UTILIZATIONS OF MOBILE APPLICATIONS IN MARITIME SEARCH AND RESCUE OPERATIONS

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ABSTRACT

Maritime transportation forms a fundamental pillar of international trade and the global economy. More than 80% of goods trade in the world is carried out using sea transport, with that percentage being a bit higher for developing countries. In this regard, the various operational aspects applying to ship operators and technical managers in their respective duties are extremely complex and continually changing, such as the effective management of timeliness inspection and inventory management.

Mobile applications have contributed to significant improvements in efficiency and effectiveness in maritime search and rescue (SAR) operations. They provide a platform for coordination and information exchange among different authorities designated, following the relay of a distress message to make for prompt efficient response within inshore areas and territorial waters.

The main aim of this study is to investigate the adoption of mobile applications in the maritime industry, with priority focus on search and rescue (SAR) operations. The study uses a qualitative approach to evaluate the existing gaps in SAR practices within the territory of Egypt. In addition, the study advocates making a collaborative mobile application and network coverage within local mobile operators to be used together by concerned authorities and individuals in distress. The suggested mobile application is expected to have considerable impact in terms of responsiveness and effectiveness of SAR operations.

Keywords: Maritime Communication, Mobile Application, Search and Rescue, Emergency Communication, Mobile Communication.

1. BACKGROUND:

Cellular and radio communication plays a vital role in mastering communication, safety, and operational efficiency within the maritime sector. These technologies offer seamless connectivity for navigation, search, and rescue operations, as well as online monitoring of all maritime activities.

Increased connectivity demand by thousands of devices increasingly complicate device-to-device connection with the increase of IoT applications for expansive monitoring over water. Hence, millions of internet-connected devices will be carried in a freight and container vessel for each voyage, capable of reporting multiple measurements as well as local conditions. However, some generated data are not heavily critical, which still need management.

As a result, maritime cellular connectivity is becoming far more challenging and crucial than ever. The services and coverage offered should cater for all possible uses and include space for dynamic environments. Qos and the entire user experience should be the most important as vessels continue to navigate between locations and change connectivity mediums

On the other hand, Mobile application relates to a software program designed to work especially on a mobile platform such as a mobile phone or a tablet. They are purely technology-based and it's really a new emerging function as far as media, information technology, and the emerging internet are concerned. Mobile telecommunications have been under much investigation for years, in all fields of research and development by mobile device manufacturers, service providers and application developers.

The different mobile platforms and operating systems offer a stiff challenge to a business in developing mobile applications. Developers end up doing extensive testing on each of the platforms to make sure the applications are interoperable across all platforms.

Recent reports have claimed that there are around 8.93 million mobile applications worldwide. Notably, the growth of mobile app development is not exclusively attributed to either Apple's App Store or Google Play. But, around 40% of the mobile app development in 2019 was accounted for by Chinese app stores such as Apkgk, Apkpureco, and Androidappsapk. [37].

Historically, the main factors driving the development of ship-shore communication were the safety of the crew and passengers, navigational aid, and reporting. The first use of radio to communicate the need for assistance occurred on March 3, 1899, when a freighter rammed the East Goodwin Lightship, which was anchored ten miles offshore from Deal in the Straits of Dover off the south-east coast of England.

In this respect ,The foundational specifications of the global maritime distress and safety system, or GMDSS, were adopted by IMO Member States in 1988 as part of SOLAS, and the system was phased in beginning in 1992. [5] The GMDSS is an internationally recognized distress and radio communication safety system that has been in use for several decades. The GMDSS is an automated ship-to-shore and ship-to-ship communication system that employs satellites and/or terrestrial radio networks equipped with digital selective calling technology. This system provides life-saving information and maritime communication that alerts vessels to navigational warnings, dangers and weather conditions, as well as the ability to initiate distress calls with relevant location and identity information at the touch of a button.

