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A REVIEW ON SOME RESEARCH ISSUES ON AIS TO IMPROVE THE SHIP SAFETY OPERATION AT SEA

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ABSTRACT

This paper reviews research direction on AIS carried out in Indonesia in conjunction with effort to enhance ship safety operation at sea. The initiation, current condition and future research trend on AIS are briefly observed and some results are shown. Some statistical data on marine incidents are also provided and analyzed. It is became conscious that there is a challenge in developing and maintaining a culture of safety in Indonesia and there are some more rules to be prescribed by the government bodies that have authorization in managing sea transportation in Indonesia, and researches on AIS is one of the way in examining the current and proposed rules. Researches on AIS are not only being of assistance for safety of ship operation, but also create an environmentally friendly sea transportation system. Hence, two current global issues, safety and environment, could be positively constructed by the result of research on AIS.

Keywords: AIS, safety, hazard, inspection, emission, data mining

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1. INTRODUCTION

Shipping for Indonesia provides a commercial lifeline for the country domestically as well as with its trading partners, internationally. It is vital that this mode of transport be operated safely. Otherwise, human lives, the marine environment and cargo will be endangered.

Ship incident, anything that happens to ship by chance with or without any clear cause, may happen anytime in anywhere at sea. Ship incident as an event that causes or involves loss or miss of person from the ship, death or injure of crew, collision of two or more ships, material/hull damage of ship, sunk of ship, grounding, drifting of ship, fire, or engine trouble.

As shown in Figure 1, various kinds of incident reported and identified in Indonesia during 2007-2009 (compiled from Mahkamah Pelayaran Indonesia and others) (Artana 2006). The incident kinds reported are clustered as sunken, collision, grounding, hull damage, fire, engine trouble, and other. Sunk and ship collision are still dominating the type of incident. This indicates that marine traffic is still a major problem in maritime transportation of Indonesia.

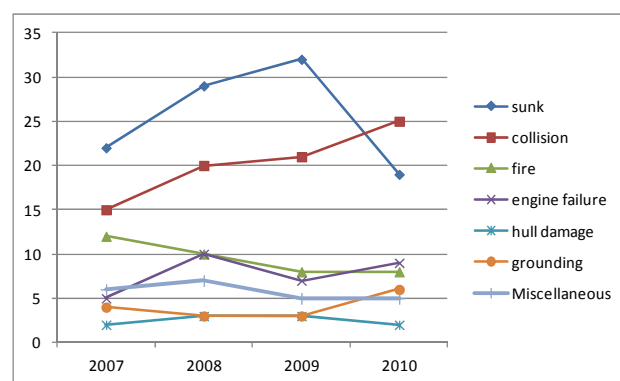


Figure 1 Ship incidents in Indonesia by type

Though traffic is not the only cause of the marine incident, as far as the Indonesian situation is concern, the above figure indicates that traffic is one of the major reasons, apart from weather, regulations, crew performance, and etc.

Ship safety management investigation in Indonesia carried out by JSPS in Marine Transportation Engineering (1997-2006) (Ishida 2006) concluded that in responding the considerably high number of ship incident in Indonesia, ship safety management in Indonesia must accommodate, at least, 5 primarily aspects to improve its ship safety level to some extent that would promote safety operation of ship. Those aspects are: (1) Quality of ships, (2) Operational issues, (3) Port state control, (4) Crew training, (5) and Competency and crew welfare.

One of the main concern regarding the operational issues is the implementation of safety management system, that includes: (a) a safety and environmental protection policy, (b) instructions and procedures to ensure safety and environmental protection, (c) levels of authority and lines of communication between and amongst shore and

shipboard personnel, (d) procedures for reporting accidents, (e) procedures for responding to emergencies, (f) procedures for internal audits and management review. In this perspective, role of the implementation of AIS would be very imperative.

2. SOME ISSUES ON AIS IN INDONESIA

The Automatic Identification System (AIS) is an automatic tracking system used on ships and by Vessel traffic services (VTS) for identifying and locating vessels by electronically exchanging data with other nearby ships and AIS Base stations. AIS information supplements marine radar, which continues to be the primary method of collision avoidance for water transport. Via a visualization system that system on board a ship presents the bearing and distance of nearby vessels in a radar-like display format, the function of AIS can be significantly increase the safety of ship operation.

