ISSN 2278-3091
Volume 8, No.4, July – August 2019
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse32842019.pdf
https://doi.org/10.30534/ijatcse/2019/32842019

A Prototype Implementation of an Emergency Communication Device and Locator for Small-Scale Fishing Boats

Miriam A. Mejias[1], Cenie V. Malabanan [2]
[1] Instructor, University of Science and Technology of Southern Philippines, Philippines, miriam.mejias@ustp.edu.ph
[2] Professor, Mindanao State Unversity-Iligan Institute of Technology, Philippines, cenie.malabanan@g.msuiit.edu.ph

ABSTRACT

This paper presents the results of the investigation made for the prototype implementation of an emergency communication system and locator for small-scale fishing boats using a license-free band and long-range marine wireless network. The prototype has an emergency button that allowed fishermen-participants to send a distress signal to the base station and, in turn, a light emitting diode (LED) that can notify the warning signal that was transmitted from the base station. The network module periodically transmitted the boats' coordinates to the base station and these position reports received are displayed in real-time through a mapping system. Through these, the base station can geolocate the fishing paths and the last known location of the fishing boats. This study was able to implement a prototype for a long-range wireless network between two boats, a floating buoy, and the base station. The transmission of distress signals from the boats to the base station and warning signals that were broadcast from the base station was successful up to 5.4 kilometers. This research has proven the potential of Sub-1 GHz through wireless transmission in an open sea communication, which can help small-scale fishermen to be easily located when emergency situations arise and ease the burden in search and rescue operations.

Key words : Emergency Communication, Geolocation, Small-Scale Fishermen, Sub-1 Ghz, Wireless Marine Network

1. INTRODUCTION

Fishing at sea can be one of the most dangerous occupations in the world, with over 32,000 deaths recorded every year[1]. In the Philippines, marine fishing is an important sector in the country's economy, employing about 1.6 million people in the municipal scales alone, according to Fisheries and Aquaculture Country Profile of the Philippines. Of these, an estimated 800,000 are small-scale fishermen using traditional, low-cost techniques, notably net fishing from small boats and the fish "corrals" [2].

Most small-scale fishermen face a multitude of problems that increase their vulnerability to hazards particularly prone to natural disasters such as storms or super typhoons that can strike suddenly without warning. This can cause tangible losses in the form of damaged or lost boats and even human casualties.

In December 2012, when typhoon 'Pablo' hit the main southern island of Mindanao, an estimated of more than 300 fishermen went missing [3]. The Philippine Coast Guard and the Philippine Navy launched a search and rescue operations but they were never found. In 2017, 40 fishermen went missing in Palawan where 26 motorbancas were battered by stormy seas at the onslaught of tropical storm "Vinta"[4]. Station commanders cannot account how many were missing because the hospital staff were not able to get accurate figures since reports were based on estimated numbers. In addition to this, the Philippine Coast Guard kept records of missing fishing boats and fishermen regularly, even without weather disturbances or heavy storms [5].

The sea can be a dangerous place for fishermen. Mobile signals can be unstable or unreachable in the open sea, resulting in blank-zero communication channels and the absence of GPS signal, causing information blackout when there is a sudden emergency situation or change in weather updates. Traditional fishermen, when in distress, have an option to try contacting the nearest on-shore rescue station using Very High Frequency (VHF) communication, but this is also subject to whether this feature is available for them, especially that a VHF equipment is not a cost-effective option for small-scale fishermen. Satellite-based monitoring system like Vessel Monitoring System (VMS) has also been developed worldwide which at regular intervals provides data to the fisheries authorities on the location, course, and speed of vessels[6], but they are only used in commercial fishing entities to allow environmental and fisheries regulatory organizations to track and monitor the activities of these vessels. As to small-scale fishermen, there are limited technologies that are being used to locate them when disaster strikes.

When authorities are alerted of missing fishermen or vessels, searching for them may take some time due to the missing information of the last known location. Coast Guard spends hours and resources to determine whether these reports were genuine or mere false alarms, and in addition, search and rescue operations at sea are costly and time-consuming.

That is why accurate information and a time-efficient response to open sea search and rescue operations are two crucial factors in addressing crises involving lost fishing vessels and its fishermen.

