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INFORMATION UNFITNESS OF AIS

ABSTRACT

Commonly used AIS devices on the ships covered by SOLAS Convention creates ideas of the use of AIS data in the situation of the risk of collision. AIS position report is a source of supplementary information derived from error leveraged radar measurement. However, many of users has opinions with regard to inconsistent AIS dynamic data in the process of decision-making by the officer of the watch. Taking into consideration the recordings of the studies and technical specification of AIS, the results of inconsistent data has been analysed in the context of collision avoidance.

Keywords:
AIS, anti-collision.

INTRODUCTION

Probably for every deck-officer it stands no dubt's that radar is a most perfect device for the avoidance of collisions at sea. However in the same way is common knowledge that radar and ARPA has some efficacy limitations. Effective look-out should ensure early detection of objects, but small objects detection is limited by sea clutters and unfavorable weather conditions (rain, snowstorm etc). Another problem is to assess ship motion parameters and foresight situation, specifically when the observed vessel changes her heading. In practice we often use the values of relative courses determined on the basis of altered vessel's observed positions and assumption about the steady moving of both ships. So if the bearing does no change and distance is decreasing, it is considered that the other ship is on a collision course.

Characteristic phenomenon is death-zone appearance (minimum range of detection), radar shadow effect (there are reflections from funnel, mast and other

constructions on the vessel) and wave reflection. As far as ARPA devices are concerned, automatic tracking objects can be lost during torrential ship manoeuvring or when passing ships within close distance.

In addition, in relation to accuracy of present navigation devices (GNSS) radar information is less accurate and generally speaking it can be evaluated by error exceeding 1° in bearing and 1% of distance.

Therefore it is reasonable to supplement the information derived from radar information system operating automatically and continuously with accuracy of the information comparable to the radar and DGPS. A system that appears to be suitable to provide this kind of information is AIS, which may be classified as radio navigation system that use radio waves to transmit data with regard to the ship motion parameters.

QUALITY OF AIS INFORMATION

To illustrate AIS information with respect to the movement of objects in the operation area of the system are elements of the 'Position Report' containing the AIS messages 1, 2 and 3, namely:

— SOG (Speed over ground);
— ROT (Rate of turn);
— HDG (Heading);
— geographic position;
— time stamp.

Dynamic information has been used in the calculations performed by MADSS (Multi-agents Decision Support System), described by [2]. On the basic of received messages AIS calculates ship motion parameters and generates new motion parameters of own vessel (course, speed), which leads to pass by one another depending on calculated CPA (Closest Point of Approach).

Common use of AIS caused the emergence of opinion on the imperfections of the system related to the lack of transmission or the transfer of not integrated information. Studies on the incompletness and integrity of AIS information published to date are generally linked to message No. 5 (Static & voyage related data). This problem was also analyzed by [5] and [1, 4, 6, 7]. However, it seems there is no publications concerning quality of the dynamic information, particularly the one that is important in the analysis of anti-colisionmaneuvering. In view of this facts, an initial investigation has been conducted to determine to what extent the information transmitted by AIS and derived from ship sensors is complete.

INVESTIGATION OF THE AIS DYNAMIC INFORMATION INCOMPLETENESS

Completeness of the messages No. 1, 2, 3 based on contents analysis of messages AIVDM has been studied. Analyzed data origin from the Gulf of Gdańsk and contain recorded information of AIVDMmnemonic from 2006.04.12, at 00.00 to 2006.04.12, at 23.59. Results of studies are presented in figure 1. Dark grey bar shows the percentage of messages that contain incomplete information, and the light grey bar shows the percentage of vessels responsible for this state.