AIS provides a graphical display on board a ship where Information provided by AIS equipment, such as unique identification, position, course, and speed, can be displayed on a screen or an ECDIS. AIS is intended to assist a vessel's watch-standing officers and allow maritime authorities to track and monitor vessel movements.

The International Maritime Organization's (IMO) International Convention for the Safety of Life at Sea (SOLAS) requires AIS to be fitted aboard international voyaging ships with gross tonnage (GT) of 300 or more tons, and all passenger ships regardless of size. It is estimated that more than 40,000 ships carried AIS class A equipment In 2007, the new Class B AIS standard was introduced which enabled a new generation of low cost AIS transceivers.

The use of AIS in maritime transportation sector has been significantly and widely developed. From its basic idea in assisting navigation, vessel traffic services, search and rescue and collision avoidance, the application of AIS has been moving to a more advance application such as accident investigation, binary messages, computing and networking, AIS data on the Internet, range limitations and space-based tracking, and others. This, consequently, opens a broader chance in R&D perspective.

According to Indonesian Government Decree No. 5/2010 concerning Navigation, Article 14, point (1) to point (3), it is very clear that the Government of Indonesia requires that all vessel operates in the Indonesian territory to report her identity and voyage data to shore based radio station including her call sign, Maritime Mobile Services Identities (MMSI), tonnage, destination, speed, course and estimation of arrival time by using AIS or Long Range Identification and Tracking of Ships/LRIT.

However, some practical and technical problems arise and lead to the ignorance to the regulation. Those problems are, for example:

1. Inadequate infrastructure (low ratios between number of radio/navigation station to coastal line of Indonesia)
2. Inefficient way and lack of facility in monitoring the implementation of the regulation.

3. Lack of knowledge in utilizing the data and information obtained from AIS.
4. And, unclear response procedure of data acquisition and utilization.

3. RESEARCH ROAD MAP

The laboratory of Reliability and Safety, Department of Marine Engineering ITS, has been for some years focusing attention on the utilization of AIS for the purpose of the enhancement of ship safety operation. Some issues that to be solved by the implementation of AIS are issue on quality of ships by development of a tool for ship's inspection, issue on human factor by implementing AIS as an additional information in navigating vessel in congested water area, issues on environment and operational by implementing AIS to predict ship's emission and its distribution as well as issue on maritime hazard by implementing AIS to develop a new method on danger measurement method called danger score.

