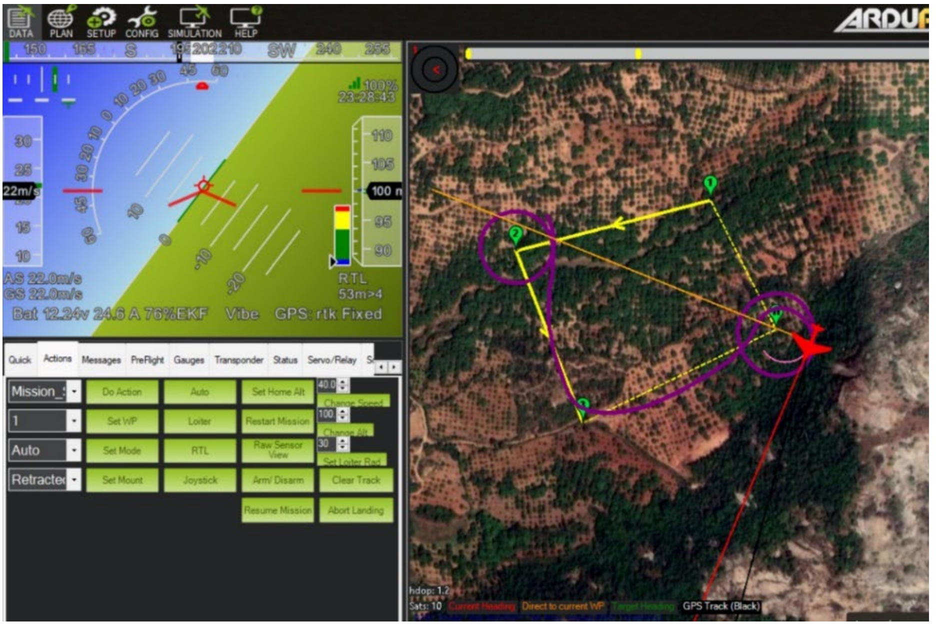

Fig. 9 – Flight mode - Return to Launch

3.2 Auto Mode

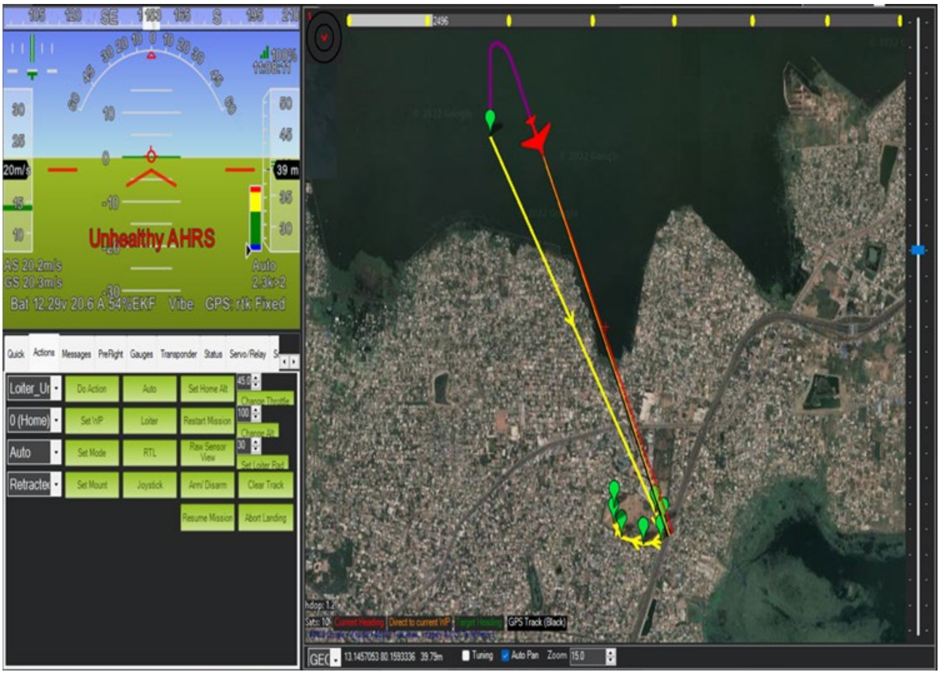

Fig. 10 – Flight mode – Auto

The flight plan is set when manually launching the UAV, and AUTO mode is enabled to perform an autonomous mission. This mode has speed protection that will not allow the UAV to stall, but will automatically enter RTL and landing modes in the event of an engine failure and change direction to the home location. This the safest and most efficient mode of all available flight modes.

