Available online at www.sciencedirect.com

ScienceDirect

International Journal of e-Navigation and Maritime Economy 3 (2015) 142 – 149

International Journal of e-Navigation and Maritime Economy

www.elsevier.com/locate/enavi

Original article

Ship-to-Ship Radiocommunication Trial by Using Wireless LAN *

Yasuyuki NIWA [1], *Hisaya MOTOGI* [2], *Chihiro NISHIZAKI* [1], *Misako URAKAMI* [2]
Takahiro SETA [1], *Mitsuru KOBAYASHI* [1], *Makiko MINAMI* [1]

[1] National Maritime Research Institute (NMRI), Japan, yaniwa@nmri.go.jp
[2] National Institute of Technology, Oshima College, Japan

Abstract

Seamless transfer of electronic information/data between ship-to-shore and vice versa and between ship-to-ship and shore-to-shore is being developed in the IMO e-Navigation strategy implementation plan (SIP). We have been focused on wireless LAN for ship-to-ship radiocommunication.

In a former field radiocommunication trial, omni-directional antennas were used and a few hundred kbps throughput between two ships was measured, which was not enough for our research target (over 1Mbps). In order to get faster throughput, a field radiocommunication trial was carried out again with a few types of directional antennas and RSSI (Received Signal Strength Indication) and the throughput between two ships was measured simultaneously. As a result, multi-path (2-path) model affected by the reflection of the sea surface was confirmed and also the characteristics of the directional antennas such as half-power angle were confirmed, but the measured throughput was fast enough to meet our expectation.

Keywords: ship-to-ship radiocommunication, wireless LAN, directional antennas, RSSI, throughput

* This is a revised version presented at the 2nd Ai-MAST held at Mokpo National Maritime University in Mokpo, Korea, May 17-19, 2014.

I. Introduction

"E-navigation is the harmonized collection, integration, exchange, presentation and analysis of marine information on board and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment." (IMO MSC 85/26/Add.1, Annex 20, 2009, p.1) IMO NAV (Safety of Navigation) and COMSAR (Radiocommunications and Search and Rescue) Sub-committees, currently NCSR (Navigation, Communications, and Search and Rescue) Sub-committee, agreed "the development of e-Navigation strategy should be user-driven and not technology driven." (IMO COMSAR 11/18, 2007, p.43) So the development of the e-Navigation strategy was based on the user needs. In table 1, the use of wireless technology was addressed in the issues to consider the captured user needs (IMO NAV 56/WP.5/Rev.1, 2010, p.8). Furthermore, the system architecture of the e Navigation was based on 4S (Ship-to-Ship, Ship-to-Shore, Shore-to-Ship and Shore-to-Shore) communication. So we have been focused on Ship-to-Ship radiocommunication by using wireless LAN.

User Need	Justification	Relation to IMO Strategy (Section 8.2)	Priority in terms of work required	Issues to Consider
Effective and robust Communications	A clear need was expressed for there to be an effective and robust means of communications for ship and shore users. Shore-based users require an effective means of communicating with vessels to facilitate safety, security and environmental protection and to provide operational information. To be effective, communication with and between vessels should make best use of audio/visual aids and standard phrases to minimize linguistic challenges and distractions to operators. Research has indicated that a high percent of mariners regards language incompatibility and non-standard phrases a major problem. They also highlighted equipment failure and busy communication channels a concern that needs to be addressed.	Automated and standardized reporting functions. Effective and robust communications. Common Marine/Data Structure Data and System Integrity Human Centred Presentation Needs	Research into how voice and digital communication can be made more effective. Plan for greater use of IMO SMCP. Identify reliability standards for communication technology. Identify communication capacity issues to ensure adequate bandwidth for essential communication needs.	Navigational intention exchange Use of AIS application specific messages. Use of Wireless technology (Wi-Fi and Wi-MAX).

Table 1: A part of user needs on e-Navigation

II. Trial Method

2.1. Trial Ships

Training ship Oshima-maru and small ship Subaru were the trial ships. They belong to the National Institute of Technology, Oshima College, formerly the Oshima National College of Maritime Technology. Their outward forms and principal dimensions are shown in Figure 1, 2 and Table 2.