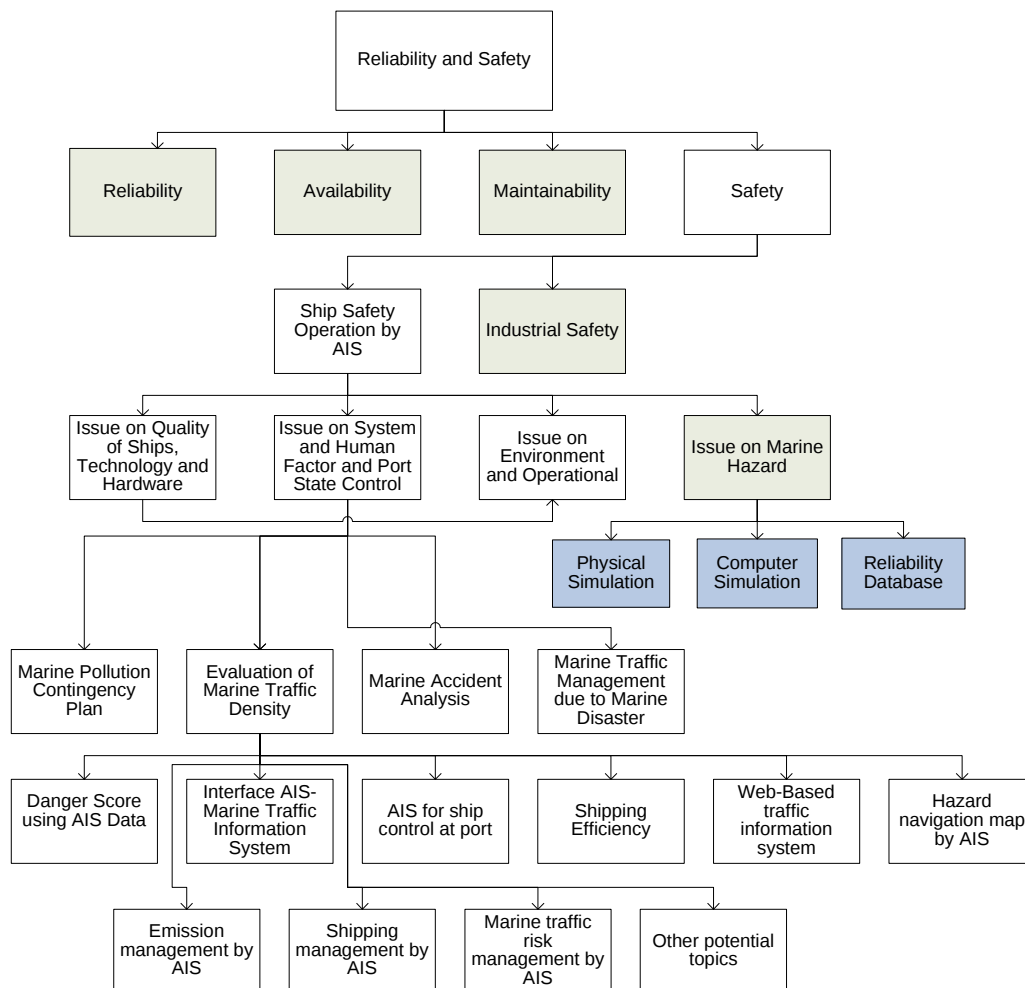


Figure 2 Research road map on AIS

Apart from those above AIS implementation, the need of operating vessel in efficient and effective ways is also part of the interest. The Use of AIS to monitor energy consumption onboard has been implemented by many parties; include the way of monitoring vessel routing as well as web-based traffic information system.

Throughout the above descriptions, it is evidence that AIS plays a very significant role now and in the future.

4. SOME RESULTS OF AIS RESEARCHES

4.1 AIS for danger score

Traffic density has been very potential in contributing several ship incidents. To measure the potential of incident, some researchers introduced a method of measuring the level of danger called danger score.

This study is aimed to enhance the method in calculating danger score by identifying some variables that influence the value of the danger score and to determine the weight of each variable. Fuzzy clustering is utilized to group some data into a homogenous data and expert system is then applied to determine rules in making decision and determine the weight of each variable. The value of each variable is calculated from several data sources such as statistical data of ship incident in the period of 2001-2009, Indonesian weather authority (BMKG) and AIS data installed at the reliability and safety laboratory of ITS Surabaya.

Five new variables are introduced to the nomenclature of the danger score, namely: wave height, speed over ground, course over ground, distance between ships and human error.

Artana and Syarifudin (2009) utilized AIS (Automatic Identification System) data to determine the danger score by means of Analytical Hierarchy Process (AHP) method in determining the weight of each criteria/variable of the danger score (Saaty 1993). The danger score was then calculated by multiplying the weight of each criteria and its function value, as shown in equation 1.

$$\text{danger score} = \sum_{i=1}^n w_i f_i \quad (1)$$

From that research, some approaches need to be re-evaluated, such as:

1. Weighting method by AHP seems to be quite subjective; hence, respondent needs to be carefully responding the questions.
2. Previous researches took too many assumptions in determining the danger score of vessels. As an example, distance between vessels as one variable of the danger score was brought with a weak numerical approach to represent the closeness of the distance.

This research investigates a quantitative approach in determining the weight of criteria constructing the danger score. This research further tries to recalculate the weight of danger score criteria by incorporating fuzzy clustering method.

According to that research, human factor constitutes 88% of the vessel incidents as shown in Figure 1. Present paper classifies criteria into two groups, namely: quantitative and qualitative criteria.