According to SOLAS regulation IV/4.1.2, GMDSS equipment must be used for both transmitting and receiving general radiocommunications. Frequent usage of GMDSS equipment guarantees equipment availability and fosters operator competency. In order to guarantee operator competency and equipment availability, as well as to help lower the frequency of false alerts, ships that rely on other radiocommunication systems for the majority of their business communications should implement a regular program of sending selected traffic or text messages via GMDSS equipment. [12]

In this regard, Channel 16 (156.80 MHz) is the International Maritime Channel for distress, urgent, safety, and voice communication. Non-GMDSS-equipped vessels must maintain a listening watch on Channel 16 for initial routine contact with other vessels or coast stations. Once established, they should switch to a functioning channel as quickly as practicable. If you have a prior arrangement or intend to connect with a port operations service, you can bypass Channel 16 by using another operating channel. [20]

Alternatively, the "Mayday" distress call is made if the vessel is in serious danger, such as sinking or on fire, and immediate aid is needed. This distress call is normally transmitted via channel 16 and takes ultimate priority over all other messages.

2. INTRODUCTION:

The internet increasingly finds access through mobile phones since calling the number of mobile phone owners is among other possible indicators of how widespread use of the internet is. [26] Mobile phone data are obtained from several sources, including carriers, sensors, and phone applications. Carriers collect mobile phone data such as Call Detail Records (CDRs), SMS usage, traffic volume, and sensor data such as GPS and Bluetooth. [16]

The use of mobile applications during emergency situations has been employed by several countries such as South Africa where the Namola mobile app enables residents to quickly and easily request emergency assistance from the South African Police Service (SAPS) as well as other emergency services. The application uses the GPS location of the user to inform police stations as well as other appropriate rescue authorities regarding the situation of distress and provides the user updates about the status of the request. [19]

On the other hand, An app came up from Belgium 112 BE mobile application which combined all the emergency services, i.e., fire, police, and ambulance, offered to residents of Belgium during an emergency. [9] The Kenyan coast guard similarly came up with the Usalama Baharini app to allow distress messages to reach through mobile devices. [10]

The latest iPhones on the market- series 14 and up from Apple- have this built-in feature that allows a user to relay an emergency text message through a satellite link when terrestrial telephony or the internet is unavailable. Furthermore, Google has electronic SOS for Android interfaces, with quite similar functionalities but using satellite as well. [35, 36]

From March 2022 onwards, the source of the call location should be derived in every mobile phone and made available to emergency services for all devices being sold across the European Union countries. This highly meets the requirements of Android and iOS. Now, search and rescue authorities will be able to receive calls for help from smartphones that have lost coverage. The number to call for emergencies from ships in French territorial waters is 196. Interestingly, reports indicate that in 2022, 93% of all distress calls made in French territorial waters emanated from vessels within 12 nautical miles of the inshore stations, areas typically covered by French mobile operators. The French Maritime Rescue Coordination Center (MRCC) employs Advanced Mobile Location (AML) for accurately positioning where available distress calls come from via hotline number 196 to ensure a quick response. There has been a significant rise in mobile-generated distress calls in 2023, with 1,078 alerts transmitted from sea to MRCC by mobile phones, compared to 580 in 2022. [11]

Figure 1: shows the hotline designated in Belgium for each emergency case, Source:112.be/en/mobile-application [30]

The United States Coast Guard has developed an app that serves as an alternative communication channel between the Coast Guard and mariners. This application provides several services, including: identifying the nearest NOAA buoy; requesting vessel safety check; reviewing safety equipment; filing float plan; reporting hazards; suspicion of any unusual behavior; reporting pollution; and requesting emergency assistance. Pressing the red "Emergency Assistance" tab on the homepage sends the real-time GPS location to the nearest Coast Guard unit or 911 emergency services. [31, 32].

