Maritime Aerial Surveillance: Integration Manual Identification System to Automatic Identification System

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Abstract. Indonesia has an almost 100,000 km coastline with a very busy shipping and maritime activity. To regulate ship traffic, the government relies on Vessel Traffic Service (VTS) and Automatic Identification System (AIS). VTS functions like Air Traffic Control (ATC) in commercial flight traffic control, which relies on radio conversations to communicate between VTS officers and the ship's captain. While AIS uses transponders mounted on ships to send ship position data which are then displayed virtually in the form of ship icons. However, both VTS and AIS do not display the real picture of the ship’s description. VTS, AIS Receiver and Electronic Chart Display Information System (ECDIS) only presented the ship's movement through radio voice and the ship's icon on the monitor. With Reporting Interval from 2 seconds until 180 seconds. It is because AIS is designated to send data every 2 – 180 seconds depending on vessel moving status. But within the reporting interval 180 seconds, the condition of the ship can change a lot. This is the motivation of this paper was written to propose monitoring vessel traffic through an aerial flying camera that can monitor real ships with cinematic class video quality in real-time because the video latency can be achieved faster than 10 milliseconds. The research is conduct by simultaneous monitoring the marine traffic through web and launching the flying camera at the same time and place. And the results is very surpris, because many ship found not AIS detected compare to flying camera results video.

1. Introduction
In the period from 2010 to 2016 recorded about 300 people died in Indonesian waters (KNKT, 2016). Which fires dominate the cause of the accident, followed by collisions and sinking. The cause of this accident can certainly be predicted and prevented because it contains elements of negligence and violations of discipline in complying with safety regulations on board. In the case of the Lintas Bahari 8 vessel fire at Gudang Mataso Juruju jetty in Pontianak, May 2018, the cause was a sparks of grinders during the repair of the ship fence. The sparks were not protected until they were release to the engine room and triggered fires. This kind of trivial cause is certainly the result of predictable and preventable carelessness.
Table 1. Cause of Accident Chart (KNKT, 2016)

| Cause of Accident | Count |
|-------------------|-------|
| Fire              | 35    |
| Collision         | 34    |
| Sink              | 21    |
| Grounded          | 6     |
| Other             | 4     |

While ship collisions that occupy two ranks are actually predictable and prevented. In Surabaya the ship line is very narrow with around 100 meters wide. Therefore, the ships traffic management and coordination between ships and port authority in this area should be strictly.

Figure 1. Surabaya West Access Channel (SWAC) (Source : Peta Laut No. 96a, Dishidros TNI AL)

At present day, there are several systems for monitoring ship traffic. Vessel Traffic Service (VTS), Automatic Identification System (AIS), Radar, Long Range Identification Tracker (LRIT), and Voyage Data Recorder (VDR) which this equipment equivalent to a black box on an airplane that is useful for accident investigations.

AIS is a transponder (VHF transmitter) equipment installed on a ship that functions to send ship identification and vessel position to other ships and port authorities automatically, without operator intervention.

2. The Existing Application Automatic Identification System Analys

Automatic Identification System transmitter installed on the vessels and AIS receiver installed at the port or ground station. AIS data sent from vessel are 168 bits, then processed and presented in the Electronic Chart Display Information System (ECDIS) / Electronic Navigation Chart (SENC) or
Electronic Navigation Chart (ENC). Furthermore sent to the web like marine traffic, vessel tracker etc. So the range of monitoring is worldwide.

Figure 2. AIS transmitting illustration. (Source:http://www.vtexplorer.com/what-is-ais/)

Figure 3. The AIS equipment illustration. (Source:http://www.vtexplorer.com/what-is-ais/)

When the position of the ship is vanish to the eye because it is swallowed by horizon, it means that AIS is outside from the range of the VHF wave. And then the AIS signal will be received by the satellite. So that ships sailing in the oceans far from ports can still be monitored. Indonesia has two satellites to receive AIS data. LAPAN A2 with equatorial orbit as high as 642 Km and LAPAN A3 with polar orbit as high as 500 Km. Almost all regions of Indonesia can be monitored by these two satellites.

