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THE DESIGN AND BUILD A NAVIGATION SENSOR INTEGRATION SYSTEM FOR INDONESIAN WAR SHIP DETACHABLE INFORMATION (CASE STUDY OF KRI CLASS FPB 57)

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ABSTRACT

The KRI is the main defense equipment owned by the Indonesian Navy which has a very important main task to maintain peace at sea and the sovereignty of the Republic of Indonesia. To facilitate the main task of KRI, a navigation sensor integration system tool is needed for information on the detachment of KRI from the pier. The problem in this study is how to read and make a multiplexer to integrate navigation data with Lidar, GPS, gyoro compas, wind direction and wind speed sensors. Meanwhile, the purpose of this study is to design and find out how the navigation multiplexer system works to integrate ship navigation data when carrying out De-docking. The method used in this study is to use a descriptive qualitative approach through Trial and error test, by conducting various kinds of experiments and measurements on the module and analyzing the results adjusted to the applied theory. While the results obtained from the testing of sensors and modules are the results of testing lidar sensors at a distance of 0.04cm, obtaining a high erosion level of 0.75% while at a distance of 9m, obtaining a low erosion of 0%. Testing of the GPS module shows data compatibility between the GPS module and Google Maps with insignificant differences. Testing of HMC5883L compass modules with 0°-360° direction changed shows good accuracy compared to compasses in smartphones. The inspection of the wind direction and speed sensors showed good accuracy, with consistent results and little variation in experiments. Testing of the CAN Bus module showed smooth communication without any problems, with each sensor successfully transmitting data according to its respective ID. The ID priority system ensures efficient data delivery. The results of all tests show that all sensors and modules are functioning well and reliably in carrying out the docking and deboarding of the ship.

Keywords: *Navigation, Lidar Sensor, Can Bus.*

1. INTRODUCTION

KRI is a defense equipment that requires a high level of readiness, both personnel and material readiness. Material readiness includes the condition of all technical equipment that is able to support KRI operations in accordance with its basic function. To carry out its basic function, the KRI must be supported by various reliable equipment. One of them is equipment in the field of navigation. This is very important because navigation has an important role especially to avoid factors that can cause accidents at sea, especially due to negligence of personnel. Technically, the movement of the KRI when it is about to take off the ship at the port is supported by navigation data obtained from various equipment such as GPS, gyro compass, wind direction and wind speed, and other navigation equipment. When the ship carries out the docking, it is often seen that a KRI commander is always on the wing bridge of the platform because to visually see the condition of the pier to avoid accidents when carrying out the ship's docking.

In addition, there is also information needed to lean on a ship or a loose ship, namely the distance of the dock, to get this information, an officer who is in the bow or stern reports by logically using the sense of sight and reports the distance logically using Handy Talkie (HT), which generally does not

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have a ship navigation sensor integration system that can tell how far the ship is from the dock. Therefore, when going to take off the dock from the pier, there is often a *miscommunication* between the platform and the bow and stern. To avoid this *missed communication*, it is necessary to install a navigation sensor integration system between the distance between the ship and the pier and the distance between the ship and the ship in front of it and the ship behind it using lidar sensors, in order to avoid material and personnel losses.

The advantages of the ship navigation sensor integration system when it is going to take off from the dock, among others, have a high level of accuracy and make it easier for the commander and crew of the ship when going to lean the ship so that it can be directly monitored through the platform. Has both active and passive detection capabilities, Has the ability to accurately analyze the distance between ships and docks. It has monitoring capabilities that can be seen directly by the commander without the need to leave the platform to check the certainty of the ship when it is about to carry out dedocking.

Design and Build a Navigation Sensor Integration System for KRI Docking Information on ships must be able to take into account mobility factors and the ability to be operated in different situations. This tool must also be able to operate properly and accurately when carrying out the ship's docking, the Navigation Sensor Integration System must also be able to work effectively and reliably to display navigation data in real time.

1.2 Problem Formulation

From the above background, several problems can be formulated to correct the shortcomings and weaknesses that exist in the Navigation Sensor Integration system for information off the KRI dock. The problems are:

a. How do I read and recognize navigation data on Lidar, GPS, gyoro compas, wind direction and wind speed sensors?

b. How do I create a multiplexer to integrate Navigation data with Lidar, GPS, gyoro compas, wind direction and wind speed sensors?

