Design and Build an EVTOL Drone

ME 470 Design Document
Chenyang Huang
Zhengpu Ye
Xuan Chen
Hongfan Liu
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TA: Yanzhao Gong
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1. Introduction

1.1 Objective

In recent years, the load-bearing transport UAV technology has been rapidly developed, and its practical applications in agriculture, medical rescue, logistics distribution, environmental monitoring and other fields are increasingly extensive, becoming an important force to promote social progress and technological innovation.

In agriculture, transport drones can improve the efficiency of pesticide and fertilizer spraying and achieve precision agriculture operations. The UAV can carry a certain weight of agricultural materials, carry out low-altitude flight operations in the specified area, evenly distribute pesticides and fertilizers on the farmland, greatly reduce the manual labor intensity, and improve the accuracy and safety of application.

In terms of medical rescue, drones become quick delivery of first aid equipment and consumables. When the geographical location is remote or inconvenient, drones can quickly transport emergency drugs, blood samples and organs, significantly shortening the golden time of medical treatment, and greatly improving the efficiency of disaster relief and rescue.

In the field of logistics distribution, drone delivery has begun to be tested and deployed in some areas. Drones can carry heavy loads and quickly deliver packages to consumers over short distances, especially in areas with heavy traffic or rough roads. Amazon, UPS and other companies have explored drone delivery services, heralding a future of logistics possibilities.

Environmental monitoring is also an area where transport drones are showing their strength. They can not only carry various detection instruments over areas that are difficult to reach manually, collect data, but also transport collected samples for further analysis. Drones have played a huge role in forest fire reconnaissance, wildlife monitoring, and air pollution assessment.

In addition, transport drones also have potential applications in commercial photography, geological exploration, rapid building construction and other industries. As technology continues to advance, the endurance, reliability and intelligence of drones are increasing, enabling them to carry out more complex missions and make a difference in a wider range of fields.

It can be said that heavy-carrying transport drones are gradually becoming the "air workers" of modern society, showing great potential and value in improving work efficiency, responding to public health events, ensuring supply chain stability, and promoting economic development. With the improvement of regulations and systems and the improvement of public acceptance, the application prospects of transport drones will be broader.

The solution we use to solve this growing social demand is to develop an eVTOL drone that can meet a certain carrying capacity, set up corresponding communication modules and cameras for it, and transmit real-time data back to the data cloud we build on the server, so as to achieve large-scale, long-distance accurate detection.

1.2 Background

In recent years, with the advancement of battery technology, motor efficiency and flight control systems, EVTOL drone research and development has made remarkable achievements, and many innovative companies and traditional aviation manufacturers have invested resources in development.

The first pilot model has already conducted successful test flights, demonstrating EVTOL' drones potential for human and cargo transport. At present, the research focus is mainly on improving safety, increasing driving range, optimizing noise reduction and building intelligent management systems.

In order to make it more usable, our design has been optimized with new algorithms and feature development in terms of cost control and user interaction, reliability enhancement

1.3 High-level Requirements

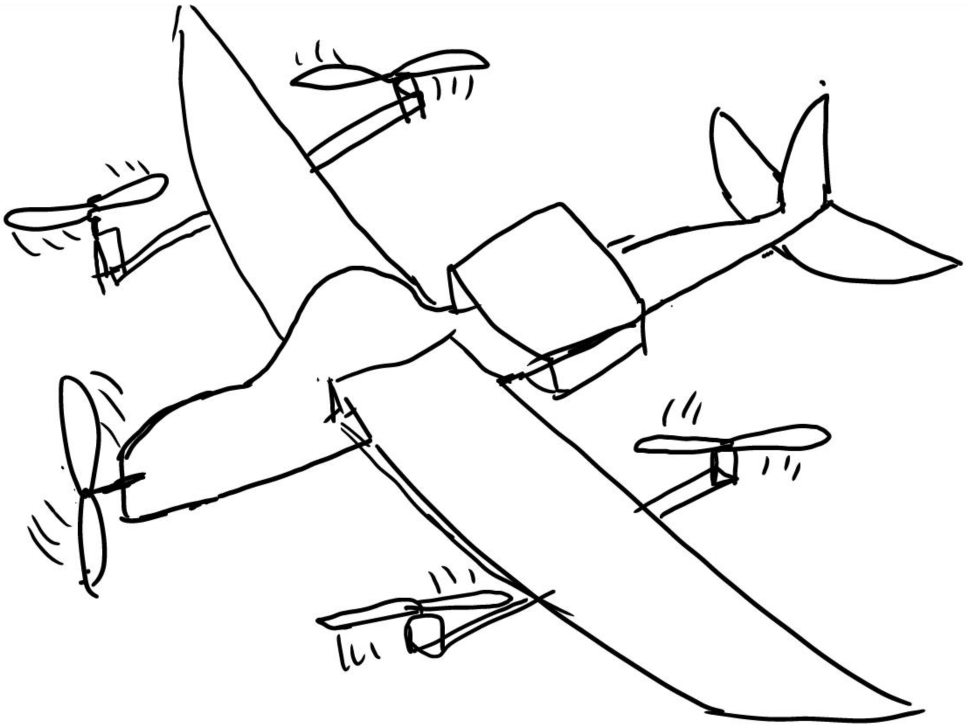
The plane must be able to fly properly with **load**.

