

# DESIGN AND CONTROL SYSTEM OF VTOL DRONE BOM CARRIER

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**Abstract**– This study presents the development of a Vertical Take-Off and Landing (VTOL) drone system capable of autonomously carrying and releasing a lightweight bomb payload with high precision. The drone employs a hybrid quadcopter–fixed-wing configuration, using the Speedybee F405 flight controller with ArduPilot firmware, supported by GPS, IMU, and barometer sensors for autonomous navigation. Testing was conducted through Software-In-The-Loop (SITL) simulation and limited field trials. Results demonstrate stable hovering with a position deviation of less than  $\pm 0.5$  meters, waypoint navigation accuracy of  $\pm 1.2$  meters, and a payload release success rate of 75%. The system shows strong potential for further development as a tactical UAV platform with semi-autonomous and high-precision operational capabilities.

**Keywords** –UAV, VTOL, Drone, Flight Controller, Payload, Autonomous Control, Light Bomb

## I. INTRODUCTION

As the 15th-largest country in the world by land area, Indonesia faces strategic challenges in designing an effective and efficient defense system. Mistakes in planning can impact national sovereignty. Currently, defense strategies continue to evolve from conventional approaches to more modern and adaptive methods (Roza et al., 2024).

The Indonesian National Armed Forces (TNI) consists of three main branches: the Army, the Navy, and the Air Force. The Navy (TNI-AL) is responsible for defending Indonesia's sovereign territory at sea. Currently, TNI-AL forces are divided into five Main Commands (Kotama) that carry out operational and strategic functions.

The Indonesian Navy (TNI-AL) has special forces units, including the Jala Mangkara Detachment (Denjaka), the Marine Amphibious Reconnaissance Battalion (Taifib), and the Frogman Commando (Kopaska). Kopaska's primary duties include underwater demolition operations, sabotage of enemy ships and installations, reconnaissance, and beach preparation for amphibious operations. Kopaska also plays a role in anti-terror missions and attacks on vital strategic targets.

One strategic innovation in modern defense is the use of advanced technology such as drones or Unmanned Aerial Vehicles (UAVs). The use of UAVs opens a new dimension in defense systems by replacing conventional methods that rely on physical military force and direct visual surveillance (Roza et al., 2024).

One type of autonomous weapon is the Kamikaze Drone, or suicide drone. This hybrid weapon system combines guided munitions and unmanned combat aerial systems (UCAS). This drone can maneuver to find and attack targets autonomously in a single deployment.

Based on this foundation, this final project focuses on the design of a VTOL Drone Bomb Carrier control system. This research aims to introduce innovation in UAV technology while contributing to the development of national defense systems.

### Formulation of the problem

This research aims to formulate the problems in designing a VTOL drone bomb carrier control system to support side units and attacks on vital objects. Some of these problems are:

- a. How to design and build a VTOL Drone Bomb Carrier flight control system?
- b. How to design and build a VTOL Drone Bomb Carrier data communication system?
- c. How to design and make a mechanical bomb carrier release system?

### Research purposes

The aim of the design of the "VTOL drone bomb carrier control system" is to support the side units attacking vital objects:

- a. Design and manufacture of VTOL Drone Bomb Carrier flight control system
- b. Design and build a VTOL Drone Bomb Carrier data communication system
- c. Design of VTOL Drone Bomb Carrier for Attacks on Vital Objects.

#### **Benefits of research**

The benefits of designing a VTOL drone bomb carrier control system are:

- a. As a sensing vehicle that is capable of flying long distances or short distances, it is very important in effective and efficient rescue activities.
- b. In addition, this research also provides knowledge about drone technology and can be used as a very useful safety tool for future tasks.

#### **Scope of problem**

The limitations of the design of the Vtol Drone bomb carrier control system are:

- a. The research will only cover the development of flight control systems for stabilization and maneuvering of VTOL drones.
- b. This research discusses the design and assembly of the bomb carrier control and release system.
- c. This research does not discuss the payload system and real tests of active weapons, only miniatures and system control integration.

## **II. METHOD**

### **Research Methods**

This research aims to design a VTOL control system for a bomb-carrying drone to support the Indonesian Navy's (TNI) mission. The research design involves several stages, as described below:

- a. Identify needs and specifications
- b. Studies Literature At this stage, a literature study was conducted related to the design and development of the Rescue VTOL Drone Control System Design.
- c. Conceptual Design: After understanding the needs and information from the literature study, conceptual design is carried out.
- d. Simulation and Analysis: After conceptual design, simulation and analysis are carried out using software or other engineering tools.
- e. Software control system assembly: After the design is confirmed through simulation and analysis.

By means of this comprehensive research design, it is hoped that it will produce a design for a bomb drone VTOL control system.

