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Smart Life Jacket with Embedded SOS Transmitter

Onkar Sunil Godge[1], Pranav Sandip Kadu[2], Om Raosaheb Kakad[3], Kartik Raju Kale[4], Prof. A. E. Kachare[5]

[1,2,3,4] Students and [5] Professor of Department of Electronics & Telecommunication Engineering, Amrutvahini College of Engineering, Sangamner, Maharashtra, India.

Abstract: *The Smart Life Jacket with Embedded SOS Transmitter is an IoT-based wearable safety system designed to improve maritime rescue operations. The system integrates an ESP32 microcontroller, GPS module, LoRa communication module, water immersion sensor, and manual SOS button to provide automatic and manual emergency alerts. When the wearer falls into water or activates the SOS button, the device obtains real-time GPS coordinates and transmits distress messages over long distances using LoRa technology. The system operates with low power consumption and is enclosed in a waterproof casing, making it suitable for marine and flood-prone environments. This solution enhances victim tracking, reduces rescue response time, and improves overall maritime safety.*

Keywords: Smart Life Jacket, ESP32, LoRa Communication, GPS Tracking, SOS Transmitter, Water Immersion Sensor, Maritime Safety, IoT, Emergency Rescue, Wearable Device.

I. INTRODUCTION

Maritime safety is an important concern worldwide due to the increasing use of waterways for transportation, fishing, tourism, and rescue operations. Every year, numerous accidents occur at sea and in flood-prone regions, resulting in injuries and loss of lives because victims are unable to communicate their location effectively during emergencies [1]. Traditional life jackets provide buoyancy and help keep a person afloat, but they do not offer any mechanism for distress communication or real-time tracking [2].

Existing emergency communication systems such as Emergency Position Indicating Radio Beacons (EPIRBs), Automatic Identification System (AIS) beacons, and GSM-based tracking devices have several limitations. Satellite-based systems are often expensive and bulky, while GSM-based systems depend on cellular network availability, which is generally absent in offshore and remote marine environments [3][4]. These limitations highlight the need for a compact, cost-effective, and reliable emergency alert system integrated directly into personal safety equipment [5].

Recent advancements in the Internet of Things (IoT) and embedded systems have enabled the development of intelligent wearable safety devices [6]. Low-Power Wide-Area Network (LPWAN) technologies, particularly LoRa (Long Range), provide long-distance communication with minimal power consumption, making them suitable for maritime emergency applications [7][8]. LoRa technology can transmit critical information over several kilometers without relying on cellular infrastructure, ensuring communication even in isolated regions [9].

The proposed Smart Life Jacket with Embedded SOS Transmitter integrates an ESP32 microcontroller, GPS module, LoRa communication module, water immersion sensor, and manual SOS button to create an intelligent rescue assistance system [10].

II. PROBLEM STATEMENT

Maritime accidents, flooding incidents, and water-related emergencies often result in significant loss of life due to delayed rescue operations and the inability of victims to communicate their location accurately. Traditional life jackets

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provide flotation support but lack any mechanism for emergency communication, real-time location tracking, or automatic distress signaling. Existing solutions such as GSM-based trackers, AIS beacons, and satellite emergency systems are either dependent on network availability, limited in coverage, expensive, or unsuitable for personal wearable applications.

Therefore, there is a need to develop a smart, low-cost, and reliable life jacket capable of automatically detecting emergency situations, acquiring the wearer's real-time GPS location, and transmitting SOS alerts over long distances without relying on cellular networks. The proposed Smart **Life** Jacket with Embedded SOS Transmitter addresses this challenge by integrating ESP32, GPS, LoRa communication, and water immersion sensing technologies to enhance maritime safety and improve rescue response time.

III. OBJECTIVES

- To develop a smart life jacket capable of transmitting emergency SOS alerts during maritime accidents.
- To implement GPS-based real-time location tracking for accurate victim positioning.
- To utilize LoRa technology for long-range communication without cellular network dependency.
- To enable automatic SOS activation using a water immersion detection sensor.
- To design a low-power, waterproof, and wearable safety system for enhanced maritime rescue operations.

