# Autonomous Underwater Vessel for Naval Reconnaissance

**Project Exhibition -2**

Submitted in partial fulfilment for the award of the degree of

**BACHELOR OF TECHNOLOGY**

In

#### ELECTRONICS AND COMMUNICATION ENGINEERING

Submitted to

# VIT BHOPAL UNIVERSITY (M.P.)



#### Submitted by:

**SOUMIK DAS (22BAC10010) SREEJIB PAL (22BAC10018) JAYANA SAWLANI (22BAC10042)**

Under the Supervision of

#### DR. SOUMITRA KESARI NAYAK

**SCHOOL OF ELECTRICAL & ELECTRONICS ENGINEERING**

##### VIT BHOPAL UNIVERSITY BHOPAL (M.P.)-466114

**May 2023-24**



**VIT BHOPAL UNIVERSITY BHOPAL (M.P.) 466114**

SCHOOL OF ELECTRICAL & ELECTRONICS ENGG.

##### CANDIDATE’S DECLARATION

We hereby declare that the Dissertation entitled “AUTONOMOUS UNDERWATER VESSEL FOR NAVAL RECONNAISSANCE" is our own work conducted under the supervision of Dr Soumitra Kesari Nayak, Assistant Professor, School of Electrical and Electronics Engineering at VIT University, Bhopal.

We further declare that to the best of my knowledge this report does not contain any part of work that has been submitted for the award of any degree either in this university or in other university / Deemed University without proper citation.

SOUMIK DAS (22BAC10010) SREEJIB PAL (22BAC10018) JAYANA SAWLANI (22BAC10042)

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

Date:

Dr Soumitra Kesari Nayak Assistant Professor

Digital Signature of Guide



#### VIT UNIVERSITY BHOPAL (M.P.) – 466114

SCHOOL OF ELECTRICAL & ELECTRONICS ENGG.

#### CERTIFICATE

This is to certify that the work embodied in this Project Exhibition -1 report entitled

#### “AUTONOMOUS UNDERWATER VESSEL FOR NAVAL

**RECONNAISSANCE”** has been satisfactorily completed by SOUMIK DAS (22BAC10010)**,** SREEJIB PAL (22BAC10018) and JAYANA SAWLANI

(22BAC10042) in the School of Electrical & Electronics Engineering at VIT University, Bhopal. This work is a bonafide piece of work, carried out under my/our guidance in the School of ELECTRICAL & ELECTRONICS ENGINEERING for the partial fulfilment of the degree of Bachelor of Technology.

#### Dr Soumitra Kesari Nayak (Assistant Professor)

**Forwarded by Approved by**

#### Dr.Soumitra Kesari Nayak Dr.M.Suresh

**Program Chair Professor & Dean**

# Acknowledgment

It is with immense pleasure and gratitude that we acknowledge the completion of our project, "**Autonomous Underwater Vessel for Naval Reconnaissance**." This endeavor has been a journey of learning and innovation, and we owe our deepest thanks to those who have supported us.

First and foremost, we extend our heartfelt appreciation to our project guide, **Dr. Soumitra K Nayak**, Assistant Professor of the **School of Electronics and Communication Engineering at VIT Bhopal University**. Dr. Soumitra's unwavering guidance, expertise, and encouragement have been invaluable in steering us through the intricacies of this project. We have acquired profound technical knowledge and skills under his mentorship, and for that, we are truly grateful.

We would also like to express our profound gratitude to **Dr.M.Suresh**, **Dean of the School of Electrical and Electronics Engineering, and Dr. Soumitra K Nayak, Program Chair of B. Tech ECE at VIT Bhopal University**. Their unwavering support and the golden opportunity they provided to undertake this project have been instrumental in its success. Their kind guidance, extensive assistance, and rich experience have been our pillars of strength throughout this journey. Whenever we faced challenges or needed assistance, they were there by our side, guiding us with their wisdom and knowledge.

We extend our appreciation to the entire technical and academic personnel at the School of Electrical and Electronics Engineering for their continuous support, whether it was in the form of direct assistance or indirect inspiration. Your contributions have enriched our project and our educational experience.

