A Project On

A Stable Flight Intelligence Technology of Multipurpose Autonomous Aerial Navigator for Surveillance/ Disaster Management

Completed Successfully.

In persuasion for the award of degree of **BACHELOR OF TECHNOLOGY**

Under the guidance of Prof. Anirban Ghosal

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CERTIFCATE

TO WHOM IT MAY CONCERN

This is to certify that project titled-

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Of B.tech 8th Semester, in partial fulfillment of the requirement for the degree of **Bachelor of Technology** in Electronics & Communication Engineering from JISCE(Autonomous Institute), Kalyani, during the academic year 2024-25 is their original Endeavour carried out under my supervision and guidance and has not been presented anywhere else.

……	……
HOD of ECE Dept.	Mr. Anirban Ghosal (Project guide)

ABSTRACT

A quadcopter can achieve vertical flight in a stable manner and be used to monitor or collect data in a specific region such as mapping terrains. Technological advances have reduced the cost and increased the performance of the low power microcontrollers that allowed the public to develop their own quadcopter. The goal of this project is to build, modify, and improve an existing quadcopter kit to obtain stable flight, gather and store GPS data, and perform auto commands, such as auto-landing. The project used an aero quad quadcopter kit that included a frame, motors, electronic speed controllers, Arduino Mega development board, and sensor boards and used with the provided Acero quad software. Batteries, a transmitter, a receiver, a GPS module. The aero quad software was modified to properly interface the components with the quadcopter kit. Individual components were tested and verified to work properly. Calibration and tuning of the PID controller were done to obtain proper stabilization on each axis using custom PID test benches. Currently, the quadcopter can properly stabilize itself, determine its GPS location, and store and log data. This report also described the auto commands that can be implemented at a later stage. Most of the goals in this project have been achieved, resulting in a stable and maneuverable quadcopter.

TABLE OF CONTENTS

SL.NO.	TABLE OF CONTENTS	PAGE NO.
1.	ACKNOWLEDGEMENT	5
2.	INTRODUCTION	6 - 7
3.	OBJECTIVE	8
4.	SERVEY ON RECENT INVESTIGATIONS	9 - 18
5.	BASIC COMPONENTS	19 - 32
6.	FLOW CHART OF MULTIPURPOSE AUTONOMOUS AERIAL NAVIGATOR	33
7.	FLIGHT CONTROLER SETUP AND CALIBRATION DESCRIPTIONS	34 - 45
8.	MISSION PLANNING	46 - 49
9.	ADVANCED MISSION PLANNING	50 - 56
10.	SURVEILLANCE	57 - 61
11.	PROTOTYPE MODEL	62 - 64
12.	CONCLUSION	65 - 66
13.	FUTURE SCOPE	66 - 69
14.	REFERENCES	70 - 80

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Also, I express my sincere thanks to my parents, well-wishers, and friends for roles during my research work. There are many whom I should mention. I beg to be excused for not mentioning individual names of them.

This report may contain errors and shortcomings. Thus, we remainopen to all criticisms and suggestions which could present us with new sources of inspiration as we develop in our ability to research and learn.

INTRODUCTION

A quadcopter is an aerial vehicle that uses four rotors for lift, steering, and stabilization. Unlike other aerial vehicles, the quadcopter can achieve vertical flight in a more stable condition. Furthermore, due to the quadcopter's cyclic design, it is easier to construct and maintain. As technology becomes more advanced and more accessible to the public, many engineers and researchers have started designing and implementing quadcopters for different uses. One of the main uses is surveillance. Surveillance is critical for security operations. In the past, helicopters were used for these types of missions. Recently, Unmanned Aerial Vehicles (UAVs) are (have grown in popularity and are an excellent Resource that can be) utilized for surveillance missions. Unmanned aerial vehicles are helpful to observe, analyze and get information and transfer it to base station. UAVs can perform missions with high level of complexity and at the same time, they require less human operator involvement due to their autonomous behavior. The additional advantage is, they are agile in nature and can have degree of freedom up to 10.

The goal of this project is to build an UAV in structure of x shaped quad rotor that houses a camera with a wireless transmission system. This

unmanned aerial vehicle will be used for campus surveillance. Aerial surveillance will be done by monitoring the real time environment with the help of UAV. Surveillance of banks, highly crowded areas, aerial traffic, and security watch can be easily done with the help of this UAV.

OBJECTIVE

The objective of this project is to build an UAV in structure of quad rotor which can maintain safe and stable flight and houses a camera with a wireless transmission system to provide surveillance of real time environment. These are the following objectives.

a) Design and implementation of UAV in structure of X Shaped quadcopter.

b) Development of stable flight intelligence technology of multipurpose autonomous aerial navigator interfacing of GPS and Wireless telemetry to perform auto mission and to get inflight data.

c) Apart from the stable flight, a camera is interfaced with quadcopter's processor to record the aerial view for surveillance.

d) A wireless transmission system is added to transmit the video to ground station.

SURVEY ON RECENT INVESTIGATIONS:

Background

F.A.A's Aerospace Report of 2017 reveals forecasts for the future growth potential of the drone market for both model (hobby/recreational) and non-model (commercial) users [2]. As of December 2016, there were 626,000 hobbyists registered, and an estimation of around 1.1 million drones that belong to those hobbyists. FAA forecasts a total hobbyist fleet of 3.55 million drones by 2021 in a base scenario, and 4.47 million drones in a best-case scenario. On the other hand, FAA forecasts 422,000.

Methodology

A survey instrument was developed by following the KAP model. Initially, a pilot test was distributed to 25 random subjects to determine the reliability of survey items (May 2017). Considering the results of the pilot survey and feedback from the participants, a few questions were removed, and a few questions were edited. To increase the reliability of the survey instrument, Cronbach's alpha values for set of questions related to ‘commercial, public safety, hobby, and scientific applications.

Results

The ordinal Likert scale was converted into an interval scale by assigning numbers 1 through 5. As a starting point to each analysis regarding the survey, normality assumption was tested to determine the use of non-parametric or parametric statistical methods. The research questions listed on Table 2 were analyzed sequentially. Minitab 17 was utilized for conducting statistical tests. The order in the survey structure will be followed for representing the results: Knowledge, attitudes.

Discussion and implications

Drone technology is emerging rapidly, and its applications are advancing beyond public knowledge. There are vast numbers of technical studies that emphasize improvements on the specifications of drones such as payload capacity, flight time, collision avoidance, and signal range, etc., and capabilities such as communication of swarms of drones, artificial intelligence, and virtual reality enrichments. However, an adequate understanding of policy, environmental, ethical, and societal.

Civil Applications

Unmanned aerial vehicles can be practiced in various civilian uses due to their low preservation cost, deployment efficiency, high mobility, and ability to hover (Kardasz et al. 2016). Several civil applications are listed here and summarized in Fig. 5.

- Disaster management: assessing the damage, locating victims, care of public safety, search and rescue actions and delivering aids (Hayat et al. 2016).
- Construction and infrastructure inspection: creating accurate 2D and 3D data, maps, and models, conducting surveys before, during and after construction, monitoring gas, oil and water pipelines (Greenwood et al. 2019).
- Agriculture and remote sensing: planting crops, disease finding, monitoring, irrigation, water quantity nursing, yield approximations, deficiency monitoring (Norasma et al. 2019).
- Healthcare: delivering medical services in remote areas (Wulfovich et al. 2018).
- Waste management: identifying garbage sites (Leizer 2018).

- Utility inspecting: telecommunication towers, tracking oil spills (Johnsen et al. 2020).
- Urban planning: providing instant mapping and ready to use data for planning (Noor et al. 2018).
- Wildlife conservation: monitoring the number of animals, species, collecting samples for conservationists to track porches (Ivosevic et al. 2015).
- Geographic mapping: acquiring high-resolution data, downloading imagery in challenging to reach locations like coastlines (Yavaşlı 2020).
- Weather forecasting: accessing weather trends to understand imminent dangers (Balaji et al. 2018).
- Mining: measuring minerals, surveying operations (Park and Choi 2020).
- Law enforcement: monitoring large crowds, tracking illegal activities (Stelmack 2015).
- Real-time monitoring of road traffic flow: field provision sides, rescue teams, traffic police, road inspectors, hovering roadside unit and hovering dynamic traffic signals (Elloumi et al. 2018).
- Commercial photography: images and videos are both popular outcomes from commercial drone jobs. These could be for wedding and commercial photography/videography, real estate marketing photography, or even filming with big-budget motion pictures.

Unmanned aerial vehicles are declared to be highly propitious in places where a person cannot move or is incapable of performing in an

exceedingly reasonable and sufficient practice. Improving work performance and potency, minimizing workload and merchandise cost, refining service, and customer relations, increasing precision, and fixing security problems on a broad scale are the first UAV uses that give industry globally. The rapid mobility of UAVs, frequent packet losses and weak connectivity between UAVs are addressed to affect data delivery reliability (Oubbati et al. 2019). The drones maintain the flexibility to achieve significant isolated areas with little to no human resources required and wish the smallest amount of energy, effort, and time. It is one of the most important goals of being embraced worldwide, especially by these four sectors: disaster management, precision agriculture, construction and infrastructure inspection and healthcare, as shown in Fig. 6. A detailed description of the four sectors is presented below.

Disaster management

A disaster is an event caused by a natural or man-made hazard that occurs over a short or extended period. It results in significant physical harm or destruction, as well as mortality or a big alteration in the environment. The disaster management team supports search and rescue operations, such as public safety, locating victims, assessing damage, and delivering aids (Oubbati et al. 2020). Drones can step in for relief workers and manned vehicles in situations when they are needed. Drones can be easily used to access hard to reach areas. Drones are used to enable communication coverage during natural or man-made disasters such as floods or terrorist attacks, as well as essential infrastructure like water and electrical utilities (Tanzi et al. 2016). Drones provide timely disaster warnings as well as assistance in restoring public communication networks that have been interrupted. It can also supply medical aids to classified inaccessible areas and search missing persons/animals in disastrous situations like poisonous gas leakage,

forest fires, and avalanches (Restas 2015). These are the main areas where drones help to improve search and rescue missions.

- Use of mapping and imaging technology to provide quick situational awareness.
- Help rescuers locate hot spots and examine property damage.
- Capture imagery for communications and news coverage.
- Search for survivors.
- Assess utility and infrastructure damage.
- Create before/after maps of the affected region (Erdelj and Natalizio 2016).
- Unmanned aerial vehicles have been applied in a wide variety of disaster management applications, but the following are the most common (Chowdhury et al. 2017):
- Pre-disaster planning refers to incidents linked to surveying that occur prior to the calamity.
- Evaluation of disasters: provide real time situational awareness of the event and complete logistic damage studies.
- Disaster response and recovery: Search and Rescue (SAR) missions, building the communications backbone, and insurance-related field surveys are just a few examples.

