Journal of Traffic and Transportation Engineering 14 (2026) 128-132
doi: 10.17265/2328-2142/2026.03.004

About Vessel Traffic Management Support System at Tokyo Bay using AIS and Traffic Flow Network

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Abstract: With the spread of AIS, it has now become easy for us to obtain the computerized status information of ship. In this paper, a basic of the vessel traffic management system using AIS information intended for the vessel underway at Tokyo Bay is suggested. We established nodes and rinks from the limited possible navigation waters between the entrance of Tokyo Bay and the inner part of the bay, and chose the routes from the departure to the destination. In addition, we standardized the navigation route of the vessel based on observed AIS data and performed the extracted route comparison with the route provided by AIS. We inspected whether we can cope with the prediction of the ship trend from the extracted route and the actual route. It was effective for future systems construction although there is a problem in practical use.

Key words: Port traffic, traffic flow network, AIS.

1. Introduction

Various information for ship operation is provided by AIS (Automatic Identification System). Besides dynamic information such as the position, heading, speed over the ground etc. the necessary information for the vessel traffic management like destinations is included in AIS information. The input method of the destination cord of the AIS was determined with the partial revision of the Act on Port Regulations and the Maritime Traffic Safety Act in Japan from July 1, 2010 [1], and the input was made mandatory. When a port of destination, the course (such as mooring places) in the port, other necessary information (such as passage routes) were coded, and Format of this destination cord was input and performed a traffic analysis from AIS information, the processing with the calculator became easy. It may be possible to improve safety of the vessel traffic in the congested area by using this information effectively.

The distance from the entrance of Tokyo Bay to the inner part of bay is approximately 70 km, so Tokyo Bay is a large water. But the navigation route of the ship especially large is almost decided for the safety in the congested area such as the established route in Tokyo Bay, the management of the traffic by VTS (Vessel Traffic Service), the limit of the navigation area.

2. Characteristic of the Traffic Flow Network in the Tokyo Bay

An input method of the information about the destination along the method that IMO recommended [2] was made a rule in Japan from July 2010, the input was made mandatory. Vessels carrying AIS enter the destination code, so we can obtain the information of departure and the destination from AIS information. Destination code is used to predict each other's courses, in addition to course display by international maritime signal flags and by the whistle in port. The input methods of the destination cord of the AIS are as follows [3].

In the case of the ship which will sail on the route to establish in the Maritime Traffic Safety Act (Uraga

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Suido Traffic Route, Naka-no-se Traffic Route), and the ship which will sail in the port concerned or in the vicinity of its boundary for the purpose of entering the port to which the Act on Port Regulations applies (Keihin port, Chiba port, Kisarazu port, Yokosuka port) (Fig. 1).

In addition, in Tokyo Bay the waters that can navigate the large ship is limited to and a route and navigation are determined as local rule in detail, so a traffic area is limited by a model of a vessel and it is thought that we can estimate a plan route to some extent. About a plan route, we expressed it by establishing the network using the node and the link in Tokyo Bay, and we decided to use network simulation to reproduce a traffic flow.

We show traffic flow in the Tokyo Bay and network (nodes and links) in Fig. 2 [4]. The dark blue lines which showed traffic flow of the Tokyo Bay are trajectories of the ships (The ships which depart from the entrance of Tokyo Bay for arrival in port or anchorage, and the ships which depart from Keihin port, Chiba Port or the Kisarazu Port for the entrance of Tokyo Bay). We showed a node of the network with a number and showed a link between nodes in yellow, light blue, green line each. The light blue line shows the route of the ship leaving for the entrance of Tokyo Bay from each port, the yellow line shows the route of the ship toward each port from the entrance of Tokyo Bay. The yellow and light blue line is one-way traffic. In contrast, the green line shows the route that is movable in both directions, two-way traffic.

