

Development of Automatic Identification System (AIS) for Vessels Traffic Monitoring in the Strait of Singapore and Batam Waterways

Hendra Saputra,^{a)*} Sapto Wiratno S,^{a)} Mufti Fathonah M,^{a)} Didi Istardi,^{b)} Ardian Budi K.A,^{b)} Mir'atul Khusna Mufida,^{c)} J.Koto,^{d)}

^{a)} Ship Design and Construction Technology Study Program, Department of Mechanical Engineering, Politeknik Negeri Batam, Batam, Indonesia

^{b)} Department of Electrical Engineering, Politeknik Negeri Batam, Batam, Indonesia

^{c)} Department of Informatics Engineering, Politeknik Negeri Batam, Batam, Indonesia

^{d)} Faculty of Mechanical Engineering, Universiti Teknologi Malaysia (UTM), 81310, UTM Johor Bahru

*Corresponding author: hendrasaputra@polibatam.ac.id

Paper History

Received: 30-October-2017

Received in revised form: 15-January-2018

Accepted: 30-January-2018

ABSTRACT

AIS (Automatic Identification System) is an automatic tracking system used by ships and vessel traffic service (VTS) for identifying ship information by electronically exchanging data with other vessels, coastal station, and satellite. AIS can be used to monitor vessels traffic on a strait channel by detecting a large number of vessels and collecting the ships information related to ship static, dynamic and voyage information such as MMSI number, navigation status, rate of turn (ROT), ship speed, ship position, course over ground (COG), ship heading (HDG), time stamp, RAIM flag and radio status at once. On this paper we try to develop an AIS system for vessel traffic monitoring purpose in the Strait of Malacca especially in the Strait of Singapore and Batam Waterways as one of the world's most congested straits used for international shipping. The method of AIS system development is divided onto 2 stage. Firstly, AIS raw data sent by ships are recorded and decoded as ships information into an application at once. Secondly, the output of AIS decode is used into web based interactive visualization application to visualize the vessels traffic. The development of AIS system has been tested by running the AIS record, decode and web visualisation

and shown that the system could be applied to vessel traffic monitoring.

KEY WORDS: AIS (Automatic Identification System), Vessel Traffic Monitoring, Web Based Interactive Visualization Application

NOMENCLATURE

AIS Automatic Identification System
MMSI Maritime Mobile Service Identity
IMO Internationa Maritime Organization
VTS Vessel Traffic System

1.0 INTRODUCTION

Automatic identification systems (AIS) is a system which has capability to provide information of ships and broadcast the information between ships and coastal automatically. AIS message are consist of static and dynamic information. The static information including ship name, ship MMSI, ship type ship size and current time and the dynamic information consist of ship location, speed, heading angle, rate of turn, destination and estimated arrival time. The autonomously broadcasted of AIS is use full on Vessel Traffic System (VTS) for monitoring traffic and intelligent maritime traffic manipulations such as ship tracking prediction and collision avoidance. In addition,

additional radar system is used on VTS to control ship in and out at the port area.

Automatic identification systems (AIS) are designed to be capable of providing information about the ship to other ships and to coastal authorities automatically for ship 300 gross tonnage and above engaged on international voyages, cargo ships of 500 gross tonnage and upwards not engaged on international voyages and all passenger ships irrespective of size (IMO, 1998).

On this study, we try to develop an AIS system for vessel traffic monitoring purpose in the Strait of Malacca focused on the Strait of Singapore and Batam Waterways as one of the world's most congested straits used for international shipping. The AIS station on this study is located in the main building of Politeknik Negeri Batam (Batam Polytechnic).