1.3 Research Objectives

The objectives of the Design and Construction of the Navigation Sensor Integration System for Information Off the KRI Leaning are:

a. Knowing and understanding how the Navigation Sensor Integration System for Information Takes Off the KRI Side.

b. Create and design navigation multiplexers to integrate ship navigation data when performing Detoxification.

1.4 Research Benefits

The benefits obtained from writing this final project are as follows:

a. Theoretical Benefits

To apply the knowledge that has been obtained while studying at the Naval College of Technology.

b. Practical Benefits

1) Applying the knowledge that has been obtained.

2) It can provide information data to help the process of ship's docking activities.

3) It can reduce the danger of ship collision and does not harm personnel or materials so that it can be used as a reference for the KRI Commander in making decisions for the process of ship docking activities.

1.5 Problem Limitations

In completing the writing of this final project, the author compiles the boundaries to be more focused and the problem is not too broad. The limitations of the problem are as follows:

a. This research will focus on collecting data on the distance off the ship berthing vetivally.

b. This research will focus on the development of a Navigation Sensor Integration System when carrying out deboarding and will not include major changes to the existing KRI navigation system.

c. Testing of the Navigation Sensor Integration System will be carried out under adequate simulation conditions to ensure the accuracy and reliability of the system.

2. LITERATURE REVIEW

2.1 Microcontrollers

According to Dharmawan, H. A. (2017), a microcontroller is a microcomputer chip that is physically in the form of an *IC (Integrated Circuit*). Microcontrollers are typically used in systems that are small, inexpensive and do not require very complex calculations like in PC applications. Microcontrollers are widely found in appliances such as microwaves, ovens, keyboards, CD players, VCRs, remote controls, robots etc. The microcontroller contains the main parts, namely *the CPU (Central Processing Unit), RAM (Random-Access Memory), ROM (Read-Only Memory)* and port 1/0 (Input/Output). In addition to these main parts, there are several hardware that can be used for many purposes such as enumeration, serial communication, interrupting etc. Certain

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microcontrollers even include *ADCs (Analog-To-Digital Converters), USB controllers, CAN (Controller Area Network) etc.*

2.1 LIDAR (Light Detection and Ranging)

LIDAR (Light Detection and Ranging) is an optical long-range tactile technology that measures the properties of scattered light to find distance and/or other information from distant targets. The method to determine the distance to an object or surface is to use laser pulses. Like radar technology, which uses radio waves rather than light, the distance to an object is determined by measuring the time interval between the transmission of the pulse and the detection of the emitted signal. Lidar technology has applications in the fields of geodesy, archaeology, geography, geology, geomorphology, seismology, remote touch and atmospheric physics. Other names for Lidar are ALSM (Airborne Laser Swath Mapping) and laser altimetry. LADAR (Laser Detection and Ranging) is often used in military contexts (Dimitri De Jonghe, et al., 2008).

2.2 GPS (Global Positioning System)

GPS (Global Positioning System) is a system to determine the location on the earth's surface by synchronizing satellite signals. The system uses 24 satellites that transmit microwave signals to Earth, which are received by receiving devices to determine location, speed, direction, and time. Systems similar to GPS include Russia's GLONASS, the European Union's Galileo, and India's IRNSS. GPS, also known as NAVSTAR GPS, has three segments: satellite, controller, and receiver/user (Winardi, 2006).

There are 24 GPS satellites orbiting the earth, with 21 active satellites and 3 reserves. The GPS receiver receives signals from these satellites to determine the position displayed as latitude and longitude coordinate points on electronic maps. GPS satellites are in orbit about 12,000 miles above the earth's surface and circle the earth every 12 hours at a speed of 7,000 miles per hour.

2.4 Gyrocompass

A gyrocompass is a navigation tool that uses a gyroscope that is constantly rotating to accurately find its true northerly direction. It works by finding equilibrium under the influence of gravity and the rotation of the earth, making it immune to magnetic interference from steel structures or electrical circuits. The gyrocompass is widely used in warships for weapon control and torpedoes, as well as a reliable compass for ship navigation (Encyclopedia Britannica, 2019).

A gyroscope is a gyro with an angle of right on the axis of rotation. Under normal conditions, the axis of rotation is horizontal and facing north, while the pendulum is facing downwards. If the gyrocompass starts from the horizontal axis of rotation and points a few degrees to the east, the rotation of the earth causes the axis of rotation to rise above the horizon, or rather, the horizon to descend below the axis of rotation that is stationary in inertial space.