AIS information studies were based on recorded messages in text files containing the messages (received by AIS) about vessels located in the Gulf of Gdańsk during one day. Preliminary analysis of the results leads to the conclusion that the biggest indicator of unfitness is characterised by information about the rate of turn. Incompletness of messages is at the level of 23%. These messeges were sent by approximately 24% of ships. Additionally, it is worth noting the incompleteness of information concerning True Heading, which is approximately 16%, was observed in the case of 19% of vessels. Therefore, there is a reason to perform detailed studies on the incomplete information concerning True Heading and Rate of Turn.

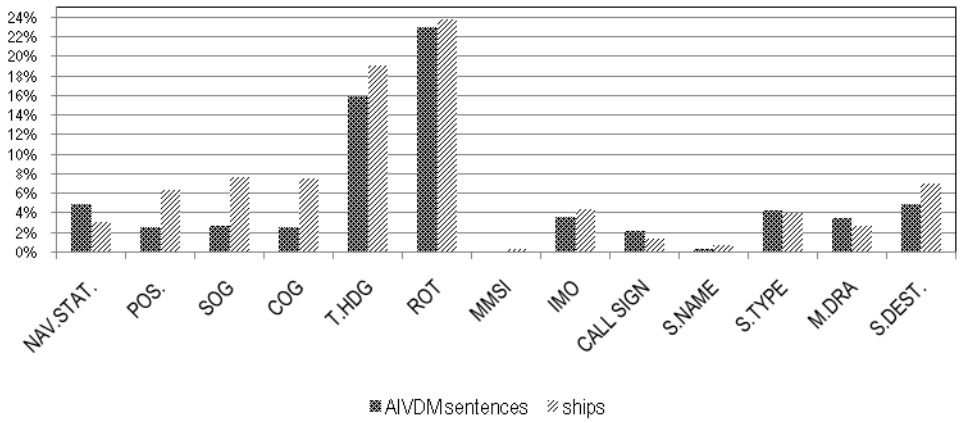

Fig. 1. Initial results of incomplete AIS information [own study]

STUDIES OF INCOMPLETENESS OF SELECTED ELEMENTS OF AIS DYNAMIC INFORMATION

On the basis of AIS specification, AIS correct statement of data concerning volume and value of the incomplete information are shown in table 1.

Table 1. Summary of the ranges of correct and incorrect data in the message No 1 [own study]

Type of information	Correctly value	Incomplete information
TRUE HEADING	[0, 359]	511 (149 hex)
RATE OF TURN	±127	128 (80 hex)

According to assumptions, detailed studies of dynamic information has been pefromed. These studies based on AIS data, concerning ship motion on Gulf of Gdańsk, in wider than those are shown in figure 1. Information about True Heading and Rate of Turn characterise the biggest information unfitness in the preliminary study. Analyzed data contain recorded AIS information with AIVDM mnemonic for selected 49 days. Summary of studies are presented in table 2.

Table 2. Summary of unfitness studies concerning True heading and Rate of turn [own study]

Date	**TRUE HEADING [%]**		**RATE OF TURN [%]**	
	incompleteness (AIVDM sentences)	unfitness (ships)	incompleteness (AIVDM sentences)	unfitness (ships)
2006.04.03	18,40	20,73	26,21	24,70
2006.04.04	17,68	22,83	24,58	26,77
2006.04.05	16,57	20,00	22,97	22,18
2006.04.06	15,25	18,95	21,78	22,88
2006.04.07	17,96	19,81	24,90	25,60
2006.04.08	17,65	21,50	25,69	25,26
2006.04.10	18,85	18,41	24,91	21,53
2006.04.11	16,27	19,11	22,75	23,82
2006.04.12	16,00	17,65	23,07	23,98
2006.04.13	17,81	24,27	26,98	31,80
2006.04.18	21,60	21,16	31,53	30,71
2006.04.19	20,45	22,26	32,70	29,38
2006.04.20	19,92	20,33	30,37	28,65
2006.04.21	19,71	20,78	24,80	27,68
2006.11.22	22,37	26,67	21,83	30,67
2006.11.23	19,93	25,77	21,99	21,99
2006.11.24	21,42	25,26	20,59	26,32
2006.11.25	14,62	24,47	16,81	27,66

