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Proposed Framework and Features of SeaCure: An IoT-Based GPS Monitoring and Emergency Alert System Using LoRa Technology for Small-Scale Fisherfolk

Jovani Joshua Espiritu, John Steven Sañana, Jeah Laulita, Divine Mhay Canono, Mark Leslie Melendez

Bachelor of Science in Information Technology, Pangasinan State University

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ABSTRACT

Small-scale fisherfolk face high occupational risk from storms, engine failure, and medical emergencies, yet most work offshore without communication devices or any means of being tracked. Existing vessel monitoring systems are designed for commercial fleets and depend on cellular coverage, satellite subscriptions, or costly hardware, which places them out of reach of community-level fishing organizations. This study presents SeaCure, a low-cost, web-based Internet of Things (IoT) GPS monitoring and emergency alert system that uses LoRa technology to transmit boat positions and distress signals beyond cellular coverage. The system was developed for the Abagatanen Western Fishermen Association (AWFA) in Agno, Pangasinan, Philippines, using a descriptive developmental research design and an Agile prototype-based process. Requirements were drawn from interviews with the association president and members and from observation of fishing operations. The boat unit combines a Heltec LoRa 32 V3 microcontroller, a GT-U7 GPS module, an OLED display, separate SOS and medical-emergency toggle switches, a buzzer, and a rechargeable battery. A shore-based receiver forwards the data to a web dashboard that provides live fleet tracking, color-coded alerts, geofenced safe zones, device management, and family access control. The estimated cost of a boat unit is ₱1,500 to ₱2,700, and a gateway costs ₱4,000 to ₱15,000, with no subscription fees. Acceptability will be evaluated with the ISO/IEC 25010 quality model through Likert-scale questionnaires administered to fisherfolk, their families, and IT experts, and analyzed using the weighted mean. This paper reports the problem analysis, system architecture, hardware and software design, and interface prototype of SeaCure. The design indicates that long-range, subscription-free LoRa communication can address the monitoring and emergency-response gaps of small-scale fishing communities. Field-testing and evaluation results will determine the system's readiness for wider deployment.

Keywords: IoT GPS Tracking, LoRa, Emergency Alert System, Small-scale fisherfolk, ISO/IEC 25010.

INTRODUCTION

Fishing remains a vital livelihood in many coastal communities, especially in developing countries, where small-scale operations provide food security, income, and employment. However, it is also one of the most hazardous occupations, with fisherfolk facing unpredictable weather, rough seas, and mechanical failures far from shore. The lack of reliable communication offshore worsens these risks, as weak or absent cellular signals prevent fisherfolk from calling for help, leading to delayed emergency responses and greater danger during crises.

To address these challenges, researchers have explored technologies such as the Internet of Things (IoT), GPS, and wireless communication systems. In the Philippines, IoT-based vessel monitoring systems combining GPS and LoRa communication have been tested to track boats in real time, offering safer and more efficient monitoring. Organizations like WWF Philippines and USAID Oceans have deployed similar technologies to support fisheries management and safety. Yet, most existing solutions are designed for large-

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scale operations, requiring costly hardware, satellite links, or stable internet—making them unsuitable for small-scale fisherfolk in rural communities with limited infrastructure.

This study focuses on Agno, Pangasinan, particularly the Abagatanen Western Fishermen Association (AWFA), whose members face risks such as engine breakdowns, medical emergencies, and delayed rescues due to the absence of tracking systems. To bridge this gap, the study develops SeaCure, a low-cost IoT GPS monitoring and emergency alert system using LoRa technology. The system includes GPS-based tracking, wireless communication, an SOS alert feature, and a web-based dashboard. Its scope is limited to AWFA fisherfolk, with prototype testing conducted among selected respondents. While full deployment and long-term maintenance are beyond the study's scope, collaboration with AWFA, IT personnel, and future proponents is recommended to sustain and expand the system for broader community safety.

