# Research Note-1

## Automatic Identification System (AIS) Data Analysis

**Shridhar Prabhurman & Arnab Das**

Maritime domain awareness (MDA) is defined by the International Maritime Organization (IMO) as the effective understanding of anything associated with the maritime domain that could impact the security, safety, economy, or environment of the nation [1]. A large part of these activities relate to movement of vessels and therefore detection, classification, identification and monitoring of vessels is a key component of MDA. The Automatic Identification System (AIS) is a tool for identifying and monitoring maritime traffic by sending and receiving vessel information to nearby ships and coastal authorities on two dedicated VHF radio frequencies [2]. Information provided by AIS equipment, such as unique identification, position, course, and speed, can be displayed on a screen or an Electronic Chart Display and Information System (ECDIS). Primarily AIS was developed as a tool for collision avoidance and was intended to assist a vessel's watch standing officers and maritime authorities to track and monitor vessel movements [3, 4].

AIS was developed in the 1990s by the IMO technical committee as a high intensity, short-range identification and tracking network. After 9/11 incident in United States, vessels were deemed to have important roles in terrorism case so it was crucial to develop a network that would help vessel monitoring [4]. Therefore, in 2002, IMO SOLAS Agreement included a mandate that required vessels over 300GT on international voyages to fit AIS transponder [5]. The SOLAS vessels (as per the definition above) are required to install Class A transceiver which transmits designated information as compared to Class B transceivers which can be voluntarily installed by the Non-SOLAS vessels. Originally, AIS was used terrestrially, meaning the signal was sent from the boat to land, and had a range of roughly 40 nautical miles (74 km). As ships began sailing further and further away from land, with the advent of Satellite AIS (S-AIS), they began sending the signal to low orbit satellites, which then relayed information back to land [6, 7].The key advantage of S-AIS over terrestrial AIS is that, with sufficient, suitably placed satellites, the entire surface of the earth can now be monitored for AIS transmissions, removing the dependence on terrestrial receiving stations. Each individual satellite can also cover a very large area. The result is that individual vessels or entire fleets can now be monitored, wherever they are in the world, be it the middle of the Indo-Pacific Ocean or in the most isolated inland sea [8]. Irrespective of the mode of transmission used, the information transmitted by the AIS can be categorized into Dynamic and Static. The dynamic category include information related to ship's navigational status, position, speed and course and is transmitted every 3 minutes if ship is underway and 6 minutes if the ship is anchored. The static category include information such as ship's unique ID, name, dimensions, source, destination and estimated time of arrival and is manually fed into the AIS system by the ship's officers and transmitted on request [9]. More detailed information about the AIS, it's working, message types and encryption techniques have been discussed in the attachment linked at the end of this research note in the useful links section.

Since the advent of AIS, it has been found to be extremely useful and has since been taken up as an interesting area of research by many across the globe for multiple applications [39], all of which broadly fall under Safety and Security aspects of MDA. The applications of AIS have been categorized into their respective domains and the most notable research work in the recent decades have been briefly explained below.

### 1. Maritime Safety: Collision Avoidance

AIS was developed by the IMO technical committees as a technology to avoid collisions among large vessels at sea that are not within range of shore-based systems. As AIS is not used by all vessels, it is usually used in conjunction with radar by the military. There are umpteen number of work that have been published under collision avoidance. Probabilistic assessment, statistical analysis, mathematical models, and fuzzy logic have been widely used in order to estimate the frequency and the risk of collisions in specific maritime areas:

