Automatic Indentification System (AIS) Decode Design for Ship Monitoring using Labview Software

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ABSTRACT

The AIS (Automatic Identification System) is used for monitoring ship traffic in the Singapore Strait. The AIS system is automated tracking system that was used in ship industry. The system consists of hardware that functions as AIS data receiver and AIS decode software developed with LabVIEW programming language. The system visualizes real-time coordinates of ships (longitude and latitude) to google maps. The method of decoding from AIS data onto ship data consists of 3 stages. Firstly, AIS data with char data type is converted to decimal. Secondly, decimal data is converted to binary and mirrors binary data results. Lastly, binary grouping according to ITU Recommendation M.1371 and binary grouping conversion with MSB reading to decimal are done. Results from the AIS system are: decoded MMSI, navigation status, Rate of Turn (ROT), ship speed, ship position (Longitude and Latitude), Course over Ground (COG), True Heading (HDG), Time Stamp, RAIM flag and Radio status. The accuracy of the system is 99.61%.

KEY WORDS: *AIS systems, Labview, Decode, receiver, tracking*.

NOMENCLATURE

API	American Petroleum Institute
ΔT	Temperature Difference in and out
F_T	Thermal Expansion
L_A	Anchor Length
ΔL	Expansion
F_p	Pressure Force
F_F	Friction Force
ε_{sd}	Design Compressive Strain
ε_c	Critical Strain

1.0 INTRODUCTION

The AIS is an automated ship tracking system and ship traffic service identification system. Vessel Traffic Services (VTC) is used to identify and send or receive information. There are two types of data received. Firstly, the data received is electronic data exchange with another ship nearby, BTS AIS, and satellite. The other is the ship transmit data directly. The ship data information that was taken from vessel, were Maritime Car Service Identity (MMSI), speed of ship (Speed over ground), ship position (longitude and latitude), Navigation Status, Course over Ground (COG), and others. The data information was recorded by AIS every 2 until 10 seconds. This duration is depending on the speed of the ship [1,2].

AIS is required by the International Maritime Organization (IMO) of the International Convention for the Safety of Life at Sea (SOLAS) that effective since 31 December 2004 for all cargo ships with Gross Tonnage (GT) more than 300 GT on international shipping, All cargo ships above 500 GT, and all passenger ships regardless of size [3]. The AIS tracks ship positions automatically. The vessel traffic service (VTS) can be identified and located ships with electronic media data exchange with other nearby vessels [4-5].

This research is an interesting area that can be used to monitor the ships [6]. According to such a condition, this paper develops the AIS system for the Singapore Strait vessel monitoring system. The AIS system consists of AIS receiver, signal capture antenna, data storage system, and stored AIS message translator application. The AIS systems can be seen in Figure 1 [6,7].

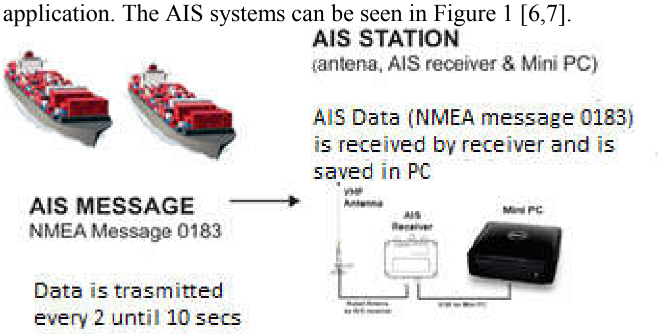

Fig. 1 the AIS Data system

The design of antenna based on the research by [8,9]. There are also another method in method that was implemented by [10]. The data that was received by the AIS station can be process using different tools [11-13]. This paper was implemented this process using Labview software and hardware to monitor the ships that it is still new in this area.

The paper is organized as follows: In the next section, a brief review of decode and data mining are presented. In Section III presents design AIS system using Labview. The next section discuss about the result of the system after implementation. Finally, the conclusions are made in section V.

2.0 DECODE AND DATA MINING

2.1 Data Mining in AIS Systems

AIS data is binary code that can be extracted using ITU M.1371-2 standard. Standard NMEA uses two sentences AIVDM (Accepted Data from other vessels) and AIVDO (ship own information). In this paper use AIVDM.

