An Experimental Study of Infrastructure Configuration for Improving AIS Coverage Area

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Abstract. In 2002 the International Maritime Organization (IMO) issued Regulation 19 and Annex 17, which requires the Automatic Identification System (AIS) to be installed on every ship with a size of 300 gross tonnages and above. One potential use of AIS as an assistance for anti-collision devices. AIS is not only to be installed on the ship but also can be installed on the shore and act as a base station. Hence, the monitoring of vessel traffic can be done by this base station. Indonesia is an archipelagic country with more than 17,000 islands spread over the country and also known as the second longest coastline in the world at 108,000 km. This paper aims to give some ideas on the establishment of land-based monitoring system infrastructure in Indonesia. Main Base Station (MBS) is used for AIS data storage, AIS data integration and processing in the core while Remote Base Station (RBS) is used for receiving AIS data from ships and then sent to MBS. In general, RBS uses two antenna are omnidirectional and yagi directional, each antenna will connect the AIS receiver. According to this configuration, the coverage of MBS is limited to 100 km into the sea from land. To increase the coverage area, a modification was done by adding several types of antennas and applying into the MBS and RBS integration system. The modification shows that the number of RBS to be installed to cover the same coverage area can be reduced. The MBS and RBS integration are not only covered the Surabaya but also Rembang, Semarang, Cilacap, Cirebon, Jakarta and Cilegon. The result of integration is the total ship each day for almost North Java Island and one place in South Java Island is 507 ship and average ship each day is 240.

1. Introduction
Indonesia as a maritime and archipelago country numbering more than 17,000 islands. Indonesia as the country with the second longest coastline in the world is 108,000 km. Indonesia's geography is very strategically so that it has the potential to always be traversed by ships that sail from the Australian continent to the Asian continent. This potential can benefit Indonesia but there is a possibility of harming the sea and the shipping lanes of Indonesia, namely seizing of marine wealth and destruction as one of Indonesia's valuable assets. The possibility of a crime that occurred in Indonesian assets is divided into sectors - maritime security (piracy), marine safety (accident), blue
economy (illegal fishing), human security (human trafficking), and Seapower (terrorist acts) [1]. Marine Safety is being applied to ship shipping lanes in the Madura Strait, this is due to collisions between ships with other ships, that can occur along the shipping lanes up to the Port of Tanjung Perak. [2]. The incident was influenced by various factors, namely the negligence of the ship's crew, not updating the sea map, lack of experience of the narrow shipping lanes and the crew's lack of communication with the station operator so that they did not know which ship was headed at the same meeting point. Another accident, the ship that was moving towards the Port suddenly reduced the speed of the ship to stop, then lowered the anchor in the dangerous zone area that has the potential to damage marine properties such as platforms, oil and gas pipelines [3]. In that event, there is a possibility that the ship's anchor can damage the oil or gas pipeline by twisting or scratching or breaking the pipe so that oil or gas can come out of the pipe. In addition, when the ship increases the speed of the ship without knowing the visibility in front so that the ship can crash into objects in front because the ship does not have brakes like land vehicles, accidents that have occurred are platforms that were hit by ships in the Madura Strait. The application of Marine Safety in the Madura Strait continues to be researched and developed by utilizing technology that can send information related to the ship such as ship info, vessel position and other states to the station. Technology devices that can show the coordinates of the ship's position are Radar and Automatic Identification System (AIS). Radar can inform the coordinates of the ship's position, but cannot provide complete shipping information, if the weather is bad then Radar cannot function properly [4]. AIS technology device that can provide information on vessel information, the latest ship position, which is not affected by weather. AIS has become a mandatory technology device installed on all vessels over 300 tonnages based on regulation 19 and annex 17 by the International Marine Organization (IMO). This regulation must be implemented as an initial step to prevent collisions between ships and crew safety [5]. Although, IMO has issued mandatory regulations on the installation of AIS on ships, this is still not going well in Indonesia where most ships are not installed by AIS. Only in 2020, the Ministry of Maritime Affairs, through the Sea Transportation Office, has issued new regulations based on IMO regulations for all ships in Indonesia to install AIS and activate AIS [6]. Vessels that do not comply with this new regulation will be sanctioned so as to reduce violations and damage to Indonesian assets.

