Study on Application of Real Time AIS Information

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Abstract

Now AIS (Automatic Identification System) has been under full operation for ocean-going vessels, and it is expected not only to identify target ships but also to take collision avoidance using AIS information with Radar and ARPA information in restricted waters. AIS information is very useful not only for target identifications but also for taking collision avoidance, but OOW (Officer OF Watch-keeping) should take care of systematic observation of AIS because of miss-operation or malfunction of AIS. In this paper, we propose the application of Onboard Ship Handling Simulator with visual system displayed 3D scene added AIS performance such as blind areas of Island, microwave propagation, etc. and maneuvering simulation using TK models, applied real time AIS information and research the effectiveness of this system for ship handling in restricted waters, and discus the principal issues through the on board experiments. Conclusion will be expected that; 1) systematic observation of AIS information using visual scene simulator with AIS information will be effectively done, 2) observation compared with Radar and ARPA information will be also useful to make a systematic observation, 3) using the recording and replay function of simulation will be useful not only for systematic observation but also to measure and to encourage officers' skill.

1. Introduction

Today it is coming UAIS (formally UAIS should be used for ocean-going vessels, AIS will be used later in this paper) has been under full operation for ocean-going vessels, and it is expected not only to identify target ships but also to take collision avoidance using AIS information with Radar and ARPA information in restricted waters. It means that AIS information such as ship's identification issues, her ship's position, SOG (Speed Over the Ground), COG (Course Over the Ground), Heading, ROT (Rate Of Turn), etc. is very useful not only for identification but also for ship-handling to take collision avoidance. So, it is expected that AIS information is very useful, but OOW should take care of systematic observation of AIS because of miss-operation or malfunction of AIS and system concept of AIS which means that UAIS should not be applied to ships bellow 300GT engaged on any voyage and 500GT not engaged on international voyage.

AIS have superior performance to get target navigational information, but there are some problems to use AIS information except applications of target identification which is original object of AIS. In this paper, we propose the concept of Onboard Ship Handling Simulator, which has visual system displayed 3D scene added AIS performance such as blind area of Island, microwave propagation, etc. and maneuvering simulation using TK models, applied real time AIS information and research the effectiveness of this system for ship handling in restricted waters. Conclusion will be expected that; (1) systematic observation of AIS information using visual scene simulated with AIS information will be effectively done, (2) observation compared with Radar and ARPA information will be also useful to make a systematic observation, (3) using the recording and replay function of simulator will be useful not only for systematic observation but also to measure and to encourage officers' skill.

2. Application System

It should be necessary to get target ships' movements for making good decisions in case of collision avoidances. It is enough in an ideal condition to get target ships' information using by AIS communication, but there are some cases when it misses the information according to no good communication conditions. So, it is necessary to take systematic observation even in case of using AIS and needs to visual and Radar watch. In this chapter, first briefly AIS information will be introduced, and second the proposed system using AIS information and simulation technique will be discussed with total system, Look-out Monitoring mode, Trail Simulation mode and Onboard Simulation mode.

2.1 AIS

AIS information transmitted from target ships is defined in 2002 SOLAS Chapter V[1] and IMO Resolution MSC.74(69)[2] and consists of navigational information and the accuracy or performance of them shown in Table 1. In Fig.1 the definitions of AIS information will be presented.

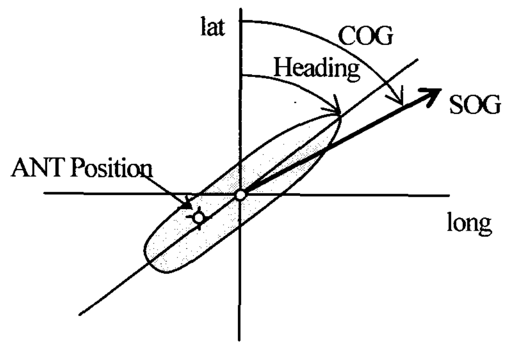

Fig.1 Definition of Information

Table1 AIS Information

Information	Items
STATIC	IMO number Call Sign and name Length, Beam, Type of Ship Location of Pos.-fixing ANT onboard
DYNAMIC	Ship's Pos. with accuracy and integrity Time in UTC COG (Course Over the Ground) SOG (Speed Over the Ground) Heading Navigational Status (Manual Input) Rate Of Turn (where available)
VOYAGE related	Ship's draught Hazardous cargo (type) Destination and ETA (at masters discretion)