The receiver data get data in the ASCII type using NMEA 0183 data format. Binary code that was contained in NMEA messages uses 6 bits or 8 bits. The ASCII format has been defined in IEC-PAS 61162-100 standard, "Maritime navigation and radio communication equipment and systems". The AIS message that use ITU and ASCII standard can be seen in Table 1:

Table 1: *AIS Decode Message*

Bit	**Length**	**Comments**
0-5	6	Message Type
6-7	2	*Repeat Indicator*
8-37	30	MMSI
38-41	4	Status Kapal
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*

The decode process is very long with the basic conversion that must recognize the character types on the original data and binary data. The data types that was used in the decoding process are char data types as input data, ASCII data type, decimal data type, and binary data type. The decoded process can be seen in Figure 2.

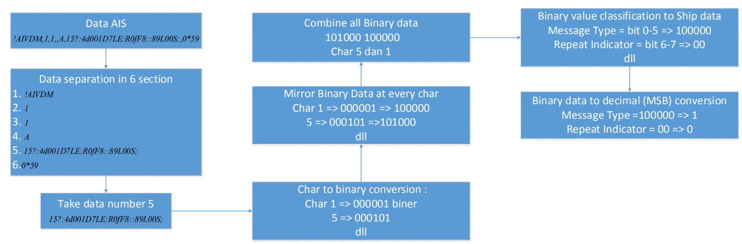

Fig. 2 The decoded process block diagram

This step was done using The LabVIEW program that processed data from raw data. The data will be extracted in time and date that recorded into text file.

2.2 ASCII to Biner Conversion

The Char data type is converted into ASCII data. After that, the data converted into decimal with 6 bit binary. The reference char that was used in the conversion is AIVDM/AIVDO Protocol Decoding shown in Table 2.

Table 2: Char Data conversion, ASCII, Decimal, and Biner

Char	ASCII	Decimal	Bits	Char	ASCII	Decimal	Bits	Char	ASCII	Decimal	Bits
0	48	0	000000	F	70	22	010110	d	100	44	101100
1	49	1	000001	G	71	23	010111	e	101	45	101101
2	50	2	000010	H	72	24	011000	f	102	46	101110
3	51	3	000011	I	73	25	011001	g	103	47	101111
4	52	4	000100	J	74	26	011010	h	104	48	110000
5	53	5	000101	K	75	27	011011	i	105	49	110001
6	54	6	000110	L	76	28	011100	j	106	50	110010
7	55	7	000111	M	77	29	011101	k	107	51	110011
8	56	8	001000	N	78	30	011110	l	108	52	110100
9	57	9	001001	O	79	31	011111	m	109	53	110101
:	58	10	001010	P	80	32	100000	n	110	54	110110
;	59	11	001011	Q	81	33	100001	o	111	55	110111
<	60	12	001100	R	82	34	100010	p	112	56	111000
=	61	13	001101	S	83	35	100011	q	113	57	111001
>	62	14	001110	T	84	36	100100	r	114	58	111010
?	63	15	001111	U	85	37	100101	s	115	59	111011
@	64	16	010000	V	86	38	100110	t	116	60	111100
A	65	17	010001	W	87	39	100111	u	117	61	111101
B	66	18	010010	'	96	40	101000	v	118	62	111110
C	67	19	010011	a	97	41	101001	w	119	63	111111
D	68	20	010100	b	98	42	101010				
E	69	21	010101	c	99	43	101011				

The process of this conversion was shown in Table 3, 4, and 5.

Table 3: Conversion process of Char to 6 bit Binary at on position

10	9	8	7	6	5	4	3	2	1	Nomor karakter
D	1	0	0	d	4	:	?	5	1	Char
0 1 0 1 0 0	0 0 0 0 0 1	0 0 0 0 0 0	0 0 0 0 0 0	1 0 1 1 0 0	0 0 0 1 0 0	0 0 1 0 1 0	0 0 1 1 1 1	0 0 0 1 0 1	0 0 0 0 0 1	LSB
0 0 1 0 1 0	1 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0	0 0 1 1 0 1	0 0 1 0 0 0	0 1 0 1 0 0	1 1 1 1 0 0	1 0 1 0 0 0	1 0 0 0 0 0	MSB
0 0 1 0 1 0	1 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0	0 0 1 1 0 1	0 0 1 0 0 0	0 1 0 1 0 0	1 1 1 1 0 0	1 0 1 0 0 0	1 0 0 0 0 0	MSB
84		0	0			351438000		0	1	Desimal
									1	Message Type
								0		Repeat Indicator
						351438000				MMSI
			0							Navigation Status
		0								Rate of Turn
84/10=8.4										Speed Over Ground
										Position Accuracy
										Longitude
										Latitude
										Course Over Ground
										True Heading
										Time Stamp
										Manuver Indicator
										Spare
										RAIM flag
										Radio ststus