### **Research Procedures**

This research procedure will discuss the time and location of the research, the tools and materials used in the construction of this device, and the design, data collection, and data processing. The design and construction of the VTOL bomb carrier drone control system were carried out manually. This began with the joining of materials by soldering. Assembling prototype parts such as motors and propellers, ESCs, batteries, power modules, GPS and compass sensors, and circuit boards became one of the drone's design units. After that, the drone also requires other software such as data cables to manage and program the remote control.

### **Time and Place of Research**

Research time is a crucial factor in conducting any research. This research will be conducted at two main locations: the Surabaya Naval Technology College (STTAL) campus. The research will utilize STTAL's laboratory and workshop facilities. The research period will run from January 2025 to the end of June 2025.

### **Research Tools and Materials**

In conducting this research, several supporting tools and materials were required to facilitate the design and testing. The following are some of the tools and materials used by the author:

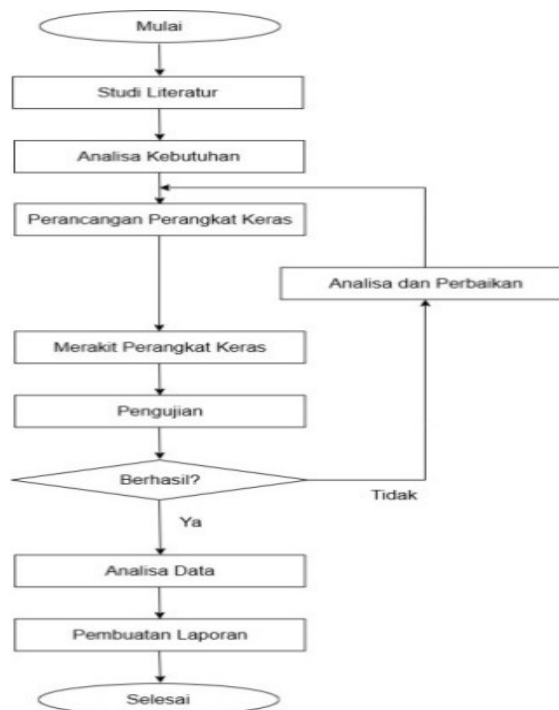
Table 1 Tools and materials

No	Name of Tools and Materials	Type
1	Flight Controller	PIXHAWX-4
2	GPS	Neo-M8
3	Compass	IST8310
4	Gyro	ICM-20689
5	Barometer	MS5611
6	Telemetry	433 mhz 3DR
7	Camera	Caddx ANT 1200 TVL
8	Tx Video	AKK X2P
9	Video Rx	SKYDROID 5.8 OTG
10	PC/Laptop	Windows 11 64 bit

### Research Design

Design and Construction of a Control System on a Vtol Drone Bomb Carrier for Attacking Vital Objects. Implementing the following research stages:

Research Flowchart



Picture 1 Research Flowchart

### Data collection

Data collection methods are a crucial approach in research, as they allow the necessary data to be collected with high validity and reliability. In the context of this final project, we employed several different data collection methods to obtain comprehensive and in-depth information. The data collection methods we employed include:

- a. Method Observation of the design and trial of the VTOL drone bomb carrier control system.
- b. Interview method
- c. Method questionnaire
- d. Method documentation

By using these various data collection methods, we were able to obtain the diverse and in-depth data needed in this study.

### Data processing

The author will undertake this process after obtaining some information gathered during the data collection process. The data obtained will be analyzed and used as a reference in the analysis and design process for the system.

By carrying out this systematic and directed data processing process, we are confident that we can produce valid, reliable information that can provide in-depth insights.

### Operational Definition

The operational definition in this design-build research explains and defines the variables used in this design-build research. The following is the operational definition in design-build research, namely:

- a. Drone is an aircraft without a pilot
- b. *Flight Controller* often also called FC is the brain of a drone.
- c. *Mission Planner*: is a software designed to make it easier for users to design automatic flights.

*Telemetry*: is a data communication device between the drone and the remote control via an RF radio communication network.

## III. RESULTS AND DISCUSSION

In this stage, the author will discuss the process of designing control systems and software programming, starting from the design system for the circuit schematic that will be used in manufacturing. Design and construction of a VTOL control system for bomb carrier drones for attacking vital objects.

### Design of VTOL Drone Bomb Carrier System

The rapid development of Unmanned Aerial Vehicle (UAV) technology, particularly in the defense sector, has driven innovation in VTOL (Vertical Take-Off and Landing) systems. VTOL technology combines the vertical maneuverability of helicopters with the cruising efficiency of fixed-wing aircraft, making it ideal for reconnaissance missions and the transport of payloads such as replica bombs.

### System Implementation

The control system implementation on the VTOL Drone Bomb Carrier aims to ensure stability, precision, and safety in every phase of the mission, from vertical takeoff to payload release on vital targets. This system integrates a firmware-based flight controller such as ArduPilot, GPS sensors, and a compass for accurate navigation and orientation.

