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## On VDES/ECDIS Integration

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### ABSTRACT

Recently, the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) has developed VHF data exchange system (VDES). It is recognized as an efficient tool for the usage of the radio spectrum with applied new techniques in information transmission. The authors propose the possibilities of VDES to be integrated with Electronic Chart Display and Information system (ECDIS), performing as a single point for data acquisition and distribution for monitoring and processing in the ECDIS. VDES satellite link component is emphasized as a part which could extend the safety of navigation as well as possible VDES applications for future service. A completely new architecture is proposed to get efficient and reliable data path, especially in ship's communications. VDES could become a key point in safe and secure communications with both terrestrial and satellite components, resulting in a new area of integration possibilities. The main role of VDES in ship communications could be in critical instances of the ship's operation as well as distress situations.

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## 1 Introduction

The VDES is recognized as the efficient use of radio capabilities, based on the Automatic Identification System (AIS). The main advantage of the VDES is higher data rate usage than the AIS. Generally, VDES should improve the safety and efficiency of navigation, and contribute to more effective use of maritime radio spectrum without unnecessary use of maritime radio voice channels. According to the International Maritime Organization (IMO), the *e-Navigation is the harmonized collection, integration, presentation and analysis of maritime information onboard 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* [1]. Therefore, the VDES should also improve the e-Navigation and enable the faster organization of port operations.

Moreover, all newbuild vessels and a big part of already operating vessels have to be equipped with dual ECDIS on board, according to IMO. However, paperless navigation includes much more than only chart visualization. As the

name says, it is also an information system that becomes a central part of navigation with all possibilities offered on it. One of these possibilities is the visualization of NAVTEX (Navigational Telex) Maritime Safety Information (MSI) reports with details on the electronic chart. Another great example of interfacing ECDIS system with peripheral equipment is the integration with the AIS, where ECDIS operator puts all necessary details which are usually entered directly on AIS, and all the information is transmitted immediately over the AIS transceiver. Due to these possibilities, a possible new approach to further integration of the ECDIS system with the part of GMDSS equipment and the VDES is presented in this paper.

## 2 Overview of ECDIS, DSC, AIS, and VDES

The ECDIS is the advanced information system used for navigation purposes, which partially relieves officers on the watch (OOW) and serves as a sort of decision support system. It provides for the navigators the presentation of all necessary information for safe navigation and saves time

usually spent on planning and documentation of voyage. According to IMO, the scope of the system is a contribution to the safety of navigation. An ECDIS system displays data from electronic navigation charts (ENCs) and integrates the main vessel's navigational (heading, speed, and position) sensors regarding her movement through water and over the ground, respectively, which is the main purpose of the system. Some sensors are interfaced with ECDIS but are not mandatory, such as depth sensor, radar, AIS, NAVTEX, etc. Also, ECDIS can be used as a unique tool for analysis and playback of finished voyages, where navigators can put personal notes and warnings to make better plans for the future. Generally, ECDIS can be described as a unique computer-based system used to help and contribute OOWs in vessel navigation. ECDIS application layer versatility could improve the monitoring and development of peripheral bridge equipment [2, 8, 12, 14].

Digital Selective Calling (DSC) system is a part of the Global Maritime Distress and Safety System (GMDSS) used for transceiving pre-programmed messages. Each DSC station has the unique Maritime Mobile Service Identity (MMSI) number. The added value of DSC system usage is that the operator does not have to interfere or occupy a terrestrial voice or telex channel when there is a need to contact shore, other vessels or specific geographical areas using VHF, HF and/or MF frequency band. Another possibility of the DSC system is relaying of distress alerts by the ship stations and coast stations. However, the VHF DSC

system achieves a data rate of 1.2 kbps, while the MF/HF DSC achieves data rate of only 100 bps [3].

AIS is designed to autonomously provide identification and navigation details for vessels and shore stations at a data rate of 9.6 kbps using two maritime VHF channels. The technology of the system has proven to be very useful, and it is being used for other purposes, such as non-SOLAS vessels, Aids to Navigation (AtoN), Application Specific Messages (ASM), AIS Search and Rescue Transmitter (AIS-SART), etc. [1]. Consequently, excessive usage of AIS resulted in the congestion of the AIS channels in some parts of the world. Another data exchange standard using 25 kHz, 50 kHz, and 100 kHz channels with data rates up to 307.2 kbps was introduced by the International Telecommunication Union (ITU) in 2012 [4]. The above-mentioned developments and AIS problems have led to a new data exchange system propose by the IALA, i.e., VDES. Technical characteristics of the VDES are based on the previously mentioned AIS system. In other words, VDES is the extension of the AIS system with the possibility of streaming data on higher data rates using both terrestrial and satellite links on additional VHF channels. It also provides the possibility to transmit to a unique vessel, all vessels in vicinity, group of vessels or fleet of vessels. Since the number of vessels fitted with AIS is still rising, two AIS channels used for data transmission are becoming overloaded. VDES, as a new system, will keep the original function of AIS and make possible new features. VDES

