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To cite this article: W H K Kadir *et al* 2022 *IOP Conf. Ser.: Earth Environ. Sci.* **1064** 012037

Vessel charges estimation by using geospatial approach for Kuantan Port, Pahang

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Abstract. Rapid changes in global shipping transportation introduce numerous technologies, among them known as “Automated Identification System (AIS)”. AIS is a transponder system that continuously transmits vessel information data between nearby vessels and shore stations via “Very High Frequency (VHF)” signals channels. In the recent past, a majority of the ports in the world use AIS to monitor and handle vessel activities within their jurisdiction. Nevertheless, there are integration issues with other information systems such as Geographic Information System (GIS) for marine and maritime environments. In regards to these issues, this study highlights the study of vessel charges estimation by using a geospatial approach for Port Kuantan, Pahang. The methodology involves tasks such as reviewing the current practice of vessel port charges estimation, undertaking geospatial analysis for vessel movement charges, estimating and validating charges for selected vessels. The result shows the information of vessel movement that is used to estimate specific vessel charges where finally this result is validated using Kuantan Port Consortium (KPC) charges system known as “Estimation Charges”. To conclude, the vessel charges estimation enables the integration between AIS and GIS in solving the problem of maritime transportation at port industries.

1. Introduction

Port operators face an increasing demand for operation efficiency on top of comprehensive security and environmental management [1]. Vessel traffic management system (VTMS) under supervision of port authority was implemented to enhancing navigation safety, environment protection and co-ordination of life-saving and emergencies.

VTMS is equipped with the latest equipment including radar, VHF radio communication, automatic vessel identification system (AIS), CCTV and weather monitoring system. According to [2], the industrial port sector grew stronger and plays a major factor in the evolution of international transport management. The process of constant changes in the international transport management within the last 10 years gives an impact that increases pressure to port authority [3]. This supported by [4], where he stated structural change in shipping logistic continuously challenges the task of port manager and policy nowadays. According to [5], changes also increase the manufacturing demand and this lead the port authority to serve detail access, update information and careful analysis for better decision-making [1].

The rapid changes of global shipping transportation has introduce numerous technologies, among them known as “Automated Identification System (AIS) [6]. In general, AIS is an onboard transponder system that continuously transmits the vessel information data between the nearby vessel and shore station via “Very High Frequency (VHF)” signal channel. The signal channel contains information about the vessel which is dynamic, static and voyage information [7]. The static information contains information about vessel such as IMO number, call sign, MMSI and length of the average vessel (LOA) [8]. The dynamic information contains information about vessel movement such as vessel position, course over ground (COG), speed over ground (SOG), heading (HDG) and rates of turn (ROT). Voyage information is an information that describes the voyages of vessels such as ship draught, destination and estimate time arrival (ETA). The fact that AIS data contains dynamic information such as vessel position makes it Geographical Information System (GIS) compatible. Figure 1show the vessels activity at Kuantan Port Authority.

Figure 1: Vessels activity at Kuantan Port

Few researchers use AIS data to understand the concept of spatio- temporal analysis [9]. [10] uses AIS data in carrying out spatio-temporal analysis for ship collision using Closest Point Approach (CPA). He undertakes trajectory analysis in New Zealand water by utilizing CPA and clustering techniques. Although beneficial, AIS data is always treated in a stand-alone environment. As such, AIS data is rarely integrated with geospatial aspect (GIS). AIS is always define in a stand-alone environment where it is only use for visualization, monitoring and handling of vessel movement in waterways. Advance vessel applications such as vessel movement, berth assignment and port charges estimation need integration with GIS. Therefore, this paper highlights the spatio-temporal analysis using AIS data in better representing vessel movement and port charges estimation.

2. Methodology

The important tasks to be highlighted in the methodology section are: (2.1) case study area, (2.2) AIS data collection, processing and simulation, and (2.3) application development for port charges estimation.

2.1. Case study area

The case study is Port Kuantan which is one of the main container port in Malaysia. According to [11], throughout the years Port Kuantan has been developing aggressively to become one of the busiest port in Malaysia. Port Kuantan is located in Tanjung Gelang, 25 kilometres north of Kuantan and surrounded by the industrial areas of Gebeng and Semambu [11]. Figure 2 shows the location of Port Kuantan within Malaysia.