METHODOLOGY

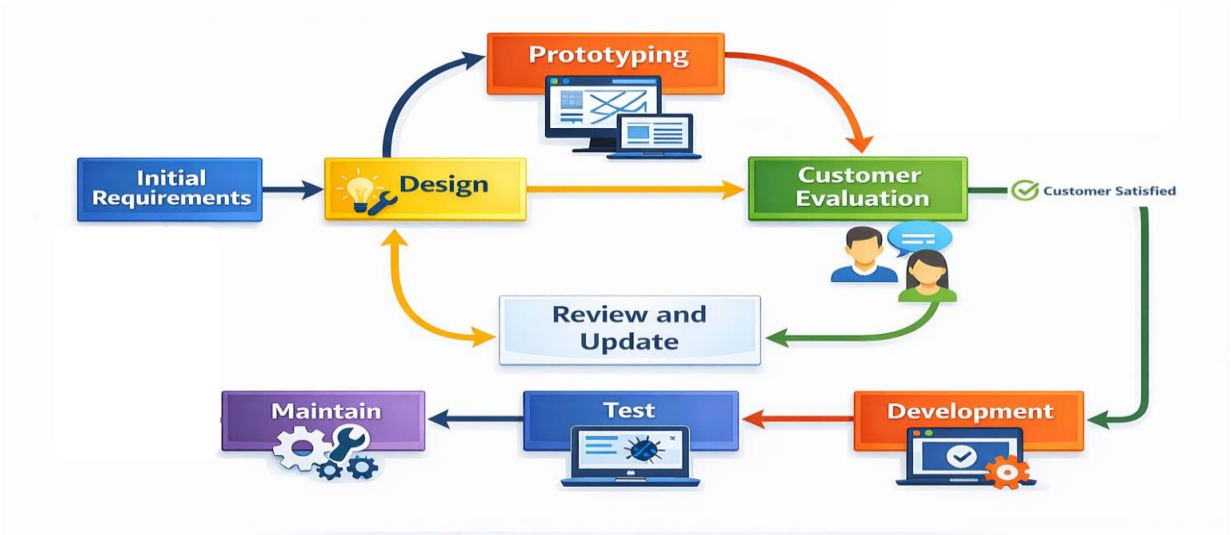


Figure 1. Agile Methodology

The study adopted a descriptive developmental research design. The descriptive component gathered information on current fishing operations, challenges, and safety concerns through interviews, observation, and surveys, and served as the basis for determining the required features. The developmental component covered the design, development, and testing of the system following the Software Development Life Cycle (SDLC). An Agile model with a prototype-based approach was used because it supports iterative development, early prototype testing, continuous refinement from user feedback, and early detection of issues.

Development Phases

Initial requirements. Interviews and observation with AWFA officers and fisherfolk identified current operations, problems at sea, and monitoring needs. The key requirements were GPS tracking, an emergency alert button, real-time monitoring, and location history recording.

Design. The user interface was prototyped in Figma, system diagrams were produced in draw.io, and the database was modeled in MySQL Workbench. The hardware prototype was designed around a microcontroller, GPS module, LoRa radio, emergency switches, and a rechargeable battery.

Iteration. The initial prototype is presented to AWFA fisherfolk and officials for evaluation of usability, tracking accuracy, and alert functionality. Suggested improvements, such as clearer location displays and alert indicators, are documented and implemented in each cycle.

Development, testing, and maintenance. The refined prototype guides the final system, which integrates

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hardware and software. Testing covers GPS accuracy, LoRa range, functionality, and field testing, and identified errors are corrected. Post-deployment maintenance is recommended to be managed by AWFA with future proponents, IT personnel, or relevant agencies.

Respondents and Locale

The study was conducted in Abagatanen, Agno, Pangasinan, where AWFA fisherfolk travel several miles offshore, particularly during night fishing, with limited communication support. Purposive sampling was used to select respondents with firsthand knowledge of fishing operations. Table 1 shows the 65 respondents.