The information will be transmitted to refresh in every some seconds decided by her navigational condition such as her ship's speed, etc. shown in Table 2.

Table2　Reporting Interval

Type of Ship	Reporting Interval	Type of Ship	Reporting Interval
Ship at Anchor	3 min	――――――――	――
Ship 0-14knots	12 sec	Ship 0-14 knots and Changing Co.	4 sec
Ship 14-23 knots	6 sec	Ship 14-23 knots and Changing Co.	2 sec
Ship > 23 knots	3 sec	Ship > 23 knots and Changing Co.	2 sec

2.2 Performance of AIS

Main purpose of AIS is to identify the target ship existing around own ship, so one of AIS performance is the detection range which is told to be able to communicate between 20 and 30 nautical miles in typical condition. One more characteristics of AIS is the transmission of navigational information such as heading which is not able to obtain from the Radar and/or ARPA information, and there is no swapping data in AIS which happens sometimes in ARPA.

2.2.1 Detection Range

The detection range of AIS using with VHF band radio wave is approximately similar as Radar radio wave in the air, so it's line of sight (LOS nm) is shown as (1) equation same as Radar propagation.

$$LOS = 2.22 * (\sqrt{h} + \sqrt{H}) \qquad (1)$$

Where h and H is own ship's and target ship's antenna height (units are meter).

Although the propagation characteristics are approximately similar, but in propagation of VHF radio wave, there is the affection of edge diffraction in the case of passing over mountain, Islands or large obstructions. When there is a large obstruction such as Island or large construction, the radio wave diffracts and the radio wave will be able to reach over the obstruction, not just behind.

2.2.2 AIS Information

AIS transponder transmits navigational information described in Table 1, but heading and ROT (Rate Of Turn) are not in forced now and AIS are not carried by all ships in forced. So, in present the utilities of navigational information of AIS are not perfect and it is necessary to take sequential and systematic observation.

3. Application using Real-Time AIS Information

In case of collision avoidance, it should be necessary to get information of target ship's movement for correct judgment, but is it enough for information got by AIS to get target ship's movement? It is enough to do in ideal situation, but there are some cases when it is not able to get enough information for collision avoidance because of signal interruption just mentioned above.

3.1 Application for Collision Avoidance

Considering application of real-time AIS information, it is the first issue to take a collision avoidance. It consists of three modes which are;

(1) Look-out Monitoring,

(2) Trial Simulation and

(3) Onboard Training.

The details of each mode will be introduced bellow.

3.1.1 Look-out Monitoring

In case of Look-out Monitoring, it is able to observe target ships' movement systematically, and take a relationship between visual, AIS and Radar/ARPA information. So, this mode is adapted according to reducing OOW's load.

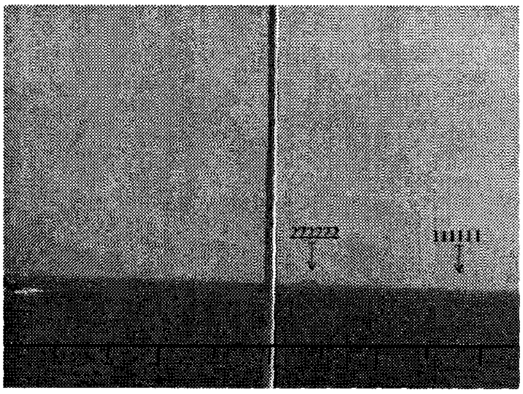

Fig.2 Example of Look-out Monitoring image

Discussing reliability on detecting target ship, visual system has best one, Radar has second one and AIS has worst one. So, Look-out Monitoring mode consists of three information and presents on one screen superimposing Radar image and AIS information based by visual image through video camera. Fig.2 shows example of Look-out Monitoring image. In this figure numbers and devices shows MMSI numbers and relative bearing. MMSI is assigned with formally 9 digits, but here used imaginary numbers.