### System Implementation *Electronic Speed Controller*

In the VTOL (Vertical Take-Off and Landing) drone system, the use of an Electronic Speed Controller (ESC) is a crucial component for controlling the speed and direction of electric motor rotation, both for vertical mode (take-off/landing) and horizontal mode (cruise/forward flight).

The Electronic Speed Controller (ESC) is a vital component in the VTOL drone propulsion system that functions to regulate the speed and direction of rotation of the brushless motor based on signals from the flight controller.

### Flight Control System Implementation

The flight control system of a VTOL drone is a complex integration of manual input, digital signal processing, electronic controls, and aeromechanical dynamics. The drone's seemingly simple movements are the result of precise calculations and rapid coordination of various subsystems. The main components of this system include:

- a. SpeedyBee Flight Controller (F7/F405 Wing)
- b. ESC for VTOL motors
- c. Vertically-propelled (VTOL) motorcycle
- d. Aileron control servo
- e. External GPS/compass
- f. RC Receiver (SBUS/CRSF)
- g. Power module and battery

*Flight controller* regulates motor response based on pilot input and sensor data in real-time, and sends control signals to the ESC.

#### **GPS System Implementation**

In the development of modern drone navigation systems, Global Positioning System (GPS) technology has become a crucial component, enabling high autonomy and precision in flight operations. GPS enables drones to determine their geographic location in real time, supporting various automated functions such as takeoff, hover, waypoint navigation, and return-to-home (RTH).

Software configuration is done via Betaflight Configurator:

- a. Activate GPS serial in the Ports tab (UART RX/TX).
- b. Selection of UBLOX protocol and GNSS provider in the Configuration tab.
- c. Connection testing is done in the GPS tab, where satellite data, location and altitude can be monitored.

#### **Camera Installation**

In navigation systems and rescue missions using VTOL (Vertical Take-Off and Landing) drones, camera integration plays a crucial role in supporting situational awareness and real-time observation of target areas. The camera functions as a visual monitoring device.

#### **Remote Control**

In UAV control systems, particularly VTOL (Vertical Take-Off and Landing) drones, the remote control plays a crucial role in ensuring stability, maneuvering precision, and operational flexibility. This design utilizes the RadioMaster TX16S, a 16-channel multifunction transmitter operating at 2.4 GHz and supporting various communication protocols such as CRSF, SBUS, DSMX, and others.

The RadioMaster TX16S serves as the main control unit, sending command signals to the drone's flight controller. This transmitter is equipped with various switches and potentiometers that can be customized for additional functions.

#### **Tool Testing**

Testing is a crucial stage in the drone system engineering process to ensure that all implemented hardware and software functions as designed.

This testing focuses on individual components, such as sensors, communication modules, motors, and software. Each component is tested independently by connecting it to the flight controller and monitoring its response through software such as Mission Planner or ArduPilot.

After all components have been partially tested, full integration and testing is performed. This includes drone flight tests to evaluate the system's overall performance. Two types of flight log data are used for system performance analysis:

- a. Telemetry Log: Records data while the drone is active and connected to the ground station via the telemetry module in real-time.
- b. Flash Log Data: This is flight data that is internally stored in the flight controller and can be downloaded after the drone has landed.

In this study, the focus of data collection was carried out via Flash Log Data, by connecting the ground station to the flight controller using a USB cable.

#### **Goku GM10 Pro V3 GPS Module Testing**

The GPS test results in Table 2 show the latitude and longitude values which are the position coordinate points, the Hdop value which explains the GPS accuracy variable, Alt as the altitude variable and Spd as the speed variable.

Table 2 GPS Test Results

HDop (Keakuratan posisi)	Latitude	Longitude	Alt(m)	Spd (km/jam)
1	2	3	4	5
0.63	-63.052.319	107.0398221	57.86	34,5
0.63	-63.052.318	107.0398399	58.72	35,6
0.63	-63.052.314	107.0398583	59.44	37,5
0.63	-63.052.306	107.0398777	60.01	39,2
0.63	-63.052.294		60.43	41,2
0.63	-63.052.277	107.0399191	60.71	43,2
0.63	-63.052.257	107.0399412	60.89	45,1
0.63	-63.052.234	107.0399642	61.09	46,6
0.63	-63.052.207	107.0400568	63.06	40,2
1	2	3	4	5
0.63	-63.052.254	107.0400957	65.15	38,7
0.63	-63.052.283	107.0401155	66.30	41,0
0.63	-63.052.315	107.0401364	66.59	43,0
0.63	-63.052.349	107.0401583	66.86	45,0
0.63	-63.052.384	107.0401814	66.95	47,6
0.63	-63.052.418	107.0402056	67.06	49,4
0.63	-63.052.456	107.0402302	67.22	49,9
0.63	-63.052.499	107.0402547	67.75	48,7
0.63	-63.052.548	107.0402782	68.57	46,7
0.63	-63.052.601	107.0403004	69.56	44,4
0.63	-63.052.658	107.0403221	70.54	44,5
0.63	-63.052.718	107.0403441	71.31	46,6

### Goku GM 10 Pro V3 Compass Testing

The test results can be explained in the form of test images, in this test the researcher used the monitor terminal feature on the Arduino IDE to display the results of the compass sensor readings in the 3 axes x, y and z. Table 3 shows the results of testing the compass sensor readings in degrees.