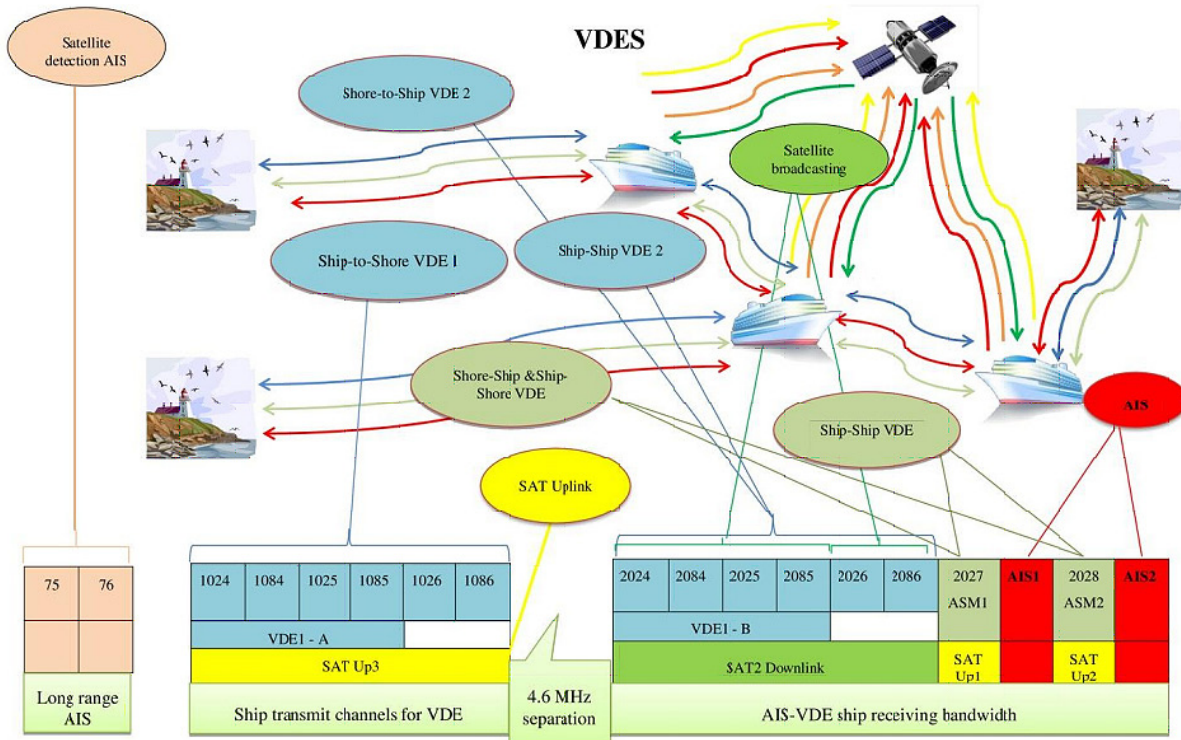


Figure 1 VDES architecture

will increase the number of channels from two to six. It will provide simultaneously both terrestrial and satellite communication components using VHF channels and enable new possibilities for e-Navigation. Channel allocation and system architecture of the VDES are presented in Figure 1. AIS1 and AIS2 (channels 2087 and 2088) are channels defined by ITU Recommendation ITU-R M.1371 [17]. ASM1 and ASM2 (channels 2027 and 2028) are the channels used for ASM. VDE1-A (channels 1024, 1084, 1025, 1085) is ship to shore VHF data exchange channel, while VDE1-B (channels 2024, 2084, 2025, 2085) are shore-to-ship and ship-to-ship VHF data exchange channel. Mentioned channels represent terrestrial part of the VDES. AIS1 and AIS2 (channels 2087 and 2088) are also used as uplinks for satellite receivers. Channels 75 and 76 are Long Range AIS channels used as uplinks for receiving AIS messages by satellite. Sat Up1 and Sat Up2 (2027 and 2028) are used satellite receiving ASM. Sat Up3 (channels 1024, 1084, 1025, 1085, 1026, 1086) are used for ship-to-satellite VDE uplinks, while SAT2 Downlink (channels 2024, 2084, 2025, 2085, 2026, 2086) are used for satellite-to-ship VDE downlinks. All VDES stations will be identified with a unique number, for example, Maritime Mobile Service Identity (MMSI), as a successor of AIS, additionally offers the aforementioned satellite part of communication, which opens new possibilities of communication for vessels not equipped with regular satellite systems. The benefit of the VDES satellite component is used on vessels outside of terrestrial VHF signal coverage.