Alternatively ,FarrPoint, a completely independent connectivity and smart technology advisory company, has developed a system comprising a smart electronic box and small antennas. The box gets plugged into a power socket, and the antennas are mounted on the roof. The data received by this box is mapped out on some online map. [6]

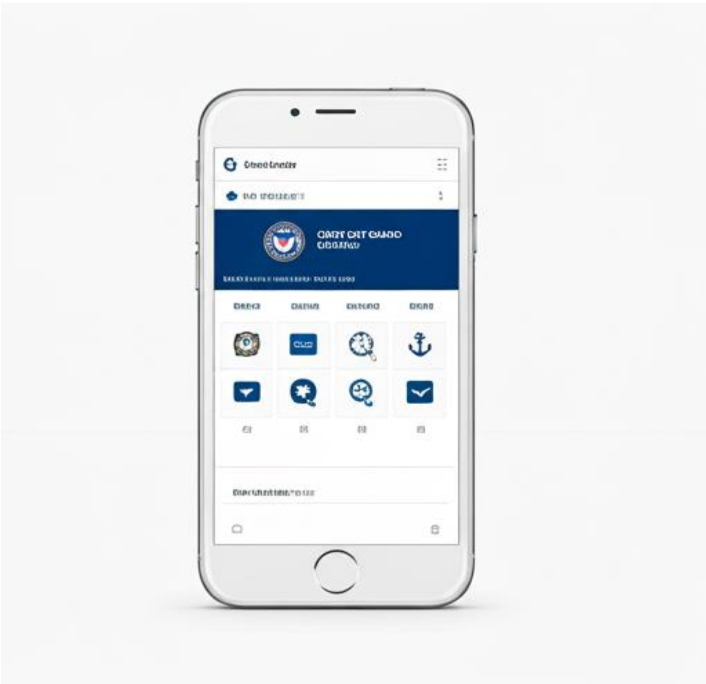


Figure 2 shows the US coast guards mobile applications to serve the maritime community within the mobile network coverage (source: :boatingsafetymag.com) [33].

Notably, however, in the context of China Mobile and Huawei, they bring together their ingenuity towards establishing such a magnificent development of a maritimes 5G coverage as extending about 50 kilometers at sea. This advanced network, comprising various frequency bands, is designed specifically to provide consumer services including tourism, energy, and maritime management applications. It is set up to provide high speed 5G access to thousands of islands and ships along the Fujian coastline. [29]

Thus, these and many other factors can lead to deteriorated or at best varying coverage, data speed, and performance: all over a maritime area, which might extend from 20 to 70 km from the coast, as marked by base stations along coastlines, where often mobile 4G and 5G networks of Tesla offer service in Australia. [7]

3. RESEARCH METHODOOGY:

Research Methodology

The qualitative research design has been developed to attempt identifying gaps in the current SAR practices in Egypt. Data Collection:

Analysis of current patterns on SAR practice and mobile applications artificiality in maritime communications.

Evaluation Framework:

Exploration into how mobile applications facilitate inter-stakeholder coordination, for instance, in distress signal handling, between maritime authorities.

Proposed Model:

Development of a collaborative mobile application designed specifically for the SAR operations in Egypt.

Emphasis on improvement of efficiency concerning distress communication through the use of local mobile network systems.

3.1. Research Objectives:

Investigate Mobile App Utilization in SAR:

- Explore, in a greater context, the use of mobile apps to improve maritime search and rescue operations across the globe.
- To find out how these mobile applications are being currently used in emergencies, find out the pros and cons of mobile applications usage in emergencies.

Identify Gaps in SAR Practices:

The research aims to identify the deficiencies in the SAR systems of Egypt and the communication between the designated authorities and the distressed mariners.

Proposed Solution:

Construct ideas on the collaborative application that joins communication to local mobile operators for real-time collective experience in dealing with distress cases within the territorial waters of Egypt.

International standards have to be met, such as the IAMSAR Manual and Advanced Mobile Location (AML).

investigate the use of AI-enabled voice assistants or chatbots that help the person in distress communicate faster with SAR centers by instantly translating their communication messages.