Quantitative criteria can be directly calculated and compared. Ship dimension, distance between vessels, wave heights are some examples of quantitative criteria. Meanwhile, qualitative criteria need further description to be measured, such as noise, human error and others.

This research measures weight of each criterion by means of fuzzy logics through linguistic and numeric values (Artana, 2011). This paper proposes a method in solving several problems; (1) what criteria will affect danger score? (2) how to measure the weight of those criteria (3) how to incorporate the weight of each criterion into a single value of danger score, and (4) what is the main influencing criterion of the danger score?

4.2 AIS for hazard navigation map

Automatic Identification System (AIS) is used to monitor the movement and position of ship. AIS gives several input data such as MMSI number, speed of ground, position of ship and ship type, which are used to evaluate the marine traffic as well as the movement of ship. The increasing of marine traffic may contribute ship navigator stress and marine accident.

The main purpose of this study is to formulate a method of ship's Dangerous Score (DS) in certain area. The information from ship database such as the length and type of ship is then combined with AIS data to determine the dangerous score when the ship is in sailing condition.

The combination of dangerous score and Geographic Information System (GIS) is used to develop hazard navigation map based on the weight criteria, obtained from analyzing using Analytical Hierarchy Process (AHP) and dangerous score. In this study, the research area is selected in Madura Strait, which is considered as one of the busiest marine traffic in Indonesia, not only domestic but also international voyage, which is located in Tanjung Perak Port. This results shows that AIS data can be used to develop a hazard navigation map as a consideration of dangerous area of the ship navigation.

Hazard navigation map (Pitana 2011) could be generated by combining several results of each ship DS. The result of DS combination, which is represented by hazard navigation map. Figure 3(a)-(d) represent hazard navigation map of each ship, which is obtained from DS of general cargo 1 (a), container ship (b), tugboat (c) and general cargo 2 (d) respectively. Therefore, by considering the combination of each hazard navigation map, the overall hazard navigation map is obtained (Fig. 4). The values of criteria are referred to a research result, which was developed by Inoue [6].

The result shows that the risk area are presented by yellow, therefore, the navigator should be careful when they through that channel (see Fig. 3 and Fig. 4).