- In Kujala et al.2009 [10], they used AIS data to simulate traffic routes including the number of vessels, departure times, vessel dimensions, and sailing speed to estimate the frequency, time, and the location of collision incidents in the Gulf of Finland.
- Mou et al. (2010) [11] applied AIS data to study the actual behaviour of ships involved in collision incidents in the Port of Rotterdam. The proposed model investigates the statistical relationship among collision incidents and ship size, speed, and course.
- Silveira et al. (2013) [12] decoded, visualized, and analysed AIS data along the coast of Portugal to estimate the collision risk associated with each route to local ports. Their model incorporates the position, course, and speed of the ships in each route to identify the collision candidates.
- Son et al. (2012) [13] suggested a fuzzy algorithm to estimate collision risk among multiple ships in Korea using real-time AIS data, while Idiri and Napoli (2012) [14] proposed a rule-based method applied to the movements of ships under changing sea conditions which would give an identification of the risks in real-time and potentially trigger an alarm to help prioritize interventions.
- Jiacai et al.2012 [15] used the rate of turn, the ship acceleration, and ship encounters extracted from the AIS data, in order to develop an index of dangerous areas.

## 2. Fishing Fleet Monitoring and Control

AIS is widely used by national authorities to track and monitor the activities of their national fishing fleets. AIS enables authorities to reliably and cost effectively monitor fishing vessel activities along their coast line, typically out to a range of 100 km (60 mi), depending on location and quality of coast based receivers/base stations with supplementary data from satellite based networks [16]. Several recent studies have used S-AIS as the main source of fishing/fishing vessel monitoring data.

- One of the notable study was conducted in 2015 by Cazzanti and Pallotta [17] to identify and characterize main stationary areas for vessels. They created an algorithm to detect vessels' status as "sailing" or "stopped" using AIS data. Clustering methods are then used to determine the generalized stopping areas for vessels and/or to detect anomalies. If the identified stop area is not a port or harbour and it is far from coastline, it is asserted to be a fishing area.
- Another application of AIS data is to be used in order to distinguish between fishing and non-fishing behaviour as projected by de Souza et.al.2016 [18] in his work.

## 3. Maritime Security (Suspicious vessel identification)

For enhanced coastal security, naval authorities and agencies require an up-to-date information of vessels and their cargos for incident prevention and/or response [1].

- West et al. [19] in their work described how the analysis of AIS data is useful for counter-piracy operations. The AIS has been used to characterize the traffic density, patterns according to the type of ship, speed, etc. In this paper, they decided to focus on destination analysis using a phonetic algorithm. The idea is two-fold: (1) help develop threat assessment for ships traveling to a common destination, and (2) help guide patrols escorting ships in complex or vast areas at vulnerable times of the day.

## 4. Aids to Navigation

AIS transmitters can also be affixed to a floating or fixed aid to navigation (ATON), such as a buoy, beacon, or light. The AIS broadcast provides the position and purpose of an aid, such as a port or starboard lateral buoy, even before it is close enough to be visible from a ship or to provide a radar return. This can help mariners confirm their ship's position or to prepare to make a turn that is based on passing a particular aid. ATONs enable authorities to remotely monitor the status of a buoy, as well as transmit live data from sensors (such as weather and sea state) located on the buoy back to vessels fitted with AIS transceivers or local authorities.

**Real AIS ATON** – A physical aid to navigation structure on which an AIS transmitter is affixed and from which AIS messages are broadcast. **Synthetic AIS ATON** – A physical aid to navigation structure, without an AIS transmitter, but for which AIS messages are broadcast from another (usually land-based) location. **Virtual AIS ATON** – An aid to navigation with no physical structure.

It exists only through AIS messages broadcast from another location. A few uses of virtual ATONs include environments where buoys are moved seasonally, such as in sea ice, or where a marker needs to be placed quickly, such as to mark a newly identified isolated danger or wreck. These aids can only be seen on an ECDIS, or other AIS enabled display, such as a ship's radar [20].

### 5. Oil Spill Monitoring

AIS has gradually become one of the main data sources for marine oil spill monitoring. Schwehr and McGillivary (2007) [21] discussed the different ways that oil spill analysis can benefit from AIS data sources, identifying:

1. Risk analysis: as a direct way to identify high- and low-risk areas for ships and consequently reduce and prevent the risk of shipping accidents which may lead to oil spills [22, 23].
2. Response time: information on traffic flows and location of oil spill incidents can provide relevant agents with real-time positions of incidents and reduce the overall response time [24].
3. Identification: AIS can be helpful in detecting and identifying responsible vessels in case of illegal oil discharges [25, 26].