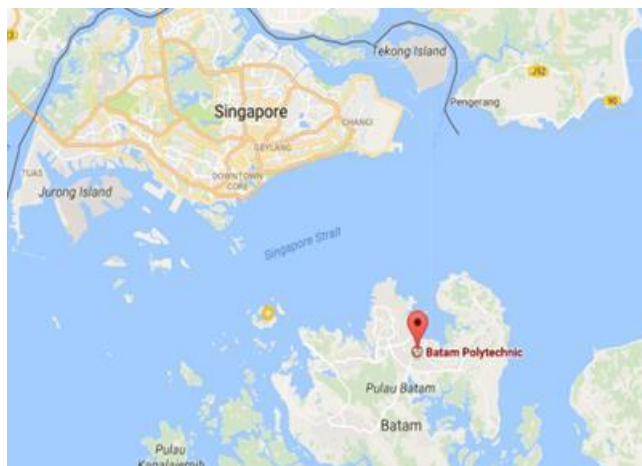


Figure 1: AIS Station (receiver) in Batam

The AIS system developed in this study is functioning to record & decode AIS message (NMEA Message 0183) which sent by ships and visualize the ships traffic through a web based platform. AIS message are recorded and decoded through an application at once which built using LabView programme, whereas the output of AIS decode is used into web based interactive visualization application to visualize the vessels traffic.

2.0 AUTOMATIC IDENTIFICATION SYSTEM

The Automatic Identification System (AIS) is an automatic tracking system used on ships for identifying and locating vessels by electronically exchanging data with other nearby ships, AIS base stations, and satellites. A vessel carrying AIS equipment (AIS transponder) can communicate automatically to a neighbouring vessels and nearby station by VHF radio.

The requirements for AIS are outlined in Regulation 19 of Chapter V of the IMO (International Maritime Organization) Convention for Safety of Life at Sea (SOLAS). requires AIS Class A to be fitted on board ship related to international voyages of 300 gross tonnage and above which includes all seismic vessels, cargo vessel of 500 gross tonnage and upwards not engaged on international voyages and all passenger ships irrespective of size (IMO, 1998). In May 2014, EU (European

Union) fishing vessels of 15 metres and over (but less than 18 meter) are required to fit and maintain in operation an automatic identification system (AIS). Class B equipment is used by pleasure craft, fishing boats and other vessels smaller than 300 tons, but is not mandatory.

AIS is used by marine vessels in coordination with VTS to monitor vessel location and movement primarily for traffic management, collision avoidance, and other safety applications (Perez, 2009). The information provided by AIS can be displayed on a screen and is intended to assist vessel officers and also allow authorities to track and monitor vessel movements.

AIS system has capability to handle more than 2000 data per minute and updates every two seconds (Maciej, 2010). AIS system (transponders and receivers) use two VHF radio frequencies i.e 161.975 MHz (AIS1, or channel 87B) and 162.025 MHz (AIS2, or channel 88B). AIS is classified into 7 types: Class A, Class B, Base Station, Aids to Navigation (AtoN), Search and Rescue Transponder (SART) and AIS Transponder Specialist. Class A shipborne mobile equipment is using SOTDMA (Self-Organized Time Division Multiple Access) technology that complies with IMO / SOLAS standards. Class B of AIS operates a different system to Class A transceivers. Class B operated by using Carrier Sense Time Division Multiple Access (CSTDMA) or SOTDMA. This type of AIS does not comply to IMO/SOLS standard, but comply to ISAF Cat OSR standards 1 and 2 (IMO, 1998).

The AIS class A will give information every 2 to 10 seconds while underway an every 3 minutes while anchoring. The information includes (Maciej, 2010):

- MMSI number
- Navigation status (as defined by COLREGS "at anchor", "under way using engine", "not under command")
- Rate of turn – right or left, 0 to 720 degrees per minutes
- Speed over ground – 1/10 knot resolution from 0 to 102 knots
- Position accuracy
- Longitude and Latitude
- Course over ground
- True heading

In addition, the information will be given by AIS Class A every 6 minutes includes:

- MMSI number
- IMO number
- Radio call sign
- Name of ship
- Dimensions of ship
- Reference point location
- Types of position fixing devices
- Draught of ship
- Destinations
- Estimated time of Arrival at destination

Class B messages have longer reporting intervals than class A when moving; the shortest reporting interval is 30 sec for equipment using carrier-sense TDMA (CSTDMA), and 5 second for equipment using self-organized TDMA (SOTDMA) moving faster than 23 knots. Static and voyage related data for class A

equipment and the extended class B position report is transmitted once every 6 min in two slots (ITU, 2010)

Table 1: Class A Shipborne Mobile Equipment Reporting Intervals For Dynamic Messages