In emergency situations these fishermen are facing, a cost-effective platform to seek help through a distress alert signal and locating their position is very important [7]. Hence this study aimed in designing and developing an emergency communication device using license-free band and long-range marine wireless network for small-scale fishermen that can send a distress signal to the base station and receive warning signal from the base station and also tracks and locates the real-time and last known position of the fishing boat.

2. METHODOLOGY

2.1 Emergency Communication

When a fisherman-participant was in distress and needed immediate help, the emergency button was pressed and it was able to send a trigger signal to the base station, which in turn, alerted the system indicating that a certain boat was in distress [8]. The prompt distress message contained a predefined message, the boat ID number, and the latitude and longitude coordinates of the boat. The coordinates were obtained using a GPS module present on the boat.

When there was a sudden critical change of weather update that needed the fishermen to be alerted for them to go back to shore, the base station sent an emergency signal and was broadcast to all the connected boats in the network. The on-board module received the alert from the base station, an indicator that the alert was acknowledged was through a repetitive blinking of the LED light.

The system for the boat module was composed of an RF transceiver, a microcontroller, a GPS Module, a LED, and an antenna that was connected directly to a 5V power source.

The components for the floating buoy and base station module was similar to the boat module except for the GPS since these two nodes will only serve as gateways for communication.

The remote units will transmit coordinate messages with an interval of 10 seconds. Whenever a remote unit receives a coordinate message coming from another remote unit, the receiving unit must re-transmit the message without packet manipulation. Whenever a remote unit receives a coordinate message with a repeating packet number, the receiving unit must discard the message. The middle unit (buoy) must re-transmit any message received.

The network topology used is hybrid mesh star topology. Mesh network for the buoy and base, was used since it can receive any data from any of the boats and can transmit/receive data with each other. Star network was adopted for the boats since it cannot receive data from each other but only to and from the buoy or base. The nodes at sea were limited to the municipal fishing boundary only, which was within 15 kilometers from the shoreline.

2.2 Location Tracking of Fishing Boats

To determine the location of boats, geolocation using GPS was used in getting the real-time coordinates of the boats. This coordinates were passed through the Sub-1 GHz network and was displayed in the coordinate mapper software in the base station.

The coordinate mapper tracked the paths traversed by the boat and its last known location. This software can determine in real-time the location of the fishermen and can receive distress signals from the fishermen and broadcast emergency signal to the fishermen.

To provide stable mapping of the coordinates of the area, the software must run even without the connection of the internet, therefore a static map is required. The map has corner coordinates which determined the maximum and minimum of both longitudes and latitudes.

When launched, the application perpetually went on active stand-by for any transmission sent on the serial communication interface. When data was received, the software decoded the data by extracting necessary information.

To display the GPS location on a map it used an extracted image map of the target location as a GPS layer and then it displayed the GPS location data, including the current location, previous track points, and a trail connecting the track points.

The data received from the boats to the base node was communicated through the serial port and was connected to the laptop. Also during the flight of the boat, there was an indicator in the map that shows the current location of a certain boat and this was moved in real-time, parallel to the boat's movements.

2.3 System Integration

System integration included mounting the wireless network node prototype to the boat. The on-board components include the RF transceivers, microcontroller, and GPS receiver. Software is loaded through as a stand-alone desktop java application in .jar format. The buoy and base station components included the similar prototype used in the boat except for the GPS module.

The on-board module was put in a 2.5 meters bamboo pole and was mounted in the boat. Also the base station was situated at the second floor of the house near the seashore which is approximately eight (8) meters high.

After all components was integrated, the marine wireless network system was complete and ready for launch testing.

2.4 Testing

The deployment system was tested in the open sea with at least two boats. Effectiveness and accuracy of the overall system shall be measured.

For computation of long range capability of the Sub-1 Ghz network made, the GPS location of the base station was recorded as starting coordinates. To test the maximum distance travelled, once the signal was lost it would indicate that it had reached it to a maximum. The last known transmitted GPS location from the boats was subtracted from the base station. The coordinates were given in the form of decimal degrees, where x and y represents the latitude and longitude degrees of two points. To compute for the distance in degrees, the basic two point distance formula was used as shown in Equation 1.

$$d^{o} = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad (1)$$

To convert the distance in degrees to kilometers, it was multiplied by a constant value 111, where each degree of latitude was approximately 111 kilometers [9] apart as shown in Equation 2.

$$d_a = 111 * d^{o} \quad (2)$$

Degrees of latitude were parallel so, for the most part, the distance between each degree remained constant.

