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Functional Requirements to Support Traffic Organization Service

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ABSTRACT: In the era of e-Navigation, the future VTS is anticipated to play an important role on the enhancement of maritime safety and the efficiency of maritime transport as a key stakeholder of e-Navigation. The VTS services need the advanced Traffic Organization Service(TOS). In this paper, the VTS functions for TOS is revisited from the reports of IMO e-Navigation Correspondence Group and IALA VTS Committee. In Korea, the research activities to enhance the existing VTS functions have been conducted. In terms of TOS, some VTS functions have been developed. In conclusion, all the past traffic data and real-time ship data are required to provide the advanced TOS. For this, the advanced functions to support TOS should be implemented on VTS console.

1 INTRODUCTION

In the era of e-Navigation, the future VTS(Vessel Traffic Services) is anticipated to play an important role on the enhancement of maritime safety and the efficiency of maritime transport as a key stakeholder of e-Navigation. To enhance VTS services, VTS operator needs the advanced functions to support the VTS Services.

In the IMO Resolution A.857(20), the three services for VTS are defined (IMO. 1997a), i.e., INformation Service(INS), Navigational Assistance Service(NAS), and Traffic Organization Service(TOS). Among them, the TOS concerns the operational management of traffic and the forward planning of vessel movements to prevent congestion and dangerous situations, and is particularly relevant in times of high traffic density or when the movement of special transports may effect the flow of other traffic. The TOS is a service to prevent the development of dangerous maritime traffic situations and to provide for the safe and efficient movement of vessel traffic within the declared VTS area. It also includes establishing priority of movements, allocating space, routes to be followed, speed limits to be observed or other appropriate measures which are considered necessary by the VTS authority (IALA. 2012a). Taking into the IALA VTS strategy paper account (IALA. 2012b), it is expected that the future VTS focuses on further development of TOS in its operation. In the 35th session of IALA VTS committee, the draft guideline on the provision of VTS Type of Service was finalised (IMO. 2012b). In contrast to a general definition of TOS in A.857 (20), the VTS draft guideline defines concrete services for TOS (IALA. 2012c). On the other hand, various roles of e-Navigation stakeholders are included in its architecture specification process (IMO. 2012b), i.e., the roles for master, pilot, and VTS.

In this paper, the VTS functions to support its TOS are revisited, considering the reports of e-Navigation strategy and IALA VTS committee. Several functions to support the TOS are exemplified. Such functions need to be presented on the VTS console for an effective VTS operation.

2 TRAFFIC ORGANIZATION SERVICES FOR VTS

2.1 *Functions to be carried out in the era of e-Navigation*

In e-Navigation, a stakeholer – a person or an organization – may have several different responsibilities. All functions to fulfil the responsibilities may be carried out by persons or systems, or a combination of both (IMO. 2012b). The functions are sorted by stakeholders, i.e, master, pilot, tug service providers, shore organizations. Table 1 represents main functions to be conducted by a stakeholder (IMO. 2012b).

Table 1. Functions to be conducted by a stakeholder.

Stakeholders	Functions
Master	Support and Control Navigation
	Safe Navigation
	Management of Information
	Support to Incident Handling and Emergency Management
	Support Maritime Security
Pilot	Prepare Pilotage
	Conduct Pilotage
On shore	Fairway Utilization Planning
	Vessel Traffic Services
	Port Operation Support
	Emergency Management

In Table 1, all the functions of stakeholders contain their sub-functions. Several sub-functions need to be supported by shore organization, such as VTS. For example, the function, Support and Control Navigation, requires to use shore-based information services, i.e, Maritime Safety Information(MSI) Service, Routeing Information Service, Hydrographic Information Service, Ice Information Service, Port Authority Instruction, Meteorological Information Service and Warning so on.

It is natural that each function is also interrelated to other function. The function, Vessel Traffic Services, includes 'Monitor High Seas', 'Manage VTS', 'Manage Tracking Information', 'Operate Ship Reporting System', 'Exchange Information with Relevant Authorities', 'Exchange Information on Emergency'. The TOS is a crucial service for the effective management of VTS. In the era of e-Navigation, the VTS require an intelligent TOS which contains the following sub-functions:

- Plan Traffic Flow
- Plan Traffic Organization Criteria
- Monitor Traffic Situation and Prediction
- Decide on Priority – e.g. allocation of time slots

2.2 *IALA VTS Traffic Organization Services*

In the 35th session of IALA VTS committee, the draft guideline on the provision of VTS Type of Service was finalised and is supposed to be delivered to the IALA Council for approval (IALA. 2012d). As mentioned in the IALA VTS Strategy Paper (IALA. 2012b), the TOS will be further developed over the next 10 to 20 years. It is expected that the future VTS operation focuses on the delivery of the advanced TOS. The IMO Resolution A.857 (20) states that a VTS should at all times be capable of generating a comprehensive overview of the traffic in its service area combined with all traffic influencing factors. To respond the traffic situations developing in the VTS area and to determine appropriate actions, the acquired data should be processed and evaluated. As mentioned in Section 1, the TOS is a service to prevent the development of dangerous maritime traffic situations and to provide for the safe and efficient movement of vessel traffic within the declared VTS area. The draft guideline suggests the cases that the TOS should be provided as follows (IALA. 2012c).