Ship's dynamic conditions	Nominal reporting interval
Ship at anchor or moored and not moving faster than 3 knots	3 min
Ship at anchor or moored and moving faster than 3 knots	10 s
Ship 0-14 knots	10 s
Ship 0-14 knots and changing course	3 1/3 s
Ship 14-23 knots	6 s
Ship 14-23 knots and changing course	2 s
Ship >23 knots	2 s
Ship >23 knots and changing course	2 s

2.1 AIS Message Encoding

AIS data is reported as ASCII data packets as a byte stream using the NMEA 0183 or NMEA 2000 data formats. NMEA defines many different sentences, two of which are normally used for containing AIS data named !AIVDM and !AIVDO. The content of both these sentences are identical (!AIVDM is transmitted, !AIVDO is on board). NMEA sentences are split into words separated by a comma. An example of a typical AIVDM data packet is:

!AIVDM,1,1,,A,14eG;o@034o8sd<L9i;a;WF>062D,0*7D

The meaning of each field is:

- !AIVDM** Tipe NMEA Message
- 1** Number of Sentences (some messages need more then one)
- 1** Sentence Number (1 unless it's a multi-sentence message) The blank is the Sequential Message ID (for multi-sentence messages)
- A** The AIS Channel (A or B)
- 14eG;...** The Encoded AIS Data
- 0*** End of Data
- 7D** NMEA Checksum

NMEA encoding of AIS message using ASCII format where each of ASCII character on the message corresponds to 6 binary bits. There are 168 total of bits, occupying one AIVDM sentence. Every sets of bit (packet bitfields) represent pieces of informasi of the AIS message by converting its to decimal. The ASCII format for AIVDM/AIVDO representations of AIS radio messages have been set by IALA Technical Clarifications on Recommendation ITU-R M.1371.

The first 6 bits of the payload (0-5) are the message type. There are 27 AIS messages types, but the most used in the wild are the position reports that can analyzed using ITU-R M.1371 standard. On this paper, we focused on type 1, 2 and 3 message only. Type 1, 2 and 3 messages share a common reporting structure for navigational information, its called as Common Navigation Block (CNB) (Eric, 2016)

```
2017/08/13 01:59:59.396,0,0,!AIVDM,1,1,,A,18I3=10P00NKiJ40gu@00?vr28AT,0*09
2017/08/13 01:59:59.466,0,0,!AIVDM,1,1,,B,18LIwr?0007Jt>h0g5IP0:Jt00RW,0*50
2017/08/13 01:59:59.491,0,0,!AIVDM,1,1,,B,17rD6C0P00MM2KR0hLSLU?vr20ST,0*57
2017/08/13 01:59:59.546,0,0,!AIVDM,1,1,,B,B7ld VP00insF P:pPICKwfu0P06,0*3A
2017/08/13 01:59:59.596,0,0,!AIVDM,1,1,,B,18KcL00007KkuP0gFJ3InLp0@Ad,0*17
2017/08/13 01:59:59.611,0,0,!AIVDM,1,1,,A,H8HswQL5@E:1@5PV0UJ2222220,2*05
2017/08/13 01:59:59.651,0,0,!AIVDM,1,1,,B,18Htve`00f7LG p0iFc<KIRt0688,0*4B
2017/08/13 01:59:59.706,0,0,!AIVDM,1,1,,A,133vJB300I7JPs@0e4R5h58n80SM,0*36
2017/08/13 01:59:59.731,0,0,!AIVDM,1,1,,B,38KKw:5P0j7KQJH0c16<<0vv06gk,0*62
2017/08/13 01:59:59.761,0,0,!AIVDM,1,1,,B,18Ht?f0P02WL=rp0jci3q?vr2<?4,0*03
2017/08/13 02:00:00.003,0,0,!AIVDM,1,1,,B,1815Ek001WKh680`e50qP6r8<:,0*2E
2017/08/13 02:00:00.023,0,0,!AIVDM,1,1,,A,18Htq?`001WkmMv0gNDCv68r00>?,0*2B
2017/08/13 02:00:00.038,0,0,!AIVDM,1,1,,B,18Hs48PP007KdmB0fJhP0?vr0HAt,0*4E
2017/08/13 02:00:00.108,0,0,!AIVDM,1,1,,B,4h50Ko1v66A2NML8wp0@G700<69,0*56
2017/08/13 02:00:00.128,0,0,!AIVDM,1,1,,A,18HtTq00027KkM00gNm@v>v00B0,0*18
2017/08/13 02:00:00.158,0,0,!AIVDM,1,1,,A,18Ht3M0000JrNf0csTrVVFH20B1,0*11
2017/08/13 02:00:00.183,0,0,!AIVDM,1,1,,A,18Iq:t00027KLUv0gVLQWVF00?-,0*00
2017/08/13 02:00:00.208,0,0,!AIVDM,1,1,,A,19H5Ac002@Wkb3F0duab`28v00S4,0*31
2017/08/13 02:00:00.238,0,0,!AIVDM,1,1,,B,1776590023WJvJ0a8MAWQB0LEr,0*78
2017/08/13 02:00:00.268,0,0,!AIVDM,1,1,,B,18Hu4JPP017Kvj:0g6501A6t0688,0*19
2017/08/13 02:00:00.293,0,0,!AIVDM,1,1,,B,18HtWj8P1vWk>>p0d8?1=?vt2D<>,0*78
2017/08/13 02:00:00.308,0,0,!AIVDM,1,1,,A,B8Hu8Ch001nmh00;D?Q3whTSP06,0*24
```