Based on the allocation of obtaining AIS data sources, it is divided into two, namely AIS Terrestrial obtains AIS data in the vicinity of stations or ports with limited area, while AIS Satellite obtains AIS data with wide area coverage according to the rotation of the Satellite around the earth [7]. AIS functions to monitor ship movements and the ship stops starting from stations or ports to entering and exiting shipping lanes (surveillance) [8] and prevent ships from colliding with other ships in the shipping lane (anti-collision) [9]. AIS Base Station (ABS) has the main functions of surveillance and anti-collision and then combined to improve the safety of the crew in a dense shipping lane so that the development of ABS further turns into a Vessel Traffic System (VTS) [10]. AIS data processing for VTS can be sourced from AIS Terrestrial and AIS Satellite but the use of AIS Satellite is preferred because of the ease of obtaining AIS data based on the location needed to monitor the ship's shipping flow [11]. The disadvantages of AIS Satellite are that it doesn't require a small amount of money and the AIS data received is not real-time, but compared to AIS Terrestrial, AIS data is obtained in real time but is limited. Further development of AIS Terrestrial is carried out to expand strategic and economic areas compared to AIS Satellite. Main Base Station (MBS) is a Terrestrial-based AIS Base Station that has been developed based on frequent damage to marine property in the Madura Strait region. Although, Satellite-based ABS has added AIS Satellite namely Lapan A2 and A3 to increase AIS data reception, but that is still not enough when compared to AIS-based Terrestrial MBS-based data received in real time. The MBS section consists of web systems, mobile applications, antennas, cables, towers and data centers, internet and electricity [12]. Early Warning System (EWS) is the main function of the MBS which is developed based on the prevention and protection of marine properties when the ship decreases speed and stops potentially dropping anchors in the danger zone in the Madura Strait. The main function can only be used in the area around Surabaya and half the island of
Madura so that other areas have not been reached. The SBM allocation is within the campus area of the Ten November Institute of Surabaya (ITS).

The MBS coverage area is still limited, but there are still opportunities to expand the coverage area even though it is not as wide as ABS based on Satellite. One way to expand is to install MBS in the area closest to or right in a dangerous zone, but not economically. Alternatively, Mobile Station can be used to receive AIS data from ships and then send AIS data to MBS via the Internet [13]. The Mobile Station sends the results of processing AIS Data to MBS, but the developed MBS only accepts raw AIS messages. The concept of Mobile Station is used to develop new stations, namely integration between stations by using the internet. Remote Base Station (RBS) is a station with minimalist infrastructure that functions to connect to the MBS and send Raw AIS messages from the nearest ship and then send directly to MBS. Remote Base Station (RBS) is installed patent and is close to the dangerous zone and then continuously receives the ship's signal after it sends Raw AIS Message to MBS. RBS has the advantage of being a small packet sent according to the size of the Short Message Sent (SMS) and the time required is only one second per message. RBS infrastructure can be used in other regions and not only that RBS can be modified according to regional conditions. Until now RBS that has been installed is in Surabaya and other cities, namely Jakarta, Semarang, Cilacap, Rembang, Cirebon and Cilegon. The integration of RBS with MBS can increase the coverage of AIS Terrestrial-based ABS regions.