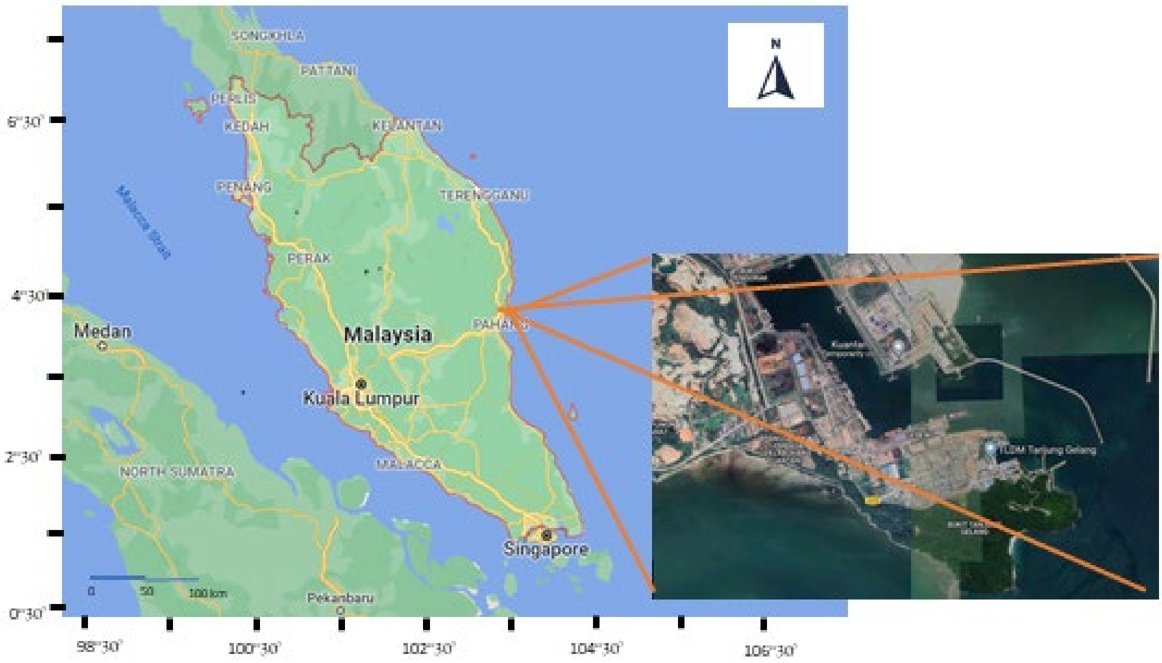


Figure 2 The location of Port Kuantan within Malaysia

2.2. AIS data collection, processing and simulation

The data collection process involves the acquisition of spatial and non-spatial data. The only non-spatial data acquired is the data on port charges which is freely downloadable from the official website of Kuantan Port Consortium (KPC). On another note, spatial data acquired are AIS data, land use and administrative boundaries data of Kuantan and road network data.

AIS data is acquired using the VT Explorer 6.4 software. The software is a maritime surveillance software that shows vessel position as well as dynamic, static and voyage information in the real-time state around the globe. The corresponding AIS data is recorded manually in Microsoft Excel where later on, it is converted into GIS format. AIS data is recorded for a seven-day time window from 8 May 2016 until 14 May 2016. The recorded AIS data includes information such as vessel position, speed over ground (SOG), course over ground (COG), heading (HDG), IMO number, call sign, MMSI number, draught, vessel type, gross registered tonnage (GRT) and time/date.

The current land use data is acquired from the PLANMalaysia@Pahang which is already available in shapefile (.shp) format and projected using Rectified Skewed Orthomorphic (RSO) projection. Example of land use category within the data are port, residential and industrial areas. The road network data is acquired from the Open Street Map (OSM) portal which is an open source freely available data. The positional accuracy of OSM data is 1.57 m which made it suitable for planimetric map in the scale 1: 5,000 [13].

IOP Conf. Series: Earth and Environmental Science 1064 (2022) 012037 doi:10.1088/1755-1315/1064/1/012037

AIS data processing involves using Tracking Analyst, from ESRI ArcGIS 10.2 package. Initially, the converted AIS data needs to be loaded into Tracking Analyst by using “Add Temporal Wizard Data” tool for adding temporal data. Three conditions must be fulfilled before using Tracking Analyst. Firstly, the data must have an identifier (ID). Secondly, the data needs to have an attribute field which contains date and time. Finally, the data must contain a field that describes the event.