IV. LITERATURE SURVEY

Haxhibeqiri J., De Poorter E., Moerman I., Hoebeke J. (2018) presented a comprehensive survey titled *"A Survey of LoRaWAN for IoT: From Technology to Application."* The study discussed the architecture, advantages, and challenges of LoRaWAN technology for IoT applications. The authors highlighted LoRa's long-range communication capability and low power consumption, making it suitable for remote monitoring systems. However, limitations such as low data rates and network scalability issues were identified. This work provides a strong foundation for selecting LoRa communication in maritime emergency applications.

Apriliansyah B. A. and Iqbal M. (2024) proposed a *"LoRa Based Long-Range Traceable Life Jacket System Design"* for fishermen operating in remote sea regions. The system integrated GPS and LoRa modules for location tracking and distress communication. Experimental results demonstrated a communication range of approximately 13 km with satisfactory performance. However, battery life and signal attenuation due to environmental obstacles remained challenges. The study validates the feasibility of LoRa-based wearable safety devices.

Masril M. A., Caniago D. P., and Wibowo S. A. (2025) developed *"SERA (Smart Ergonomic Rescue Apparel)"* incorporating biometric sensors, GPS, and LoRa communication. The system monitored body temperature and heart rate while providing real-time location tracking during rescue operations. Results showed reliable communication over long distances and effective health monitoring. However, increased hardware complexity and power consumption were observed. This research highlights the potential of integrating health monitoring with maritime safety systems.

Dehda P. S., Jayram S., Abu-Mahfouz A. M., and Ouahada K. (2024) introduced *"A Sea Rescue Operation System Based on LoRa."* Their system employed GPS, pulse sensors, and LoRa communication for emergency response. The proposed solution achieved accurate location tracking and low communication latency, improving rescue efficiency. Nevertheless, communication range was influenced by environmental conditions. The study demonstrates the effectiveness of combining GPS and LoRa technologies for marine rescue applications.

Sarkar S. (2025) proposed a *"Smart Life Safety Jacket for Rescuers"* using ESP32, IoT sensors, and GPS technology. The system was designed to support rescue personnel during flood and disaster management operations. It enabled real-

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time monitoring and location tracking while maintaining low power consumption. However, dependency on external monitoring infrastructure was identified as a limitation. The research supports the use of ESP32 as a reliable controller for wearable rescue systems.

Muthuselvan S., Chandru A., Lavanya R., Gnana Adarsh G., Venket K. V. S., and Rajasekaran R. (2025) developed an *"Intelligent Safety Life Jacket Using LoRa Technology."* The system integrated LoRa communication, GPS tracking, and emergency detection sensors to improve outdoor and maritime safety. The authors reported enhanced communication reliability and extended battery life. However, performance under extreme weather conditions required further investigation. This study directly supports the development of smart life jackets for real-time emergency communication and rescue assistance.

Comparison Table

Author & Year	Method Used	Advantages	Limitations
Haxhibeqiri et al. (2018)	LoRaWAN for IoT	Long-range, low-power communication	Low data rate and scalability issues
Apriliansyah & Iqbal (2024)	LoRa + GPS Life Jacket	Up to 13 km communication range	Limited battery life
Masril et al. (2025)	LoRa + GPS + Biometric Sensors	Health monitoring and tracking	Higher power consumption
Dehda et al. (2024)	Sea Rescue System using LoRa	Accurate tracking and low delay	Range affected by environment
Sarkar (2025)	ESP32-based Smart Safety Jacket	Real-time monitoring and alerts	Requires monitoring infrastructure
Muthuselvan et al. (2025)	Intelligent LoRa Life Jacket	Reliable communication and safety	Performance affected by extreme weather

IV. WORKING OF SYSTEM

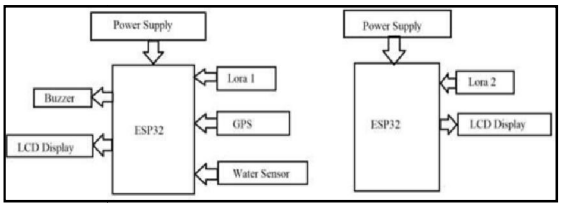

Fig 1: Design of the system

The Smart Life Jacket with Embedded SOS Transmitter consists of two sections: a **transmitter unit** integrated into the life jacket and a **receiver unit** located at the rescue station.