### 6. Ocean Currents Estimates

- Thomas D Jakub [27] in his work has proposed estimation of ocean surface current based on the Ship Drift using the location parameters from AIS Data.
- French company, e-Odyn commercially provide this service and explain that their algorithm collects positional parameters of AIS data and analyses each vessel's path in different navigation conditions and produces a model of hydrodynamic behaviour. Based on the vessel's movement in relation to its planned path, it deduces the direction and intensity of the current it is affected by [28].

### 7. Ocean Ambient Noise Mapping

Ship radiated noise has long been identified as the most dominant anthropogenic (Wenz1962) contributor to ocean noise [29]. Thus, the AIS can play an important role in allowing us to estimate the extent, quantity, and impacts of the shipping radiated noise. Many notable efforts have been made to model/map the radiated noise of the ships indicated through AIS by generaing shipping radiated noise through the length and speed parameters derived from AIS data and applying channel models on them in order to supplement marine spatial planning, acoustic capacity building and many more such applications. Some of the most notable works in this area is done by Erbe et al. 2015 [30]; Hatch et al. 2008 [31]; Scheer and Ritter 2013 [32]; and Veirs et al. 2016 [33] and for Indian Ocean Region by Piyush et.al [40], Roul et.al [41] and Shridhar et.al [42]

## Way Ahead

This note has presented widespread use of the AIS since its introduction by the IMO and how important a tool it is for a nation to achieve MDA and more recently UDA [43]. Although umpteen number of research efforts have taken place, tackling a wide range of maritime issues, there exists some key challenges that are shared across all the above mentioned solutions and can be taken up as research problems, a few of them that have been identified are listed below.

- Data quality/data entry error rate.
  The value of the AIS system is limited to the quality of the information which it can provide. In particular, elements of the system which require user input (vessel particulars, destination, etc.) may suffer from widespread data entry errors, limiting their utility and also favouring illegal actions, a detailed analysis of which has been presented by Cyril Ray.et.al 2015 [34] in their work. Further research in this area can be made such as algorithms can be developed that could validate the static data entered manually by the officers. Artificial Intelligence based solutions may come handy here.

- AIS transponders being unavailable in smaller vessel classes (weighing below 300 GT).
  Although the use of Class B Transponders are encouraged for such vessels, lack of awareness and hence generated negligence may be considered as the prime cause of vessels not being

fitted with AIS. For countries that are economically challenged, deficiency of resources can be added to the list. Further research may be taken up in this area which could revolve around suggesting policy frameworks and strategies.

- Unavailability of Navigational Aids in National Waterway established across India
Raising the attractiveness of inland waterways (IW) as a transport path is a main objective of National Waterways Act 2016, within which 106 new National Waterways are proposed to be established across India [35]. However, to achieve this, adequate service quality must be provided to become more competitive against road and rail transport. Currently the total cargo moved (in tonne kilometres) through the already established inland waterways is just 0.1% of the total inland traffic in India, compared to the 21% figure for United States [36]. This is true inspite of the fact that the cost of water transport in India is roughly ₹1.19 a kilometre, as compared to ₹1.41 by railways and ₹2.28 by roads [37]. S.Sriraman [38] in his work has mentioned “unavailability of navigational aids” as one of the reasons limiting the usage of Inland Water Transport (IWT) in India. Establishing navigational aids using AIS and associated data analytics can be taken up as an interesting research problem.

## REFERENCES


[1] "Amendments to the international aeronautical and maritime search and rescue (iamsar) manual" (PDF). International Maritime Organization:

[2] Tetreault, B. J. (2005, September). Use of the Automatic Identification System (AIS) for maritime domain awareness (MDA). In Proceedings of OCEANS 2005 MTS/IEEE (pp. 1590-1594). IEEE.