The processed temporal data is simulated using Playback Manager functionality in Tracking Analyst. Playback Manager is able to simulate temporal data by setting out the starting and ending date and time for the playback of data. On top of that, the speed of simulation can be control either slower or faster. Here, AIS data is simulated between 08 May 2016, 01:01:09 pm until 14 May 2016 2016, 07:25:34 am. Simulation speed is set to 5 minutes. The movement of the vessel is observed from time to time.

3. Application development for port charges estimation

The final task is the application development for port charges estimation. The task involves two integral steps which are reviewing the actual port charges and developing graphical user interface (GUI). The actual port charges are listed by [14] where these charges are used to develop algorithms for port charges estimation. Table 1 highlights these charges.

Table 1. Actual Port Kuantan charges

Charges Name	*Formula*	*Formula description*	*Charges description*
Pilotage	PL (I,O) = 2 x CLOA	PL = pilotage charges (I,O) = inward and outward to port CLOA = charges base on length of average vessel	Piloting the vessel from station to station
Stevedore	STV = DW x SVT	STV = stevedore charges DW = total dredge weight SVT = tariff stevedore type	Calculate base on the charge of stevedore type
Port dues	PD = GRT x CBTL	PD = port dues GRT = gross register tonnages CBTL = charge base on type of loading	The charge that should pay by all vessels that enter to port
Hire of Tug	HTC = 2 x TOWC x 2	HTC = Hire of tug charges TOWC = towage charges	Charge for towing services calculate for tow the vessel inwards to any berth or from outward berth
Mooring	MR = 2 x MRC	MR = mooring charges MRC = mooring charges base on LOA	Charges for all mooring services
Dockage	DOC(ta,td) = T x LOA x DBVt	DOC = dockage charges (ta,td) = time arrival, departure LOA = length of average vessel DBVT = dockage charges base on vessel type	Charge refer tp change that all vessel should be pay from time of arrival (ETA) until time of departure (ETD)
Harbour	HR = DW x 1.2	HR = Harbour rate DW = total dredge weight	Charges that charge to all vessel for any discharging or loading cargo at port.

The second step is the development of GUI using Microsoft Visual Basic (VB) 6.0. The initial interface is made using three command buttons where each button shows port information, port tariffs and port charges application respectively. The second, main interface is made using the combination of text box, combo box, command button and label. The GUI procedures is based on the port charges estimation flowchart as presented in Figure 3.