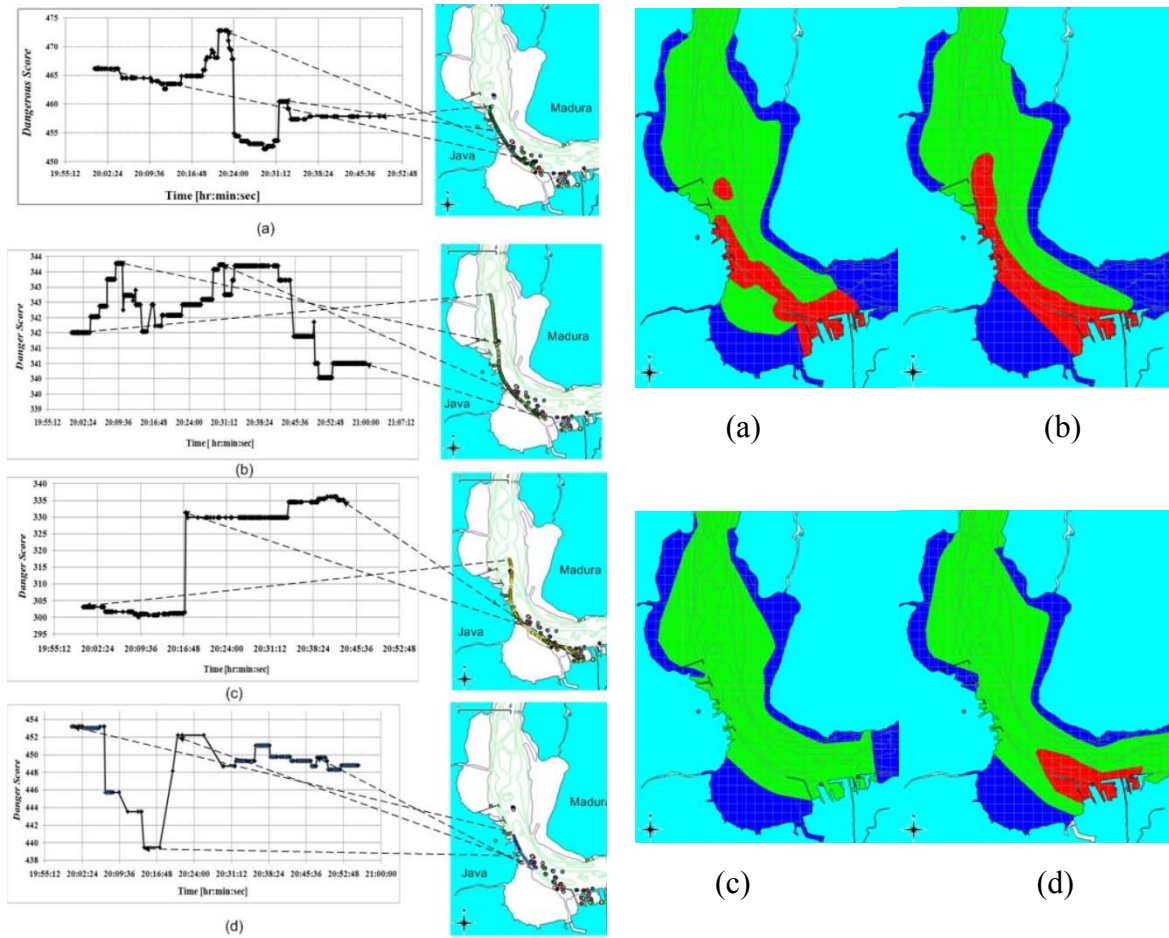


Figure 3 Hazard Navigation Map

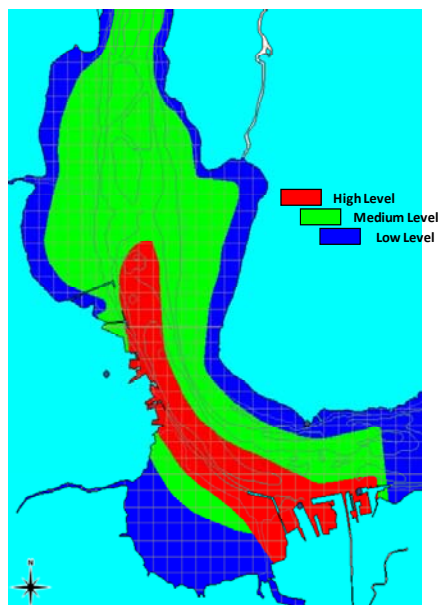


Figure 4 Combined hazard navigation map

4.3 AIS for ship inspection

Poor implementation of safety standard is considered as one reason of high ship accident level in Indonesia. One attempt to increase the safety standard of ship is to

implement one of rules published by International Maritime Organization (IMO) regarding to inspection strategy for ships that operate in port area. The inspections are done by port state control officer (PSCO).

In respect to the inspection strategy, Tokyo MOU requires that 25% population of ocean going ships other than home flag state that enter the port area should be inspected by PSCO. Based on this condition, PSCO needs to define a rank for each ship to make priority ranking for conducting the inspection. ITS Surabaya has developed an internet-based ship inspection strategy by utilization of Automatic Identification System (AIS) data and Geographic Information System (GIS) (see Fig. 5).

Ship inspection strategy is done by calculating inspection score as consideration to determine the inspection priority of ship. Inspection score is determined by weighting inspection variables defined by Tokyo MOU using Analytical Hierarchy Process (AHP). AIS data which is combined with ship database, inspection score is then to be overlaid with Google Map to develop this internet-based ship inspection strategy.

The developed system was done using AIS data at Tanjung Perak and Gresik Ports. The system displays ship position, identity, inspection rank and inspection status of ship (Garnawan, 2010). Figure 5 shows the flow of think of the web-based ship inspection interface which combining AIS Data, web browser, Navigation Map and shipping data. Figure 6 shows one example form of the interface.

