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ECDIS Possibilities for BWE Adoption

S. Žuškin, D. Brčić, & S. Valčić
University of Rijeka, Rijeka, Croatia

ABSTRACT: The Electronic Chart Display and Information System (ECDIS) development and implementation have been linked primarily to the safety of navigation. Further development allows the implementation from other aspects of navigation. This primarily pertains to the Harmful Aquatic Organisms and Pathogens (HAOP) from Ballast Water Exchange (BWE) and the use of ECDIS system for improving environmental protection. The paper contains an overview of important legal aspects of sea environment protection related to the Ballast Water Management (BWM) Convention on global as well as on local scale. Apart from enhancing the safety of navigation, integration of the proposed tool for sea environment protection in the ECDIS with onboard ballast water system can significantly contribute to sea and sea environment protection from harmful substances. In this paper, the architecture of such system is suggested. This approach also ensures a reduction of possible consequences on ecological incidents and human errors.

1 INTRODUCTION

The ECDIS final implementation date is reaching its completion. However, considering certain issues to be solved properly, ECDIS development allows furthermore the implementation from other aspects of navigation. It harnesses the technology to improve safety of navigation, but despite that, it requires well trained end-users to make all navigation decisions, appropriate actions and new decision system adoptions in the future. New possibilities primarily pertain to the new Ballast Water Management convention and the use of ECDIS system for improving environmental protection. Ballast water onboard is essential for safe and modern shipping industry to maintain ship stability, stress, and furthermore to control ship's trim, list and draft. The transfer of HAOP with ballast water has great harmful impacts to the environment. Therefore, loading ballast water from one and discharging to another port from different region represents a potential risk which causes environmental changes. These changes include modifications of biodiversity and species biogeography, predator and harmful algae development, ecosystem engineers, parasite and disease agents resulting in economic problems of marine environment and harmful impact to the human health (Gollasch et al. 2009). The problem is generally recognized on a global scale by the International Maritime Organization (IMO) and United Nations (UN) as specialized agencies for the international transport regulations. The proposed paper deals with the legal aspects concerning ecological normalization of the Ballast Water Management with the special references to the Ballast Water Exchange regulations. Therefore, understanding of BWE theoretical background is essential. In order to achieve the desired results that the BWM convention regulation demand, it is necessary to enhance ECDIS technological system in function of significant navigation and other improvements. By utilizing the intelligent ECDIS system and voyage planning, Officers of the Watch (OOWs) can additionally contribute to sea environment protection. In this paper the architecture of Decision Making BWE Algorithm is suggested. The motivation of the research is need for system architecture development with aims of better understanding the implementation of the new possibilities. The paper is concluded with summary aiming safer navigation and raising mariners' ecological awareness.

2 LEGAL ASPECTS OF BALLAST WATER MANAGEMENT WITH BALLAST WATER EXCHANGE

The IMO together with the World Health Organization (WHO) noted harmful impact from the ballast water to the environment in the 1970's. Marine Environmental Protection Committee (MEPC) started afterward to develop research study "Research into the Effect of Discharge of Ballast Water Containing Bacteria of Diseases" (IMO 1973). However, processes and procedures related to ballast water control measures are mostly defined in BWM Convention (IMO BWMC) which was adopted in February 2004 together with other relevant resolutions and guidelines. Since adoption, fourteen Technical (G1-G14) and two additional Technical guidelines have been prepared for an overall convention structure at IMO. These guidelines and obligations are intended to be met by all stakeholders including shipowners, vessel Administrations, Flag State, Port State and other relevant representatives. Nowadays, the BWM Convention is ratified by a sufficient number of states that together represent more than 35 % of the world's total merchant shipping tonnage. Furthermore, the International Convention for the Control and Management of Ship's Ballast Water and Sediments will enter into force on 8 September 2017 on a global scale for ship environmental safety and marine environment protection (IMO Press 2016). According to IMO, BWM means mechanical, physical, chemical, and biological process, either singularly or in a combination, to remove, render harmless, or avoid the uptake or discharge of Harmful Aquatic Organisms and Pathogens within Ballast Water Sediments (IMO Res. A.868 (20)). With the adoption of this Convention, the term HAOP is defined as any aquatic organisms or pathogens, which, if introduced into the fresh or salt water, may create hazards to human health and the environment, property or resource, impair biological diversity or interfere with other legitimate uses of such areas (IMO BWMC 2004, Gollasch et al. 2015). In other words, HAOP includes living organisms (non-indigenous, cryptogenic and native species), marine plants and microbes like North America comb jelly, Australian spotted jellyfish, West Atlantic brackish clam, Conrad's false mussel, Zebra mussel, Asian kelp, North Asian amphipod, fish-hook, Water Flea, Asian skeleton shrimp, Chinese mitten crab, Cholera, Toxic Algae, etc. (GloBallast Programme, 2013). These living species have directly harmful impact to the human health and invaded environment. Despite prescribed standards from the convention, there are two cornerstone standards for environment protection from HAOP (IMO BWMC 2004);

