JCI
Jurnal Cakrawala Ilmiah
Vol.4, No.4, Desember 2024

DESIGN AND DEVELOPMENT OF A STEALTH UNIC FOR SILENT OPERATION WITH ESP32-BASED AUTONOMOUS CONTROL

Oleh
Nur Rachman Supadmana Muda[1], Hasby Fajrus Shodiq[2]
[1,2]Politeknik Angkatan Darat
E-mail[1]: nurrudal@gmail.com

Article History:
Received: 06-11-2024
Revised: 21-11-2024
Accepted: 18-12-2024

Keywords:
Silent Drone, Stealth, Autonomous Navigation.

Abstract: *This research aims to design and build a stealth kamikaze drone for Silent Operation, named Unic, with an autonomous control system. In a modern context that increasingly emphasizes military technology, the existence of drones capable of conducting precision attacks without detection has become essential. This drone is designed to target enemy objectives with the aim of effectively detonating targets without being detected. The design process includes the selection of key components using ESP32, the development of autonomous navigation algorithms, and the integration of secure communication systems. In terms of stealth, the drone is equipped with silent-designed brushless motors that produce noise levels below 25 dB to reduce the likelihood of being heard from a distance. This research also includes performance testing of the drone in simulated scenarios, focusing on maneuverability, navigation accuracy, and stealth capabilities to avoid radar detection and other surveillance systems. Test results show that Unic can perform autonomous flights with high accuracy, optimizing stealth to evade radar and sound detection. These findings are expected to contribute to the development of military drone technology and enhance the effectiveness of national defense strategies. Future research will focus on improving sensor capabilities and anti-jamming systems to support operations in complex environments.*

INTRODUCTION

In military technology has become an important aspect of a country's defense strategy. The use of drones for various military needs, including reconnaissance and precision strikes, has increased significantly. However, the challenges of maintaining the security and effectiveness of drone operations, particularly regarding the risks of detection and counterattacks, remain a primary concern. One effort to address these challenges is through the development of stealth drones with anti-detection capabilities and autonomous control.

This research aims to design and build a stealth kamikaze drone in a fixed-wing configuration, named Unic, equipped with an autonomous control system and designed to avoid detection through anti-airdump techniques. This drone is constructed using radar-absorbing materials previously researched to minimize radar wave reflections, thereby enhancing its stealth capabilities. To reduce noise that could reveal the drone's presence, the motor system is fitted with sound dampeners made from special acoustic-absorbing materials. These dampeners reduce the noise level of the brushless motors to below 40 dB, making it difficult to detect by hearing from a distance and allowing Unic to approach its target more quietly.

The drone is also equipped with an advanced navigation system based on the ESP32, which functions to automatically manage input and output systems. By using an Inertial Measurement Unit (IMU), the drone can determine its position and maintain balance with respect to Yaw, Pitch, and Roll angles, ensuring stability during flight. Unic is designed to reach its targets with high precision without being detected. The research process includes component selection, the development of navigation algorithms, integration of secure communication systems, and performance testing in simulated scenarios, particularly regarding stealth capabilities, maneuverability, and noise resilience.

Materials

Unic is designed using high-quality components that support stealth capabilities and autonomous operations to enhance the effectiveness of precision strike missions. The drone's frame is made from Radar Absorbing Material (RAM), which is capable of absorbing radar waves, thereby minimizing reflections and improving the drone's stealth capabilities to avoid detection by enemy radar. As the main control system, the ESP32 microcontroller is used to autonomously manage all input and output functions. This microcontroller supports secure wireless communication and is compatible with various sensors and actuators, ensuring full control over each component of the drone.

Figure 1. ESP 32 Microcontroler

Figure 2. Motor F40 PRO

For propulsion, the drone is equipped with T-Motor F40 PRO brushless motors, known for their high speed and optimal thrust efficiency, allowing the drone to achieve the speeds required for kamikaze missions and to support the heavy load of components and explosives.

