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**□** ARM **□** ENG **□** PAP **X**  Input

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Agenda item [[2]](#footnote-2) 6

Technical Domain / Task Number 2 …………………………………

Working Group WG3

Author(s) / Submitter(s) Juntae KIM, Kaemyoung PARK, Jinho YOO (Korean Register)

Seung-Hyun CHOI (Hanwha System)

The design of VDES testbed and gateway under Smart-Navigation Project

# Summary

As part of the Smart-Navigation Project in Republic of Korea, it is planned to build, develop and operate a VDES Testbed for the sake of testing the e-Navigation service data transfer using VDES communication from 2019 to 2020. In this regard, this document introduce the design of network interface structure and VDES gateway for the reliable and efficient delivery of e-Navigation service data from a service host to a service client based on our VDES testbed design under development. In addition, this document contains information on the message definition, interface design, message operation scenario, equipment design and implementation plan in our project.

VDES testbed under development consists of a VDES Test Center, VDES shore stations and VDES ship stations. The test center includes a management system, a VDES shore gateway and a service host for testing e-Nav service data transfer. Based on this testbed architecture design, we plan to complete the development of supporting equipment for the testbed such as VDES gateway, management system, service host and client devices for e-Nav service data generation and testing by the end of this year.

## Purpose of the document

This document is intended to provide the idea pertaining to the network interface structure and gateway design for reliable and efficient transfer of e-Navigation service data with VDES system on the basis on the result of VDES testbed design under the Smart-Navigation Project. In addition, we would like to introduce the progress and plan of VDES testbed development under Smart-Navigation Project.

## Related documents

IALA Guideline G1139 Ed.2: The Technical Specification of VDES

IEC 61162 Series: Maritime navigation and radio communication equipment and systems — Digital interfaces

# Background

## Smart-Navigation Project

Smart-Navigation project funded by Korea’s Ministry of Oceans and Fisheries, was initiated in 2016, and is now underway for the development and construction of Korean e-Navigation testbed.

KR is working on the development and construction of VDES testbed and supporting equipment in the core task III of the Smart-Navigation Project along with the development of VDES equipment.

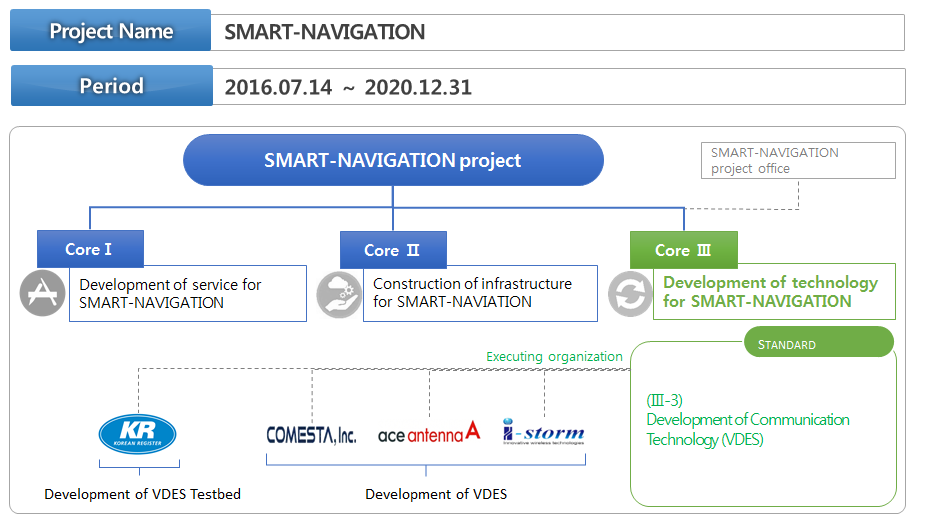


Figure 1. SMART-NAVIGATION Project

## VDES Testbed building and operation plan

The construction of the VDES testbed is planned for two years from 2019 to 2020. The approximate schedule is as follows.

1. Design and Development : 2019. 01 ~ 12.
2. Installation : 2020. 01 ~ 06.
3. Operation and Test : 2020. 07 ~ 12.

KR plans to build the VDES testbed including a test center, VDES shore station and VDES ship station by 2020. The interoperability and performance test for e-Nav service data transfer through VDES communication will be conducted in VDES testbed by interoperating service host and client through VDES base and mobile station. VDES shore stations will be provisionally located in Busan or southern coastal area of Korea.