2. Methodology
2.1. Automatic Identification System (AIS)

The International Marine Organization (IMO) designs safety and security regulations for shipping and prevention of nuisance at sea and pollution caused by ships [14]. AIS can be operated by adjusting the frequency with a size from 161.975 to 162.025 MHz or using a Channel that is 87B - 88B. The raw format of AIS message uses AIVDMA / AIVDO which consists of two data types, namely Static Data and Dynamic Table 1.

| Static                        | Dynamic                        |
|-------------------------------|--------------------------------|
| Name And Call Sign Ship       | Course Over Ground (COG)       |
| Mmsi (Mobile Service Identity) Number | Speed Over Ground (SOG)       |
| Imo Number                    | Position Vessel (Latitude and Longitude) |
| Type Of Ship                  | Heading                        |
| Dimension                     | Rate of Turn (ROT)             |

Vessels that are required to install AIS are divided into two types, namely Class A and B. Vessels classified as Class A such as Tanker Ship, Bulk Carrier, Container Ship, Passenger or Voyager Ship and ships above 300 tonnages. Vessels classified in Class B are ships that have special functions, using relatively few sources of strength, such as Tug Boat, Pilot Crafts, Cable Layers, Research Vessels and other ships that have special functions [15]. Static data is information that must be filled when first installing AIS on a ship while dynamic data is data that is always changing by the movement or stopping of the ship. Raw AIS messages on every ship are sent every six seconds, but, can change to every two seconds when the ship will turn or maneuver, one example of a ship that sends raw AIS messages every two seconds is a tanker. AIS is included in portable devices and sensors that can notify the position and information of the ship so that AIS can be integrated with other systems. AIS Receiver has an advantage over other devices, namely AIS can send signals to from 1-3 ships near the ship. The signal can be received by AIS Antenna so that the position of 1-3 ships can be obtained by the AIS Receiver.
Antenna AIS uses an antenna that is straight like a pipe and long. Omni Directional is a special AIS Anna Marine VHF. AIS antennas are connected to AIS Transponder ships using coaxial cable. AIS Receiver at AIS Base Station applies the same thing as a ship, only there is a computer or server that serves to translate the raw AIS message. The results of the message translation are used to analyze the ship's movement patterns.

2.2. Infrastructure AIS Base Station (IABS)

The construction of terrestrial-based ABS infrastructure is close to the Port which aims to facilitate the receipt and delivery of raw AIS message messages and then display them on the monitor screen. Vessel Tracking System (VTS) is a Terrestrial or Satellite-based ABS and has been implemented at major ports in Indonesia. VTS were developed specifically to monitor the density of shipping lines and notification of ships to stop at the parking zone (surveillance) [16]. In addition, Notification to the ship's captain by the station operator aims to move the ship to a new coordinate that is not opposite to the ship in front of the ship, so there is no collision between ships (anti-collision) [17]. In the Madura Strait there are various marine properties such as oil, gas pipes, platforms and electric cables or fiber cables (internet). VTS uses the ship's perspective as a monitoring target while the marine property is not monitored so a system that can monitor ships and sea property is needed.

This terrestrial-based ABS has gone through extensive research, development and installed at the Nasdec Building of the Ten November Institute of Technology (ITS). Terrestrial-based ABS has three main functions are Early Warning System (EWS), Inspection Score (IS) dan Vessel Tracking (VT). EWS has functioned to notify the station operator to always be alert to conditions around dangerous zones such as decreasing or increasing the speed of the ship drastically, stopping the ship abruptly without apparent cause and effect, lowering the anchor intentionally or unintentionally [18]. The IS was developed to inspect ships by making decisions based on the age of the expired ship, class of ship, MMSI and the name of the ship [19]. VT was developed to trace the coordinates that have been passed by the ship [20]. VTS only focus on the density of the movement of the port, shipping lanes while the EWS focuses on stopping movement and decreases the speed of ships around or right in the area of underwater property, especially those in the shipping lanes. Terrestrial-based ABS has been supported by Artificial Intelligence (AI) which is used to predict empty ship's Heading using Artificial Neural Network Wide Genetic Algorithm (ANN-WGA) [21], predict collisions between ships with Fuzzy [22] and predicting a meeting point that allows the location of the ship's intersection in the shipping lane [23].