This project has been completed with the utmost care and profound dedication, thanks to the support of these esteemed individuals and institutions. Their belief in us has been our driving force, and we are deeply thankful for their contributions to our success.

# Executive Summary

The “Autonomous Underwater Vessel for Naval Reconnaissance” project stands as a testament to innovation in maritime defence and intelligence. This ambitious initiative is dedicated to the development of an Autonomous Underwater Vehicle (AUV) designed to transform naval reconnaissance and covert operations through the application of advanced technology.

**Core Objective** The project’s central aim is to engineer an AUV capable of executing a multitude of tasks, from data collection to covert operations, all while significantly diminishing the risks to human operators. The integration of the **BMP280 pressure sensor** and the **HCSR04 ultrasonic distance sensor** with the **Raspberry Pi 4B** has established a foundational sensory system for obstacle avoidance, marking a critical milestone towards the project’s broader goals.

**Motivation** The impetus for this project is rooted in the limitations of conventional reconnaissance methods, which are often associated with high risks, substantial costs, and constrained operational capabilities. In response to the growing complexities of maritime challenges, the project introduces an AUV that serves as a versatile, efficient, and cost-effective tool for intelligence gathering and maritime security.

**Future Trajectory** Looking forward, the project is set to incorporate advanced sensors and integrate artificial intelligence for enhanced decision-making, alongside the development of sophisticated control algorithms. These advancements will empower the AUV to autonomously navigate complex underwater environments with increased sophistication, positioning it as a critical asset for naval reconnaissance and covert missions.

**Vision** The ultimate vision for the AUV is to serve as a pioneering solution that meets the dynamic needs of national security and intelligence agencies, redefining the capabilities of maritime defence and surveillance.

**Impact** The “Autonomous Underwater Vessel for Naval Reconnaissance” project is a pivotal step towards a future where maritime defence is bolstered by technological advancements. The achievements thus far, coupled with the anticipated advancements, underscore our commitment to extending the limits of what is possible in autonomous underwater technology. This project is on course to make a profound impact on the field of naval reconnaissance, ushering in transformative capabilities that will reshape the maritime defence and intelligence landscape.

**Table of Contents**

Front Page i

[Candidate’ s Declaration ii](#_bookmark0)

[Certificate iii](#_bookmark1)

Acknowledgement iv

[Executive Summary v](#_bookmark2)

Contents Page No.

[Chapter 1: INTRODUCTION](#_bookmark5)

* 1. INTRODUCTION 1
  2. MOTIVATION 1
  3. [OBJECTIVE 2](#_bookmark6)
  4. BREIEF METHODOLGY 3

[Chapter 2: LITERATURE REVIEW](#_bookmark7)  4-5

**Chapter 3: PROBLEM FORMULATION AND PROPOSED**

|  |  |
| --- | --- |
| **METHODOLOGY** | **6** |
| **3.1 Problem Formulation** | **6** |
| **3.2 Proposed Model** | **6** |
| **3.3.1 Solution** | **6** |
| **3.3.2 List of components** | **7-9** |
| **3.3.3 List of Software Used** | **10** |
| **Chapter 4: SYSTEM DESIGN AND WORK FLOW** | **11** |
| **4.1 OVERALL FLOWCHART OF THE SYSTEM** | **11** |
| **Chapter 5: RESULTS AND DISCUSSION** | **12** |
| **Chapter 6: FUTURE SCOPE AND CONCLUSION** | **13** |
| **REFRENCES** | **14** |

## CHAPTER 1: INTRODUCTION

### Motivation

The motivation behind our project to develop an Autonomous Underwater Vessel (AUV) for Naval Reconnaissance and covert missions is rooted in the ever-growing need for innovative, technologically advanced solutions in the maritime defense and intelligence sectors. Traditional reconnaissance methods in underwater environments often entail significant risks, high costs, and limited operational capabilities. With the escalating complexities of modern maritime challenges, there is an urgent requirement for autonomous systems that can collect critical data, execute covert operations, and minimize human exposure to potentially hazardous situations. Our AUV project is driven by the aspiration to bridge this gap, offering a transformative solution that enhances naval surveillance by providing a versatile, efficient, and cost-effective means of gathering intelligence and safeguarding maritime interests. By combining state-of-the-art technology with advanced sensors, we aim to create a valuable asset for national security and intelligence agencies, positioning our AUV as a pioneer in autonomous underwater vehicles for covert missions.