# Design for VDES Testbed

## Testbed architecture and Functions of components

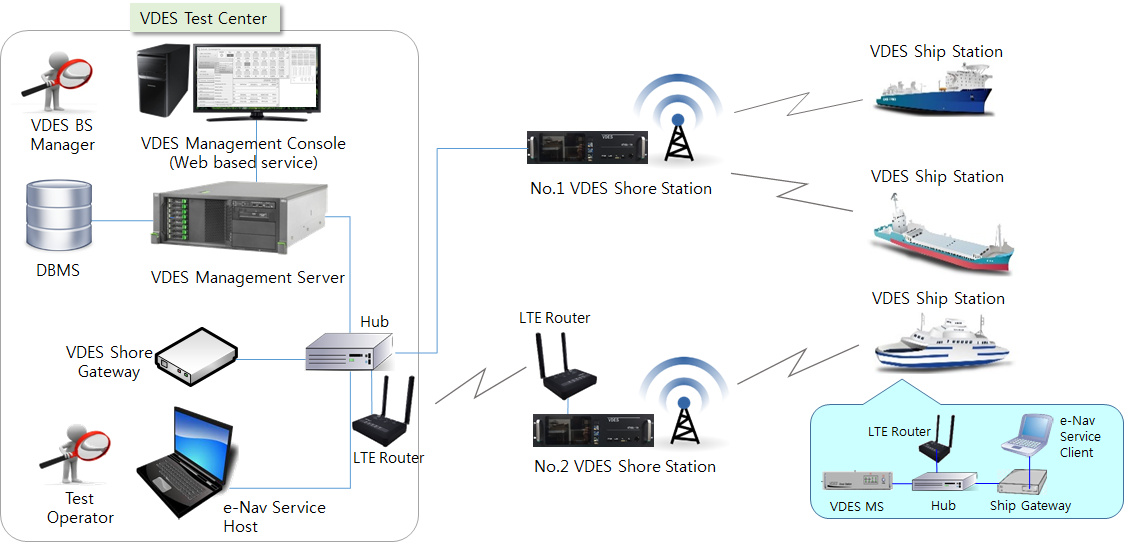


Figure 2. Proposed Architecture of VDES Testbed

The architecture of the VDES testbed is designed as shown in Figure.2. VDES Testbed consists of a VDES Test Center, two VDES Shore Stations and three VDES Ship Stations but there is possibility to be changed according to the progress of the Project.

The VDES test center includes the VDES management system, the e-Nav service host, the VDES shore gateway and associated network devices.

* The VDES management system provides the functions of monitoring equipment, configuration of VDES Base Stations and gateways, traffic data storage, user interface, ASM message generation.
* The e-Nav service host device includes the MMS host simulator and is able to input Korean e-Nav service data for testing based on S-100.
* VDES shore station gateway is core equipment that supports network connection and inter-operability between Non IP based VDES shore station and TCP/IP based e-Nav service host device. It provides the function of converting network protocol and converts e-Nav service message to VDES PI sentences. Another main function is to provide the routing function to send incoming e-Nav service message to the transferable VDES base station based on MRN information.

