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Research Article

Vessel Safety Monitoring System (VSMS) Based on LoRA for the Safety of Indonesian Traditional Fishers

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Abstract

Based on data obtained from Indonesian fisheries statistics, over ten years, it is known that 90% of the fishing fleet in Indonesia is dominated by fishing vessels under 30 GT. Generally, these vessels are not equipped with the calculations of the shipping architect or planning drawings. the large percentage of shipping disasters or vessel accidents in Indonesia, including fishing vessel accidents, is caused by several factors: 43.67% due to human error, 32.37% due to nature, 23.94% due to technical factors. Accidents due to bad weather cannot be avoided during fishing operations. However, with the quality of human resources and technical factors that have improved, it is hoped that vessel accidents can be avoided or minimized. According to the Global Maritime Distress and Safety System (GMDSS), vessels with the IMO standard are already based on satellite communications. Vessels required to use the GMDSS standard are vessels with a size of 300 GT and above. We develop a Vessel Safety Monitoring System (VSMS) which has a lower cost, which can be used to determine the vessel's position and is added by using a distress button system such as the satellite-based GMDSS system. the communication from the coast guard post to the vessel uses the LoRA module based on radio frequency, although without pressing the distress button on the vessel, the device on the vessel will continue to send location, vessel's speed, and rpm to the coast guard station. If the distress button is pressed, the location will still be sent, the buzzer at the coast guard post will turn on, and the vessel's location can be seen on the local web server so that the coast guard post officers can immediately find out the coordinates of the vessel. It can minimize the time to search for the vessel's location because the vessel's coordinates are known. Based on the results of the Vessel Safety Monitoring System (VSMS) test, 10 data transmission from the vessel to the coast guard post can work on the land and the sea it can send nine types of data with 0 - 50 meters distance, it can send 1 type of data with a 0 - 100 meters distance, with an average delivery delay of 5 seconds. The amount of data and the delivery delay affects the working distance of the tool. The distress function or the danger signal requires data transmission for 0-15 seconds manually or automatically until the alarm goes off at the coast guard post since the vessel's danger signal is activated from the vessel to the coast guard post.

Keywords— LoRA; Vessel Safety Monitoring System (VSMS); Global Maritime Distress and Safety System (GMDSS); Safety of Indonesian Traditional Fishers

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Introduction

Based on data obtained from Indonesian fisheries statistics, over ten years, it is known that 90% of the fishing fleet in Indonesia is dominated by fishing vessels under 30 GT [1]. Generally, these vessels are not equipped with the calculations of the shipping architect or planning drawings. The Directorate General of Sea Transportation states that the large percentage of shipping disasters or vessel accidents in Indonesia, including fishing vessel accidents, is caused by several factors: 43.67% due to human error, 32.37% due to nature, 23.94% due to technical factors [2]. From its type, it can be classified that collisions, leaks, run aground, and burn caused shipping disasters or vessel accidents in Indonesia. Meanwhile, the most significant impact of the four types of disaster is the sinking of the vessel. Based on IMO's data (International Maritime Organization), fishing vessel accidents were caused by 43.06% of human error factors, 33.57% of natural factors, and 23.35% of technical factors [3] [4].

Judging from the Directorate General of Sea Transportation of Indonesia and IMO's data, it is known that human, natural, and technical factors are the dominant factors causing vessel accidents. Accidents due to bad weather cannot be avoided during fishing operations. However, with the quality of human resources and technical factors that have improved, it is hoped that vessel accidents can be avoided or minimized. Public awareness of the role and function of safety equipment, especially in shipping, can minimize accidents[5][6].

According to the Global Maritime Distress and Safety System (GMDSS), vessels with the IMO standard are already based on satellite communications. Vessels required to use the GMDSS standard are vessels with a size of 300 GT and above [7]. If there is a danger such as an accident or damage on vessels with the GMDSS standard, the crew only needs to press the distress button transmitted via satellite, and then it will be sent to the coast guard for continuous action [8].