Electric control is to ensure **hover and control**.

Stable communication in **10 km** and **30 minutes**, and upload the camera image to the cloud.

2. Design

The wing is 1.5m long, the fuselage is 875mm long, and four V2207 KV1750 motors are used to provide lift for vertical takeoff and landing. In level flight, it is powered by the propulsion motors in the nose and the fixed wing, the fuselage and wing are made of EPO material, and the four-axis motors are attached to the wing with carbon tubes as brackets.



2.1 Power Supply

The circuit is powered by a BOSLI-PO battery with a 1300mAh capacity. Our power budget is 195A (maximum) at 22.2V, mostly consumed by five propeller motors. Each motor consumes 36.6A of current. This battery is chosen for its affordability and sufficient power.

Requirement	Verification
Outputs larger than 183A (36.6A*5=183A) at 22.2V	A. Measure the open-circuit voltage with a voltmeter, ensuring that it is at 22.2V B. Ensure that the current through the motors are about 36.6A using an ammeter in series

2.2 Control Module

The control module receives signal from drone controller and controls the flight. It contains a Pixhawk flight controller, a remote-control receiver, a remote control and five electronic speed controllers.

2.2.1 Pixhawk flight controller

The Pixhawk 2.4.8 Drone Flight Controller works as the brain of our drone. It analyzes the commands of the user and transmitting electrical signals to electronic speed controllers. We choose this version because of its powerful functions and friendly price.

Requirement	Verification
Analyze commands and regulate the motors.	Works successfully in QGround control simulation.

2.2.2 Micro zone MC6C remote control and MC7RB remote-control receiver

The remote control and receiver make sure that the flight could receive our commands. It works will in our computer software simulation.

Requirement	Verification
Receive signals from ground control.	Works successfully in QGround control simulation.

2.2.3 BLHe li-S electronic speed controllers

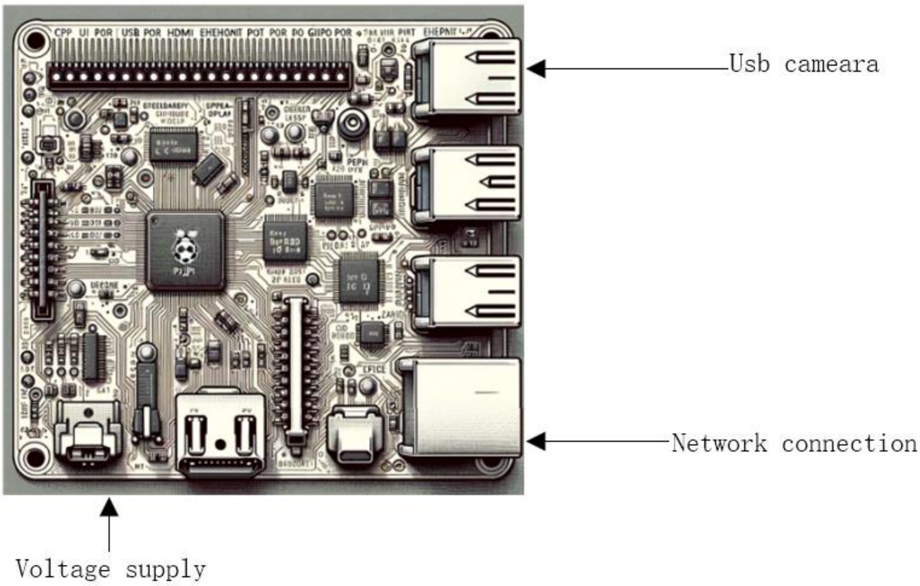
The electronic speed controllers (ESCs) control the speed of motors. BLHe li-S ECSs are chosen for compatibility of protocols.

