International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 12 December 2025
Page No: 4535-4541
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2025.0666

# Design and Fabrication of Blue Shield Recon

*Haritha V[1], Indhu R[2], Sasidharan M[3], Deepak Kumar M[4], Mithran N[5]*
*[1]Associate Professor, Dept. of Mechatronics, Sri Krishna College of Engg. & Tech., Coimbatore, Tamilnadu, India.*
*[2,3,4,5]UG Scholar, Dept. of Mechatronics, Hindusthan college of Engg. & Tech., Coimbatore, Tamilnadu, India.*
***Emails:*** *harithavenkat1036@gmail.com[1], mithrann@skcet.ac.in[5]*

## Abstract
*This research showcases the creation of an underwater control robot with live video output using an ESP32-CAM module and propulsion created with four 60 RPM DC geared motors. The robotic unit serves as a surveillance tool for limited-distance detection activities, including tank inspections and shallow aquatic investigations as well as elementary laboratory studies. To overcome underwater RF wave signal degradation and to establish a reliable power and data connection between the surface unit and the robot operation uses a physical tethered connection is used rather than wireless transmission. The bot's movement is managed by an L298N motor driver, while its main propulsion power switching is controlled by a relay module. The compact mechanical unit is positively buoyant while achieving electronic component protection through specialised waterproof sealing. Testing of the developed prototype took place within a water tank laboratory setup to check navigation capabilities together with stability and video streaming performance. The data proves the bot achieves both forward and backward movements together with turning capabilities, during stable video streaming between the submersible and surface. This research shows how basic components can work together to create a low-cost, wired underwater surveillance robot, opening the door to adding sensors and autonomous functionality.*

***Keywords:*** *ESP32-CAM; DC gear motor; L298N motor driver; Underwater surveillance; Wired communication.*

## 1. Introduction

Underwater monitoring and inspection are crucial in a number of industries, including aquaculture, security surveillance, pipeline and tank inspections, and marine research. However, due to their high cost and intricate design, professional underwater robots and remotely operated vehicles (ROVs) are not the best option for small-scale academic research or cost-conscious applications. The creation of inexpensive underwater robots with straightforward control systems and easily accessible electronic components has become more popular as a result. Signal loss in underwater environments, especially in conductive seas like seawater, significantly hinders radio frequency (RF) communication systems like Bluetooth and Wi-Fi. This has sparked a growing interest in creating affordable underwater bots using easily accessible electronic components and straightforward control systems. This limitation makes traditional wireless control methods less effective. To tackle this issue, many small ROVs rely on a tethered (wired) system for both communication and power supply between the surface unit and the underwater vehicle. This project adopts the same approach to ensure dependable video streaming and control. The focus here is on developing a wired underwater surveillance bot that utilizes an ESP32-CAM module, which combines a microcontroller and camera in one. The bot is powered by four 60 RPM DC gear motors paired with propellers to create thrust in various directions. An L298N motor driver is employed to operate the DC motors, while a relay module manages the main power for the propulsion system. The entire setup is designed, built, and tested in a water tank to assess its performance. The primary goals of this project are: - To create a budget-friendly wired underwater bot suitable for basic surveillance. - To enable live video streaming using the ESP32-CAM over a tethered connection. - To facilitate basic manoeuvring (forward, reverse, and turning) with the help of DC motors and propellers. - To evaluate the stability and practical challenges associated with underwater operations.

### 1.1. Background on Underwater Communication

This study outlines the creation of an underwater control robot powered by four 60 RPM DC geared motors for propulsion, along with an ESP32-CAM module for live video streaming. This robotic unit serves as a surveillance tool for tasks that are typically performed over short distances, such as inspecting tanks, exploring shallow waters, and conducting basic lab research. To tackle the issue of underwater RF wave signal degradation, we opted for a physical tethered connection instead of relying on wireless transmission, ensuring a stable power and data link between the surface unit and the robot. The bot's movement is managed by an L298N motor driver, while a relay module controls the main propulsion power, turning it on and off as needed. Designed with special waterproof sealing, this compact mechanical unit not only protects the electronic components but also allows it to float. We tested the prototype in a water tank lab to evaluate its navigation, stability, and video streaming capabilities. The findings show that the robot can move forward and backwards, as well as turn, all while keeping a steady video feed between the submersible and the surface. This research showcases how basic components can come together to build an affordable, wired underwater surveillance robot, setting the stage for adding sensors and autonomous features in the future.