### 3 Possibility of VDES Application

The VDES is a system that could extend the capability of ships' communications and contribute to e-Navigation. The present communication system, i.e., GMDSS, can be integrated over VDES and ECDIS. When there is a need for contacting vessel or shore side, the VDES can be used to send a data call to the unique vessel and call's information could be presented on ECDIS system with an audible alarm, so that the operator is aware that somebody wants to contact them [13].

The integration should result in added value when compared to the sole system. As stated before, one of the possibilities could be displaying additional information such as berth, local weather forecast, or a call from other vessels. Furthermore, the VDES system onboard vessels can improve the safety of navigation with real-time pilot information or pilot details and specific pilot instructions. This proposal for ECDIS and VDES integration comes from the fact that a large amount of dispersion and lack of standardization in equipment is still present on vessels, even on newbuilds, leading to reduced safety during vessel's navigation. For example, a usual allocation of radio equipment is the following: the main VHF unit is placed in the main navigation console, while the backup arrangement of VHF and main MF/HF unit and/or INMARSAT unit are placed in radio console. On most of the cargo vessels,

there is only one crew member present during navigation and watchkeeping. Therefore, if there is a call or just an announcement on the radio equipment, the duty officer has to acknowledge or discard the call or message on each part of the mentioned equipment, and additionally note it by hand into the radio log. These actions require time and attention from the duty officer to accomplish them, and simultaneously he has to take care of the vessel's movement, speed, position, vessels in the vicinity, etc. The VDES system or VDES transceiver could be used on vessels as a data collector with the possibility of sharing the information with other equipment such as the ECDIS system. The purpose of collecting data by the VDES is the possibility of sending all the collected data to the owner, government agencies, or third-party companies. It would be particularly useful when considering the utilization of the satellite component of the VDES system since satellites have large coverage areas when compared to terrestrial VHF link [15, 16].

### 4 Current Bridge Integration

Navigation bridge integration enables efficient vessel operation and monitoring of all crucial processes necessary for safe navigation, where all navigation sensors are interconnected with all bridge workstations. Besides navigation, some systems integrate alarms and monitoring systems, conning systems, fire dampers, ventilation, propulsion control system, and CCTV (Closed Circuit Television) system. Currently, the communication system's integration by itself is done by networking units, but there is no single point of integration and monitoring of the communication system onboard, besides alarm panel, which is mandatory only on international passenger vessels. This alarm panel represents only a brief indication of communication system alarms. Figure 2 shows the current level of bridge equipment integration [6, 9]. From Figure 2, it is clear that the integrated navigation system comprises of sensors and monitoring systems that provide the navigator the complete picture of the vessel's operation and current conditions onboard. This system is fast and accurate, enabling quick actions necessary for various navigational situations. It also offers redundancy for each part of the bridge, so navigator can be sure the integrity of the system is not disrupted, i.e. even if one part of the system is out of order it is still safe for navigation. Figure 3 represents the most common ergonomic layout of bridge communication equipment. From Figure 3 it is clear where OOW has to go if any communication alarm appears. Usually, OOW is standing or sitting on pilot place in front of ARPA radar, and communication equipment is placed all over the bridge. VHF stations are on front part and all other communication systems like MF/HF, satellite phones, NAVTEX etc., are on the rear part. The idea of integrating all communication equipment over VDES to ECDIS is to make safer and faster action for OOW. The VDES could be the integration part for all the mentioned equipment