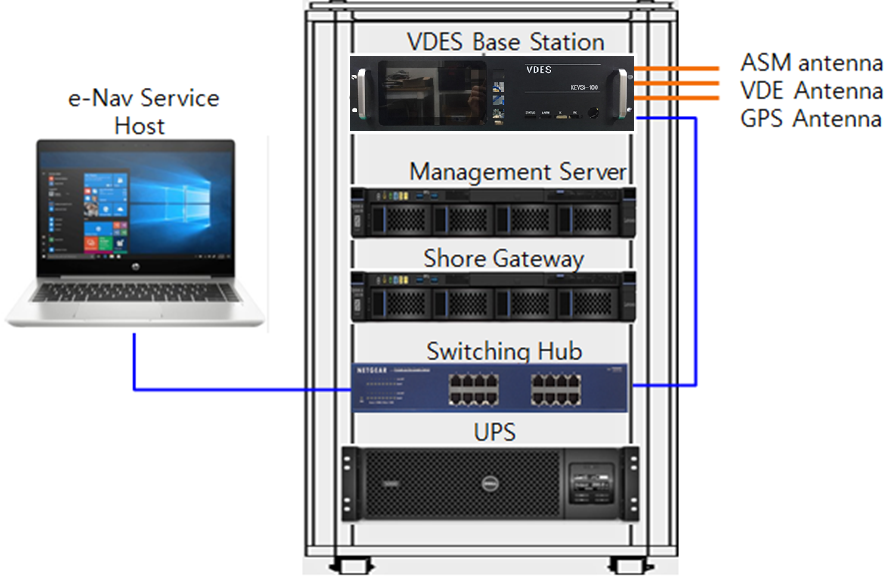


Figure 3. VDES Test Center and VDES Base Station

The VDES Test Center will be installed in the same place with No.1 VDES shore station, and which is connected via Ethernet network, and another No.2 base station will be connected via commercial LTE-Router for remote networking.

VDES shore station includes VDES base station equipment, antennas, cavity filters and network devices. The VDES base station equipment(KEVSS-100) developed under Smart-Navigation Project containing the function of ASM and VDE-TER communication including AIS receiver and GPS module to be operable by itself.

VDES ship station includes VDES mobile station, ship gateway, e-Nav Service client device and LTE-Router.

* VDES mobile station is now under development to providing the function of ASM and VDE-TER including AIS receiver and GPS module to be operable by itself.
* VDES Ship gateway supports network connection between VDES Mobile station and e-Nav service client device.
* e-Nav service client includes MMS client simulator and collecting data and log necessary for testing, however, a graphic display device showing S-100 data such as ECDIS is not included in the Testbed.
* LTE-router equipment is used for testing the text message transmission between two different communication means of VDE and LTE.

# E-Navigation Service and VDES Interface Design

## e-Nav Service Host and Client Devices Design

In order to simulate the provision of various e-Navigation service, we designed the functions of e-Navigation service host and client devices. It is important to design the function for providing the e-Navigation service taking into account the reliable and efficient message delivery. To provide e-Navigation service, the functions of host and client are designed to enable to interoperate with VDES system and the implementation methods are described in Table 1 for each function. The service host device in a shore station interacts with the service client device located in a ship station via the VDES communication according to the service scenario of the host.

Table 1. e-Nav Service Host/Client Functions

|  |  |  |
| --- | --- | --- |
| Functions | Implement Method | Applied Equip. |
| MMS essential function for test of e-Nav service message transmission through VDES | Implementation of MMS essential functions(Message Relaying/Long or Short Polling/Queuing) | HOST |
| Transmission and reception function of e-Nav service message | Implementation to exchange maritime service messages to HTTP-based messages via the VDES gateway according to the VDES service scenario | HOST/Client |
| Message transmission and reception between heterogeneous communication | Implementation for message transmission from enabling service client with commercial LTE communication to enabling service client with VDES communication | HOST |
| Function for Data information storage and display | Data logging and recording for transmission and reception data | HOST/Client |
| Installation and operation on a window-based notebook PC | Implementation as a solution that can be installed and operated on a window-based notebook PC. This function provides the GUI for user test and performance analysis. | HOST/Client |

## Shore and Ship Gateway Design

The VDES gateway is divided into shore gateway and ship gateway and the basic function designs are described in Table 2.

The shore gateway serves as a gateway for the connection between non-IP based VDES networks and TCP/IP based service host. The shore gateway can interoperate with a service host and a VDES base station by processing the e-Nav service message(message relaying, polling) and by converting from HTTP based service message to VDES PI sentence message and vice versa. Another key function of a shore gateway is to route the incoming messages to the transferable base station or suitable service host by identifying the type of service message and destination ship information based MRN information located in HTTP header. It also creates and manages the routing table to identify transferable shore station for routing function.

The ship gateway performs the conversion between HTTP based message(HTTP header, payload) and PI sentence to be interoperable with the service client. In addition, it also processes e-Nav service messages (message relaying, message polling).