Table 3 Compass Test Results

Mag Roll	Mag Pitch	Mag Yaw
337	130	315
-317	166	-311
290	154	-284
-286	159	-274
-265	168	306
271	164	288
255	164	-311
233	150	-286
-228	146	303
-243	134	-310
273	125	333
301	136	358
-215	128	370
-217	-143	-360
-220	-126	-336
-223	-140	-333
-224	-151	-306
-227	-156	-279
-225	-161	-232
-223	-130	-242

#### MS5611 Barometer Sensor Testing

The MS5611 is a piezoresistive sensor that detects pressure. Piezoresistive sensors consist of a semiconductor material that changes resistance when a mechanical force such as atmospheric pressure is applied. Table 4 shows that the use of a pressure sensor compensated with a temperature sensor will show height accuracy.

*Table 4 Barometer Testing*

Altitude (m)	Suhu (derajat)	Tekanan (kpa)
10	50.61	100454.1
20	50.76	100343.2
30	50.84	100222.2
40	50.98	100121.1
50	51.22	100006.3
60	51.97	99899.97
70	52.68	99788.38

#### ICM-20689 Gyro sensor testing

Gyroscope testing aims to determine the accuracy of the gyroscope in detecting dynamic angular velocity changes in the drone. The gyroscope sensor will output a value when rotating clockwise around the Y-axis, resulting in a decrease in output voltage.

*Table 5 Orientation Data Log*

Roll	Pitch	Yaw
-2.93	12.96	127.72
-2.94	13.03	127.70
-2.96	13.11	127.67
-3.02	13.15	127.63
-3.03	13.17	127.58
-3.07	13.17	127.51
-3.10	13.12	127.43
-3.14	13.04	127.34
-3.18	12.93	127.25
-3.22	12.81	127.15
-3.24	12.68	127.04
-3.25	12.57	126.94
-3.28	12.51	126.84
-3.28	12.49	126.74
-3.27	12.52	126.64

**Flight Controller Device Testing**

In the following discussion, the author will explain the testing process. *Speedybee F405 Flight Controller*. In this test, the author wants to prove that the flight controller can work well. The connection process is shown in Figure 2.



Picture 2 Flight Controller Testing

**Mission Planner Software Testing**

The Mission Planner application is an open-source Ground Control Station (GCS) application. Developed by Michael Osborne, it is the most widely used GCS application. Mission Planner is used to control and monitor flight missions. It can also receive and send flight data commands.

**Camera Testing**



*Picture 3 Camera Monitor View*

Monitor using Caddx Ant camera with transmitter and receiver AKK FX2 Analog with a frequency of 5.8 Ghz is capable of producing full HD images with good quality in monitoring the situation and when releasing life buoys.

**Flight Testing With Waypoint**

How to use waypoint, select "plan" then "waypoint" then select "do set servo" then select "RTH" finished. The test results using waypoints are a test stage that determines the success of a drone on one of the automatic features with Gps data. To get the results of this test can be limited to the area or terrain designed in such a way according to the operational area, there are 4 times testing between using 4 points between the home point, waypoint 1, waypoint 2, and waypoint 3. During the test, it was carried out in Loiter and Auto modes to be able to operate the drone autonomously or manually by wire.

**Bomb Replica Release Testing**

In designing the Vtol drone, researchers used a servo motor to unlock the bomb when the replica bomb was about to be dropped. The servo motor was controlled by a remote control from the operator.

In the design of the Vtol Drone, there are three locks to fasten the bomb replica located on the bottom side of the drone body so that it does not move or shift.

**IV. CONCLUSION**

Based on the results of the research and discussion presented above, the following conclusions can be drawn:

- a. Based on the results of the Vtol Drone flight test, the results obtained show that the Drone can communicate well with the remote control and data reading communication on the PC/Mission planner can be read well.
- b. Based on data from the data communication test between the remote control and the receiver at a safe and stable point, the longest distance achieved is 5 km. The author assumes the longest distance with a good signal reception, as indicated by the full signal indicator on the remote control.
- c. Bomb release tests using replicas obtained good results and the bomb replica could fall using a mechanical system.

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