In Indonesia, Vessel Monitoring System (VMS) technology as marine communication technology is only used on large-capacity vessels because it requires a large amount of money for the system installation. Meanwhile, Indonesian fishers cannot obtain technology like this [9][10]. From the VMS system [11][12], which is used to determine the position of the vessel, it can be developed into a Vessel Safety Monitoring System (VSMS) which has a lower cost, which can be used to determine the vessel's position and is added by using a distress button system such as the satellite-based GMDSS system. The GMDSS system is modified to the SMDSS system, which still uses a radio wave-based distress button system[13].

To monitor the vessel's position, the coast guard post's personnel do not need to bother. They only need to use electronic equipment connected to wifi, such as cellphones, laptops, or other equipment. The display of the Vessel Safety Monitoring System (VSMS) is using a web server. To make it more comfortable and familiar, Google Maps is used to view the map and coordinates. The use of VSMS is expected to be a solution to the high cost of safety equipment and the difficulty of installing the safety equipment. Previous research related to the VSMS prototype was the VMES (Vessel Messaging System) prototype. The difference is that the VMES prototype only informs the vessel's position via text[14].

Study Signification

Servqual Method

The following is a work flowchart from the VSMS (Vessel Safety Monitoring System) with automatic and manual distress features. Figure 2.1 is a VSMS work flowchart.

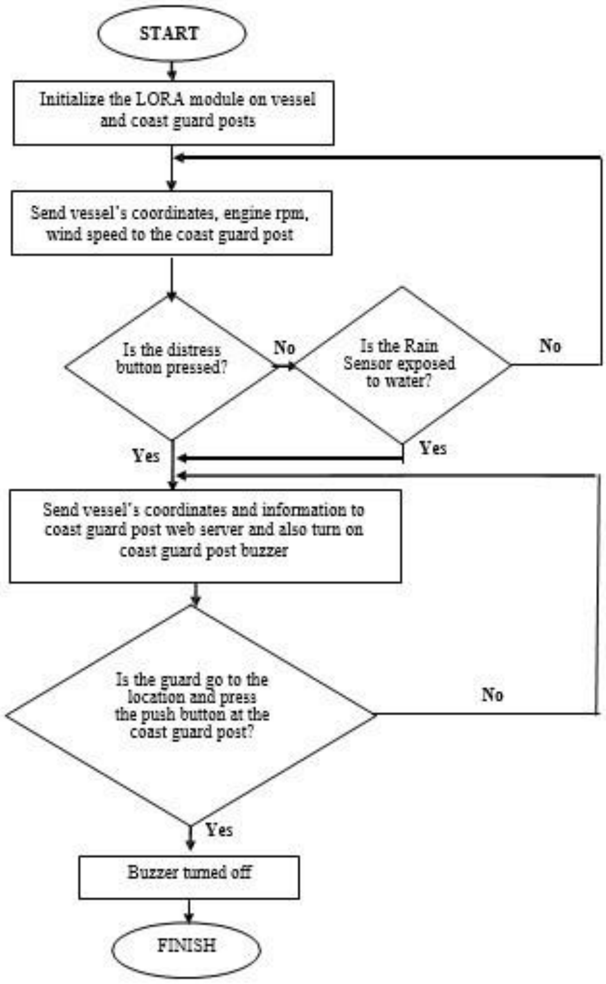

Fig. 2.1 Flowchart of VSMS workflow

Figure 2.1 explained the working principle of the program algorithm to be compiled, as follows:

1. Initialization of LoRA modules on vessels and coast guard posts is used as TX and RX. Here, the two LoRA modules will match the frequencies used. For example, if the two LoRA modules use a frequency of 915 MHz, then the two LoRA modules' frequency cannot go directly to the value of 915 MHz. The two LoRA

modules will match each other's frequency values close to 915 MHz / to 915 MHz so that the two modules can communicate as TX and RX.