Table 2. Function of Shore/Ship Gateway

|  |  |  |
| --- | --- | --- |
| Function | Implementation Method | Applied Equip. |
| e-Nav service message format conversion function | Conversion function between e-Nav service message based on HTTP header and payload format and VDES PI sentence format | Shore/Ship GW |
| e-Nav service message processing function | Provides function to send and receive Polling, relaying and HTTP response messages interoperating with service host and client | Shore/Ship GW |
| Message transfer routing | Create and update routing table DB using srcMRN and base station identification of messages received from VDES base station  Extracts VDES base station identification information to be sent through routing table DB using dstMRN included in service message received from service host | Shore GW |

## VDES protocol for the provision of e-Navigation Service

The interface components of the VDES system are divided into three parts, as shown in Figure 4.

Table 3 describes the major interface functions of each component.

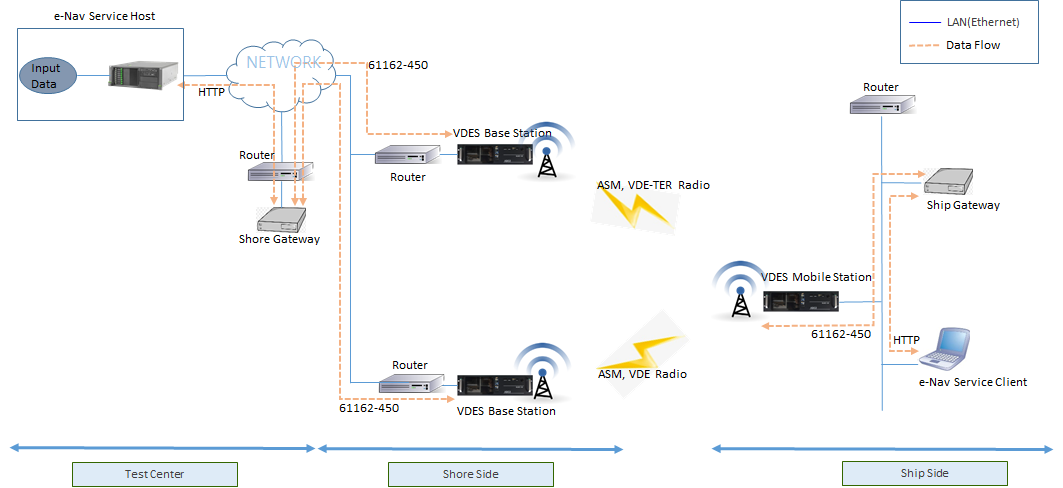


Figure 4. VDES System Design

Table 3. Main function and interface

|  |  |  |
| --- | --- | --- |
| Classification | | Main Function and Interface |
| 1 | Test Center | Input Data – e-Nav Service Host : GML(S-100) Data  e-Nav Service Host – Shore Gateway : HTTP |
| 2 | Shore Station | Shore Gateway – VDES Base Station : UDP(61162-450)  VDES Base Station – VDES Mobile Station : VDES Radio Channel |
| 3 | Ship Station | VDES Base Station – VDES Mobile Station : VDES Radio Channel  VDES Mobile Station – Ship Gateway : UDP(61162-450)  Ship Gateway – e-Nav Service Client : HTTP |

All service messages from a ship station are sent to a ship gateway and which delivers data packets to VDES mobile station after changing service messages into the format of IEC 61162-450 messages. The VDES mobile station sends a packet to the VDES base station through VDE-TER radio channel. The detail procedure for sending a message is described in Figure 5.