We show the route example of the ship sailing in Tokyo Bay. For example, in the case of a ship which leave the entrance of Tokyo Bay for the Keihin port (Tokyo Section), the destination cord is "> JP TYO S". "TYO" means the ship's destination is Keihin Port (Tokyo Section), and "S" means the vessel is heading for the berth in Shinagawa Wharf in the destination port. Orange line in Fig. 3 show the trajectory of the ship which input destination code "> JP TYO S". Also, in Fig. 3 we superimposed number "1"-"58", those

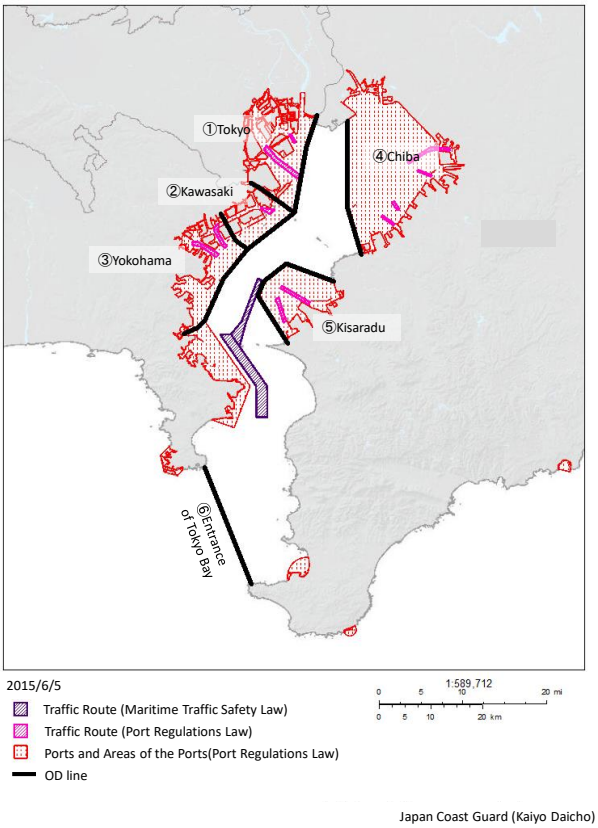

Fig. 1 Summary of Tokyo Bay.

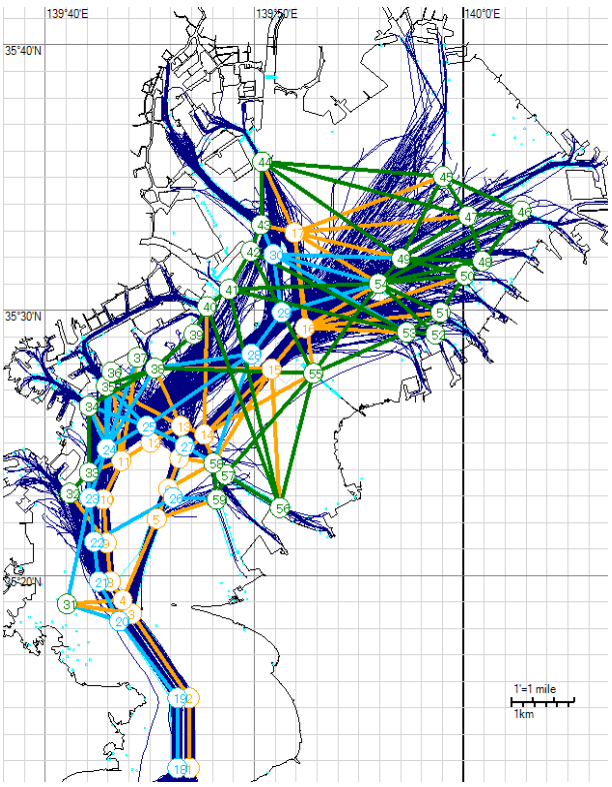

Fig. 2 Traffic flow and network in the Tokyo Bay.