2.5 Wind Direction and Speed Anemometer Sensor

Wind is the movement of air that is parallel to the earth's surface. Air moves from a high-pressure area to a low-pressure area. Wind has a physical quantity, speed, and direction caused by a difference in air pressure in an area.

a. Wind Speed

Wind speed is the speed of air moving horizontally which is influenced by the barometric gradient of the location of the place, the height of the place, and the topographic state of a place. For units of wind speed in meters per second, kilometers per hour or knots.

b. Wind Direction

Wind Direction is the direction from which the wind blows and is expressed in Direction *Degrees* measured clockwise starting from the north point of the Earth or simply according to the angular scale on the compass. The potential of the wind in a place is depicted in a polar diagram, which is a diagram that describes the position of the wind relative to the cardinal direction and the magnitude of the wind speed and the length of time it blows. Such a diagram is called a Wind Rose, with the duration expressed in percentages during daily, monthly or yearly observations. The length of each line expresses the frequency of the wind from that direction.

2.6 Can Bus

Can Bus is a serial communication defined by the International Standardization Organization (ISO) originally developed for the automotive industry to replace complicated wiring harnesses with two-cable buses. In addition, this protocol uses a differential wiring mode, represented by CAN_H and CAN_L, which increases immunity to noise and electrical interference. From a logic point of view, the signal has two states (voltage levels): the dominant logic '0' and the recessive logic '1', meaning that the bus signal remains '0', the dominant logic, as long as one of the nodes releases the logic '0' to the bus (Mehmet Bozdal, 2018).

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3. RESEARCH METHODS

3.1 Research Design

Design The design of this research is applied research where in this research it is carried out to provide solutions to certain problems practically. However, this research can also be categorized as engineering research because it applies science into a design to get performance in accordance with the specified requirements. The design is a synthesis of design elements combined with scientific methods into a system that meets certain specifications. In this study, the design of KRI Navigation Sensor Integration System hardware with monitoring for KRI Docking Information will be carried out.

3.2 Time and Place of Research

The final project research time that will be carried out is starting in January 2024 until July 2024. Meanwhile, the place for the implementation of the research is at STTAL and KRI Shark Class in Koarmada II Surabaya

3.3 Research Design

This design aims to provide an overview of the course of the tool system that will be made as a whole which aims to provide a clearer direction and targets to be achieved so that the research can run according to what is expected.

3.4 Hardware Design

The hardware design on this system begins with preparing the materials to be used, then setting and installing. Figure 3.2 is a chart of the system plan that has been created.