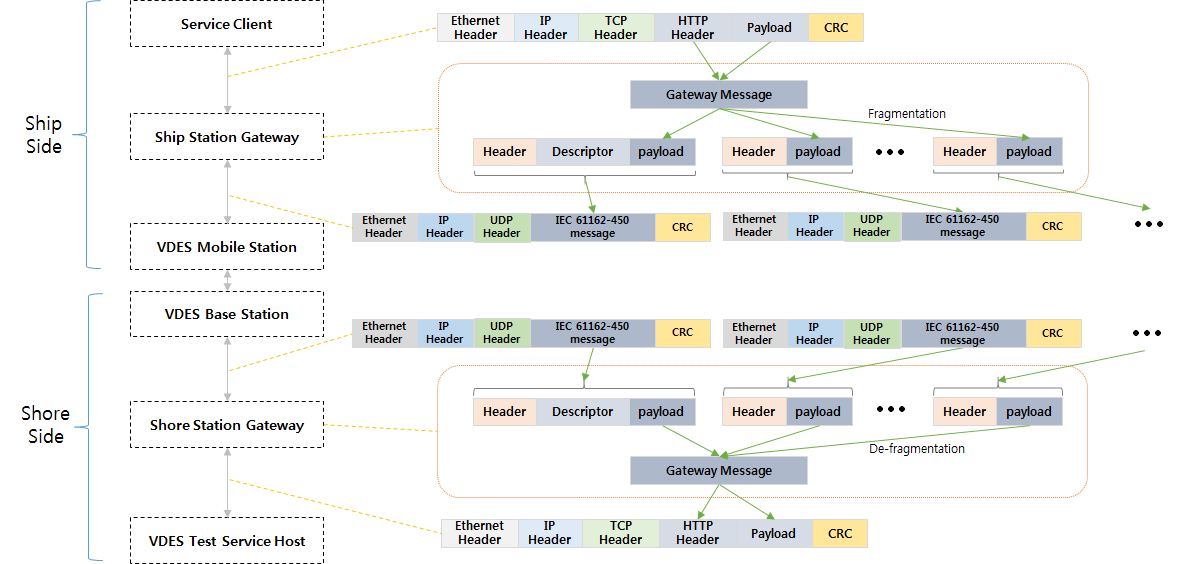


Figure 5. VDES Message Processing

* Ship to Shore Message Processing
* The e-Nav service client can only send requests defined as HTTP protocol to the ship gateway.
* The ship gateway receives the service messages of HTTP protocol from the service client and re-assembles the HTTP header and payload for the gateway message.
* The ship station gateway messages is composed of header, binary image descriptor and binary image data fragment(Payload) according to the defined structure of IEC 61162-450 standard and transmitted to VDES mobile station by using UDP connection. For reference, binary image data format is used because VDE message format is still not officially defined and it is possible to send multi-datagrams, and the maximum size for each datagram is limited to 1472 bytes according to the standard.
* VDES mobile station transmits data to the base station through VDE radio-communication.
* The base station transmits the received data to the shore gateway.
* The shore station gateway recovers the received data into the gateway message format based on header information and binary image description as defined in IEC 61162-450 standard. The shore station gateway recovers the gateway message back into service message of HTTP protocol and sends this service message to the e-Nav service host through TCP/IP network.
* Shore to Ship Message Processing
* After HTTP message is sent from the shore station gateway to the e-Nav service host, the e-Nav service host sends an HTTP response to the shore station gateway.
* The shore station gateway reconfigures the HTTP response received from the e-Nav service host into a gateway message format by re-assembling the HTTP head and the payload.
* The shore station gateway transmits the gateway message to the VDES base station by using a UDP connection, consisting of a header, a binary image descriptor, and a binary image data fragment(Payload) according to the defined structure of IEC 61162-450 standard.
* The base station transmits data to the mobile station through the VDE radio-communication, and the received message at the mobile station is delivered to the ship gateway.
* The ship gateway recovers the received data in the format of IEC 61162-450 message to gateway message. The ship gateway reconfigures the gateway message back into the header and payload for the HTTP protocol. The ship gateway sends the recovered HTTP response message to the e-Nav service client that sent request message.

The detail structure of VDE PI sentences using IEC 61162-450 messages is shown in Table 4, and VDE header field is added to identify the shore station and the ship station by VDES equipment.