Requirement	Verification
Control the speed of motors	Works successfully in QGround control simulation.

2.3 visual functions

In our drone construction process, we also added visual functions to the drone. This function mainly consists of a Raspberry Pi PCB board, a USB camera, and a communication module based on a SIM card. Below, we will elaborate on the following points.

2.3.1 Rasperry Pi(3B) in evtol drone



1. Controller
Raspberry pie can serve as the main controller of drones, responsible for processing flight control logic and responding to remote control commands. It can be used in conjunction with flight control boards (such as Pixhawk) to achieve more complex flight modes and automatic navigation functions.
2. Real time video transmission
Using its USB interface, Raspberry Pi can connect to a USB camera, capture real-time video, and transmit it back to the ground station via wireless network, providing the operator with a first person view (FPV) or video monitoring.
3. Data collection and processing
Raspberry pie can connect multiple sensors (such as GPS, barometer, temperature sensor, etc.) to collect various data during flight. These data can be used for flight log recording, environmental monitoring, geographic information system (GIS) data collection, etc.
4. Artificial Intelligence and Image Processing
Raspberry pie has the ability to process images and run lightweight artificial intelligence models. This can be used for real-time target recognition, tracking, and

obstacle avoidance, enhancing the autonomous flight capability of drones.
5. Communication and network functions
Raspberry Pi supports Wi Fi and Bluetooth communication and can be used for remote control and data transmission of drones. In addition, Raspberry Pi can also achieve network communication with other drones or ground stations, supporting complex collaborative tasks and group flights

2.3.2 USB connected micro camera

Raspberry pie combined with a USB camera can build a low-cost and powerful video surveillance system. Using software like Motion can achieve motion detection, video recording, and real-time streaming functions. In the project, USB cameras can serve as the "eyes" of robots, helping them navigate, avoid obstacles, and recognize specific objects or signs. This is particularly important for the development of autonomous guided vehicles, drones, or other types of autonomous robots. Our drone will primarily use the mjpg-streamer module for video communication and OpenCV Python code training for deep learning, ultimately achieving object recognition functionality

2.3.3 SIM card communication module

After possessing the above hardware, our visual system can now broadcast videos on the same LAN, but we still need a self-built communication module to simulate communication functions in real environments.
We choose to independently build a communication module based on SIM cards. The main function of connecting SIM cards to Raspberry Pi to build a network module in communication is to provide mobile network access capability for Raspberry Pi. This

setting can expand the functionality of Raspberry Pi, allowing for data transmission and communication without traditional wired networks such as Ethernet or Wi Fi.
The most important functions are data transmission and Remote control. Raspberry pie can send and receive data through mobile networks, which is very useful for remote monitoring and management systems. It can remotely log in to Raspberry Pi, execute commands, or update configurations from anywhere in the world through a mobile network.
In addition, having a SIM card communication module can even provide communication and data services. For example,
SMS service: The SIM card module allows Raspberry Pi to send and receive SMS, providing another form of communication for certain applications.
Voice call: Some SIM card modules also support voice calls, and Raspberry Pi can be used as part of the phone system.
The raspberry pi can even act like a phone.

2.3.4 Implementation of video live streaming

Setting up a camera for live streaming on Raspberry Pi can be achieved through various methods, and our approach is to use mjpg streamer. Since mjpg streamer is not in the standard repository of Raspberry Pi, we will compile it from the source code.
After compiling and installing mjpg streamer, it can be run to start the video stream, and the video stream can be obtained by agreeing to access the Raspberry Pi IP through the still and configured access on the local area network.

As a lightweight video streaming service software, mjpg streamer has the following advantages:
Low latency: mjpg streamer streaming servers have lower latency during the streaming process, which is crucial for applications that require fast response, such as remote control or monitoring.