Agriculture

The rapid improvement and growth of UAVs as a remote sensing platform, as well as advances in device downsizing and data systems, have resulted in increased adoption of this technology in metropolitan areas and remote sensing social networks. Drones can be used to collect data from ground sensors and distribute it to ground base stations. Drones with sensors can be used to create an aerial sensor network for disaster management and environmental monitoring (Tsouros et al. 2019). Drones, remote sensing applications from tree species, water quality monitoring, disease detection, crop monitoring, yield predictions, and drought monitoring are just a few of the data sources. Some of the applications of drones in agriculture are:

- Crop monitoring: The crop fields are vast and challenging to monitor volatile weather conditions, increasing the field risk and labour costs. Unmanned aerial vehicles equipped with RGB or multispectral cameras help to eliminate these challenges (Hassan-Esfahani et al. 2015).
- Precision agriculture: Vegetation that focuses on crop diseases, nutrient deficiencies, and pest infestation reduces productivity. Crop data is collected by UAVs and processed with AI techniques to address these challenges (Radoglou-Grammatikis et al. 2020).
- Irrigation management: UAVs assist in obtaining critical irrigation data at any time and at a low cost (Kim et al. 2019).
- Aerial mustering: Aerial stock mustering occurs when a UAV is used to locate, direct, and concentrate livestock while flying below 500 ft above ground level. It is utilised to supplement the employment of horses and motorcycles in traditional mustering tactics (Katke

2019). Mustering operations are defined as activities linked to the aerial monitoring and control of livestock that is handled by helicopter and fixed-wing aircraft and include: animal culling, aerial stock mustering and aerial stock spotting (Barbedo et al. 2020).

- Artificial pollination: The decrease in the honeybee population has gained immense concern worldwide. Hence, UAVs act as pollinators to transport pollen from flowers using hair coated with gel (Potts et al. 2018).

Construction and infrastructure inspection

Unmanned aerial vehicles used in real-time monitoring development project sites and examining high voltage of power synchronized lines. Drones are used to recognize the buildings near the power lines and the location of trees (McCabe et al. 2017). Small UAVs are deployed, observe the facilities, infrastructure, including water, gas, oil pipelines. The gas controller unit is deployed in UAVs to identify gas, air leaks and content. Drone inspection applications throughout the construction cycle (Anwar et al. 2018) are mentioned below:

- Monitoring project progress: Project maps are built using drone data for regular monitoring and planning, avoiding delays and additional expenses. Progress monitoring helps the projects to move according to their plan with no deviations. Construction/deconstruction sequences, crane positions, perimeter security, and many other aspects are evident due to UAV-based progress monitoring (Shahmoradi et al. 2020).

- Construction site mapping: The creation of drone maps has become more straightforward, inexpensive and results in less intense civil engineering work than older methods. Drones may now easily access any location using topographic surveys to create visual representations for evacuations, stockpile measurements, and correct transport prices. For real-time computer mapping of information, Pix 4D software is used (Getsov et al. 2017).

- Volumetric measurement: To keep records of the onsite raw materials used during construction to improve efficiency and reduce stock waste. In stockpiles volume estimates, 99% accuracy is achieved by incorporating state-of-the-art technology, such as machine learning. Volumetric measurements are high speed, precise, and cost-effective using Equinox drones (Fan and Saadeghvaziri 2019).

- Building surveillance: Inspections of buildings can be dangerous and challenging for humans to carry out independently. Building UAV surveillance helps lower personal safety risks and boosts productivity by recording vast and essential data. Drone surveillance or aerial surveillance helps in finding potentially risky scenarios for better decisions more efficiently. Drones equipped with thermal sensors are popular amongst building surveillance projects to evaluate roofs for faults without going there.

Health care

Drones have the potential to collect real-time data and deliver payloads at a low cost, and they have sped up the development of various industrial, commercial, and recreational applications. Telecommunication drones are used for diagnosis and treatment, perioperative evaluation, and telemetering in remote locations (Rosser Junior et al. 2018). Microbiological and laboratory samples, drugs, vaccines, emergency medical supplies, and patient transportation can all be delivered using drones. Drones have a variety of practical applications that have much potential and are listed below:

- Emergency supplies or medications on board: EpiPens, poison antidotes, and oxygen masks are just a few types of life-saving kit (Thiels et al. 2015).
- Blood and tissue sample collection: Drones may be able to provide goods and services while also allowing for speedier return transit to labs that are adequately prepared, eliminating human work and time (Konert et al. 2019).
- Performing search and rescue missions: People that have gone missing or been injured can be rescued at sea, in the mountains, in the desert, or in the bush (Fotouhi et al. 2019).
- Accessibility to far-flung patients: People are typically found in situations where the infrastructure for efficient emergency or continuity of care is lacking. Drones are being used to provide telemedicine, vaccinations, prescription drugs, and medical supplies to people at home.

- Integration of cloud and internet of things (IoT): It presents a cost-effective way to connect heterogeneous devices and address rising data demands in healthcare applications, including seamless application deployment and rendering service (Malleswari and Vadivu 2019).

Conclusion and future studies

This study explored the public and stakeholders' knowledge, attitudes, and practice of drones. I believe the most important finding is that public perception of drones did not change after seeing the benefits and risks of drones in the same survey. Even though respondents representing the public were shown 40 different applications of drones, most of which were public safety related, their perception did not improve. This is because they were also provided with the risks associated with

BASIC COMPONENTS

1. F450 Drone Frame

Description: F450 Quadcopter Frame with 4 arms is made of high-quality Glass Fiber which makes it tough and durable. Ultra-durable Polyamide-Nylon is used for manufacturing arms that are much stronger molded arms providing better thickness.

Image:

Specification:

- Wheelbase: 450mm
- Material: Glass Fiber + Polyamide-Nylon
- Motor Mounting Hole Diameter: 3 mm
- Arm Size: 220 x 40 (LxW) mm.
- Arm mounting holes (on frame): 3 mm.
- Arm mounting holes (on arm): 2 mm.

2. DJI 2212 920KV Brushless Motor

Description: Brushless motors used in drones work through a combination of electromagnetism and a control system. The motors consist of two primary components: stator and rotor. The stator consists of electromagnetic coils while the rotor consists of permanent magnets.

Image:

Specification:

- Model: 2212
- Motor KV (RPM/V) : 920
- Maximum Thrust (gm): 500
- Compatible Lipo Batteries: 3S ~ 4S
- Shaft Diameter (mm): 6
- Rated Voltage(V): 7 ~ 12
- Required ESC (A): 30
- Length (mm): 28
- Width (mm): 28
- Height (mm): 46
- Weight (g): 60

3. Favourite LittleBee BLHeli-S Spring 30A OPTO ESC

Description: Electronic speed controllers (ESCs) are devices that allow drone flight controllers to control and adjust the speed of the drone's electric motors. A signal from the flight controller causes the drone ESC to raise or lower the voltage to the motor as required, thus changing the speed of the propeller.

Image:

Specification:

- Light weight:
- MCU: SILABS EFM8BB21F16, MCU running at 48MHz
- Dedicated driver chip
- Battery: 6 - 25.2V (2-6S Lipo)
- PCB board: 4 layers blind pole board, 3 oz copper
- Motor Wire: 70mm (20AWG)
- Signal Wire: 120mm
- Firmware: BLHeli_S (Supports Oneshot / Oneshot42 and Multishot / Active Braking – dampened light mode)

4. 9” Propeller(2x CW, 2x CCW)

Description: Propellers for Drones and UAVs. Propellers are devices that transform rotary motion into linear thrust. Drone propellers provide lift for the aircraft by spinning and creating an airflow, which results in a pressure difference between the top and bottom surfaces of the propeller.

Image:

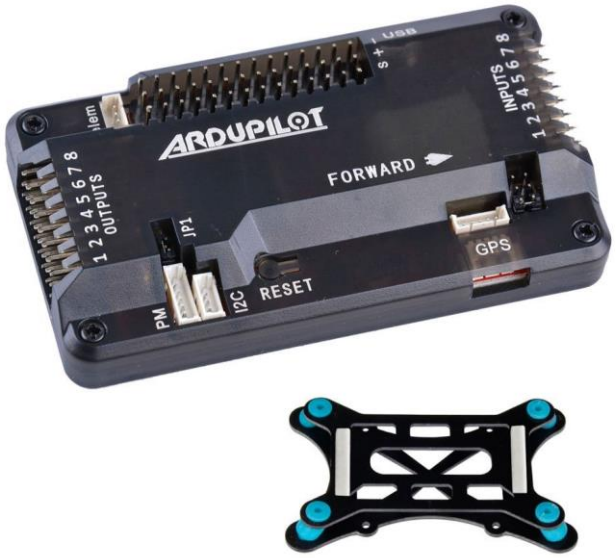
Specification:

- Material: ABS.
- Color: Black.
- Length (Inch): 9
- Pitch(inch): 4.7.
- Shaft Diameter (mm): 7-(Flat Side) and 8-(Round Side)
- Total Length(mm): 230
- Weight (g): 18

5. APM 2.8 Flight Controller

Description: The APM 2.8 Multirotor Flight Controller is a complete open-source autopilot system. This is the best-selling technology that won the prestigious Outback Challenge UAV competition. It allows the user to turn any fixed, rotary wing.

Image:



Specification:

- Port: MUX (UART0, UART2).
- Input Voltage (V): 12~16 VDC.
- Sensor: 3-Axis Gyroscope, Accelerometer, High-performance Barometer.
- Processor: ATMEGA2560 and ATMEGA32U-2.
- Dimensions (LxWxH)mm ：70 x 45 x 15
- Weight (g): 82

6. M8N GPS Module

Description: It acts as a navigation and positioning system, providing crucial information to the pilot or flight control software. With the help of GPS, a drone can fly with complete autonomy, follow predefined routes with precision and maintain a stable position, as it will be able to determine its surroundings in real time.

Image:

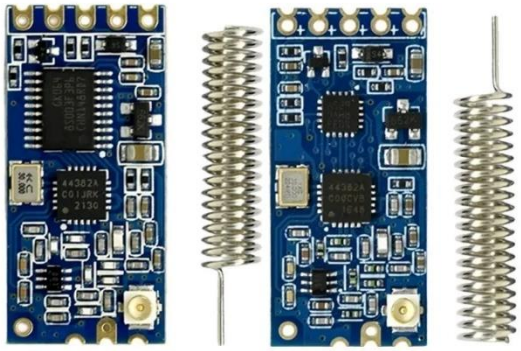
Specification:

- Receiver Type: 72-channel Ublox M8 engine.
- Main Chip: Ublox NEO-M8N.
- Input Supply Voltage (VDC): 0.5 ~ 3.6
- Sensitivity (dBm): Tracking & Navigation: -161 dBm
- Position Accuracy (Meter): 2, 2.5
- Acceleration (g): <4
- Navigation Update Rate: up to 18 HZ.
- Operating Temperature (°C): -45 to 105
- Tracking Sensitivity (dBm): -161 dBm
- Avg Cold Start Time (s): 30
- Warm Start Time (s): 1
- Boot Time: 1s.
- Maximum Altitude (m): 18000
- Weight (g): 23

7. HC12 Transceiver Module x 2 (Telemetry Data Link)

Description: Telemetry data is the information that your drone sends back to your controller or device, such as speed, altitude, battery level, GPS position, and more. By analyzing this data, you can improve your flight performance, avoid crashes, and optimize your drone settings.

Image:



Specification:

- Operating voltage: 3.2 ~ 5.5V
- Transmission power: 20dBm (maximum)
- Reference distance: 1000 meter
- Working frequency band: 433.4 ~ 473.0MHz
- Antenna interface: Spring Antenna/Antenna Socket
- Working Humidity: 10% ~ 90%
- Working temperature: -25°C ~ +75°C
- Length (mm): 27.5
- Width (mm): 13.5
- Height (mm): 4
- Weight (g): 2

8. Flysky FSI6 Proportional Radio Control System

Description: A drone's transmitter, also known as the remote control or controller, is the device used by the pilot to control and navigate the drone. It sends commands wirelessly to the receiver, which is located on the drone itself.

