ISSN: 2454-9940

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

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www.ijasem.org

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT
ISSN 2454-9940
www.ijasem.org
Vol 18, Issue 4, 2024
https://doi.org/10.5281/zenodo.14065454

FABRICATION OF A DRONE USING APM ADVANCED DEVELOPMENT BOARD

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Abstract.
This **work demonstrates** the development of a **quadcopter** drone **that can track** the **location** of a cert ain area on autopilot. The system includes Ardupilot Mega (APM) 2.8 flight controller, Ublox NEO M8 N GPS module with compass, Racerstar 920kV 2-4S **brushless motor,** Flysky **receiver** FS-iA6B with FSi6 **remote control transmitter, Landing Tool** DJI F450 **Quadcopter Frame Kit Skate board** and **Lithium battery** 3300 mAh 35C. **Ground** control is set up and **operated** through **open sou rce** software **called** Mission Planner. The tracking system **turned into** a **payment system** with BME28 0 **sensor** controlled **by** Arduino Uno R3 SMD. Google Maps **in** Mission Planner **is organized accordin g to** waypoints. The **reading** from the BME280 barometer sensor **is** used to **check** the **accuracy of** the **orientation.** This correction **will** be **important when using** a drone **for delivery.** The results show that the average error **for each orientation** is 5%, **indicating** that **orientation** can be **important in downgr ading the product** for **the customer.**

Keywords: Quadrotor, Ardupilot, Arduino Uno, BME280, Position tracking

1. Introduction

Unmanned aerial systems (UAVs), commonly known as drones, are becoming increasingly popular in modern logistics operations. In recent years, due to the rapid spread of online ordering and the boom in the e-commerce industry, labor demand for shipping operations has doubled. This, coupled with the COVID-19 pandemic, has accelerated the need to find alternative safe and contactless delivery models [1]. Road traffic congestion in urban areas, especially road traffic that is being used beyond capacity, is spurring the development of drone delivery technology. As a result, many retail and logistics industries such as Amazon, DHL, FedEx, Google, PizzaHut, UPS, and Walmart have invested in and used drone technology to implement alternative scalable delivery models [2- 4]. All of the above industries such as Flirtey, Matternet, Volansi, Wing and Zipline are supported by specialized drone suppliers and technology providers. With the advancement of drone technology and increasing commercial use, quadcopters with stable vertical flight capability or VTOL (Vertical Takeoff and Landing) can be used to fly luggage, parcels, fast food, groceries, medical products or other destinations 's product. These drone delivery operations are gaining traction in last-mile delivery due to their improved accuracy, ease of operation, faster delivery times, and lower operating costs [5]. According to analysts, operating costs for drone delivery services are 40% to 70% lower than traditional vehicle delivery service models. This will increase the global demand for drone delivery services and the drone parcel delivery market is currently growing from US$228 million in 2022 to US$5.556 billion in 2030, at a CAGR of 49.0% expected to grow [6].

This research will develop a low-cost drone solution that can be implemented for drone delivery. Many types of drones can be used as delivery drones, including fixed-wing, multi-rotor, and hybrid drones. In this work, we will develop a multi-rotor drone with four motors, a so-called quadrocopter. The advantage of this quadcopter is that it is VTOL ready and does not require a runway for takeoff and landing. Companies like Amazon are using hexacopters to operate Prime Air delivery drones to expand unmanned parcel delivery [7]. Bhardwaj et al. [8] proposes a GPS-equipped quadcopter as a tracking device to locate the consumer and get the live location to deliver the package accurately within the set time. A tracking system consists of a GSM provider, a vehicle or person equipped with a suitable device, a location tracking server, and a client system. Regardless of the type or shape of drone used for delivery, the biggest challenge today is package weight and distance travelled. These two factors are related to battery life, and the average lifespan of drone flight capability is currently only around 10-20 minutes. Innovations are constantly being developed to achieve a battery life of 30 minutes or more, so they are capable to deliver goods weighing between 5 and 30 kg and fly at speeds of up to 100 km/h. For example, there has been a lot of research on building drones for delivery systems, mainly to discover battery power in long-distance deliveries. Park et al. [9], Liu [10], Huang et al. [11] and Hong et al. [12] proposes a battery allocation strategy by opening battery charging stations throughout the city to recharge/replace batteries when the battery supply runs low before the drone reaches its final destination. Regarding drone range due to limited battery power, Huang et al. [13] propose transporting drones on public transport to extend the range of needs met and light. This means that the company's conventional vehicles can be used for backup transportation to reach the final destination.