Figure 2: A few of AIS message (NMEA message) on observation

Table 2: Common Navigation Block

Field	Length	Description
0-5	6	Message Type
6-7	2	Repeat Indicator
8-37	30	MMSI
38-41	4	Navigation Status
42-49	8	Rate of Turn (ROT)
50-59	10	Speed Over Ground (SOG)
60-60	1	Position Accuracy
61-88	28	Longitude
89-115	27	Latitude
116-127	12	Course Over Ground (COG)
128-136	9	True Heading (HDG)
137-142	6	Time Stamp
143-144	2	Maneuver Indicator
145-147	3	Spare
148-148	1	RAIM flag
149-167	19	Radio status
No of bits	168	

The example of information in the AIS system as the result of decode of AIS message can be show on figure 3. The information gets from decode process are Tanggal (Date), Jam (time), Packet Type, Channel, AIS Type, Repeat Indicator, MMSI, Navigation Status, Rate of Turn, Speed Over Ground, Position Accuracy, Longitude, Latititude, Course Over Ground, True Heading, Time Stamp, and Maneuver Indicator.

Tanggal	Jam	MMSI	Nav Status	ROT	SOG	Long	Lat	COG	True Head	Time Stamp	Manuv .indic
8/12/2017	23:59:59	563138000	0	128	0	103.93	1.2993	0	-1	29	0
8/12/2017	23:59:59	566657000	15	0	0	103.75	1.2985	0	-179	30	0
8/12/2017	23:59:59	533005900	0	128	0	104.21	1.3229	-876	-1	29	0
8/12/2017	23:59:59	525019290	0	0	4.9	-126.8	19.019	-1169	-9	18	3
8/12/2017	23:59:59	565894000	0	0	0	103.94	1.293	871	206	28	0
8/12/2017	23:59:59	563013630	1	112	33.6	-151.6	-54.89	-1528	65	1	0
8/12/2017	23:59:59	563035830	8	0	4.6	104.06	1.3477	-915	-207	30	0
8/12/2017	23:59:59	205501000	3	0	2.5	103.66	1.2307	1472	164	27	0
8/12/2017	23:59:59	565641000	5	128	5	103.88	1.1747	-975	-1	31	0
8/12/2017	23:59:59	563023800	0	128	0.2	104.03	1.3838	996	-1	29	0
8/13/2017	0:00:00	538006991	0	0	0.1	103.93	1.1115	230	3	29	0
8/13/2017	0:00:00	563034430	8	0	0.1	103.95	1.2963	1016	196	31	0
8/13/2017	0:00:00	563004450	0	128	0	103.92	1.2675	0	-1	29	0
8/13/2017	0:00:00	5250012	1	248	39	-209.2	15.725	-1215	227	-32	0
8/13/2017	0:00:00	5250012	0	62	28.6	218.61	0.32	0	0	0	0
8/13/2017	0:00:00	563029220	0	0	0.2	103.94	1.2966	218	199	31	0
8/13/2017	0:00:00	563020660	0	0	0	103.75	1.1996	-1382	204	30	0