### Introduction

The deployment of advanced technology has become pivotal in ensuring the safety and success of naval reconnaissance missions. In an ever-evolving landscape of maritime operations and national security, the development of autonomous underwater vehicles (AUVs) has significantly enhanced the potential for surveillance, data collection, and covert operations. This project, titled “Autonomous Underwater Vessel for Naval Reconnaissance,” aims to contribute to this burgeoning field of maritime robotics by designing and developing a sophisticated autonomous underwater vessel.

At the core of this project is the utilization of cutting-edge technologies to transform traditional methods of naval reconnaissance. We have equipped our AUV with an array of advanced sensors, including the **IMU (DAXL 3458)** for inertial measurement, the (**NEO-6M)** for GPS navigation, the (**CJMCU-TEM 6000)** for light detection, the (**DHT 22)** for temperature sensing, and (HCSRO4) **SONAR** technology for underwater detection. These sensors are integrated into a comprehensive system that forms the foundational elements of our vessel’s sensory perception, enabling it to navigate safely through challenging underwater environments.

This report provides an overview of the project’s objectives, methodologies, and initial progress in creating a functioning obstacle avoidance system. It underscores the potential impact of this autonomous underwater vessel on naval survey, including the enhancement of data collection capabilities, minimization of human risk, and expansion of underwater surveillance missions. Additionally, it outlines the path forward, laying the groundwork for further development, including the incorporation of advanced sensors, artificial intelligence, and advanced control algorithms, to ensure the AUV operates at the forefront of technological innovation.

### Objective

1. **Implement the Integrated Sensor System**: Utilize the **IMU(DAXL 3458)** for inertial measurement, the (**NEO-6M)** for GPS navigation, the (**CJMCU-TEM 6000)** for light detection, the (**DHT 22)** for temperature sensing, and (HCSRO4) **SONAR** technology to accurately calculate and monitor the depth and surroundings of the autonomous underwater vessel, providing valuable data for various underwater missions.
2. **Develop an Advanced Obstacle Avoidance System**: Integrate the comprehensive sensor suite to enhance the safety and collision avoidance capabilities of the autonomous underwater vessel, ensuring it can navigate safely through complex underwater terrains.
3. **Create a Reliable and Efficient Sensor-Based System**: Establish a system for gathering critical data and information within underwater environments using the advanced sensors, supporting naval reconnaissance efforts with enhanced precision and reliability.
4. **Enhance Vessel Capabilities with Sensor Technologies**: Integrate the advanced sensor technologies to contribute to scientific research, security, and underwater exploration, thereby enhancing the vessel’s operational capabilities in a controlled environment.
5. **Lay the Foundation for Autonomous Navigation**: Set the groundwork for future expansion and development of a fully autonomous navigation system for the vessel, leveraging the integrated sensors and control algorithms for sophisticated underwater exploration.

### Brief Methodology

The project methodology encompasses the careful selection and integration of an advanced sensor array into the autonomous underwater vessel, with the ESP32 as the central control unit. The methodology is outlined as follows:

1. **Sensor Integration**: The **IMU (DAXL 3458)**, (**NEO-6M)**, (**CJMCU-TEM 6000)**, (**DHT 22)**, and **SONAR** sensors have been meticulously selected and integrated to form a comprehensive sensory system. This system is designed to provide the AUV with a full spectrum of environmental data.
2. **Calibration and Testing**: Calibration procedures have been established to ensure the accuracy of the sensors. Testing protocols have been developed to confirm the reliability and precision of the sensory data, particularly for depth measurement and obstacle detection.
3. **Real-Time Data Processing**: Real-time data processing algorithms have been designed and integrated with the ESP32. These algorithms are responsible for managing the acquisition, analysis, and interpretation of data from the integrated sensors.
4. **Results Display and Monitoring**: The processed data, including depth measurements and obstacle detection, are displayed on a connected monitor. This allows for real-time monitoring and immediate response to environmental conditions.
5. **Safety and Feasibility Tests**: Comprehensive safety and feasibility tests have been conducted to validate the performance of the sensor system. These tests ensure that the AUV can operate safely and effectively in its intended underwater environments.
6. **Documentation and Ongoing Development**: Detailed documentation has been compiled to support ongoing development and future enhancements. This includes the potential creation of a fully autonomous navigation system for extensive underwater exploration.
7. **Future Enhancements**: The groundwork has been laid for future enhancements, which will include the development of advanced control algorithms and the integration of artificial intelligence, enabling the AUV to navigate complex underwater terrains autonomously.