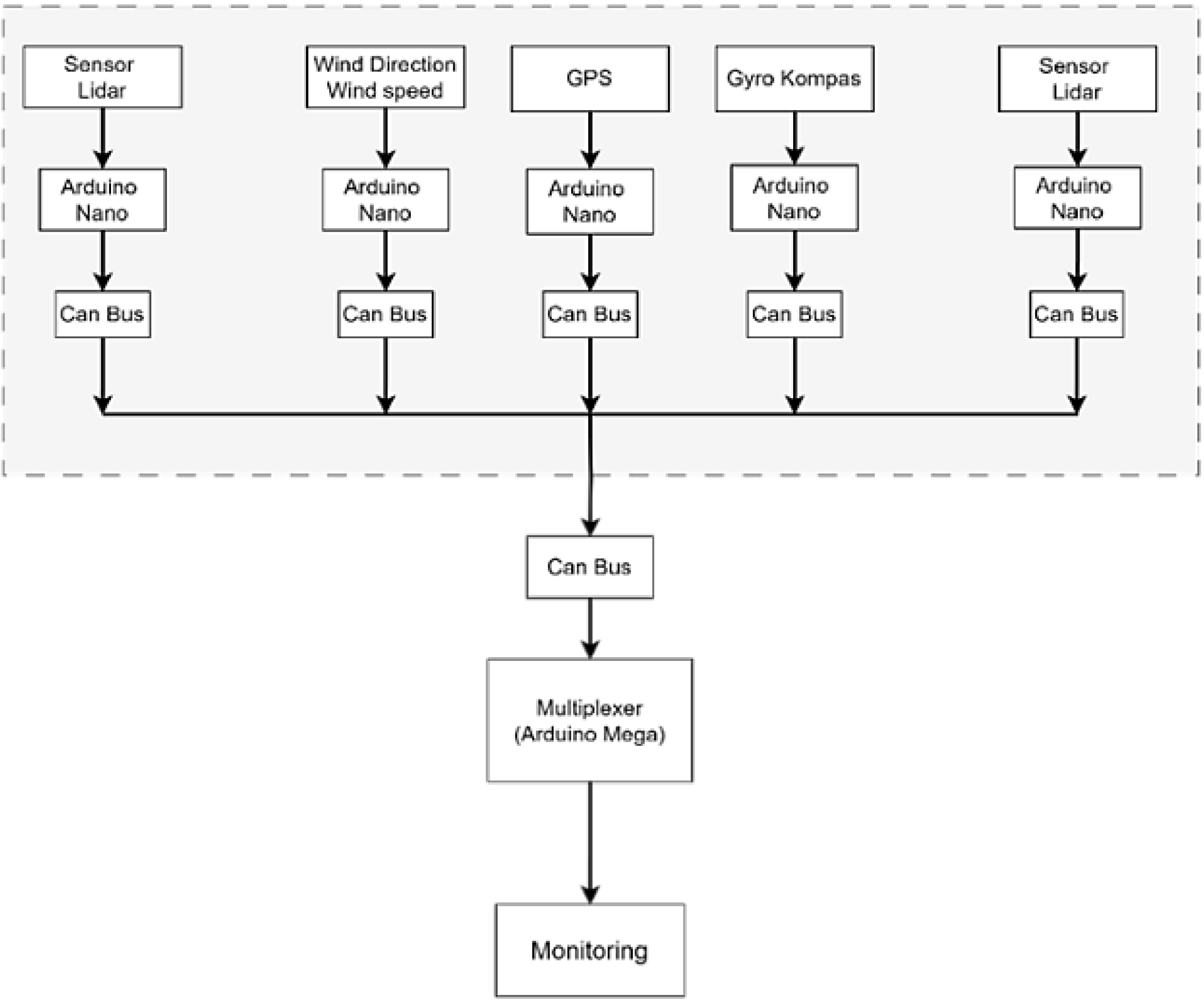

Figure 1. System Design Chart

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Monitoring system is a system used to monitor a desired object. This monitoring is designed for the monitoring of the KRI off-ramp. The sensors used are LIDAR (Light Detection and Ranging) sensors to detect the distance of the ship to the dock when carrying out the KRI docking, GPS module to find out position data (Latitude, Longtitude), HMC5883L module to find out the actual direction of the exit, wind direction anenometer sensor to find out where the wind direction comes from and wind speed anemometer to find out what the wind speed is. Sensor data processing is done by an arduino nano microcontroller. There are two Lidar sensors that are used as guards when carrying out the KRI de-docking. The data from each sensor is sent by the Can bus with a serial data communication system. The data obtained is then sent to the publisher in turn. The Arduino Mega microcontroller as the master will process the data from each sensor and display the data on the display (PC/Laptop).

3.5 Data Collection

Data collection is a process of searching for information and data as well as clues needed in a research. In this study, the author carried out data collection by several methods. Among others:

a. Observation Methods

This method is carried out by making direct observations of the situation in the field that is directly related to this research.

b. Method *Interview*.

The *interview method* is a method by conducting interviews or questions and answers that are carried out directly to several sources related to the design of the tool that the author will make.

c. Methods of study pustak

This method is a method of collecting data by looking for references from several books, journals, and internet media related to this research.

3.8 Data Processing

Data processing is a stage of processing data that has been collected, then processed and applied in a system that is being designed by the author. The data will be sorted and filtered according to the actual situation at this time, then the filtered data will be used as a benchmark from the research results.

3.9 Operational Definition

Operational definition is the determination of various definitions that will be used by the author in carrying out research. The following is the operational definition in design research, namely:

a. The Navigation Sensor Integration System is a system used to determine or monitor the position, direction, and movement of an object or device in a certain space.

b. Data communication is the process of sending and receiving data or information from two *device* (devices such as computers, laptops, printers, mobile phones and other communication devices) or more that are connected in a network.

c. Monitoring system, which is a system that functions as supervision of predetermined objects.

d. Programming languages according to Suyanto (2006:107) programming languages are the languages used by programmers to write sets of instructions (programs) in computers.

4 ANALYSIS AND DISCUSSION

4.1 Planning

Design is a process of initial activities carried out in research that comes from data collection in the field. The design of the tool is obtained from a series of existing analysis, grouping, systematic, interpretation and verification activities so that it can be processed and run according to the design of a system.

4.2 Implementation

Implementation is the stage carried out after the design of tools and systems in this final project. Users carry out implementations to complete the design as needed, document, and test the program created.