Figure 1: T.S. Oshima-maru and antenna installation (circle)

Figure 2: Subaru and antenna installation (circle)

Table 2: Principal Dimensions of Trial Ships

	T.S. Oshima-maru	Subaru
Length	41m	14.5m
Breadth	7.6m	4.15m
Draft	3.5m	2.3m
Gross tonnage	228ton	14ton

2.2. Trial Sea Area

The trial sea area is shown in Figure 3, Seto Inland Sea around the National Institute of Technology, Oshima College.

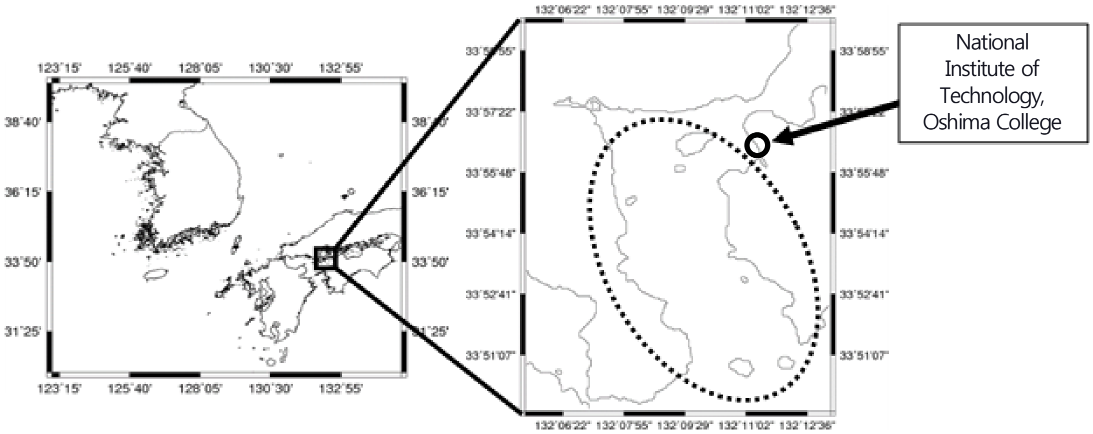

Figure 3: Trial Sea Area

2.3. Directional Antennas

The preliminary trial was carried out with a few types of directional antennas. Their specifications are shown in Table 3. The following results were obtained in the preliminary trial. The half-power angle of Yagi antenna was too narrow and the gain of the Cardioid antenna was too weak for ship-to-ship radiocommunication. So two types of Patch antennas were selected for the field trial. These antenna heights were 10m (T.S. Oshima-maru) and 6.5m (Subaru) above sea level (refer to Figure 1 and 2).

Table 3: Specifications of Directional Antennas

Type	Gain [dBi]	Half-power angle [deg.]	
		E-plane	H-plane
Yagi	19	22	24
Patch (A)	13	40	40
Patch (B)	9	63	77
Cardioid	5	75	135

2.4. Encounter Situation for the Field Trial

Two types of the encounter situation were set up for the field trial.

Encounter situation (1)

The field trial was done by sailing a ship (Subaru) along the heading line of another ship (T.S. Oshima-maru) moored to a pier (refer to Figure 4). When Subaru was leaving from T.S. Oshima-maru, the directional antenna of Subaru was set towards the stern side.

Figure 4: Encounter Situation (1)

Encounter situation (2)

The field trial was done by sailing both ships in parallel and head-on situation keeping enough distance (0.5 nautical mile, 900m) (refer to Figure 5).

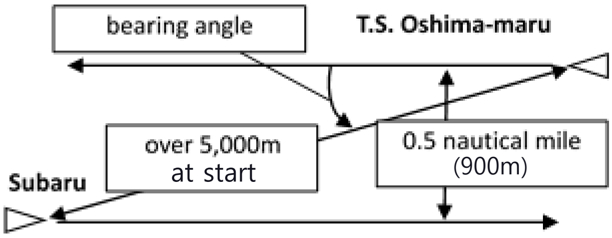

Figure 5: Encounter Situation (2)

2.5. Measurement Items

The following items were measured in the field trial; the ships' position (latitude/longitude), speed and course over ground by GPS receivers, the heading angle (only T.S. Oshima-maru) by the gyrocompass, RSSI (Received Signal Strength Indication) and the throughput (average in 10 seconds) between two ships simultaneously. The distance of the two ships and the bearing angle were calculated by their position (latitude/longitude) and the heading angle data.

III. Trial Results

Encounter situation (1)

Figure 6 and 7 show the trial results (RSSI and the throughput) of encounter situation (1). The antenna type and the ship's speed were as follows.