Table 1. Respondents of the Study

Respondents	**Number of respondents**
President of AWFA	1
Fisherfolk members	30
Fisherfolk families	30
Arduino experts	2
IT experts	2
Total	**65**

Instruments and Data Analysis

Data were gathered through interviews on fishing schedules, travel distance, monitoring practices, emergencies, and the need for tracking; observation of fishing workflow; and a survey questionnaire based on ISO/IEC 25010 covering functional suitability, usability, reliability, and performance efficiency. Responses are analyzed using the weighted mean, $\bar{x} = \Sigma fx / N$, where f is the frequency of responses, x is the Likert-scale weight, and N is the total number of respondents. Table 2 gives the scale used for interpretation. System design is documented using flowcharts, UML diagrams, data flow diagrams, an entity relationship diagram, a database schema, and a data dictionary.

Table 2. Likert Scale

Scale	**Limits**	**Rating**	**Interpretation**
4	3.26 – 4.00	Excellent	The system is highly acceptable and performs very well.
3	2.51 – 3.25	Very good	The system is acceptable and functions properly.
2	1.76 – 2.50	Fair	The system is slightly acceptable but needs improvement in functionality.
1	1.00 – 1.75	Poor	The system is not acceptable and does not function effectively.

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Development Tools

The monitoring dashboard is built with HTML, CSS, JavaScript, and PHP in Visual Studio Code, with MySQL for storing fisherfolk information, GPS data, alerts, and trip records, XAMPP (Apache and MySQL) as the local server, and a mapping library such as the Google Maps API for displaying boat positions. The device firmware is written in the Arduino IDE for the Heltec LoRa 32 V3, which processes GPS coordinates from the GT-U7 module and transmits them by LoRa.

System Design and Prototype

System Architecture

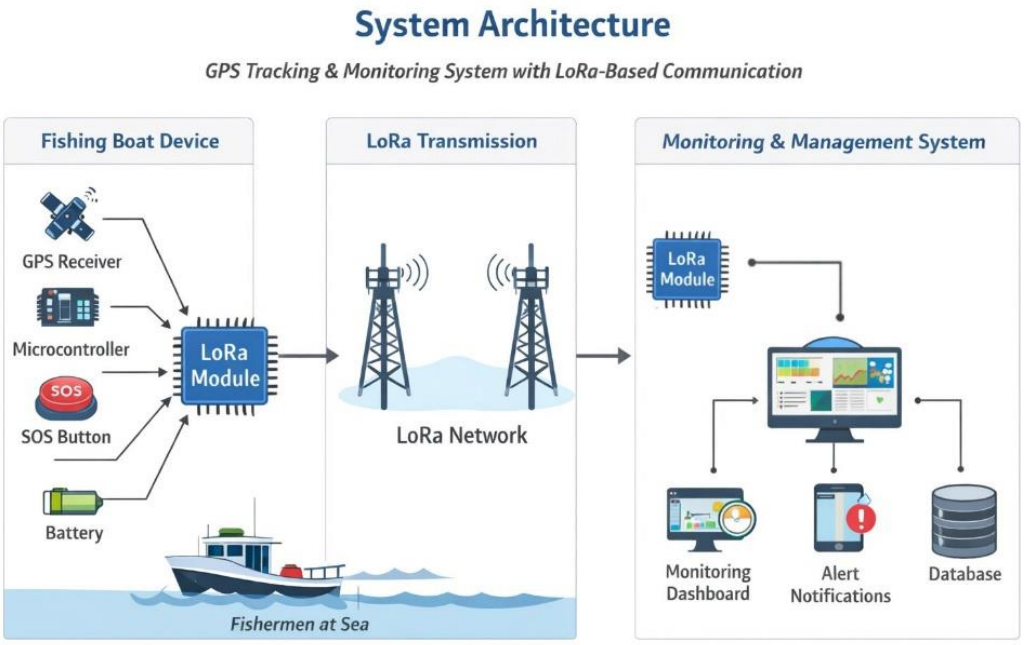


Figure 2. System Architecture of SeaCure

SeaCure has three layers: the boat device, the LoRa transmission network, and the monitoring and management system (Figure 2). Separating the layers allows each component to be managed independently while keeping the system interoperable.