The implementation steps include assembling the hardware, scripting the program on the Arduino, and uploading it to the microcontroller. Once the tool is complete, it will be installed on the ship and integrated with the existing system. Sensors will be installed in the bow, stern, and platform of the ship as a tool to remove the ship's berth.

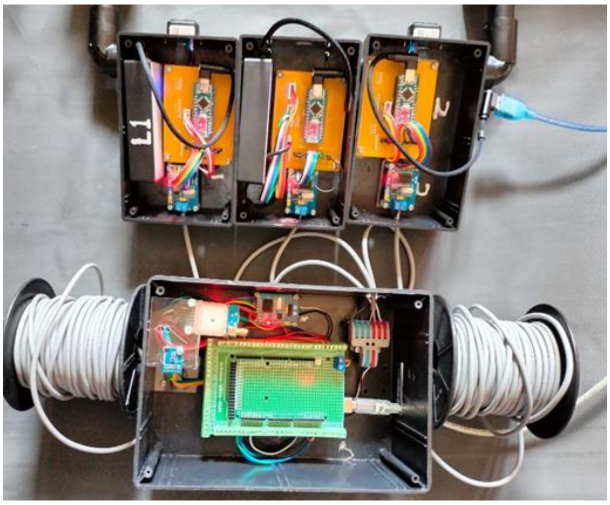

Figure 2. Implementation of Navigation Sensor Integration System

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4.3 Testing

System testing is important to find out the shortcomings and errors in the *hardware and software* devices that are being tested whether they are running well as expected. Testing is carried out on each part, it is hoped that if there is an improvement in one system, it will minimize the occurrence of improvements in the other system.

4.3.1 Testing Lidar Sensors with Arduino

Lidar sensor testing aims to measure the distance of the ship to the dock when undocked. The results of observations and data are expected to assess the condition and performance of the equipment, as well as be a reference for conclusions. The test was carried out by testing the sensitivity of the sensor to the increase in the distance of the pier through a gradual shift. This test compares the value of the Lidar sensor with a manual measuring instrument (meter). The simulation of the data collection test can be seen in Table 1.

Table 1. Lidar Sensor Test Results

Lidar sensor (Meter)	Meter (Meter)	Data difference (Meters)	Error Description (%)
0.01	0.04	0.03	$\frac{0.03}{0.04} x\ 100\% = 0.75\%$
0.51	0.5	0.01	$\frac{0.01}{0.5} x\ 100\% = 0.02\%$
1.02	1	0.02	$\frac{0.02}{1} x\ 100\% = 0.02\%$
2	2	0	$\frac{0}{2} x\ 100\% = 0\%$
3	3	0	$\frac{0}{3} x\ 100\% = 0\%$
5	5	0	$\frac{0}{5} x\ 100\% = 0\%$
7.03	7	0.03	$\frac{0.03}{7} x\ 100\% = 0.004\%$
9	9	0	$\frac{0}{9} x\ 100\% = 0\%$

From Table 1 Data collection was carried out with nine experiments with varying distances. Based on the results of distance measurements from lidar sensors and manual measuring instruments (mearan) as a comparison. The author took 8 data as a sample. From the test results, all differences in data in the test of the device can be summed up and divided by the number of test attempts of the tool by the calculation of the equation, the result of the average error percentage of the lidar sensor test is 0.099%.

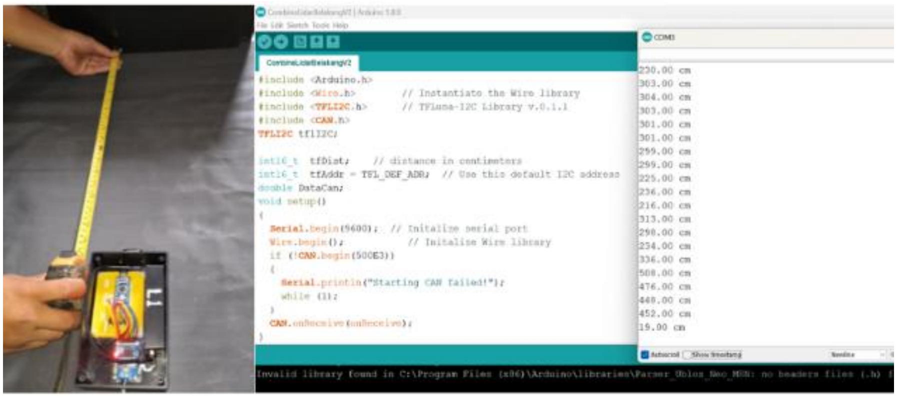

Figure 3. Lidar sensor testing

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4.3.2 GPS Module Testing with Arduino Nano

The GPS module test aims to determine accurate latitude and longitude coordinates. The results of observations and data will assess the condition and performance of the module, as well as be a reference for conclusions. The test was carried out by testing the sensitivity of the module to the displacement of the specified location, comparing the data from the GPS module with Google Maps. The simulation of the data retrieval test can be seen in Table 2.