This number is able to be changed to ship's call sign or ship's name and in request the AIS information received should be displayed. MMSI number should be put on the display calculated by the target ship's relative bearing.

3.1.2 Trial Simulation

In case of Look-out Monitoring, it is taken properly to judge situation not only same as ARPA trial simulation but also there is some possibility of more effective utility.

This effective utility is to simulate target ship's operation, not own ship's. In this simulation mode, the condition should be required that un-carriage AIS vessels in the vicinity of the selected target ship should be detected by visual or Radar. The best way is that all vessels should be carried AIS and it should be able to get information from any vessels by not only AIS communication but also any other wireless broad band communication such as TV broadcasting, etc.

Trial simulation should have two display mode which are (1) visual sight mode and (2)Radar mode.

(1) is using the video information from bridge sight, just as Fig.4. In poor visibility or target ship's mode, it is able to interpolate by the 3D Computer Graphics. In using 3D-CG, it is able to change eye-position on demand. The target model should be assigned by the AIS information, so visual model would be simple model (ship's length and her beam) and target ship's maneuvering mode would be able to be simulated by TK model, if necessary. Own ship's maneuvering mode is able to be simulated by MMG model.

(2) is superimposing AIS information received on Radar image and chart information such as ENC. This mode already is applied to ECDIS.

3.1.3 Onboard Training

Onboard Training is able to be applied (1) observation for cadets training onboard and (2) recording and replay system, after the condition mentioned before should be satisfied.

(1) is usually used on training vessel. Instructor is able to teach navigational situation exactly and systematically.

(2) is useful for encourage the officers' skills and survey not only case studying but also establishing navigators' behaviors and skills statistical systematically.

3.2 System Evaluation

It should be discussed the condition of AIS information communication to discuss the possibility of proposed system. The survey on the communication condition of AIS Information was done using T/S Kaigi-maru belonged by MTC. So, in this chapter we discuss the result of experience on AIS Information and the possibility of application.

3.2.1 Condition of AIS Information communication

As general performance of AIS is described in 2.2.1 section, coverage of AIS within 20 or 30 nautical miles, but it is said that the possibility of slot collision should be affect the communication disturbance and missing data. One more important issue is the reliabilities on AIS information.

According to experimental observation of monitoring AIS, the maximum range is sometimes over 70 or 80 nautical miles, but it is not able to take continuously monitoring because of collision of slots. Fig.3 shows the example of edge diffraction. The observation condition is ANT height is 8 meters and anchored (+ marking is anchored position).

Fig.3 shows the affection of edge diffraction over the mountain on island, but in this case also not continuously monitoring same as in the case of long distance. There are little cases which the interruption of receiving within 20 nautical miles.

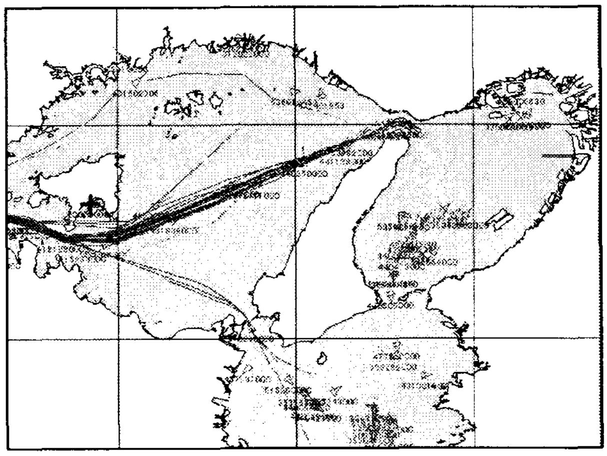

Fig.3 Example of AIS monitoring (in Inland Sea)