4. LITERATUR EREVIEW:

Liu et al. (2018) identified the integration between different mobile operators as a significant challenge for the widespread adoption of mobile communication technology in maritime environments. Furthermore, Quality of Service (QoS) assurance standards can vary significantly across these operators. [2]

Alternatively, Ahmad et al. (2018) investigated the challenges associated with the development and implementation of mobile applications. Their findings highlighted several key challenges, including compatibility across different operating systems, rigorous testing processes, efficient update mechanisms, and the optimization of User Interface (UI) and User Experience (UX) in hybrid application development. [38]

Aram et al. (2014) emphasized the potential of mobile applications to empower fisherfolk communities by providing access to location-specific and demand-driven advisories that can improve their livelihoods. Fishermen who utilize mobile notifications have improved access to critical information compared to those who do not. Mobile apps have proven to be valuable tools for decision-making, particularly among fishermen operating small boats. [1]

Alternatively, Li et al. (2022) monitored how the movement of people is influenced by extreme weather events. The studied case was the city Zhuhai in China, and mobile phone data was used to find the geographic coordinates of the base station associated with each data point. [21]

In this sense, Osorio Arjona (2024) used mobile data to analyze how population mobility patterns changed in Andalusia, Spain, during the COVID-19 pandemic in 2021. [28]

In this context, Jo and Shim (2019) studied the application of LTE mobile technology to build the wireless network allowing coastal vessels to operate high-speed data services within coastal areas that are 100 km away from the shore. [18]

Alternatively ,The MAMIME program under the fund of the Norwegian Research Council is paving the way for establishing a 5G communication network for maritime. The initiative is aimed not only at improving IoT integration towards automated operations but also improving communications amongst ships and between ships and shores as well as search and rescue operations so that autonomous ships can be piloted for efficiency and cost savings. The MAMIME, in collaboration with Super Radio AS, also supports Pre-5G testing for the Yara Birkeland, the first fully autonomous container ship in the world. The program also studies remote pilotage and autonomous tows and copious standards set to ensure that vessels, ports, logistics, and customs can communicate more easily, thus speeding up operations in an efficient manner.[40]

Wireless Sensor Network (WSN) can be defined as an intelligent type of network made up of devices or nodes. A WSN typically has a number of nodes, usually ranging between a few up to hundreds or even thousands, depending on the actual application. Sensor Dot-Node is typically cheap, small in size, and less powered, thus favoring its large-scale deployment. [4]

Roste, Terje, Kun Yang, and Fritz Bekkadal (2013), in that context, considered the installation of a Wireless Sensor Network (WSN) with coastal stations. These stations usually serve as base stations for smaller vessels which operate up to 12-20 nautical miles within coastal areas. The tracking and monitoring solution enables two-way communication and continuous data transfer between the coastal stations and navigating vessels. [3]

According to Maalel et al. (2013); one novel application potential can be derived from IoT capabilities in emergency applications by detecting the existence of "things" and through sensing activities, resulting in economically reliable services and solutions. [8]

Alternatively, Du et al. (2021) analyzed the convergence of broadband technologies with those of broadcasting/multicasting in maritime information networks to improve coverage. Their plan deals with shore towers, insular towers, and seaborne floating towers fitted with cellular base stations or broadcast antennas to provide for a wider range of communication capabilities and models. The most advanced concepts in maritime broadcast networks will allow distributed bandwidth access for multimedia services on ships. [17]

Alternatively, Sakkopoulos et al. (2017) demonstrated a data fusion platform designed to detect and track moving objects in maritime surveillance. The proposed approach leverages existing communication and networking technologies for surveillance, creating a single-window data fusion environment to enhance detection, early identification, and tracking of moving targets for improved security and surveillance. [13]