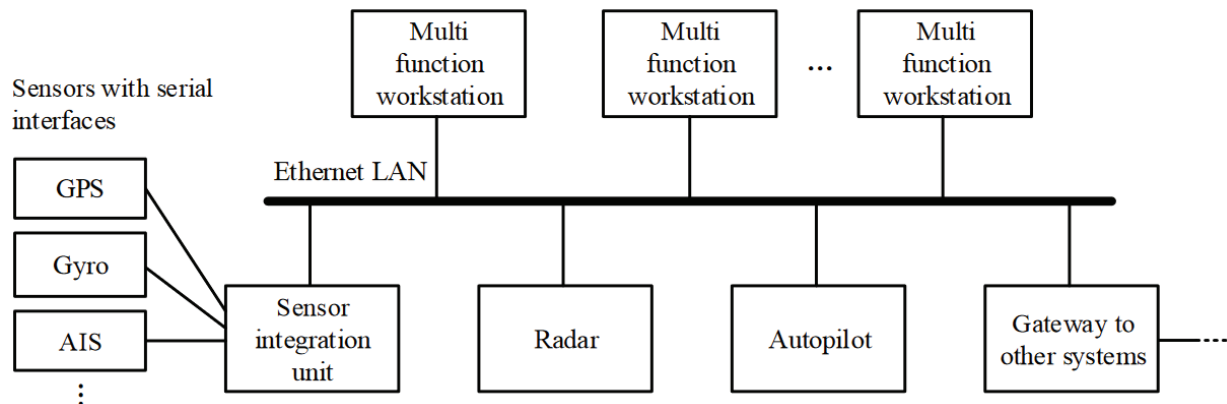


Figure 2 Integrated navigation system

Source: [5]

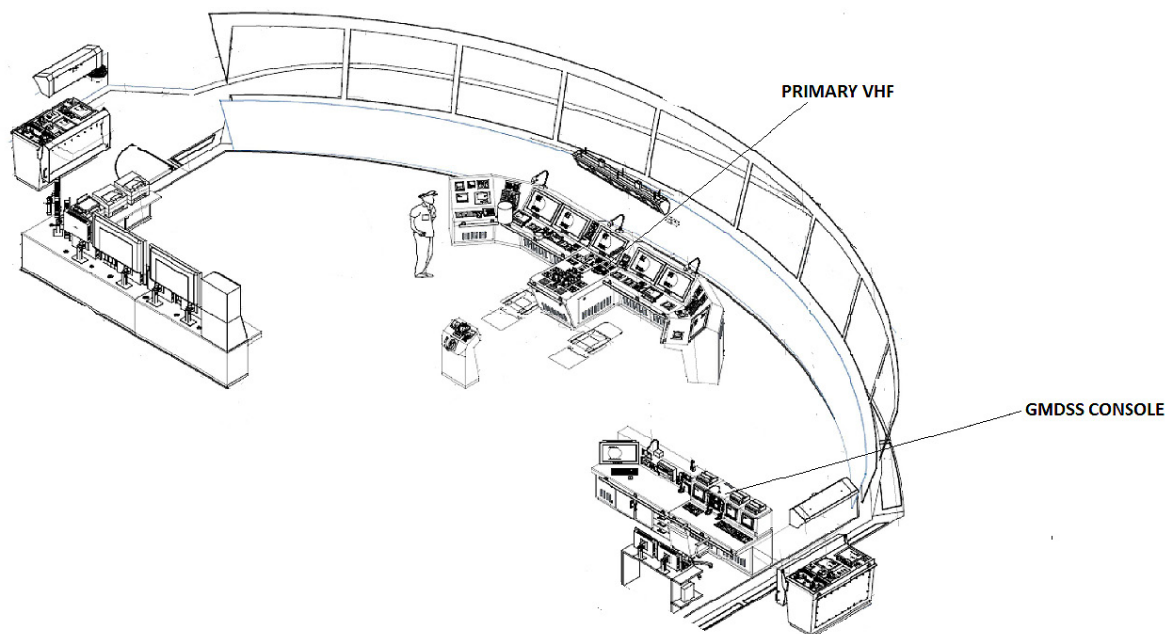


Figure 3 Navigation bridge layout

Source: Made by authors

so that every collected data could be sent immediately to the party which is concerned, either for the timely update informing or for later analysis. Additionally, the ECDIS system could compress all the information to the unique digital radio log, so there would be no more need for hand-writing into the radio logbook.