Date	TRUE HEADING [%]		RATE OF TURN [%]	
	incompleteness (AIVDM sentences)	unfitness (ships)	incompleteness (AIVDM sentences)	unfitness (ships)
2006.11.26	14,61	20,43	19,92	25,81
2006.11.27	16,21	20,45	24,97	23,86
2006.11.28	17,75	24,18	27,61	30,77
2006.11.29	20,94	23,26	26,45	27,91
2010.12.16	7,69	21,37	7,80	21,37
2010.12.17	7,81	18,56	7,81	18,56
2010.12.26	11,82	19,47	12,41	20,35
2010.12.27	14,97	23,62	14,57	23,62
2010.12.28	15,25	26,12	13,20	25,37
2010.12.29	10,97	23,88	10,37	23,88
2010.12.30	14,58	24,79	13,74	23,97
2010.12.31	14,59	25,21	14,15	23,53
2011.01.01	16,13	28,57	16,09	27,62
2011.01.02	14,26	24,56	14,22	22,81
2011.01.03	10,93	24,55	10,11	22,73
2011.01.04	12,86	27,83	12,70	26,96
2011.01.05	14,05	25,89	13,87	25,00
2011.01.06	17,07	26,09	16,23	24,35
2011.01.07	15,34	27,83	15,14	26,09
2011.01.08	14,64	24,59	13,96	22,95
2011.01.09	12,80	20,80	10,69	19,20
2011.01.10	14,94	22,58	12,21	20,97
2011.01.11	15,52	26,40	12,88	24,80
2011.01.12	10,08	21,30	9,91	20,37
2011.01.14	12,51	27,62	12,33	25,71
2011.01.15	14,89	24,53	12,95	22,64
2011.01.16	15,79	22,86	14,61	20,95
2011.01.17	17,01	25,00	16,62	24,14
2011.01.18	17,38	24,07	17,75	24,07
2011.01.19	13,99	26,61	13,90	25,69
2011.01.20	13,25	23,58	15,88	23,58
2011.01.21	9,12	21,88	13,21	22,92

Figure 2 presents summary of studies concerning AIS information unfitness, and takes into consideration incompleteness of Rate of turn. Dark grey bar presents percentage of incomplete messages concerning Rate of Turn, whereas light grey bar presents percentage of ships, which are responsible for this state.

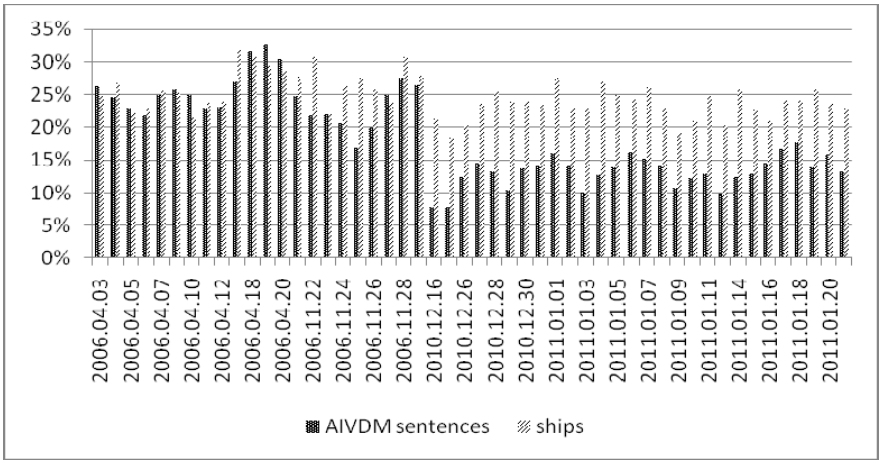

Fig. 2. Summary of unfitness studies of AIS information concerning Rate of turn [own studies]

Figure 3 presents results of incompleteness studies of AIS information concerning True Heading. As previously mentioned, dark grey bar presents percentage of incomplete messages, whereas light grey bar presents percentage of ships, which are responsible for this state.