## 2. Methodology

The design of the bot focuses on being compact and waterproof. Inside a sturdy container, like an acrylic or plastic enclosure, you'll find the ESP32-CAM, relay module, L298N driver, and all the necessary wiring neatly secured. To keep water at bay, rubber gaskets and sealants are meticulously applied at the joints and where cables enter. The bot glides forward and turns effortlessly, thanks to the four propellers that encircle its body, all powered by 60 RPM DC gear motors.

### 2.1. Electrical and Electronic Design

The ESP32-CAM runs on a steady 5 V power supply. The L298N motor driver is hooked up to four DC gear motors. The driver's enable, and input pins connect to the GPIO pins on the ESP32-CAM. To control the main motor supply line, a relay module is wired in series, acting as an ON/OFF switch that the microcontroller or surface command can manage. A wired tether, made up of several conductors, is used to transmit power and communication signals between the surface and the bot.

### 2.2. Control Strategy

The bot is operated from the surface by sending commands to the ESP32-CAM via the wired connection. Depending on the commands received, the ESP32-CAM adjusts the logic levels on the L298N input pins to steer the direction and speed (if PWM is applied) of each motor. For moving forward, both the front and rear motors spin to push water backward. To turn left or right, the motors on one side either slow down or reverse.

### 2.3. Software Implementation

To get the ESP32-CAM working, you'll need the Arduino IDE or something similar. The code handles a few main things: First, it sets up the camera so you can stream video. It also configures the GPIO pins that connect to the L298N driver and the relay. Then, the code listens for control signals from the surface system and decodes them. Based on what the user sends, the logic decides which way the motor should spin.

### 2.4. Testing the Prototype

We ran tests in a water tank and kept a close eye on several things: The bot moves forward and backward without trouble. It can turn left and right. We checked how stable it stays while moving, and we watched how smooth and steady the ESP3 CAM's live video stream looked.

#### 2.4.1. Overview of the Purpose of the Tests

These tests (Table 2.1) are designed to evaluate the performance of an underwater robot under varied parameters of water depth, motor voltage, tether length, and motion commands. Every test captures the robot's actions for a predetermined amount of time.

### 2.4.2. Integrated Motor Control and Camera System Architecture

This block diagram (Fig. 2.1) illustrates the design of an underwater robotic system that combines motor control, camera processing, and user interface communication. The ESP32-CAM module, which is in charge of both taking and processing photos, is vital to the system. It employs a tether wire to deliver data to the User Device via the Communication and Power interface and communicates with the Camera Processing Block for onboard picture management. A specific Motor Control Block, which is coupled to a 4-Relay Module, is in charge of motor control. This module distributes control signals to two different motor controllers, each responsible for powering two DC motors, resulting in a total of four motors capable of movement in all directions.

### 2.4.3. Graph Analysis

This graph (Fig. 2.2) displays the distribution of von Mises stress across different nodes in a structural or mechanical simulation. Von Mises stress is a critical measure used in engineering to predict the yielding of materials under complex loading conditions.

**Table 1 Component Specifications**

| S. No | Component | Specification / Rating | Quantity |
|---|---|---|---|
| 1 | ESP32-CAM module | 240 MHz dual-core MCU, OV2640 camera, 5 V input | 1 |
| 2 | DC gear motor | 60 RPM, 12 V DC, metal gear, bidirectional | 4 |
| 3 | Propeller | 2-blade/3-blade plastic propeller, matched to motor shaft | 4 |
| 4 | Motor driver | L298N dual H-bridge, 5–35 V motor supply | 1 |
| 5 | Relay module | 1-channel, 5 V control, 10 A contact rating | 1 |
| 6 | Power supply / battery | 12 V DC (surface/battery), regulated 5 V for ESP32-CAM | 1 |
| 7 | Tether cable | Multi-core cable for power + control signals | 1 |
| 8 | Enclosure | Waterproof housing (acrylic/plastic box) | 1 |
| 9 | Sealing materials | Rubber gaskets, O-rings, silicone sealant | As req. |
| 10 | Miscellaneous | Wires, connectors, screws, mounting brackets | As req. |