The boat device contains a GPS receiver, microcontroller, LoRa module, SOS switch, and power supply, so location and emergency signals can be sent where there is no cellular coverage. The LoRa network carries data from boats to a gateway using scheduled, interval-based transmission to reduce congestion and packet collision. The prototype is designed to support approximately 10 to 30 active boats in the deployment area, and capacity can be expanded with additional gateways and optimized scheduling. The monitoring and management system comprises the server, database, and dashboard. The server processes coordinates, alerts, and trip information; the database stores history, user profiles, trips, and alerts; and the dashboard shows boat locations on a map and notifies officials immediately when an SOS is triggered.

Boat (transmitter) Unit

The transmitter is built around the Heltec LoRa 32 V3, which receives coordinates from the GT-U7 GPS module and transmits them through its built-in LoRa radio (Figure 3). A 0.96-inch I2C OLED display shows the current latitude, longitude, and status. A red toggle switch sends a general SOS alert, and a blue toggle switch sends a resolute medical-emergency alert, so the receiving system can distinguish the two; both alerts carry the current GPS position. A buzzer warns the fisherman when the boat approaches the limit of LoRa

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range so the operator can return to the coverage area before contact is lost. The unit is powered by a 3.7 V, 5000 mAh Li-ion battery managed by the board's charging and power-management circuit.

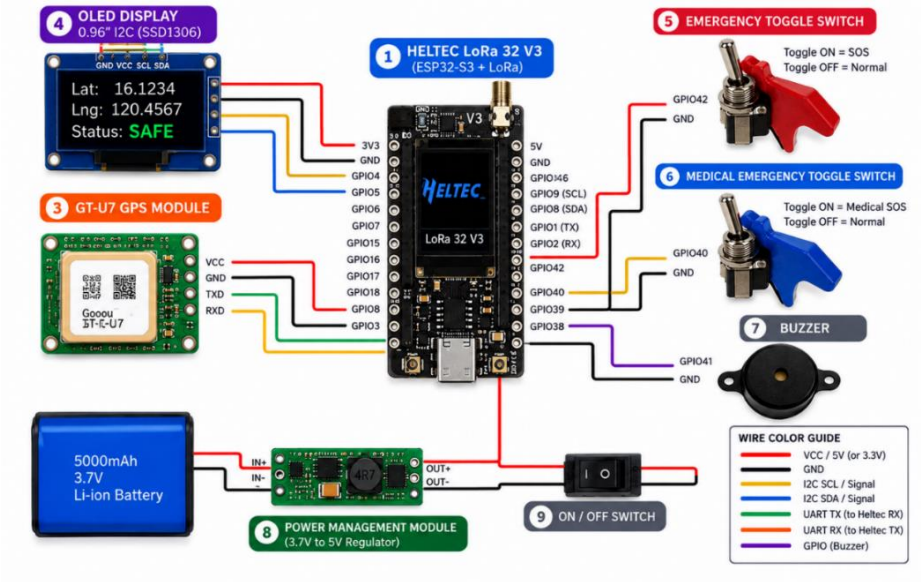


Figure 3. Transmitter (boat) Unit Wiring Diagram

Shore (receiver) Unit

The receiver also uses a Heltec LoRa 32 V3, whose integrated ESP32-S3, SX1262 LoRa radio, and OLED display receive location data and alerts, show receiver status, signal strength, and the latest coordinates, and forward data to the web system over Wi-Fi (Figure 4). Status LEDs indicate the condition at a glance: red for SOS, blue for a medical emergency, green for normal online operation, and yellow for a weak or unstable LoRa link. A buzzer uses different sound patterns for each emergency type, and a micro-SD card module keeps a local backup of GPS data, alerts, and logs during internet interruptions. The receiver runs on a 5000 mAh Li-ion battery or a 5 V USB-C supply for continuous operation.