Image:

Specification:

- Channels: 6
- RF range: 2.4055 - 2.475 GHz
- Bandwidth: 500KHz
- Band: 140
- RF Power: Below 20 dBm
- System with 2.4G: AFHDS 2A & AFHDS 2B
- Sensitivity: 1024
- DSC Port: PS2
- Output: PWM, PPM, I-BUS
- ANT length: 26mm*2 (dual antenna)
- Weight: 392gm
- Display mode: Type positive transflective STN type, 128*64 dot matrix.

9. FPV Camera 1200TVL

Description: The FPV (first-person view) camera allows its user to see remotely controlled operations. It is thus used in remotely controlled vehicles or crafts, applied in many fields, but heavily used in applications for security and defense.

Image:

Specification:

- Image Sensor: 1/3 CMOS SUPER HAD II
- Horizontal Resolution (TVL): 1200
- Minimum Illumination: 0.01Lux/1.2F
- AGC & Backlight Compensation: Yes
- S/N Ratio (dB): >60
- Operating Temperature (°C): -10 to 50
- Dimensions (LxWxH) mm : 26 x 26 x 30
- Weight (g): 15

10. Analog Video Transmitter – VTX

Description: The transmitter is responsible for transmitting or broadcasting a connected audio-video device, while the receiver outputs that transmitted audio-video signal to a connected television. The remote-control relay permits infrared remote controls to operate the equipment whose output is being transmitted.

Image:

Specification:

- Antenna Type: Male RP-SMA
- Audio Bandwidth: 6.5M
- Frequency: 5.6 to 5.9GHz
- No. of Channels: 48
- Operating Current: 0.22A
- Operating Temperature Range: -10°C to 85°C
- Rated Power: 600mW
- Video Bandwidth: 8M
- Video Format Supported: NTSC/PAL
- Voltage: 7 to 24V
- Length: 54mm
- Height: 10mm
- Width: 32mm

11. Analog Video Receiver – VRX

Description: A video receiver is an electronics device used in UAVs. Its purpose is to receive video signals from a source, and to process them and route the video to display on monitors or video projector.

Image:

Specification:

- Model: ROTG01 (UVC OTG FPV Receiver)
- No. of Channels: 150
- RF Range: 5645~5945 GHz
- Rx Sensitivity (dBm): -90
- Operating Voltage (VDC): 5
- Current Consumption (mA): 200
- Operating Temperature (°C): -10 to 60
- Connector to connect Antenna: SMA Female
- Antenna Length (mm): 110
- Video Format Supported: NTSC/PAL
- Color: White
- Net weight (gm): 28
- Dimensions (LxWxH) mm: 61 x 33 x 0.9

12. Orange Lipo Batter 5200mAh 3S 40C

Description: Lithium polymer battery, or more correctly lithium-ion polymer battery, is a rechargeable battery of lithium-ion technology using a polymer electrolyte instead of a liquid electrolyte. Highly conductive semisolid polymers form this electrolyte. It has high energy density, makes it the best choice for powering drones and UAVs.

Image:

Specification:

- Weight (g): 360
- Output Voltage (VDC): 11.1
- Charge Rate (C): 1 ~ 3.
- Discharge Plug: XT-60
- Balance Plug: JST-XH
- Length (mm): 134
- Width (mm): 40
- Height (mm): 27
- Max. Burst Discharge (C): 80C(416.0A)
- Max. Charge Rate: 5 C
- Max. Continuous Discharge: 40C(208.0A)

13. SKYRC IMAX B6 MINI Professional Balance Charger

Description: Balancing chargers ensure that all the cells are charged evenly and there are no differences in voltages between them. Balancing also makes sure that none of the cells are over-charged, as over-charging may have unwanted consequences. So, make sure you are using a balancing charger with your LiPo batteries.

Image:

Specification:

- Input Voltage: DC11-18V.
- Circuit Power: Max Charge: 60W
- Max Discharge: 5W
- Charge Current Range: 0.1-6.0A
- Discharge Current Range: 0.1-2.0A
- LiPo/LiFe/Li-Ion Cells: 1-6S
- NiMH/NiCd Cells: 1-15S
- Pb battery Voltage: 2-20V
- Net Weight: 233g
- Length: 84mm
- Width: 102mm
- Height: 29mm

14. 12V 5A SMPS

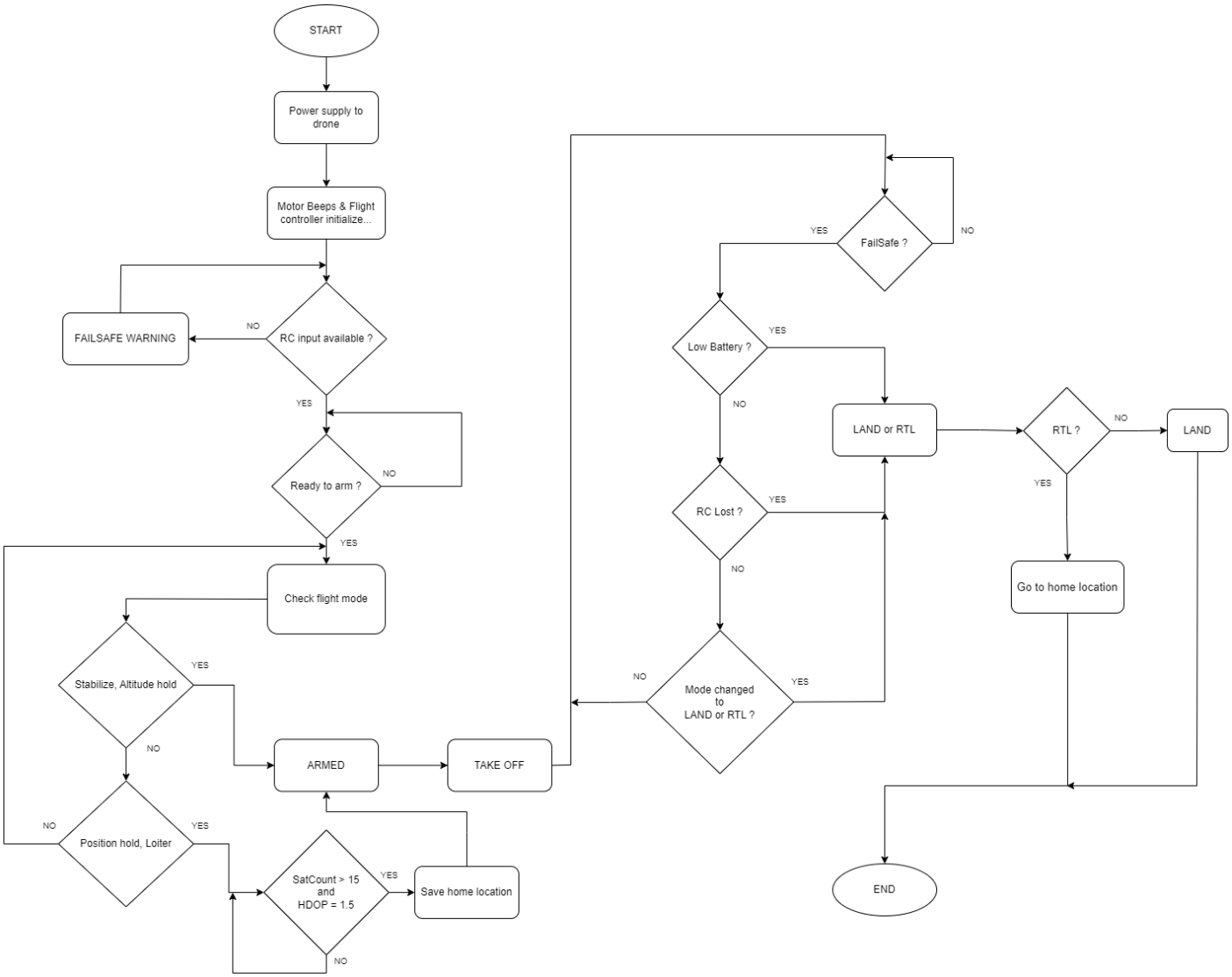
Description: A switched-mode power supply, also called switching-mode power supply, switch-mode power supply, switched power supply, or simply switcher, is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently.

Image:

Specification:

- Input Voltage: AC 100 - 264V 50 / 60Hz
- Output Voltage: 12V DC, 5A, and 60W
- Output voltage Adjustment Range: ±20%
- Protections: Overload / Over Voltage / Short Circuit
- Auto-Recovery After Protection
- Universal AC input / Full range
- Design with Built-in EMI Filter, improve signal precision.
- Compact Size Light Weight, High Efficiency, Reliability.
- Shell Material: Metal Case / Aluminum Base
- Dimension: (165 x 98 x 42) mm / (6.50 x 3.85 x 1.57) inch (L x W x H)

FLOW CHART OF MULTIPURPOSE AUTONOMOUS AERIAL NAVIGATOR:



FLIGHT CONTROLER SETUP AND CALIBRATION DESCRIPTIONS :

1. Software required to setup APM2.8 flight controller:

Description:

To configure APM 2.8 flight controller we need the help of mission planner software. All the settings and parameters are nicely described inside mission planner software.

Supporting image:

2. STEP - 1 Flash firmware to the flight controller:

Description: Connect flight controller to the computer. Open mission planner software and go to SETUP tab. Install firmware option is there, select quadcopter X and hit install. Keep an eye on green progress bar it will show whether installation is completed or not. After successful installation press the connect button.

Supporting image:

3. STEP - 2 Mandatory hardware setup - Frame Type:

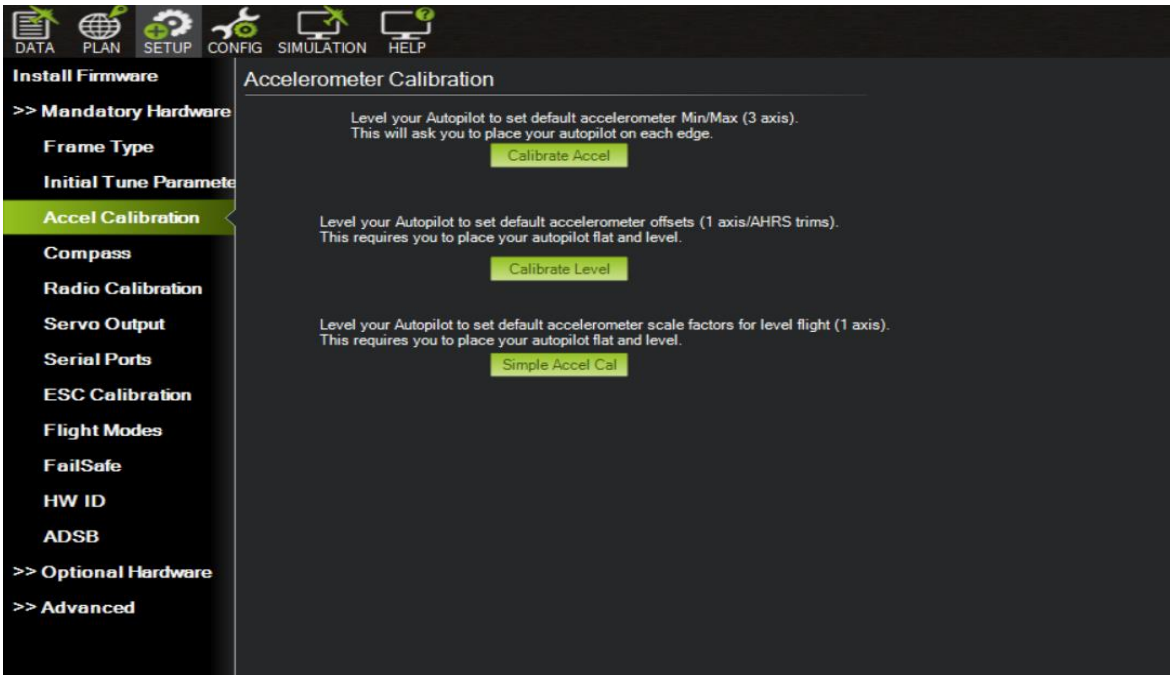
Description: Go to Frame Type tab select quadcopter X frame. This will change the frame type to the selected one.