Table 1 summarizes some key findings of the literature review

Study	Key Findings
Liu et al. (2018)	Integration problems of mobile operators and differing standards of QoS do not facilitate the broad use of mobile communication at sea.
Ahmad et al. (2018)	Application development challenges include: compatibility issues, extensive testing, effective upgrades, and UI/UX optimization.
Aram et al. (2014)	Mobile apps empower fisherfolk with location-specific advisories, improving livelihoods and decision-making.
Li et al. (2022)	Mobile phone data can track population movements during extreme weather events, demonstrated in Zhuhai, China.
Osorio Arjona (2024)	By using mobile data, changes in population mobility due to the pandemic in Andalusia, Spain, can be revealed.
Jo and Shim (2019)	High-speed data services are enabled through LTE technology for coastal vessels operating not more than 100 kilometers from shore.
MAMIME Program (2024)	Focus on establishing 5G networks for maritime IoT, autonomous operations, and improved communication between vessels and shore.
Roste et al. (2013)	WSNs with coastal stations support two-way communication and continuous data transfer for vessels within 12-20 nautical miles.

5. SEARCH AND RESCUE PROCESS:

The IAMSAR Manual outlines immediate actions to be taken when a person falls overboard. These actions vary depending on the situation, such as whether the incident is observed directly from the bridge or reported by an eyewitness. Regardless of the situation, crucial steps include marking and noting the position and time of the incident using GNSS, throwing a life ring, sounding three prolonged blasts on the ship's whistle, hailing "man overboard," and informing the master of the vessel and the engine room. The speed and effectiveness of recovery efforts are significantly influenced by factors such as the ship's manoeuvrability, wind and sea conditions, crew experience, engine capabilities, incident location, visibility, chosen recovery techniques, and the availability of assistance from other vessels.

Accordingly, The SAR system has three general levels of coordination:

- On-scene coordinators (OSCs)
- SAR mission coordinators (SMCs) based at rescue coordination centres (RCCs)
- SAR coordinators (SCs) (national level)

In this regard,The SAR operations are normally coordinated from specially equipped operational centres or RCCs with the following Land-based communication facilities:

- land earth stations (LESs)
- Cospas-Sarsat mission control centres with local user terminals (LUTs)
- Independent coast radio stations (CRSs) or CRSs associated with the RCCs
- Air traffic services (ATS) units
- Mobile phone networks F

- Internet
- Public telephone alerting systems.[41]

Accordingly, Several designated focal persons from the police, fire, medical, port, armed forces, telecommunication companies, voluntary organizations, civil defense, and air traffic control must be able to work with each other to effect the SAR process. Thus, SAR becomes increasingly complicated, since it involves many interdependent tasks of varying complexities and coordination with other agencies. Timing is everything, though, for communication with the distressed may often apply toward the success of the search and rescue operations. Within the first two to six hours, the chances of good search and rescue efforts remain very high. [27].

Alternatively, Nasar et al. in 2023 suggests that the SAR cycle consists of those four stages: readiness, response, recovery, and mitigation. Each phase has its specific importance in the so-called cycle of disaster management. Readiness includes planning and training for SAR specialists. Mitigation attempts to decrease the chances of a disaster occurring, usually by eliminating possible threats and reducing their effects. Response and recovery are often viewed as events that happen after a disaster, but in fact, many pre-disaster actions take place within these phases. Actions taken to conduct SAR operations in a disaster are under the response phase. Activities that relate to damage assessments due to a disaster and the end of the SAR operation fall under recovery. [22]

Figure 3: Key stakeholders involved in maritime search and rescue operations in Egypt. Typically, the SAR authority collaborates with various agencies to address distress cases. While other entities may contribute to the search and rescue process, this research focuses on those with primary roles in managing these situations.[42]

6. Process of Developing the proposed Mobile App

Mobile phone applications allow users to conveniently access services that significantly contribute to the provision of governmental and commercial services [24] [25], taking into consideration that mobile applications normally require access to confidential information such as location and contacts. Therefore, normally mobile applications will employ user authentication techniques to verify the users' identities before allowing them to sign in to the application.