These motors are paired with T-Motor CF Series silent propellers, specifically designed to reduce noise to an optimal level. This type of propeller features an aerodynamic blade shape that significantly decreases sound during rotation, enhancing the drone's stealth capabilities with minimal noise levels.

The navigation system of the drone uses the BerryGPS-IMU V4 module, a GPS that ensures accurate position determination and target location, enabling precise strikes according to specified coordinates. To maintain stability during flight, the drone is also equipped with an Inertial Measurement Unit (IMU) that includes an accelerometer and gyroscope, which work in real-time to stabilize the drone's position and maneuvers with precision.

Figure 3. GPS-IMU

As Shown in Figure 3. GPS IMU, for real-time monitoring and surveillance, this drone is also equipped with a camera that has a video sender and video transmitter to transmit images and videos directly from the operational area to the control center, providing operators with an accurate view of the terrain.

Figure 5. Video sender and receiver

As a power source, the drone uses a small yet high-capacity Li-Po (Lithium Polymer) battery, enabling flight times of over one hour. The battery's endurance is crucial for supporting the drone in long-range operations.

Figure 6. Longrange fpv Camera

The longrane fpv camera is used on the drone to see the target from a distance, so that the operator can point the drone at the target precisely and accurately. The drone is also equipped with a LiDAR sensor that aids in autonomous obstacle detection and avoidance, emitting laser beams to measure the distance and size of surrounding objects so that the drone can maneuver around barriers without manual intervention. To trigger the explosives, this drone is equipped with a Load Cell sensor that acts as a detonator upon reaching the target, ensuring that the explosion occurs at the precise moment according to the mission scenario.

Unic carries 3 kg of explosives that can produce a blast radius of up to 2 km, providing a significant destructive impact on the target. With the selected components, this drone can reach its targets with high precision, stability, and stealth capability, making it an effective tool for kamikaze missions that require maximum destructive power in the target area.

METHODS

This research was conducted through several main stages, namely design, construction, testing, and performance evaluation of Unic. The first stage, design, involved selecting components that support the stealth and autonomous performance requirements of the drone. The main components used include a frame made of Radar Absorbing Material (RAM) to avoid radar detection, the ESP32 as the autonomous control system, and T-Motor F40 PRO brushless motors to support high speed and thrust. To enhance stealth capabilities, the drone is equipped with T-Motor CF Series silent propellers, designed to reduce operational noise, as well as sound dampening systems using special acoustic-absorbing materials, allowing the overall noise of the drone to be reduced to below 5 dB. The propulsion system of the drone consists of T-Motor F40 PRO brushless motors, known for their high speed and optimal thrust efficiency. These motors allow the drone to achieve the necessary speed for kamikaze missions and support the heavy load of components and explosives. To reduce the noise generated during flight, the drone is equipped with T-Motor CF Series silent propellers. These propellers have an aerodynamic design that significantly reduces air turbulence and noise. Additionally, to further optimize stealth capabilities, the drone is also equipped with a sound dampening system using special acoustic-absorbing materials, such as acoustic foam and composite materials, strategically placed to minimize operational noise to below 35 dB. This makes the drone harder to detect by both radar and human hearing. The construction stage includes the integration of these components into the drone's design. This process is conducted carefully to ensure that each component is properly installed and functions optimally. The drone is assembled according to the design, paying attention to the layout of components to achieve optimal stability and efficiency during flight. During this stage, the autonomous navigation algorithm supporting anti-detection capabilities is also developed and implemented on the ESP32 control system, configured to communicate with other components such as GPS, IMU, and the camera for real-time monitoring. Next, performance testing of the drone is conducted in various simulated scenarios. Testing includes maneuverability tests to measure the agility and ability of the drone to avoid obstacles, battery endurance tests to ensure flight times of over one hour, and stealth capability tests to verify the effectiveness of RAM and anti-airdump systems in avoiding radar detection. This testing also includes evaluating the effectiveness of the noise dampening system in suppressing sounds produced during flight. Noise testing is conducted by measuring the decibel (dB) level of the sound produced by the drone during operation, using sound measuring equipment to ensure that the noise level remains below the threshold detectable by listeners from a distance. The data generated during this testing is crucial for assessing the extent to which the drone can operate quietly without being detected. During the design stage, the drone's electronic circuit diagram is designed to show the main connections between components such as T-Motor F40 PRO brushless motors, the ESP32 control system, the GPS module, and the IMU sensor. This diagram illustrates the flow of power and signals between components, facilitating an understanding of the interactions and roles of each part within the system.