Table 2. GPS Test Results

Location	GPS Coordinates		Google maps coordinates		Information
	Years	**Long**	**Years**	**Long**	
1	-7.805493	112.527046	-7.805493	112.527046	Unreadable
2	-7.228202	112.717302	-7.228200	112.717300	Unreadable
3	-7.913301	112.669501	-7.913300	112.669500	Unreadable
4	-7.218033	112.715651	-7.218030	112.715650	Unreadable
5	-7.217994	112.715644	-7.217990	112.715640	Unreadable

From the results of the above test data, it provides information that the results of the GPS module test provide information on data analysis and evaluation of the accuracy of the GPS module, comparison with google maps data can evaluate the performance of the GPS Module in data collection and it can be ensured that the Module provides accurate and reliable results.

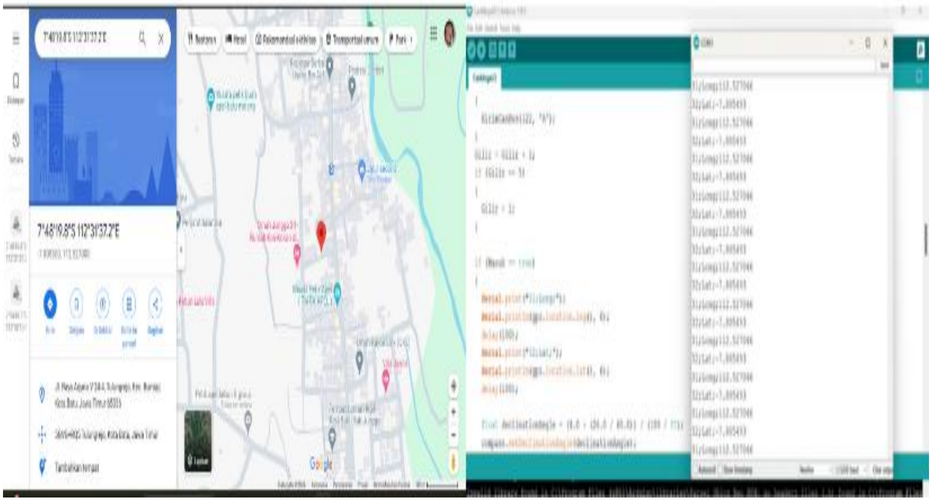

Figure 4. GPS Module Testing

4.3.3 Testing HMC5883L Module with Arduino Nano

The testing of HMC5883L module aims to accurately determine the direction of the ship. The results of observations and data will assess the condition and performance of the module, as well as be a reference for conclusions. The test was carried out by testing the sensitivity of the module to changes in direction, comparing data from the HMC5883L module with a compass on a smartphone. The simulation of the data collection test can be seen in Table 3.

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Table 3. HMC5883L Module Test Results

Directional Orientation	Sensor HMC5883L (°)	Smartphone (°)	Information
Utara	0°	0°	Unreadable
Northwest	315°	315°	Unreadable
West	270°	270°	Unreadable
Southwest	225°	225°	Unreadable
South	180°	180°	Unreadable
Southeast	125°	125°	Unreadable
East	90°	90°	Unreadable
Northeast	45°	45°	Unreadable