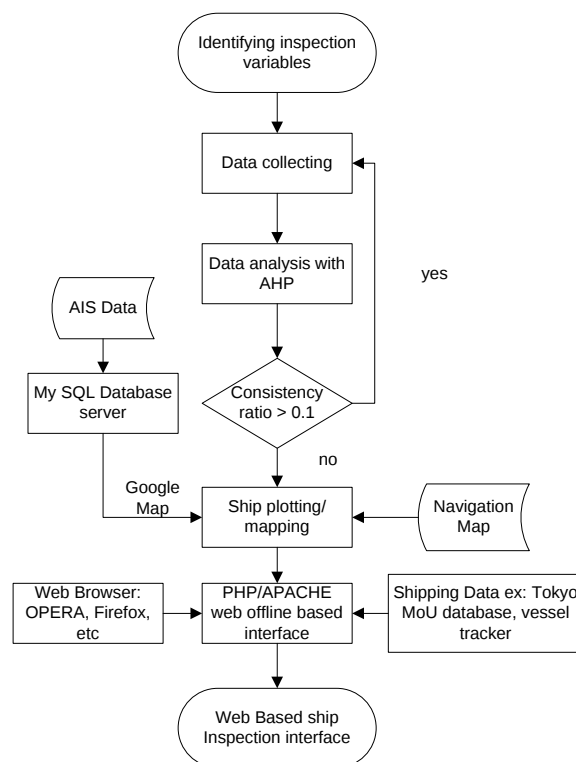


Figure 5 Web-based ship inspection interface

By means of such an interface developed here, an inspection strategy can be constructed in the website offline interface. This will ease the Port State Control Officer (PSCO) in inspecting vessels that are approaching the port. Nonetheless, access to shipping database must be provided to enable the functionality of the interface.

4.4 AIS for emission monitoring

Madura Strait is one of the areas in Indonesia having the heaviest marine traffic. The traffic causes high air pollution impact to the people lives in surroundings and to the environment. Exhaust emissions from ship engines can cause health and environmental problems. Nitrogen oxides (NO_x), carbon monoxide (CO), and sulfur oxides (SO_x) are kinds of air pollutants contained in exhaust gas emissions from ships and those can be harmful to human health, where the substance of these air pollutants can enter the body through the respiratory system.

In this study, data of Automatic Identification System (AIS) and the Geographic Information System are used to calculate the estimated amount of emission and concentration distribution of the diffuse emission using Carlo Trozzi's methodology for calculating emissions estimation. Gaussian Plume Model is used to determine the concentration and distribution of these emissions (Pitana 2010; Setyawan 2010).

This study is found that the amount of NO_x, SO_x, CO, and PM are 932 kg/hr, 1446.4 kg/hr, 1741.7 kg/hr, 29.5 kg/hr respectively. While the largest concentration of emissions NO_x, SO_x, CO, and PM are 184.924 µg/m³, 377.959 µg/m³, 479 µg/m³, and 7.364 µg/m³ respectively. Coordinates areas with the largest concentration is in the 7.164946 south latitude and 112.676002 east longitude or in port of Semen Gresik area.

This study also confirmed that emissions which is caused from marine transportation does not give bad affect to human health, except the one contributed by PM. Figure 8 and 9 shows some examples of emission distribution and concentration in the surrounding area of Madura Strait Indonesia.