| System               | Installation | Range      | Media       |
|----------------------|--------------|------------|-------------|
| VTS Radio            | Base Station | VHF 40 nM  | Voice       |
| Vessel Radio         | Vessel       | VHF 40 nM  | Voice       |
| AIS Receiver         | Base Station | VHF 40 nM  | Satellite   |
| ECDIS/SENC/ENC       |              |            | Graphic     |
| AIS Transmitter      | Vessel Onboard| VHF 40 nM Satellite | Radio Wave |
| Vessel Radio         | Vessel Onboard| VHF 40 nM | Radio Voice |
| Satellite            | Orbit        | World      | Radio Voice |
| Web Service          | Base Station | World Wide Web | Graphic |

The range of AIS signal from on ships transmitted with omnidirectional antennas in all directions reaches a radius of around 40 nautical miles. Limited to the line of sight. Using Very High Frequency Frequencies (VHF) 161.975 MHz and 162.025 MHz with a wavelength (lambda) of two meters. Which means in principle that the antenna used must be a multiple of two meters in a vertical position. So it is not practical to be installed in small vessels. If the antenna length is shortened like Handy Talk, the reception and transmission range will be decrease dramatically.

| Static Information | Dynamic Information |
|--------------------|---------------------|
| Identification     | Position            |
| MMSI Number        |                     |
| Name of Ship       | Time UTC (seconds)  |
| Type of Ship       | Course over Ground (SOG) |
| Call Sign          | Speed over Ground (COG) |
| Ship Dimension     | True Heading        |
Reporting Interval (RI) is the time interval for sending reports. Based on the recommendation of the International Telecommunication Union ITU-R M.1371-5 (02/2014), RI ranges from 2 seconds up to 180 seconds, depending on the ship's activities. For ships that are stopping then the interval is every 180 seconds. As for ships that move at speeds of 23 Knots or 11.8 meters per second, the intervals are every 6 seconds. In interval of 6 seconds the ship had changed position as far as 70 meters. This RI recommendation is determined to save bandwidth. Because the amount of data sent must be stored, but the memory capacity is not unlimited. This is the typical problem that always arises over surveillance issues. Namely data storage. Who, where and how long time the history data will be stored.

| Transponder Class | Vessel's Speed (Knots) | Status          | Transmission Rate (seconds) |
|-------------------|------------------------|-----------------|-----------------------------|
| A                 | 0                      | Anchoring       | 180                         |
| A                 | 0 – 14                 | Sailing         | 10                          |
| A                 | 14 – 23                | Sailing         | 6                           |
| A                 | 0 – 14                 | changing course | 3.33                        |
| A                 | 14 – 23                | Changing course | 2                           |
| A                 | >23                    | sailing         | 2                           |
| A                 | >23                    | Changing course | 2                           |
| B                 | 0 - 2                  | stopped         | 180                         |
| B                 | >2                     | sailing         | 30                          |

According to Lloyd’s List Intelligence there are several benefits of AIS for vessels monitoring, but each system has unique limitations. For AIS the drawbacks are the limitations of VHF range about 30 mils and degradation of data quality processed by satellite.

| Features                      | Drawbacks                                                                 |
|-------------------------------|---------------------------------------------------------------------------|
| 1 AIS use VHF.               | 20 – 30 mil range                                                         |
| 2 Designated for local and small number of vessels. | Many vessels cause interference.                                           |
| 3 MMSI not IMO Number.       | MMSI can relocate to another vessel. Vessel can show 2 locations. Spoofing. |
| 4 VHF can detect by Satellite. | Less granular data vessel position.                                      |
| 5 Self transmitting, self receiving. | Open to data GPS manipulation. Can turn off manually. No maritime data provider can offer completely always on AIS network. |
| 6 Suspectable to technical malfunction. | Relies on constant power supply and internet connection. |

Source: Understanding AIS Lloyd’s List Intelligence 2017

This statement below quote from Lloyd Intelligence:

“Relying on AIS alone risks inaccurate information and confusion due to technical limitations, ease of manipulation or insufficient human intelligence and verification. It is vital that AIS is analysed in conjunction with other information sources, especially on the ground human intelligence, such as port agents. Without this, insurers, financial institutions and others relying on this data to make commercial and security decisions will not have an accurate picture of vessel movements on the water.”
AIS data provides a wealth of information, but has many inherent data issues. Some of these issues include data overload to satellites, vessel operators intentionally switching off equipment, and errors in reported speed and time stamp.