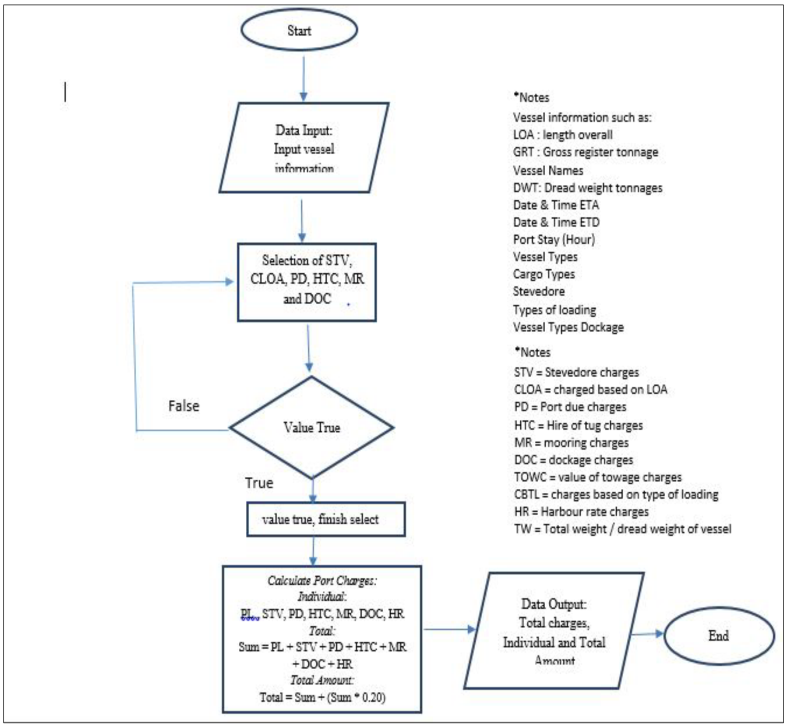


Figure 3: GUI procedures is based on the port charges estimation

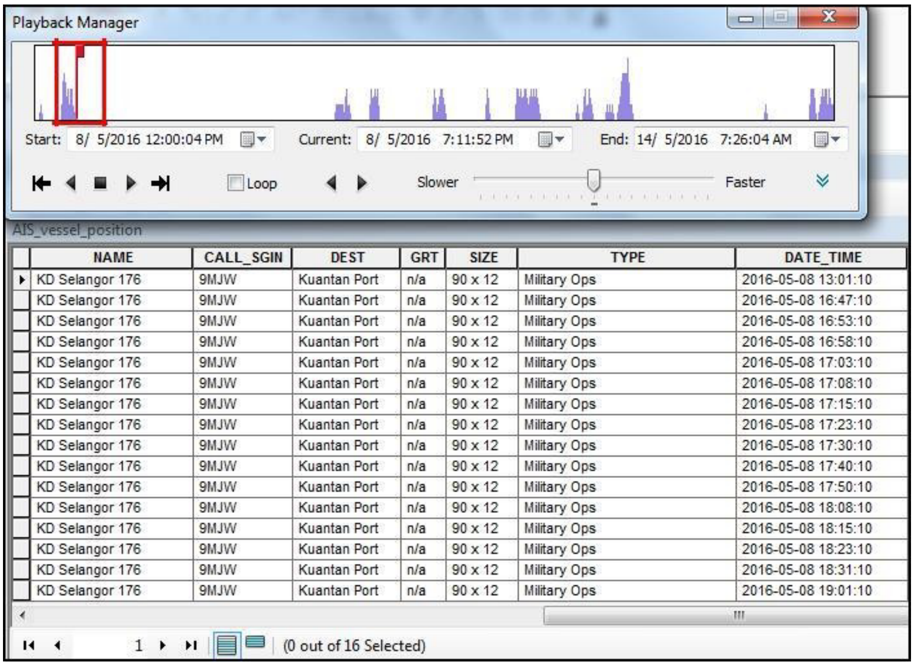
4. Result and discussion

Two important results are presented and discussed which are: (4.1) vessel movement analysis, and (4.2) port charges estimation.

4.1 Vessel movement analysis

The vessel movement analysis is presented in the form of histogram pattern analysis. The histogram pattern denotes the distribution of vessel point on specific time and date. Each single pattern of histogram is analyzed and logical justification is made for any change of pattern. Apparently, the histogram patterns on 8 May 2016 was chosen for the analysis.

The analysis of vessel movement begins on 8 May 2016 at 16:43:26 until 19:11:52, the same day. Figure 4 shows the histogram pattern between 8 May 2016 at 16:43:26 until 19:03:00, the same day for KD Selangor 176 vessel. The movement pattern starts to increase in a time between 16:43:26 until 17:23:55. This is due to the temporal interval between one specific location to another being close. During this time window, the temporal interval is five to eight minutes. Hence, this is the reason for the increase pattern of movement.



NAME	CALL_SGIN	DEST	GRT	SIZE	TYPE	DATE_TIME
KD Selangor 176	9MJW	Kuantan Port	n/a	90 x 12	Military Ops	2016-05-08 13:01:10
KD Selangor 176	9MJW	Kuantan Port	n/a	90 x 12	Military Ops	2016-05-08 16:47:10
KD Selangor 176	9MJW	Kuantan Port	n/a	90 x 12	Military Ops	2016-05-08 16:53:10
KD Selangor 176	9MJW	Kuantan Port	n/a	90 x 12	Military Ops	2016-05-08 16:58:10
KD Selangor 176	9MJW	Kuantan Port	n/a	90 x 12	Military Ops	2016-05-08 17:03:10
KD Selangor 176	9MJW	Kuantan Port	n/a	90 x 12	Military Ops	2016-05-08 17:08:10
KD Selangor 176	9MJW	Kuantan Port	n/a	90 x 12	Military Ops	2016-05-08 17:15:10
KD Selangor 176	9MJW	Kuantan Port	n/a	90 x 12	Military Ops	2016-05-08 17:23:10
KD Selangor 176	9MJW	Kuantan Port	n/a	90 x 12	Military Ops	2016-05-08 17:30:10
KD Selangor 176	9MJW	Kuantan Port	n/a	90 x 12	Military Ops	2016-05-08 17:40:10
KD Selangor 176	9MJW	Kuantan Port	n/a	90 x 12	Military Ops	2016-05-08 17:50:10
KD Selangor 176	9MJW	Kuantan Port	n/a	90 x 12	Military Ops	2016-05-08 18:08:10
KD Selangor 176	9MJW	Kuantan Port	n/a	90 x 12	Military Ops	2016-05-08 18:15:10
KD Selangor 176	9MJW	Kuantan Port	n/a	90 x 12	Military Ops	2016-05-08 18:23:10
KD Selangor 176	9MJW	Kuantan Port	n/a	90 x 12	Military Ops	2016-05-08 18:31:10
KD Selangor 176	9MJW	Kuantan Port	n/a	90 x 12	Military Ops	2016-05-08 19:01:10

