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Analysis of Data Communication Networks for VTS Surabaya in Class I Type A Navigation District Tanjung Perak

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ABSTRACT
A reliable data communication network is essential in supporting Vessel Traffic Service (VTS) operations, especially in managing vessel traffic in the Class I Navigation District of Tanjung Perak, Surabaya. However, challenges such as network reliability, bandwidth capacity, and potential interference are still obstacles in ensuring efficient operations. This research aims to analyze the condition of the data communication network at the Tanjung Perak Class I Navigation District VTS, focusing on the technology used, its performance, and the obstacles faced. This research uses a qualitative descriptive approach, with data collected through direct observation, interviews with VTS operators, and analysis of related documents. The results show that the communication network at VTS uses Very High Frequency (VHF) frequency-based radio communication technology to support operations, such as digital maps of ship traffic and Automatic Identification System (AIS) systems. In conclusion, the data communication network at the Tanjung Perak Class I Navigation District VTS has met basic operational needs, but still requires further development in terms of technology and infrastructure to improve its efficiency and reliability. This research provides recommendations for the integration of advanced technology, infrastructure improvement, and human resource training to optimize the performance of the communication network.

Introduction

In today's shipping world, information is needed, especially in terms of shipping traffic service information (Hebbar et al., 2024). In accordance with the shipping law, the authority to regulate traffic is handed over to the Navigation District according to their respective areas of authority (Yang et al., 2023).

In accordance with the Decree of the Director General of Sea Transportation No. NV.101/1/14/DJPL-15 concerning the Implementation of Standard Operational Procedures of Vesel Traffic Service (VTS) Surabaya, VTS Surabaya Standard Operational Procedures apply to operational areas including: (Kementerian Pehubungan, n.d.)

a. 1 (one) Public port Surabaya Port

b. Coastal areas comprise the location boundary:
   1. The western boundary is longitude 112° 30'T starting from the island of Java to latitude 6° 30'S.
   2. The northern boundary is latitude 6° 30'S starting from longitude 112° 30'T to longitude 113° 00'T.
   3. The eastern boundary is longitude 113° 00'T starting from the island of Java to latitude 6° 30'S.
   4. The southern boundary is the coastline of Java Island

The Surabaya Vessel Traffic Service (VTS) Standard Operating Procedure applies to vessels sailing in the Surabaya operational area, as follows: (Baldauf et al., 2020)

a. Vessels of 300 GT or more;
b. SOLAS passenger ships;
c. Vessels of 30 meters or more in length or that are towing or pushing with a combined length of 30 meters or more;
d. Ships of all sizes that are carrying cargo that falls into one of the following categories:
   1) Goods classified as dangerous under IMDG (International Maritime Dangerous Goods) rules;)
   2) Materials classified under Chapter '17 of the IBC rules (International Code for the Construction and Equipment for Ships Carrying Dangerous Chemicals in Bulk and Chapter 19 of the IGC rules (International Code for the Construction and Equipment for Ships Carrying Liquefied Gasses in Bulk);
   3) Oil as defined in Marpol Annex l;
   4) Toxic materials as defined in Marpol Annex ll;
   5) Destructive material as defined in Marpol Annex lll;
   6) Radioactive material declared under the safe transportation rules for INF (lnadiated Nuolear Fuel); and Ships of all sizes undergoing voyages under the category of special operations voyages.

While the functions of VTS or operating activities in organizing VTS stations include: (Yoo & Kim, 2021)

a. Provision of information services, navigation assistance services, and/or traffic management services.
b. Maintain the safety and efficiency of shipping traffic and environmental protection in the relevant vesse / Traffic service (ws) operation area.
c. Safeguard resources, facilities, and installations within the relevant WS operation area.
d. Maintain the reliability of the Vesse / Traffic Station (WS) through the implementation of operations and maintenance in accordance with the provisions of standard operating procedures.
e. Take necessary measures on behalf of the National Authority in the event of any activity that may endanger shipping traffic within the relevant WS operating area.

