

Research on risk long range identification for vessel traffic dynamic system

Ji Qi^{1,a,*}, Ruijuan Guo^{1,b}, Xiaoyu Wang^{2,c} and Hainan Zhang^{3,d}

¹The College of Engineering and Technology, Jilin Agricultural University, Changchun, Jilin, 130118, China

²Faculty of Automation and Information Engineering, Xi'an University of Technology, Xi'an, Shanxi, 710048, China

³School of Electronic and Electrical Engineering, Shanghai University of Engineering Science, Shanghai, 201620, China

^a *olifant@foxmail.com, ^bguiruijuan022@163.com, ^cwangxiaoyuvvv@foxmail.com, ^dzhn2368@163.com

Abstract. Vessel Long-range identification and tracking system has already been widely installed and applied in vessel. In this paper AIS system, vessel reporting system and LRIT in China are compared and analyzed based on the coverage area, confidentiality and accuracy of the LRIT information. Vessel Long-range identification and tracking model is established through a combination of AIS with LRIT system, which is applied to the research of vessel traffic dynamic system risk long range identification. Finally, the application of LRIT in the maritime field is discussed.

1. Introduction

In 2014 June, the International Maritime Organization (MSC) 93rd meeting has been sponsored and organized in London, which suggested that the IDE encryption technology should be adopted to carry out calculations and discussed the technical implementation as well as security of LRIT system^[1]. At the 95th maritime safety meeting held in Shanghai in 2015 May, navigation, communications and search and Rescue Committee (NCSR) dictated the secretariat to modify the COMSAR module of Global Integrated Ship Information System GISIS, so that it could accept the SAR geographical boundaries as the LRIT standard form. In view of consummating the LRIT technology problems further, LIRT system is becoming more and more important to the influence on ships safe passage.

2. The summary of vessel risk long range identification and tracking system

Vessel Long Range Identification and Tracking System obtains information from communication service, it could send the message back to the flag state through the supplier who owns the only-allowed application business and provide users with LRIT data through the LRIT system data center. With high recognition efficiency and accuracy, LRIT system can help us to identify various types of information in offshore vessels immediately so that it could improve navigation safety of vessels and decrease potential risk at sea ultimately^[2]. LRIT system is regarded as the necessary navigation device for special vessels to guarantee safety by IMO since January 1, 2008. The general description of only several typical LRIT data transmission ways; however, it is more complicated of



the transmission ways in practical. The contents could be summarized as following: The information of the vessel could be obtained by country A only if it is within the territorial waters of the country or ready to enter the port in country A but not in its territorial water simultaneously, when Country A has right to acquire LRIT information from international LRIT through its national LRIT date center. When the vessel of country A is within 1000 miles distances off the baseline of territorial sea in country B and out the range of the territorial water in other country, country B has right to acquire the vessel LRIT information of country A through its national LRIT date center from international LRIT.

3. LRIT system database

In order to establish the database of LRIT system, the respective features of AIS, ship reporting system and LRIT are required as well as the advantages in terms of geography coverage, information content, supervision of ships, the time intervals for information acquisition from base station, confidentiality of information and so on^[3]. The characteristics are showed in chart 1.

Chart 1 Characteristic comparison chart of AIS and ship reporting system and LRIT

	AIS	ship reporting system	LRIT
Coverage	Sea area A1, 25n mile offshore	North of 9° N, west of 130° E	Within 1000 miles off the baseline of territorial sea
Information content	Static information, dynamic information	Seven optional sending report according to the situation	Ship identification code, position and time
Supervision of ships	Almost all ships in the world within the range	Ships of compulsory participations with Chinese nationality and encourages participation with foreign nationalities within the range	Ships of all nationalities within the range and ready to enter the domestic port
Time intervals for information acquisition	Once per 6 minute for static information, once per 2 second for dynamic information	Once per 24 hours for position report	Once per 6 hours or variable according to the paging of shore station, the shortest time intervals is once per 15 minute
Confidentiality of information	Unclassified, broadcast	Unclassified	Good confidentiality

As shown in chart 1, AIS system has the most detailed and accurate information, but its coverage is poorer; as the two major monitor ways when the cover range is out of AIS, LIRT and ship reporting system have close coverage, similar position information and same management model; in terms of accuracy, LIRT has the highest positioning accuracy when its information comes from GPS. The monitoring precision of ship position would be improved effectively if the simulating and predicting functions of ship reporting system were combined with the position information of LIRT system^[4]. By analyzing the advantages and disadvantages of various systems, a proper ship monitoring system could be established for making up the defect of blind zone in existing systems through a combination of monitoring and tracing functions in AIS system and the Information data of LIRT system, then the new technological measures of vessels management and technological service would be improved for the maritime business in China.