Table 4. VDES interface message

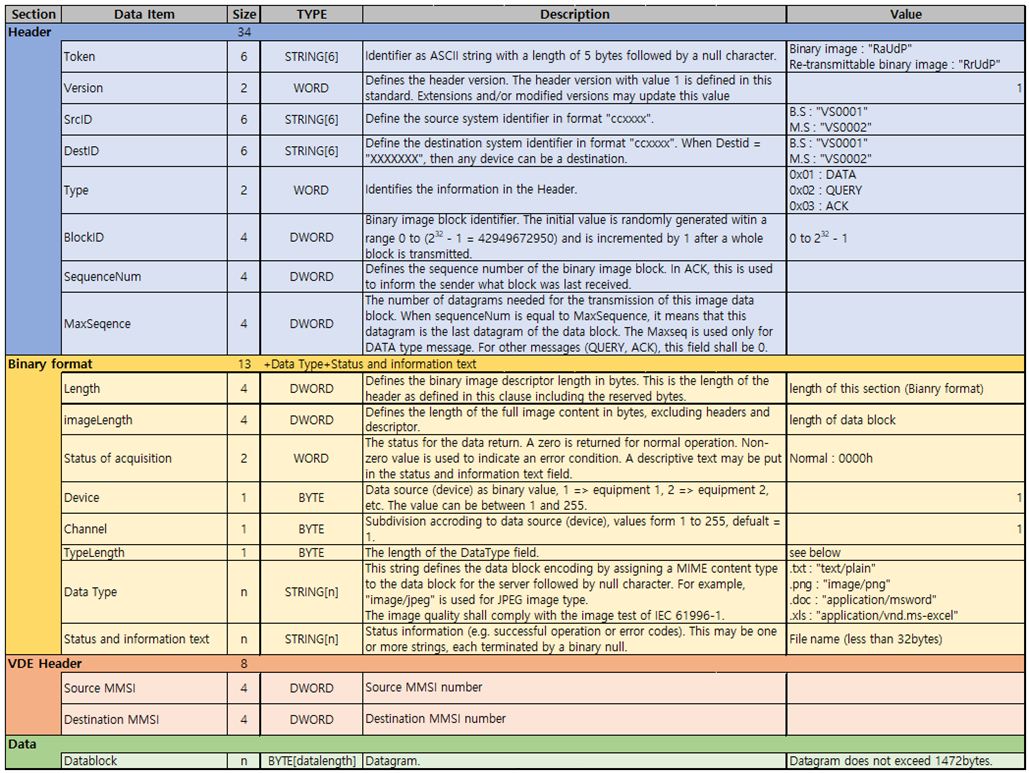


Figure 6 shows the protocol stack between interworking VDES devices. The physical line is the LAN, and the data flow uses from the first layer to application layer(HTTP).

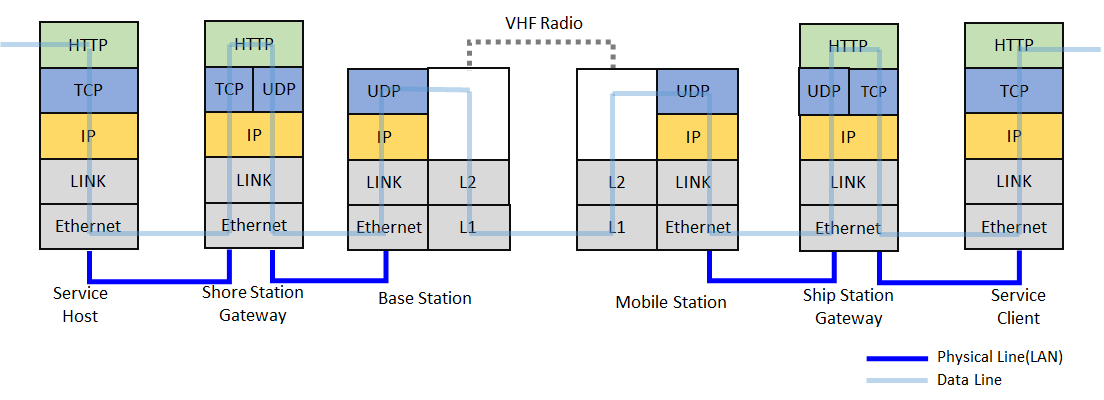


Figure 6. VDES Protocol Stack

## Interface Design for VDES Testbed

The interface of the VDES network is designed as shown in Figure 7. The management system and ASM client provide ASM message test function over VDES radio channel and display the monitoring ship and shore stations through a map and statue for network performances and user managements. Table 5 shows interface classification between devices. The defined message structure will be verified according to our proposed service scenarios.