To validate if the distance obtained from the computed value, was correct, another equation – Haversine Formula using Microsoft Excel was used. The Haversine formula determined the great-circle distance between two points on a sphere given their longitudes and latitudes. Equation 3 is an Excel formula of the ‘Haversine’ equation (actually, using the "spherical law of cosines") for distances between points in kilometres[10].

$$d = ACOS(SIN(Lat1) * SIN(Lat2) + COS(Lat1) * COS(Lat2) * COS(Lon2 - Lon1)) * 6371 \quad (3)$$

Since the GPS points (Lat/Lon) were in decimal degrees, not radians, the Latitude And Longitude In Excel (under the "Great Circle Distances" section) by Chip Pearson [11] was used as shown in the modified excel formula of the ‘Haversine’ equation as shown in Equation 4,

$$d = RadiusEarth * ACOS(COS(RADIANS(90 - Lat1)) * COS(RADIANS(90 - Lat2)) + SIN(RADIANS(90 - Lat1)) * SIN(RADIANS(90 - Lat2)) * COS(RADIANS(Long1 - Long2))) \quad (4)$$

where RadiusEarth = earth’s radius (mean radius = 6,371 kms).

A third party mobile application called “Map My Walk” that recorded the track and distance of the boat travelled, and a web-based platform called “GPS Visualizer” that generated a trail map and distance way points based on the uploaded data logs from the system were also used to compare the results. The maximum actual distance of the RF transceivers attained was then compared to its theoretical value. As to the packets sent during transmission, a separate log file was recorded in the boat and in the base station to compare packets loss and to check the delay of successful transmitted data. To further validate the data logs, a third party mobile application called “Serial USB Terminal” was run in the phone that was connected in the boat modules to record the sent GPS coordinates from the boat and compare it to the successfully received GPS coordinates in the Coordinate Mapper software in the base station.

3. RESULTS AND DISCUSSION

3.1 Emergency Communication

The implemented license-free band marine wireless network using Sub-1 RF technology was tested. Figure 1 shows the finished network hardware modules. The RF modules theoretically can communicate up to eight (8) kilometers per node within line of sight.

Figure 1 a, b: Actual Device Set-Ups

The following data show the communication from the base station to the boats. Whenever the base station wants to send an emergency signal to the fishermen, a message prompt will appear asking for confirmation before broadcasting. After clicking yes, it is expected that the boat nodes will receive the signal as a way of knowing that they needed to go back to shore immediately.

Figure 2 : Message prompt before broadcasting emergency signals to connected boats

When the base station has sent the signal, it will be seen through the blinking of LED for two minutes signaling the fisherman to return to shore immediately. To further validate the signal, aside from the hardware, an application was installed in the phone called "Serial USB Terminal" that was connected to the device to show that indeed an SOS signal has been received. Figure 3 shows that a broadcast message was received in the boat.

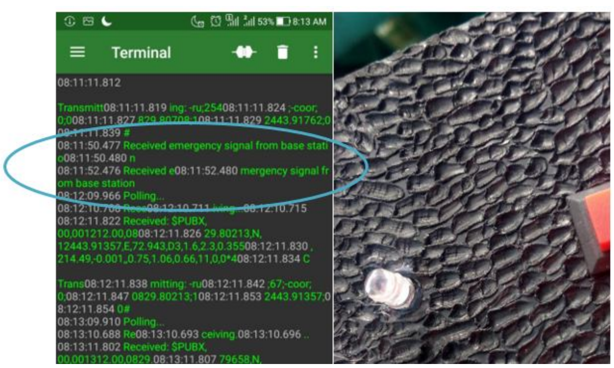


Figure 3 : SOS signal from base station received

Figure 4 shows that whenever a fisherman pressed the emergency button, it will prompt in the base station that the Boat with an ID no. N has sent an emergency signal showing its current location.