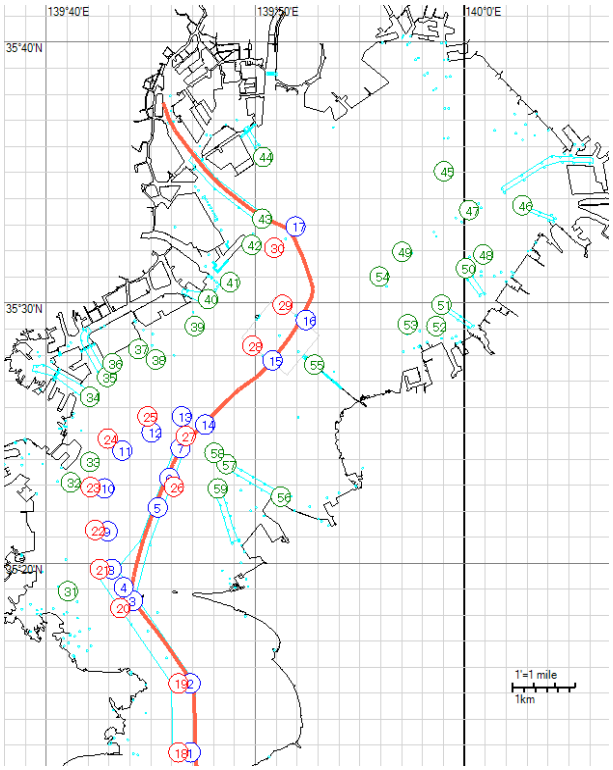

Fig. 3 The route example of the ship sailing in Tokyo Bay.

number mean node of the above-mentioned network. The ship more than 50 meters in length which leave the entrance of Tokyo Bay for the Keihin port (Tokyo Section) must sail Uraga Suido Traffic Route, so the ship is required to sail “1”, ”2” and ”3” at a speed through the water of 12 knots or less. In addition, the ship is required to sail “3”, ”5” ,”6” and ”7” because the ship more than 50 meters in length with a draft less than 20 meters must sail Naka-no-se Traffic Route. Next, the ship is required to sail in order of “7”, ”14” ,”15” and ”16”, a vessel of 3,000 gross tons or more which sail toward the Tokyo Wan Aqua Line from the Naka-no-se Traffic Route must sail through the Tokyo Aqua Line East Fairway. Finally, a ship within a circle of 1 mile radius centering around Tokyo Offing Light-buoy (it's between “17” and “43”) must sail so as to keep the same buoy on their port side. So the ship will sail in order of “16”, ”17”, ”43”, ”Tokyo west passage” and “Keihin Port (Tokyo Section) Shinagawa Wharf”.

Fig. 4 and Tables 1, 2 show the traffic route and passage in Tokyo Bay [5, 6].

In this paper, a route for simulation is made from the traffic flow network by a departure node and arrival node. So, we made a route data base from each departure node to arrival node. The extracted route information is provided as a passage node number from departure node number and a destination node number. And the departure node number is estimate by ships position, the destination node number is estimated by a destination code by AIS.

At some route, a destination was the same as departure place, but a route was different because of ships type and size. As this countermeasure, we added an information route to a data base (see Table 3).

For example, when a vessel enters port, we can extract the link node when We choose departure node number 1 and arrival node number 5 and, in the case of a small boat, can extract the route which is different from the vessel by choosing 101 and arrival number 105.