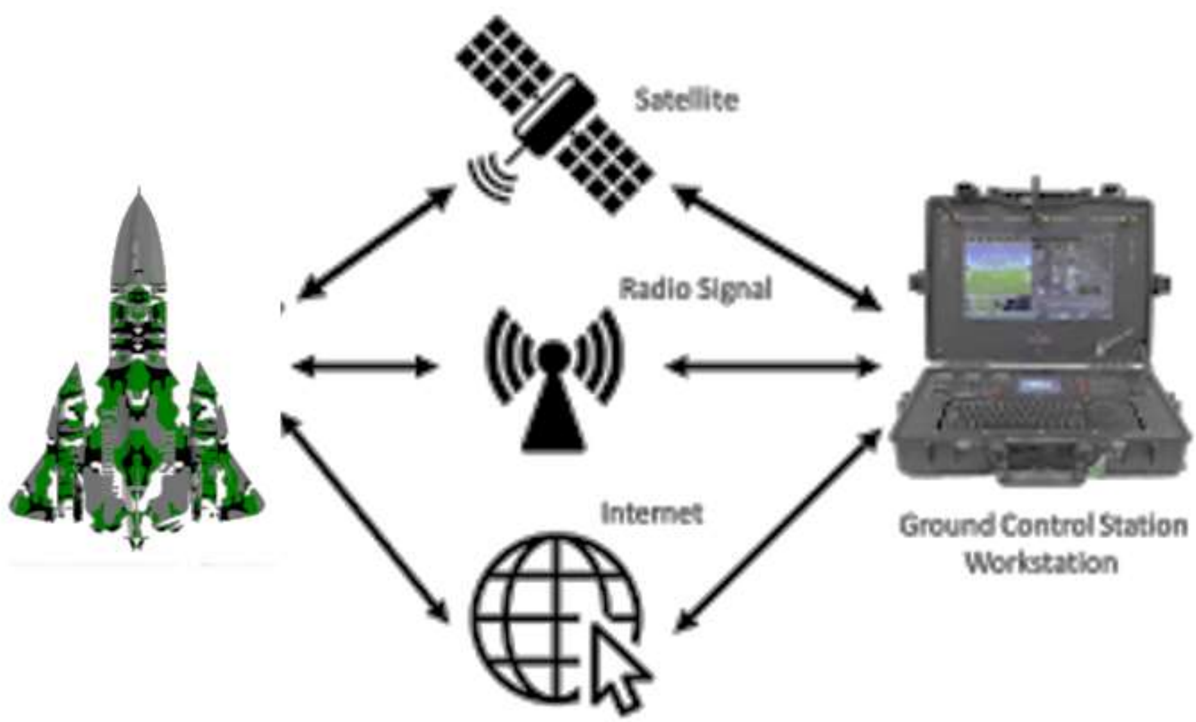

Figure 7. Circuit Diagram of the Kamikaze Drone

As shown in Figure 7, the diagram of how the unic kamikaze drone works is based on the operator's control at the ground control station and can also be controlled on autopilot.

In addition, a flowchart of the system has been created to illustrate the workflow of the autonomous control in the drone. This flowchart includes the processes of device initialization, data collection from the GPS module and IMU sensor, processing by the ESP32, and decision-making control to direct and stabilize the drone. The presentation of this flowchart provides a clear visual guide to the control steps implemented in the drone's operations.