- Ballast Water Exchange Standard (Regulation D-1)
- Ballast Water Performance Standard (Regulation D-2)

Ballast Water Performance Standard together with ballast water treatment implementation is not subject of this paper. According to (IMO Resolution MEPC. 124(53)) there are three accepted method which can be used;

- Sequential method – a process by which a ballast tank intended for the carriage of ballast water is first emptied and then refilled with replacement ballast water at least a 95 % volumetric exchange.
- Flow-through method – a process by which replacement ballast water is pumped into a ballast tank intended for the carriage of ballast water, allowing water to flow through overflow on deck or other arrangements.
- Dilution method – a process by which replacement ballast water is filled through the top of the ballast tank intended for the carriage of ballast water with simultaneous discharge from the bottom at the same flow rate and maintaining a constant level in the tank.

So far, sequential method is most commonly used ballast water exchange method in maritime industry with specific procedures for onboard operators/mariners in function of minimizing harmful organisms in ballast water. Its specific procedure for exchange is based on reducing extra pressure on the ballast tank structure and it takes less time than the other two methods. Under specific regulations (IMO BWMC D-4 2004), every vessel using BWE method should apply ballast exchange at least 50 nautical miles from the nearest land and in water at least 200 meters depth in all cases. These requirements are mandatory to be fulfilled according to convention. However, in shallow seas or semi-closed sea areas, Port State may adopt Ballast Water Exchange Area (BWEA). According to (IMO Resolution MEPC. 151(55)), the location and size that provide the least risk to the environment, human health, property or resources should be designed having in mind shipping traffic, security of the area and shipping routing system. The BWEA identification should take into account the following criteria: oceanographic (e.g. currents and tides), physico-chemical (e.g. salinity), biological (e.g. HAOP presence), environmental (e.g. pollution from human activity) and location of important resources (e.g. key fishery). Nevertheless, according to regulation A-3, certain exemptions are determined to ensure safety of navigation in all cases, especially in case of: a vessel in emergency situation, accidental discharges resulting from damage to another ship, avoiding pollution incident, vessel situation where the uptake and discharge of ballast water are taking place in the high seas or uptake and discharge of ballast water originate from the same location.

Theoretical background and understanding Ballast Water Management legal aspects are essential for the end user to be in compliance for upcoming convention. Despite that, end users onboard mostly deal with ECDIS system as a powerful tool for route planning, route monitoring and displaying additional navigation related information. ECDIS system, which constantly keeps track of the ship's position via Global Navigation Satellite System (GNSS) and depth using Electronic Navigational Chart (ENC) respectively, could be significantly helpful with ballast water exchange proposed algorithm. However, collaboration with industry to facilitate the successful transfer of new technologies in raising environmental awareness and developing existing ECDIS system with the additional features can significantly contribute to sea and sea environment protection from harmful substances. Furthermore, it is necessary to define ECDIS general consideration and new BWE possibilities in the system.