Suparta and Handayani [14] reported on the development of a quadcopter for atmospheric data acquisition using an APM 2.8 flight controller. This development shows that there are many possible uses for drones, such as photography, transportation, surveillance, or agricultural applications such as for spraying pesticides, fertilizing, etc. This present work is to continue the application of drones [14] for the delivery system of goods. A delivery drone is a type of UAV used to deliver packages and goods to consumers, as long as the delivery system process complies with existing aviation regulations. The drone's height and range (distance) from the ground are the main criteria in the drone's flight space. On the other hand, this paper discusses the development of quadcopter for goods delivery. In particular, this work proposes and tests a quadrocopter for depositing goods at specific locations. This point is the coordinate of the customer picking up the goods. To highlight the development of drone delivery systems, this whitepaper is divided into four sections: Section 2 provides materials and methods for developing a quadcopter. Section 3 describes experiments, measurements, and how the system works. Section 4 completes the work.

2. Materials and Methods

A drone can be said to be functional if it can fly stably and maneuver according to the conditions desired by the pilot. To achieve this goal, it is necessary to select components with good quality and certain specifications for drone delivery. Table 1 shows the selection of basic components and their functions in producing optimal drone performance.

Table 1. Selection of drone components and their function

No.	Component	Physical	Function
1.	Ardupilot APM 2.8		The ultimate flight controller of the entire drone operating system

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https://doi.org/10.5281/zenodo.14065454
ISSN 2454-9940
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Vol 18, Issue 4, 2024

No.	Component	Physical	Function
2.	Ublox NEO M8N GPS module with compass and stand		A module equipped with a compass to determine the vehicle's position with respect to the earth. This module helps the vehicle find its way back to the starting position if communication is lost. Drones cannot work autonomously without GPS.
3.	ESC brushless hobbywing skywalker 20A 2s-3s		An electronic circuit that controls and regulates the speed of an electric motor (in this case is a BLDC)
4.	BLDC Racestar BR2212 920KV		It is used to convert electrical energy which diverts DC current to the motor windings to generate a magnetic field and turn into mechanical energy to rotate the propellers
5.	Power module for APM/Pixhawk		This is a module to provide the net power of the LiPo battery as well as the current and voltage consumption of the battery required by the flight controller
6.	LiPo battery 3s 3300 mAh 35C		LiPo battery for powering circuits in the drone
7.	F450 quadcopter kit frame with high landing gear skid		To put all components including payload where there is also a power distribution board (PDB)
8.	2 pairs propeller (9450) DJI model		To generate lift by creating a pressure difference between the top and bottom surfaces of each propeller
9.	Dumper anti vibration controller (shock absorber)		To place the flight controller so that it is free from shock due to strong winds, flight failure, or possibly flight accidant
10.	FlySky remote control FS-i6 (transmitter)		This is a flight control device from ground control and is connected to a receiver on the drone with a 2.4 GHz frequency.
11.	Flysky 2.4GHzFS-iA6B Receiver		This is a 6-channel receiver that sits on the drone and communicate with the RC FS-i6 set up via binding process
12.	Mission Planner Firmware		Mission Planner is a ground control station for Planes, Copters and Rovers. It can be used as a configuration utility to make the vehicle autonomous

This is a DIY drone in the form of a quadcopter. After selecting the main components needed, the drone is assembled as shown in Figure 1. The drone is then set up via the Mission Planner tool to synchronize the drone as autopilot. Calibration and settings can be done in the Mission Planner menu as input controls. If all calibration steps have been carried out and the drone is ready for autopilot, it can be tested to fly, hover, and maneuver. Figure 2 shows the steps of how the drone developed in this present study. The operation of a drone is controlled by remote control (RC) from the ground station.

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The signal transmitted by the RC is received by the receiver on the drone and activates the propulsion system. This signal drives the BLDC through the Electronic Speed Control (ESC) and finally rotates the propeller. As shown in Figure 1, the Barometric sensor using BME280 is attached to Arduino Uno to measure the altitude of vehicles during fly from the mean sea level. This reading compared with the setting value from waypoints determined using Google Maps. The similarity of this position will be used as a reference point of coordinates to drop off goods to the customer.