4. The navigation risk analysis of LRIT system based on AIS

The performance of AIS system can be directly affected by communication performance of SOTDMA and CSTDMA agreement since its core concept comes from broadcast repeater principle. The Communication simulation model of LRIT in AIS system is built on SOTDMA agreement to support analyzing the navigation safety.

Set the number of a kind of vessels as $M_i (i=1,2,...,7)$, the reporting period as $T_i (i=1,2,...,7)$ second, then the total number of slot time occupied by various types of vessels is as follows.

$$N = \sum_{i=1}^7 \frac{60}{T_i} \times M_i \quad (1)$$

Set the system capacity as C , the total number of slot time as SL , the report rate as R_i (usually take 10 times /min), then we have the following equation in single channel operation.

$$C = \frac{SL}{R_i} \quad (2)$$

In the condition of binary channel, the above equation can be expressed:

$$C = 2 \times \frac{SL}{R_i} \quad (3)$$

The equation for calculating the actual capacity N_c in the simulation system is as follows.

$$N_c = \frac{N_s}{C} \times 100\% \quad (4)$$

In the equation, N_s is the actual number of AIS slipway in the AIS base station system, C is the capacity of the AIS base station system.

The time slot utilization rate P can be expressed:

$$P = \frac{N_s \times R}{2250 \times 2} \times 100\% \quad (5)$$

The time slots are free and wouldn't be reused if $P < 100\%$; the time slots are all occupied and could be reused if $P > 100\%$; then the number of multiplexing time slots is expressed as:

$$S_{reuse} = N_s \times R - 2 \times 2250 \quad (6)$$

The risk probability P_m of the conflict between the transmission of the given vessel and the any other vessel from AIS subnet within the visual time range is as follows:

$$P_{\Delta T} = 1 - \frac{N_{tot}}{37.5 \cdot n_{ch} \cdot M \cdot \Delta T} \quad (7)$$

Set N as the number of vessels covered by AIS subnet, N_{max} as the maximum number of vessels by AIS subnet, N_{tot} as the total number of vessels, spose $N_{tot} = NM$, $n_{ch} = 2$.

Within the observation time T_{obs} , the probability P_n of each vessel detected by satellite in the coverage area is the following equation:

$$P_n = 1 - \left[1 - \frac{N_{tot}}{37.5 \cdot n_{ch} \cdot M \cdot \Delta T} \right]^{M-1} \frac{T_{obs}}{\Delta T} \quad (8)$$

We can know from the analyzing of the risk probability, the greater the number of vessels N covered by AIS subnet, and the more the sum M of AIS subnet inside the viewable area, the less the probability P_n of the location and quantity of vessels being detected, this demonstrates a higher risk of safe navigation in vessels; and vice versa.

AIS system and LRIT system are independent each other and there are many differences in the transmission distance, transmission mode, transmitter and receiver, the confidentiality of information between them, information. The maritime search and rescue organization based on LRIT system can not only obtain the information of national or regional database, but also have free access for LRIT information of marine vessels from other databases in view that LRIT system greatly increases the scope of search and rescue in AIS system^[5].

Rescue coordination center (RCC) in the wrecked sea area conducts a comprehensive analysis of the received information from AIS system and LRIT system to diagnose the information in quantity, position and state of nationality of wrecked ship, then the analyzing and diagnosing results would be sent to the wrecked ship. It is thus clear that the LRIT system based on AIS would be of great benefit to the analysis and research of ship navigation safety.

5. The influence of LRIT system on Chinese maritime accident

Strengthening the identification and tracking of unknown ships is very important to guarantee the national security, defend source or origin prerequisite to ensure national security, ready for defense and reduce risk. The information acquisition of LRIT has a very wide scope, which would notify the country and port being attacked in advance and extend the monitoring range to a distance within 1000 nautical miles from the baselines of the territorial waters. When the country and port could be aware of the danger as soon as possible, monitor the tendency of dangerous ships, and managed to assemble enough naval vessels for intercepting at the same time. In conclusion, LRIT provides an effective time assurance for dealing with such emergencies.

LRIT system has the function of checking passing vessels within region time, especially in tracking and managing the focus ships into or out of the port carrying oil or hazardous chemicals. The assistant support methods, such as risk assessment of ports and docks and incensement of reaction time, are provided to prevent the accidents of oil leakage and spill and the investigate illegal discharge into sea, recognition of oil spill accident, admiralty action and so on.

About 90 percent of the ship-owners did not receive any warning information about danger and suffered great loss, so LRIT system has become the necessary equipment of the ship which could generate pre-alarm information^[6]. Because the unique properties of LRIT report, the ship-owning company and the relevant agency-in-charge still could detect and track the abnormal navigating vessels promptly, lock the position of the criminal, warn the coming and going vessels, and inform the near cordon force to coordinate and organize for capturing the pirates, even when the alarm system of LRIT is out of order.

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