Terrestrial-based ABS infrastructure needs consist of AIS Devices, buildings, towers, antennas, power sources, technology and the internet. The AIS Device must be installed in the operator's room IE AIS Receiver Class A or B type while the AIS Transponder ship must be in accordance with the size and type of the ship. The building has a room according to the standard monitoring room and data center. Tower as an antenna installation with a minimum height of 30 m. The antenna needed is a special marine antenna with VHF signal 161 - 162 Mhz. Power sources needed include monitoring room and data center. The technology used must be able to support the system performance and features of terrestrial-based ABS. There are two basic needs, namely server and internet. The server consists of monitoring server, database server, backup server, server system. The internet must not be broken and bandwidth must be separate from general needs. The construction of terrestrial-based ABS is connected to each other from antennas, cables, servers and monitors. If there are problems with terrestrial-based ABS, you should check end to end to find the damage. Terrestrial-based ABS focuses on one location and AIS data is stored in a data format based on the system. Other terrestrial-based ABSs may not be able to read AIS data because of different formats.

3. Proposed Method

3.1. Main Base Station (MBS)
Terrestrial-based ABS was upgraded to Main Base Station (MBS) to broaden the scope of the ship's movement and to obtain AIS data outside of Surabaya. MBS can be installed in other regions, but it is not economical. The MBS infrastructure was developed as a small-scale Data Center for data storage. The installation of MBS at each point of the shipping lane in the northern part of the island of Java and the south of the island of Java is inappropriate. The station needed is a station that can send AIS data using the internet [24]. The AIS data that is sent is not the result of translation or addition, data on the MBS, but rather the raw AIS Message that will be sent to the Data Center for storage and then translated. Continuation of the process is used by the three main and supporting functions, namely EWS, IS, VT and AI. The system will be displayed in the monitor room and mobile application.

3.2. Remote Base Station (RBS)

Stations developed to obtain stationary ship signals such as drones are used to capture ship movements and are sent to other stations [25]. This station must have a patent installed and has a wide area to the sea. This station implements minimalist infrastructure. Remote Base Station (RBS) is made with the simple necessity of not storing AIS data, but directly sending raw AIS messages directly to MBS. RBS must be connected to the internet and especially must have a stable power source so that it does not interfere with the performance of the AIS Receiver to receive raw AIS messages. The design of MBS and RBS integration is shown in Figure 1.

![Figure 1. System Architecture Main and Remote Base Station](image)

MBS consists of a Web Server to set the server, Traffic Server Status to see the status of the server that is on MBS and RBS - RBS, Application Server to open the system and display in to monitor. The Master Database and the 2 Slave Databases as a place to store raw AIS messages and translate into a database, Storage Server to store the analysis of AIS data and Scientific Solver are a combination of Artificial Intelligence combination to analyze the results of translating raw AIS messages and then become new AIS data. RBS consists of two original AIS antennas namely Omni Directional while the second Antenna is Custom Antenna, Yagi Directional. This antenna has a different scope with Omni Directional which is circular while Yagi Directional is conical according to the direction. Both of antennas can complement the Omni Directional shortcomings which cannot be blocked by thick objects while the Yagi Directional gets the ship's movement in a straightforward way. The cable length used corresponds to the tower height of the antenna to the Outer Distribution Cabinet (ODC).

The ODC includes AIS Receiver raw AIS message receiver, Switch Hub for connecting Receiver with the Mini Computer, Power Supply for power source, Fiber Optic Media Converter to internet cable and Mini Computer for connecting RBS to MBS and a place for software installation. AISUdpcast functions to read raw AIS messages and send raw AIS to MBS. Following this, the experimental architecture design for the northern part of Java and South Java is shown in Figure 2.
Figure 2. Configuration Infrastructure MBS and RBS Java Island.

The configuration used to carry out the MBS and RBS infrastructure configuration experiments are shown in tables 2 - 8. Each location almost applies a different configuration because the location for station installation is not high enough. The configuration of infrastructure in the Surabaya part of MBS and RBS is shown in Table 2.