In order to help mobile application development firms measure and enhance their readiness prior to beginning development activities, we looked into and identified the problems posed by the increasingly varied demands of mobile applications. To the best of our knowledge, no particular study—that is, an empirical study based on SLR and interviews—has been carried out to examine the difficulties involved in effectively creating and overseeing mobile applications, whether they be native, web, or hybrid.

According to Kang et al. (2015), application development follows four different phases. The first phase normally investigates the framework design of the mobile app. It covers feasibility, specs, platform, and features. This stage ensures that the mobile app development aligns with your specifications. Following, the second phase involves creating an application prototype through gathering comprehensive requirements, designing displays and user interfaces, and creating a mock-up app that simulates the final product. The next phase involves the design and testing of the target app, known as implementation. This phase includes the development method that considers additional elements such as information transfer between activities SQ Lite Database, usage intention, navigation, and list of views. The final phase involves the deployment and publication of the application. [15]

The proposed mobile application development will follow the Agile approach as mentioned by K. Flora et al. (2014) to promote quick project completion, app flexibility, total business expansion, and responsiveness. respectively, Agile methodologies break down the software development lifecycle into smaller iterations to reduce risk, adapt to changes quickly, avoid requirement freezes, and maintain project schedule and budget. Agile software development is an iterative and incremental approach that involves self-organizing and cross-functional teams collaborating to create software. [14], further the research will demonstrate the first two phases (framework design and prototype) as mentioned by Kang et al. (2015).

6.1. framework layout

This study carries forward the previous discussion with respect to mobile application development phases and proposes a methodology for developing an application specifically for maritime search and rescue operations. After examining the barriers and approaches of mobile app development, like the Agile approach as well as key phases highlighted by Kang et al. (2015), we now proceed towards the technicalities with regard to mobile application framework. This section elaborates on the programming languages and platforms to be used for the app in such a way that it would meet the functionality as well as performance standards that are set for maritime scenarios regarding communication for search and rescue.

Programming language and platform:

Python will be the primary programming language used for the development of this mobile application. Python offers programmers all the tools they need to build a reliable and safe application backend. It is an ideal language for developing mobile apps because it is strong and simple to learn and use. [34]

Key Features:

Sending distress messages from the person in distress to the search and rescue center.

- Distress Signaling: Gives the user the ability to send distress messages to the Search and Rescue (SAR) center.
- Vessel Tracking: A special feature to track and locate small vessels.
- Weather Information: Provides weather bulletins along the route planned by the user.
- Navigation Warnings: Receives navigational warnings from the SAR about hazards like misplaced buoys, submerged ships, or other obstacles in Egyptian territorial waters.
- Suspicious Activity Reporting: Gives users a way to report suspicious activities to the SAR center.

- Pollution Reporting: Allows users to report pollution incidents.
- Chat Interface: This serves as a direct communication channel with appropriate authorities (e.g., Coast Guard) for incident reporting and updates.

AI-based Features:

1. **Predictive Analytics for Distressed Situations:**

Proactive Alerts: Alerts shall be given out to the user when probable hazards are in place, such as during extreme weather or when one is near an accident hotspot.

Creating personalized risk profiles for every user, based on their Boat type and experience level as well as historical data, to assess individual risk levels and thus provide them with customized safety recommendations.

2. **Upgraded Distress Message Analysis:**

NLP: the use of natural language processing for better analysis of the contents of the distress messages to improve means of extraction such as location, nature of emergency, number of persons involved.
Automatic prioritize: Prioritize those distress calls according to their severity and urgency so that responders can first attend to those situations that are most critical.
Sentiment analysis: detect emotional distress through messages and amplify reactions according to the message.

