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Input paper for the following Committee(s): check as appropriate Purpose of paper:

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

**□**ENAV **X**VTS **□** Information

Agenda item [[2]](#footnote-2) 9.6

Technical Domain / Task Number 2 1.4.3

Author(s) / Submitter(s) China Maritime Safety Administration

Suggestions on the establishment of "public communication network +VDES" fusion communication mode

# Summary

Project 1.4.3 in the IALA VTS Committee's 2018-2022 work plan, Prepare a living document on future VTS, including emerging technologies and human element, will be initiated at VTS 50. The core of future VTS is the deep development and application of maritime traffic and environment data. As the main mean of ship data acquisition in current VTS, AIS (automatic identification system) has encountered bottlenecks in ship-shore/ship-ship data interaction due to its own limitations. In order to facilitate the application of new fusion communication technology in future VTS, China Maritime Safety Administration has carried out the research and practice on fusion communication mode of "public communication network + VDES". Comprehensively utilizing public communication network based on mobile communications (shore-based and satellite-based) and VDES communication link, the fusion communication mode can flexibly select the suitable mean according to the need of data exchange, and thus reduce the communication cost and solve the lack the bandwidth of mass communication. The research is envisaged to promote the ship-shore data exchange for future VTS and development of the e-Navigation application.

## Purpose of the document

The purpose of this document is to provide input documents for the VTS Committee to complete the 1.4.3 project Prepare a living document on future VTS, including emerging technologies and human element.

## Related documents

VTS Task Plan 2018-2022 (20191010)

VTS49-7.1.2 From VTS48 - VTS Task Register 2018-2022 (20191010)

# Background

In recent years, the public communication network has developed rapidly, and the effective coverage of the shore-based mobile phone base station has been continuously expanding, basically covering the nearshore waters and port areas. The public communication network has the advantages of high communication rate, stable data transmission and low communication cost. At the same time, with the development of technology and the increase of users, the satellite communication has its bandwidth been significantly improved, while its cost greatly reduced. The development of public communication network has laid a solid foundation for the fusion communication of "public communication network + VDES".

Along with in-depth study of e-Navigation strategy, a number of pilot projects on MSI information broadcast, route meteorological and hydrological information service, routes exchange, routes suggestion, ship pilotage assistant services, port logistics management, maritime search and rescue assistance, automatic certification of crew's certificates, maritime information sharing and other functions have been completed and demonstrated by IALA. The demands for ship-shore data exchange, including ship dynamic and static data and maritime services portfolio, have reached a new level.

Since 2016, China Maritime Safety Administration has been trying to implement maritime data exchange through public communication networks, and has developed multiple software based on mobile phone APP. With the mobile phone communication base stations along the coast and islands, ship can implement various practical functions, such as electronic chart updates, intelligent route planning, MSI services, hydrometeorological information query, navigation warnings query and so on (detailed information in Annex A). Due to its enhanced functions and the convenience of no additional ship equipment required, the maritime information service provided based on mobile phone APP is widely welcomed by small and medium-sized ships navigating along the coast, port areas and inland river waters. As for VDES, China Maritime Safety Administration also conducted long-distance ship-to-shore communication test in September 2020, and the test results show that VDES can support a data transmission at image level within 25 nautical miles (detailed information in Annex B).

# Discussion

## Analysis of [Necessity](javascript:;)

As the principle mean of collecting ship data for current VTS, the AIS fails to have its ability of ship- shore data exchange match the development of shipping industry. The application of emerging technologies such as big data analysis and artificial intelligence in future VTS require higher ability in ship-shore/ship-ship data exchange.

1. Limitations of current ship-shore/ship-ship data exchange modes:
   * AIS equipment standard does not cover all ships, especially small ships near shore;
   * AIS and VDES base station layout and maintenance are of high cost and limited coverage;
   * The transmission distance of AIS is short, while the single transmission is of small data capacity and limited by the overall time slot capacity, causing communication conflicts and long information update period in the waters with high traffic density;
   * The application of AIS ASM is far from popularity;
   * With limited bandwidth and low transmission rate, VDES is only suitable for the transmission of small amount of information, which is difficult to meet the development requirements of e-Navigation and S-100 electronic chart, and its application expansion is limited.
2. Future VTS development needs: The architecture of future VTS is expected to be more open, more compatible to APP modules. The data storage and information processing will be realized in the cloud, and deeper development and application of maritime traffic and environment data will be implemented. All of these will put forward higher requirements for ship-shore data exchange ability of future VTS.