**Table 2 Experimental Test Conditions**

| Test No. | Water depth (cm) | Supply voltage to motors (V) | Tether length (m) | Motion command | Observation duration (s) |
|---|---|---|---|---|---|
| 1 | 30 | 9 | 2 | Forward | 30 |
| 2 | 30 | 9 | 2 | Reverse | 30 |
| 3 | 40 | 12 | 3 | Left turn | 20 |
| 4 | 40 | 12 | 3 | Right turn | 20 |
| 5 | 50 | 12 | 3 | Forward + video stream | 60 |

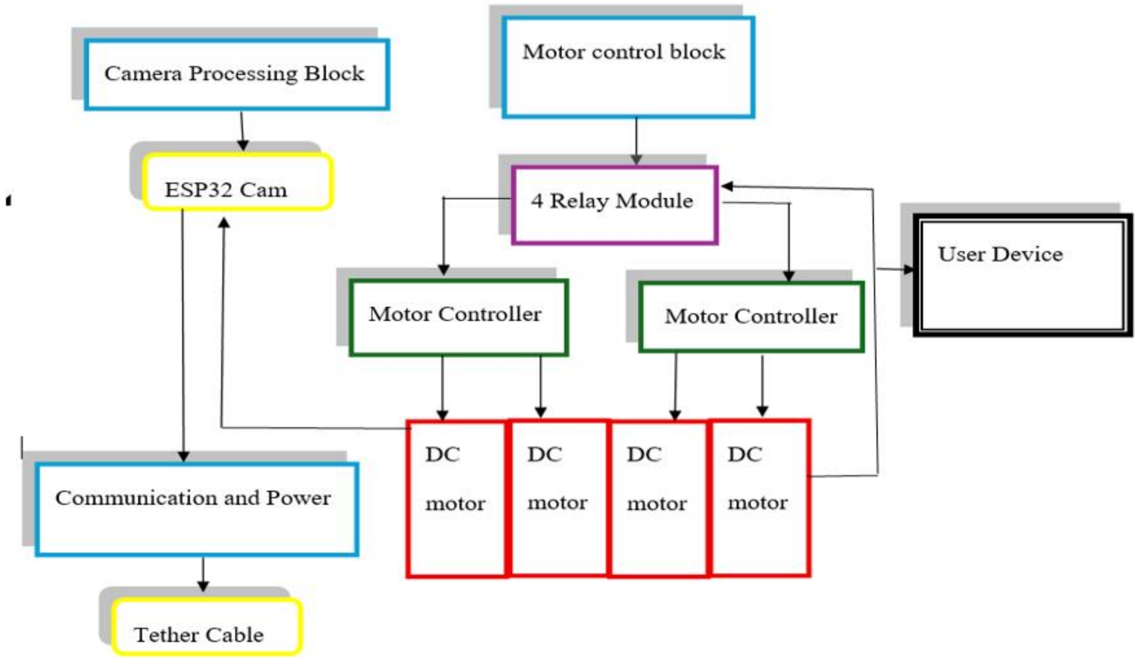


**Figure 1** **Block Diagram for Blue Shield Recon**

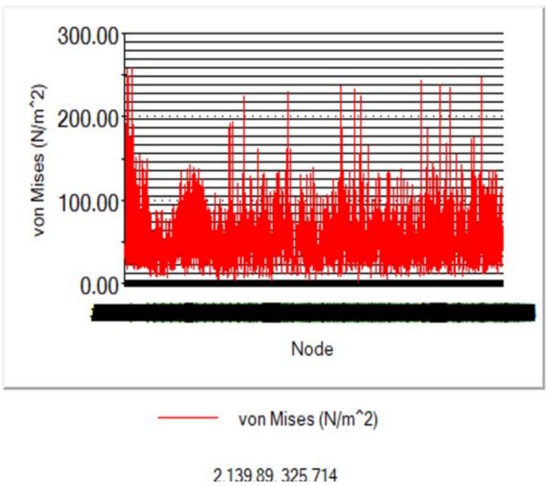


**Figure 2** **Stress Analysis of Our Model**

## Graph Characteristics

- The **red line** traces the von Mises stress values across all nodes.
- The stress distribution shows **significant fluctuations**, indicating that different parts of the structure experience varying levels of stress.
- **Peaks** in the graph suggest regions of **high stress concentration**, which may be critical for structural integrity.
- **Troughs** indicate areas with **lower stress**, possibly less affected by the applied loads.

The graph (Fig. 2.3) displays the Equivalent Strain (ESTRN) distribution obtained via SolidWorks Simulation's static structural analysis of the underwater bot chamber. Equivalent strain is a measure of how much the material deforms under the applied load. It yields a single value by combining deformation in all directions.

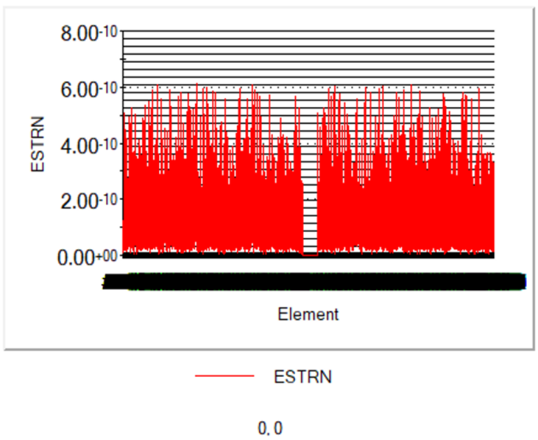


**Figure 3** **Strain Analysis of Our Model**

The graph (fig. 2 .4) illustrates the total resultant displacement (URES) of each node in the

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 12 December 2025
Page No: 4535-4541
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2025.0666