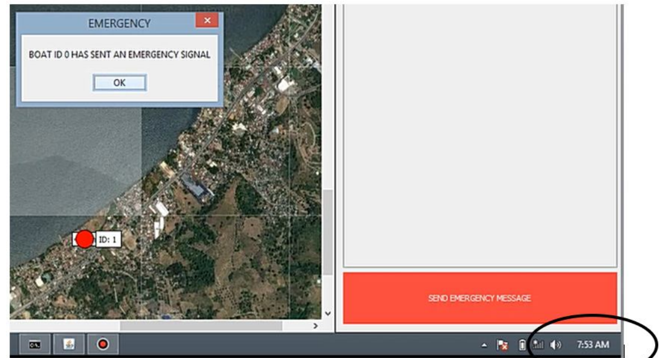


Figure 4 : SOS signal from the boat sent to the base station

To verify the exchange of data, a screen record has been captured in the Coordinate Mapper Software with the time stamp if it coincides with the log file of the 'Serial USB Terminal" app as shown in Figure 5.

Figure 5 : Log file saved in phone from the boat showing the timestamp of the SOS signal

Figure 6 shows the pop up messages in the base station software whenever a connected boat sends a distress signal from the sea. It also shows the current location and time of the sent distress signal.

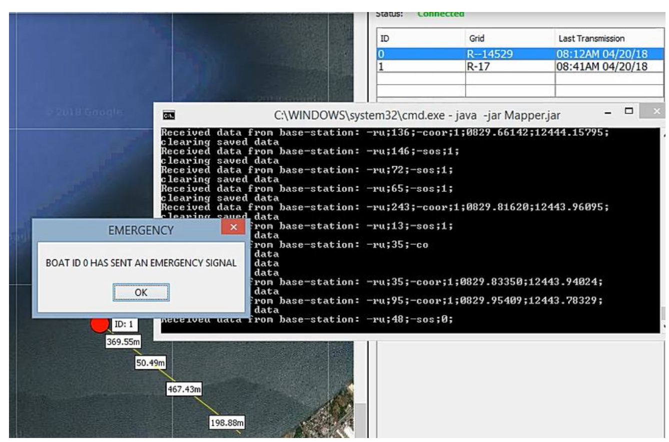
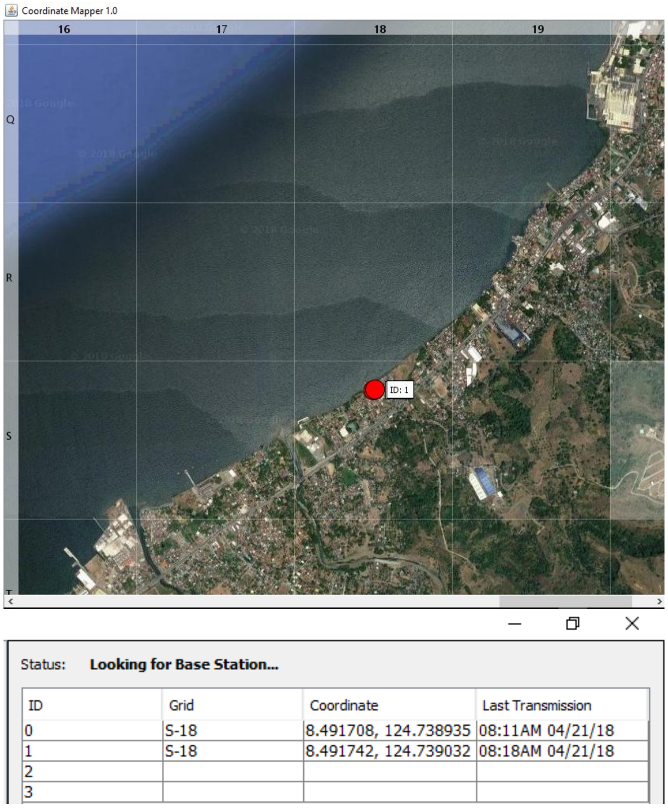


Figure 6: Pop up messages in the base station showing that a certain boat is in distress and also showing its current location.

3.2 Location Tracking of Fishing Boats

Before testing the system in the open sea, the GPS module was tested first onshore whether it can transmit the correct location.

Figure 7 shows the last coordinates of boats recorded at different time stamps and their current location as shown in the dot when the system was deployed at sea and then brought back to the shore. After returning to land, the two boats have similar coordinate values recorded indicating that the two boats are positioned near each other in the shoreline of which one dot is shown overlapping each other in the map.