Table 3 represents the conversion of data from char to binary with decimal results.

Table 4: Conversion process of Char to 6 bit Binary at off position

	19	18	17	16	15	14	13	12	11	Nomor karakter
	8	F	f	0	R	:	E	L	7	Char
1 0	0 0 1 0 0 0	0 1 0 1 1 0	1 0 1 1 1 0	0 0 0 0 0 0	1 0 0 0 1 0	0 0 1 0 1 0	0 1 0 1 0 1	0 1 1 1 0 0	0 0 0 1 1 1	LSB
0 0	0 0 0 1 0 0	0 1 1 0 1 0	0 1 1 1 0 1	0 0 0 0 0 0	0 1 0 0 0 1	0 1 0 1 0 0	1 0 1 0 1 0	0 0 1 1 1 0	1 1 1 0 0 0	MSB
0 0	0 0 0 1 0 0	0 1 1 0 1 0	0 1 1 1 0 1	0 0 0 0 0 0	0 1 0 0 0 1	0 1 0 1 0 0	1 0 1 0 1 0	0 0 1 1 1 0	1 1 1 0 0 0	MSB
			759328				62433617		0	Desimal
										Message Type
										Repeat Indicator
										MMSI
										Navigation Status
										Rate of Turn
										Speed Over Ground
									0	Position Accuracy
							62433617/600000=104.06			Longitude
			759328/600000=1.27							Latitude
										Course Over Ground
										True Heading
										Time Stamp
										Manuver Indicator
										Spare
										RAIM flag
										Radio ststus

The Table 4 obtained the ship data Position Accuracy, Longitude, and Latitude.

Table 5: Conversion process of Char to Binary in 6 bit (result)

28	27	25	25	24	23	22	21	20	Nomor karakter
;	S	0	0	L	9	8	:	:	Char
0 0 1 0 1 1	1 0 0 0 1 1	0 0 0 0 0 0	0 0 0 0 0 0	0 1 1 1 0 0	0 0 1 0 0 1	0 0 1 0 0 0	0 0 1 0 1 0	0 0 1 0	LSB
1 1 0 1 0 0	1 1 0 0 0 1	0 0 0 0 0 0	0 0 0 0 0 0	0 0 1 1 1 0	1 0 0 1 0 0	0 0 0 1 0 0	0 1 0 1 0 0	0 1 0 1	MSB
1 1 0 1 0 0	1 1 0 0 0 1	0 0 0 0 0 0	0 0 0 0 0 0	0 0 1 1 1 0	1 0 0 1 0 0	0 0 0 1 0 0	0 1 0 1 0 0	0 1 0 1	MSB
	2251		0, 0	0, 46	260		2600		Desimal
									Message Type
									Repeat Indicator
									MMSI
									Navigation Status
									Rate of Turn
									Speed Over Ground
									Position Accuracy
									Longitude
									Latitude
							2600/10=260		Course Over Ground
					260				True Heading
				46					Time Stamp
				0					Manuver Indicator
			0						Spare
			0						RAIM flag
	2251								Radio ststus

3.0 DESIGN AIS DATA RECEIVER USING LABVIEW SOFTWARE

The design of software was follow the flow chart in Figure 2. The AIS Receiver program records data in NMEA Message 0183 data. There are two option in duration of storage data; a minute or an hour. The data was filtered based on MMSI data. The MMSI filter data was displayed in front panel display at LabVIEW.