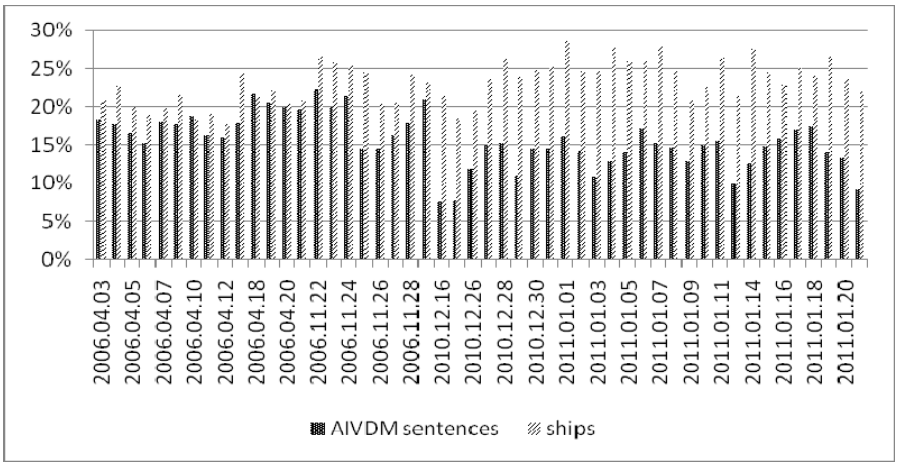

Fig. 3. Summary of studies of unfitness of AIS information concerning True heading [own study]

Taking into consideration investigations from 2010 and 2011, imperceptible decrease of HDG and ROT coefficients with 'AIVDM sentences' criterion is observed. The analysis of results was presented in table below.

Table 3. Analysis of studies of AIS information unfitness from 2006.04.03 to 2006.11.29 [own study]

	TRUE HEADING		RATE OF TURN	
	Sentences (AIVDM)	ships	Sentences (AIVDM)	Ships
$\bar{x}$	18,27%	21,74%	24,70%	26,36 %
m_e	17,89%	20,97%	24,85%	26,07%
max	22,37%	26,67%	32,70%	31,80%
min	14,61%	17,65%	16,81%	21,53%
σ	2,25%	2,46%	3,68%	3,03%
σ^2	0,05%	0,06%	0,14%	0,10%

m_e — median, x — arithmetic mean, σ — standard deviation, σ^2 — variance

Table 4. Analysis of studies of AIS information unfitness from 2010.12.16 to 2011.01.21[own study]

	TRUE HEADING		RATE OF TURN	
	Sentences (AIVDM)	ships	Sentences (AIVDM)	Ships
$\bar{x}$	13,58%	24,29%	13,19%	23,36%
m_e	14,42%	24,56%	13,48%	23,60%
max	17,38%	28,57%	17,75%	27,62%
min	7,69%	18,56%	7,80%	18,56%
σ	2,59%	2,49%	2,42%	2,21%
σ^2	0,07%	0,06%	0,06%	0,05%

CONCLUSIONS

The application of AIS information concerning True Heading and Rate of Turn for collision manoeuvring rises a number of questions among practitioners. Conducted studies have proved this thesis. Two approaches have been applied in the research presented in this paper. Unfitness rate was based on analysis of transmitted AIVDM messages and on the number of ships transmitting AIVDM messages. Arithmetic means of statistical features take similar values. Variance of data reveals high variability characteristic of the study and the incompleteness of Rate of turn is at the level of 15,89% (table 3). Variance of random variables provides information about low dispersion. It is worth noting that the sample taken for testing was performed only on the Gulf of Gdańsk, and the number of statistical units gives a general view of the information unfitness during anti-collision manoeuvring.

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