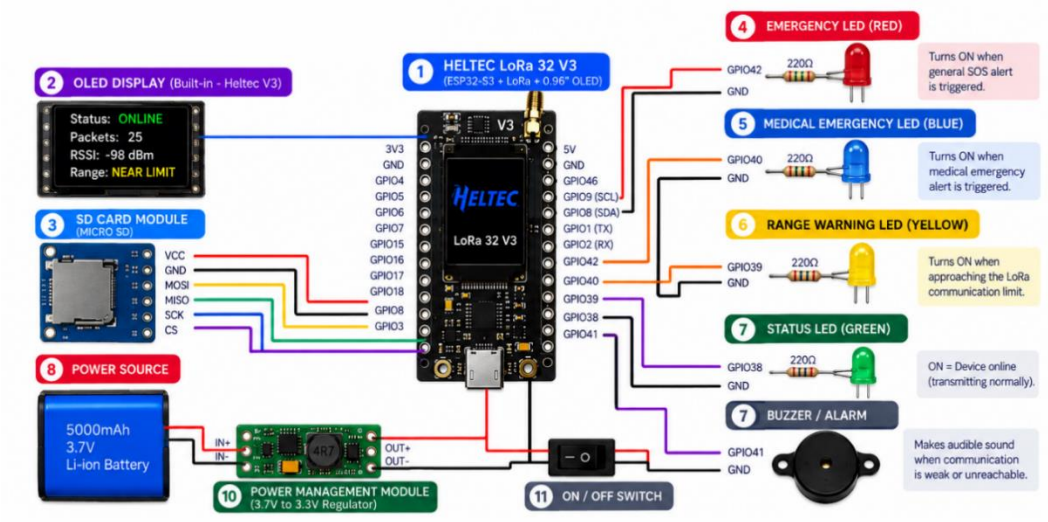


Figure 4. Receiver (shore) Unit Wiring Diagram

Web-based Monitoring Dashboard

Authorized users sign in with a registered phone number and password. Relatives of registered fisherfolk can request access to monitor a specific vessel, and the administrator approves or rejects each request, which protects the privacy of real-time location data. The main dashboard (Figure 5) displays a live fleet map withmovement tracks, summary statistics, recent logs, and a registry of fisherfolk with boat ID, status,

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battery level, distance from shore, and last GPS update. Boats in emergency are highlighted with a "Respond" action.