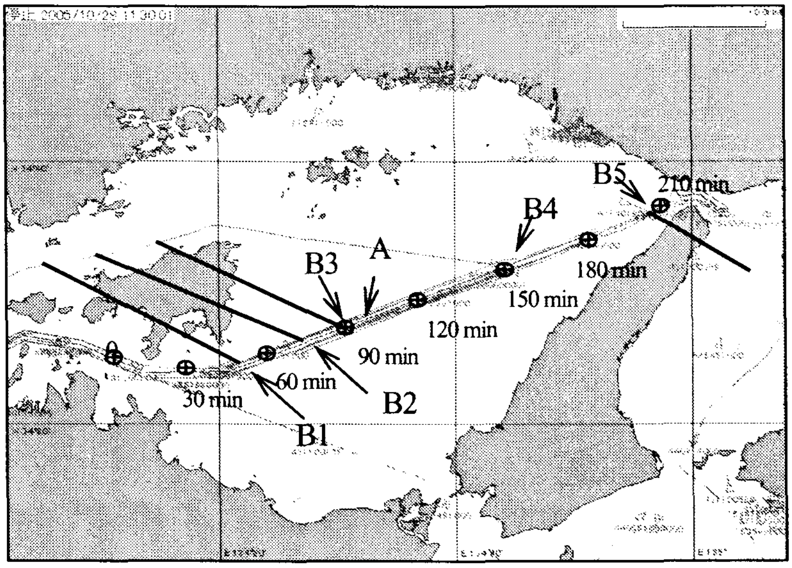

Fig.4 Truck of Own Ship during survey

The AIS receiving situations were surveyed under sailing and sampled two cases which are (1) the case in LOS (Line Of Sight) and (2) the case out of LOS. Fig.4 shows the truck of own ship and target ships.

(1) The case within LOS

Own ship (T/S Kaigi-maru) was sailing course 067 degrees, and after 90 minutes passed at point A she and target ship (Lpp = 117 meters, B = 19 meters) passed each other, these trucks of own and target ships are shown Fig.4 and interval time and range from target ship are shown in Fig.5. Target ship's speed is approximately 12.5 knots, so interval should be 10 sec.

When no signal receiving does sequentially continue more than 5 times of interval, then AIS judges lost target. So, in Fig.5 the dot straight line named "LOST LINE" shows the limit of lost target.

In this case, the coverage of AIS is approximately 15 nautical miles, and in astern it might be affected by the mast, etc. because of installation of AIS antenna.

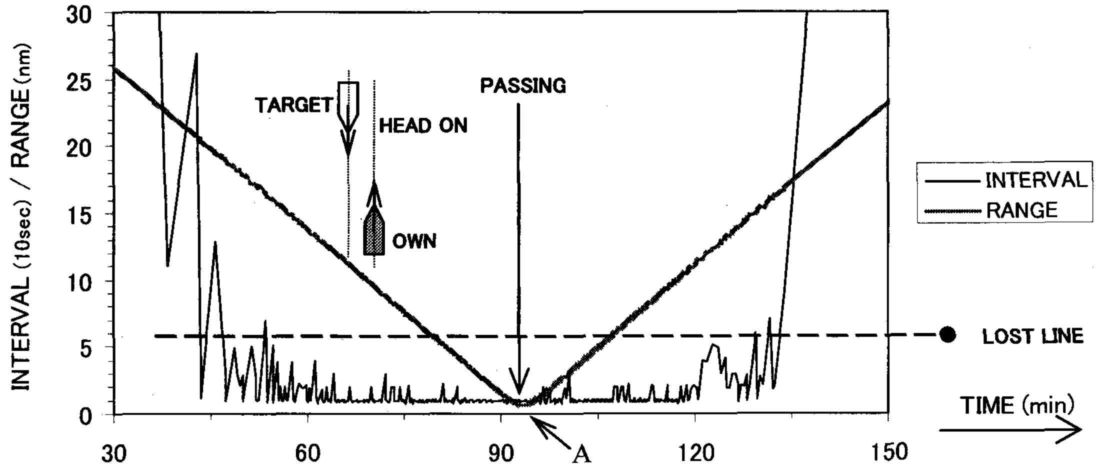

Fig.5 The Relationship between Interval and Range (In case of head on)