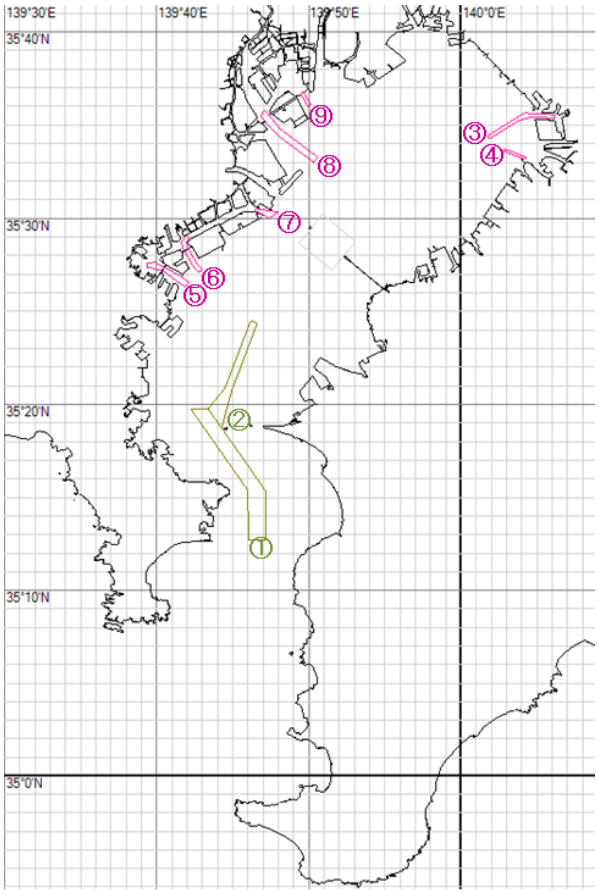

Fig. 4 The traffic route and passage in Tokyo Bay.

Table 1 Traffic route in Tokyo Bay.

Traffic Routes	Compulsory Transit of Traffic Routes	Services Offered
(1) Uraga Suido Traffic Route (2) Naka-no-Se Traffic Route	50 meters and upwards inlength (20 meters and upwards of draft is exempted from compulsory usage of the Naka-no-se Traffic Route)	Tokyo Wan Vessel Traffic Service Center ("Tokyo MARTIS")

Table 2 Passage in Tokyo Bay

Name of passage	Controlled vessel	Vessel subject to control	Competent authority
(3) Chiba Passage	140 m or over in length overall (For oil carriers, 1,000 GT or over)	50 m or over in length overall (excluding those less than 500 GT)	Chiba Port Traffic Control Office
(4) Ichihara Passage	125 m or over in length overall (For oil carriers, 1,000 GT or over)	50 m or over in length overall (excluding those less than 500 GT)	Chiba Port Traffic Control Office
(5) Yokohama Passage	160 m or over in length overall (for oil carriers, 1,000 GT or over)	50 m or over in length overall (excluding those less than 500 GT)	Yokohama Port Traffic Control Office
(6) Tsurumi Passage	1,000 GT or over	1,000 GT or over	Kavasaki Port Traffic Control Office
(7) Kavasaki Passage	1,000 GT or over	1,000 GT or over	Kawasaki Port Traffic Control Office
(8) Tokyo East Passage	150 m or over in length overall (For oil carriers, 1,000 GT or over)	50 mor over in length overall (excluding those less than 500 GT)	Tokyo Port Traffic Control Office
(9) Tokyo West Passage	300 m or over in length overall (For oil carriers, 5,000 GT or over)	100 m or over in length overall	Tokyo Port Traffic Control Office

Table 3 Example of Data base

Departure Node	Link Node				Arrival Node
1	201	···	325	322	5
51	201	···	325	322	55
101	201	···	310		105

Now, we must select 1974 routes from departure node to arrival node in the data base.

3. Estimated Route Using Network Data

In this paper, a scenario that is include departure node, departure time and arrival node was made. But all ship's speed is assumed at 12 knots.

A Ship's positions, heading are calculated on estimated route on a certain time (Fig. 9).

Similarly, we can demand the position of other ships, too and estimate position relations at the certain time and judge the presence of the collision.

A collision risk point is found by CPA. The criterion is DCPA is with L (L is ship's length that is include AIS information)/2*3.2 and less than five minutes at the TCPA.

Fig. 10 is shown collision area by this simulation. Blue points is crossing, pink points is head-on vessel, Orange points are overtaking. The target ship on simulation was chosen by the next condition (departure place and destination. See Table 2).

From Bay Entrance to Chiba Passage

From Bay Entrance to Ichihara Passage

From Bay Entrance to Yokohama

From Bay Entrance to Kawasaki

From Bay Entrance to Tokyo East Passage,

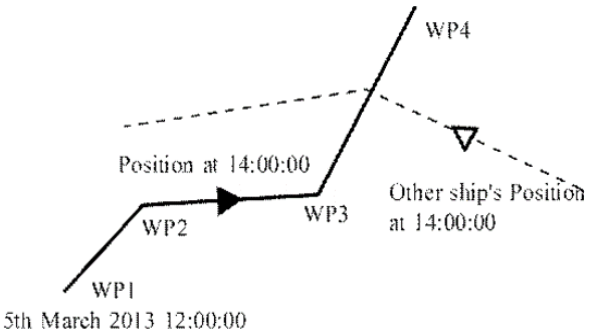

Fig. 9 Scenario for simulation and calculation of ship's position.