Supporting image:

4. STEP - 3 Mandatory hardware setup - Accel Calibration:

Description: Inside Accel Calibration tab click calibrate accel to calibrate accelerometer. Follow the onscreen prompts accordingly. It will ask to place the drone on its every side. e.g. Place vehicle level, Place vehicle on its right, on its left , nose down, nose up, on its back. Place the drone exactly how it asks for, to ensure successful accel calibration.

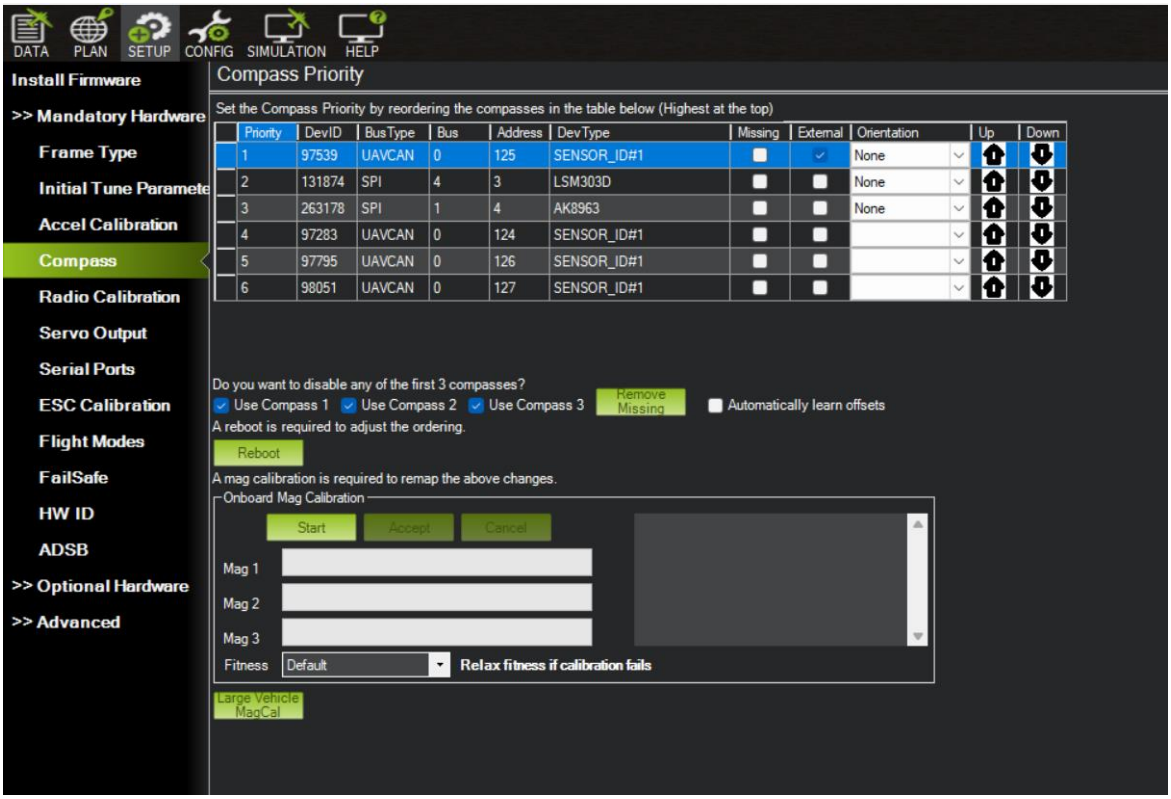
Supporting image:



5. STEP - 4 Mandatory hardware setup - Compass Calibration:

Description: Compass calibration is a crucial part of flight controller setup. Click the start button inside of compass tab and move the drone in every possible direction. The magnetometer of flight controller will collect samples of earth's magnetic field. And then adjust its offsets accordingly. It may take several minutes.

Supporting image:



6. STEP - 5 Mandatory hardware setup - Radio Calibration:

Description: In Mission Planner, radio calibration is a process used to ensure accurate communication between your ground control station (GCS) and your unmanned aerial vehicle (UAV) or drone. This calibration is essential for stable and reliable control of the drone, as it ensures that the radio signals transmitted by your controller are correctly interpreted by the aircraft.

During radio calibration, you typically move the control sticks on your transmitter to their full extent while connected to Mission Planner. This allows Mission Planner to record the range of values being transmitted by each control channel. By calibrating the radio, you ensure that the drone responds accurately to your inputs, and you minimize the risk of interference or control issues during flight.

Supporting image:

7. STEP - 6 Mandatory hardware setup - Flight Modes:

Description: Flight modes determine how the aircraft behaves in different situations and are typically controlled by switches or buttons on your transmitter.

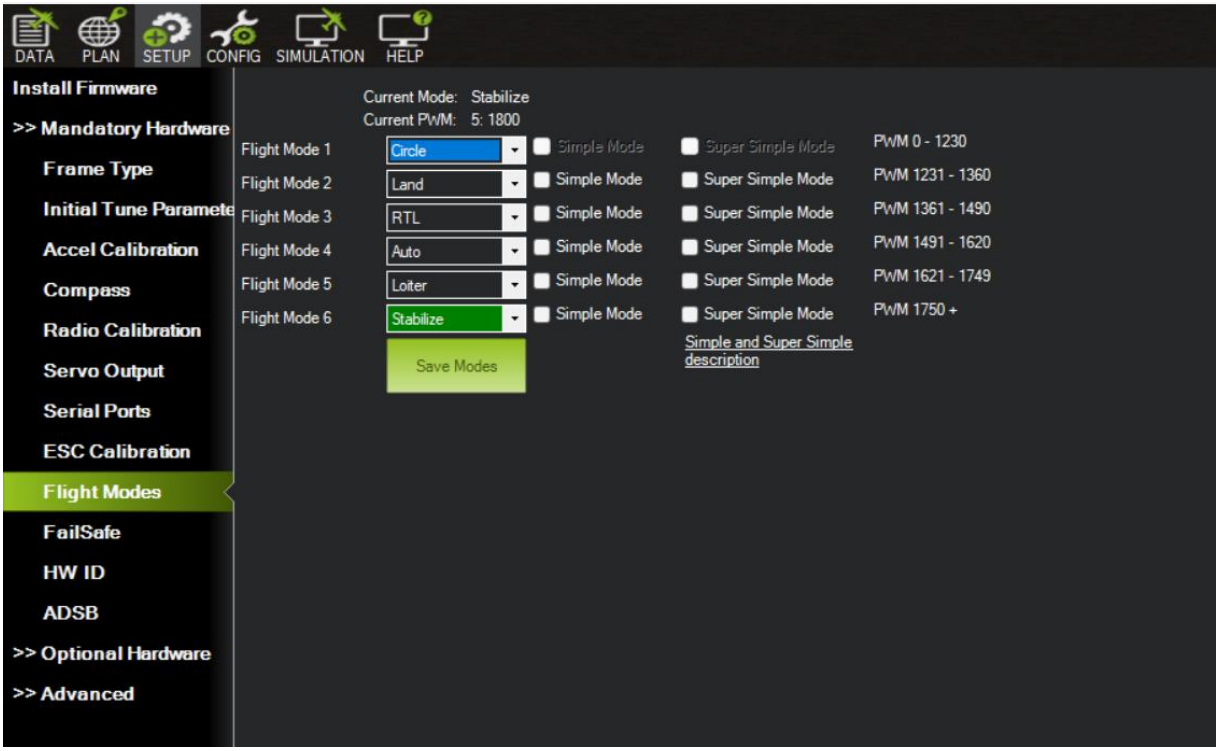
1. Access the Flight Modes page: In Mission Planner, navigate to the configuration or setup section where you can adjust flight parameters. This is usually found in the Initial Setup menu.
Select your flight controller: If you have multiple flight controllers connected, choose the one you want to configure.

2. Configure flight modes: You'll see a list of available flight modes such as Stabilize, Alt Hold, Loiter, Auto, etc. Depending on your drone's firmware and flight controller, the available modes may vary. Each mode has a specific behavior, such as manual control, altitude hold, position hold, autonomous missions, etc.

3. Assign switches or buttons: For each flight mode, you'll assign a switch or button on your transmitter that will activate it. This allows you to change flight modes during flight according to your needs and the requirements of your mission.

4. Verify and save settings: Once you've configured the flight modes and assigned switches, verify that everything is set up correctly. You may want to test the switches to ensure they're activating the correct modes. Once satisfied, save the settings to your drone.
Flight mode setup is crucial for ensuring that your UAV behaves as expected during flight and that you have easy access to different flight modes for various scenarios, such as manual piloting, autonomous missions, and emergency procedures. Mission Planner provides a user-friendly interface for configuring these modes to suit your specific requirements.

Supporting image:



8. STEP - 7 Mandatory hardware setup - FailSafe:

Description: Failsafe setup in mission planner involves configuring safety measures to ensure that your unmanned aerial vehicle (UAV) or drone can respond appropriately in the event of a critical failure, loss of signal, or other unforeseen circumstances. Failsafe procedures are essential for minimizing the risk of accidents and protecting both the aircraft and any people or property on the ground.

1. Access the Failsafe Settings: In your Ground Control Station (GCS), such as Mission Planner, navigate to the failsafe settings section. This is usually found in the configuration or setup menu.
Choose Failsafe Actions: Determine what actions your drone should take in the event of a failsafe condition. Mission planner offers several failsafe options, including:

RTL (Return to Launch): The drone will automatically return to its launch location and land safely.

Land: The drone will land at its current location.
Continue with Mission: If the drone is on a mission, it will continue to the next waypoint.

Hold: The drone will hold its current position and altitude.
Cut Throttle: The drone will immediately cut throttle and initiate a controlled descent.

Circle: The drone will circle its current position.
Custom Failsafe Action: Some setups allow you to define a custom failsafe action, such as executing a specific flight pattern or triggering external devices.

Set Failsafe Triggers: Specify the conditions that will trigger failsafe behavior. Common triggers include:

Lost RC Signal: If the radio control signal is lost or weak.

GPS Glitch: If there's a problem with the GPS signal.

Low Battery Voltage: When the battery voltage drops below a predefined threshold.

High Altitude: If the drone exceeds a maximum altitude threshold.

Test and Verify: Once you've configured the failsafe settings, perform ground tests, and verify that the failsafe actions trigger as expected in simulated failsafe scenarios.

Supporting image:

8. STEP - 7 Optional Hardware – Battery Monitor:

Description: Battery Monitor refers to a feature that allows you to monitor the status of your drone's battery during flight.