[3] "Regulations for carriage of AIS". Imo.org.

[4] “AIS - The Ultimate Guide to Automatic Identification Systems”. Raymarine

[5] “The IMO Convention for the Safety Of Life At Sea (SOLAS) Regulation V/19.2.4”.

[6] “White paper: understanding satellite ais and the sdpob advantage” ORBCOMM

[7] “Identifying marine communication channels” .MarineInsight

[8] Carson - Jackson, J. (2012). Satellite AIS - developing technology or existing capability?. Journal of Navigation, 65 (2), 303-321

[9] “AIS Messages". U.S. Coast Guard Navigation Center.

[10] Kujala P, Hänninen M, Arola T, Ylitalo J (2009) Analysis of the marine traffic safety in the Gulf of Finland. Reliab Eng Syst Saf 94(8):1349–1357

[11] Mou JM, Tak C, Ligteringen H (2010) Study on collision avoidance in busy waterways by using AIS data. Ocean Eng 37(5):483–490

[12] Silveira P.A.M., Teixeira A.P., Guedes Soares C. (2013). Use of AIS data to characterise marine traffic patterns and ship collision risk off the coast of Portugal, The Journal Of Navigation, 66, 879–898. ©The Royal Institute of Navigation 2013. doi:https://doi.org/10.1017/S0373463313000519

[13] Son NS, Kim SY, Lee CS (2012) On the monitoring system of collision risks among multiple ships. Annual of Navigation 19(1):149–163

[14] Idiri B., Napoli, A. (2012). The automatic identification system of maritime accident risk using rule-based reasoning. In Proc.of the 7th International Conference on System Of Systems Engineering - IEEE SOSE. pp. 125-130

[15] Jiacai P, Qingshan J, Jinxing H et al (2012) An AIS data visualization model for assessing maritime traffic situation and its applications. Procedia Eng Elsevier:365–369

[16] Natale, F., Gibin, M., Alessandrini, A., Vespe, M., & Paulrud, A. (2015). Mapping fishing effort through AIS data. PloS one, 10(6), e0130746.

[17] Cazzanti L, & Pallotta G. (2015) Mining maritime vessel traffic: promises, challenges, techniques. In OCEANS 2015-Genova. 1-6. IEEE

[18] de Souza EN, Boerder K, Matwin S, Worm B (2016) Improving fishing pattern detection from satellite AIS using data mining and machine learning. PLoS One 11(7):e0158248

[19] West M, Cooper T, Kachoyan B (2010) AIS analysis in support of counter-piracy operations. Aust J Marit Ocean Aff 2(4):110–111

[20] “Portrayal of AIS Aids to Navigation” NOAA Office of Coast Survey

[21] Schwehr KD, McGillivary PA (2007) Marine ship automatic identification system (AIS) for enhanced coastal security capabilities: an oil spill tracking application. In OCEANS 2007.1-9. IEEE

[22] Eide MS, Endresen Ø, Breivik Ø, Brude OW, Ellingsen IH, Røang K, Brett PO (2007a) Prevention of oil spill from shipping by modelling of dynamic risk. Mar Pollut Bull 54(10):1619–1633

[23] Eide MS, Endresen Ø, Brett PO, Ervik JL, Røang K (2007b) Intelligent ship traffic monitoring for oil spill prevention: risk based decision support building on AIS. Mar Pollut Bull 54(2):145–148