3.3 Loiter Mode

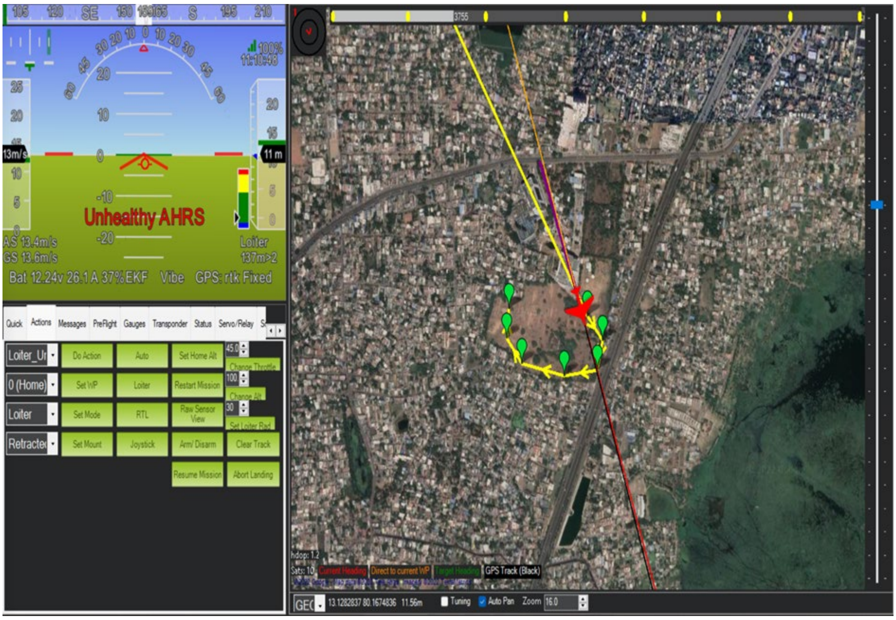

Fig. 11 – Flight mode – Loiter

Loiter mode is used to make the UAV fly about around a fixed point. This mode is mostly used by the armed forces for reconnaissance around a hostile territory. The mode must be changed in the Mission Planner in the Actions module. The loiter radius, throttle and altitude can be changed according to the mission requirements. If a flight plan is incomplete, the UAV will change mode to Loiter at the known final destination point.

3.4 Fly By Wire Mode

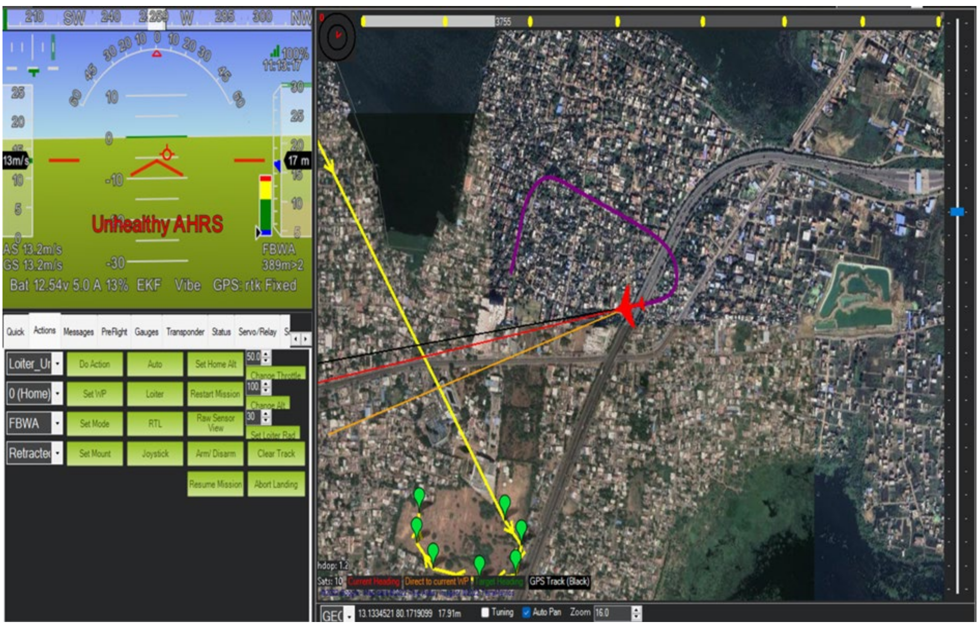

Fig. 12 – Flight mode – Fly by Wire

The Fly By Wire – Mode A is for amateur UAV pilots. This mode is used to maintain altitude. It is recommended to use this mode to conduct reconnaissance and surveillance missions in urban areas to monitor civilians. All these modes have auto stabilization i.e., a component of the STABILIZATION mode, so it is not necessary to program a channel only for stabilization mode.

4. CONCLUSIONS

The complete location of the UAV was obtained in this paper by connecting the Ground Control System to the Telemetry and the Global Positioning System. The UAV test model was developed, and the communication was established between the mission planner, telemetry, and GPS. This autonomous UAV mission was successfully demonstrated and safely retrieved by allocating three alternative flight modes. Experimental results show the developed autonomous UAV had a greater range and endurance standby transmitter and outlasted other rotary-wing UAVs.

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