2. After the initialization process, there will be a communication process on the vessel's LoRA module and the coast guard post. The device from the vessel will send the vessel's coordinates to the coast guard post.
3. Is the distress button pressed? If yes, the vessel coordinates and information will be sent to the Coast Guard post web server and turn on the Coast Guard Post buzzer. If the distress button is not pressed, chances are the rain sensor has been exposed by water. If it is, then it will send the vessel's coordinates and information to the local coast guard post's web server and turn on the coast guard post buzzer. If the rain sensor is not exposed to water, send the vessel's coordinates to the coast guard post.
4. Does the Coast Guard go to the vessel's location? If not, then the buzzer remains turned on. If yes, then the push button must be pressed so that the buzzer turns off.

2.1 Coast guard post communication with vessels

Figure 2.2 explains that the communication from the coast guard post to the vessel uses the LoRA module based on radio frequency, although without pressing the distress button on the vessel, the device on the vessel will continue to send location, vessel's speed, and rpm to the coast guard station. If the distress button is pressed, the location will still be sent, the buzzer at the coast guard post will turn on, and the vessel's location can be seen on the local web server so that the coast guard post officers can immediately find out the coordinates of the vessel. It can minimize the time to search for the vessel's location because the vessel's coordinates are known.

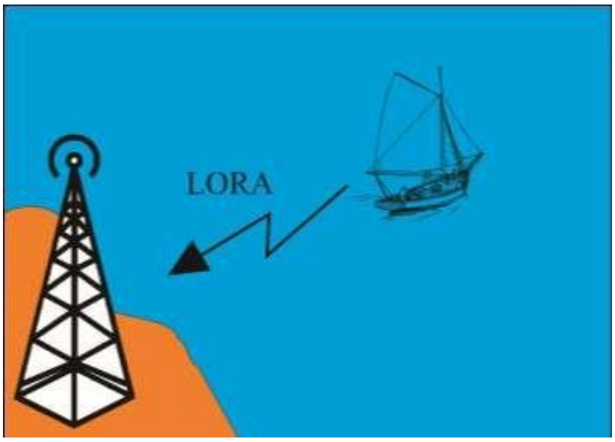

Fig. 2.2 Coast guard post communication with ships

2.2 Input & Output Block Diagram

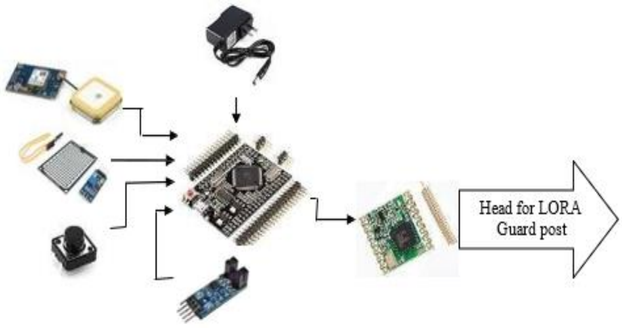

Fig. 2.3 Input & Output block diagrams on vessels

Fig. 2.4 Input & Output block diagrams on coast guard posts

Figure 2.3 contains more details about the system to be made. Arduino receives a power source from the power supply, which will then be given to all components connected via Arduino. Arduino gets input from the GPS module (location and speed), optocoupler sensor (rpm of ship engines), a push button (manual distress, rain sensor (automatic distress)). Then the information obtained will be sent via the LoRA module based on radio frequency communication. The information sent by the vessel's LoRA module is the location, engine rpm, speed, wave height (without distress).

Meanwhile, the information sent is the same but sends a signal that triggers a buzzer at the Coast Guard post if using distress.

Figure 2.4 explains the input & output block diagram. NodeMCU receives a power source from the power supply, which will then be given to all components stuck on the NodeMCU pin. NodeMCU gets input in the form of a LoRA module at the guard post and a push-button. The LoRA mode for the coast guard post receives information from the vessel's LoRA module. If the information is received without distress, it will be sent to the Coast Guard post web server so that only internal parties can access it. If the received information contains distress, the information will be displayed on the webserver, and a buzzer will let out a sound indicating the vessel is in danger, and the officer can see the vessel's current location/coordinates on the local webserver. The buzzer will stop if the push button on the coast guard post is pressed to sign that officers have headed to the vessel's location.