AIS information gives an abundance of data, yet has numerous intrinsic information issues. Some of these issues incorporate information over-burden to satellites, vessel administrators purposefully turning off hardware, and mistakes in detailed speed and time stamp [10].

AIS data received by Satellite LAPAN-A2 on average per day in the period of November 2017 to October 2018 were 1,730,868 data. While the LAPAN-A3 Satellite data averages 1,009,477 data. Data damage that occurred was 59.5% for LAPAN-A2 Satellite and 56.1% LAPAN-A3 Satellite. The data correction that was successfully validated using interpolation and extrapolation methods reached 22.6% for LAPAN-A2 Satellite and 20.8% for LAPAN Satellite -A3 [3].

3. The Literature of Drones on Maritime Operations.
In 2019 Malaysia acquisition of 12 drones BOEING Scan Eagle from USA for Maritime Security Initiative program for Southeast Asia surveillance, especially Malacca Strait and South China Sea. Fully funded by USA worth almost US$ 40 Million. The capability of BOEING Scan Eagle about 4500 meter altitude and 24 hours flight time, Figure 4.

![Figure 4](https://www.boeing.com/history/products/scaneagle-unmanned-aerial-vehicle.page)

In 2016, the European Space Agency (ESA) and the European Maritime Safety Agency (EMSA) choose the AR5 Life Ray TEKEVER drone for maritime surveillance system where drones are integral to operations over the Maltese waters of the Mediterranean, Figure 5.

![Figure 5](Photo credit: TEKEVER)

Actually there are still many literature which utilize drone on maritime operation at the present day. But the interesting question is when the first drone utilize in the past day? Martin Stopford in the Maritime Economics revealed the golden era of sea trade in Mesopotamia since 5,000 years ago. This mean the era before Noah flood. As known Noah release dove and raven for maritime navigation. But the story of Noah did not alone. There is another story named The Epic of Gilgamesh who act like Noah for maritime navigation using bird released from vessel.
4. Objectives of Integrated Automatic Identification System (AIS) and Flying Camera Manual Identification System (MIS)

With some limitations of the AIS and radio conversations, the use of flying camera or drones can complement these limitations. The advantage of drone is the real picture of ship in almost real time with video latency less than 10 milliseconds. The drone is an aerial vehicle that is equipped with a high quality camera. For still image quality up to 12 MP while for video up to 4K. Drone flying distances can reach 30 Km and altitudes up to 1000 meters with 30 minutes flight duration. But is depend on the battery and signal strength. Even though the drone many autonomous system like autopilot, auto return to home, auto take off and auto landing, but the control still need human interaction. Especially for identification of the ships, controlling the drone to pursuit the ships position and capture video or image, skill and trained pilot are necessary. Therefore for this system called as Manual Identification System.

5. Simultaneous AIS monitoring with drone surveillance

The research conduct at Kamal Lama Port Madura Island on May 24, 2020 16:00. With monitoring the marine traffic and launching the drone simultaneous. Location monitoring from marine traffic selected to Madura and Surabaya waters area. At the same time the drone take off from Kamal Lama Port, for surveillance to waters port area Figure 9.
At the moment the marine traffic shown several icon of vessels based on AIS, Figure 10. At the same time the video capture the real picture of vessels at the same location displayed at marine traffic, Figure 11.

Furthermore, marine traffic shown to the east side which no AIS ship detected Figure 12. Interestingly, contradictive to the real fact which many vessels seen by flying camera, including at the port, Figure 13.
Figure 12. From marine traffic show at the right side, there is no AIS ship icon detected. (https://www.marinetraffic.com/ May 24, 2020 16:30)

Figure 13. More than ten ships have no AIS detected but visual detected, at the same location and time from Figure 12. (Author property May 24, 2020 16:30)

For sample identification, a ship is chosen which not AIS detected at marine traffic, Figure 14. And then the drone flying approaching to the ships to capture the ship identity. And the results is BUKIT PATUNG JAKARTA with Indonesia flag, Figure 15. The time required for ship identification by drone is depending to the distance from port to the ships. Drone flying speed can reach 40 Km/hour. But during flying, the video from drone send to the ground station almost real time.