3 ECDIS GENERAL OVERVIEW AND NEW BWE POSSIBILITIES

ECDIS is a complex system forming Information and Communication Technology which integrates relevant navigational data together with ENCs in order to achieve safe navigation. The system can be accepted as complying with the up to date chart required by regulation of the Safety of Life at Sea (SOLAS) Convention, displaying selected information from a System Electronic Navigational Chart (SENC) with positional information from navigational sensors (SOLAS 1974, IMO MSC 232(82), IMO A 817(19), IMO MSC 191(79)). Besides three mandatory sensors (position, heading and speed source) that should be connected directly to the system, it enables fusion of additional information and application regarding navigation environment, by employing equipment providing information of surrounding objects. According to International Hydrographic Organization (IHO) standards, ENC intended for navigation consists of cells that an ECDIS utilizes with all useful data, and also may contain supplementary information which may be considered necessary for navigation safety and furthermore. Considering fast technology development, the new IHO and IEC standards raised up referring to electronical chart protection standards, system presentation library, new test data sets and presentation of navigation related information (IHO 2014a, IHO 2014b, IHO 2014c, IHO 2015, IEC 2014, IEC 2015). ECDIS system develops further and represents obvious advantages, meanwhile various problems appeared in its operation related to: technical and system, navigation and positioning, system handling, dealing with ENC/RNC and insufficient knowledge (Brčić et al. 2016). Additionally, it should be noted that safety parameters and primary positioning sensor found not to be always respected (Brčić et al. 2015, Žuškin et al. 2016). In accordance with the current problems and future system evolution, theoretical knowledge and understanding should be essential for new-coming development. Furthermore, implementing new navigational technology onboard vessels requires appropriate professional training standards (Žuškin et al. 2013). As the implementation date reaches its end, it is obvious that the system will develop further with new features. Besides hardware equipment, various computer programs with functional applications together with existing onboard systems will become part of the Integrated Navigation System (INS). The ECDIS system architecture consists of significant applications: ENC viewer, Data tool Utilities, Playback mode, Chart Assistant and other applications. Besides these valuable system applications, Ballast Water Exchange Application is proposed and presented on Figure 1.

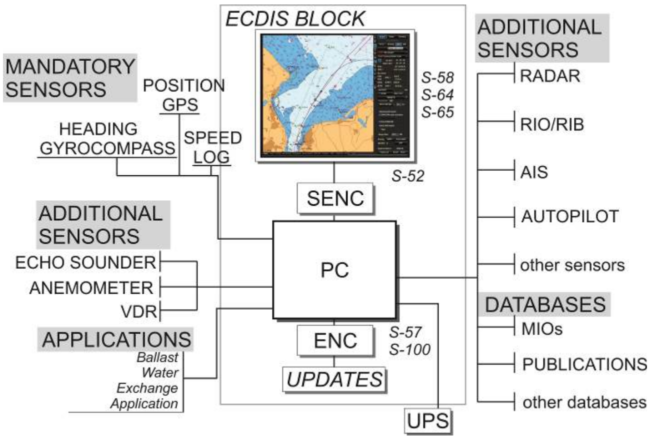

Figure 1. ECDIS system architecture with BWE application

Furthermore, for BWE in ECDIS adoption, it is necessary to produce ENC with additional information by authorized national hydrographic authorities such as Hydrographic Offices. Meanwhile, the ENC contains all chart information in the form of geographical objects represented by point, line and area shapes, carrying individual attributes, which make any of these objects unique. These navigational charts also may contain supplementary information relating to the BWM Convention which is useful for safe navigation and environmental protection. Supplementary information presupposes the implementation of the geographical line/area where the Ballast Water Exchange limits (>50 NM distance of shore and >200 meters of depth) could be found. In addition, Ballast Water Exchange Area designed according to the Convention together with the Particular Sensitive Sea Areas (PSSA) from the IMO or other significant area adopted from the Port State, could be implemented as additional chart area information. It is further considered to adopt additional chart layer which consist of all significant areas where ballast water discharge is forbidden according to the Port State regulation. For example, according to the United States Federal Regulation Final Rule, BWE is restricted and the vessel must meet BWM Convention D-2 Standard for discharging ballast water. This standard is subjected to a US Coast Gard review for onboard Ballast Water Management System (BWMS) and ballast water treatment implementation. Furthermore, in some areas time domain should be included for BWE. For example, vessels on a voyage to the Great Lakes Basin, St. Lawrence River or Gulf of St. Lawrence, may conduct an exchange from 01st December till 01st May, in the Laurentian Channel east of 63° west longitude where the water depth as at least 300 meters (Gollasch et al. 2015).