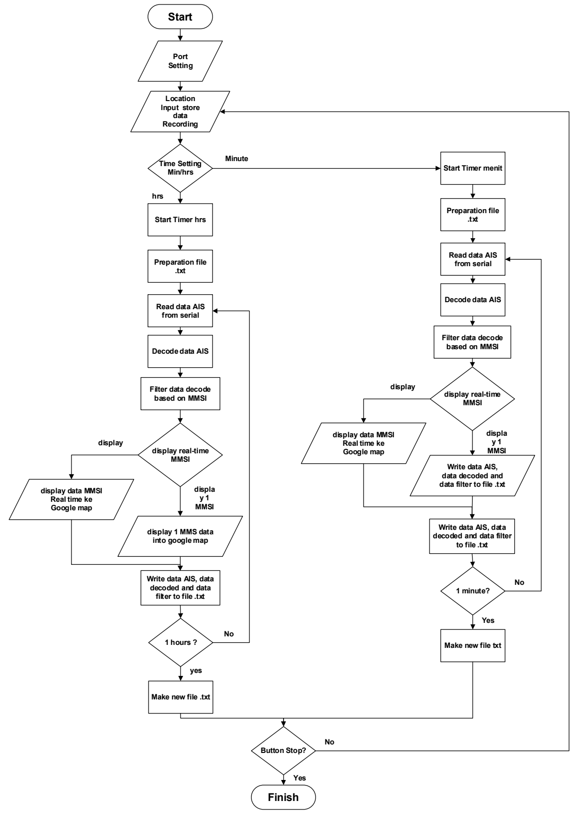

Fig. 2 *Flow Chart* Program LabVIEW

There are three stages to decode the raw AIS data into ship data; separating AIS Data Section encoded, dividing AIS Data per character, and converting binary into ship data.

3.1 Separating AIS Data Section Encoded

The program separate the characters by its structure using the comma "," sign. The process is shown in Figure 3.

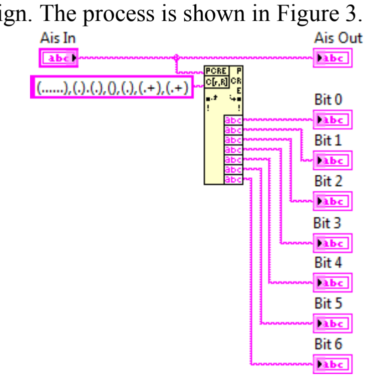

Fig. 3 Character division of AIS Data

It can be seen that the AIS data is divided in 6 data. The result can be found in bit 5 that contains character data ("15?: 4d001D7LE: R0fF8 :: 89L00S;",).

3.2 Dividing AIS Data per Characters

The output data from previous process is converted to decimal then converted again into binary data. The process continue with the character data to binary conversion. The program can be seen in Figure 4.

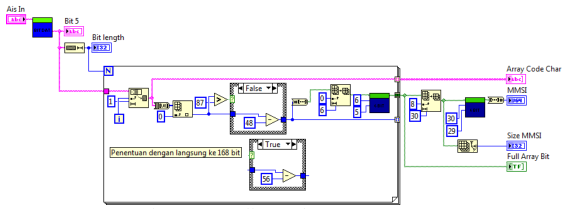

Fig. 4 Decoding sub-program

3.3 Binary to Ship Data Conversion

The binary to ship data conversion is done by MSB method (reads starting from left) that can be seen in Figure 5. The conversion change bits 8 to 37.

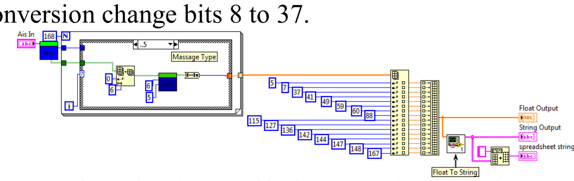

Fig. 5 The Binary to ship data conversion in Labview

Figure 4 shows the repeat indicator that generate the value of the Type Message ship data. This sub program can convert binary to decimal data with 6 character. The character in Repeat Indicator take in address bit number 6 and 7 for ship data. The third is the MMSI data ship with a length of 30 bits starting from address bit number 8 to 37. The bit is converted to decimal number. Data number 4 is the Navigation Status starting from the 38th bit shown in Figure 6.