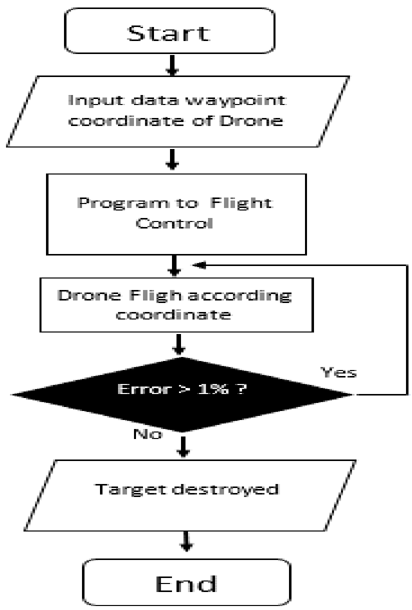

Figure 8. Flowchart of Uniqe Drone Action

The final stage is performance evaluation, where the testing results are analyzed to assess the effectiveness of the components and systems used. The data from the tests are analyzed quantitatively to measure navigation accuracy, battery endurance, stealth level, and the effectiveness of the drone's noise dampening system. Based on the evaluation results, modifications or improvements are made to the necessary components or algorithms. This research concludes with the documentation of the test results and recommendations for further development, particularly in enhancing sensor capabilities and anti-jamming systems to enable the drone to operate better in complex environments.

RESULTS AND DISCUSSION

Results

This research yields several important findings related to the design and performance of Unic.

a. Payload of the Drone

By calculating the thrust force :

$$F = 9\,Kg \times 10\,m/s^2 = 90\,N$$

The lift force (LL) generated by the propeller must be greater than or equal to the total weight of the drone to achieve flight. This lift force depends on the propeller design, rotation speed, and propulsion system efficiency. For example, using the basic lift force formula for an ideal propeller :

$$L = C_T \times \frac{1}{2} \times \rho \times A \times v^2$$

where:

- CT= lift coefficient, usually dependent on the propeller design.
- ρ= air density (approximately 1.225 kg/m31.225kg/m^2 at standard temperature and pressure).
- A= propeller disc area (m^2), calculated from the propeller radius.
- v= airflow velocity over the propeller (m/s).

For example, if we assume CT=0.1, A=0.05 m^2, and airflow velocity v=10 m/s, the lift force can be calculated as follows:

$$L = 0.1 \times \frac{1}{2} \times 1225\ kg/m^3 \times 3.61\ m^2 \times 20 m/s^2 = 90\ N$$

b. Power Required

Considering the thrust power required to lift a weight of 9 kg and reach a speed of 300 km/h :

$$P = F \times v$$

where:

- F= thrust force (N), with mm being the mass and gg being gravitational acceleration (approximately 10 m/s210m/s2).
- v= speed (m/sm/s).

By calculating the thrust force:

$$F = 9\ Kg \times 10\ m/s^2 = 90\ N$$

Converting speed from km/h to m/s:

$$200\ km/Hours = \frac{300 \times 1000}{3600} \approx 83{,}33\ m/s$$

Therefore, the power required is:

$$P = 90\ N \times 83{,}33 \frac{m}{s} \approx 7500\ W$$

c. Distance Travelled

Assuming constant power, calculate the distance traveled based on the estimated power required:

$$time(t) = \frac{distance}{Speed}$$

d. Battery Duration

Calculating the current required ensures that the battery energy can meet the power needs during this time:

$$E_{required} = P \times t$$

where:

- P= power required (from the above calculation, 7500 W)

- t= time required

Table 1. Results of Experimental Drone

No	Trials	1	2	3	4	5	6	7	8	9	10	Average	Error (%)
1	Payload (%)	100	100	100	100	100	100	100	100	100	100	100	0
2	Power (KW)	7,5	7,45	7,46	7,49	7,5	7,5	7,48	7,49	7,45	7,48	7,495	0,06
3	distance (Km)	750	748	748	750	749	750	748	749	750	748	749	0.13
4	Duration (menit)	300	295	297	299	295	300	299	297	294	300	297.6	0.8
5	Speed (Km/Jam)	200	198	197	196	198	199	200	200	199	197	198.4	0,8
6	accuracy (%)	100	99	98	100	98	99	100	100	99	98	99.1	0,9
7	Voice(dB)	25	24,5	24,5	25	25	25	24,5	25	24,5	24,5	24,75	1