underwater bot chamber under the applied load during the SolidWorks static analysis. Resultant displacement represents the overall movement of a node, combining X, Y, and Z directional displacements into one value.

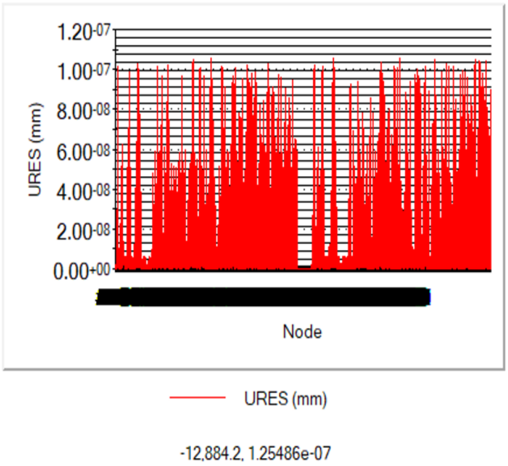


**Figure 4** **Displacement Analysis of Our Model**

## 3. Results and Discussion

### 3.1.Results

The wired submerged surveillance bot did a great job throughout its tank tests. The following are the key lessons:

- The bot was able to go forward as well as reverse with ease thanks to its four-motor propulsion system.
- By modifying the motors on opposite sides, it was able to do abrupt left and right turns. The ESP32-CAM continuously streamed footage to the surface while maintaining good clarity in clear water.
- The wired tether provided consistent power and connectivity, and there was no noticeable signal degradation over the tested length.

The underwater surveillance bot operates consistently across every motion types, based on the performance results. The bot (Table.3.1)recorded its highest speed of 10 cm/s during forward motion with smooth movement and perfectly stable video. Reverse motion was slightly slower at 8 cm/s, indicating moderate stability, because there was less backward thrust. The bot consistently achieved turning radii of 25 cm (left) and 24 cm (right) during turning tests while maintaining a controlled speed of 6 cm/s and stable video. In the combined forward-plus-turning test, the bot reached 9 cm/s, and despite a slight video delay, overall stability was good. These results confirm that the bot provides reliable video streaming, strong manoeuvrability, and balanced performance suitable for underwater surveillance applications.