ID	Grid	Coordinate	Last Transmission
0	S-18	8.491708, 124.738935	08:11AM 04/21/18
1	S-18	8.491742, 124.739032	08:18AM 04/21/18
2			
3			

Figure 7: Last known location recorded

Figure 8 shows the mapping of the paths traversed by the two boats with its distance calculated and plotted based on the equations discussed in the Methodology section. It also shows that the boat signals could reach close to near 6 kilometers from the base station, which is nearer to its theoretical value of 8 kilometers. The maximum distance where the signals from the device was still reachable or optimal was 5.41 kilometers for Boat ID0 and 5.23 kilometers for Boat ID1.

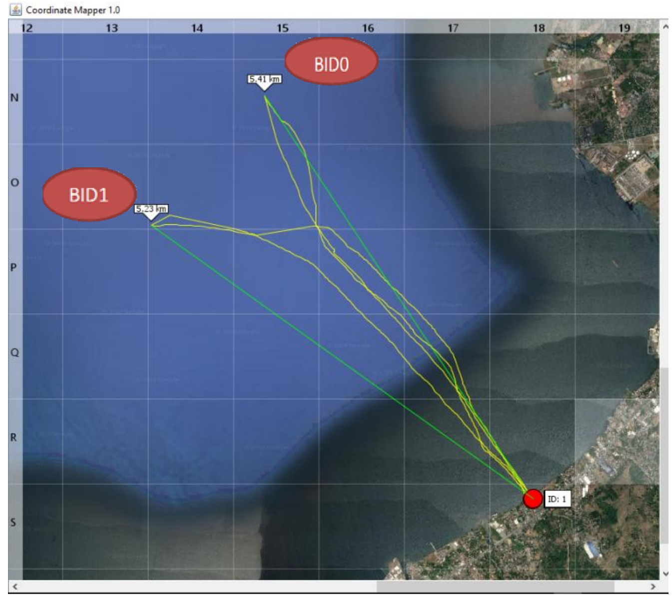


Figure 8: Trail track of the boats with distance mapping

To validate if the developed coordinate mapper was similar to other GPS coordinates mapper, an online application was used - called GPS Visualizer that allows recorded GPS data logs to be mapped showing its trail and distance travelled. The following are comparisons of the map in real time versus the map generated using the data logs.

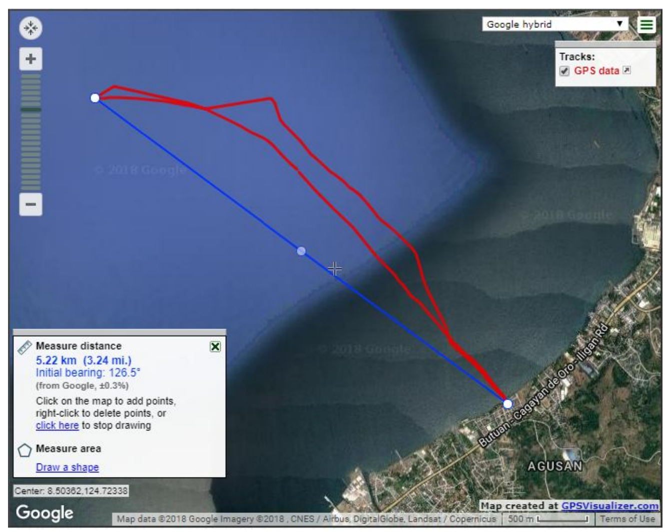


Figure 9: Map of Boat ID1 GPS coordinates using GPS Visualizer

As seen in Figure 9, B1D1 from the GPS Visualizer (GV) had the same trail as shown in Figure 8 using the designed Coordinate Mapper Software (CMS). With respect to its distance, CMS' distance from base station was 5.19km while from GV, it was 5.22km.