(2) The case out of LOS

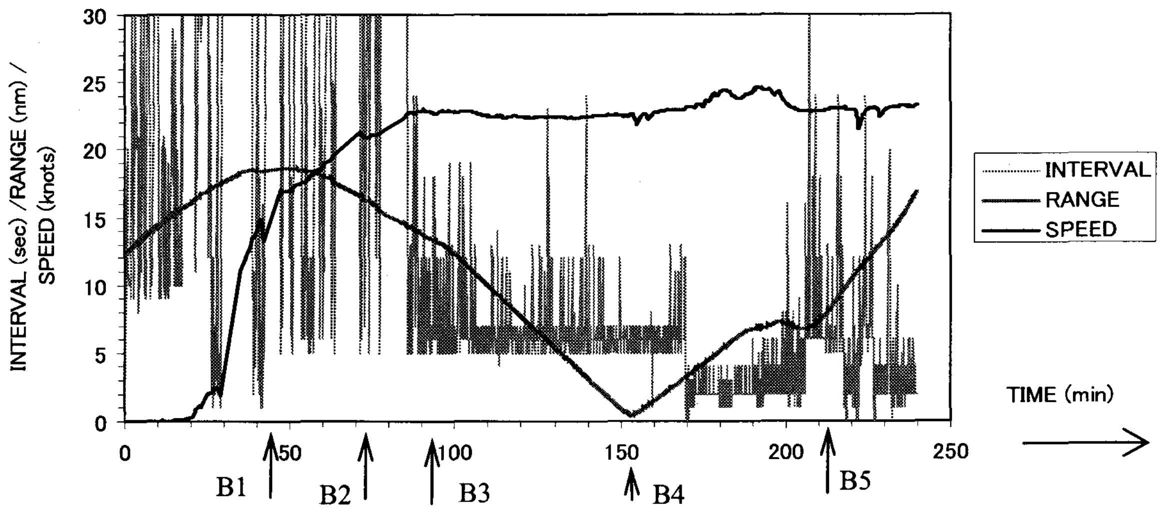

Fig.6 The Relationship between Interval, Range and Speed (Effectiveness of edge diffraction)

In this case, target ship was sailing with variable speed. After 40 minutes, her SOG was over than 14 knots, so basic interval was 6 seconds. Between 170 minutes and 205 minutes her SOG was over than 23 knots, so basic interval became to 2 seconds.

Fig.6 shows the effectiveness of edge diffraction clearly between point B1, B2 and B3, and after B3.

Target ship's Lpp is 167 meters and B is 27 meters. AIS information does not include ANT height, so we assume it from Lpp, B and/or draught. ANT height might be 25 meters, then LOS is 18.5 meters, but due to the edge diffraction coverage is approximately 15 nautical miles.

Between point B3 and B5, target lost did not occur, but the interval is sometimes twice or three times of typical one even within 3 nautical miles. Especially in the case of interval 6 sec at higher speed (approximately 20 knots) relative speed 15 knots, so it is not enough to take a judge or action against twice or three times interval.

(3) Collision Avoidance

T/S Kaigi-maru is 150 GT and bridge (or eye) and AIS antenna height are 5 meters and 8 meters. The experience was done in navigation through Akashi channel and bound for her home port east side of Kobe port. This result is shown in Fig.7 and 8. Fig.7 is the result at the starting time and Fig.8 is at the end of experience.