These lines and areas with time domain, respecting each Port State regulations, are essential data for BWE implementation in the ECDIS system application. All available information utilized in the ENC together with Decision Making ECDIS BWE Algorithm has significant advantage for OOW.

4 DECISION MAKING ECDIS BWE ALGORITHM

Past researches are based on the generic ballast water management decision support system model which is presented and validated by using ballast water discharge data from the Port of Kopar (David et al. 2015). Furthermore, ECDIS becomes a dynamic system that can contribute to the environment protection via timely critical chart updating with creation of critical environmental updates (Žuškin et al. 2011). In this paper, the architecture of ECDIS possibilities and BWE adoption with the new decision making algorithm is now suggested.

Before algorithm implementation, according to (Resolution MEPC. 124(53)), evaluation of the additional requirements should be made for ballast water exchange which includes: vessel stability with construction and admissible sea going condition. Vessel stability primary consists of the intact stability criteria which must be always monitored. Additionally, shear and torsional forces and bending moments should be monitored not to exceed permitted values. Forward and aft draught, together with vessel's list, trim, bridge visibility under SOLAS and propeller immersion are significant factors for proper BWE implementation. While discharging water ballast, Free Surface Correction (FSC) on intact stability influence must be monitored at all times. Vessel construction for BWE includes ballast pumps and piping system arrangement in good working condition to control maximum pumping/flow rates and to avoid pressure system limitations. Ballast Water Exchange at sea should be avoided in poor sea going conditions which may threaten vessel safety. In heavy weather with significant waves and in freezing area conditions BWE should be avoided.

Suggested Ballast Water Exchange application in ECDIS system consists of Decision Making Algorithm which uses significant data from the ENC cells. Utilizing the intelligent ECDIS system, OOWs can additionally contribute to sea environment protection; heretofore the Decision Making ECDIS BWE Algorithm is presented in Figure 2.

This Decision Making Algorithm is essential for BWE application in the ECDIS system. The GNSS for constant monitoring of position and echo sounder for constant measuring depth is used for BWM Convention adoption. For system effectiveness, ENC data should consist of four different area information:

- Sea area at least 50 nautical miles from the nearest land and at least 200 meters water depth,
- Ballast Water Exchange Area (BWEA),
- Restricted Area for BWE according to the Port State or IMO,
- Restricted Area with time domain for BWE adoption.