Table 2. Configuration Infrastructure MBS and RBS Surabaya

| STATION COVERAGE AREA | LOCATION | CONFIGURATION | ITEM | UNIT |
|-----------------------|----------|---------------|------|------|
| **MBS SURABAYA**      | Coverage Area | 150 km | VHF | 1 |
|                       | Omni     | 1            | Omnidirectional | 1 |
|                       | Building Office | 30 m | AIS Receiver | 1 |
|                       | Nasdec ITS | 30 m | 1 |
|                       | Small Tower | 5 m | AIS udpcast | 1 |
|                       | Total MBS Building | 35 m | Switch Hub | 1 |
|                       | Coverage Area | 160 km | VHF Yagi 9 element | 1 |
|                       | Yagi West | 1            | 1 |
|                       | Coverage Area | 350 km | VHF Yagi 11 element | 1 |
|                       | Yagi East Building | 60 m | AIS Receiver | 2 |
|                       | Nasdec ITS | 60 m | 1 |
|                       | Small Tower West | 5 m | AIS udpcast | 1 |
|                       | Small Tower East | 10 m | Switch Hub | 1 |
|                       | Total RBS West / East | 65 m / 70 m | Power Supply | 1 |
|                       |  | Media Converter | 1 |
|                       |  | Fiber Optik | 1 |
|                       |  | Wife Lite Beam | 1 |

Nasdec ITS Building is not too high and there is a wall on the roof of the Building. The wall of name Nasdec Billboard can be used to lean against iron pipes instead of towers. On the side of the iron pipe will be associated with an iron sling on the roof.
This was done to increase the area coverage to obtain the movement of ships to the bottom of Bawean Island on the Map. MBS and RBS use fiber optic cable for the internet and if the internet is broken, then MBS can use the Wifi light beam as an alternative connection to RBS.

RBS Surabaya aims to cover more remote areas than SBM. RBS implements two Antenna are Yagi Directional elements 11 and 4 that are made specifically with different elements to obtain more extensive area coverage than the Omni Directional Antenna. There are two locations that are aimed at the North West and East. The Northwest location is the entrance to the Madura Strait and at that location there are platforms and oil pipelines. Eastern location is a location that is not too dense like the Madura Strait, but in the southern part of measure there is an oil and gas pipeline connected from Surabaya to Kangean Island. In addition, the eastern part is the location of passenger ship shipping lines from Bali to coastal cities in East Java such as Probolinggo, Situbondo, and Banyuwangi. This design was made to obtain the movement of ships in dangerous zones, namely oil and gas installation pipes that pass through the shipping lanes.

RBS installation must not be moved - moved and not disturbed by other devices. Bali Tower Sentra Indonesia (BTS) collaborates with ITS for tower utilization as research. The location of the tower installation is approximately 5-10 km to the north in the sea. The tower is included with ODC. BTS Tower can be used for RBS installation. Although, the Tower is not too high only 20 m but the Tower location is quite strategically close to the sea, so that it can be used to obtain ship movement.

Table 3. shows the configuration of RBS and Semarang RBS infrastructure. The antenna used is only Omni Directional, because there is no barrier to tall buildings near RBS Tower in Rembang and Semarang.

| STATION COVERAGE AREA | LOCATION | CONFIGURATION | ITEM | UNIT |
|-----------------------|----------|---------------|------|------|
| **RBS REMBANG**<br>(FIGURE 4.) | Coverage Area | 30 km | VHF | 2 |
| | Omni | | Omnidirectional | |
| | **BTS Tower** | 20 m | AIS Receiver | 2 |
| **RBS SEMARANG**<br>(FIGURE 5.) | Coverage Area | 30 km | AIS udpcast | 2 |
| | Omni | | | |
| | **BTS Tower** | 20 m | Switch Hub | 2 |
| | | | Power Supply | 2 |
Approximately the distance obtained from the BTS Tower to the sea for about 30 km is shown in Figure 4a. RBS Rembang (right) and Figure 4b. RBS Semarang. Based on Figure 4b, RBS Semarang only gets moved in the shipping lanes in and out of Semarang. The shipping route of the ship that passed from Rembang to West Java was cut off because the range was too far from RBS Semarang because the tower was still not high enough.