- vessel movements need to be planned or prioritised to prevent congestion or dangerous situations;
- special transports or vessels with hazardous or polluting cargo may affect the flow of other traffic and need to be organised;
- an operating system of traffic clearances or sailing plans, or both, has been established;
- the allocation of space needs to be organised;
- mandatory reporting of movements in the VTS area has been established;
- special routes should be followed;
- speed limits should be observed;
- the VTS observes a developing situation and deems it necessary to interact and coordinate vessel traffic;
- nautical activities (e.g. sailing regattas) or marine works in-progress (such as dredging or submarine cable-laying) may interfere with the flow of vessel movement.

Here is an example of the TOS information with relation to waterway management (IALA. 2012c).

- The use of one way traffic as an alternative of two way traffic, depending on the dimensions of ship or the weather conditions;
- Organising other traffic when a vessel has passed point of no return;
- Slot management to allocate ships in a time window;
- Organising the traffic concerning vessel dimensions in comparison to fairway restrictions;
- Instruct vessels when overtaking is not permitted;
- Establish and organise ship safety zones in case of particular operations;
- Establish and organise exclusion zones;
- Instruct vessels to keep clear from special areas/positions;
- Organising the traffic as regards to meteorological, hydrographical or other restrictions such as visibility, wind speed, current, sea state, and under keel clearance.

3 VTS FUNCTIONS TO SUPPORT TOS

3.1 *Examples of Functions for TOS*

To provide the TOS, as mentioned in section 2.1 and 2.2, the VTS requires further information, which is obtainable by implementing the following functions.

- Ship Reporting System(SRS), Sailing Plan (SP) and information transfer among authorities and ship.
- Calculation of traffic congestion rate in the water-area of interest
- Decision-making for collision avoidance
- Monitoring of ship trajectories
- Risk assessment in the water-area of interest.

3.2 *Ship Reporting System, Sailing Plan, and Information Transfer*

The information which is collected from SRS contains ship particulars, ship's draft, spatial and temporal information of ship movements, cargo type. Such information may be utilised to organise the ship or other ships in a fairway, to allocate the ships in a time window, and also to keep clear from special areas/positions so on. The SP may be used to provide various services belonging to TOS, i.e, wateway management and collision avoidance etc.

3.3 *Calculation of Traffic Congestion Rate in the Waterarea of interest*

Large part of the TOS may be conducted by predicting the direction of traffic flow and its volume. All information from SRS and/or SP may be used not only to predict such traffic flow prediction, but also to predict the area to be congested. The static and dynamic information from non-AIS ships should be combined with all the information from SRS and SP.

Figure 1. Lateral distribution of Traffic along a fairway.

The lateral distribution of traffic helps not only to understand traffic flow direction but also to mitigate the congestion by allocating traffic route. In addition to the spatial distribution of traffic, the speed distribution can be also used to calculate the traffic congestion rate in a time window as well as in the special area. The traffic congestion rate may be simply calculated from the ratio of the total ship bumper areas over the total waterarea in a fairway. However, the ship speed affects the number of ships in a fairway and the distance among ships. To obtain more practical congestion rate, it is realistic to consider the other parameters including ship particulars, ship dynamic conditions, courses, weather, sea state. The calculation of traffic congestion rate is open. Figure 1 shows the lateral distribution of traffic which is obtained from the data collected along a fairway. The lateral distribution in a fairway can be plotted at arbitrary gateline of interest.

Figure 2 represents the distribution of ship speed at the observed area or a fairway. From the speed distribution, the average and standard deviation of speed are calculated. The standard deviation of speed will affect a navigational safety in waterarea. The speed distribution can use to determine the safe speed or the speed limit criteria.

Figure 3 shows CPA distribution as TCPA varies with time at the waterarea of interest. The CPA is normalized by the major diameter of an elliptic model for ship bumper area (A.G. Frandsen. 1991). In Figure 3, the red dot line means the boundary of ship safe domain. If a vessel enters into the boundary of target vessel, the two vessels may be in danger.