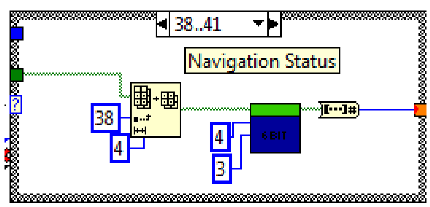

Fig.6 *Case Structure* Program *Navigation Status*

Navigation status is a vessel data showing the activity of the vessel, whose 38th bit to the 41st bit as shown in Figure 6. The fifth vessel data is a Rate of Turn which has an 8 bits length and starts from the 42th bit as shown In Figure 7.

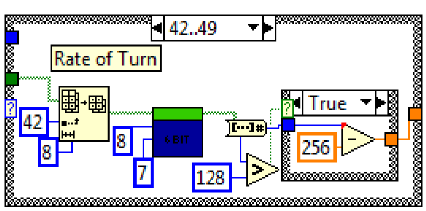

Fig. 7 *Case Structure* Program *Rate of Turn*

The Rate of Turn data have 8 bits. The box in the right can control the direction of rotation the ship. The Speed over Ground (SOG) data of the ship can be seen in Figure 7. The SOG data take 10 bits length (50 to 59).

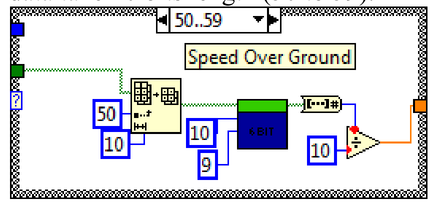

Fig. 7 *Case Structure* Program *Speed over Ground*

The next data that was be taken from AIS is the accuracy. The accuracy only have two condition; accurate or error.This can be shown in Figure 8.

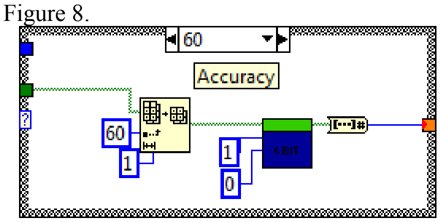

Fig. 8 *Case Structure* Program *Accuracy*

This data consist a bit only at address bit 60. The position data of the ship addresses in longitude and latitude. The programs can be seen in Figure 9.

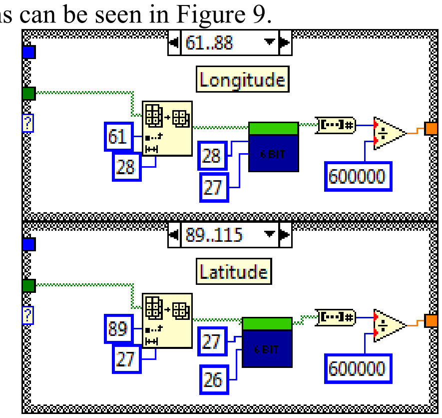

Fig. 9 *Case Structure* Program *longitude* and *latitude*

Longitude and latitude is the coordinates of the ship based on the map. The longitude coordinates use address bit 61 with data length 28 bits and the latitude coordinates use bit number 89 with 27 bits data length. The next ship data is the Course over Ground that can be shown in Figure 10.

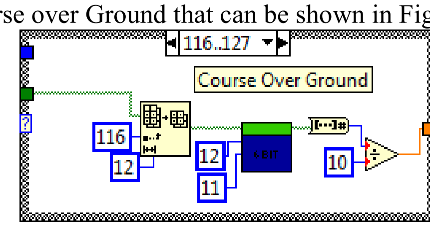

Fig. 10 *Case Structure* Program *True Heading*

True Heading is the degree of rotation of the ship. The length of data are 12 bits (116 to 127 bit address). The Timestamp is a unit of time (seconds) to make the message. This Timestamp data can be seen in Figure 11. The data length are 6 bits (137 to 142). This data inform the intensity of message delivery on each ship.

The next data is Maneuver Indicator shown in Figure 14. The data length are 2 bits (143-144). This data informs the condition of ship maneuver; 0 is Not Available, 1 is No special maneuver, and 2 is special maneuver.