- Antenna type: Patch (A) (both ships)
- Speed of Subaru: 5 knots (9 km/h)

The longer the distance between two ships became, the lower RSSI became. The throughput was much faster than our target (1 Mbps) under the distance of 4,500m. At the distance of 1,100m, both RSSI and the throughput dropped down. The reason of this result was due to multi-path (2-path) model affected by the reflection of the sea surface.

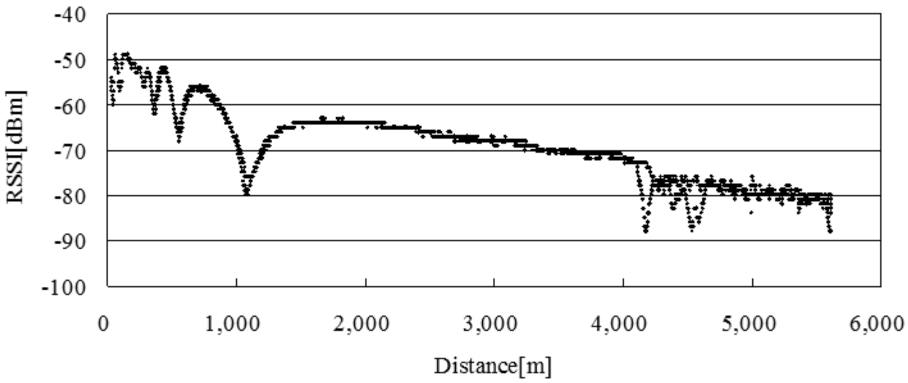

Figure 6: Trial Results of Encounter Situation (1); RSSI

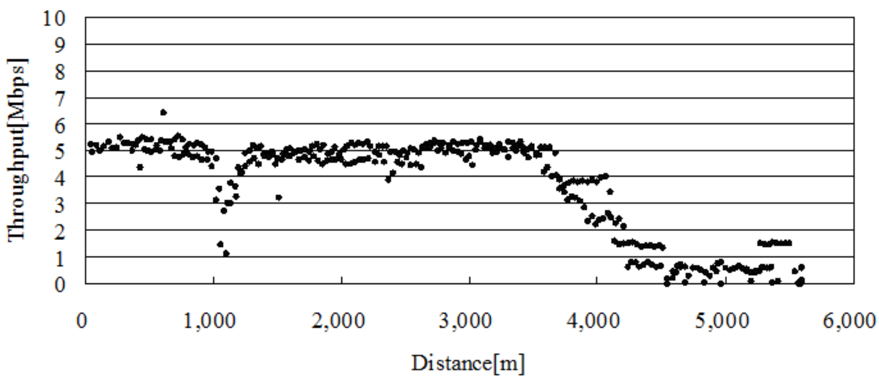

Figure 7: Trial Results of Encounter Situation (1); Throughput

Encounter situation (2)A

Figure 8 shows the trial results (RSSI and the throughput) of encounter situation (2)A. The antenna type and the ships' speed were as follows.

- Antenna type: Patch (A) (both ships)
- Speed of T.S. Oshima-maru: 8.5 knots (16 km/h)
- Speed of Subaru: 6 knots (11 km/h)

Encounter situation (2)B

Figure 9 shows the trial results (RSSI and the throughput) of encounter situation (2)B. The antenna type and the ships' speed were as follows.

- Antenna type: Patch (B) (both ships)
- Speed of T.S. Oshima-maru: 8.5 knots (16 km/h)
- Speed of Subaru: 6 knots (11 km/h)

At the distance of over 2,000m, the throughput of encounter situation (2)A was faster than that of encounter situation (2)B. When the bearing angle defined in Figure 5 was narrow, RSSI and the throughput depended on the gain of the directional antennas.

On the other hand, at the distance of 1,500 ~ 2,000m, the throughput of encounter situation (2)B was faster than that of encounter situation (2)A. As the bearing angle became wider, RSSI and the throughput depended on the half-power angle of the directional antennas.

Referring to the antenna specification in Table 3, these results were reasonable. However, the throughput was over 1 Mbps and the transferred data size was over 100 MB in any case. So the selected Patch antennas were suitable in the encounter situation for radiocommunication between ships.