Hardware Compatibility: First, ensure that your autopilot system (flight controller) supports battery monitoring and that you have the necessary hardware connected to your drone. This usually involves connecting a battery monitor device to your flight controller.

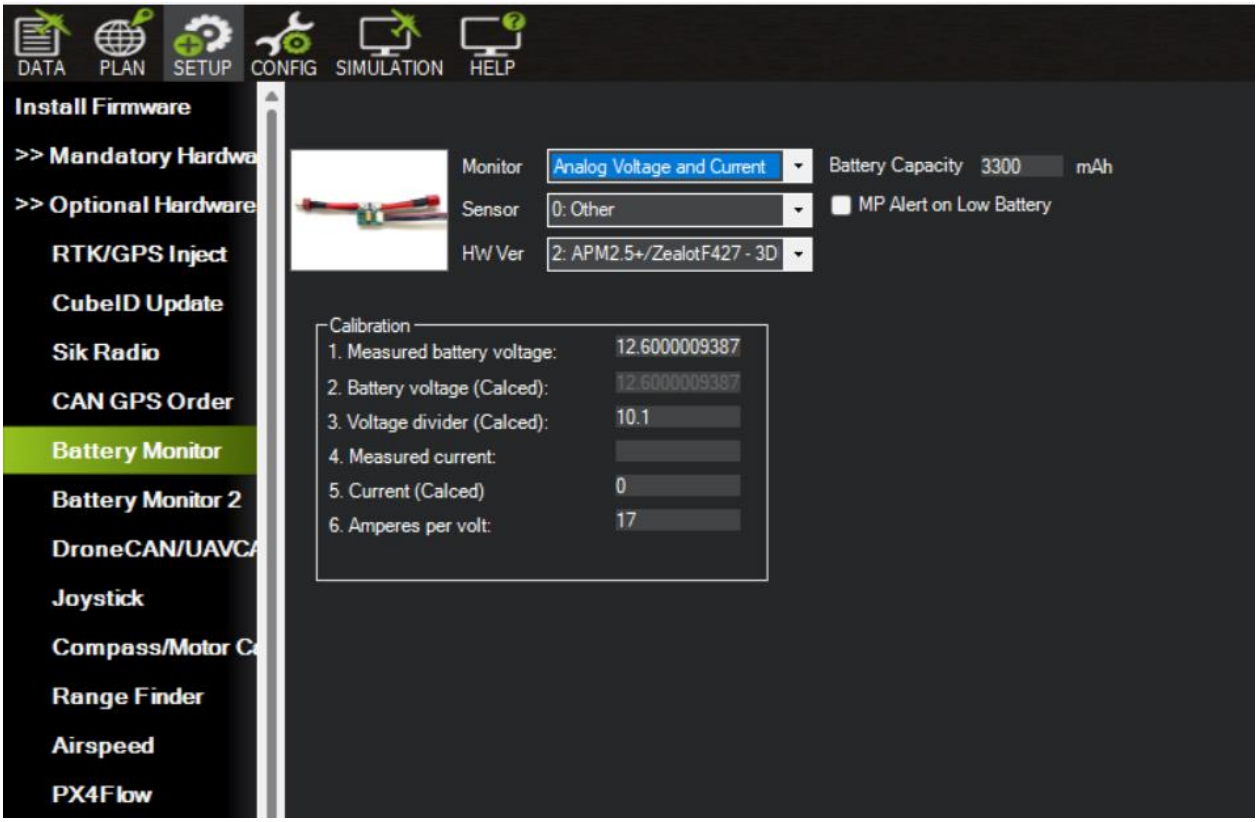
Configuration: In Mission Planner, navigate to the appropriate settings menu for battery monitoring. This may vary depending on your autopilot system, but it's usually found in the Configuration or Optional Hardware section.

Calibration: Depending on the type of battery monitor you're using, you may need to calibrate it to ensure accurate readings of the battery's voltage and current.

Monitoring: Once configured, Mission Planner will display real-time information about your battery's voltage, current consumption, remaining capacity, and other relevant metrics. This information helps you monitor the health and status of your battery during flight.

Setting Alarms: You can often set up alarms or warnings in Mission Planner to alert you when the battery voltage drops below a certain threshold, indicating that it's time to land and replace or recharge the battery.
Battery monitoring is crucial for safe and efficient drone operations, as it allows you to avoid over-discharging the battery, which can damage it, and ensures that you have enough power remaining for a safe return to launch or landing. Mission Planner provides a convenient interface for configuring and monitoring battery status during flight.

Supporting image:



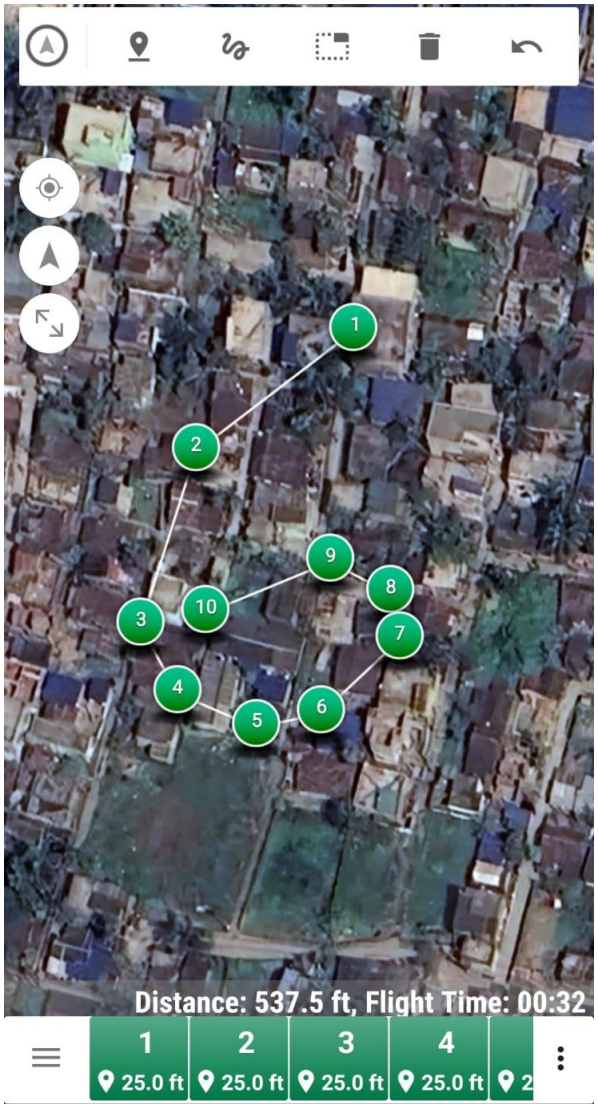
MISSION PLANNING:

What is mission planning:
Mission planning refers to the process of creating a sequence of waypoints and commands for an unmanned vehicle, such as a drone or rover, to follow autonomously. ArduPilot is an open-source autopilot software suite that provides navigation, guidance, and control capabilities for autonomous vehicles.

In mission planning, users typically use ground control station (GCS) software, such as Mission Planner or Tower, to define a mission. A mission consists of a series of waypoints, which are specific geographic coordinates that the vehicle should navigate to, as well as other commands such as loitering at a specific location, changing altitude, or triggering payload actions like taking a photo or dropping a payload. The mission planning process usually involves the following steps:

Waypoint Selection: Users select the waypoints on a map interface provided by the GCS. They can specify the latitude, longitude, and altitude of each waypoint.

Supporting image:

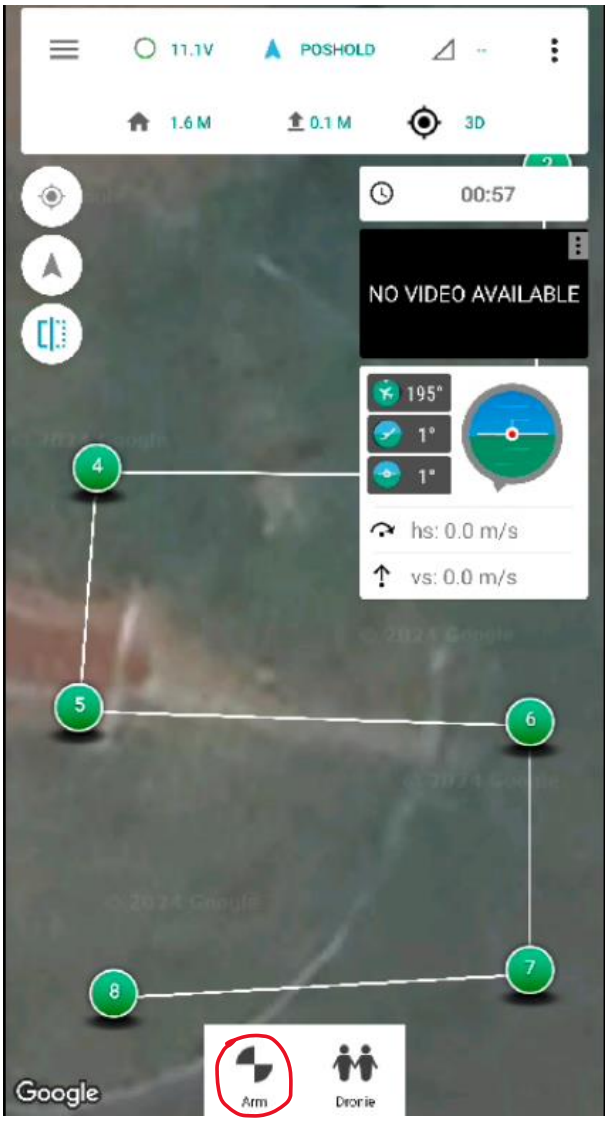


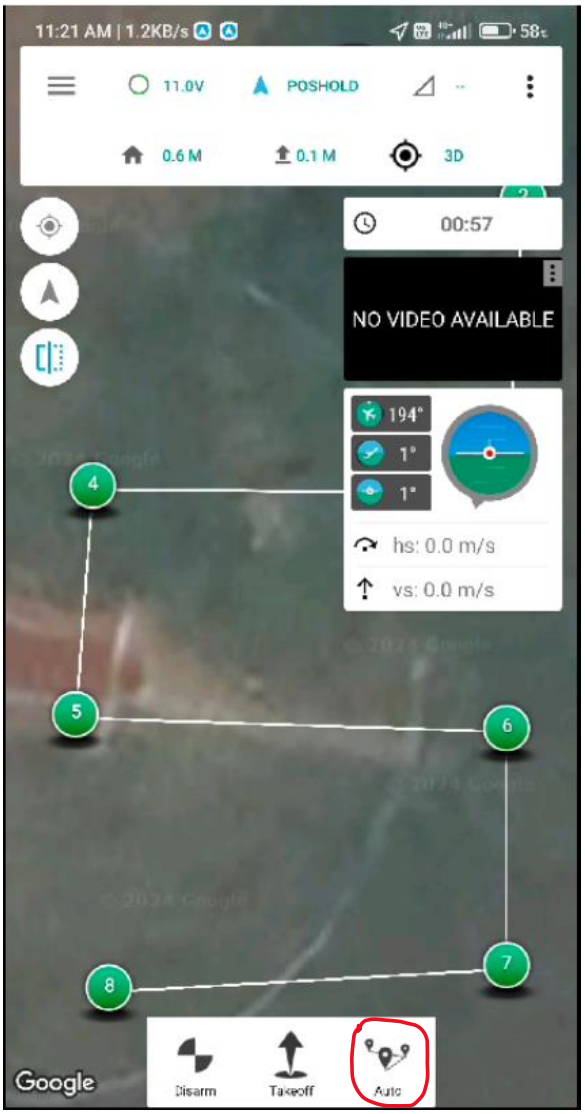
Waypoint Sequence: Users define the order in which the waypoints should be visited to achieve the desired mission objectives.