6.2. Technical Framework:

Programming Language: Python will be the primary language owing to its simplicity, user-friendliness, and strong facilities for backends of applications that are secure and reliable.
User Authentication:
SIM-Based Authentication: This is authentication that uses a SIM card to verify the identity of a user.
One-Time Passwords (OTP): This is an authentication mechanism that implements OTPs as an additional protective measure during registration in order to minimize fraudulent attempts.
Development Process:
The methodology to be adopted is Agile, which ensures its ability to speed up development as well as allowing the application to be more flexible and responsive to changes. Agility provides the development lifecycle with small parts that can be taken independently to maintain the following:

- Speeding up the adaptation to changes
- Avoiding freezing of requirements
- Keeping budgets and schedules at project level

Framework Design: stages would include:

- Assess the feasibility
- Set requirements
- Identify platforms and features
- Align everything to meet project goals.

Prototype: This will involve:

- Detailed requirements gathering.
- Designing to build UI and UX.
- Mock up of an app that simulates the product, which will be completed.

The research will emphasize how UI/UX strengthens an application in its ability to define a mobile application readily and accurately.

Proto.io, the prototyping tool, will be used in the interface design of the proposed application.

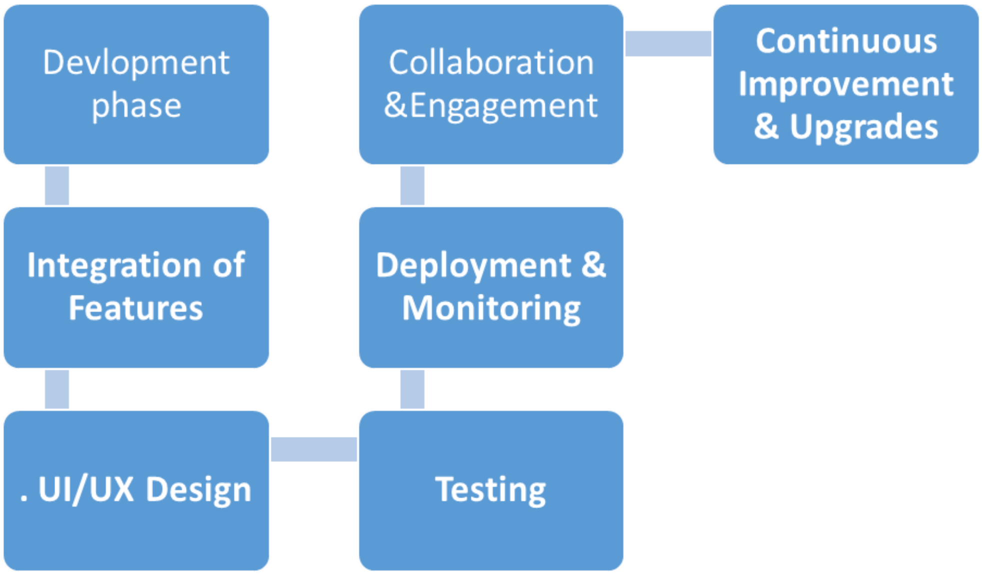
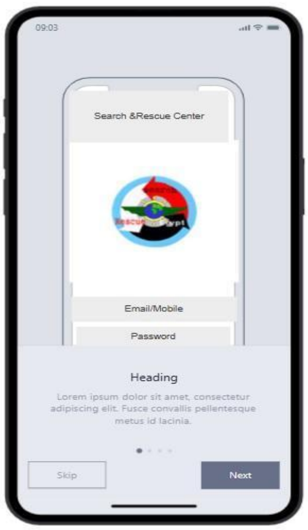


Figure 4: demonstrates Development Phases of the proposed mobile application



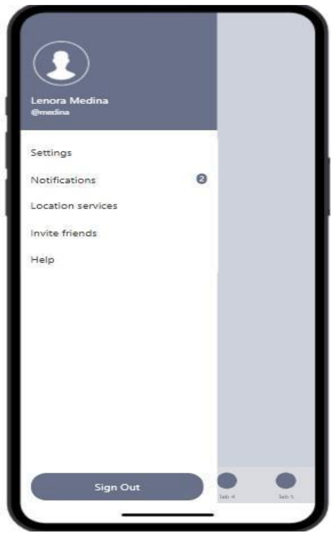


Figure (4) shows a sample of the login page *Figure (5) shows the profile user details to the application*

The mobile app screen demonstrated in figure-4 shows the initial setup or login page.