From the above information, especially the function of VTS as a provider of information services, navigation services and or shipping traffic services, VTS requires good communication and information technology to support the services that are burdened on VTS.

Efficient and reliable data communication networks are vital for modern maritime operations, especially in Vessel Traffic Services (VTS), which ensure safe and orderly shipping traffic. VTS operations rely heavily on advanced communication technologies to manage increasing traffic complexity and address safety concerns. Despite the critical role of these networks, challenges persist in integrating and maintaining robust systems within specific regions.

In Surabaya's Class I Navigation District, VTS functions are underpinned by a data communication network that bridges the VTS tower and ships navigating its operational area (Gordyn, 2020). This network supports various critical activities, including traffic monitoring, collision prevention, and navigation assistance, achieved through real-time data exchange. However, issues such as network reliability, bandwidth limitations, and susceptibility to interference can hinder seamless operations.

The purpose of this study was to determine the Data Communication Network Overview at VTS Class I Navigation District Tanjung Perak Surabaya. The results obtained from a study cannot be separated from the benefits that can be felt by various parties. This research is expected to contribute both theoretically and practically. Theoretically, this research can add to the author's insight, especially related to Data Communication Networks. While practically, this research is expected to be a useful basis for various parties. First, for the Surabaya Shipping Polytechnic, the results of this study can help in understanding the description of the Data Communication Network at the VTS of the Tanjung Perak Class I Navigation District Surabaya. Second, for the community, especially actors in the world of education, this research is expected to be a reference for understanding the Data Communication Network at VTS Navigation District Class I Tanjung Perak Surabaya.

Research Methods

Type of Research

This research the authors conducted research with a qualitative descriptive approach, qualitative descriptive research, descriptive is a problem formulation that guides research to explore and portray the conditions to be studied broadly and deeply. Qualitative research focuses on the phenomenon of data communication networks.

A qualitative approach is an approach intended to understand phenomena about the situation that occurs on a computer network as a research subject, for example, the number of connected devices, Quality of Service of the network, network down time and network traffic.

Research Location

The research location is in the Class I Navigation District of Tanjung Perak. This location was chosen because it is in accordance with the title and designation of research to analyze the Data Communication Network of the Navigation District Class I Tajung Perak Surabaya.

Data source

The data source used by researchers in this study is to use the data communication network observation technique of the Tanjung Perak Class I Navigation District Surabaya, this observation is carried out by capturing (mapping) the data communication network, this data as primary data. Secondary data can be taken from literature books as supporting data.

Data Collection Techniques

Data collection was done through the following methods:

1. Observation: Researchers made direct observations of the condition of the data communication network, including the devices used, data traffic, and digital maps in the VTS control room. This observation provides a real picture of the network function in supporting VTS operations.
2. Interviews: Researchers conducted semi-structured interviews with VTS operators and technical staff to gather information regarding their experience in managing the communication network, challenges faced, and solutions implemented.
3. Documentation: We collected data from official documents, such as technical reports, network maps, and operational manuals, for additional analysis.

Data Analysis Technique

Data analysis was conducted in a descriptive qualitative manner by describing the results of observations, interviews, and documentation. The collected data were analyzed to identify patterns, challenges, and opportunities for the development of data communication networks in the Tanjung Perak Class I Navigation District.

Results and Discussion

Results

VTS (Vassel Traffic Service) in accordance with the Decree of the Director General of Sea Transportation No. NV101/1/14/DJPL-15 (Kementerian Pehubungan, n.d.) has the responsibility:

- Provision of Information services, navigation assistance services, and/or traffic management services.
- Maintain the safety and efficiency of shipping traffic and environmental protection in the relevant VTS (Vassel Traffic Service) operation area.
- Maintain resources, facilities or installations within the relevant VTS operating area.
- Maintain the reliability of the Vessel Traffic Service VTS station through the implementation of operations and maintenance in accordance with the provisions of standard operating procedures.
- Take necessary measures on behalf of the National Authority in the event of any activity_ that may endanger shipping traffic within the relevant VTS operating area.