Mission Upload: Once the mission is planned, it is uploaded to the autopilot system onboard the vehicle. The autopilot then executes the mission autonomously, following the predefined waypoints and commands.

Mission Commands: Users can insert various mission commands between waypoints to control the vehicle's behavior. These commands may include changing flight altitude, adjusting speed, triggering actions, or waiting at a waypoint for a specific duration.

Supporting image:





Mission Monitoring: During the mission execution, users can monitor the vehicle's progress and adjust if necessary, using the GCS interface. Mission planning in ArduPilot allows for a wide range of autonomous missions, from simple point-to-point navigation to complex surveying, mapping, and surveillance tasks. It enables efficient and precise operation of unmanned vehicles for various applications, including agriculture, aerial photography, search and rescue, and environmental monitoring.

Supportive image:

ADVANCED MISSION PLANNING:

1. GEO FENCING

Geo-fencing in Mission Planner refers to the capability to set up virtual boundaries or geographical limits within which a drone or any other unmanned vehicle is allowed to operate. It's a safety feature designed to prevent the vehicle from flying into restricted or unsafe areas and to maintain compliance with regulations or operational requirements.

Defining Boundaries: Users can use the Mission Planner interface to define the boundaries of the geo-fence on a map. They can draw polygonal shapes or specify circular boundaries with a center point and radius.

Setting Altitude Limits: In addition to horizontal boundaries, users can also set altitude limits for the geo-fenced area. This ensures that the vehicle stays within a specified altitude range while operating within the defined boundaries.

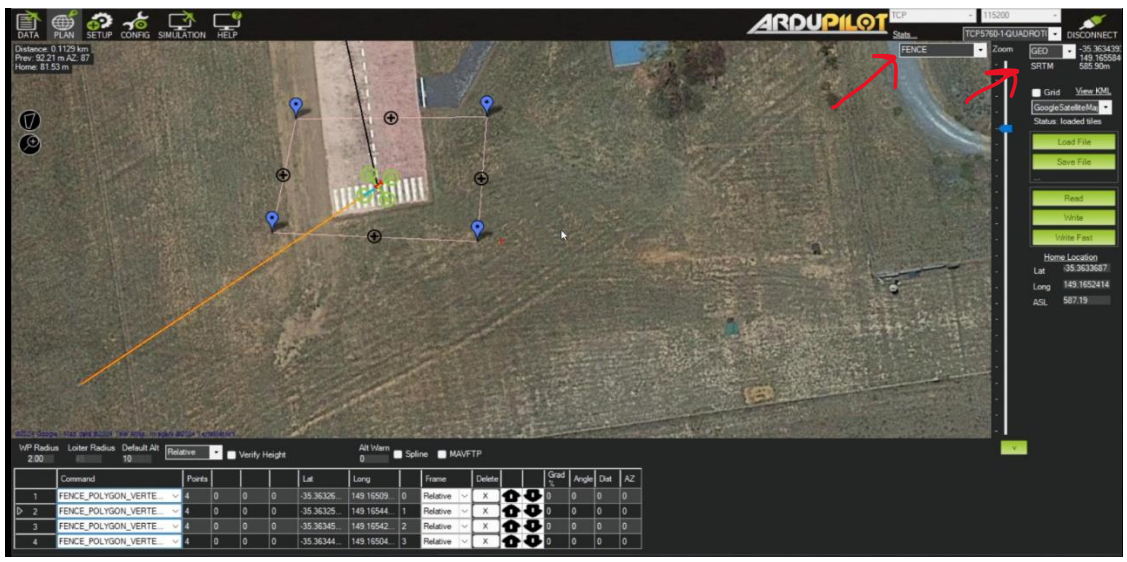
Activating the Geo-fence: Once the boundaries are defined and altitude limits are set, users can activate the geo-fence feature. This tells the autopilot system to enforce the specified restrictions during flight.

Enforcement during Flight: When the vehicle is in flight, the autopilot continuously monitors its position using GPS or other positioning systems. If the vehicle approaches or crosses the geo-fence boundaries, the autopilot triggers a response, such as slowing down, stopping, or returning to a safe location within the permitted area.

Alerts and Notifications: Mission Planner may provide alerts or notifications to the user when the vehicle approaches the geo-fence

boundaries or violates the specified limits. This allows operators to take appropriate action, such as manually redirecting the vehicle or adjusting the mission parameters.
Geo-fencing is particularly useful for ensuring safe and compliant operations, especially in areas where there are regulatory restrictions, safety concerns, or sensitive environments. It helps prevent accidents, trespassing, and unauthorized access while providing operators with greater control and peace of mind during autonomous missions.

Supporting image:



2. ALTITUDE FENCING

Altitude fencing in Mission Planner is a feature that allows users to set altitude limits for unmanned vehicles, such as drones, during flight operations. Like geo-fencing, altitude fencing adds an additional layer of safety by restricting the vehicle's altitude within predefined limits.

Setting Altitude Limits: Users specify minimum and maximum altitude limits within which the vehicle is allowed to operate. These limits can be defined based on regulatory requirements, safety considerations, or operational needs.

Activation: Once the altitude limits are configured, users activate the altitude fencing feature in Mission Planner. This tells the autopilot system to enforce the specified altitude restrictions during flight.
Monitoring during Flight: As the vehicle flies its mission, the autopilot continuously monitors its altitude using onboard sensors such as barometers or GPS. If the vehicle's altitude exceeds the predefined limits, the autopilot triggers a response.

Response to Violations: When a violation occurs, the autopilot may take various actions depending on the configuration and settings. It could initiate a corrective maneuver to bring the vehicle back within the permitted altitude range, issue warnings to the operator, or trigger a failsafe mode to ensure the vehicle's safety.

Alerts and Notifications: Mission Planner may provide real-time alerts or notifications to the user when altitude limits are approached or violated. This allows operators to stay informed and take appropriate actions as needed.
Altitude fencing is valuable for maintaining safe and compliant flight operations, especially in environments where altitude restrictions are necessary or when flying in proximity to obstacles such as buildings, terrain, or airspace boundaries. By setting altitude limits and enforcing

them during flight, operators can mitigate risks, prevent accidents, and ensure responsible operation of unmanned vehicles.

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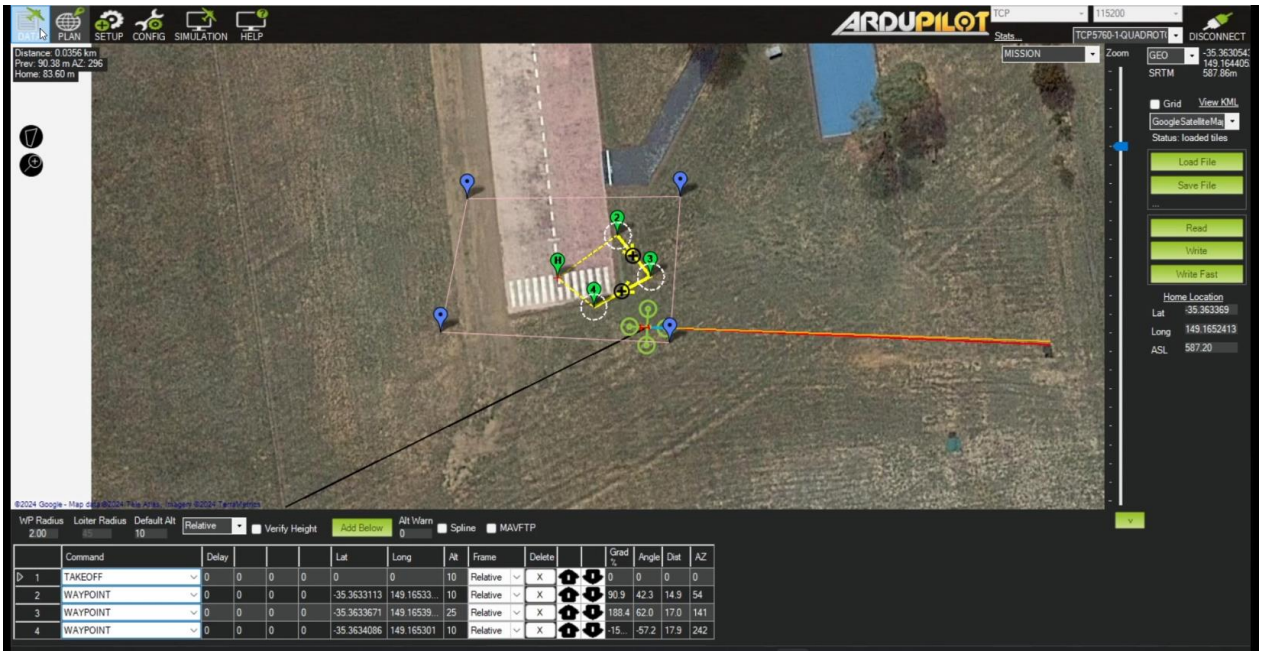


3. RALLY POINTS

In mission planning, a "rally point" refers to a specific waypoint designated as a gathering or regrouping location for unmanned vehicles participating in a mission. Rally points are strategically placed within the mission area to facilitate coordination, communication, and control of multiple vehicles, such as drones or rovers.

Strategic Placement: Rally points are typically positioned at strategic locations within the mission area, considering factors such as terrain, communication range, and mission objectives. They serve as rendezvous points where vehicles can converge before proceeding with the next phase of the mission.

Coordination Hub: Rally points act as coordination hubs where vehicles can regroup, exchange data, synchronize their positions and statuses, and receive updated instructions from the mission operator or central control station.

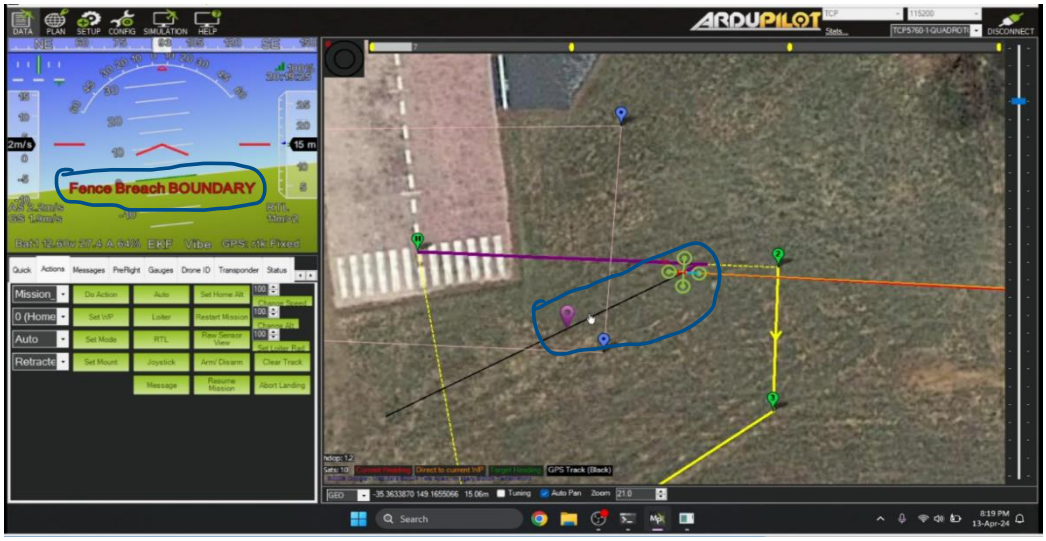
Mission Segmentation: In complex missions involving multiple phases or tasks, rally points help segment the mission into manageable segments. Vehicles can navigate to the rally point at the end of each segment to regroup, assess the situation, and receive new waypoints or commands for the next segment.