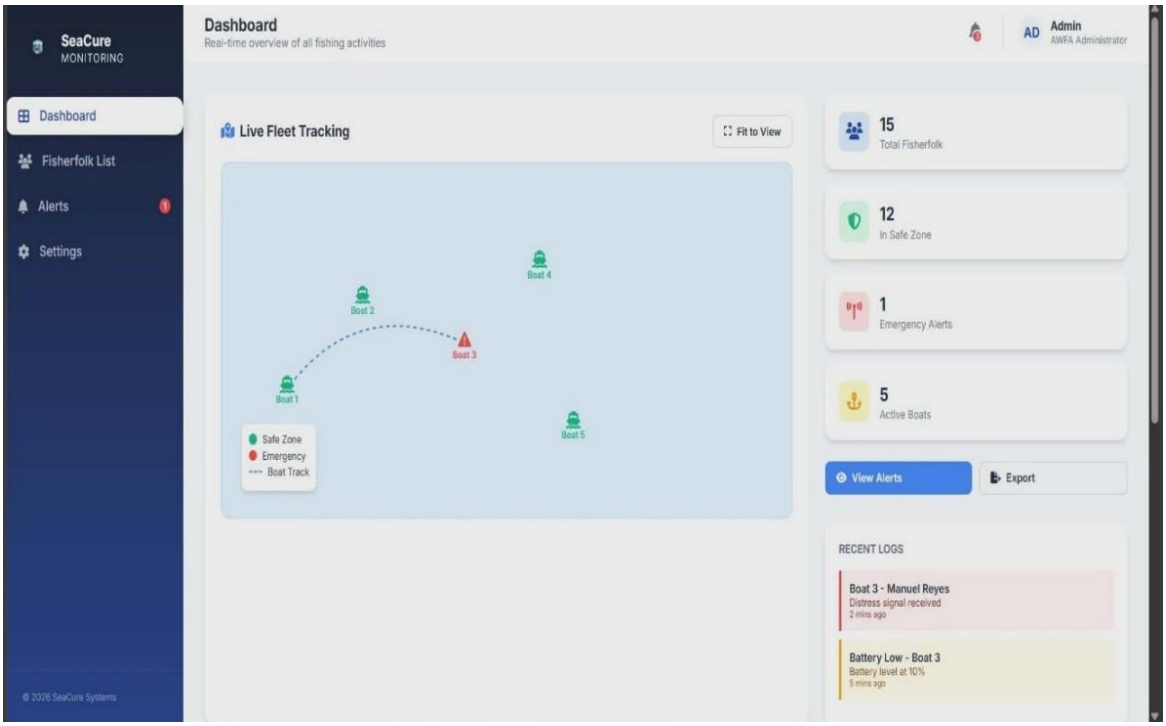


Figure 5. Dashboard – Live Fleet Tracking

The Alerts and Notifications page (Figure 6) summarizes total alerts, active emergencies, resolved cases, and battery warnings, with the boat, fisherfolk, incident type, time received, and severity of each alert. Alert categories use the color code in Table 3. The Settings module lets the administrator manage the fisherfolk registry, define safe zones and geofencing by maximum distance from shore, configure alert logic and escalation, register hardware nodes, and process family access requests.

