

Information unfitness as a factor constraining Automatic Identification System (AIS) application to anti-collision manoeuvring

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ABSTRACT

Common use of shipboard AIS creates conditions for the use of a new kind of dynamic 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, in view of the results of the studies there are opinions with regard to inconsistent AIS dynamic data in the process of decision-making by the officer of the watch. By taking into consideration the recordings of the studies and technical specification of AIS it can be concluded that the results of inconsistent data have significant role in collision avoidance manoeuvring.

Key words: AIS; collision avoidance

INTRODUCTION

According to International Regulations for Preventing Collisions at Sea, Rule V "Look-out" [7] „Every vessel shall at times maintain a proper look-out by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision”. Effective look-out should ensure early detection of objects. Another problem is to assess ship motion parameters and foresight situation. One of the effective undertakings is radar look-out in any conditions of visibility, especially, when the vessel navigates in area of intensity traffic or at night. It is common knowledge that Radar and ARPA have some efficacy limitations [8]. Detection of small objects is limited by sea clutters and unfavourable weather conditions (rain, snowstorm), and by close frequency working radio-transmitters.

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. The radar information, usually presented in polar coordinates system is subject to some measurement error exceeding approximately 1% of radar range. As far as ARPA devices are concerned, automatic tracking objects can be lost during torrential ship manoeuvring or when passing ships within close distance. Therefore it is reasonable to supplement the information derived from radar with additional information delivered automatically and continuously with better accuracy. A system which appears suitable to provide this kind of information is AIS which may be classified as radio

navigation system which uses radio waves to transmit data with regard to the ship motion parameters. This information is more accurate than radar information, however for many sea officers it looks less reliably than own radar information.

QUALITY OF AIS INFORMATION

To illustrate AIS information with respect to the movement of objects in the operation area of the system the following 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;
- can be used.

Dynamic information has been used in the calculations performed by MADSS (Multi-agents Decision Support System), described by [2]. On the basis 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 the opinion on the imperfections of the system related to the lack of transmission or the transfer of not reliable information. Studies on the incompleteness and integrity of AIS information published to date are generally linked to the message No. 5

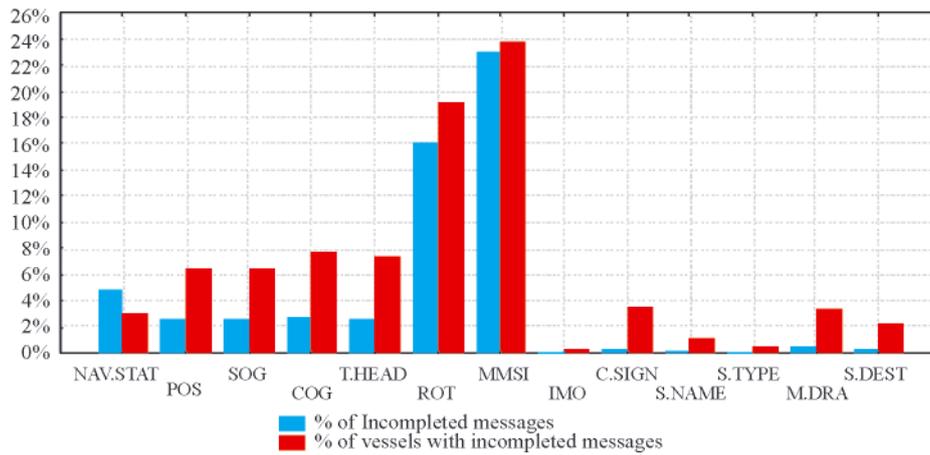


Fig. 1. Initial results of incomplete AIS information [acc. these authors' studies]. **Abbreviations:** NAV.STAT – Navigational status; POS – Coordinates of ship's position; SOG – Speed over ground; COG – Course over ground; T.HEAD – true heading; ROT – Rate of turn; MMSI – Maritime Mobile Service Identity number of the ship; IMO – Ship's IMO number; C.SIGN – Ship's call signal; S.NAME – Ship's name; S.TYPE – Type of the ship; M.DRA – Mean draft of the ship; S.DEST – Destination of the ship;

(Static & voyage related data). This problem was also analysed by [4] and [1, 3, 5, 6]. However, it seems that there are no publications concerning quality of the dynamic information, particularly the one which is important in the analysis of anti-collision maneuvering. In addition mentioned publications has been prepared in the beginning stage of AIS. In view of this facts, an initial investigation has been conducted by authors to determine to what extent the information transmitted by AIS and derived from ship sensors is complete.