RESULTS AND DISCUSSION

3.1 Testing the LoRa Module on vessels and coast guard posts

Testing the LoRa module as a communication module is carried out to ensure that the information sent and received is compatible. Testing is held by giving programs to the vessel's LoRa module and the receiver's LoRa module at the coast guard post. The test is categorized to be successful if the component runs according to its working principle.

3.1.1 Testing Distance Communication LoRa

To test the communication module is by sending the sentence "hello" with a counter. This test was conducted in a residential area, Waru Sidoarjo. Following Figure 3.1, the test's location used is a flat road. The result shows that the distance reached for LoRa communication is ± 60 meters when measured manually and ±50 meters measured via Google Maps.

Then the test was held in an open location in the Keputih Harmoni Park area. In this test, the location used is upland roads, and the distance that can be reached for the LoRa communication distance is ± 100 meters when measured manually and ± 109 meters when measured via Google Maps. The test results are shown in Figure 3.2.

Fig. 3.1 LoRa Communication Distance on Google Maps

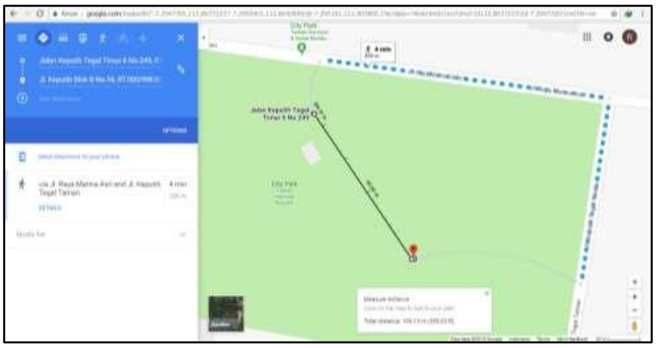

Fig. 3.2 Highland LoRa communication distance on Google Maps

3.1.2 Testing Information Received

To test the communication module is by sending the sentence "hello" with a counter. In the 95-200th transmission, characters/information were paused between each transmission by 2.5 seconds. Meanwhile, if referring to the standard delivery of LoRa, a delay/pause between each delivery is 5 seconds. After being analyzed, these missing characters can occur because of the combined supply of NodeMCU and LoRa. Furthermore, the 5 V supply to NodeMCU and 3.3 V to LoRa was separated. Missing characters received can be seen in Figure 3.3.

Fig. 3.3 Missing information on the recipient's LoRa

3.1.3 Testing the Delivery and Receipt of Information

Given the large amount of data sent and received, this test aims to see whether the information, including sensor data onboard, is compatible at the time of delivery and reception. In this test, the information delivery test is first carried out on the vessel. Figure 3.4 is the serial output of the sensor data monitor on the vessel to be sent. There is no rpm because, at that time, the vessel's engine is not rotating. The test then continued at the information recipient, likened to being located at the coast guard post. The information has been sorted, which can be seen on the monitor serial according to Figure 3.5.

Fig. 3.4 Data on the vessel to be sent

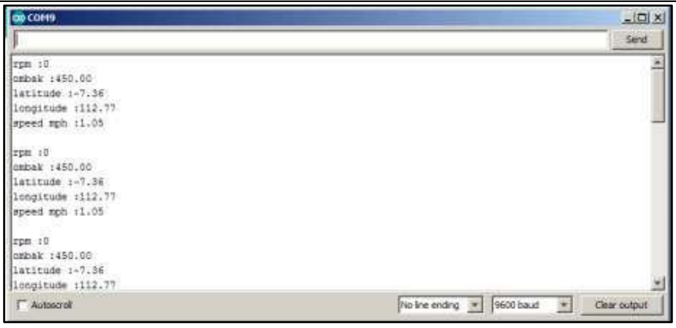

Fig. 3.5 Data on vessel received

Fig. 3.6 Fishers boat

Fig. 3.7 Preparation for data retrieval at the sea

3.2 Sea Testing

This test aims to determine if the data sent is correct / not and record the distance reached for data communication in the sea. The test was held at Bulak Kenjeran beach by bringing a vessel miniature to the sea on a fishing boat. Meanwhile, the coast guard's position/receiving post is on the mainland. The ship used is shown in Figure 3.6.