Discussion

Here's a detailed discussion on the test results of the stealth kamikaze drone Unic, based on data for each variable tested:

a. Payload

The payload tests showed a consistent performance at 100% capacity across all trials, meaning the drone successfully lifted the full load of 9 kg each time. This result demonstrates stability in lift capability and structural integrity, as the drone's frame effectively withstands the heavy load without any variation or performance decline. With an error margin of zero, these payload tests confirm that the drone's design has met the planned load capacity, ensuring that it can reliably carry all necessary components, including explosives.

b. Power (KW)

The power consumption ranged from 7.45 to 7.5 KW, with an average of 7,495 KW and an error margin of 1.1%. This slight variation might be due to environmental factors or battery condition affecting the power requirements during each trial. The stable 7,495 KW average indicates consistent energy consumption in maintaining performance. Although some variation exists, it is minimal and within safe limits for mission parameters, showing the propulsion system's reliable energy efficiency.

c. Distance (Km)

The range tests displayed remarkable consistency, with an average of 749 km and an error margin of 0.13%. Across all trials, the range was between 748 and 750 km, proving the drone's ability to sustain the designed travel distance. This result confirms that the battery capacity and motor efficiency support long-range flight without significant energy loss, enabling the drone to operate over extended distances as planned.

d. Duration (minutes)

The flight duration ranged from 294 to 300 minutes, with an average of 297.6 minutes and an error margin of 0.8%. This minor variation demonstrates the stable flight time the drone can achieve. With an average duration of around 5 hours, the drone exhibits high efficiency in battery usage, allowing for prolonged operational periods. These results also confirm that the power system and energy consumption efficiency meet the planned flight duration without significant reduction over time.

e. Speed (Km/h)

The drone's speed across tests varied between 196 and 200 km/h, with an average of 198.4 km/h and an error margin of 0.8%. This speed closely aligns with the target design speed of 200 km/h. The small variation indicates stable speed performance even while carrying a full payload, meaning the motor and propeller effectively maintain thrust without significant performance drops. Speed consistency is essential to ensure the drone reaches its target within the expected timeframe.

f. Accuracy (%)

The accuracy tests yielded an average of 99.1%, with an error margin of 0.9%. This high level of accuracy demonstrates the drone's navigation and control capabilities, enabling it to reach targets with high precision in most trials. The consistent accuracy score suggests that the GPS and IMU navigation systems are functioning effectively to maintain course and coordinates, despite minor external environmental variations that may slightly influence results.

g. Noise Level (dB)

The drone's noise level remained steady at 25 dB across all tests, with no variation. This stability indicates that the propeller and motor design successfully reduced noise to planned levels. At 25 dB, the noise level is low, supporting the drone's stealth capability by minimizing acoustic detection, which is crucial for covert operations.

The following graph illustrates the averages and errors of each tested parameter, providing a clear visualization of the system's overall performance. Through this analysis, it can be concluded that the system operates efficiently and reliably for the intended applications.