Figure 3: Example of sorts AIS information on the observation

2.2 MMSI (Maritime Mobile Service Identity) Number

Maritime Mobile Service Identities (MMSI) are nine digit numbers used by maritime digital selective calling (DSC), automatic identification systems (AIS) and certain other equipment to uniquely identify a ship or a coast radio station. MMSI are regulated and managed internationally by the International Telecommunications Union in Geneva, Switzerland. The MMSI format and use is documented in Article 19 of the ITU Radio Regulations and ITU-R Recommendation M.585-6. MMSI can be used to indentify:

- 1) Ship (Individual vessel or ship station)
- 2) Group of vessels
- 3) Shore station or group of shore stations
- 4) Search and Rescue Aircraft
- 5) AIS Aids to Navigation (AtoN)

The structure of MMSI can be seen on the following table:

Table 3: Structure of MMSI Number

Type of MMSI number	Description Structure of the number
Individual vessel (Ship station)	M ₁ I ₂ D ₃ X ₄ X ₅ X ₆ X ₇ X ₈ X ₉
Group of vessels	0 ₁ M ₂ I ₃ D ₄ X ₅ X ₆ X ₇ X ₈ X ₉
Shore station or group of shore stations	0 ₁ 0 ₂ M ₃ I ₄ D ₅ X ₆ X ₇ X ₈ X ₉
SAR aircrafts	1 ₁ 1 ₂ 1 ₃ M ₄ I ₅ D ₆ X ₇ X ₈ X ₉
Navigation aids	9 ₁ 9 ₂ M ₃ I ₄ D ₅ X ₆ X ₇ X ₈ X ₉

All individual vessels (ship station) MMSIs use the format M₁ I₂D₃X₄X₅X₆X₇X₈X₉ where in the first three digits represent the Maritime Identification Digits (MID) and X is any figure from 0 to 9. First 3 digits of MID indicates country code between 200 to 799. For instance, MID code of Indonesia is 525. On this study focused on MMSI for individual vessel (ship station) only.

3.0 DEVELOPMENT OF AIS SYSTEM IN BATAM-SINGAPORE WATERWAYS

On this paper, we try to develop an AIS system for record, decode and visualize of AIS message sent by ships passing through Strait of Singapore and Batam Waterways. The system consist of AIS receiver equipments, AIS record and decode software & web based interactive visualization application to visualize the vessels traffic. The system is installed in Politeknik Negeri Batam as AIS receiver station.

3.1 Overview of AIS Station

AIS receiver station in Politeknik Negeri Batam is used to record AIS data sent by ships which passing the nearby strait from station. The station consist of several hardware and device such as AIS antenna, AIS receiver and personal computer (PC). The connection diagram of AIS station show in figure 4.

Table 4: AIS station devices

No	Device	Specification
1	AIS receiver	Brand: AMEC CYPHO-150 Applicable standards: IEC 62287-1, ITU-R M.1371, IEC 60945 and IEC 61162 Number of AIS Receivers: 2 channels CH-1: CH 87B (161.975MHz) CH-2: CH 88B (162.025MHz) Channel Bandwidth: 25KHz Message Format: AIS Class A & B messages Data Rate: 9,600bps / per channel Receive Sensitivity: -112 dBm @ PER ≤ 20%
2	AIS Antena	VHF antenna
3	Personal computer (PC)	Mini PC Model: Intel NUC NUC5CPYH CPU Speed: 1-2Ghz Processor Type: Dual-core Tipe Processor: Intel