Step 1: Power Supply Activation

The power supply provides the required operating voltage to all system components, including the ESP32 microcontroller, GPS module, LoRa module, LCD display, buzzer, and water sensor.

Step 2: Monitoring by ESP32

The ESP32 continuously monitors the water sensor and other input signals. It acts as the central processing unit and controls all system operations.

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Step 3: Water Detection
When the wearer falls into water, the water sensor detects immersion and sends a signal to the ESP32. An emergency condition can also be triggered manually if required.

Step 4: GPS Location Acquisition
Upon receiving the emergency signal, the ESP32 activates the GPS module to obtain the current latitude and longitude coordinates of the wearer.

Step 5: SOS Data Preparation
The ESP32 processes the GPS information and creates an SOS message containing the device identification and real-time location details.

Step 6: LoRa Transmission
The prepared SOS message is transmitted through the LoRa transmitter module (LoRa 1), enabling long-range wireless communication without relying on cellular networks.

Step 7: Alert Indication
Simultaneously, the buzzer generates an audible alarm and the LCD display shows the system status, confirming that the SOS signal has been activated.

Step 8: LoRa Reception
At the rescue station, the LoRa receiver module (LoRa 2) receives the transmitted SOS message and forwards it to the receiver-side ESP32.

Step 9: Display of Location Information
The receiver ESP32 processes the received data and displays the victim's location and emergency status on the LCD display.

Step 10: Rescue Operation
Rescue personnel use the displayed GPS coordinates to quickly locate and assist the stranded individual, thereby reducing rescue response time and improving maritime safety.

V. SYSTEM DESIGN

The Smart Life Jacket with Embedded SOS Transmitter is designed as a wearable safety system that combines sensing, processing, communication, and alerting modules to provide rapid emergency assistance during maritime accidents. The system consists of a transmitter section integrated into the life jacket and a receiver section located at the rescue station.

1. ESP32 Microcontroller

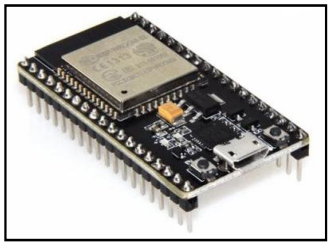

Fig.2 ESP32

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The ESP32 serves as the central processing unit of the system. It continuously monitors the water sensor, acquires GPS data, controls the buzzer and LCD display, and manages LoRa communication. Due to its low power consumption and high processing capability, it is ideal for wearable IoT applications.

2. Water Sensor

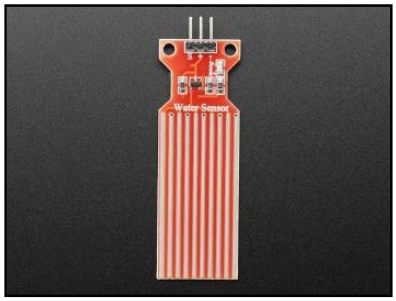

Fig.3.Water Sensor

The water sensor detects the presence of water when the wearer falls into a river, sea, or floodwater. Once immersion is detected, it sends a signal to the ESP32, which initiates the emergency rescue procedure automatically.

3. GPS Module

Fig.4.GPS Module

The GPS module provides real-time location information in the form of latitude and longitude coordinates. When an emergency is detected, the GPS module acquires the user's position and sends it to the ESP32 for transmission.

4. LoRa Transmitter Module (LoRa 1)

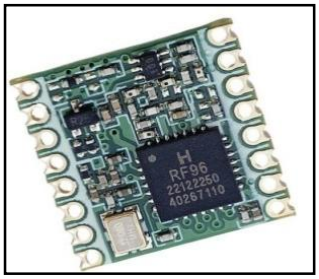

Fig.5.LoRa Module

The LoRa transmitter module is responsible for sending emergency messages and GPS coordinates over long distances. LoRa technology enables reliable communication without depending on cellular networks, making it suitable for remote marine environments.

