Development of Unmanned Aerial Vehicle (UAV) Fixed-Wing for Monitoring, Mapping and Dropping applications on agricultural land

ML Hakim¹, H Pratiwi², AC Nugraha¹, S Yatmono¹, ASJ Wardhana¹, ES Damarwan¹, T Agustianto², S Noperi²

¹Electrical Engineering Education Dept., Universitas Negeri Yogyakarta, Indonesia
²Mechanical Engineering Education Dept., Universitas Negeri Yogyakarta, Indonesia

E-mail: luthfihakim93@uny.ac.id

Abstract. UAV technology is used in various fields, namely the military, to strengthen defence, surveillance, dropping logistics. In addition, UAV applications are also used in agriculture. In this study, a fixed-wing UAV will be developed as a monitoring, mapping and dropping process. Several things were carried out in the development process, namely design, manufacturing, installing electronic components, and test flights. The results showed that the vehicle could carry out the mission well. The monitoring process is carried out to review land security. Besides that, it can monitor if there is a fire in agricultural land. In the mapping process, photo data processing taken in the context of the mapping is carried out into an orthophoto map. Meanwhile, in the dropping stage, the aircraft managed to drop a payload weighing 0.5 kg with a distance of 20m from a predetermined centre point. The dropped payload is also equipped with a parachute for increased safety and reduced speed when the payload is dropped.

1. Introduction
An Unmanned Aerial Vehicle (UAV) is a generic aircraft designed to operate without a human pilot. In recent years, unmanned aerial vehicle technology has developed very rapidly. Applications of UAVs are used in the fields of industry, agriculture, military, and others. UAV can also be used as a monitoring and mapping technology. Based on research conducted by Nugroho et al. on the use of UAVs to monitor and map disaster areas, it resulted in 3 conclusions: settlements at risk of tsunamis, no evacuation routes, and no green zones around the coastline [1]. In some cases, UAV technology is also used for monitoring access to high-risk locations [2].

Unmanned Aircraft Vehicle (UAV), which has remote sensing instrumentation, can be utilized in disaster situations. When the UAV obtains photogrammetric data with appropriate image metadata, the UAV's capabilities for disaster management can be further implemented. Another application is for volcano monitoring and coastal monitoring using unmanned aerial vehicles [3]. Xi Wang also researched the use of UAVs to monitor hazardous environments, where experimental results show that the probability of UAVs completing missions in dangerous environments is higher than in operator mode within a specific time [4].
UAV technology is applied in various fields, namely the military, to strengthen the defence, as surveillance, dropping logistics. In addition, in the civil sector, UAVs are used in the agricultural sector, namely for monitoring, mapping and shipping goods [5]. Research on the application of drones was also carried out by Hakim et al., namely using drones to deliver goods for Covid-19 patients [6]. In this study, we will discuss the role of UAVs to support agricultural processes, namely for monitoring agricultural land, mapping the area, and shipping goods.

2. Method
This research on the application of UAV as monitoring, mapping, and dropping was conducted in Pracimantoro, Central Java, Indonesia. Furthermore, several stages were carried out to make the UAV, namely the design process, manufacturing, installation of electronic components, and flight tests, as shown in Figure 1.

![Figure 1. UAV manufacturing flow](image)

The next step is to determine the dropping area, where the location is 5 km from the initial location or the location of the Ground Control Station (GCS). The UAV will fly towards the dropping zone with an autopilot system; during the flight process towards the dropping, the camera will take photos and videos for monitoring and mapping purposes. After arriving at the waypoint, the UAV will drop the payload at a predetermined location, or what we know as dropping. The weight of the payload used is 0.5 kg. Figure 2 shows an illustration of the flight mission of a drone.

![Figure 2. Illustration of a drone flight mission](image)

3. Manufacturing
Making a UAV aircraft consists of several stages: design, manufacture of aircraft parts, installation of electronic circuits, and assembling into an aircraft vehicle that can fly.

3.1. Design
At the design stage, simulations were also carried out to know the system analysis and modelling, operation data collection and observation data analysis. According to Pei-Hsiang Chung, the design process is used to
determine performance requirements, including stall speed, cruising altitude, maximum speed, absolute ceiling, and turning radius and speed [7]. The dimensions of the UAV aircraft are 2m long and 1m wide. The type of aircraft used is a twin-boom. Twin-boom aircraft have the advantage of having high efficiency; a double boom can distribute the load along the wingspan and strengthen the overall structure. Twin booms also have flexibility in setting the centre of gravity (CG) of the load so that the aircraft's performance will be equal to or without payload. The twin-boom design also has high stability due to the flat bottom airfoil design. Figure 3 shows the design of the aircraft used. The design of the aircraft is made aerodynamic so that it makes the aircraft more energy efficient. The twin-boom also has high stability due to its flat bottom airfoil design.

Figure 3. Airplane Design

3.2. Manufacturing of aircraft parts
Making parts of the aircraft vehicle is done using a CNC machine to drive the vehicle precisely or close to the design drawing. The material used for the manufacture of the aircraft is rigid foam and coated with fibre and carbon fibre so that the aircraft is stronger and not easily destroyed when a crash occurs. The production methods we use are moulding and layup. You will get a sturdy and lightweight frame with the moulding method because a little resin is used, but it is enough to make the body sturdy. Figures 4 and 5 are the wings and fuselage that have been made using high-density rigid foam.