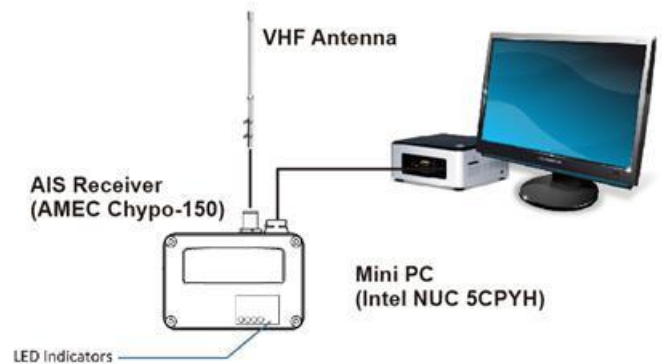


Figure 4: Connection Diagram of AIS Station



Figure 5: AIS station set-up on top building of Politeknik Negeri Batam

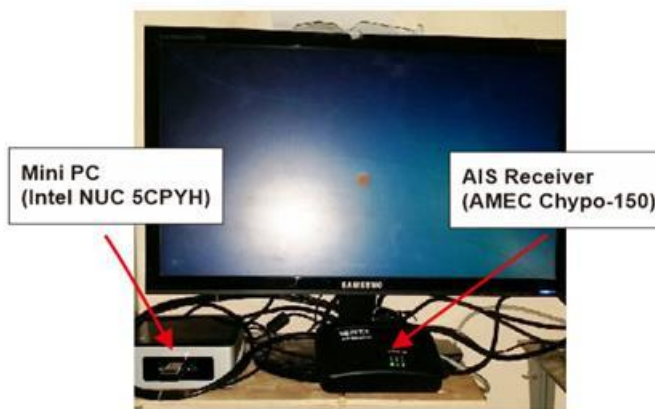


Figure 6: AIS station devices

3.2 Development of AIS System in Singapore Strait- Batam Waterways

On this study, the AIS system for record and decode was developed using LabView as showed in figure 7 named NMEA Receiver. The AIS data sent by ships will be received by AIS receiver and simultaneously stored in hardisk on the PC. The AIS data was stored in NMEA 0183 fomat.



Figure 7: The AIS record and decode

The NMEA message from AIS receiver will be simultaneously decoded and stored in in the hardisk on the PC. The NMEA Receiver will be created two different database of record & decode files and stored both databases in the different location of hardisk on the PC. The information obtained from AIS decoded was consist of Tanggal (Date), Jam (time), Packet Type, Channel, AIS Type, Repeat Indicator, MMSI, Navigation Status, Rate of Turn, Speed Over Ground, Position Accuracy, Longitude, Latiitude, Course Over Ground, True Heading, Time Stamp, and Maneuver Indicator. The AIS raw data (NMEA message) was recorded as shown in figure 2 and decoded as shown in figure 3 in every hour.

Firstly in this development of AIS system is by running the NMEA Receiver as shown in figure 7. The use of the application started from selecting port serial of USB connection from AIS receiver equipment. Then, selecting location for stored data recording, data decoding and data MMSI on hardisk in the PC. Data recording is database of NMEA 0183 message received from AIS receiver that will be stored on the choosen location. Data decoding is a database as result of decode AIS message that will be stored on the choosen location. Recording and decoding database will be saved on txt and csv format for every single hour. Data MMSI is a collected MMSI that filtered by every single hour of decode result.

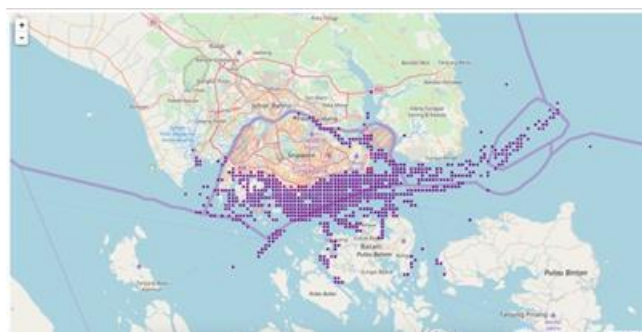
The decode process can be seen by klikcing the home button on control panel. This feature will show the information as fastly for every single message of AIS such as Message Type, Repeat Indicator, MMSI, Navigation Status, Rate of Turn (ROT), Speed Over Ground (SOG), Position Accuracy, Longitude, Latiitude, Course Over Ground (COG), True Heading, Time Stamp, Maneuver Indicator, Spare, RAIM Flag and Radio as shown in figure 8.