## 5 Architecture of Integrated Communication-VDES-ECDIS System

The architecture of integrated systems, which comprises of ECDIS with additional and mandatory sensors, VDES, and communication part of the equipment, is presented in

Figure 4. The integrated system shown in Figure 4 would ensure that all calls and system alarms are populated on ECDIS to appropriately inform OOW about calls from other vessels or shore and consequently to take any further action immediately. The existing communication systems are already integrated, and each unit of the communication system is present on the communication network, but still, it is solely a communication network. With the architecture of integration proposed in this paper, each vessel could be equipped with the central communication part, i.e., VDES, which offers a great spectrum of the real-time data stream. Communication protocols between units in the proposed architecture still have to be defined to get

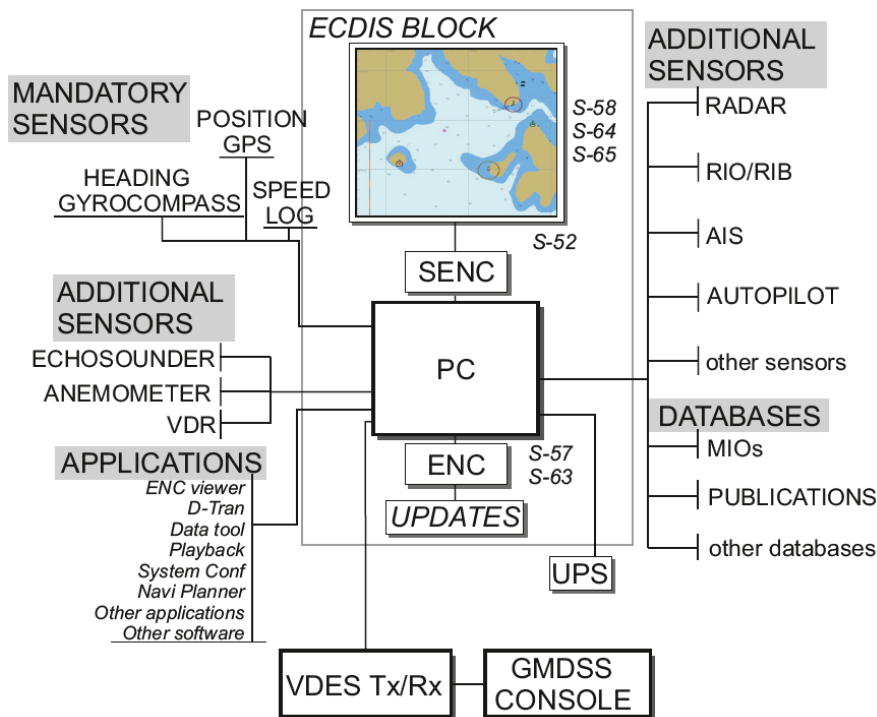


Figure 4 Integrated COMMUNICATION-VDES-ECDIS

Source: Modified by authors from [2]

the safest and most stable communication between essential parts of an integrated system. VDES's operational characteristics that are contributing to the integration part can be found in [4, 7, 11]. VDES integrated with GMDSS could offer a unique way of representing all received or sent messages on ECDIS by special application layer or overlay. Messages represented in such a way could improve OOW reaction and reduce decision making time.

The fact that vessel is all the time ready for transceiving messages leads to major improvement, especially for vessels without regular network/internet connection. However, when the terrestrial part of VDES is compared with the satellite part, it is clear that the latter part needs more time for complete implementation and validation. Generally, the VDES concept or integrated VDES concept represents the next generation of onboard mandatory VHF equipment. The VDES could have a great advantage over other systems to the IMO Polar Code, because of its communication possibilities. Further development of VDES will show if there are any potentially harmful or insecure communication possibilities in regular vessel operation and in what way could affect communication or decision making during the navigation process.

## 6 Conclusions

After ECDIS implementation on ships, navigation process quality was upgraded, while GMDSS system was never changed during years. VDES invention can be un-

derstood as a beginning of modernization GMDSS process. Integration of VDES and GMDSS interfaced with ECDIS could provide a complete image of the vessel's external communication in one place. In this way, ECDIS, supported by VDES, becomes a unique tool for communication, planning, analyses, and monitoring of all processes linked to the vessel's safety, security, and navigation. Also, the VDES system's possibility of satellite communication ensures that all data which is compressed in VDES could be visible to shore side or parties, which are included in the investigation of possible maritime accidents. Integrated VDES could enable an approach to future development and open a completely new area of ship's communications and monitoring of the ship's vital processes. Furthermore, maritime sector is expecting new possibilities of communications with full coverage. VDES, with both terrestrial and satellite part represents new way in over-the-horizon communications making ship's external communications available and reliable on any point of the Earth. VDES with its compact design could be a part of GMDSS modernization due to a fact that it will be capable of handling larger data amount with higher data rates. The proposed versatility of VDES services could be used in port operations automatization process thus reducing unnecessary time spent in communication with all parties involved in ship's preparation for port entrance. Authors' opinion is that continuous upgrade process of ship's external communication systems will contribute to navigation, better maritime traffic surveillance and global ship's connectivity.

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