Lightweight: As it is written in C language, it is relatively lightweight, occupies less system resources, and is suitable for running on resource limited devices, such as Raspberry Pi.
High compatibility: Supports multiple types of USB cameras and operating systems, which means you can use it on different hardware and software configurations.

2.3.5 Rental and video uploading of cloud platforms

In this step, we will first rent a cloud platform, such as Alibaba Cloud or Huawei Cloud. Then configure video capture and encoding settings. For example, we will use FFmpeg to encode the video stream into a format suitable for Internet transmission. Configure the transmission of video streams according to the requirements of the cloud platform. This may involve setting specific protocols (such as RTMP or HLS) and the URL of the flow destination. Then start video streaming and use FFmpeg or other tools to capture the video and transfer it to the cloud platform. The final step also involves processing and distribution on the cloud platform. This may include video analysis, storage, and transcoding. We will configure access control and security as needed to ensure the secure transmission and access of video streams.

2.3.6 Use Opencv to complete image recognition

Using OpenCV for image recognition typically involves several steps: video stream acquisition, image preprocessing, feature extraction, and classification or detection. Since the video stream we need to process is stored on the cloud platform, we first need to obtain the video stream from the cloud platform and then use OpenCV for processing.
The method of obtaining video streams from cloud platforms depends on the specific technology of video storage and transmission. Because our video stream is provided through a protocol, we can directly use the URL of the video stream in OpenCV to capture the video. Once the video stream is successfully captured, it can be read frame by frame and processed using OpenCV for image recognition.
The main goal of our project is to achieve object recognition. The function is to identify specific objects in the image, such as faces, cars, animals and plants. Used for obstacle detection in safety monitoring and autonomous driving.
Because obtaining and processing video streams may require higher computational resources, especially when performing real-time video analysis. So we hope to bypass Raspberry Pi and directly recognize OpenCV on the PC port. Simultaneously accessing video streams on cloud platforms may require handling network latency and

bandwidth limitations.
Our biggest problem with image recognition is latency, which is the part we hope to optimize in our subsequent design.

3. Cost

Part	Cost
EPO fuselage and wings	50 RMB
Motors and paddles	350 RMB
Battery	160 RMB
Pixhawk flight control	400 RMB
Remote control and receiver	130 RMB
Rasperrypi	350 RMB
4G-Module	60 RMB
Total	1500 RMB

4. Schedule

Week	Chenyang Huang	Zhengpu Ye	Xuan Chen	Hongfan Liu
2/20/24	Select motors and batteries	Design the circuit of our drone	Search for the resources about resberypi OS	Select the right version of resberypi
2/27/24	Design Bracket	Improve the design with the consider of motors and batteries	Make the plan about the foundation settings about cloud	Select the cloud
3/5/24	Designing Connectors	Select parts of the circuit	Modify the configuration file about camera in OS	Test the camera and network communication
3/12/24	Customized EPO fuselage and wings	Bulid the circuit	Establish the right system of resberypi	Establish the right system of resberypi

3/19/24	Assembling the fuselage	Soldering and adjust parameters of the flight control	Establish the right function of the camera	Establish the right function of the camera
3/26/24	Test Stability	Simlution flight in software	Establish the Cloud	Establish the Cloud
4/2/24	Install the whole drone and test flight	Help installing and test flight	Conbine the resberypi and the 4G module	Establish the 4G communication module
4/9/24	Adjustment of the structure	Adjustmens of the cicuit	Check the data on the cloud	Test the far distance transportation of the data
4/16/24	Customized Carbon Plate Replacement 3D print part	Bulid the improved circuit	Check and improve all the functions on resberypi with 4G& camera	Add the version recognize system to the camera
4/23/24	Help test whole function	Test flight and fix any possible problem	Test all functions work well on the drone	test all functions work well on the drone

5. Ethics and Safety

In strict adherence to the guiding principles and ethical standards outlined in the IEEE Code of Ethics, our organization has undertaken a comprehensive approach to preemptively tackle any potential ethical issues that might arise from the deployment of EVLOT drones within various contexts. Our due diligence encompasses stringent measures throughout different stages of drone involvement, which includes both testing and operational phases.

During the origination and execution of flight trials, along with the active use period of these unmanned aerial systems, we diligently consult and rigorously abide by the latest aviation regulations that govern airspace management and the piloting of drone technology. This ensures that our operations are not only legal but harmoniously integrated with the pre-existing frameworks that ensure the safety and coordination of multifaceted air traffic activities.