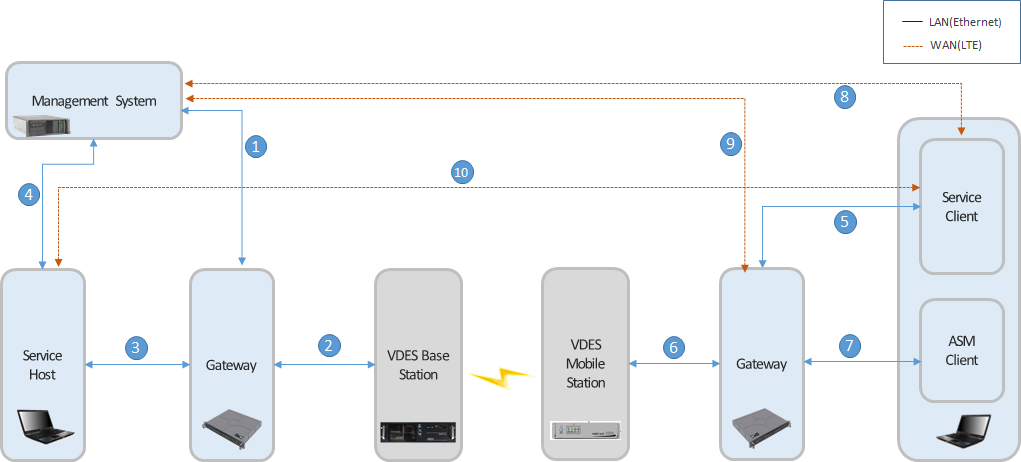


Figure 7. VDES Interface Implementation

Table 5. VDES Interface Messages

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Num | From | To | Interface | Remarks |
| 1 | Management System | Shore Station Gateway | Trx Control message  ASM test message | Ethernet |
| 2 | Shore Station Gateway | Base Station | VDE test message  ASM test message  Control message | Ethernet |
| 3 | Service Host | Shore Station Gateway | VDE message | Ethernet |
| 4 | Service Host | Management System | Service host Trx monitoring message | Ethernet |
| 5 | Service Client | Ship Station Gateway | VDE message | Ethernet |
| 6 | Ship Station Gateway | Mobile Station | VDE message | Ethernet |
| 7 | ASM Client | Ship Station Gateway | ASM message | Ethernet |
| 8 | Service Client | Management System | Service client Trx monitoring message | Commercial LTE |
| 9 | Ship Station Gateway | Management System | Ship Station gateway message monitoring message | Commercial LTE |
| 10 | Service Host | Service Client | Polling / Relaying | Commercial LTE |

## HTTP Header/Payload informations

Korean e-Navigation service is provided through the MMS(Maritime Messaging Service). MMS is the system that supports message exchange between service host and client based on HTTP protocol. Therefore, HTTP protocol is applied to service message to test Korean e-Navigation service provision through VDES testbed in conjunction with MMS.

Basic data format of e-Navigation service message used by e-Nav service host and client is shown in Table 6. The applied e-Navigation service message consists of HTTP header and payload. HTTP headers contain srcMRN, dstMRN, URL, and msgSeq. SrcMRN represents the MRN address of the sender which sent the message. DstMRN indicates the address of the MRN of the receiver. The URL indicates the address of the destination service to actually use. MsgSeq is used to identify messages to measure a performance such as message transmission error rate. By utilizing such HTTP-based message, e-Navigation service message can be transmitted to service host and client through VDES gateway.

The MRN(Maritime Resource Name) is a unique identification scheme that distinguishes maritime resources. The MCP manages and identifies ships, sailors, organizations, and services that were previously divided into individual systems in a common system called MRN. Korean e-Navigation service client and host both have their own MRN. The MMS may identify a message sender and receiver using the MRN and identify where the received message should be sent. In MMS, MRN plays a role similar to IP in general Internet communication and is used as a unique value to identify message sender and receiver.

The HTTP message structure shown in Table 6 is one of the interface messages we designed, and the detailed messages are not included in this document. We are implementing a well-designed interface message and plan to share test results later after conducting indoor and sea area test.

Table 6. HTTP Header/Payload information

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Material | HTTP Header | | | | |
| Num | field name | form | size | Value | Description |
| 1 | srcMRN | string | variable | Char, Num | Source MRN |
| 2 | dstMRN | string | variable | Char,Num | Destination MRN |
| 3 | URL | string | variable | Char,Num | Receiver Service URL |
| 4 | msgSeq | string | variable | Num | Message Sequence |
| Material | HTTP Payload | | | | |
| Num | field name | form | size | Value | Description |
| 1 | data | String | variable | Char,Num | Payload Data information  S-100 Data (XML or GML) |

Figure 8 shows one of examples for test scenario in our VDES testbed. This scenario defines an incident alarm service as a scenario for exchanging maritime exchange standard messages(GML Data). Maritime data exchange standard messages are assumed to be warning messages of dangerous situation. Vessels A and B are different VDES service clients.