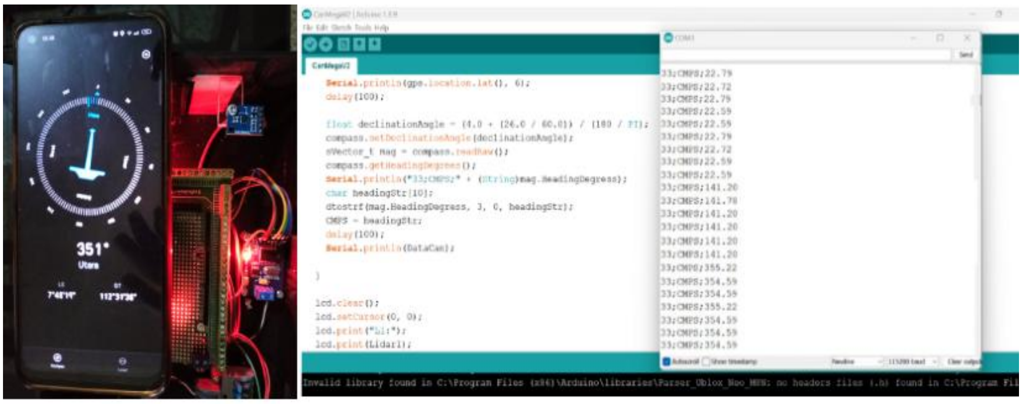

Figure 1. Module Testing HMC5883L

From the test results of Module HMC5883L in table 4, it can be concluded that by changing the direction of the compass from 0°-360°. The results of the above tests show that the data analysis and evaluation of the data accuracy of the HMC5883L module compared to the compass in the smartphone ensures that the sensor HMC5883L get accurate and reliable data.

4.3.4 Wind Direction and Wind Speed Sensor Testing with Arduino Nano

This test aims to ensure that the sensor can detect wind direction and speed and function properly. The test was carried out in several stages, including a trial of data transmission using 10, 20, 30, 40, and 50 meters of cable. The test measures the speed of data transmission and detects any delay to determine if there is a system error. The simulation of the data retrieval test can be seen in Figure 4.5.

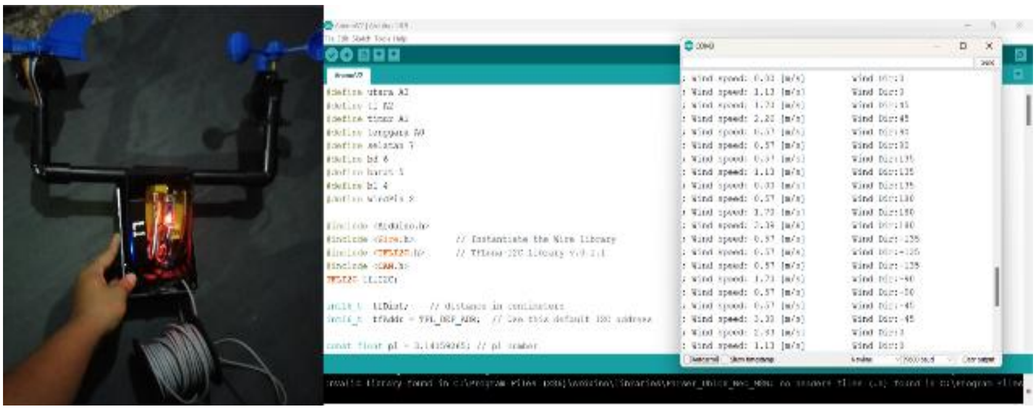

Figure 2. Wind direction and wind speed sensor testing

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Table 4. Wind Direction and Wind Speed Sensor Test Results

Sensor wind directon	Sensor wind speed (M/S)	Time(s)	Output voltage (V)	Information
Stern	1.13	1	3.3	Unreadable
Stern	1.70	1	2.3	Unreadable
Green 90	2.26	1	2.3	Unreadable
Green 90	0.57	1	2.3	Unreadable
Green 45	1.13	1	2.7	Unreadable
Red 135	0.57	1	2.7	Unreadable
Red 135	1.70	1	2.7	Unreadable
Red 135	3.39	1	2.7	Unreadable
Green 45	0.57	1	3.3	Unreadable
Green 45	0.57	1	3.3	Unreadable
I	2.83	1	3.3	Unreadable
I	1.13	1	3.3	Unreadable

From the above test results, it can be concluded that the data analysis and evaluation of the accuracy of the performance of anemometer and wind vane sensors in collecting wind speed and direction data is working well, and ensuring that the sensors provide accurate and reliable results.

4.4 Results and Discussion

The results and discussion of the research obtained based on the tests carried out are as follows:

a. Lidar Sensor Testing

The results of testing the lidar sensor with arduino were carried out by testing the sensitivity of the sensor to the increase in the distance of the pier by shifting between the sensor and the pier. The results obtained are that in the testing of lidar sensors, comparisons are carried out using 2 variables, namely the value issued from the lidar sensor and a manual measuring instrument (meter). It was found that the test of lidar sensors using a distance of 0.04cm resulted in the highest erosion rate of 0.75%. This can be caused by environmental factors that are not supportive during the testing of the device. Meanwhile, testing lidar sensors with a distance of 9m resulted in the lowest erosion level of 0.%. This is due to the fact that during the testing of the equipment the environmental conditions are very supportive, so that good results and a very low level of fatigue are obtained.