From Bay Entrance to Tokyo West Passage

From Kawasaki to Bay Entrance

From Yokohama to Bay Entrance

Simulation points a little point but area shown. Fig. 11 is shown collision points by red circle. Simulation result is shown the collision risk waters.

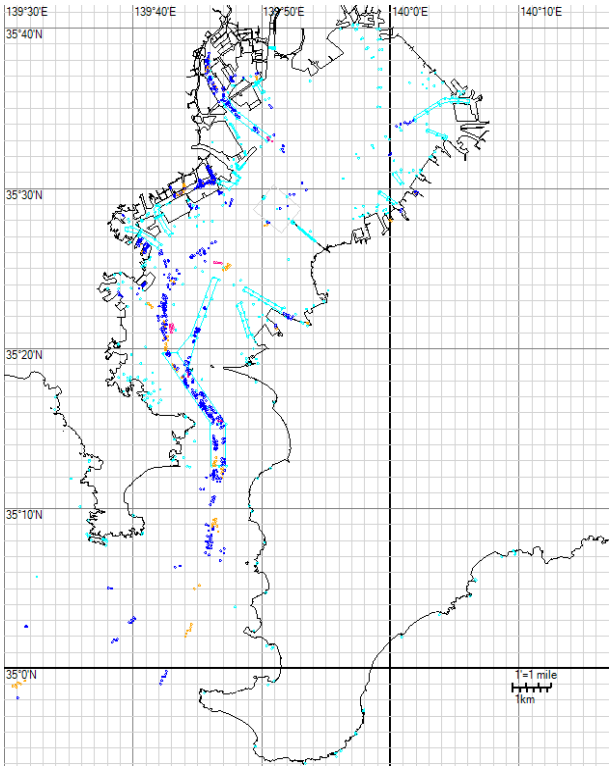

Fig. 10 collision risk point by actual data.

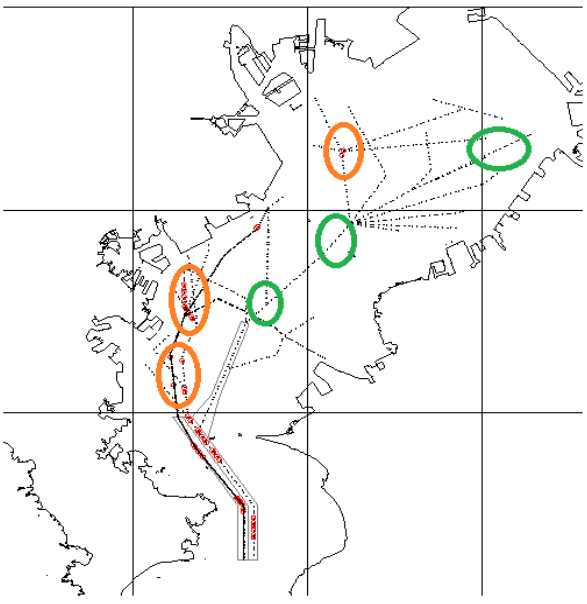

Fig. 11 collision risk point by simulation.

When we compare actual trajectories (Fig. 10) and simulation result (Fig. 11), risk point number is different. But an area of collision risk was shown (It shown by Orange circle).

Green circles in Fig. 11 are safety waters by simulation but those waters are collision area by actual ship data. In this reason, Speed is different of simulation and actual ship data. Or some ship is anchoring before barthing.

6. Conclusions

In this paper, the Tokyo Bay traffic network on the seas in consideration of an actual trajectories and regulation was expressed. Using destination code that input into AIS information, we made planned route from network, and a collision points was calculated by planned route in the future.

As a future works, we was able to find some collision place from a simple method, but it is necessary to consider the setting method of the route according to the ship type and speed adjustment.

Acknowledgments

We appreciate the help received from Maritime Traffic Department, Japan Coast Guard.

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