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IoT-Based Maritime Safety and Boundary Alert System for Small Fishing Vessels

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ABSTRACT

Maritime safety is a significant concern for small fishing vessels, particularly when fishermen operate near predefined or restricted maritime boundaries. The absence of timely boundary-related warnings may cause a vessel to unintentionally approach or cross a designated boundary. Conventional location monitoring can provide geographical information, but an integrated system that interprets the vessel's location, generates local warnings, and notifies a shore-side contact can provide additional assistance during navigation. To address this requirement, this paper presents an IoT-based Maritime Safety and Boundary Alert System for Small Fishing Vessels using GPS location monitoring, microcontroller-based processing, and GSM communication. The proposed system is developed around an ESP32 microcontroller, a NEO-6M Global Positioning System (GPS) module, a SIM800A Global System for Mobile Communications (GSM) module, an LCD, and a buzzer. The GPS module obtains the vessel's geographical coordinates in terms of latitude and longitude. These coordinates are supplied to the ESP32, which processes the location information and evaluates the vessel's distance from a predefined maritime boundary using the configured monitoring logic. The calculated distance and corresponding operating status are displayed on the LCD, enabling the fisherman to observe the vessel's position relative to the boundary. When the vessel approaches the configured boundary region, the controller activates the buzzer and displays a warning message. When the programmed boundary-crossing condition is detected, the GSM module is used to transmit an SMS notification to a registered mobile number. The project prototype illustrates the operating sequence through GPS initialization messages, GPS-fix status, distance display, proximity warnings, and a boundary-alert message associated with SMS notification. The demonstration outputs include a safe-side distance indication of 5.25 km and warning messages associated with distances of 4 km and 2 km. These values are presented as displayed demonstration outputs rather than as measurements of system accuracy or validated safety thresholds. The block diagram and working-model image illustrate the integration of the principal hardware components, while the LCD outputs provide a visual representation of the monitoring sequence. The proposed design combines location monitoring, local warning, and remote notification in a compact embedded-system prototype intended to support boundary awareness for small fishing vessels.

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1. Introduction

Maritime safety is an important consideration for small fishing vessels operating in coastal and offshore waters. Fishing activities often require vessels to travel away from shore, where continuous awareness of geographical position and nearby maritime boundaries is essential. Fishermen may unintentionally approach or cross predefined or restricted boundaries when navigation information is insufficient or when timely warnings are unavailable. Such situations emphasize the need for affordable monitoring systems that can provide clear information and alerts during navigation.

The Global Positioning System (GPS) provides geographical coordinates that can be used to determine the location of a vessel. By processing latitude and longitude values, a monitoring system can estimate the vessel's distance from a predefined reference boundary. However, location information alone may not provide an effective warning unless the information is interpreted and communicated to the user in a timely manner. A practical safety system should therefore combine location acquisition, boundary-distance calculation, visual indication, audible warnings, and communication with a registered contact.

The Internet of Things (IoT) provides a framework for connecting sensing, processing, and communication functions within a single system. In the proposed project, the ESP32 microcontroller coordinates the operation of the GPS module, LCD, buzzer, and GSM communication module. The GPS module provides location information, the controller evaluates the vessel's position relative to the configured boundary, and the output devices communicate the system status to the fisherman. When the boundary is crossed, the GSM module is intended to send an SMS notification to a registered mobile number.

The proposed IoT-based Maritime Safety and Boundary Alert System is developed as a compact and economical approach to improving boundary awareness for small fishing vessels. Its principal purpose is to provide an early local warning as the vessel approaches a predefined boundary and to communicate a boundary-crossing event to a shore-side contact. The design integrates these functions into one prototype, reducing the need for separate devices for position indication and warning.

This paper describes the problem addressed, related work, proposed system architecture, hardware components, working principle, implementation, observed outputs, limitations, and future scope of the project.

2. Literature Survey

D. Amarnath, G. Renganayahi, S. Abirami, and A. Kayalvizhi presented work titled "IoT Based Fisherman Border Alert System" in the International Journal of Advanced Research in Science, Communication and Technology in January 2025. The topic is directly related to the use of IoT technologies for detecting boundary-related conditions and providing alerts to fishermen. Such work establishes the relevance of integrating position information with an automatic warning mechanism rather than relying solely on manual observation.

R. Praba's work, "Fisherman Border Alert System Using GPS," published in the International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering in March 2025, concerns the use of GPS for fisherman boundary monitoring. GPS-based systems can obtain geographical coordinates and use them as inputs for position-dependent warning logic.