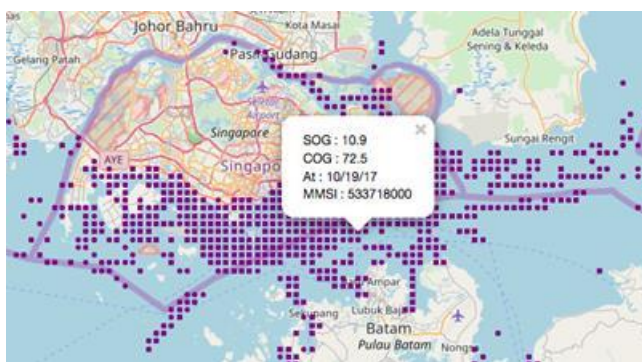
Figure 8: Decode process shown on the application

Secondly, the system can be used for navigation tracking or vessels tracking monitoring by visualize the longitude and

latitude data which obtained from AIS decoded. This application will show the position of ships (MMSI) on the map and show some data of the AIS such as Speed Over Ground (SOG), Course Over Ground (COG), Date and MMSI as shown in figure 9. The full detail of ships can be identified in the decode database.



(a)



(b)

Figure 9: (a) Ship distribution visualize on the web based interactive visualization application (b) Information show on the maps by click the icon

The web based interactive visualization application was created by applying library Leaflet.js to process AIS decode data to output map interactive marine traffic information visualization. Raw data (AIS decoded data) which is formed in CSV (comma separated file) converted to JSON (JavaScript Object Notation) pass through preprocessing to filter data from inconsistency and redundant information. GeoJSON format is extended version of JSON which specialized for geolocation data. Normally map visualization only exhibit data synchronously, but in this research we perform dynamic representation of big Data interactively. Moreover, user be able to interact directly with the data. Interaction provided in this application is click, zoom and filter to focus on data subset as shown on figure 9.

Table 5 shows the vessels traffic in the Strait of Singapore and Batam Waterways every hours on 20 October 2017. There is an average of 975 ships passing through the straits hourly indicated by MMSI. The average MMSI hourly for individual vessels (ship station) and other MMSI were about 940 MMSI (96.41%) and 35 MMSI (3.59%) , respectively.

Table 5: Vessels traffic in the Strait of Singapore and Batam Waterways on 20 Oct 2017 at 00.00 – 23.29

No	Time	Total MMSI	Individual Vessel (Ship Station)	Others	% Others
1	00:00	1030	992	38	3.69%
2	01:00	961	926	35	3.64%
3	02:00	972	937	35	3.60%
4	03:00	917	883	34	3.71%
5	04:00	903	867	36	3.99%
6	05:00	922	887	35	3.80%
7	06:00	970	939	31	3.20%
8	07:00	941	908	33	3.51%
9	08:00	1053	1018	35	3.32%
10	09:00	1066	1029	37	3.47%
11	10:00	1084	1045	39	3.60%
12	11:00	1045	1009	36	3.44%
13	12:00	1048	1011	37	3.53%
14	13:00	1077	1041	36	3.34%
15	14:00	1035	1000	35	3.38%
16	15:00	980	947	33	3.37%
17	16:00	958	922	36	3.76%
18	17:00	996	960	36	3.61%
19	18:00	1021	988	33	3.23%
20	19:00	968	933	35	3.62%
21	20:00	923	889	34	3.68%
22	21:00	906	873	33	3.64%
23	22:00	803	770	33	4.11%
24	23:00	824	791	33	4.00%
Average		975	940	35	3.59%

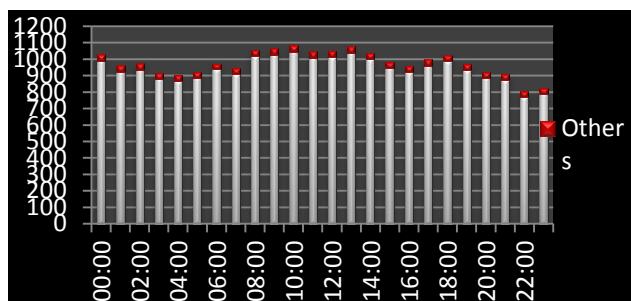


Figure 10: Number of ships (MMSI) hourly passed through the strait between Batam and Singapore on 20 Oct 2017

This study focused on individual vessels (ship station) only that have 9 digits of MMSI structure using format of $M_1I_2D_3X_4X_5X_6X_7X_8X_9$ as shown in table 3. The values of first 3 digits of MID are identified as individual vessels (ship station) between 200 and 799. These values also indicate country code of the vessels.