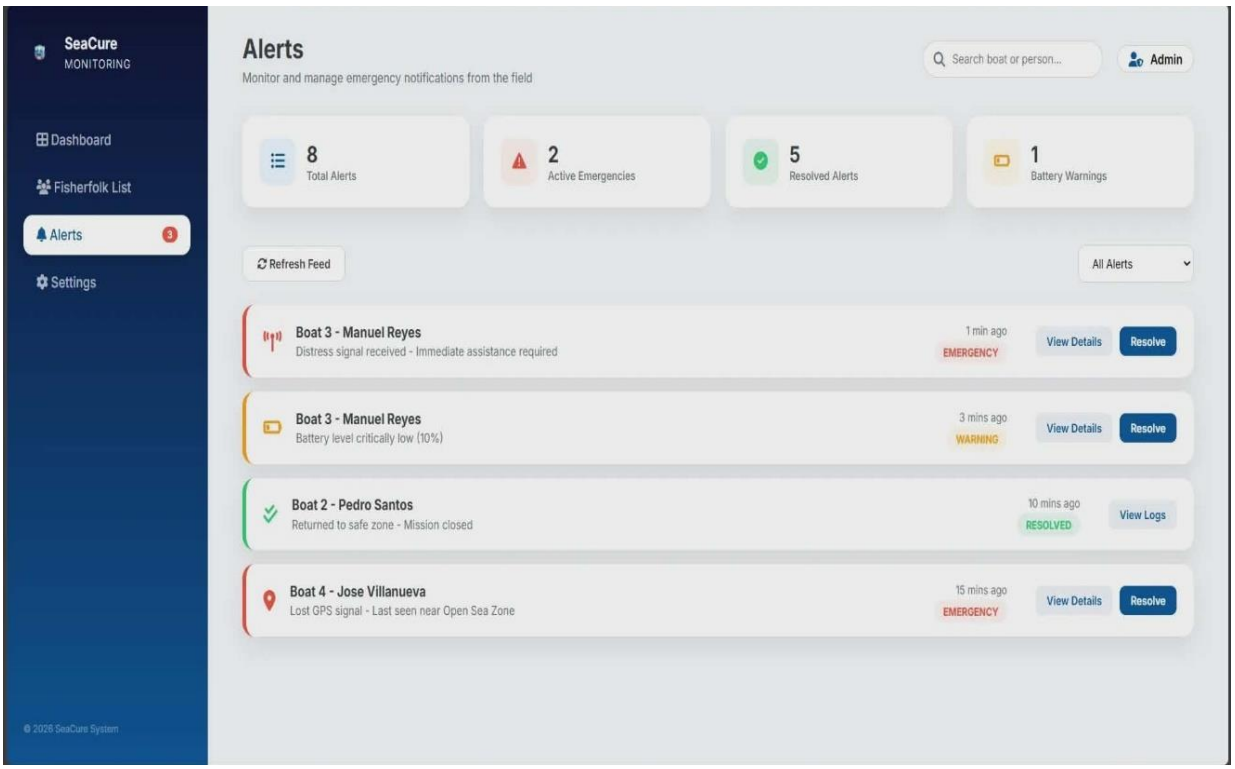


Figure 6. Alerts and Notifications Page

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Web-based Monitoring Dashboard

Table 3. Alert Color Codes

Color	Meaning
Green	Safe operational status
Blue	Medical emergency
Yellow	Missing person or loss of communication
Red	Engine failure or critical distress requiring immediate response

Cost

SeaCure is designed for community-level use. Each boat device, including the Heltec LoRa 32 V3, GT-U7 GPS module, emergency switches, power supply, and protective enclosure, is estimated at ₱1,500 to ₱2,700, depending on component availability and configuration. A LoRa gateway is estimated at ₱4,000 to ₱15,000 depending on antenna range and deployment. Compared with satellite-based maritime monitoring, LoRa offers a more affordable, subscription-free option.

DISCUSSION

The problems reported by AWFA match those in the literature: no means of reporting breakdowns or injuries at sea, no way of knowing when a member is missing, and slow external response that leaves rescue to members' own boats. SeaCure responds to each problem. Real-time position reports remove the 24-hour wait before a missing member is noticed, separate SOS and medical switches give responders the nature and location of an emergency from the first message, and the range-warning buzzer helps boat operators stay within coverage. Because LoRa operates independently of cellular networks and has been reported to reach tens of kilometers over open water [13]techn, it suits the offshore conditions of Agno fisherfolk. The low hardware cost and absence of subscription fees address the affordability barrier that keeps commercial vessel monitoring out of reach of small-scale fishers.

Several limitations should be noted. This paper presents the design and interface prototype; the acceptability scores, GPS accuracy, and LoRa range measurements from field testing are not yet reported, so claims about performance remain to be verified. The stated range figures come from the literature and will vary with antenna, terrain, sea state, and boat placement. The prototype is designed for approximately 10 to 30 boats, fewer than the roughly 152 AWFA members, so larger deployments would need additional gateways and transmission scheduling. The receiver needs internet access to forward data to the dashboard, although the SD card provides a local backup, and long-term maintenance is beyond the scope of the study. Future work should report the ISO/IEC 25010 evaluation, field-test results, and a pilot deployment with AWFA.

CONCLUSION

This study presented SeaCure, a web-based IoT GPS monitoring and emergency alert system that uses LoRa technology to improve the safety of small-scale fisherfolk of the Abagatanen Western Fishermen Association. Based on the emergency situations and challenges identified through interviews, observation, and literature review, the system combines a boat unit with SOS and medical alert switches, a shore receiver, and a web dashboard with live tracking, color-coded alerts, geofencing, device management, and family access control. Its low cost and independence from cellular and satellite services make it suited to

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community-level adoption. Evaluation with ISO/IEC 25010 and field testing will establish its acceptability and readiness for wider deployment.

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