### 3.2.Discussion

The findings show that simple parts like the ESP32-CAM, L298N, DC motors, and a module with relays can be used to create an inexpensive wired underwater surveillance bot. Nonetheless, some difficulties were noted:

- It's crucial to maintain flawless waterproofing because even tiny leaks can harm devices.
- Maneuvrability is impacted by the drag force on the cable and bot.
- To maintain the bot's stability and levelness underwater, proper balancing and buoyancy correction are necessary.
- Future enhancements could include:
- Including sensors for water quality, temperature, and depth.
- Using PWM to improve motor control for more fluid motion.
- Designing a more hydrodynamic body to reduce drag.

A static displacement analysisof a curved structural component using draft-quality mesh is shown in this figure (Fig.3.1). The simulation shows how the part deforms under inward-pointing external loads, represented by red arrows. There is very little deformation, as indicated by the displacement values, which are on the order of femtometers. The displacement distribution is represented by a color gradient that goes from blue (0 mm) to red (8.821e-16 mm), with blue denoting the lowest displacement and red the highest. The deformation is shown at true scale, emphasizing the structural rigidity and minimal response to the applied forces.

**Table 3 Performance Results**

| Test No. | Motion type | Average speed (cm/s) | Turning radius (cm) | Video stream status | Overall stability |
|---|---|---|---|---|---|
| 1 | Forward | 10 | – | Stable, no frame drop | Good |
| 2 | Reverse | 8 | – | Stable | Moderate |
| 3 | Left turn | 6 | 25 | Stable | Good |
| 4 | Right turn | 6 | 24 | Stable | Good |
| 5 | Forward + turning | 9 | 26 | Minor delay, acceptable | Good |

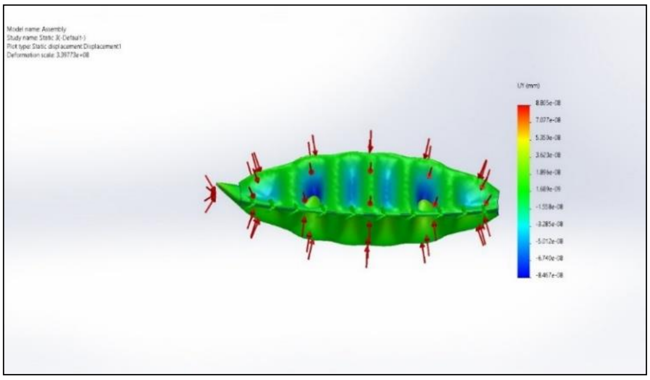

**Figure 4 Simulation of Blue Shield Recon**

## Conclusion

The ESP32-CAM, the L298N motor driver, relay module, and four 60 RPM DC gear motors with propellers have all been successfully used in the design and development of a wired underwater surveillance bot. The restrictions of wireless communication in water are overcome by using a cable tether, which guarantees dependable power and data flow between the bot and the surface. The bot can carry out simple motions and give real-time footage of the underwater environment, according to experimental testing conducted in a water tank. The project shows that inexpensive parts can be assembled to produce a working underwater surveillance system appropriate for small-scale and educational uses. Additional sensor capabilities and sophisticated control algorithms can further expand this work.

## References

[1]. Terracciano, Daniele S., Lorenzo Bazzarello, Andrea Caiti, Riccardo Costanzi, and Vincenzo Manzari. "Marine robots for underwater surveillance." Current Robotics Reports 1, no. 4 (2020): 159-167.

[2]. Ferri*, Gabriele, Andrea Munafò*, Alessandra Tesei, Paolo Braca, Florian Meyer, Konstantinos Pelekanakis, Roberto Petroccia, João Alves, Christopher Strode, and Kevin LePage. "Cooperative robotic networks for underwater surveillance: an overview." IET Radar, Sonar & Navigation 11, no. 12 (2017): 1740-1761.