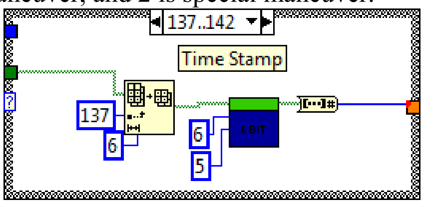

Fig. 11 *Case Structure* Program *Timestamp*

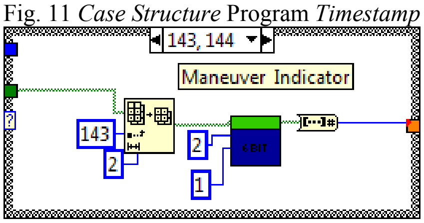

Fig. 12 *Case Structure* Program *Maneuver Indicator*

The results of the 16 vessel data are then displayed to the LabVIEW Front Panel program so that it can be read by the user shown in Figure 13.

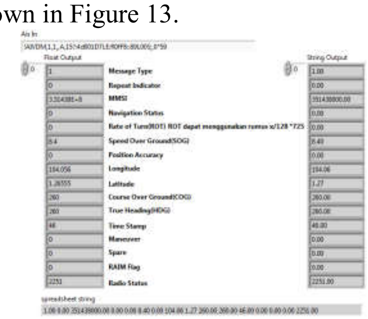

Fig. 13 Front Panel Decode LabVIEW

While the overall appearance of the program for AIS data storage and decoding process is shown in Figure 14.

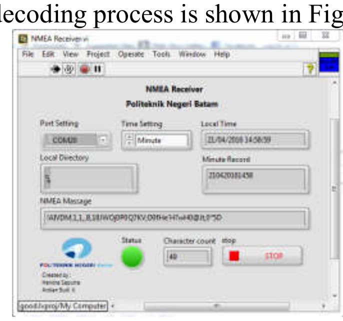

Fig. 14 AIS data storage in *Software AIS Receiver*


```
21/04/2016 15:00:00    !AIVDM,1,1,,A,376rU=0PAFWL8Qp0ejKTkSCL0120,0*7F
21/04/2016 15:00:02    !AIVDM,1,1,,B,16U?FL0uiuWL8>T0f4waoGoL08Jo,0*00
21/04/2016 15:00:02    !AIVDM,1,1,,A,18KGqL0P007Kqs`0gJPmc?wF08Jq,0*1E
21/04/2016 15:00:02    !AIVDM,1,1,,B,13f=?D000f7JjjJ0ehNq8GSL0684,0*0E
21/04/2016 15:00:02    !AIVDM,1,1,,B,18JwK20P007KFJp0f36JL?wL08Jl,0*77
21/04/2016 15:00:02    !AIVDM,1,1,,B,18JwK20P007KFJp0f36JL?wL08Jl,0*77
21/04/2016 15:00:02    !AIVDM,1,1,,B,18JwK20P007KFJp0f36JL?wL08Jl,0*77
21/04/2016 15:00:02    !AIVDM,1,1,,B,18JwK20P007KFJp0f36JL?wL08Jl,0*77
21/04/2016 15:00:02    !AIVDM,1,1,,B,18JwK20P007KFJp0f36JL?wL08Jl,0*77
21/04/2016 15:00:02    !AIVDM,1,1,,B,18JWOj0P0Q7KV;D0fHe`H?wH0@Jt,0*5D
21/04/2016 15:00:02    !AIVDM,1,1,,B,18LOnr00007Jq>N0gEvja3UL0<<=,0*07
21/04/2016 15:00:02    !AIVDM,1,1,,B,18HsJG8P007KiJJ0`mI<1wwMp8Jv,0*27
21/04/2016 15:00:02    !AIVDM,1,1,,A,17lcic@0017L1mb0bt07OT7L00RL,0*4E
21/04/2016 15:00:02    !AIVDM,1,1,,B,18IgmB8P007K@260f?i:WgwN0PRw,0*0B
21/04/2016 15:00:02    !AIVDM,1,1,,A,15?:4d001D7LE:R0fF8::89L00S;,0*59
21/04/2016 15:00:02    !AIVDM,1,1,,B,18Hsa5P02T7KUJv0eR2joBAL28K2,0*5C
21/04/2016 15:00:02    !AIVDM,1,1,,B,15Q4cP00007KQ4h0fPo4PaEL0D>D,0*6D
21/04/2016 15:00:02    !AIVDM,1,1,,A,13clS300007JMdd0dnvafS3L08K6,0*69
21/04/2016 15:00:02    !AIVDM,1,1,,A,18J8W>80017K2l<0fcMqJ0uN08K7,0*1F
21/04/2016 15:00:02    !AIVDM,1,1,,B,18KeP@00017Ku0b0gq;aoqqN0<;`,0*42
21/04/2016 15:00:03    !AIVDM,1,1,,A,18Hs290P007KIHT0fQ8VU?wN08K9,0*16
```


Fig. 15 *Database* AIS before *Decode*

In Figure 14 and Figure 15 show an AIS software receiver, where the AIS data in NMEA Message 0183 data format and the decoded data NMEA Message 0183 in actual ship was filtered based on MMSI. This result can be shown in Figure 16.