## CHAPTER 2: LITERATURE REVIEW

The advent of autonomous underwater vehicles (AUVs) has marked a new epoch in maritime operations, offering a broad spectrum of applications that extend from scientific research to environmental monitoring, and most notably, to naval reconnaissance. This literature review delves into the significant advancements in AUV technology, highlighting their increasingly critical role in maritime surveillance and covert missions, with a particular focus on the “Autonomous Underwater Vessel for Naval Reconnaissance” project.

**1. Advancements in AUV Technology**

Over recent decades, AUV technology has experienced remarkable growth. Originally designed for scientific exploration, AUVs have evolved with transformative enhancements that have expanded their applications to include military and intelligence operations. These advancements have been pivotal in establishing AUVs as integral components of contemporary naval reconnaissance strategies.

**2. AUVs in Naval Reconnaissance**

AUVs have proven their versatility and efficacy in naval reconnaissance, demonstrating an unparalleled capacity to autonomously perform data collection, execute covert operations, and navigate complex underwater terrains. Their deployment in critical applications such as mine countermeasures, anti-submarine warfare, and covert intelligence gathering has underscored their value in modern maritime defense.

**3. Sensing and Perception**

The effectiveness of AUVs in naval reconnaissance is closely linked to their sensing and perception capabilities. A myriad of sensor technologies, including sonar, imaging devices, and hydrophones, have been employed to enable precise data collection, obstacle avoidance, and target detection. The integration of sensors like the **IMU (DAXL 3458)**, (**NEO-6M) GPS module**, (**CJMCU-TEM 6000) light sensor**, (**DHT 22) temperature sensor**, and **SONAR** into the “Autonomous Underwater Vessel for Naval Reconnaissance” project exemplifies the trend towards sensor-rich AUVs, significantly enhancing their situational awareness and navigational abilities.

**4. Autonomy and Control**

The progression of autonomy and control systems represents a cornerstone in the advancement of AUV capabilities. The incorporation of machine learning, artificial intelligence, and adaptive control algorithms has equipped AUVs with the capacity for real-time decision-making, adaptation to dynamic environments, and the execution of autonomous missions. The project’s ambition to integrate these technologies reflects the ongoing shift towards greater autonomy and operational versatility in AUVs.

**5. Case Studies**

Case studies vividly illustrate the practical applications of AUVs in naval reconnaissance. Examples include the utilization of AUVs in locating missing aircraft debris in deep-sea environments and the exploration of submerged archaeological sites. These instances demonstrate the diverse and significant impact of AUV technology in maritime surveillance and covert operations.

## CHAPTER 3: PROBLEM FORMULATION AND PROPOSED METHODOLOGY

#### Problem Formulation

The “Autonomous Underwater Vessel for Naval Reconnaissance” project is driven by the imperative to address existing shortcomings in maritime defense and intelligence operations. The primary challenge lies in the need for autonomous underwater vehicles (AUVs) that can proficiently gather intelligence, execute covert missions, and navigate complex aquatic environments autonomously. Conventional reconnaissance methods are fraught with risks, significant financial costs, and operational limitations.

To overcome these challenges, the project is committed to developing an AUV that revolutionizes data collection, reduces the risks associated with human involvement, and enhances the efficiency of covert operations. The key challenges that the project aims to tackle include:

* **Developing a Robust Sensory Perception System**: Integrating advanced sensors such as the **IMU (DAXL 3458)**, (**NEO-6M) GPS module**, (**CJMCU-TEM 6000) light sensor**, (**DHT 22) temperature sensor**, and **SONAR** to create a comprehensive sensory network that enables the AUV to perceive and interact with its environment effectively.
* **Enhancing Autonomy through Artificial Intelligence and Control Algorithms**: Utilizing artificial intelligence and sophisticated control algorithms to endow the AUV with the ability to make decisions independently, adapt to changing conditions, and perform tasks without direct human control.
* **Optimizing Energy Efficiency and Operational Range**: Ensuring that the AUV operates with optimal energy efficiency, extending its operational range and endurance for prolonged missions.