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5. Buzzer

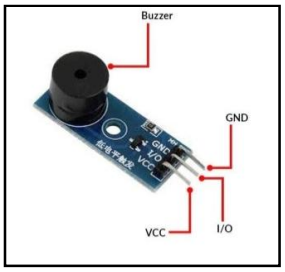

Fig.6.Buzzer

The buzzer acts as an audible alert device. It is activated when the SOS signal is triggered, providing confirmation to the wearer and helping nearby rescuers identify the victim's location.

6. LCD Display (Transmitter Side)

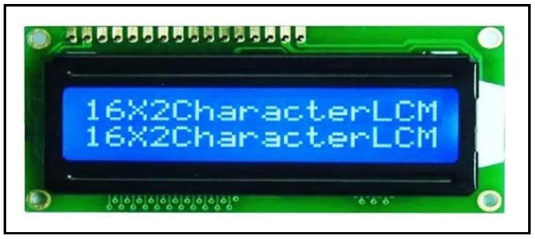

Fig.7.LCD Display

The LCD display connected to the transmitter unit shows system status information such as GPS acquisition, SOS activation, and transmission status. This helps users verify the operational condition of the device.

VI. RESULTS

The developed Smart Life Jacket with Embedded SOS Transmitter successfully demonstrated the ability to provide real-time emergency alerts and location tracking during water-related emergencies. The water sensor accurately detected immersion in water and automatically triggered the SOS mechanism without requiring manual intervention. The ESP32 microcontroller efficiently processed sensor inputs and coordinated communication between the GPS and LoRa modules, ensuring reliable system operation. The buzzer and LCD display provided immediate visual and audible feedback, confirming successful activation of the emergency alert system.

The GPS module successfully acquired the wearer's location coordinates and transmitted them through the LoRa communication module to the receiver unit. The receiver system accurately displayed the received location information on the LCD screen, enabling quick identification of the victim's position. Long-range communication through LoRa proved effective in transmitting SOS messages without dependence on cellular networks, making the system suitable for remote maritime and flood-prone areas. The overall results indicate that the proposed smart life jacket can significantly reduce rescue response time, improve victim tracking accuracy, and enhance safety for fishermen, boaters, rescue personnel, and individuals operating in aquatic environments. The system achieved reliable performance with low power consumption, demonstrating its feasibility as a cost-effective and practical wearable maritime safety solution.

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VII. CONCLUSION

The Smart Life Jacket with Embedded SOS Transmitter is an effective and innovative solution for enhancing maritime safety and emergency rescue operations. By integrating an ESP32 microcontroller, GPS module, LoRa communication technology, water sensor, and alert mechanisms, the system provides automatic detection of emergency situations and real-time transmission of distress signals along with location information. The proposed system eliminates dependence on cellular networks and ensures reliable long-range communication in remote aquatic environments. The results demonstrate that the device can significantly improve rescue response time, increase the chances of locating victims quickly, and reduce the risk of fatalities during maritime accidents and flood-related emergencies. Its low-power operation, compact design, and cost-effectiveness make it a practical and reliable wearable safety solution for fishermen, boaters, rescue personnel, and individuals working in water-prone areas.

VIII. FUTURE SCOPE

The proposed Smart Life Jacket with Embedded SOS Transmitter can be further enhanced by integrating advanced technologies to improve safety and rescue efficiency. Future developments may include the addition of biometric sensors such as heart rate, body temperature, and oxygen level monitoring to assess the victim's health condition during emergencies. Satellite communication modules can be incorporated to provide global coverage in deep-sea regions where LoRa gateways are unavailable. The system can also be connected to cloud-based IoT platforms and mobile applications for real-time monitoring and instant notification to rescue teams and family members. Furthermore, the integration of AI-based distress prediction, drone-assisted search and rescue systems, and solar-powered charging mechanisms can improve reliability, operational duration, and overall effectiveness, making the smart life jacket a comprehensive next-generation maritime safety solution.

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