The result data included MMSI data, navigation status, Rate of Turn (ROT), ship speed, position Ships (Longitude and Latitude), Course Over Ground (COG), True Heading (HDG), Time Stamp, RAIM flag and Radio status. The next process is plotting the data into google maps.

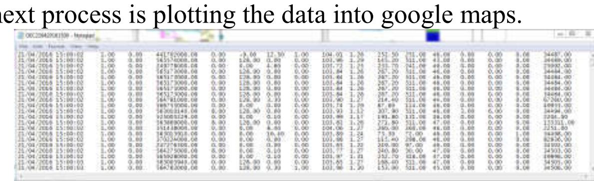

Fig. 16 *AIS decode data results* in LabVIEW

The location of the research is in Batam Island that can be seen in Figure 17.

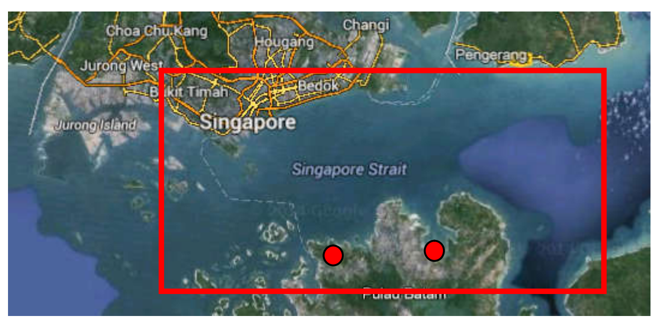

Fig. 17 *AIS decode data results* in LabVIEW

The red dots are the place are the AIS system that was installed.

4.0 RESULT AND DISCUSSION

The result show that AIS (NMEA message) data and NMEA message data can be shown and monitoring. The data consists MMSI ship data, navigation status, Rate of Turn (ROT), ship speed, ship position (Longitude and Latitude), Course Over Ground COG), True Heading (HDG), Time Stamp, RAIM flags, and Radio status. The results of the ship data can be seen in Figure 18.

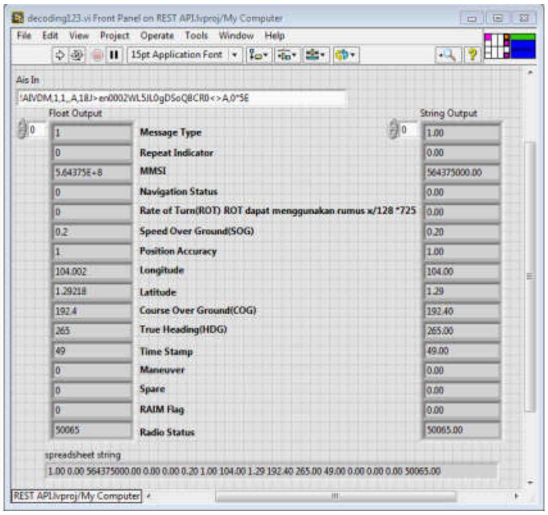

Fig. 18 *Decode* AIS data Result (NMEA *message*)

This coordinate test is a test of longitude and latitude of the position of the ship detected. This test compares the results of the system that was created with google maps and also marine traffic. Method of retrieval and comparison of data obtained is started from the data retrieval system in the form of data MMSI, longitude and latitude which then plot into google maps and compare to the truth or the accuracy of the data obtained then the data obtained results compared with the comparison data (coordinates) on Marne traffic. A total of 20 data were retrieved and compared with comparable marine traffic data and the results of those comparisons are shown in Table 6.