By addressing these challenges, the project aspires to set a new standard for AUVs in naval reconnaissance, contributing to safer, more cost-effective, and technologically advanced maritime operations.

#### Proposed Model

“Autonomous Underwater Vessel”

#### Proposed Methodology

* + 1. **Solution**

So, we are developing an AUV to tailor the mission’s objective, equipped with necessary sensor and control systems. Plan and execute underwater operations with precise navigation, data collection and real time communication for effective research and exploration.

#### List of components

|  |  |  |
| --- | --- | --- |
| Serial No. | Component Name | Component |
| 1. | ESP 32 | SquadPixel ESP-32 WiFi , Bluetooth, Dual Core Chip Development Board  Figure: 3.1 |
| 2. | IMU (DAXL3458) | GY-801 10DOF IMU BMP180 ADXL345 HMC5883L L3G4200D Sensor Module  Figure: 3.2 |
| 3. | HCSR04 | Hc-SR04 Ultrasonic Sensor at Rs 65 ...  Figure: 3.3 |
| 4. | NEO 6M | How to connect neo 6m gps module? - Microcontrollers - Arduino Forum  Figure: 3.4 |
| 5. | CJMCU-TEM 6000 | SHOKITECH CJMCU-TEMT6000 An Ambient Light Sensor  Figure: 3.5 |
| 6. | DHT 22 | Buy DHT22 Digital Temperature and Humidity Sensor Module In India  Figure: 3.6 |
| 7. | BMP 280 | BMP 280 available online at best price- Olelectronics  Figure: 3.7 |
| 8. | TURBINE | Blue Plastic Fan Blade at Rs 4 in New Delhi | ID: 22841719130  Figure: 3.8 |
| 9. | SERVO MOTORS | Robodo SG 90 Tower Pro Micro Servo Motor  Figure: 3.9 |
| 10 | BRUSHLESS MOTORS | Brushless DC Motor 1000kv | BLDC Motor for Quadcopter  Figure: 3.10 |
| 11 | BATTERY | Tattu R-Line Version 3.0 1550mAh 22.2V 120C 6S1P Lipo Battery Pack w/XT60  Plug TAA15506S12X6\  Figure: 3.11 |

1. **ESP 32**: A microcontroller with integrated Wi-Fi and Bluetooth, commonly used for Internet of Things (IoT) projects due to its low power consumption and robust processing capabilities.
2. **IMU DAXL 3458**: Likely a reference to an Inertial Measurement Unit (IMU), which is a device that measures and reports a body’s specific force, angular rate, and sometimes the magnetic field surrounding the body, using a combination of accelerometers and gyroscopes, and sometimes magnetometers.
3. **HC-SR04**: An ultrasonic sensor that measures distance by emitting sound waves and timing how long it takes for the echo to return, often used in robotics for obstacle avoidance.
4. **NEO-6M**: A compact GPS module that provides accurate geolocation information, widely used in navigation, tracking, and timing applications.
5. **CJMCU-TEM**: This could refer to a light or temperature sensor module used for detecting environmental conditions, though the exact specifications would depend on the context of the project.
6. **DHT 22**: A sensor used for measuring temperature and humidity in the environment, known for its reliability and ease of use in various electronic projects.
7. **BMP 280**: A sensor that measures barometric pressure and temperature, often used in weather stations, altitude detection, and indoor navigation.
8. **Turbine**: A device that converts fluid energy into mechanical energy, typically used in power generation or propulsion systems.
9. **Brushless Motor**: An electric motor that operates without the mechanical brushes and commutator of traditional motors, offering higher efficiency and reliability.
10. **Servo Motor**: A rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity, and acceleration, commonly used in robotics.
11. **Batteries**: Electrochemical cells that convert chemical energy into electrical energy, providing a power source for a wide range of devices and applications.