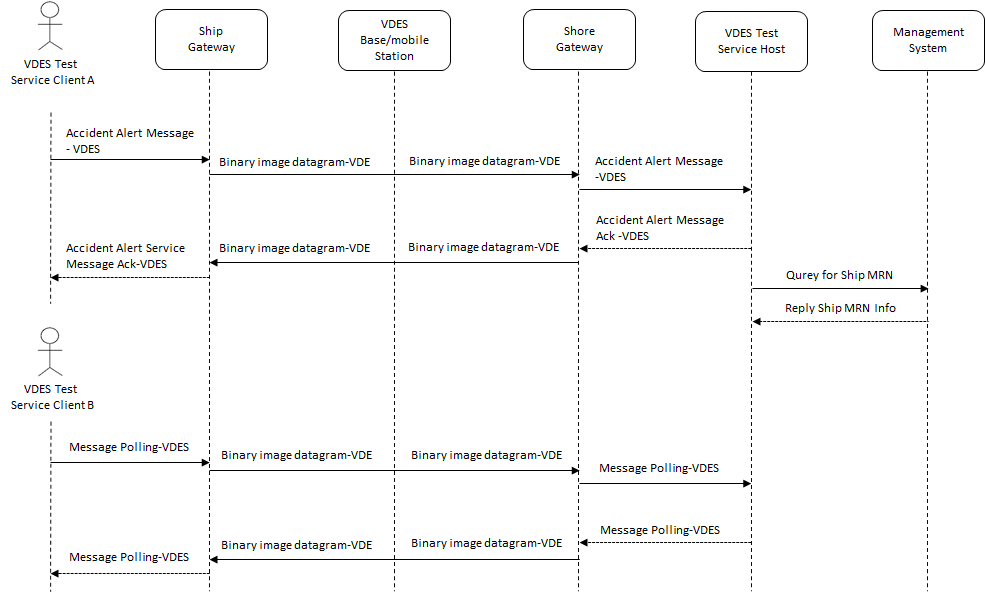


Figure 8. Service Scenario

* Scenario Description
* The accident alert service assigns a radius to identify ships that is within a certain radius of ship A and requests the management system to query the MRN within ship A’s radius.
* The management system returns the MRN of the ships(e.g. ship B) within a certain radius of ship A using the defined radius of ship A.
* Accident alert service stores the dangerous situation warning message(GML data) in the service host queue for ship B with MRN that delivered from management system.
* Ship B periodically requests polling for service through the ship gateway to the service host.
* The ship B gateway forwards the message to the shore gateway via the VDES radio-communication.
* The shore gateway forwards the message to the e-Nav service host.
* e-Nav service host returns a queued dangerous warning message to shore gateway.
* The shore gateway sends the warning message to the ship B gateway via the VDES radio-communication.
* The ship B gateway forwards the warning message to the service client.

# Conclusion

This document introduces the design concepts of e-Navigation service host/client and VDES gateway for e-Nav service data transmission through VDES network and presents the interoperating structure for VDES system. In particular, HTTP header and payload message structures are presented as e-Navigation service messages. These messages enable to interoperate between e-Nav service clients and hosts through VDES gateway.

In Smart-Navigation Project, VDES testbed will be installed by June 2020, the operation and sea trial of VDES testbed will be continued until December 2020. This test includes e-Nav service message transfer test via VDES testbed according to a predetermined service scenario in conjunction with the function and performance testing of the ASM and VDE-TER for VDES developed under the Project. Through the test and evaluation on the testbed, we will verify the interoperability and performance of VDES communication for provision of e-Nav service, and plan to research more reliable and effective data exchange methods between TCP/IP based e-Nav service host/client and Non IP based VDES network.

# References

1. Maritime navigation and radio-communication equipment and systems-Digital interface-Part 450
2. D1.29-MCP-VDES-inter-operability-report
3. MMS\_Specification\_0.8.3 on Website: https://maritimeconnectivity.net/
4. IALA ENAV23-3.1.11 Report on the development of SMART-Navigation product specification

# Action requested of the Committee

The Committee is requested to review the information and take appropriate action.

1. Input document number, to be assigned by the Committee Secretary [↑](#footnote-ref-1)
2. Leave open if uncertain [↑](#footnote-ref-2)