The above description of responsibilities shows the vital role of VTS in the process of shipping navigation and shipping traffic management. In carrying out the main tasks and functions as a provider of information services, navigation assistance and / or traffic management requires communication technology. Communication technology as a bridge between the VTS Tower and ships that are on the traffic and navigation path where VTS is located and authorized to handle shipping traffic.

Figure 1. VTS Building of Naviation District Class I Tanjung Perak Surabaya
Source: Tanjung Perak Class I Navigation District (2024)

Radio Comunication

The maritime domain employs a multitude of communication technologies across the radio spectrum to attain these objectives, which are instrumental in ensuring safe navigation, optimizing operational efficiency, and facilitating commercial activities (including trade and public correspondence). However, many of these technologies were developed with a single application in mind. Consequently, a ship must carry a variety of communication equipment to receive relevant data. In the context of e-Navigation, there is an opportunity to plan a maritime communication system architecture. This necessitates an assessment of the probable communication requirements and an understanding of the radio spectrum available to the community (IALA, 2017).

The maritime domain employs communications for a variety of critical applications, including safety, routine operational activities, and commercial applications such as trade and general correspondence. To realize the advantages of e-Navigation design, the communication architecture must prioritize a limited set of recognized applications while maintaining the flexibility to evolve and accommodate other applications as needed.

Propagation

It is important to note that both analog and digital communications will experience propagation effects. In the case of digital communications, propagation can limit or hinder the transmission of digital communications. Therefore, measures may be required to address this issue in order to reduce the adverse effects of propagation. Potential measures that could be employed include carrier selection or the use of appropriate protocols for the communication process.

Low Freqency Band (LF)

The LF radio spectrum is utilized by the maritime community for a variety of purposes. While the Loran C system is no longer operational, alternative systems, such as eLoran, are being developed to assess the potential for utilizing this spectrum.

Medium Frequency / High Frequency Band (MF/HF)

The maritime community employs the MF/HF radio spectrum for a variety of purposes, including voice and data communications. These operations are conducted in three principal modes: ship-to-ship, ship-to-shore, and ship-to-ship. MF/HF transmissions facilitate the dissemination of general maritime safety information (MSI) and distress-related communications through the use of DSC, NBDP, voice, and data. These communications traverse the maritime mobile service band, spanning the range of 1.6 to 26.5 MHz. Distress-related communications are allocated to a limited number of designated channels. The channel bandwidth is typically 0.5 kHz (DSC and NBDP) and 3 kHz (voice and data).

Digital Selective Calling (DSC)

Digital Selective Calling (DSC) is a technique that employs digital codes to enable radio stations to establish communications and transfer information to other stations or groups of stations. It is utilized for emergency or general communications over medium to long range distances (patki et al., 2022). DSC is primarily utilized for ship-to-ship, ship-to-shore, and ship-to-ship distress, urgency, and safety calls prior to the initiation of distress, urgency, and safety communications via MF/HF radio telephony or telex. DSC distress alerts, which consist of pre-formatted distress messages, are employed to initiate emergency communications with ships and rescue coordination centers. The objective of DSC is to eliminate the necessity for manual monitoring of radio receivers on distress and safety frequencies on the bridge or on shore. Additionally, six specific MF/HF frequencies have been designated for Digital Selective Calling (DSC) and safety communications, with one allocated to each communications sub-band up to the 16 MHz band. DSC is an integral component of GMDSS. Additionally, it can be utilized to establish communication with a specific station, a group of stations, or all stations within the designated radio range. Each DSC-equipped ship, shore station, or group is assigned a unique 9-digit maritime code, as defined in Recommendation ITU-R M.585. This code is known as the Mobile Service Identity (MMSI).