D. Mythily and R. Helan Renila presented "IoT Based Fisherman Border Alert and Weather Alert" in the International Journal of Engineering Research & Technology in 2020. The work connects fisherman boundary alerts with the broader context of safety-related information. It highlights the relevance of developing monitoring arrangements that can help fishermen recognize potentially important conditions during navigation.

3. Proposed System

The proposed system is an integrated GPS-based maritime boundary monitoring and alert arrangement intended to improve the awareness of fishermen operating small fishing vessels. Its primary function is to obtain the vessel's geographical position, evaluate the position in relation to a predefined maritime boundary, display the calculated distance or warning status, and generate alerts when the vessel approaches or crosses the configured boundary. The system combines location acquisition, processing, local indication, and wireless notification within a single prototype.

The ESP32 microcontroller serves as the central processing unit and coordinates the operation of the connected modules. The NEO-6M GPS module provides the geographical coordinates required for location monitoring. After receiving valid coordinates, the ESP32 processes the location information and evaluates the distance from the predefined boundary according to the implemented program. The resulting information is displayed on the LCD, allowing the fisherman to observe the monitoring status without interpreting raw geographical coordinates manually.

The alert mechanism operates through two complementary outputs. The LCD provides visual information about the system status and distance from the boundary, while the buzzer produces an audible warning when the vessel enters the configured proximity-warning region. This combination is intended to attract the fisherman's attention as the vessel approaches the boundary. When the programmed boundary-crossing condition is detected, the ESP32 initiates an SMS notification through the SIM800A GSM module. The message is intended for a registered mobile number so that a shore-side contact can be informed of the detected event.

The overall system is designed to repeat the monitoring sequence as updated GPS information becomes available. This allows the controller to evaluate changes in the vessel's position and update the displayed status. GPS initialization and valid-fix checking are important parts of the process because boundary-distance calculations require usable location data. If a GPS fix is unavailable, the system

indicates that it is waiting for location information rather than treating an unconfirmed position as a verified boundary crossing.

The proposed arrangement is intended to provide an economical prototype for location-based boundary awareness. Its functions depend on correct boundary configuration, appropriate distance-calculation logic, valid GPS information, suitable electrical power, and GSM network availability for SMS transmission.

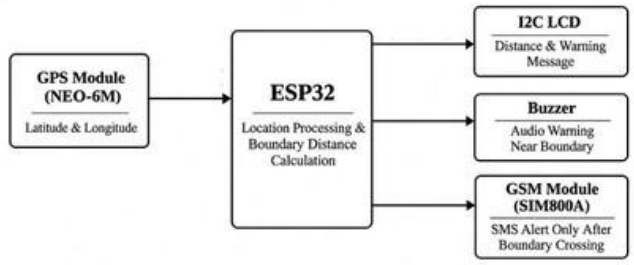


Fig 1: Block Diagram of Proposed Method

The block diagram illustrates the relationship between the location-acquisition unit, processing unit, display, audible warning device, and communication module. The NEO-6M GPS module supplies geographical coordinates to the ESP32. The controlled processes the received information and evaluates the vessel's distance from the configured boundary. The LCD receives the status and distance information for visual indication. The buzzer provides an audible warning when the proximity condition is reached, while the SIM800A GSM module supports SMS notification when the boundary-crossing condition is detected. The diagram therefore represents the main information flow from location acquisition to local and remote alert generation.

The block diagram also shows that the system's operation depends on coordination among the hardware modules. The GPS module supplies the information needed for the monitoring decision, the ESP32 performs the processing, and the output modules communicate the result. The LCD and buzzer provide local warnings, whereas SMS provides a separate notification channel that depends on cellular network availability.

4. Experimental Setup and Hardware Implementation

The experimental setup consists of the ESP32 microcontroller, NEO-6M GPS module, SIM800A GSM module, LCD, buzzer, power supply, and the required electrical interconnections. These components are assembled as a prototype to demonstrate the intended operation of the maritime safety and boundary alert system. The working-model photograph supplied in the project presentation should be used to show the physical arrangement of the available hardware.

The ESP32 is positioned as the central controller. The GPS module is connected to provide location information, and the display is used to present system status and boundary-related messages. The buzzer is incorporated as the local audible warning device. The GSM module is included to support SMS notification when the programmed boundary-crossing condition is identified.

The prototype arrangement demonstrates how the separate hardware units work together to implement location monitoring and alert generation. The GPS module supplies the position data, the controller processes the data.