INITIAL INVESTIGATION OF THE AIS DYNAMIC INFORMATION INCOMPLETENESS

Completeness of the messages No. 1, 2, 3 based on analysis of contents of the messages AIVDM has been studied. Analysed data originate from the Gulf of Gdańsk and contain recorded information of AIVDM mnemonic from 2006.04.12, at 00.00 to 2006.04.12, at 23.59. The results of the studies are presented in Figure 1. Dark grey bar shows the percentage of messages which contain incomplete information, and the light grey bar shows the percentage of vessels responsible for this state.

The 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 only. Preliminary analysis of the results leads to the conclusion that the biggest indicator of unfitness is characterised by information about the rate of turn which seems to be very important for anticollision activity. Incompleteness of messages is at the level of 23%. These messages were sent by 24% of ships, approximately. Additionally, it is worth to noting the incompleteness of information concerning True Heading, which

amounts about 6% and 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.

STUDIES OF INCOMPLETENESS OF SELECTED ELEMENTS OF AIS DYNAMIC INFORMATION

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

According to the assumptions, detailed studies of dynamic information has been performed in 2010 and 2011 in selected 49 days. Data has been recorded with shore receiver situated in the building of Polish Naval Academy in Gdynia. Information about True Heading and Rate of Turn characterise the biggest information unfitness like in 2006 preliminary study. Summary of this are presented in Tab. 2.

Tab. 1. Summary of the ranges of correct and incorrect data in the message No 1

Type of information	Correctly value	Incomplete information
TRUE HEADING	[0.359]	511 (149 hex)
RATE OF TURN	±127	128 (80 hex)

Figure 2 presents summary of the studies concerning AIS information unfitness, and takes into consideration

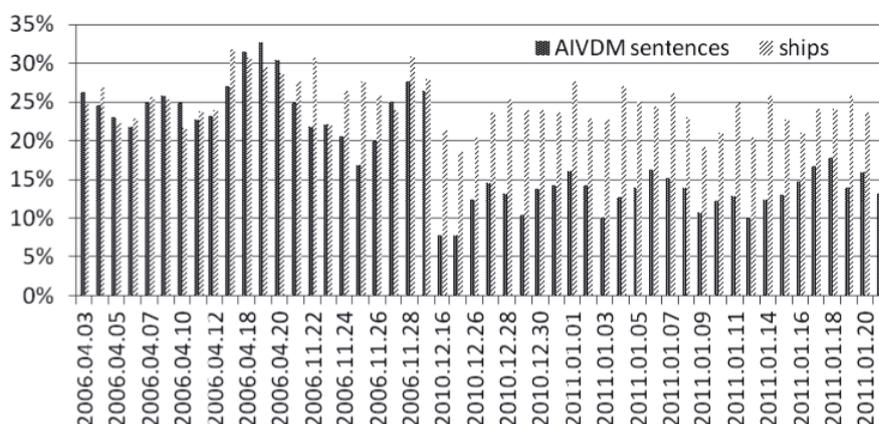


Fig. 2. Summary of unfitness studies of AIS information concerning Rate of turn [acc. these authors' studies]

Tab. 2. Summary of unfitness studies concerning True heading and Rate of turn [acc. these authors' studies]

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
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