Voice Communication

Various uses of the MF/HF radio spectrum in the maritime community for voice communications modes of operation of ships, ships-shore and shore-ships. Voice communications are common throughout the 1.6-26.5 MHz band. Channel bandwidth is typically 3 kHz. Digital communications in the MF/HF band is a relatively new technology with high potential (Goldman & Rawles, 2001).

Data Communication

The advent of new and evolving HF digital modulation techniques has opened up fresh avenues for the utilisation of frequency band (1.6-26.5 MHz) data transmission. The pertinent technologies are delineated in Recommendation ITU-R M.1798. Recommendation ITU-R M.1798-1, published in

April 2010, encompasses three systems. System 1 is an HF data service modem protocol that employs orthogonal frequency division multiplexing (OFDM) and 4/8-PSK modulation to 32 sub-carriers. System 2 is an electronic mail system that employs the Pactor-III protocol with quadrature phase-shift keying (QPSK) modulation to 18 sub-carriers. It should be noted that Systems 1 and 2 utilise the 3 kHz channel for data rates of 3 kbps or lower. System 3 is a wideband HF data system for internet access and electronic mail services using OFDM. This system employs QAM modulation to 228 sub-carriers at 10 kHz bandwidth or 460 sub-carriers at 20 kHz bandwidth, supporting data rates up to 51 kbps. All three systems are IP-level compatible, facilitating interoperability (Sandy et al., 2015).

Narrowband Direct Printing (NBDP)

NBDP is a technique that automates the process of radio signaling, which is used in telegraphy. NBDP (also referred to as radio telex) is frequency-shift keying (FSK) modulated onto a 0.5 kHz high-frequency (HF) channel and is capable of supporting low-speed data transmission (100 bps) within the maritime mobile service band, which spans from 1.6 to 26.5 MHz (Toulouse et al., 2021). NBDP is an integral component of GMDSS, facilitating text-based distress follow-up communication and general communication between ship-to-ship, ship-to-shore, and land-to-ship, thereby overcoming language barriers. The utilization of NBDP for general communication is on the decline. It is currently employed for position reporting from ships and for disseminating warning announcements and meteorological forecasts from shore stations. It has been suggested that NBDP may be phased out as a required system under GMDSS for position reporting from ships and for conveying meteorological warnings and forecasts from coastal stations.

Very High Frequency Band (VHF)

The maritime VHF frequency band (156.025-162.025 MHz) is common and is the primary means of ship-shore, ship-shore and vessel communications within the domain. It is used for distress information, safety and general communications. The frequency in use is currently 25 kHz although the use of 12.5 kHz channels on a basic basis is allowed to improve spectrum efficiency.

Regional Data Communication Systems

In many regions, VHF data communication systems are available for shore-to-ship and ship-to-shore data exchange. Such systems are commercial in nature and are used mainly for vessel tracking, search areas in SAR operations, etc.

Discussion

From the description of the communication technology described above, most of the communication technology used uses radio communication from LF, MF, HF and VHF frequencies. At VTS Navigation District Class I Tanjung Perak Surabaya also uses radio communication technology to communicate between ports to ships. At VTS Navigation District Class I Tanjung Perak Surabaya uses the Very High Frequency (VHF) frequency, in this radio communication-based communication used in all communications both voice communication and data communication (Arif, 2014). VHF frequency waves are in the 156.025 to 162.025 MHz band. Data communication is very important in VTS operations. In the comment cetre room of the VTS Building there is a monitor screen that displays a map of the shipping lanes and shipping traffic in the authority area of the Tanjung Perak Class I Navigation District.

Figure 2. VTS control room Class I navigation district tanjung Perak

Source: Tanjung Perak Class I Navigation District (2024)

In VTS operations, as a regulator of shipping traffic so that ship traffic in the shipping lane is safe and can take place in an orderly manner, good communication is needed between the VTS Center and ships or ships with ships (Parlov, 2023). Special data communication plays an important role in regulating ship traffic on the shipping channel, this communication is used in digital chart technology at the VTS center, the digital map is a reference for VTS Center officers in monitoring ship traffic movements, in the map there are ship traffic lanes, shipping channel signs and ships that are sailing on the shipping channel.