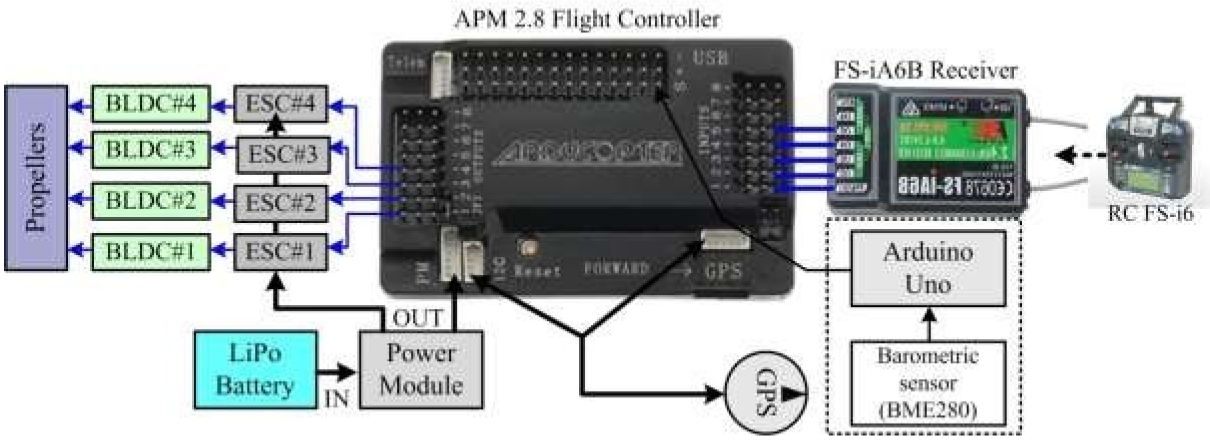

Figure 1. Basic quadcopter system developed for delivery using APM 2.8 flight controller

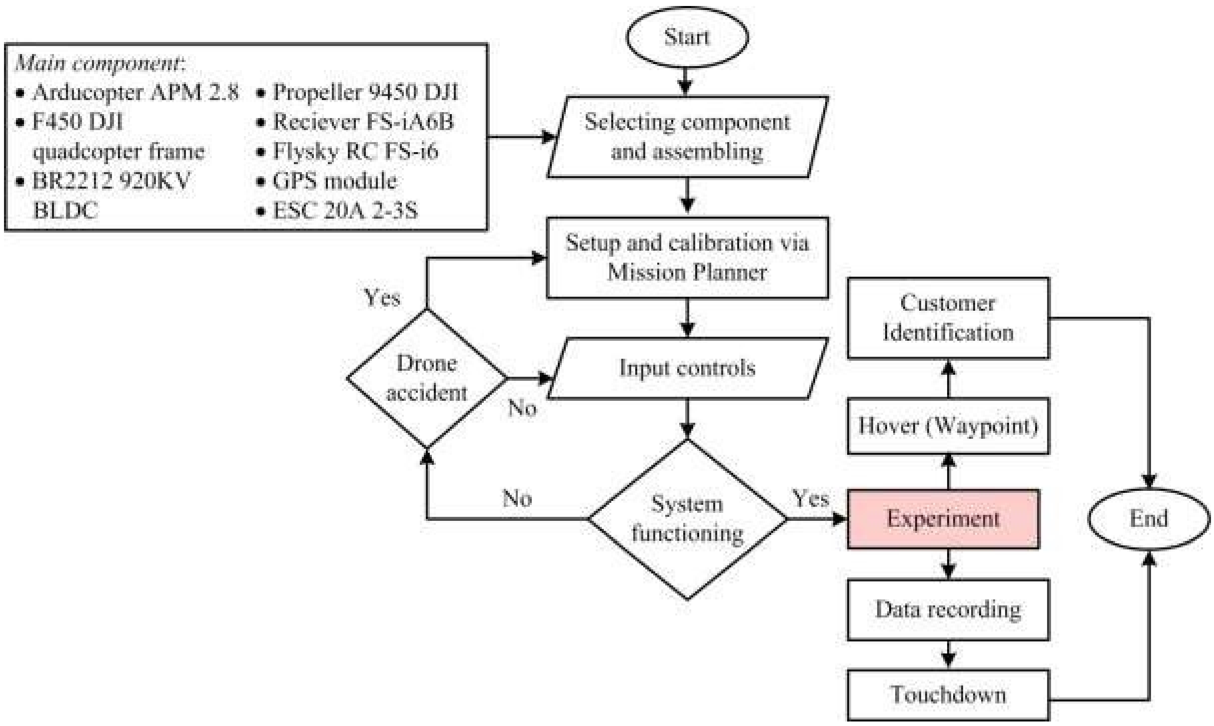

Figure 2. Block diagram of quadcopter control system design for drop-goods identification

The functioning of a drone system is a crucial point before implemented to conduct experiments, collect data, and test the stability of the quadrocopter in various maneuvers. Configuration is done via Mission Planner using firmware MissionPlanner-1.3.77.msi [15]. APM 2.8 firmware uses an improved firmware version of AC 3.2.1 (https: //firmware.ardupilot.org/Copter/stable-3.6.1/apm2-quad) is the last version of APM 2.8 before upgrading to the Pixhawk version. We recommend readers refer to [14] for how to set the quadcopter

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ISSN 2454-9940
www.ijasem.org
Vol 18, Issue 4, 2024

on autopilot. Developing a delivery drone requires self-managing quadcopters. This can be done by setting Flight Mode to Auto on one of the FS-i6 transmitter channels. Next, create a waypoint as the delivery drone route from the mission planner plan menu. Coordinates for goods delivery can be determined from this route. This coordinate point is known as the Customer ID.