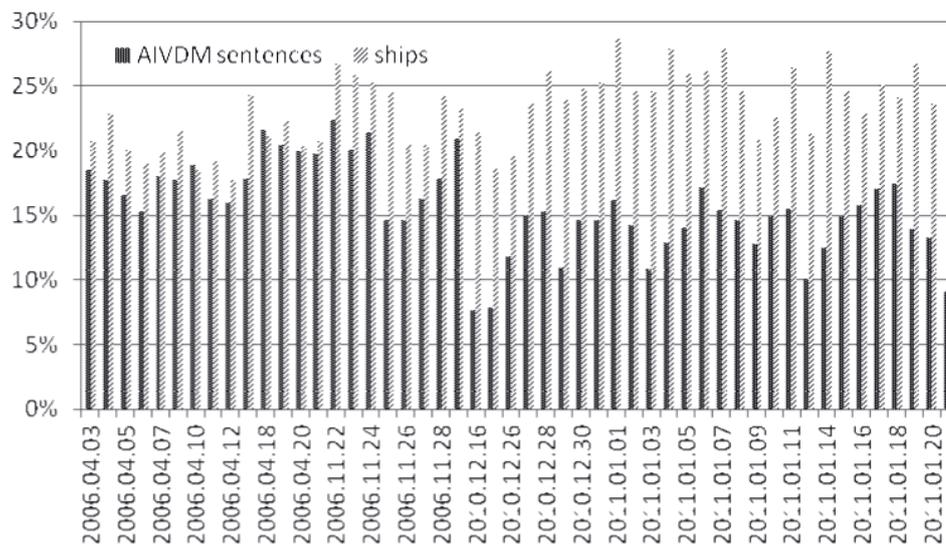


Fig. 3. Summary of the studies on unfitness of AIS information concerning True Heading [acc. these authors' studies]

incompleteness of Rate of Turn. The Dark grey bar presents percentage of incomplete messages concerning Rate of Turn, whereas the light grey bar presents percentage of ships, which are responsible for this state.

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

Taking into consideration the investigations performed in 2010 and 2011, only an imperceptible decrease of HDG and ROT coefficients with "AIVDM sentences" criterion is observed. The analysis of the results is presented in Tab. 3.

Tab 3. Analysis of the studies on AIS information unfitness, gained in the period from 2006.04.03 to 2006.11.29

	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, \bar{x} - arithmetic mean,
 σ - standard deviation, σ^2 - variance

Tab. 4. Analysis of the studies on AIS information unfitness, gained in the period from 2010.12.16 to 2011.01.21

	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%

m_e - median, \bar{x} - arithmetic mean,
 σ - standard deviation, σ^2 - variance

The essential percentage of misinformation about the Heading and Rate of Turn observed during investigations demands further explanations. One of reasons can be the frequent lack of measures of ROT on smaller ships. The other sources can be moored ships with active gyro, what can give the effect of misinformation about the Heading. Possible source of unfitted information about HDG can be some problems with connection between gyro and AIS device. Interesting is observation that different strategies of investigations gives us different results. For example mean value of wrong information about ROT is 13% or 23% - depends the name of ship is analyzed or type of AIS sentence. This leads to the conclusion that probably some ships without sources of ROT be present in analyzed radius more times than another.

CONCLUSION

- Potential application of AIS information for anti-collision manoeuvres seem to be promising however concerning True Heading and Rate of Turn data transmitted by this system rises a number of questions among practitioners. The question is why so many times information about HDG is unfitted. Suggestion is that there are some technical problems with connection between gyro and AIS device.
- During presented studies two approaches have been applied. The unfitness rate was based on analysis of messages in the system and on the number of ships transmitting this messages. The arithmetic means of statistical features take similar values. The variance of data reveals their high variability characteristics of the study and the incompleteness of Rate of turn is at the level of 15.89% (Tab. 3). The variance of random variables provides information about their low dispersion. It is worth noting that the sample taken for testing was gained only from the Gulf of Gdańsk, and the number of statistical units gives only a general view of the information unfitness during anti-collision manoeuvring. Conclusion about possible using AIS information for anti-collision tasks is that more reliable is information about course over ground transmitted by the ship than her heading.

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