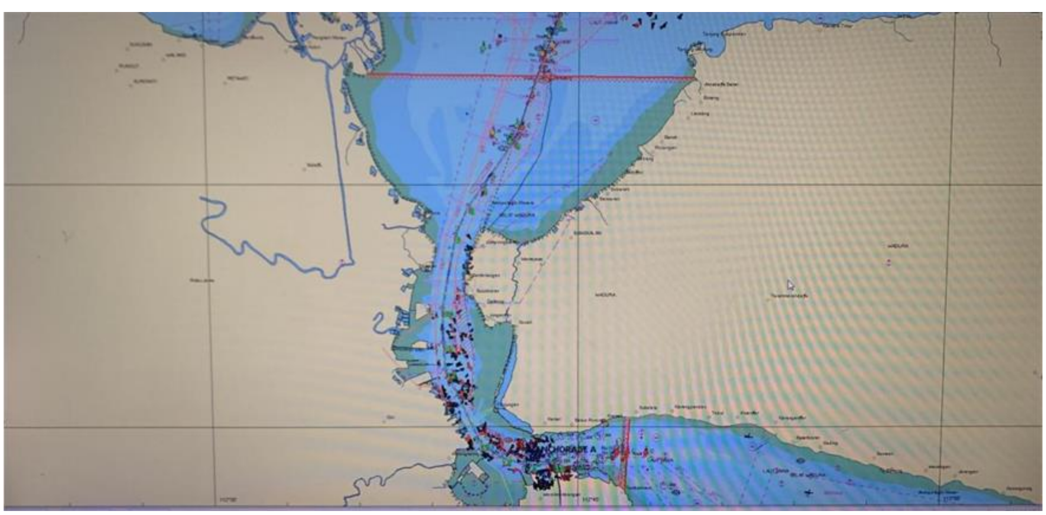

Figure 3. Digital map

Source: Tanjung Perak Class I Navigation District (2024)

Another application is in the AIS (Automatic Identification System) system, AIS is a TDMA-based data exchange system used by ship and coastal authorities (Alqurashi et al., 2023). The main purpose of AIS is to improve navigation safety by assisting the efficiency of ship navigation, environmental protection, and the organization of Vessel Traffic Services (VTS), by meeting the following functional requirements:

1. In ship-to-ship mode to avoid collisions
2. As a means for coastal States to obtain information about a ship and its cargo
3. As a VTS tool that is ship-to-shore (traffic management)

AIS provides a means for vessels to electronically exchange vessel data including identification, position, course and speed with nearby vessels and other shore stations (Tixerant et al., 2018). This information can be displayed on a screen display. AIS is intended to assist the ship's watch officer and allow maritime authorities to track and monitor vessel movements. AIS uses VHF channels AIS 1 (161.975 MHz) and AIS 2 (162.025 MHz) or regional channels defined by geographic area. In addition, AIS has the ability to exchange data via application-specific messages for navigation and safety-related purposes.

Conclusion

From the observations and documentation that have been carried out by the author, it can be concluded that the data communication network at VTS Class I Navigation District Tanjung Perak Surabaya uses radio communication technology with the Very High Frequency (VHF) spectrum with a frequency band of 156.025 to 162.025 MHz. Examples of applications of data communication at VTS are digital maps of ship traffic flow and AIS (Automatic Identification System).

This research is the beginning of the introduction of the data communication network at VTS Navigation District Level I Tanjung Perak Surabaya, there is still a lot that needs to be explored more deeply in its application, especially those that are trending about AIS (Automatic Identification System) technology. In the next research it is possible to discuss AIS as a unified system that needs to be known and studied more deeply.

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