Table 6 Data comparison between real and simulation

NO	MMSI	Koordinat Sistem Penelitian		Koordinat Marine Traffic		Error (%)
		Latitude	Longitude	Latitude	Longitude	
1	538005739	1.31	104.07	1.3059	104.068	0.61%
2	636016694	1.26	103.92	1.26	103.918	0.20%
3	563036130	1.35	104.06	1.355	104.0627	0.77%
4	566676000	1.24	103.8	1.2443	103.8027	0.70%
5	477390800	1.29	103.95	1.2924	103.945	0.26%
6	565897000	1.25	103.76	1.2443	103.771	0.53%
7	357285000	1.23	103.8	1.229	103.8	0.10%
8	477007100	1.27	103.78	1.267	103.78	0.30%
9	413135000	1.28	103.93	1.285	103.932	0.70%
10	538005881	1.27	103.9	1.268	103.9	0.20%
11	371714000	1.27	103.77	1.272	103.771	0.30%
12	220263000	1.27	103.77	1.2715	103.7734	0.49%
13	305519000	1.27	103.87	1.265	103.87	0.50%
14	566120000	1.3	103.96	1.298	103.961	0.10%
15	533836000	1.32	104.11	1.329	104.1	0.10%
16	567051900	1.23	103.8	1.234	103.796	0.00%
17	636014298	1.3	104.08	1.296	104.076	0.80%
18	305610000	1.43	103.91	1.433	103.908	0.10%
19	566592000	1.3	103.95	1.2987	103.9495	0.18%
20	538005440	1.39	103.96	1.392	103.949	0.90%
Rata-rata Error						0.39%

From Table 6, the error the system can be calculated by

$$\text{Error} = \frac{(\text{nilai latitude percobaan} - \text{nilai latitude marine traffic}) + (\text{nilai longitude percobaan} - \text{nilai longitude marine traffic})}{100}$$

The error rate is 0.39% with so the accuracy of this research is 99.61%. Comparison of these coordinates when viewed from the visual google maps with marine traffic we can see in Figure 19.

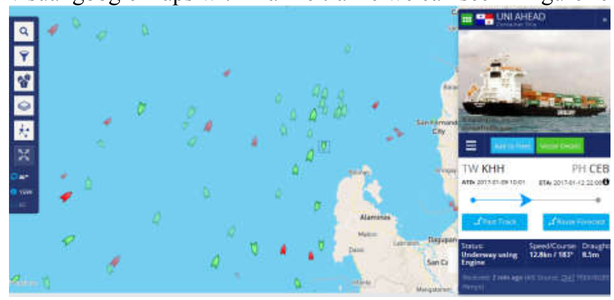

Fig. 19 *Software Marine Traffic GUI*

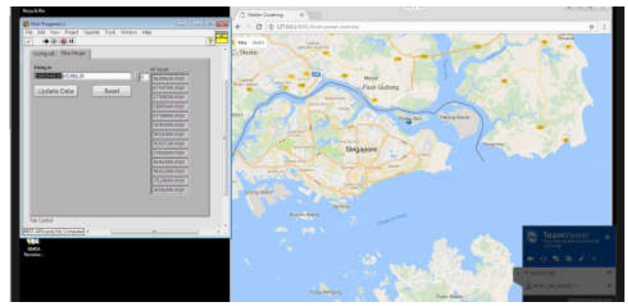

Fig. 20 *Software* LabVIEW

To know the point of coordination on marine traffic then the MMSI is copied to the search map section and then the data base on marine traffic reads and shows the ship's coordination with the destination MMSI so that on the left Figure will show the identity of the ship and the coordinates of the ship. In Figure 20 is a google map system for plotting vessels with the identity of MMSI, latitude and longitude. So to bring the coordinate on google maps then required the identity of the ship in the form of MMSI, latitude and longitude then the update data button to do plotting to google maps and reset to eliminate plotting on google maps in the Figure 20 right.

5.0 CONCLUSION

The AIS (NMEA message) data can be decoded using LabVIEW software into ship data such as MMSI, navigation status, Rate of Turn (ROT), ship speed, ship position (Longitude and Latitude), Course Over Ground (COG), True Heading (HDG), Time Stamp, RAIM flag and Radio status.

The AIS receiver consist vertical antenna tool as receiver frequency and mini PC as data recorder tool. The accuracy of the AIS System is 99.61% in monitoring ship in Singapore Strait.

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