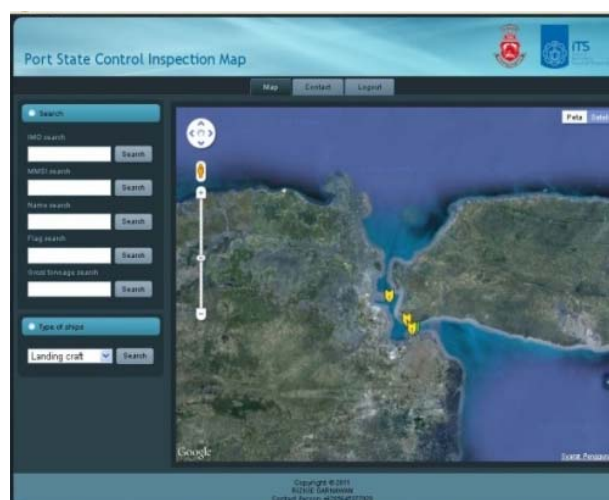


Figure 6 Web Offline Interface using Macromedia Dreamweaver

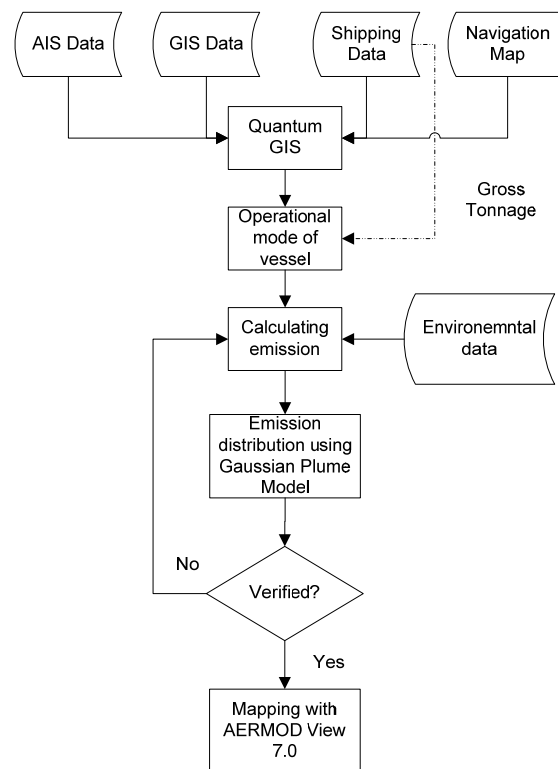


Figure 7 AIS for emission monitoring

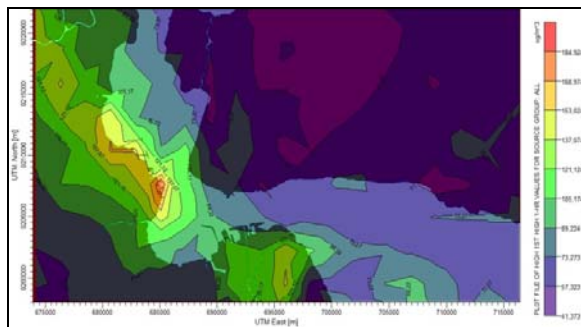


Figure 8 Distribution and concentration of NOx

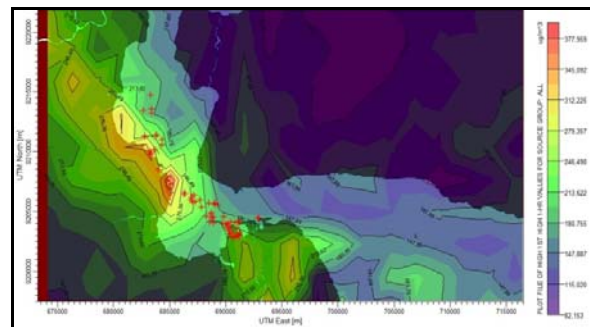


Figure 9 Distribution and concentration of SOx

5. FUTURE TREND AND CHALLENGES

Throughout the above researches area, the use of AIS for better safety maritime operation and environment is inevitable. Some challenges are need to be answer by researchers in this area. Those are:

1. Since the application involving AIS that has been described previously incorporate a lot of database and in some cases it would be following a certain pattern, the implementation of data mining could be possibly performed. The data mining itself is a process of discovering new patterns from large data sets involving methods at the intersection of artificial intelligence, machine learning, statistics and database systems.