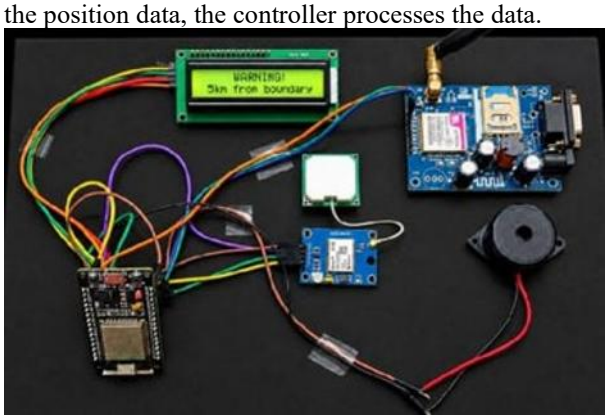


Fig 2: Experimental Setup

The ESP32 is responsible for coordinating the system's operating sequence. It receives location information fromthe GPS module, processes the coordinates, evaluates the boundary condition, and controls the output devices. The controller also manages the initiation of SMS notification through the GSM module when the required condition is detected.

The controller-based arrangement allows the system to combine multiple functions without requiring a separate processing unit for each output. The LCD, buzzer, and GSM module respond to the decisions made by the ESP32. This integrated approach simplifies the overall functional architecture and provides a common point for implementing the boundary-monitoring logic.

For reliable operation, the controller must distinguish valid GPS information from an unavailable or incomplete GPS fix. The monitoring process should use valid coordinates before calculating the vessel's distance from the boundary. This distinction is reflected in the startup and GPS-status messages shown in the project results.

After valid coordinates are obtained, the ESP32 evaluates the vessel's position relative to the predefined boundary. The resulting distance information is displayed on the LCD. As the vessel approaches the configured boundary region, the controller identifies the corresponding proximity condition and provides a warning.

The presentation illustrates a safe-side output displaying a distance of 5.25 km and warning messages associated with 4 km and 2 km. These outputs show the intended relationship between distance information and warning status. They should be treated as demonstration values displayed by the prototype, not as evidence of GPS accuracy, verified distance error, or universally applicable maritime warning thresholds.

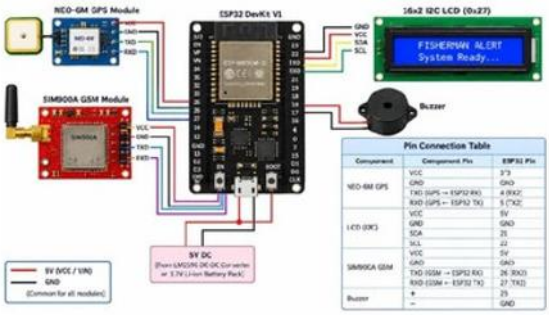


Fig 3: circuit diagram with pin connection

The prototype's operating sequence can be described through the following procedure:

1. The system is powered on, and the ESP32 initializes the connected modules.
2. The GPS module begins acquiring satellite information.
3. The LCD displays the startup message and indicates when the GPS fix is not yet ready.
4. After valid coordinates become available, the ESP32 reads and processes the location information.
5. The controller evaluates the vessel's distance from the configured maritime boundary.
6. The LCD displays the resulting distance and corresponding status.
7. When the configured proximity-warning condition is reached, the system displays a warning and activates the buzzer.
8. When the programmed boundary-crossing condition is detected, the ESP32 initiates SMS notification through the SIM800A GSM module.
9. The monitoring sequence continues as updated GPS information becomes available.

This procedure explains the intended functional demonstration of the prototype. The presentation provides images and LCD outputs associated with the sequence, but it does not provide a complete experimental log containing test duration, repeated trials, independent reference measurements, or quantified performance data. The results should therefore be discussed as functional demonstration outputs rather than as a comprehensive quantitative validation.

5. Results and Discussion

The proposed IoT-Based Maritime Safety and Boundary Alert System for Small Fishing Vessels was demonstrated using an ESP32 microcontroller, NEO-6M GPS module, SIM800A GSM module, LCD, and buzzer. The project presentation provides the working-model photograph and LCD outputs that illustrate the different stages of system operation.



Fig. 4.1. GPS Initialization Message Displayed on the LCD

When the system is powered on, the controller initiates the GPS-based location-monitoring process. The LCD displays the message "FISHERMAN ALERT! Starting GPS…" to indicate that GPS initialization has started. The subsequent message, "GPS NOT READY Waiting for fix", indicates that the GPS module has not yet provided usable location information.

This stage is important because the boundary-monitoring process depends on valid geographical coordinates. Once usable GPS information becomes available, the ESP32 can process the coordinates and evaluate the vessel's position relative to the configured boundary. The GPS-status messages therefore illustrate how the system distinguishes the initialization stage from location-dependent monitoring.



Figure 4.2: Safe-Side Distance Display Showing 5.25 km

the LCD output "SAFE SIDE Distance=5.25km". This output demonstrates the intended display of a distance-related value when the vessel is represented as being on the safe side of the configured boundary. By presenting the distance and status on the LCD, the system enables the fisherman to observe the monitoring result without manually interpreting latitude and longitude values.