Elements:

- "Title: Search & Rescue Center: — to convey the purpose of the app
- "Email/Mobile" and "Password" fields: the logins credentials to be entered by the users
- “Skip” and “Next” buttons: Let users skip setup or go to the next step.
- The screen in Figure 5 shows the user profile or account settings.
- Elements::
- Profile Avatar: An image representing the user, typically used as a default before the user customizes it.
- Handle/Username: First thing people see.
- Settings: notifications, location services, invite friends, etc.

- Sign Out: A button to log out of the account

Figure 6 demonstrates the sign-up page

Figure 7 shows a sample of a conversation

- Figure 6: Screenshot of the mobile app signing up page, possibly for reporting environmental incidents/emergencies.
- Elements:
- You can fill in your personal information: First name, Last name, Email address, Password, Birthday, Gender, Phone number.
- Buttons: "Cancel," which takes the user out of the sign-up process, and "Sign up," which continues with the account creation.
- The chat interface showing a conversation with a "Coast Guard" entity (figure 7).
- Conversation Highlights:
- Users say they have seen a big ship releasing
- He supplies details: Position (24°30′ N, 82°40′ W), vessel description (large tanker — black hull, white superstructure, name "Sea Voyager") and no flag visible.

The Coast Guard confirmed the report calling and said that they are in the process of notifying the Marine Environmental.

7. CONCLUSIONS

VHF radio is the main communication medium for vessels while these vessels are inside territorial waters. However, the mobile coverage is usually restricted alongshore, making it imperative that there is some complementary solution. Collaborative mobile application between the Egyptian Search and Rescue Center and the designated authorities can effectively facilitate the communication in case of distress.

This research proposed a mobile application that takes inspiration from other countries, like Kenya and the United States, which also have similar mobile applications to facilitate distress messaging, and France, which has its dedicated distresses hotline. These SAR mobile application offers the following attributes :

Faster response time: streamlining the communication channel speeds the mobilization of rescue assets and saves lives.

Better situational awareness: real-time echoing of data to application users can further enlighten those involved in the distress incidents to better profile their rescue efficacy.

Break coverage limits: the application is not a substitute for VFH, but it has a stretch-circuited reach of emergency communication in areas where VHF coverage is limited.

Modernization of SAR operations: by inducing mobile technology into the setting, Egypt would modernize its sea search and rescue into global best practice.

This new approach could change maritime safety in Egypt in such a way as to ensure that distress cases at sea are responded to more effectively and quickly, thus saving lives.

8. ACKNOWLEDGMENTS

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9. APPENDIX

Table 2 details the key performance indicators (KPIs) which shall be used for monitoring and measuring performance of the mobile application.

Feature	KPI Measurement	Key Targets
Distress Signaling	% successful transmissions, avg. response time, % accurate locations, user surveys	95% success, < 30s latency, 90% accuracy, user-friendly
Vessel Tracking	Positional error (m), % territorial coverage, audit results, % battery drain	< 50m accuracy, high coverage, data privacy, low battery impact
Weather Information	Forecast error, update frequency, user feedback	Accurate, timely, relevant, intuitive UI
Navigation Warnings	% coverage, avg. warning time, false alarm rate, engagement rate	High coverage, prompt and accurate, engaging
Suspicious Activity	User feedback, avg. response time, compliance audits, incidents prevented	Easy to use, < 10m response, private, effective
Pollution Reporting	Verification results, avg. response time, data analysis reports	Accurate, actionable, < 30m response
Chat Interface	Avg. response time, user feedback	Fast (< 5m), clear, user satisfaction
Predictive Analytics	False alarm rate, user survey results, incident comparisons	Accurate alerts, accepted by users, useful profiles
General	Uptime (MTBF), security audit results, ROI analysis, performance tests	Reliable, secure, scalable, cost-effective

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