![Figure 4. Configuration Coverage Area a. RBS Rembang (Right) b. RBS Semarang (Left)](image)

The configuration of the RBS infrastructure in Cirebon and Cilacap is shown in Table 4. The height of the BTS tower is unlike other towers so that no other antennas are installed on the BTS tower except the Wifi Lite Beam used to connect the internet and the BTS tower is included with fiber optic cable so that the internet connection has two alternatives Wifi Lite Beam and fiber optic cable. The northern and eastern parts of RBS Cirebon have oil pipelines installed so that the EWS can be used to monitor ships that stop or slow down in dangerous zones.

![Table 4. Configuration Infrastructure RBS Cirebon and Cilacap](image)

The coverage area of RBS Cirebon and Cilacap are approximately the same, which is 30 km shown in Figure 5a RBS Cirebon and Figure 5b RBS Cilacap. If the northern part of Java uses optical fiber and Wifi Lite Beam, while RBS Cilacap has not used a Wifi Lite Beam and GSM. The RBS Cilacap connection is likely to be unstable compared to the BTS Tower in the northern part of Java.
The Configuration Infrastructure of RBS Jakarta and Cilegon is shown in Table 5. Installing RBS Jakarta is too difficult because the location of the BTS tower is right in front of the shop with the same height as the BTS Tower. Not only that, buildings in Jakarta are dense enough so that omni directional antennas can obtain ship movements. Alternatively, the Jakarta RBS Installation is shown on the roof of a skyscraper that is quite high. RBS Jakarta is divided into 3 antennas, namely 1 Omni Directional and 2 Yagi Directional. Although, the installation is on the roof of a skyscraper, but the location is in the middle of the city so that the Omni Directional Radius is affected by the skyscraper in front even though the distance between buildings is not too close. Yagi Directional is not affected by tall skyscrapers, because Yagi Directional is directed right to the sea.

Table 5. Configuration Infrastructure RBS Jakarta

| STATION COVERAGE AREA | LOCATION | METRIC | ITEM | UNIT |
|-----------------------|----------|--------|------|------|
| **RBS JAKARTA (FIGURE 6.)** | Coverage Area Yagi | 150 km | VHF Yagi Directional 7 element | 2 |
| | Coverage Area Omni | 100 km | VHF Omni Directional | 1 |
| | Rooftop Building Office Jakarta | 120 m | AIS Receiver | 3 |
| | Small Tower | 5 m | AIS udpcast | 1 |
| | | | Switch Hub | 1 |
| | | | Power Supply | 1 |
| **RBS CILEGON (FIGURE 6.)** | Coverage Area Omni | 25 km | VHF Omnidirectional | 1 |
| | Small Building Monitoring Steel Pipe | 15 m | AIS Receiver | 1 |
| | | | AIS udpcast | 1 |
| | | | Switch Hub | 1 |
| | | | Power Supply | 1 |

Figure 5. Configuration Coverage Area a. RBS Cirebon (Right) b. RBS Cilacap (Left)
The area covered for RBS Jakarta using three antennas is shown in Figure 6. Based on Table 5, RBS Cilegon uses a tower owned by PT Krakatau Bandar Samudra (KBS). The coverage area of RBS Cilegon is shortest when compared to other RBS towers. The building provided by KBS is not highest is only at 15 km. Although, the allocation of the building is near the sea, but the Omni Directional radius is not far enough like RBS Surabaya or other RBS that use BTS towers. The coverage of the Cilegon RBS area is shown in Figure 6.