The values excluding on the MID limits of individual vessels (ship station) was identified as others type of MMSI. This can be identified as group of vessels, shore station or group of shore stations, SAR aircrafts and navigation aids.

4.0 CONCLUSION

The AIS system has an important function in the port traffic management because the system can give an accurate position of the target ships. The development of AIS system in this study showed that the system can be used to monitor the vessel traffic in the Strait of Singapore and Batam Waterways as one of the world's most congested straits used for international shipping.

The AIS system developed in this study has many advantages especially in capability for record & decode of AIS message and good visualization of the vessels traffic using web based interactive visualization application. The system has been tested by running the AIS record, decode and web visualisation and shown that the system could be applied to vessel traffic monitoring.

However, several future work need to be done to improve the capability of the system. First, need to develop a real-time visualization system for traffic monitoring. Second, the system need additional ship database such as ship principle dimension, GT, DWT and etc so that the ships data for analysis and visualization is not only MMSI number but real ship data.

REFERENCE

1. Amirrudin Yaacob, M. Rashidi, Jaswar Koto, 2014, *Marine Navigation Collision Preventing System*, Jurnal Teknologi 69(7), pp.97-100.
2. Eric S. Raymond. 2016. AIVDM/AIVDO protocol decoding. http://www.catb.org/gpsd/AIVDM.html#_ais_payload_data_types
3. http://arundale.com/docs/ais/ais_decoder.html
4. <http://leafletjs.com>
5. <http://www.itu.int/en/ITU-R/terrestrial/fmd/Pages/mid.aspx>
6. IMO, 1998. Recommendation on performance standard for a universal shipborne Automatic Identification System (AIS), London: IMO Resolution MSC 74 (69).
7. ITU-R M.1371-4, (2010): "Technical Characteristics for a Universal Shipborne Automatic Identification System using Time Division Multiple Access in the VHF Maritime Mobile Band"
8. J. Koto, M. Rashidi, A. Maimun, 2014, Tracking of ships navigation in the Strait of Malacca using automatic identification system, *Developments in Maritime Transportation and Exploitation of Sea Resources*, Taylor & Francis Group, London, ISBN 978-1-138-00124-4, pp.721-725.
9. Jaswar Koto, M.Rashidi, 2014, Collision Preventing System of Marine Navigation using AIS System, *The 1st Conference on Ocean, Mechanical and Aerospace -Science and Engineering-*, Vol.1, pp.108-112.
10. Jaswar Koto, Nur Aireen Amran, 2016, *Development of Automatic Identification System in Strait of Batam-Singapore*, Journal of Ocean, Mechanical and Aerospace - Science and Engineering-, Vol.29, pp.16-19.
11. Maciej, 2010. Low cost AIS receiver for coastal zone monitoring, Poland: s.n.
12. NurAireenAmran, Jaswar Koto, Adi Maimun, 2015, *Integration System of Automatic Identification System and Radar for Port Traffic Management*, Jurnal Mekanikal, Vol 38, pp. 32-45.
13. Perez, M., Chang, R., Billings, R., Kosub, T.L.,. 2009. Automatic Identification System (AIS) data use in marine vessel emission estimation. 18th Annual International Emission Inventory Conference
14. Ray C., Devogele T., Noyon V., Petit M., Fournier S., Claramunt C. GIS Technology for Maritime Traffic Systems. In: In European Research Consortium for Informatics and Mathematics News: Special Theme on Traffic Planning and Logistics, vol. 68, pages 41-42, Kuntz, P. (eds.), ERCIM EEIG, January 2007
15. Recommendation ITU-R M585-2. 2015. Assignment and use of identities in the maritime mobile service.