Using Equation 5 in getting the percentage error, if the distance from GV will be referenced as the true value, then the computed distance error is -0.5747% only or the designed coordinate Mapper software is 99.4253% accurate in Boat

ID1.

$$\text{Percentage error} = \frac{|V_{true} - V_{observed}|}{V_{true}} \times 100 \quad (5)$$

Table 1: Comparison of Distance Computation of Boat ID1 using Two Point Formula Versus Haversine Equation

	BASE		SHORE		Distance in Kilometers: Two point formula	Distance in Kilometers: Haversine Equation
213	8.491742	124.739	8.519025	124.7017	5.132	5.104
214	8.491742	124.739	8.519043	124.7014	5.157	5.129
215	8.491742	124.739	8.519083	124.7012	5.186	5.157
216	8.491742	124.739	8.520135	124.7029	5.097	5.071
217	8.491742	124.739	8.51873	124.7096	4.436	4.417

Table 1 shows the extracted data from the log files showing the comparison between the computed maximum distance using the direct two point formula and using the Haversine equation (which is using the "spherical law of cosines") for distances between points in kilometers. There is only a slight difference in using the direct approach. Using the maximum distance recorded (highlighed), if Haversine equation is the true value, then the computed two point formula used in the coordinate mapper software is 99.4408% accurate in Boat ID1.

Table 2: Comparison of Distance Computation of Boat ID0 using Two Point Formula Versus Haversine Equation

	BASE		SHORE		Distance in Kilometers: Two point formula	Distance in Kilometers: Haversine Equation
225	8.491708	124.7389	8.532041	124.7124	5.361	5.353
226	8.491708	124.7389	8.527719	124.7135	4.984	4.884

For Boat ID0, using the maximum distance recorded (highlighed), if Haversine equation is the true value, then the computed two point formula used in the coordinate mapper software is 99.850800% accurate in Boat ID0.

Comparing the results, it shows that the trail map created using the Coordinate Mapper Software is reliable in finding the exact path and last known location of the fishermen using the coordinates transmitted from the GPS modules to the RF transceivers.

Using the log files in the testing at the sea, the researcher was able to track the success rates of sending GPS coordinates. In one particular testing, Boat IDO has transmitted 355 GPS coordinates to the base station in a span of 1 hour and 21 minutes. In this test, GPS coordinates were programmed to transmit data every 10 seconds. If that would be the basis, an expected 486 of GPS coordinates should have been sent to the base station. But due to the distance, the farther the boat goes, the number of transmission of data per minute decreases. For the farthest distance, instead of 6 coordinates, it only has 3 received coordinates at that particular time. There were also instances that there was a gap between the time of the last successful transmission due to loss of signal since it has reached its maximum distance. The good thing is, it did record the last known location if ever an unfortunate situation will happen to the boat or the fisherman.

Table 3: Computation logs when boat is closer from the base station

	BASE		SHORE		Distance in Kilometers		
					Two point formula	Haversine Equation	Time
	Latitude	Longitude	Latitude	Longitude			
5	8.491708	124.7389	8.491665	124.739	0.006	0.006	06:51AM 04/21/18
6	8.491708	124.7389	8.49166	124.739	0.007	0.006	06:51AM 04/21/18
7	8.491708	124.7389	8.491662	124.739	0.006	0.006	06:51AM 04/21/18
8	8.491708	124.7389	8.491663	124.739	0.007	0.007	06:51AM 04/21/18
9	8.491708	124.7389	8.491664	124.739	0.006	0.006	06:51AM 04/21/18

Table 4: Computation logs when boat is at its maximum distance from the base station computation logs

	BASE		SHORE		Distance in Kilometers		
					Two point formula	Haversine Equation	Time
	Latitude	Longitude	Latitude	Longitude			
219	8.491708	124.7389	8.529949	124.7138	5.081	5.073	07:37AM 04/21/18
220	8.491708	124.7389	8.530469	124.7134	5.152	5.144	07:37AM 04/21/18
221	8.491708	124.7389	8.53073	124.7132	5.188	5.180	07:37AM 04/21/18
222	8.491708	124.7389	8.531251	124.7128	5.259	5.250	07:38AM 04/21/18
223	8.491708	124.7389	8.531501	124.7127	5.293	5.284	07:38AM 04/21/18
224	8.491708	124.7389	8.531766	124.7125	5.327	5.319	07:38AM 04/21/18
225	8.491708	124.7389	8.532041	124.7124	5.361	5.353	07:38AM 04/21/18
226	8.491708	124.7389	8.527719	124.7135	4.894	4.884	07:47AM 04/21/18

Table 3 and 4 show some snippets of the GPS coordinates with respect to time and the distance. The closer the distance it is, the stable is the number of signals sent, the more it went farther, the lesser it transmit successful GPS coordinates.