![Figure 6. Configuration RBS Jakarta and Cilegon Coverage Area](image)

### 4. Result

Based on the experimental configuration of the infrastructure table 2-5 which has been implemented into the integration of MBS and RBS almost all parts of Java and Madura. Table 6 shows the total number of ships and the average number of ships passing a day in the northern and southern parts of Madura Island.

| No | City    | Number of Ships in a Day | Total Number of Ship | Average number of Ship |
|----|---------|--------------------------|----------------------|------------------------|
|    |         | MBS Omni Directional     | RBS Omni Directional | RBS Yagi Directional   |                       |
|    |         | North West | East | Northeast |                       |                       |
| 1  | Surabaya^2nd | 100        | -    | 30      | 50    | -                      | 180                  | 60                        |
| 2  | Rembang  | -          | 15   | -       | -     | 15                     |                       | 15                        |
| 3  | Semarang | -          | 37   | -       | -     | 37                     |                       | 37                        |
| 4  | Cirebon  | -          | 30   | -       | -     | 30                     |                       | 30                        |
| 5  | Cilegon  | -          | 10   | -       | -     | 10                     |                       | 10                        |
| 6  | Jakarta^rd | 60        | 80   | -       | 80    | 220                    | 73                    |                            |
| 7  | Cilacap  | -          | 15   | -       | -     | 15                     | 15                    |                            |
|    |         |            |      |         |       | **607**                | **240**               |                            |
The first rank of the city with the highest number of ships and highest average is Jakarta and the second is Surabaya. RBS Jakarta Infrastructure utilizes the roof of the Building with a height of 120 meters for Omni Directional and adds a tower with a height of 5 meters as an additional tower for Yagi Directional. Weaknesses at Omni Directional do not get AIS signals because they are blocked by skyscrapers in Jakarta, because the allocation of RBS installations is in the middle of the city. The result of Omni Directional is used in the Jakarta are 40 ship each day less than Surabaya. Yagi Directional is used to cover areas not covered by Omni Directional from Northeast and North West each Yagi Directional are given 80 ship each day. Even thought, The Omni Directional in Jakarta is not better than Surabaya, but Jakarta is still the first place in Indonesia than Surabaya is ranking two. Although the number of ships in a day with Omni Directional is more than Jakarta because there is no building in the way. Surabaya is still inferior to Jakarta, the majority of which all types of ships lean to unload goods and sail at Jakarta Ports.

A visualization map of the SBM and RBS Integration System from Surabaya, Rembang, Semarang, Cirebon, Cilacap, Jakarta to Cilegon is shown in Figure 7. On the map shows the position of ships and sea properties (green and red lines). The southern part of Java Island is difficult to pass because of extreme sea wave height and is difficult to predict while the northern part of Java becomes the main shipping channel that is always passed by all types of ships.

![Map of SBM and RBS Integration System](image)

**Figure 7. Result Experimental Installation Configuration Infrastructure Modification MBS and RBS**

The integration of MBS and RBS proves ABS base of AIS terrestrial can be on a level of scope and economical compared to ABS based on Satellite. In addition, MBS will store raw AIS Messages as historical AIS data so that it can be used for analysis, such as illegal fishing, shipwrecks, transshipment and other events that could endanger the safety of the crew and marine property. As long as RBS continues to send raw AIS messages to MBS, the three basic functions of MBS can estimate events at that location. Internet connection and large and small bandwidths affect the process of sending raw AIS messages so that the internet network used is a special line and other users cannot use other Internet.

**5. Conclusions**

The results of the configuration of the MBS and RBS infrastructure experiments is able to AIS data integration and AIS data storage between all of RBS. The MBS and RBS integrated can monitor the movement or stopping of ships in the North and South of Java Island event only half of Java has been covered. The total number of ships per day is 507 ships and the average number of ships per day is 240 ships in Java Islands. Although, the integration of MBS and RBS succeeded in connecting distant locations, but regulations from IMO were not implemented properly by the ship's authorities. The
The scope of integration of MBS and RBS is not efficient enough to monitor ship movements or stopping. The Sea Transportation Office has continued the IMO regulation by issuing. The integration of MBS and RBS only monitors the shipping lanes of the northern and southern parts of the island of Java, which are not too comprehensive, so there is still an opportunity to increase RBS by modifying infrastructure parts such as antennas, towers, systems, power sources, energy and integration between RBS.

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