3. Results and Discussion

After the drone function properly, it was first launched and tested on June 15, 2022, at 04:48 PM West Indonesian Time and is able to fly stably as shown in Figure 3. Before being able to hover as in Figure 3(b), the drone has been configured to work autonomously. Autonomous can be done through flight mode settings where SWB on RC (Flysky transmitter) is switched to 2 as Auto mode.

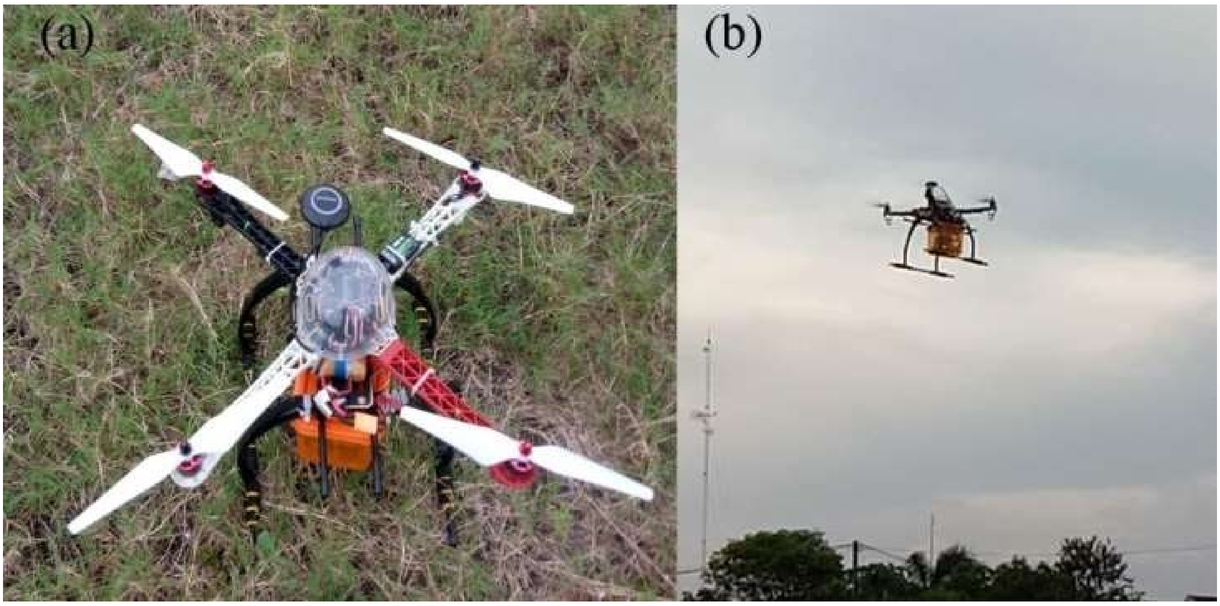

Figure 3. Unedited photos (a) standby before take-off and (b) successfully fly stable and hovered

For drone delivery purposes, a waypoint method is implemented via the plan menu in the mission planner. The purpose is to plan the route from when the drone takes off, to unloading the goods at a specific coordinate point, and then when the drone returns to the starting point. The routes and coordinates created in this first experiment are shown in Fig. 4. The experimental locations with starting points (HOME – H) are located in the Tajem Baru area, Maguwoharjo, Depok, Sleman Regency, Special Region of Yogyakarta, Indonesia (latitude: 7° 44' 48.92" S, longitude: 110° 26' 22.26" E and Altitude of 174.58 m ASL. As shown in Figure 5, point 6 is the coordinate position where the drone begins dropping the package to begin preparation (parachute) for loading. If the waypoints are set as shown in Figure 5 (bottom), the quadcopter will appear unstable during the DO_PARACHUTE command. The instability may be due to the wind generated around the drone. Assuming the wind does not affect the correct coordinates for the drop, additional commands such as DO_CHANGE_SPEED should be given before and after the parachute or package drops. In this case, changing the drone's speed and direction to the next waypoint before the RTL (Return To Launch) point seems stable. This assumption was tested in the second test on June 26, 2022 at 05:47 AM with the same starting position and route as the first test. As a result, the drone showed high stability while unloading the goods. The flight payload is 2.1 kg including the drone's own weight. Table 2 shows the comparison results.