Figure 14. This ship chosen for identification sample. (Author property May 24, 2020 16:32)

Figure 15. The name and flag ship identified by drone flying to the ships. (Author property May 24, 2020 16:34)

After find the ship name then looking up for ships information from marine traffic data base, Figure 16. The result is KM BUKIT PATUNG last position at Bali Strait at April 30, 2020 13:00 UTC, Figure 17.
Figure 16. Looking Up for the ship information based on the ship name at marine traffic data base. (https://www.marinetraffic.com/ May 24, 2020 16:40)

Figure 17. The latest position of the ship located at Bali Strait. 300 Km from current location. (https://www.marinetraffic.com/ May 24, 2020 16:40)

This finding concludes that the AIS of KM Bukit Patung ships already off since April 30, 2020 13:00 UTC or 24 day before this research day May 24, 2020, at Bali Strait or 300 Km from current location. But the cause can be the data corrupt received by satellite (Abdul Karim, 2018), vessels density at the waters or even intentionally switch off the AIS device (Jessica H. Ford, 2018).

6. More Advantage of Manual Identification System

Drone with high quality camera is very powerful to conduct maritime activity surveillance. Drone can capture live video for maritime activity like ferry inter island crossing, sea crossing by road bridge, vessel scrapping for example. Effective for SAR operation, to understand the disaster condition before send SAR team. Moreover drone can surveillance the illegal activity, like illegal fishing, illegal refugee, pirate, marine pollution and surveillance for counter terrorism.

Figure 18. Maritime Traffic Surveillance at Surabaya West Access Channel. (Author property Feb 12, 2020)

Figure 19. Sea crossing activity at Suramadu Bridge. (Author property Dec 8, 2019)
Figure 20. Port activity surveillance Tanjung Perak Surabaya. (Author property Nov 29, 2019)

Figure 21. Vessel scrapping activity Madura Island. (Author property Feb 8, 2020)

Figure 22. Marine pollution at Vessel Scrapping Industry Madura Island. (Author property Nov 27, 2019)

Figure 23. Marine Pollution from Tambak Wedi River. (Author property Dec 8, 2019)

Figure 24. Marine Pollution at Kamal Lama Port Madura Island. (Author property Feb 12, 2020)

Figure 25. Marine Pollution at Kamal Lama Port Madura Island. (Author property Feb 12, 2020)
Figure 26. Marine Pilot activity at Sembilahan Madura Strait. (Author property Feb 8, 2020)

Figure 27. IMO Number identification at Scrapping Industry Madura Island. (Author property Nov 27, 2019)

Figure 28. Ferry Joko Tole inter island crossing surveillance at night. Author property Feb 8, 2020)

Figure 29. Ship deck activity surveillance. (Author property May 24, 2020)

Conclusion
Each system has advantage and weakness. With the advantage of drone and integrated with AIS technology we can manage the vessel traffic with high accuracy. To complement each other. AIS has the advantage of vessel ID and GPS location information sent from vessel. While the drone cannot read the gps location of the ship being monitoring, because it doesn't have AIS receiver.

However, AIS has a disadvantage due to the data received by Satellite LAPAN A2 suffered almost 60% damage. (Abdul Karim et al, 2019). In addition, the effect of dense ship population can affect the quality of AIS data (Jessica, 2018). Since the Reporting Interval which ranges from 2 to 180 seconds makes the AIS system cannot be said to be real time as well as videos obtained by drones. With drones we can compared AIS data sent by vessel with real photos and videos from drones. So that we can prevent the falsification of AIS data that was deliberately made by ship operators. Therefore, the integration AIS with MIS drones is a step forward to manage the maritime traffic. Especially in Surabaya West Access Channel it is very appropriate to apply surveillance with drones ranging from Bangkalan Lighthouse to the Suramadu Bridge.
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