b. GPS module testing

The results of testing the gps module with Arduino with a comparison of 2 variables, namely the values issued from the GPS module and Google Maps, provide information that the display value on Google Maps is in accordance with what is obtained by the GPS device, in the GPS device movement test, the results of latitude and longitude data were obtained with lat data: -7.805493 and long data: 112.527046. For the data obtained from Google, namely LAT: -7.805493 and LONG: 112.527046, which is not too much of a change that is as significant as the GPS module with actual movement on Google Maps. So it is ensured that this gps module can be used properly and reliably when carrying out deboarding of ships.

c. Module testing HMC5883L

The results of the test of the HMC5883L module by changing the direction of the compass from 0°-360°For the data collection of the HMC5883L module with the comparison of the Compass on the smartphone, the data analysis and evaluation of the accuracy of the module HMC5883L the comparison with the Compass data on the smartphone can evaluate the performance of the HMC5883L module in the collection of compass data and ensure that the sensor provides accurate and reliable results.

d. Wind Direction Sensor And Wind Speed Sensor Testing

1) The results of the Wind Direction Sensor test with arduino provide information that the accuracy value of the wind direction sensor obtained by comparing the sensor measurement results with a standard measuring instrument. For example, if the sensor shows the direction of the wind from the east and the standard gauge also shows the same direction, then the sensor is considered accurate. The sensor can respond quickly to changes in wind direction in a matter

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of seconds and the sensor can provide consistent results even if environmental conditions change.

2) The results of the wind speed sensor test with arduino provide information that the accuracy value measured by the wind speed sensor by comparing the measurement results of the standard measurement sensor provides a reference value. For example, if a sensor measures a wind speed of 10 m/s and a standard measuring sensor shows the same value, then the sensor is considered accurate. This wind speed sensor can respond to wind speed quickly in a matter of seconds. In several trials, it can be concluded that the results obtained are quite consistent and show slight variations.

5. CONCLUSIONS AND SUGGESTIONS

5.1 Conclusion

From the results of the discussion in the previous chapter and based on the results of testing and analyzing how the design and build of the Navigation Sensor Integration System for KRI Docking Information series works, it can be concluded as follows:

a. Reading and recognizing navigation data from Lidar, GPS, gyro compass, wind direction, and wind speed sensors requires an understanding of how each sensor works and data formats, as well as the use of appropriate software or programming libraries to analyze the data. Here's how to read the data from each sensor:

1) Lidar: Measures distances using lasers and generates coordinate data from light reflections. Tests with a distance of 0.04 cm show an error of 0.75% due to environmental factors, while at a distance of 9 m an error of 0% due to favorable environmental conditions.

2) GPS: Provides geographic positions in the form of latitude and longitude coordinates with NMEA 0183 or NMEA 2000 data format. The test results showed data that matched Google Maps, with no significant changes.

3) Gyro Compass: Provides orientation information (heading) in degrees relative to north with NMEA data format. The test results show angles from 0° to 360°.

4) Wind Direction: Measures the direction of the wind with the output in degrees, using NMEA data formats such as $WIMDA or $WIMWV.

5) Wind Speed: Measures wind speed with output in knots or meters per second, using NMEA data formats such as $WIMWV.

b. To create a multiplexer that integrates data from various navigation sensors, such as Lidar, GPS, gyro compass, wind direction, and wind speed, it is necessary to understand how each sensor works and the data format, as well as the use of appropriate development platforms and programming libraries. Integration steps include:

1) Collect data from each sensor with different communication formats, such as UART, I2C, and SPI.

2) Using the Arduino Nano to process the data and transmit it through the CAN bus module.

3) The Arduino Mega2560 as a multiplexer will process and determine which data is displayed to the monitoring unit with serial output.

5.2 Suggestion

In this research, there are several things that can be developed in order to get more optimal results, including:

a. This research is limited to designing a tool as a Navigation Sensor Integration System for Floating Information KRI. For optimization, it is necessary to improve the specifications and quality of the sensors used by selecting high-quality and original sensors.

b. Currently, researchers use 5 types of sensors to help the process of undocking ships. Furthermore, it is necessary to add more significant sensors to support the KRI commander in the process.

c. The designed appliance has a weakness in the CAN bus module, which is susceptible to electromagnetic interference (EMI) and environmental noise. The module is optimal in undisturbed wired conditions and quiet environments, but is less suitable for moving or noisy conditions.

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