The preparation for data collection in the sea using fishing boats shown in Figure 3.7. Meanwhile, the miniature boats brought to the fishing boats are shown in Figure 3.8. In this test, it is known that the distance that can be reached from the coast guard post/land is as far as ± 70 meters. In Figure 3.9, the view of zoom out distance is measured by Google Maps. In comparison, the view of zooming in is shown in Figure 3.10.

For sea testing, researchers boarded a fishing boat in the area of Bulak Kenjeran. The fishing boat and the data collection preparation process are in Figure 3.7. The boat's position has been pointing to the sea, and it is just waiting for the fisher's readiness. Data communication is measured by drawing a straight line of ±40 meters on Google Maps. Fig. 3.11 Dynamic Web Server Data On Sea Testing.

The miniature boats used are brought out to sea by fishing boats. Figure 3.8 shows the fishing boat's position at sea, and the vessel miniature has sent data with a measured distance by Google Maps, as shown in Figure 3.9 and Figure 3.10.

Fig. 3.8 Miniature of the Ship

Fig. 3.9 Testing Distance on the Sea (Zoom Out)

According to Figure 3.9 and Figure 3.10, from 70 meters away (measured by Google Maps), the incoming data is obtained on the webserver. The data is shown in Figure 3.11.

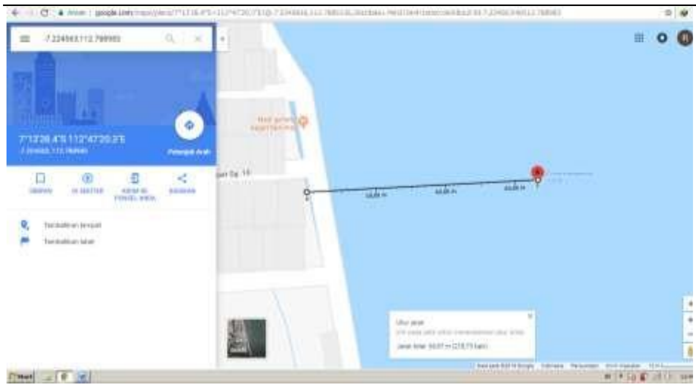

Fig. 3.10 Testing Distance at Sea (Zoom In)

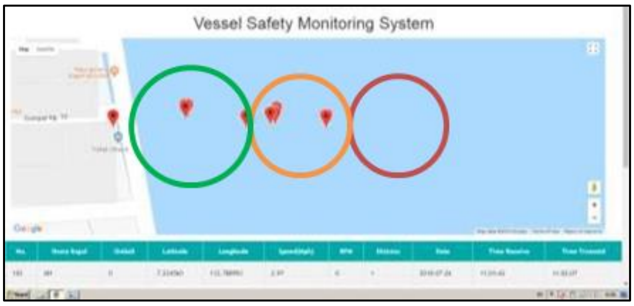

Fig. 3.11 Dynamic Web Server Data On Sea Testing

In Figure 3.11, there are many markings due to dynamic ship movements. The meaning of dynamic movement is the speed of a fishing boat that moves from slow to fast and becomes slow again. This test can be divided into three areas representing the smooth transmission of data to the coast guard post. They are marked in green, yellow, and red. The green circle areas can transmit data well. In yellow circles areas, sometimes have a time lag compared to green circles. There are errors in the red areas, and the difference in delivery time is too far compared to the green and yellow zones circles. In this test, communication data runs with a non-constant time lag. An average delay value for each data transmission is 30.5 seconds. The calculation of the time difference value can be seen in Table 3.1.