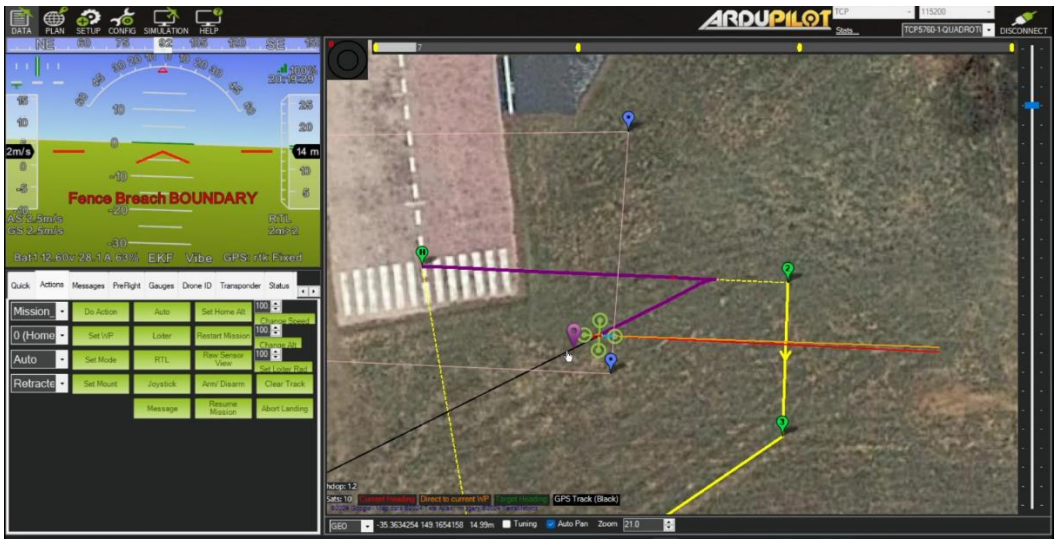
Emergency Response: Rally points can also serve as designated locations for emergency response or contingency plans. If a vehicle encounters issues or malfunctions during the mission, it can navigate to the nearest rally point for assistance or recovery.

Navigation Aid: For autonomous vehicles, rally points serve as navigation waypoints that help guide the vehicle through the mission area. By navigating to and from rally points, vehicles can maintain their bearings and ensure efficient movement within the mission area. Overall, rally points play a crucial role in mission planning by providing a

framework for effective coordination and control of unmanned vehicles. They enhance the flexibility, reliability, and safety of autonomous missions, particularly in scenarios involving multiple vehicles operating in dynamic environments.

Supporting image:


ARDUPILOT
Fence Breach BOUNDARY


ARDUPILOT
Fence Breach BOUNDARY

ARDUPILOT

SURVEILLANCE:

Drone surveillance refers to the use of unmanned aerial vehicles (UAVs), commonly known as drones, equipped with cameras or other sensors to gather visual or data intelligence from the air. This technology has seen rapid advancement in recent years, becoming increasingly accessible and capable of fulfilling various surveillance roles.

Applications: Drone surveillance has numerous applications across various sectors, including:
Security and Law Enforcement: Drones are used for monitoring public events, patrolling borders, and assisting in search and rescue operations.

Military: Military drones, also known as unmanned combat aerial vehicles (UCAVs), are extensively used for reconnaissance, intelligence gathering, and targeted strikes.
Infrastructure Inspection: Drones can inspect critical infrastructure such as power lines, pipelines, and bridges more efficiently and safely than traditional methods.

Agriculture: Agricultural drones are used for crop monitoring, spraying pesticides, and assessing soil conditions.

Technology: Modern drones come in various shapes and sizes and are equipped with advanced technologies, including:
Cameras: High-resolution cameras, infrared cameras, and thermal imaging cameras are commonly used for visual surveillance.

Sensors: Drones can carry sensors for detecting radiation, chemical agents, and other environmental parameters.

GPS and Navigation Systems: GPS enables precise navigation and geolocation of surveillance targets.

Communication Systems: Drones can transmit real-time data to ground stations or command centers via wireless communication systems.

Autonomous Capabilities: Many drones have autonomous flight capabilities, allowing them to follow predefined routes or perform specific tasks without constant human intervention.

Privacy and Legal Considerations: The use of drones for surveillance raises privacy concerns and legal questions regarding their deployment. Regulations governing drone surveillance vary from country to country and often include restrictions on where drones can fly, how they can be used, and the collection and storage of data.

Ethical Implications: Ethical considerations surrounding drone surveillance include issues such as the potential for abuse, the risk of civilian casualties in military applications, and the impact on personal privacy and civil liberties.

Future Trends: The future of drone surveillance is likely to see continued advancements in technology, including improvements in autonomy, sensor capabilities, and endurance. Additionally, developments in artificial intelligence may enable drones to analyze surveillance data in real-time, providing valuable insights to operators. Overall, drone surveillance is a powerful tool with diverse applications, but its use must be balanced with considerations for privacy, legality, and ethics.

Supporting image:

PROTOTYPE MODEL

TOP VIEW:

FRONT VIEW:

DURING FLIGHT:

CONCLUSION

Unmanned aerial vehicles are now being built with highly versatile technology, continually developing creative ways to provide more outstanding service. This paper provides a detailed systematic literature analysis of the context classification, UAVs specification, and applications to the respective models. The study also presents various aspects of drones such as technological requirements, drone models, parts, possible payloads, and sensors. The use of UAVs is rapidly increasing in substantial civil application domains. Compared to other studies, this paper comprehensively analyses existing literature and UAV uses that accurately represented their civil applications while further analyzing the research trends, key challenges, and potential perspectives for each category. This analysis covers the different types of drone models currently being used, their configuration and applications, and the imminent technical enhancement of UAV technology. Unmanned aerial vehicles are widely employed in precision agriculture for crop management and tracking, weed detection, irrigation scheduling, disease detection, pesticide spraying, and field sensor data collection. Artificial intelligent pollinators are a wonder in precision agriculture. In the future, UAVs will play a vital role in precision agriculture by

incorporating image processing techniques such as georeferencing, mosaicking, classification algorithms, and collecting high-resolution images. The key research challenges in precision agriculture raise the opportunities and further pave the way for researchers to develop future drone applications.

FUTURE SCOPE

Despite efforts to propose acceptable solutions to address the UAV challenges discussed in the previous section, a significant number of unsolved difficulties require new effective solutions. In this section, we highlight new opportunities for the UAV systems, including security and privacy, battery charging, machine learning, and other interesting future research topics and directions.

Swarm UAV Systems

In swarm UAV systems, a set of UAVs work together to achieve a specific goal. Each UAV has a small mission which is a part of a bigger mission; this concept was mainly developed by the military for reconnaissance and surveillance applications. Civilian applications also adopted the same concept for several applications, including precision agriculture and SAR operations.

Machine Learning and Deep Learning

Machine learning and deep learning algorithms have recently received a high level of support in different applications related to UAVs, such as resource allocation, obstacle avoidance, tracking, path planning, and battery scheduling. The development of more accurate algorithms and improvement of onboard computational power will lead to the design of nano UAVs that are much smaller, more lightweight, and smarter than available UAV models to achieve the required mission accurately and without the risk of collision. Furthermore, the availability of accurate data can facilitate UAVs to perform accurate control and path planning and vision tasks.

Several applications of deep learning in UAVs were reviewed, such as feature extraction using UAVs. By implementing different cameras on the UAV, various types of images can be taken for further processing. UAV planning, including path motion, navigation, and manipulation planning were presented, as the UAV navigates the environment to find a suitable path. Another application is the motion control of UAVs based on deep learning.

Security and Privacy

The security and safety of UAVs are essential parameters due to their wireless connectivity and limited computational capabilities. They

receive potential threats from intruder attacks which can disrupt the privacy and confidentiality of the collected data. It might be stolen or replaced. Therefore, new onboard techniques are required to ensure privacy on the mission. Recent techniques, such as blockchain and physical layer security, require further research and improvement to achieve a required security level with the required quality and reliability.

Trajectory and Path Planning

Tracking and path planning techniques should be improved to optimize the mission path of UAVs while minimizing the energy consumption of flights with collision avoidance. Recent work on the topic of tracking is mainly based on heuristic algorithms, while path planning of complex paths to avoid obstacles and find the shortest path to consume low energy can be carried out by using a multi-objective optimization algorithm.

Energy Charging

Recent developments in battery technologies, including enhanced lithium–ion batteries and hydrogen fuel cells and green energy sources such as solar energy, have been used recently to extend flight times. However, energy collecting efficiency is low due to random energy arrivals. Novel energy-delivering technologies, such as energy

beamforming through multiantenna techniques and distributed multipoint WPT, can enhance the charging efficiency.

Optical Communication

Optical Wireless Communications (OWCs) have proved their efficiency in 4G, 5G, and beyond 5G mobile networks. They are widely adopted in UAV communication, and they are expected to be used in the 6G mobile network. However, several challenges facing this technology need to be addressed, including the high blockage probability of the signals, the power consumption, and weather conditions.

REFERENCES

Akturk E, Altunel AO (2019) Accuracy assessment of a low-cost UAV derived digital elevation model (DEM) in a highly broken and vegetated terrain. Measurement 136:382-386.
» https://doi.org/10.1016/j.measurement.2018.12.101

Alzahrani B, Oubbati OS, Barnawi A, Atiquzzaman M, Alghazzawi D (2020) UAV assistance paradigm: State-of-the-art in applications and challenges. J Netw Comput Appl 166:102706.
» https://doi.org/10.1016/j.jnca.2020.102706

Anwar N, Najam FA, Izhar MA (2018) Construction monitoring and reporting using drones and unmanned aerial vehicles (UAVs). Paper presented The Tenth International Conference on Construction in the 21st Century (CITC-10). AIT; Colombo, Sri Lanka.

Arfaoui A (2017) Unmanned aerial vehicle: Review of onboard sensors, application fields, open problems and research issues. Int J Image Processing 11(1):12-24.

Balaji B, Chennupati SK, Chilakalapudi SRK, Katuri R, Mareedu K (2018) Design of UAV (drone) for crop, weather monitoring and for spraying fertilizers and pesticides. Int J Res Trends Innov 3(3):42-47.