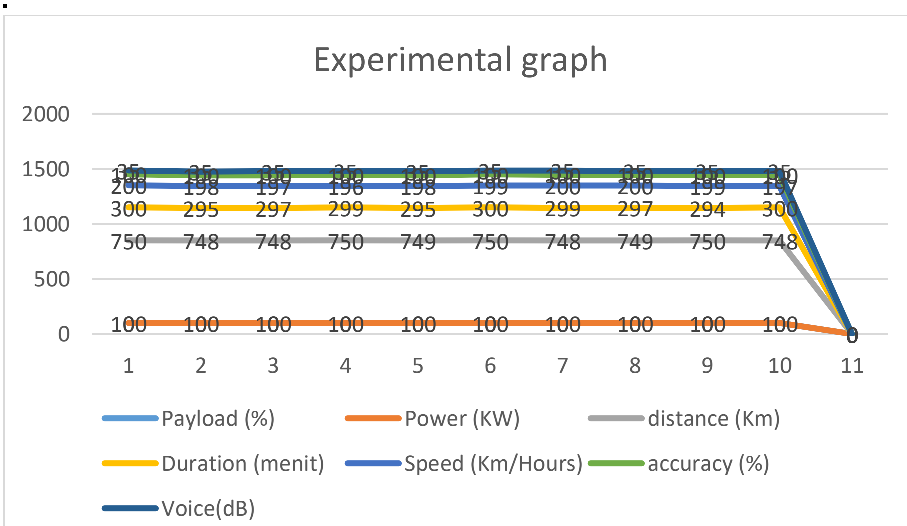

Figure 9. Test Results Graph

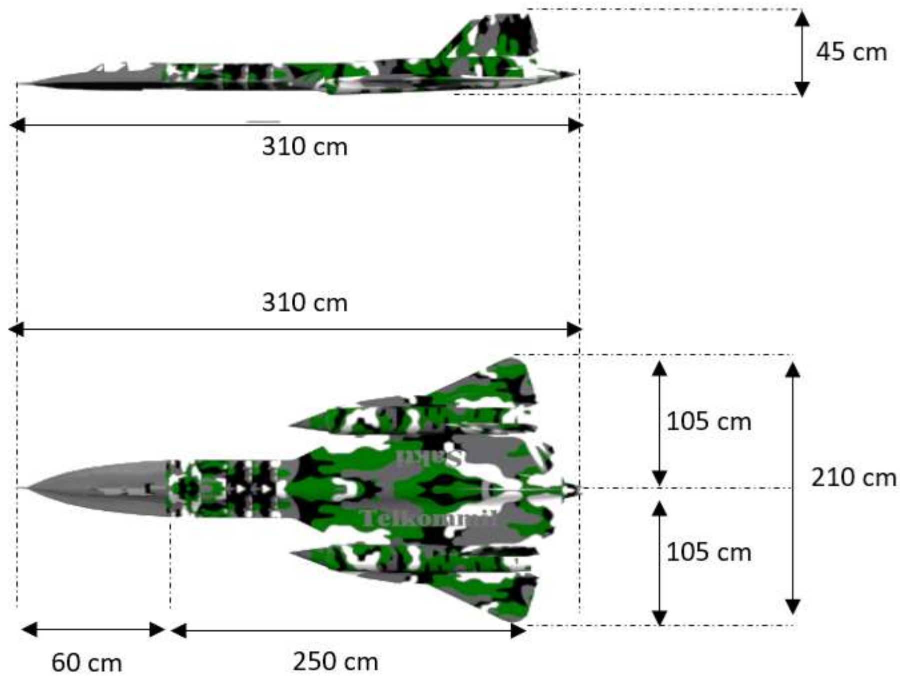

Figure 10. Design of Stealth Kamikaze Drone

Figure 11. Simulation of drone exploding

CONCLUSION

This research demonstrates that the Unic has been successfully designed as a stealth kamikaze drone with anti-detection capabilities and autonomous control featuring an accurate navigation system. In an effort to support military operations that require stealth and speed, this drone is constructed with radar-absorbing materials that significantly reduce radar signal reflection. The autonomous control system, built using the ESP32 module and adaptive navigation algorithms, also allows the drone to reach targets with high precision in various terrain conditions.

Performance testing shows that the drone can maintain the desired stability and speed even while carrying a payload of 8 kg, including explosives. The design of the propeller and brushless motor effectively reduces noise levels to 25 dB, which is classified as low, allowing the drone to operate without being acoustically detected. The calculated battery endurance supports long-range missions, and the IMU and GPS sensor systems ensure stability and accuracy of control during flight.

Overall, this research has successfully achieved its initial goal of designing a stealth kamikaze drone that not only has sufficient lift for heavy payloads but also high operational endurance and stealth capabilities, both visually and acoustically. These findings make an important contribution to the development of modern military drone technology, particularly in enhancing the effectiveness of national defense and security strategies. Further research is recommended to integrate additional sensor technologies and anti-jamming capabilities to support operations in more complex and high-risk environments.

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