2. Result of data mining as in point (3) could be directed in re-evaluating the danger score algorithm. This could be carried out by increasing size of data sets used for data mining and machine learning applications and followed by developing an algorithm to rank variables in related dataset, as well as for ranking values of a specific variable. Some new techniques of Max Gain (MG) and Sum Max Gain Ratio (SMGR) [10], can be utilized to developed marine traffic safety domain using categorical traffic accident data, instead of using conventional statistical techniques for ranking variables and values.
3. Robust integration of AIS with Vessel Traffic Information and vessel traffic management system can be further developed by using vessel traffic Programming and decision-making. This can be carried out by improving database technology, which is used to realize information management system, and then compared a few data models and established the system scheme and realized the system combined with the technology of data mining. The decision making model can effectively use the information gathered from the data mining model. This hopefully provides more precise information in how to response a situation where vessels are located in a congested area.
4. The use of autopilot system combined with information gathered from AIS has also been researched by many parties. With Onboard Windows navigation program combined with charts and connected to a GPS, a real time on screen chart positioning and advanced navigation calculations, can be displayed and used to automating and simplifying the process of planning, piloting and navigating vessel.

6. CONCLUDING REMARKS

This paper has presented an overview on current AIS research and its results. 4 fields of researches has been described, namely (1) danger score, (2) hazard navigation map, (3) AIS for vessel inspection and (4) AIS for emission distribution and monitoring. It is concluded that the utilization of AIS in supporting the establishment of safety maritime transportation is unarguable. Some future trends and challenges have also briefly described with an objective to converge the research agenda on AIS, especially in the frame of AIS join research led by International Maritime Research Center of Kobe University.

Collaboration between expert on several fields, covering maritime and marine technology, ICT, safety engineer, statistician, computing science and other is required.

Some additional keywords like data mining application, data intelligence, decision making procedure, optimization, web-based interface, traffic programming and so on will be some of essentials words in further development of AIS research.

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REFERENCES

- Artana, K.B., Masroeri, A.A., Baliwangi, L. and Ishida, K. (2006). Some Considerations in Enhancing Ship Safety Operation and Management of Indonesia. *DGHE-JSPS Program in Marine Transportation Engineering, Ship Safety Management Group*.
- Artana, K.B., Dinariyana, D.P., Masroeri, A.A., Pitana, T. (2011) Combining AIS data and Fuzzy Clustering to Measure Danger Score of Ships, *Journal of Maritime Researches* 1 (1) : 33-41.
- Bayu Fitra Perdana Setyawan, Pitana, T. and Priyanta, D. (2010). *Estimasi Pencemaran Udara Dari Transportasi Laut di Daerah Shore Line Selat Madura Dengan Menggunakan Data Automatic Identification System (AIS) dan Sistem Informasi Geografis (SIG)*. Tugas Akhir, Jurusan Teknik Sistem Perkapalan.
- Garnawan, R., Pitana, T. and Dinariyana, D.P. (2010) *Studi Integrasi Automatic Identification System (AIS) Data Dan Geographic Information System (GIS) Untuk Pengembangan Strategi Inspeksi Kapal*. Tugas Akhir, Jurusan Teknik Sistem Perkapalan.
- Inoue, K. (2000) Evaluation Method of Ship handling Difficulty for Navigation in Restricted and Congested Waterways. *Journal of Navigation* 53: 167-180.
- Ishida, K., Masroeri, A.A., Artana, K.B, et.al. (2006), *Final research report of JSPS in Marine Transportation Engineering (1997-2006)*.
- Pitana, T., Dinariyana, D.P., Artana, KB., Zaman, B. and Persada, H. (2011) Development of Hazard Navigation Map by Using AIS Data. *Journal of Maritime Researches* 1 (1): 43-52.
- Pitana, T., Kobayashi, E., and Wakabayashi, N. (2010) "Estimation of Exhaust Emissions of Marine Traffic Using Automatic Identification System Data (Case Study: Madura Straut Area, Indonesia)"., Proc. of OCEANO10, Sydney, Australia, 2010.
- Saaty, T. L. (1993) *Pengambilan Keputusan Bagi Para Pemimpin, Proses Hierarki Analitik untuk Pengambilan Keputusan dalam Situasi yang Kompleks*. Pustaka Binama Pressindo.

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Smith, R.K. and Wang, H. (2005) *Data Mining to Improve Traffic Safety*, Department of Computer Science The University of Alabama.