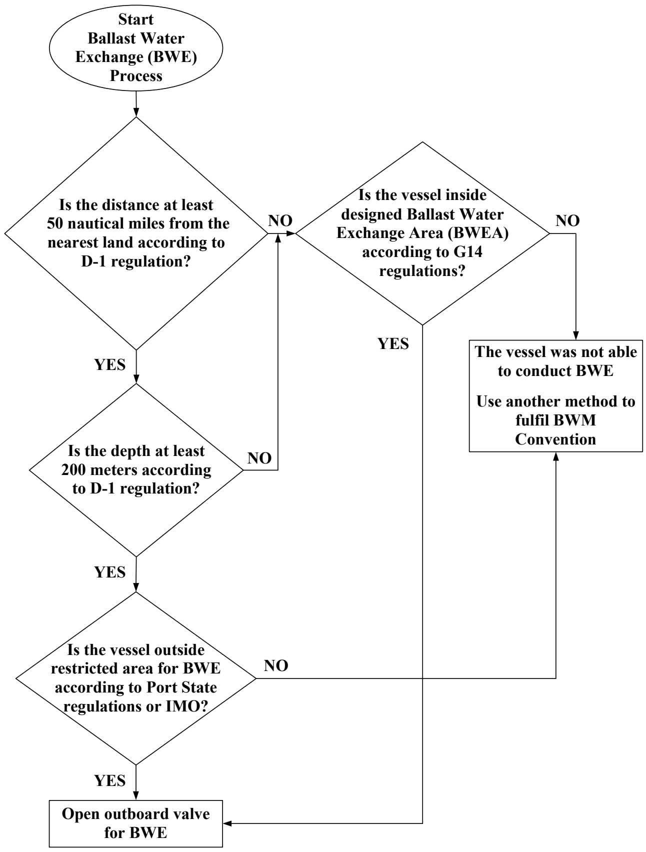

Figure 2. Decision Making ECDIS BWE Algorithm

ECDIS BWE application should be directly connected to the Outboard ballast valve which is controlled from Decision Making Algorithm. The system will additionally give significant information to the OOW to protect the environment from the harmful impacts. The suggested application should consist of Electronic Ballast Water Log for continual monitoring of water exchange. From ECDIS, all relative data for the log are available; ship's position, speed over ground, course over ground, sea temperature, salinity and hydro-meteorological conditions. Furthermore, the system will use the quantity of ballast water to discharge, theoretical capacity of the water ballast pump and the ship average speed to calculate time and distance to complete Ballast Water Exchange. This approach also ensures a reduction of possible consequences on ecological incidents and human errors.

While considering the planned voyage, the ECDIS system with Decision Making BWE Algorithm could timely announce the precise time when the preparation for ballast exchange should begin in order for the ship to run into significant area and meet the BWM Convention requirements. The intelligent ECDIS system could also warn the OOW when the ballast water exchange should begin in order for the ballast exchange to be carried out in time before exiting the prescribed area (Sea area at least 50 nautical miles from the nearest land and at least 200 meters water depth or BWEA). The BWE activity for each ballast tank should not start if the process cannot fulfil convention requirements. BWE is not always practicable in the maritime industry. Anyway, deviation from intended voyage route is not an option, except in a case of BWEA establishment from the Port State. Otherwise, the vessel will use other methods to fulfill BWM Convention.

5 CONCLUSION

Sea and environmental protection consists of various activities which can be seen exclusively in supplementing relevant conventions. The International Convention for the Control and Management of Ship's Ballast Water and Sediments will enter into force on 8 September 2017 to prevent harmful aquatic organisms and pathogens to be further spread in the natural environment. Despite prescribed standards from the convention, main standards for environment protection are Ballast Water Exchange Standard (BWE) and Ballast Water Performance Standard. Some are easier to complete than others and some take valuable time to be performed. In addition, the BWE process is not always easy or advisable in certain sea conditions so there need to be other solutions to manage the ballast water to achieve the goals required by the Convention. Legal aspects of Ballast Water Management with Ballast Water Exchange are analyzed and described in this paper. Furthermore, future ECDIS development allows the implementation from other aspects of navigation besides navigation safety. By utilizing the intelligent ECDIS system with new application and voyage planning, OOWs can additionally contribute to sea environment protection. Therefore, the authors suggest an ECDIS system architecture with BWE application together with new Decision Making BWE Algorithm.

The suggested application should consist of Electronic Ballast Water Log for continual monitoring of ballast water exchange. Nowadays, IMO publications may be carried out in the form of electronic media. Proposed method for BWE electronic record would be actually a byproduct of the suggested algorithm and also a new database or activity within the ECDIS system. In fact, the resulting database from the system should actually give output information instead of data reception where ECDIS has primary role.

For system effectiveness, Electronic Navigational Chart should consist of additional data to contribute sea environment protection. Considerable effort must be made by International Hydrographic Offices to achieve ENC with additional environmental layers. In addition, Marine Information Objects (MIOs) should be considered for implementation process of four different area information for BWE. The MIOs additional related information about important non-navigation information may be supplemented and displayed in conjunction with ENC in function of environment protection with large volumes of data. Therefore, the Harmonisation Group on MIOs (HGMIO) may have a significant role, independent technical group for creation and implementation of additional layers that may be incorporated into future editions of IHO standards and IEC committee.

In addition, interaction between ECDIS system and Officers of Watch is essential. The key factor is education with the extent of training and management necessary to ensure that the process of ballast water exchange at sea is effectively monitored and controlled onboard. Finally, development of the mindset required for ECDIS proper handling and interpretation of the new applications and features is aiming to reach safer navigation and also raising mariners' ecological awareness.

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