Barbedo JGA, Koenigkan LV, Santos PM, Ribeiro ARB (2020) Counting cattle

in UAV images: Dealing with clustered animals and animal/background contrast changes. Sensors 20(7):2126.
» https://doi.org/10.3390/s20072126

Bogle BM, Rosamond WD, Snyder KT, Zègre-Hemsey J (2019) The case for drone-assisted emergency response to cardiac arrest: An optimized statewide deployment approach. N C Med J 80(4):204-212.
» https://doi.org/10.18043/ncm.80.4.204

Bratanov D, Mejias L, Ford JJ (2017) A vision-based sense-and-avoid system tested on a ScanEagle UAV. Paper presented 2017 International Conference on Unmanned Aircraft Systems (ICUAS). IEEE; Miami, Florida, United States of America.
» https://doi.org/10.1109/ICUAS.2017.7991302

Burnham C (2019) A study of UAV photogrammetry software (master's thesis). Barcelona: Universitat Politècnica de Catalunya.
Cancela JJ, González XP, Vilanova M, Mirás-Avalos JM (2019) Water management using drones and satellites in agriculture. Water 11(5):874.
» https://doi.org/10.3390/w11050874

Cheema P, Luo S, Gibbens P (2016) Development of a control and vision interface for an AR.Drone. Paper presented 2016 8th International

Conference on Computer and Automation Engineering (ICCAE 2016). MATEC Web of Conferences; Sydney, Australia.
» https://doi.org/10.1051/matecconf/20165607002

Chen Y, Li Y (2019) Intelligent autonomous pollination for future farming: A micro air vehicle conceptual framework with artificial intelligence and human-in-the-loop. IEEE Access 7:119706-119717.
» https://doi.org/10.1109/ACCESS.2019.2937171

Chowdhury S, Emelogu A, Marufuzzaman M, Nurre SG, Bian L (2017) Drones for disaster response and relief operations: A continuous approximation model. Int J Prod Econ 188:167-184.
» https://doi.org/10.1016/j.ijpe.2017.03.024

Croon GCHE, Groen MA, Wagter C, Remes B, Ruijsink R, van Oudheusden BW (2012) Design, aerodynamics and autonomy of the DelFly. Bioinspir Biomim 7:025003.
» https://doi.org/10.1088/1748-3182/7/2/025003

Deepak BBVL, Singh P (2016) A survey on design and development of an unmanned aerial vehicle (quadcopter). Int J Intell Unmanned Syst 4(2):70-106.
» https://doi.org/10.1108/IJIUS-10-2015-0012

Demir KA, Cicibaş H, Arica N (2015) Unmanned aerial vehicle domain: Areas of research. Def Sci J 65(4):319-329.
» https://doi.org/10.14429/dsj.65.8631

Elloumi M, Dhaou R, Escrig B, Idoudi H, Saidane LA (2018) Monitoring road traffic with a UAV-based system. Paper presented 2018 IEEE Wireless Communications and Networking Conference (WCNC). IEEE; Barcelona, Spain.
» https://doi.org/10.1109/WCNC.2018.8377077

Erbil MA, Prior SD, Karamanoglu M, Odedra S, Barlow C, Lewis D (2009) Reconfigurable unmanned aerial vehicles. Paper presented International Conference on Manufacturing and Engineering Systems. Middlesex University; Huwei, Yunlin, Taiwan. [accessed Oct 28 2021].
»https://eprints.mdx.ac.uk/3869/1/Erbil,_M.A._Reconfigurable_Unmanned_Aerial_Vehicles_MES2009356.pdf

Erdelj M, Natalizio E (2016) UAV-assisted disaster management: Applications and open issues. Paper presented 2016 International Conference on Computing, Networking and Communications (ICNC). IEEE; Kauai, Hawaii, United States of America.
» https://doi.org/10.1109/ICCNC.2016.7440563

Fan J, Saadeghvaziri MA (2019) Applications of drones in infrastructures: Challenges and opportunities. Int J Mech Mechatron Eng 13(10):649-655
» https://doi.org/10.5281/zenodo.3566281

Fernando ECTE, Silva ATA, Zoysa MDC, Dilshan KADC, Munasinghe SR (2013) Modelling, simulation and implementation of a quadrotor UAV. Paper presented 2013 IEEE 8th International Conference on Industrial and Information Systems. IEEE; Peradeniya, Sri Lanka.
» https://doi.org/10.1109/ICIInfS.2013.6731982

Fotouhi A, Qiang H, Ding M, Hassan M, Giordano LG, Garcia-Rodriguez A, Yuan J (2019) Survey on UAV cellular communications: Practical aspects, standardization advancements, regulation, and security challenges. IEEE Commun Surv Tutor 21(4):3417-3442.
» https://doi.org/10.1109/COMST.2019.2906228

George Fernandez S, Vijayakumar K, Palanisamy R, Selvakumar K, Karthikeyan D, Selvabharathi D, Vidyasagar S, Kalyanasundhram V (2019) Unmanned and autonomous ground vehicle. Int J Electr Comput Eng 9(5):4466-4472.
» https://doi.org/10.11591/ijece.v9i5.pp4466-4472

Gerdes J, Holness A, Perez-Rosado A, Roberts L, Greisinger A, Barnett E, Kempny J, Lingam D, Yeh C-H, Bruck HS, et al (2014) Robo Raven: A flapping-wing air vehicle with highly compliant and independently controlled wings. Soft Robot 1(4):275-288.
» https://doi.org/10.1089/soro.2014.0019

Getsov P, Wang B, Zafirov D, Sotirov G, Nachev S, Yanev R, Gramatikov P, Atanassov V, Lukarski H, Zabunov S (2017) An unmanned aerial surveillance system in urban environments. Aerospace Research in Bulgaria 29:94-110.
Giordan D, Adams MS, Aicardi I, Alicandro M, Allasia P, Baldo M, De Berardinis P, Dominici D, Godone D, Hobbs P, et al (2020) The use of unmanned aerial vehicles (UAVs) for engineering geology applications. Bull Eng Geol Environ 79:3437-3481.
» https://doi.org/10.1007/s10064-020-01766-2

Greenwood WW, Lynch JP, Zekkos D (2019) Applications of UAVs in civil infrastructure. Journal of Infrastructure Systems 25(2):04019002.
» https://doi.org/10.1061/(ASCE)IS.1943-555X.0000464

Gupte S, Mohandas PIT, Conrad JM (2012) A survey of quadrotor unmanned aerial vehicles. Paper presented 2012 Proceedings of IEEE Southeastcon. IEEE; Orlando, Florida, United States of America.

» https://doi.org/10.1109/SECon.2012.6196930

Hassan-Esfahani L, Torres-Rua A, Jensen A, McKee M (2015) Assessment of surface soil moisture using high-resolution multi-spectral imagery and artificial neural networks. Remote Sens 7(3):2627-2646.
» https://doi.org/10.3390/rs70302627

Hayat S, Yanmaz E, Muzaffar R (2016) Survey on unmanned aerial vehicle networks for civil applications: A communications viewpoint. IEEE Commun Surv Tutor 18(4):2624-2661.
» https://doi.org/10.1109/COMST.2016.2560343

Hegeir OA, Nagai K, Matsumoto K, Mizutani T (2017) Inspection and detection of damages of main cable in pathein bridge using drone. Paper presented Eighth International Conference on Science and Engineering (ICSE 2017). ICSE; Yangon, Myanmar.

Hildmann H, Kovacs E (2019) Review: Using unmanned aerial vehicles (UAVs) as mobile sensing platforms (MSPs) for disaster response, civil security and public safety. Drones 3(3):59.
» https://doi.org/10.3390/drones3030059

Hovhannisyan T, Efendyan, Vardanyan MV (2018) Creation of a digital model of fields with application of DJI phantom 3 drone and the opportunities of its utilization in agriculture. Ann Agrar Sci 16(2):177-180.

» https://doi.org/10.1016/j.aasci.2018.03.006

Hubsan (2015) The Hubsan X4 Pro: Real Time FPV. Shenzhen: Hubsan. [accessed Oct 28 2021].
» https://www.drones.nl/media/files/drones/1456534783-hubsan-x4-pro-user-manual.pdf

Intaratep N, Alexander W, Devenport WJ, Grace SM, Dropkin A (2016) Experimental study of quadcopter acoustics and performance at static thrust conditions. Paper presented 22nd AIAA/CEAS Aeroacoustics Conference. AIAA; Lyon, France.
» https://doi.org/10.2514/6.2016-2873

Iost Filho FH, Heldens WB, Kong Z, Lange E (2019) Drones: Innovative technology for use in precision pest management. J Econ Entomol 113(1):1-25.
» https://doi.org/10.1093/jee/toz268

Ivosevic B, Han Y-G, Cho Y, Kwon O (2015) The use of conservation drones in ecology and wildlife research. J Ecol Environ 38(1):113-118.
» https://doi.org/10.5141/ecoenv.2015.012

Jain SK, Bora S, Singh M (2015) A review paper on: Autonomous underwater

vehicle. Int J Sci Eng Res 6(2):38-40.
Jalal AU, Umasankar Y, Christopher F, Pretto Junior EA, Bhansali S (2018) A model for safe transport of critical patients in unmanned drones with a 'watch' style continuous anesthesia sensor. J Electrochem Soc 165(8):B3071.
» https://doi.org/10.1149/2.0111808jes

Johnsen SO, Bakken T, Transeth AA, Holmstrøm S, Merz M, Grøtli EI, Jacobsen SR, Storvold R (2020) Safety and security of drones in the oil and gas industry. Paper presented The 30th European Safety and Reliability Conference, 15th Probabilistic Safety Assessment and Management Conference. Esrel; Psam; Venice, Italy.
» https://doi.org/10.3850/978-981-14-8593-0_3924-cd

Kamilaris A, Prenafeta-Boldú FX (2018) Disaster monitoring using unmanned aerial vehicles and deep learning. arXiv preprint arXiv:1807.11805.
Kardasz P, Doskocz J, Hejduk M, Wiejkut P, Zarzycki H (2016) Drones and possibilities of their using. Journal of Civil and Environmental Engineering 6(3):233.
» https://doi.org/10.4172/2165-784x.1000233

Katke K (2019) Precision agriculture adoption: Challenges of Indian agriculture. Int J Res Anal Rev 6(1).
Kim D, Son Y, Park J, Kim T, Jeon J (2019) Evaluation of calibration method

for field application of UAV-based soil water content prediction equation. Adv Civ Eng 2019: 2486216.
» https://doi.org/10.1155/2019/2486216

Kim J, Moon H, Jung H (2020) Drone-based parcel delivery using the rooftops of city buildings: Model and solution. Appl Sci 10(12):4362.
» https://doi.org/10.3390/app10124362

Kim SJ, Lim GL, Cho J, Côté MH (2017) Drone-aided healthcare services for patients with chronic diseases in rural areas. J Intell Robot Syst 88:163-180.
» https://doi.org/10.1007/s10846-017-0548-z

Kok J-M, Chahl JS (2015) A low-cost simulation platform for flapping wing MAVs. Paper presented SPIE Smart Structures and Materials + Nondestructive Evaluation and Health Monitoring. SPIE; San Diego, California, United States of America.
» https://doi.org/10.1117/12.2084142

Konert A, Smereka J, Szarpak Ł (2019) The use of drones in emergency medicine: Practical and legal aspects. Emerg Med Int 2019:3589792.
» https://doi.org/10.1155/2019/3589792

La WG, Park S, Kim H (2017) D-MUNS: Distributed multiple UAVs' network

simulator. Paper presented 2017 Ninth International Conference on Ubiquitous and Future Networks (ICUFN). IEEE; Milan, Italy.
» https://doi.org/10.1109/ICUFN.2017.7993738

Leizer GKK (2018) Possible areas of application of drones in waste management during rail accidents and disasters. Interdiscip. Descr Complex Syst 16(3–A):360-368. https://doi.org/10.7906/indecs.16.3.8

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