## Analysis of [Feasibility](javascript:;)

The progress of shore-based and satellite-based mobile communication technology and the development of VDES make it possible to integrate communication based on public communication network and VDES, which is expected to cover broader water area, and of larger communication capacity, lower communication delay, higher communication efficiency and lower communication cost.

1. Broader area: the fusion communication can not only cover the water area covered by AIS base station and public mobile communication network, but also global area with the progress of satellite communication technology;
2. Larger communication capacity: the fusion communication network bandwidth is much larger than the current AIS system, which can effectively solve the existing AIS capacity saturation problem caused by the large ship density and large amount of ship variable data. Fusion communication can also meet the needs of large capacity data communication such as image and video.
3. Lower communication latency: Fusion communication can design the forward link communication mode based on short burst signal to directly complete the channel access, saving the time and resource consumption of channel request, allocation and link establishment.
4. Wider communication applications: Fusion communication can design the group user communication in the designated geographical area to meet the requirements of location sharing and greatly improve the efficiency of search and rescue coordination communication.
5. Lower communication expense: Through computer technology, fusion communication can realize the choice of the most cost-effective communication mode. At the same time, fusion communication makes use of the existing public communication network based on shore-based and satellite-based mobile communication, VDES and other existing facilities and equipment, and will not increase the economic burden of the administrations and shipowners.

## Application Scenario Outlook

The fusion communication mode of "public network + VDES" breaks through the communication link bottleneck of ship-shore/ship-ship data exchange. It has a wide range of application scenarios and strong function expansibility, including but not limited to:

1. Aids to navigation: intelligent beacon information collection, meteorological and hydrological information services, electronic chart updates, course report and analysis services, navigation rules services, MSI services, port information services, etc.;
2. Navigation monitoring: ship real-time movement display, vessel traffic service information services, etc.;
3. Emergency search and rescue: One-button emergency call , display of distress area, distress alerting response, distress alerting forwarding, search and rescue operation support, regional ship search, etc.;
4. Multimedia information communication: users can communicate through the public network in text, voice, video and other forms of multimedia communication.

## Impact on Existing Patterns

"Public Network +VDES" fusion communication mode is expected have a fundamental impact on the future ship-shore data exchange, including but not limited to:

1. Communication cost greatly reduced: smart to choose appropriate means of communication, especially in the nearshore area, it may significantly reduce the communication cost and waters. The shore-based public communication network can also enable small ships without mandatory installation of AIS/VDES by the Convention to participate in the VTS data exchange service through mobile phone APP without additional ship equipment.
2. Promote the VTS information center position: by breaking through the communication link bottleneck, the level of software and hardware of VTS would be subsequently improved by functions such as assistant decision-making, information sensing and data processing. All of above would therefore facilitate building the land-sea-air-space integrated service system, enhancing scientific decision-making ability, promoting the VTS function extension and eventually transit VTS to VTM (vessel traffic management).
3. Promote S-100 electronic chart application: integration communication mode can provide large scale and low latency information transmission, which would effectively facilitate the S-100 electronic chart data transmission, promoting the S-100 the application of electronic chart.
4. Stimulate unmanned/smart/independent ship development: integration communication mode can provide real-time data transmission, and solve technical difficulties such as real-time collection and transmission of the traffic safety information, ship maneuvering remote support, and stimulate the development of the unmanned/smart/independent ship.
5. Promote e-Navigation application: smooth communication link will promote e-Navigation function development, effectively reduce the cost of the achievements transformation and application.
6. Promote public network infrastructure construction: the increase of maritime and coastal users would reduce the cost of the overall building of public communication network stations, and the reversely promote the construction of the public network infrastructure.
7. Strengthen VTS personnel competence: higher requirements for VTS personnel to receive, understand and the ability to use large scale real-time information would be put forward, and therefore strengthen the theoretical study and field training.
8. Impact navigation device requirements: with the improvement of the public communication network, satellite communication network cost is reduced, and therefore the necessity and function requirements of traditional AIS, VDES, GMDSS equipment would also change.