Figure 4. Histogram pattern on 8 May 2016

Subsequently, the histogram pattern shows several inconsistencies between 17:23:55 until 19:11:52. These inconsistencies happen due to temporal interval variation. Temporal interval variation is a state where the time interval consistently changes from time to time. Table 2 summarizes the histogram pattern and temporal interval changes on 8 May 2016, from 16:43:26 until 19:11:52.

Table 2. Summary of histogram pattern and temporal interval changes on 8 May 2016

Histogram pattern time	Attribute time	Temporal interval	Trend Histogram pattern
16:43:26 to 17:23:55	16:47:10 to 17:23:10	5 to 7 minutes	Increase
17:23:55 to 17:40:10	17:23:10 to 17:40:10	7 to 10 minutes	Decrease
17:37:10 to 17:50: 54	17:30:10 to 17:50:10	10 minutes	Uniformly constant
17:50:54 t0 18:09;28	17:50:10 to 18:08;10	18 minutes	Decrease
18:09;28 to 18:31:23	18:08:10 to 18:31:10	7 to 8 minutes	Increase
18:31:23 to 19:11:52	18:31:10 to 19:01:10	30 minutes	Decrease

4.2. Port charges calculation

The result of port charges estimation shows the GUI of the said application based on the calculation of charges for selected vessel. It also shows how the user can enter vessel information into the application.

The port charges estimation application consists of two GUIs. The initial interface contains three

IOP Conf. Series: Earth and Environmental Science 1064 (2022) 012037 doi:10.1088/1755-1315/1064/1/012037

menus and two symbol logos while the second interface which is the main interface contains several text and drop-down boxes for user to fill out information such as vessel type, cargo type, stevedore, vessel name, GRT, LOA, type of loading, vessel type dockage, and deadweight tonnage. Most importantly, user needs to enter temporal information such as Estimated Time of Arrival (ETA) date and time, Estimated Time of Departure (ETD) date and time and port stay, in hour. Subsequently, port charges are seamlessly calculated. Figure 5 highlights the initial GUI.

Figure 5. The initial GUI

The result of port charges estimation shown is for Orkim Leader vessel. Based on the vessel movement analysis, Orkim Leader arrives at Port Kuantan on 2 January 2017, at 7:53:37 and depart on 3 January 2017, at 9:11:08. To calculate the vessel charges, the user needs to enter this temporal information together with at least GRT, LOA, type of loading, vessel type dockage and DW tonnage Figure 6 shows the main GUI with the port charges estimation result for Orkim Leader vessel.

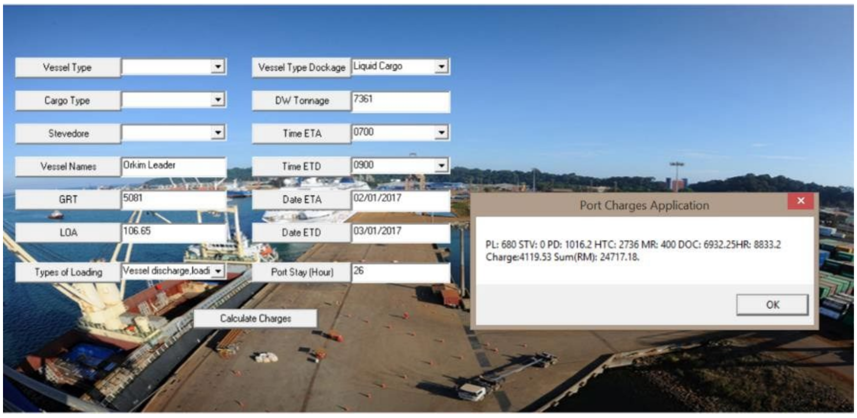


Figure 6. The main GUI with the port charges estimation result for Orkim Leader vessel

Based on Figure 7.5, the total port charges for Orkim Leader is RM 24,717.18. This is based on 26 hours port stay from 2 January 2017, at 7:53:37 until 3 January 2017, at 9:11:08. The details each charge is shown in Table 3.