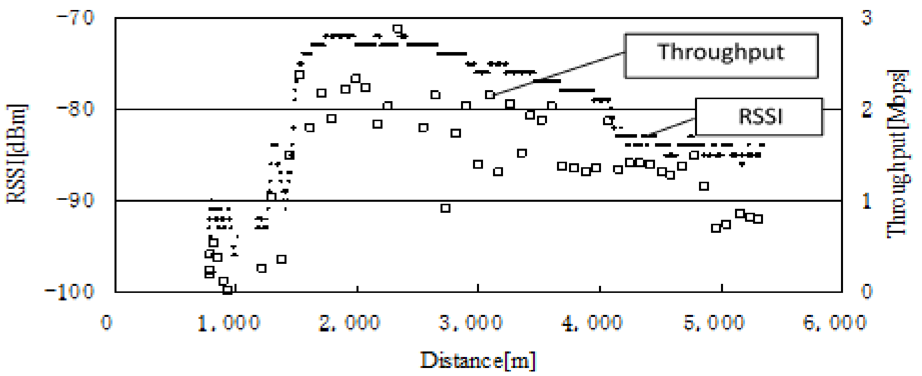

Figure 8: Trial Results of Encounter Situation (2)A; RSSI and Throughput

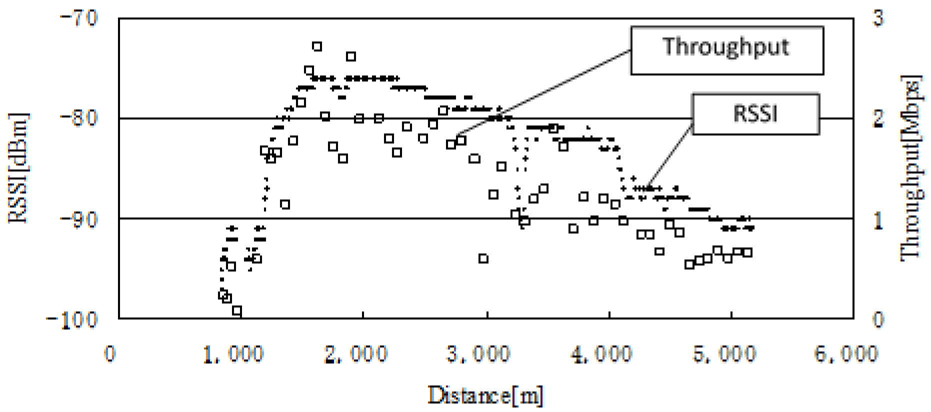

Figure 9: Trial Results of Encounter Situation (2)B; RSSI and Throughput

IV. Conclusions

Ship-to-Ship radiocommunication trial by using wireless LAN was carried out. Two types of the encounter situation were set up for the field trial. At the encounter situation (1), multi-path (2-path) model affected by the reflection of the sea surface was confirmed. At the encounter situation (2), the characteristics of the directional antennas such as half-power angle were confirmed. Selecting the suitable directional antennas, we achieved over 1 Mbps throughput between ships which was our target and showed the ability of the wireless LAN for Ship-to-Ship radiocommunication.

Submitted: September 29, 2015   Accepted: November 5, 2015

Acknowledgements

We would like to thank the Captain of T.S. Oshima-maru and the crews of both ships for the field trial. A part of this work was supported by JSPS KAKENHI Grant Numbers 22560801 and 26289342.

References

IMO (2009), MSC 85/26/Add.1, REPORT OF THE MARITIME SAFETY COMMITTEE ON ITS EIGHTY-FIFTH SESSION, ANNEX 20, STRATEGY FOR THE DEVELOPMENT AND IMPLEMENTATION OF E-NAVIGATION, p.1.

IMO (2007), COMSAR 11/18, REPORT TO THE MARITIME SAFETY COMMITTEE, p.43.

IMO (2011), NAV 56/WP.5/Rev.1, DEVELOPMENT OF AN E-NAVIGATION STRATEGY IMPLEMENTATION PLAN, Report of the Working Group, Annex 2, SHIPBOARD USER NEEDS AND PRIORITIES, p.8.

Sharma, P., Shankar, J., Lih, L., Tiing, T., Htun, W., Hsieh, R. and Wei, A. (2011), High Speed Maritime Mesh Network System for e-Navigation, Proceedings of the International Conference on e-Navigation (e-Navigation Underway), pp. 30-40.

Urakami, M., Okada, Y., Niwa, Y., Motogi, H. and Matsuno, H. (2010), Construction of Wireless Network for Information Communication for a Disaster-affected Island, Proceedings of the 2010 IEEE 24th International Conference on Advanced Information Networking and Applications Workshops, pp. 727-732.