# reference

IALA GUIDELINE G1117 VHF DATE EXCHANGE SYSTEM(VDES) OVERVIEW

# Action requested of the Committee

The IALA VTS Committee is requested to consider this in the process of developing an adaptation document for future VTS.

ANNEX 1 Introduction to China's E-Navigation Project Based on Public Communication Network

1. project brief

E-Navigation shore-based system based on public network launched in 2016, at the first phase in 2017 we build the basic architecture of e-Navigation in Pearl River Delta. In March 2018, we released the first batch of e-Navigation technology services of this project, and began to implement the second phase. In July 2019, the second batch of e-Navigation technology services released, the project expanded its service area from Pearl river delta to the coastal waters of South part of China.

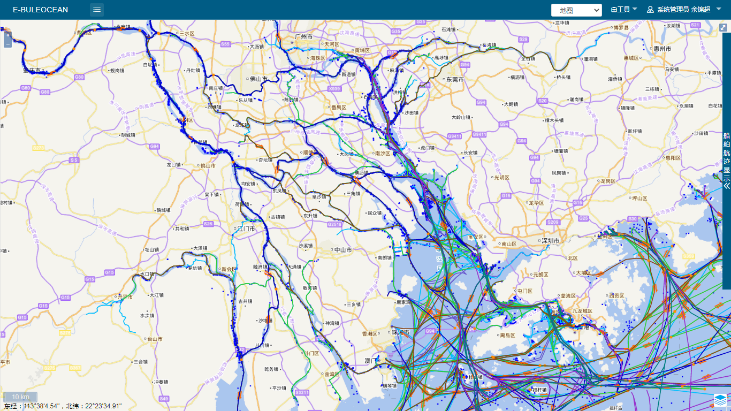
As early as the first phase of the project, service area of the project focused on Pearl river delta, one of the busiest waters for China and even the world, along both sides of the estuary the world's top ten ports have three in here (Shenzhen, Hong Kong, Guangzhou), a large density and variety of types of vessels from container ships of 20000TEU, VLCC, Luxury Cruisers to small fishing boats all crisscross in this area, leading to complicated traffic flows. Moreover, since waterways in this region were not far from shore, the Internet coverage reached almost 100%. As a result, it makes simple shipborne equipment, such as ECS, PC, PAD or mobile phones to access e-Navigation services possible. Therefore, the project received a lot of customers from small boats and non-SOLAS ships. The application and relevant communication mode and aims of this project are as follows:

|  |  |  |
| --- | --- | --- |
| Applications | communication mode | Aims |
| ECDIS | Mobile network/satellite network/VDES | ECDIS could access Technical Services through appropriate communication means to support navigation. |
| Web-based applications | internet/ private network | Access to technical services, through web services, such as SOAP, REST, could monitor ship traffic and exchange information with the ship’s systems. |
| Mobile Application | mobile communication/WIFI/Bluetooth | Access to Technical Services, through mobile communication, navigation information can be displayed and used, so as to assist navigation, and can exchange information with ECDIS. When mobile communication is not available, the application can connect to the shipboard navigation equipment via WIFI/Bluetooth to import navigation data. |
| WeChat | mobile communication | WeChat is a Chinese multi-purpose messaging, social media and mobile payment app. It has been described as China's "app for everything" and a "super app" because of its wide range of functions.  Users can use services in the “e-Navigation” Service Account and Mini Program in WeChat, and the information is synchronized and interconnected with other applications, i.e. ECDIS, web applications and mobile apps.  In particular, you can receive instant messages about important navigation information of the ship you care about. |

1. [system](javascript:;) [function](javascript:;)