There was also a delay in receiving and transmitting an SOS signal depending on the distance of the boat from the base station. At some point, there was a 1 minute or 2 minutes delay before the SOS signal was received. The results varied because of the difference in the distance traversed. There were also instances that it was not received from the base station because the boat's distance is not anymore reachable and beyond the used RF's capability.

4. CONCLUSION

The prototype emergency communication device using a long-range wireless network that was built was able to send a distress signal, and received warning signal at an optimal distance compared to its theoretical distance. Results indicated that the Coordinate Mapper Software was able to pinpoint the nearest location of the fishermen-participant's boats with limits according to the optimum distance acquired. With these, it will be easier to locate them in case of emergency. Using the devices, these will add another layer of communication and improvements in disaster relief operation for our local fishermen.

The efficiency of the wireless communication system was effective enough to be used given that the point of connection must be within line of sight to ensure that the nodes meet and that they can communicate. The setup of the wireless network must be mounted on higher location within their corresponding nodes without barriers to ensure that the communication flows smoothly without interruptions.

Overall, the emergency communication device and locator for small scale fishing boats was successfully tested and could be further improved.

5. RECOMMENDATIONS

The methodology carried out in this study opened up more opportunities to further enhance the system. For example, by improving the height of the antenna in the boats the signal could be extended at deeper sea levels as the curvatures of the sea could affect the signal. Also, putting an SD card inside each module for data logging would benefit further the evaluation of the prototype. Moreover, it would be beneficial to test a much longer range of Sub-1 GHz RF transceivers particularly a distance of 20 kilometers for the base station. Finally, the durability of the device should be ensured to better secure the devices in order to withstand extreme temperatures and weather conditions.

ACKNOWLEDGEMENT

M. Mejias acknowledge support from DOST-ERDT.

REFERENCES

1. FAO. Safety for Fishermen. Food and Agriculture Organization. [Online] June 10, 2019. http://www.fao.org/fishery/safety-for-fishermen/en/.
2. Blitz, Amy. Marine Fishing in the Philippines. Cultural Survival. [Online] June 1987. [Cited: March 3, 2017.] https://www.culturalsurvival.org/publications/cultural-survival-quarterly/marine-fishing-philippines.
3. Orosa, Rosalinda. 'Pablo' death toll climbs to 647. PhilStar Global. [Online] December 10, 2012. [Cited: November 5, 2017.] https://www.philstar.com/nation/2012/12/10/884428/pablo-death-toll-climbs-647.
4. Unite, Betheena Kae. 40 fishermen still missing off Palawan – PCG. Manila Bulletin. [Online] December 29, 2017. [Cited: January 30, 2018.] https://news.mb.com.ph/2017/12/29/40-fishermen-still-missing-off-palawan-pcg/.
5. Philippine Coast Guard. Missing Fishermen Search Index. Philippine Coast Guard. [Online] 2018. [Cited: March 9, 2018.] http://www.coastguard.gov.ph/index.php.
6. European Commission. Vessel monitoring system (VMS). [Online] 2018. [Cited: March 9, 2018.] https://ec.europa.eu/fisheries/cfp/control/technologies/vms_en,
7. A. Senthilkumar1, “Portable Life Protection System for Fishermen Using Global Positioning System,” International Journal of Emerging Technology and Advanced Engineering, Vol 3, Issue 9, PP 60-64,2013.
8. A. Bharadwaj et al. (n.d.). Satellite and RF Enabled Assistance for Marine Navigation. Sambhram Institute of Technology.
9. What Is the Distance Between Degrees of Latitude and Longitude?. [Online] September 28, 2018. [Cited: January 30, 2019.] https://www.thoughtco.com/degree-of-latitude-and-longitude-distance-4070616.
10. Excel formula to calculate distance between 2 latitude, longitude (lat/lon) points (GPS positions). [Online] January 6, 2007. [Cited: January 30, 2019.] https://bluemm.blogspot.com/2007/01/excel-formula-to-calculate-distance.html.
11. Pearson Software Consulting, Betheena Kae. Latitude, Longitude, And Great Circles. [Online] May 6, 2018. [Cited: January 30, 2019.] http://www.cpearson.com/EXCEL/LATLONG.ASPX.