The displayed value of 5.25 km is a demonstration output from the project. It should not be interpreted as a verified measurement of distance accuracy



Figure 4.3: Boundary Proximity Warning at 2 km

Warning outputs associated with distances of 4 km and 2 km. These outputs illustrate the intended warning sequence as the displayed distance approaches the configured boundary region. The LCD provides visual information about the warning condition, while the buzzer is intended to provide an audible indication to attract the fisherman's attention.

The use of visual and audible warnings provides two local notification methods. This arrangement is intended to make the boundary-related status easier to recognize during operation. The exact activation thresholds and warning conditions must correspond to the program implemented in the prototype. The displayed distances represent demonstration outputs and should not be treated as universally applicable maritime warning thresholds.



Figure 4.4: Boundary Crossing Alert

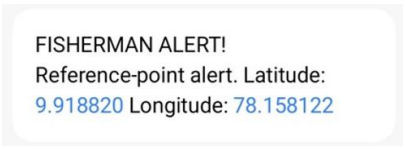


Figure 4.5: Boundary Crossing Alert and SMS Notification

The LCD output "BOUNDARY ALERT! SMS notification" represents the boundary-alert stage of the monitoring process. When the programmed boundary-crossing condition is detected, the ESP32 initiates the SMS-notification process through the SIM800A GSM module. The message is intended to notify a registered mobile number about the detected event. This function complements the local LCD and buzzer warnings by providing a remote notification channel. However, the successful delivery of an SMS depends on the GSM module configuration, SIM availability, power supply, and cellular network coverage. The presentation shows the boundary-alert notification stage, but it does not provide measured SMS delivery time or sufficient evidence to establish delivery reliability under all operating conditions.

The demonstration outputs illustrate the intended sequence of the proposed system: GPS initialization, GPS-fix checking, distance evaluation, safe-side indication, proximity warning, and boundary-alert notification. The working-model photograph documents the hardware arrangement, while the LCD outputs provide visual evidence of the messages associated with the monitoring process.

The results support the functional concept of integrating GPS-based location monitoring, microcontroller processing, local warning, and GSM-based notification in a single prototype. The system is designed to help fishermen recognize when a vessel approaches or crosses a configured boundary. Nevertheless, the available project material does not provide quantitative data for GPS accuracy, distance-calculation error, repeated-test performance, SMS delivery latency, power consumption, or operation during actual sea trials.

Consequently, the findings should be interpreted as a functional demonstration rather than a complete quantitative performance evaluation. Further testing using known reference coordinates, repeated proximity and boundary-crossing tests, recorded SMS delivery outcomes, and practical marine trials is required to establish the accuracy and reliability of the system

The prototype can be improved through more extensive testing and additional monitoring capabilities. A first priority is to evaluate GPS performance by comparing reported coordinates with known reference positions under different operating conditions. Distance calculations should be verified against independently calculated reference distances, and the boundary configuration should be checked for correctness.

Further development could include data logging, historical position records, a more detailed visual interface, and remote monitoring features where suitable connectivity is available. A more advanced version could incorporate additional environmental or vessel-status sensors if these functions are defined, implemented, and evaluated separately.

The physical design could also be improved for marine use through appropriate enclosure protection, corrosion-resistant connections, stable power management, and testing under vibration and moisture exposure. Finally, controlled trials followed by carefully planned sea trials would be needed to assess the practical usefulness of the warning thresholds and the overall monitoring sequence.

6. Conclusion

This paper presents an IoT-based Maritime Safety and Boundary Alert System for Small Fishing Vessels that integrates GPS-based location monitoring, boundary-distance evaluation, visual indication, audible warnings, and GSM-based SMS notification. The ESP32 acts as the central controller, while the NEO-6M GPS module supplies location coordinates. The LCD displays system status and distance-related messages, the buzzer provides a local warning when the vessel approaches the configured boundary, and the SIM800A GSM module supports SMS notification when the boundary-crossing condition is detected. The project demonstrates the intended sequence through GPS initialization messages, a waiting state for GPS acquisition, safe-side distance display, proximity warnings, and a boundary-alert message associated with SMS notification. These outputs illustrate the functional concept of combining location information with local and shore-side alerts. The proposed design offers a foundation for an economical maritime boundary-awareness prototype for small fishing vessels. However, the available material does not provide quantitative accuracy measurements or sea-trial results. Further evaluation of GPS performance, distance-calculation accuracy, SMS delivery, power consumption, and marine operating reliability is required before practical deployment. With suitable testing and refinement, the system could contribute to the development of integrated electronic warning aids for maritime safety.

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