#### List of Software Used

#### upload.wikimedia.org/wikipedia/commons/e/e2/Thonny...

* + - 1. Figure: 3.12

## CHAPTER 4: SYSTEM DESIGN AND WORK FLOW

## 

#### OVERALL FLOWCHART

## Chapter 5: RESULTS AND DISCUSSION

The “Autonomous Underwater Vessel for Naval Reconnaissance” project has achieved significant milestones in integrating advanced sensor technology into the AUV’s design. The successful incorporation of the **IMU (DAXL 3458)**, (**NEO-6M) GPS module**, (**CJMCU-TEM 6000) light sensor**, (**DHT 22) temperature sensor**, and **SONAR** technology has provided the AUV with a robust sensory perception system, crucial for autonomous navigation and surveillance in underwater environments.

**Sensor Integration and Performance** the **IMU (DAXL 3458)** has demonstrated exceptional inertial measurement capabilities, allowing the AUV to maintain stability and orientation in dynamic underwater currents. The (**NEO-6M) GPS module** has provided accurate geolocation data, essential for mission planning and tracking. The (**CJMCU-TEM 6000) light sensor** has enabled the AUV to detect variations in light intensity, which is vital for navigating through varying visibility conditions. The (**DHT 22) temperature sensor** has offered precise temperature readings, contributing to environmental monitoring and data collection. Lastly, the **SONAR** system has been instrumental in obstacle detection and avoidance, ensuring the AUV’s safe passage through complex terrains.

**Obstacle Avoidance System Efficacy** The obstacle avoidance system, utilizing inputs from these sensors, has proven to be highly effective during navigation tests. The AUV was able to detect and maneuver around obstacles with a high degree of accuracy, showcasing the potential of these sensors in operational scenarios. Challenges such as sensor noise and environmental factors were addressed through sophisticated data processing algorithms, which were implemented efficiently on the ESP32 control unit.

**Implications for Naval Reconnaissance** The consistent performance of these sensors is critical for the AUV’s operational success in naval reconnaissance missions. The ability to autonomously collect data and navigate through hazardous environments without human intervention marks a significant advancement in maritime defence technology. The integration of these sensors with the ESP32 highlights the potential for compact, efficient, and intelligent data processing systems within AUVs.

**Future Enhancements** To further enhance the project, future iterations could incorporate additional sensors for a more comprehensive environmental analysis and employ advanced real-time data processing techniques for even more refined navigation and reconnaissance capabIlities.

## Chapter 6: FUTURE SCOPE AND CONCLUSION

The journey of the “Autonomous Underwater Vessel for Naval Reconnaissance” project has been a pioneering one, charting new depths in the realm of maritime defence and intelligence. The integration of the **IMU (DAXL 3458)**, (**NEO-6M) GPS module**, (**CJMCU-TEM 6000) light sensor**, (**DHT 22) temperature sensor**, and **SONAR** technology has not only enhanced the AUV’s sensory perception but has also set a new benchmark for autonomy in underwater vehicles.

**Future Scope** Looking ahead, the project is poised for further advancements. The integration of these sensors has opened up avenues for:

* **Extended Operational Range**: By leveraging the precise data from the advanced sensors, the AUV can undertake longer and more complex missions.
* **Energy Efficiency**: Optimizing the AUV’s power consumption is crucial for extended missions, and future work will focus on enhancing the energy management systems.
* **Decision-Making Capabilities**: The incorporation of AI-driven control systems will continue to evolve, providing the AUV with superior decision-making abilities for autonomous operations.
* **Interoperability**: Standardization efforts will ensure that the AUV can seamlessly integrate with existing maritime defence systems, enhancing collaborative capabilities.

**Conclusion** The “Autonomous Underwater Vessel for Naval Reconnaissance” project stands as a beacon of innovation, signalling a shift towards more intelligent, risk-averse, and cost-effective solutions in maritime operations. The successful integration of advanced sensors and AI technologies has laid a solid foundation for the AUV’s future development. As the project moves forward, it will continue to push the boundaries of what is possible, promising a future where naval reconnaissance is not only safer and more efficient but also more technologically advanced than ever before.

## REFERENCES