Table 3. The details charge

Charges detail	Charges (in Malaysia Ringgit, MYR)
Pilotage	680
Port due	1,016.20
Hire of tug charge	2,736
Mooring service charge	400
Dockage charge	6,932.25
Harbor rate	8,833.20
Total charge	20,597.95
Additional 20% charge	4,119.53
Total payable amount	24,717.18

5. Conclusion

This study highlighted the spatio-temporal analysis using AIS data in better representing vessel movement analysis and port charges estimation. It improves the port management aspect by combining GIS together with AIS data, rarely seen in the practice of port management today.

For doing this, AIS data is converted into a GIS compatible format where later on, Tracking Analyst of ESRI ArcGIS 10.2 package is used for simulating the movement of KD Selangor 176 vessel from 8 May 2016 at 16:43:26 until 19:11:52, on the same day. This is done by analysing the histogram pattern. Next, Microsoft VB 6.0 is used to design the GUI of port charges estimation where this GUI is finally used to estimate the port charges for Orkim Leader vessel from 2 January 2017, at 7:53:37 until 3 January 2017, at 9:11:08. The final charge is estimated at RM 24,717.18 which includes the additional 20% charge.

In the future, it is proposed for other aspects of vessel movement analysis via combination of GIS and AIS data to be further investigated. This chapter only covers the temporal variation of vessel ETA and ETD, which apparently based on two-dimensional period. Other aspects such as the actual spatio-temporal pattern of vessel movement and the influence of other external factors towards vessel movement for instance wind speed, vessel traffic, geographical and seasonal factors can be ventured

Acknowledgement

The authors wish to acknowledge the contribution made by Kuantan Port Authority (KPA) and Kuantan Port Consortium (KPC) towards data sharing and information which enables this study to be executed. This work has been funded by UTM Encouragement Research Grant Vot number: PY/2019/01672.

References

[1] ESRI. 2007. *GIS Solutions for Ports and Maritime Transport* (*Online*). Retrieved from http://www.esri.com/library/brochures/pdfs/gis-sols- for-ports.pdf

[2] Idris, H. 1998. Kepentingan untuk mempertingkatkan peranan pelabuhan-pelabuhan di Malaysia dalam abad ke-21. *JATI- Journal Of Southeast Asian Studies,* 4**,** 97-107.

[3] Juhel, M. H. 1999. Global challenges for ports and terminals in the new era. *Ports and Harbors*, 17-27.

[4] Othman, M. R. Jeevan J, Rizal S. 2016. The Malaysian Intermodal Terminal System: The Implication on the Malaysian Maritime Cluster. *International Journal of e-Navigation and Maritime Economy* 4, 046 – 061

[5] David, M., Gollasch, S. & Hewitt, C. 2015. *Global Maritime Transport and Ballast Water Management*, Springer.
[6] Bailey, N. J., Ellis, N. & Sampson, H. 2008. *Training and technology onboard ship: how seafarers learned to use the shipboard automatic identification system (AIS)*, Seafarers International Research Centre (SIRC), Cardiff University.
[7] Bole, A. G., Wall, A. D. & Norris, A. 2013. *Radar and ARPA Manual: Radar, AIS and Target Tracking for Marine Radar Users*, Butterworth-Heinemann.
[8] Zaman, M. B., Kobayashi, E., Wakabayashi, N. & Maimun, A. 2015.Risk of Navigation for Marine Traffic in the Malacca Strait Using AIS. *Procedia Earth and Planetary Science,* 14**,** 33-40.
[9] Shelmerdine, R. L. 2015. Teasing out the detail: How our understanding of marine AIS data can better inform industries, developments, and planning. *Marine Policy,* 54**,** 17-25.
[10] Wang, Y., Zhang, J., Chen, X., Chu, X. & Yan, X. 2013. A spatial–temporal forensic analysis for inland–water ship collisions using AIS data. *Safety science,* 57**,** 187-202.
[11] Kuantan Port Consortium Sdn Bhd. 2016. *Where is Kuantan Port?* http://www.ijm.com/infrastructure/port/kuantanport/aboutUs/port_location.asp.
[12] El-Ashmawy, K. L. 2016. Testing the positional accuracy of OpenStreetMap data for mapping applications. *Geodesy and Cartography,* 42**,** 25-30.
[13] Kuantan Port Consortium Sdn Bhd. 2011. *Estimate Charges* (*Online*). Retrieved from http://www.kuantanport.com.my/en_GB/port-info/estimate- charges/