Figure 4. Airplane Wing
3.3. Electronic circuit installation
The vehicle is equipped with an autonomous system that can carry out missions outside of take-off and landing. The rides use batteries as a power source. The specifications for the electronic components of the UAV include a brushless electric motor and radio control system (transmitter and receiver) with a frequency of 433 Mhz, telemetry with a frequency of 433 MHz with a maximum power of 200 mW and a video transmitter with a frequency of 5.8 MHz with a maximum capacity of 1W. Figure 6 shows the process of assembling an electronic circuit with aircraft components.

3.4. Airplanes
Figure 7 is an aircraft vehicle that is ready for a flight test. The aircraft can carry out flying missions well. Furthermore, the aircraft can carry out the process of monitoring, mapping and dropping on agricultural land.
Figure 7. Aircraft rides

4. Results and Discussion

4.1. Monitoring
UAV applications for monitoring systems have been widely used globally. Several examples of the use of monitoring technology have been carried out by Shults, namely for monitoring warehouse development [8]. This technology is used to monitor the warehouse excavation work process. The monitoring process is carried out to review land security; besides, it can watch a fire in agricultural land. Figure 8 shows the results of monitoring from the aircraft vehicle.

Figure 8. Results of monitoring aircraft rides

4.2. Mapping
The use of mapping techniques using unmanned aircraft has several advantages: mapping that is more accurate than using satellite imagery [9]. Mapping techniques are also very effective in terms of costs and time required. In general, the mapping technology concept consists of planning, installation of GCP (ground control point), data acquisition, data processing, reporting. Figure 9 shows the mapping results from the aircraft, and the mapping process is taken as far as 5 km.
4.3. Dropping

In the dropping stage, the aircraft will drop a payload weighing 0.5 kg. In order to increase the safety of the dropped payload, the payload is parachuted to reduce the speed of the payload as it falls. The development of this research can also be used to send packages in quarantine areas for the Covid-19 infectious disease epidemic. This is done to ensure that monitoring activities and delivery of aid packages can be carried out quickly and effectively, which is expected to reduce the risk of disease transmission to other areas and aid workers. In addition, package delivery using UAV technology can be used to deliver fertilizer to agricultural land.

5. Conclusion

The research results on the development of unmanned aerial vehicle (UAV) fixed-wing for monitoring, mapping and dropping applications on agricultural land show that the vehicle has been able to carry out all missions well. The monitoring process is carried out to review land security; besides, it can monitor a fire...
in agricultural land. In the mapping process, photo data processing taken in the context of the mapping is carried out into an orthophoto map. Meanwhile, in the dropping stage, the aircraft managed to drop a payload weighing 0.5 kg at a distance of 20m from a predetermined centre point. The dropped payload is also equipped with a parachute for increased safety and reduced speed when the payload is dropped.

References

[1] G. Nugroho, Z. Taha, T. S. Nugraha, and H. Hadsanggeni, "Development of a Fixed Wing Unmanned Aerial Vehicle (UAV) for Disaster Area Monitoring and Mapping," J. Mechatronics, Electr. Power, Veh. Technol., vol. 6, no. 2, pp. 83–88, 2015, doi: 10.14203/j.mev.2015.v6.83-88.

[2] V. Baiocchi, D. Dominici, and M. Mormile, "UAV Application in Post–Seismic Environment," Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci., vol. XL-1/W2, no. September, pp. 21–25, 2013, doi: 10.5194/isprsarchives-xl-1-w2-21-2013.

[3] S. M. Adams and C. J. Friedland, "A survey of unmanned aerial vehicle (UAV) usage for imagery collection in disaster research and management BT - 9th international workshop on remote sensing for disaster response," vol. 8, no. February, 2011.

[4] X. Wang, C. OuYang, XianglingShao, and HuiXu, "A method for UAV monitoring road conditions in dangerous environment," J. Phys. Conf. Ser., vol. 1792, no. 1, 2021, doi: 10.1088/1742-6596/1792/1/012050.

[5] M. R. Sirojuddin, S. B. Wibowo, and G. Nugroho, "Perancangan dan Pengujian Terbang Pesawat Tanpa Awak Lokeswara," Semin. Nas. Inov. dan Apl. Teknol. di Ind., pp. 334–338, 2019.

[6] M. L. Hakim, S. Yatmono, A. C. Nugraha, and M. Khairudin, "The Effects of Vertical and Horizontal Distance on the Performance of QR Code Detection System," J. Phys. Conf. Ser., vol. 1737, no. 1, 2021, doi: 10.1088/1742-6596/1737/1/012029.

[7] P. H. Chung, D. M. Ma, and J. K. Shiau, "Design, manufacturing, and flight testing of an experimental flying wing UAV," Appl. Sci., vol. 9, no. 15, 2019, doi: 10.3390/app9153043.

[8] R. Shults, K.-K. Kassymkanova, S. Burlibayeva, D. Skopinova, R. Demianenko, and Y. Medvedskyi, "UAV Monitoring of Excavation Works," 11th Int. Conf. Environ. Eng. 11th ICEE Sel. Pap., no. July, pp. 0–6, 2020, doi: 10.3846/enviro.2020.696.

[9] S. Sugeng, R. A. Putra, R. F. Muslim, and Y. Septianto, “Unmanned Aerial Vehicle (UAV) for Mapping Plantation Area,” Telekontran J. Ilm. Telekomun. Kendali dan Elektron. Terap., vol. 7, no. 1, pp. 79–89, 2019, doi: 10.34010/telekontran.v7i1.1642.