The one of issues is no missing during experience and it may be concluded that in the vicinity of own ship there is no missing, but in the situation when the signal level is low by the radio wave propagation such as edge diffraction or the case when propagation distance is approximately limitation.

Reliability of AIS information consists of two points. One is the detection of non carriage vessels and the other is the reliability of information.

The former issues request the monitoring visual sight and/or Radar information. During this experience, non carriage vessels were passing T/S Kaigi-maru, in Fig.4 shows two non carriage vessels, one of which is the left side of display and another one is the beside of MMSI 222222. So, instead of visual lookout, it is suitable to apply the visual information by video camera. But even using video information, it is very difficult to get the detail information from target ship.

The latter one is the error or trouble of instruments onboard and at now it is not required to send information such as heading and rate of turn in force. So, it should be desired to monitoring system of malfunction of target ship's sensor, such as gyrocompass and/or GPS. In GPS it is preparing RAIM flag, RAIM means Receiver Autonomous Integrity Monitoring, regarding of this reason this kind of procedure will be useful of information reliability in future.

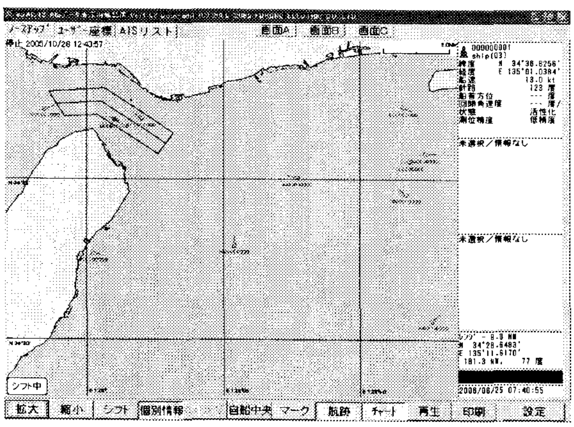

Fig.7 Result of Experience onboard (1)

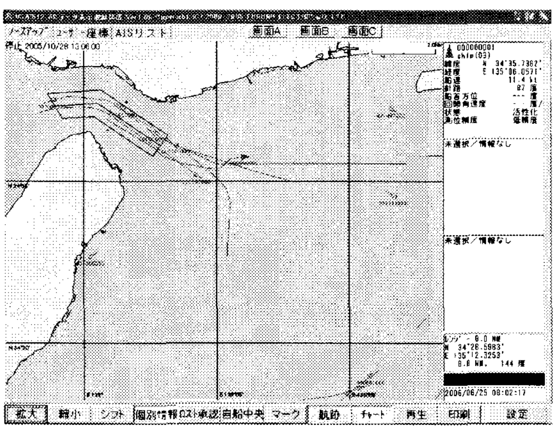

Fig.8 Result of Experience onboard (2)

3.3 System Possibility

The issues on the non carriage vessel, the range of carriage vessels will enlarge after execution of Class B which now is proceeding. Even though Class B would be executed, there is even some problem for detecting less than merchant ships such as leisure craft, etc.

Now it is under development of fusion AIS and Radar/ARPA, but information from Radar/ARPA has limitation such as no information of heading, time lag, etc.

Ideally it will be requested that any vessels should be carried in force for communication of ship's information. It will be very difficult to put into practice, so proceeding of the fusion between AIS and Radar/ARPA will interpolate the lack of performance.

4. Conclusion

Using AIS effectively, it is possible to make a good condition of communication according to a good installation of AIS ANT and for constructing fusion of Radar/ARPA and AIS we need survey more information and performance of sending and receiving signals.

Conclusion is expected as follows.

(1) Systematic observation of AIS information using visual scene simulated with AIS information will be effectively done.

(2) Observation compared with VISUAL, Radar and/or ARPA information should be essentially done to make a systematic observation.

(3) Using the recording and replay function of simulator will be useful not only for systematic observation but also to measure and to encourage officers' skill.

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