https://doi.org/10.5281/zenodo.14065454

Figure 4. Setting waypoint of drone for drop-off goods during testing steps

Overall, three times experiment was carried out in this limited range, and the measurement results were presented in Table 2. With a total distance of about 0.1714 km, the average time required was about 2 minutes. In addition to the parachute method, the drone can also be tested by setting to perform a gripper at any waypoints depending on the mechanical equipment that will be installed on the drone to unload the goods. Servo motors can be used to manage or control the movement of goods dropping. Unloading goods can also be carried out by drones with temporary landings within a certain set time. In other words, if an unknown location to drop the goods is impossible, drones can drop goods on a company vehicle or truck, and then the vehicle can deliver the goods to the recipient's address. To drop goods if there is a field to land, it is provided about 30 seconds with a height of 10 m from the earth's surface. With this condition, the previously notified customer is ready on the spot to receive the parcel, goods, food, or other groceries. To drop the goods to the recipient and there may be an area or field for landing, about 30 seconds for altitude hold is provided with a height of 5 m from the land. With this condition, customers who have been notified in advance are ready on the spot to receive parcels, goods, foods, or other groceries. On the other hand, if the location for dropping the goods is not possible, the drone can drop the goods on the deck of the company vehicle or truck, and then the vehicle can deliver the goods to the recipient's address.

The results showed that the average error between the barometer reading and the data provided by Google Maps at each waypoint was 13.97% and 10.77% for Scenario I and Scenario II, respectively. The main difference to produce errors is caused by wind conditions which change with time at that location. In other words, the time required for the drone to deliver the goods depends on the weight of the goods themselves and the route or path chosen. As shown in Table 2, at points 6 and 7 where the drone's height is set to 5 m on the Google Map, it turns out that the drone cannot descend to that height, but is still around a height of 10 m. If the drone is forced to descend at a height of 5 m, it will fall. From this case, it can be concluded that if we want to drop goods where the drone does not land, the height of dropping the goods to the recipient is about 10 m from the Earth's surface.

Table 2. The measurement result for dropping goods from drones

Waypoint				Barometer (reading in meter)		
Point	Latitude (Deg)	Longitude (Deg)	Altitude (m)	Scenario I (DO PARACHUTE)	Scenario II	Remarks
2	-7.74701	110.4395	15	17.23	16.55	Ok
3	-7.74705	110.4393	20	26.25	21.33	Ok
4	-7.74701	110.4390	20	19.98	20.21	Ok
5	-7.74697	110.4389	20	21.23	21.67	Ok
6	-7.74686	110.4389	5	10.27	10.45	Not Ok
7	-7.74686	110.4389	5	12.36	10.00	Not Ok
8	-7.74686	110.4389	20	22.12	21.88	Ok
9	-7.74674	110.4393	20	18.75	19.77	Ok
10	-7.74679	110.4393	15	14.56	15.04	Ok

Note: Scenario I (as in Figure 5), Scenario II (with DO_CHANGE_SPEED before and after in Point 7)

4. Conclusion

A product delivery drone design using Arducopter APM 2.8 has been successfully implemented. The drone works well and can be programmed automatically using the waypoint method. The test results are still simulations as we are not using any sensors or controllers in the form of real servos. The new system has been tested using barometric pressure sensors to confirm shipping and receiving coordinates. In this regard, it is emphasized that the goods can be sent to the programmed location points if the system can function automatically. As a result, the drone can reach coordinates with an accuracy of almost 90%. An external factor that affects this accuracy is the wind speed when the package is dropped. Drones that are too light or loaded beyond the drone's built-in capacity tend to be easily blown away by strong winds. For further research, cargo drones should be prepared in such a way as to transport the goods/packages to their intended destination in an environmentally friendly manner. Either in the form of a box where the drone lands and the goods can be picked up by the recipient, or the package is dropped at a height of 10 meters using servo motors or other controls. To increase the stability of the drone and allow it to fly within a certain range, it is recommended to use a hexacopter, which can fly farther and carry more weight.

Acknowledgments

The author would like to thank the ITNY leadership for the conference funding support provided through CONSER 2022.

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https://doi.org/10.5281/zenodo.14065454
ISSN 2454-9940
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Vol 18, Issue 4, 2024

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