Our commitment extends to the incorporation of advanced technological safeguards within our EVLOT drone line. These drones have been meticulously designed to include state-of-the-art safety mechanisms. The obstacle avoidance feature has undergone extensive testing to confirm its reliability in preempting potential collisions during flight operations. Moreover, emergency response protocols have been refined to enable the drone to manage unexpected scenarios effectively. Another pivotal safety component is the automatic return-to-home function, which is activated in instances where the drone's control signals are compromised, ensuring the unmanned craft navigates back to its origin without manual intervention.

In pursuit of environmental stewardship, EVLOT drones have been engineered to operate via electric power, foregoing the reliance on fossil fuels and thus considerably reducing carbon emissions and other pollutants associated with traditional transportation methods. The structural utilization of foam panels substantially lessens the overall weight of the drone, thereby enhancing energy efficiency and further diminishing its environmental footprint.

The protection of user data and personal privacy stands paramount in our design philosophy. The cloud infrastructure, entrusted with the storage and transmission of sensitive information, employs robust encryption protocols. These cryptographic shields are vigorously tested against unauthorized access, guaranteeing alignment with prevailing privacy protection legislation. We conscientiously ensure that all personal data obtained through our drone operations is safeguarded with the utmost respect for confidentiality and integrity, thereby reinforcing the trust placed in us by our users.

Conclusively, the steps we have undertaken to fortify our EVLOT drones transcend mere regulatory compliance; they echo our unwavering dedication to upholding the highest ethical standards, securing the safety of our skies, preserving ecological balance, and protecting the invaluable trust of our customers.

In consideration of maintaining the highest standards of electrical safety, our team has taken a proactive approach by selecting a circuit board that integrates a sophisticated battery management system. This system is pivotal for monitoring and safeguarding the health of the batteries by ensuring proper charging and discharging cycles. Moreover, we have bolstered our safety measures with the implementation of overload protection mechanisms. These are instrumental in preventing potential damages from an excessive inflow or outflow of electrical current. Additionally, our comprehensive safety strategy includes a short circuit protection feature to preempt any risks posed by unintentional circuit bridgings, which can lead to severe malfunctions or even hazards.

Our dedication to safety extends beyond just electrical aspects and into structural considerations. For mechanical safety, our design conforms rigorously to established international or regional safety protocols. We regularly engage in thorough inspections and perform conscientious maintenance to guarantee that this adherence results in long-term reliability and safety. Furthermore, all structural parameters of the fuselage are meticulously calculated to match exacting specifications. Such precise engineering is complemented by an innovative emergency shutdown mechanism. This critical safety feature is devised to enable a rapid cessation of flight operations in exigent circumstances, thereby curtailing potential damage.

Taking lab safety to the next level, we leverage advanced simulation software to foresee and prepare for any operational scenarios the Unmanned Aerial Vehicle (UAV) might encounter in real-world conditions. This preemptive measure entails multiple rounds of virtual testing to mitigate any foreseeable risks before UAVs are physically employed. Our lab test regime escalates from static analyses to dynamic assessments within controlled environments, concluding with full-scale operation tests that are carried out in unenclosed spaces. To further ensure lab safety, our analysts have conducted exhaustive risk evaluations aimed at identifying, managing, and counteracting potential laboratory test hazards, fostering a secure working environment for our engineers and technicians.

Finally, when considering the end-user's safety, our approach is twofold. Firstly, we employ sophisticated software capable of imposing constraints on the UAV such as geofencing, which restricts operation within predefined geographical boundaries. Secondly, by limiting the flight altitude and range through software restrictions, we significantly reduce the incidence of accidents attributable to user error. These measures play a vital role in sustaining operational safety and integrity, providing users with peace of mind while handling our state-of-the-art UAV technology.

6. Reference

[1] ***Design Reference from other product***: *http://www.vrtianxia.com/about/tool/html*

[2]***PX4 control***: *https://github.com/PX4/PX4-user_guide, https://docs.px4.io/main/zh/*

[3] ***IQ Simulations***: *https://github.com/Intelligent-Quads/iq_sim*

[4] ***MAVROS***: *https://blog.csdn.net/caiqidong321/article/details/132013439*

[5] ***Raspberrypi***: *https://zhuanlan.zhihu.com/p/92175850*