[24] Akhtar J, Bjørnskau T, Jean-Hansen V (2012) Oil spill risk analysis of routing heavy ship traffic in Norwegian waters. WMU J Marit Aff 11(2):233–247
[25] Uiboupin, R., Raudsepp, U., & Sipelgas, L. (2008). Detection of oil spills on SAR images, identification of polluters and forecast of the slicks trajectory. In 2008 IEEE/OES US/EU-Baltic International Symposium.1-5. IEEE
[26] Ferraro G, Baschek B, de Montpellier G, Njoten O, Perkovic M, Vespe M (2010) On the SAR derived alert in the detection of oil spills according to the analysis of the EGEMP. Mar Pollut Bull 60(1):91–102
[27] Jakub, Thomas Dominic, "Estimating Ocean Currents from Automatic Identification System Based Ship Drift Measurements" (2013).Aerospace Engineering Sciences Graduate Theses & Dissertations. 55. https://scholar.colorado.edu/asen_gradetds/5
[28] "eOdyn: technological breakthrough in the observation of ocean surface currents" IMT Science and Technology News
[29] Wenz GM (1962) Acoustic Ambient Noise in the Ocean: Spectra and Sources. J Acoust Soc Am 34(12):1936
[30] Erbe C, MacGillivray A, Williams R (2012) Mapping cumulative noise from shipping to inform marine spatial planning JASA.4758779
[31] Hatch L, Clark C, Merrick R, Van Parijs S, Ponirakis D, Schwehr K, Thompson M, Wiley D (2008) Characterizing the relative contributions of large vessels to total ocean noise fields: a case study using the Gerry E. Studds Stellwagen Bank National Marine Sanctuary. Environ Manag 42(5):735–752. https://doi.org/10.1007/s00267-008-9169-4
[32] Scheer M, Ritter F (2013) Underwater bow-radiated noise characteristics of three types of ferries: implications for vessel-whale collisions in the Canary Islands, Spain, In, 11. Republic of Korea, Jeju.
[33] Veirs S, Veirs V, Wood JD (2016) Ship noise extends to frequencies used for echolocation by endangered killer whales. PeerJ 4(February):e1657. https://doi.org/10.7717/peerj.1657
[34] Ray, C., Gallen, R., Iphar, C., Napoli, A., & Bouju, A. (2015). DeAIS project: Detection of AIS spoofing and resulting risks. OCEANS 2015 - Genova. doi:10.1109/oceans-genova.2015.7271729
[35] "Gazette Notification" (PDF). Gazette of India. Retrieved 08 April 2019.
[36] Wikipedia contributors. (2018, August 5). Inland waterways of India. In Wikipedia, The Free Encyclopedia. Retrieved 09:03, April 8, 2019, from https://en.wikipedia.org/w/index.php?title=Inland_waterways_of_India&oldid=853528305
[37] "If Executed Well, Waterways Can Change Inland Transportation" Hindustan Times-Nov 2018
[38] Sriraman, S. (2010). Long Term Perspectives on Inland Water Transport in India. RITES Journal, 12(1), 18-1.
[39] Fournier, M., Hilliard, R. C., Rezaee, S., & Pelot, R. (2018). Past, present, and future of the satellite-based automatic identification system: Areas of applications (2004–2016). WMU Journal of Maritime Affairs, 17(3), 311-345.
[40] Asolkar, P. M., Gajre, S. S., Joshi, Y. V., & Das, A. (2016). Validation of Webster ambient noise model for real data in tropical littoral water. OCEANS 2016 - Shanghai. doi:10.1109/oceansap.2016.7485643
[41] Roul, S., Kumar, C. R. S., & Das, A. (2019). Ambient noise estimation in territorial waters using AIS data. Applied Acoustics, 148, 375-380
[42] Prabhuraman, S., Das, A.,(2012). Shadowing a police officer: How to be unobtrusive while solving cases in spectacular fashion. Manuscript submitted for publication in Applied Acoustics Journal.
[43] "Underwater Domain Awareness and Acoustic Capacity Building – A Maritime Security Perspective in the Indian Ocean Region" , Bharat Shakti – January 2019

**USEFUL LINKS**

1. A support documentation to this research note that covers all aspects of AIS and it's working and is available for reference. (Download Here)