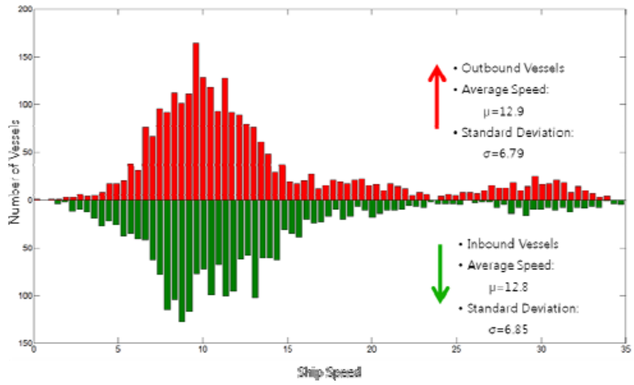

Figure 2. Ship Speed Distribution.

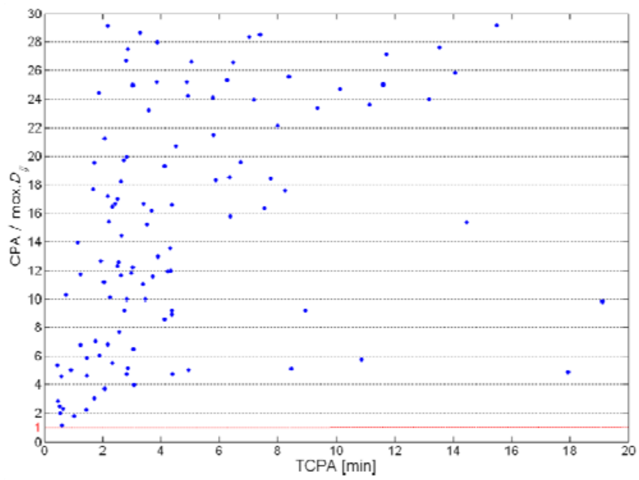

Figure 3. CPA variation as a function TCPA.

3.4 *Risk Assessment and Decision-Making for Collision Avoidance*

Several risk assessment models have been proposed to represent real-time collision risk among multiple encountered vessels in a water-area (Y.S. Park et.al.

2012). The collision risk, which is calculated by method proposed in (Y.S. Park et.al. 2012, N.S. Nam & S.Y. Kim, 2012), may be used as a reference index to support decision-making for collision avoidance in VTS or ship. On the other hand, the other models assess statistical risks by using the past ship movement data (Jun Min Mou. et al. 2010, Jakub Montewka. et al. 2010, J.S. Jeong. et.al. 2012). Figure 4 shows the variation of causation factor which is calculated by using AIS data for the last 72 hours (J.S. Jeong. et al. 2012) in WANDO waterway of Korean Southwestern coast. The causation factor is called the probability of failing to avoid a collision when the encountered vessels are on a collision course (Jakub Montewka. et al. 2010). In fact, it is difficult to assess the maritime risk by causation factor itself. The value of causation factor may be used as reference index for design of traffic lane, determination of speed limit and fairway width so on. The proper range of causation factor depends on natural environments including weather, geographical conditions.

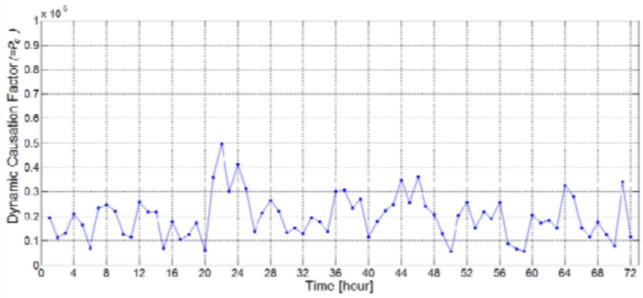

Figure 4. Variation of P_C for 72 hours.

4 CONCLUSIONS

It is expected that the TOS plays an important role on the future VTS operation. Herein, the VTS functions in the e-Navigation architecture and IALA draft guideline on the provision of VTS Type of Service were revisited. To support the advanced TOS and the decision-making for effective and safe waterway management, several examples were illustrated. The information from ship reporting system and sailing plan may be utilized to organise the ship or other ships in a fairway, to allocate the ships in a time window, and also to keep clear from special areas/positions so on. The traffic congestion level is useful for the dynamic assignment of traffic lane and width, and even speed limit. The maritime risk index also helps to manage traffic effective and safely and to design traffic lane and capacity.

To take a proactive measures for maritime safety and prevention of oil pollution, the advanced functions on VTS console should be implemented.

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