TABLE 3.1
Results of testing the communication time dynamically at the sea

No	*Time Received*	*Time Transmit*	*Difference (sec)*
1	11:03:36	11:3:47	11
2	11:03:09	11:3:36	27
3	11:01:46	11:2:52	66
4	11:01:42	11:2:07	35
5	11:01:41	11:2:01	40
6	11:01:05	11:1:40	35
7	11:01:36	11:1:47	11
8	11:01:09	11:1:36	27
9	11:01:46	11:1:26	20
10	11:01:38	11:1:5	33
Difference average			**30,5**

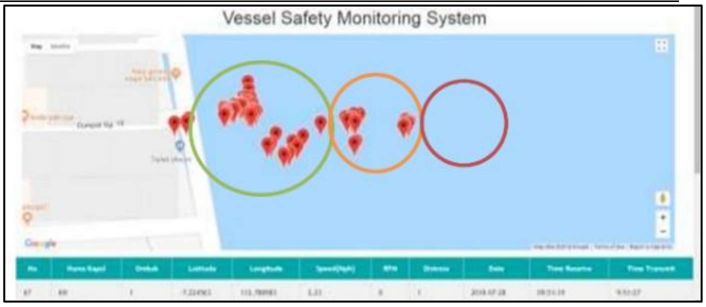

Fig. 3.12 Web Server Data Statically On Sea Testing

Figure 3.12 shows many markings due to static ship movements because the tool has been turned on while on land. Static movement means the speed used on fishing boats is fixed/used at a low speed. This test can be divided into three areas representing the smooth transmission of data to the coast guard post. The green circle areas can send the data well. The yellow circle areas can also send data well, only having a slightly longer data transmission time. Meanwhile, sometimes there are errors for the red circle areas, and the difference in delivery time is too far compared to the green and yellow circles zones.

Based on Figure 3.12, the fishing boat's speed is set very low to see the vessel's movement. The vessel's low speed affects the time lag for delivery, the suitability of data sent, and data received. In this sea test, data communication runs with a non-constant time lag, with an average delay value for each data transmission is 7.9 seconds. The calculation of the time difference value is shown in Table 3.2.

TABLE 3.2
The results of statistically communication time testing at the sea

No	*Time Received*	*Time Transmit*	*Difference (sec)*
1	09:51:19	9:51:27	8
2	09:51:14	9:51:24	10
3	09:51:09	9:51:19	10
5	09:50:59	9:51:10	9
6	09:50:54	9:51:4	10
7	09:50:49	9:50:55	6
8	09:50:44	9:50:50	6
9	09:50:39	9:50:43	4
10	09:50:34	9:50:39	5
Difference average			**7,9**

CONCLUSIONS

Based on the results that have been obtained in the analysis and testing of the system that has been made, it can be concluded that:

1. Designing a Vessel Safety Monitoring System (VSMS) for fishers using the LORA wireless module based on Arduino and NodeMCU. The distress/Emergency button on the vessel will trigger an alarm at the coast guard post manually. Meanwhile, the rain sensor on the ship will trigger an alarm at the coast guard post

automatically, and the location of the vessel can be immediately known by looking at the webserver.

2. The working principle of the Vessel Safety Monitoring System (VSMS) is to activate an alarm at the coast guard post remotely, which indicates that the condition of the vessel is in danger. The alarm system is also made automatically with a rain sensor. If the waves hit the rain sensor with a predetermined range value in the vessel's forecastle, the coast guard post's alarm will turn on.

3. Based on the results of the Vessel Safety Monitoring System (VSMS) test, 10 data transmission from the vessel to the coast guard post can work on the land and the sea it can send nine types of data with 0 - 50 meters distance, it can send 1 type of data with a 0 - 100 meters distance, with an average delivery delay of 5 seconds. The amount of data and the delivery delay affects the working distance of the tool. The distress function or the danger signal requires data transmission for 0-15 seconds manually or automatically until the alarm goes off at the coast guard post since the vessel's danger signal is activated from the vessel to the coast guard post.

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