[3]. Al Hakim, Luqman, Azli Yahya, Muhammad Abdul Rahim, and Sophan Nawawi. "Design and development of ROV for underwater surveillance." Journal of Industrial Engineering Research 2, no. 1 (2016): 9-16.

[4]. Campagnaro, Filippo, Fabian Steinmetz, and Bernd-Christian Renner. "Survey on low-cost underwater sensor networks: From niche applications to everyday use." Journal of marine science and engineering 11, no. 1 (2023): 125.

[5]. Foresti GL, Scagnetto I. An integrated low-cost system for object detection in underwater environments. Integrated Computer-Aided Engineering. 2022 May;29(2):123-39.

[6]. Coro, Gianpaolo, and Matthew Bjerregaard Walsh. "An intelligent and cost-effective remote underwater video device for fish size monitoring." Ecological Informatics 63 (2021): 101311.

[7]. Monish, R. M., R. P. Rahul, S. Sankaranarayanan, and S. Tamil Selvi. "Surveillance Bot for Monitoring and Rescue Operations." In Sustainable Materials and Technologies in VLSI and Information Processing, pp. 222-227. CRC Press, 2025.

[8]. Vivek, Sharma, and Gurpreet Kaur. "IoT-based Surveillance Robot Using ESP-32 Wi-Fi Cam." In 2025 IEEE International Conference on Interdisciplinary Approaches in Technology and Management for Social Innovation (IATMSI), vol. 3, pp. 1-6. IEEE, 2025.

[9]. Ruba, M., Ponkarthika, M., Parameshwari, V., Girinath, V. P., Soundarya, B., Janani, M., & Santhini, C. (2025, February). Enhancing Underwater Tunnel Safety through Smart Inspection: An ROV-based System with AI-Powered Crack Detection using Canny Edge Detection. In 2025 3rd International Conference on Intelligent Systems, Advanced Computing and Communication (ISACC) (pp. 1067-1072). IEEE.

[10]. Calder, Brian. "Design of a Wireless, Inexpensive Ocean of Things System for Volunteer Bathymetry." IEEE Internet of Things Journal 10, no. 11 (2023): 9534-9543.

[11]. Ananda, N. C., Maulindar, J., & Ardiyanto, M. (2025). Development of a Control and Monitoring System for an IoT Rover Based on ESP32 and LoRa in Hazardous Areas. Journal of Artificial Intelligence and Software Engineering, 5(2), 770-782.

[12]. Bahamondes, Felipe, Mathias Rohde Markvardsen, Morten Tokkesdal Henriksen, and Charalampos Orfanidis. "Toward a Testbed for the Internet of Underwater Things: Challenges and Considerations." In Companion of the 2025 ACM International Joint Conference on Pervasive and Ubiquitous Computing. Association for Computing Machinery, 2025.

[13]. Varshini, P.L., Pavithra, P. and Gracewell, J.J., 2024, December. Multipurpose Internet of Things-Based Robot for Military Use. In Proceedings of International Conference on Communication and Computational Technologies: ICCCT 2024, Volume 1 (Vol. 1121, p. 417). Springer Nature.

[14]. Beaudoin, L., Avanthey, L. and Villard, C., 2020. Porting ardupilot to esp32: towards a universal open-source architecture for agile and easily replicable multi-domains mapping robots. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 43, pp.933-939.

[15]. Hazra, N., Sarkar, S. and Bhowmick, S., 2024, July. Integrating IoT Along with WSN for Analyzing and Surveilling Water Quality in Terrestrial Water Bodies. In International Conference on Data Analytics and Insights (pp. 329-344). Singapore: Springer Nature Singapore.

[16]. Khairuddin, Hafizudin Fikri, Suziana Ahmad, Mohd Zaidi Mohd Tumari, Amirul Syafi Sadun, and Izadora Mustaffa. "IoT-based water surface cleaning robot with live streaming." Przegląd Elektrotechniczny 100 (2024).