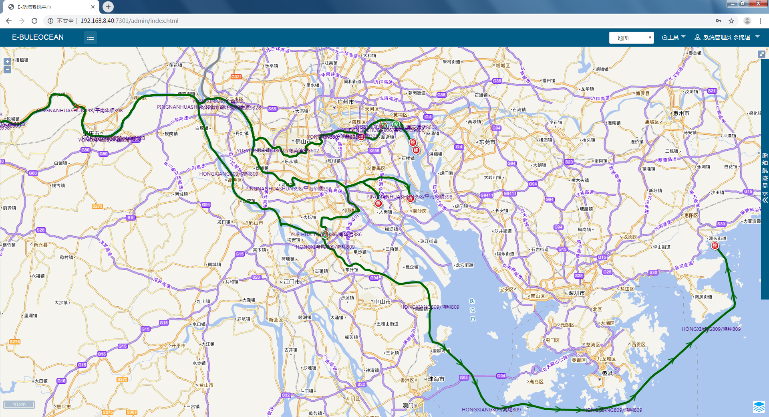
2.1 Route Information Services

Analysed the historical routes of vessels from AIS, a route network is built up, which covers the coastal waters of the South China Sea and the inland waters of the Pearl River.



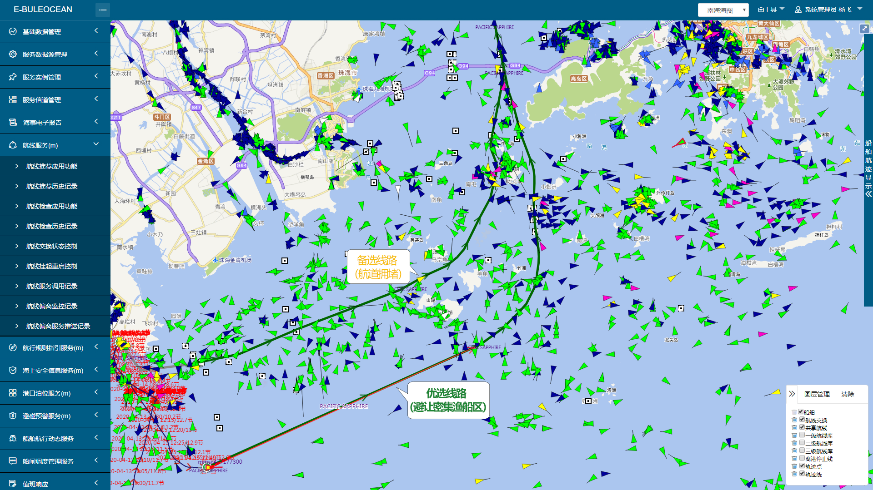
1. Route network of Guangdong-Hong Kong-Macao Greater Bay Area

Input parameters in the shipboard system, such as departure location, destination, draft, etc., based on the route network and combined with the spatial analysis of the ENCs, a safe and efficient route will be calculated and sent to the ship for planning route.



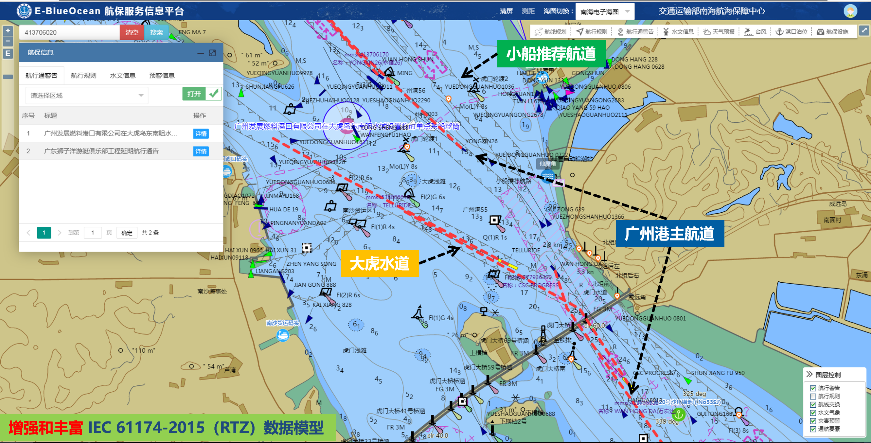
1. Examples of recommended routes for practical use on vessels

Considering factors such as hydrology and meteorology, ship congestion, etc., it can provide vessels with safe routes to avoid congested waterways or potential weather hazards.



1. Recommended routes to avoid congested waters

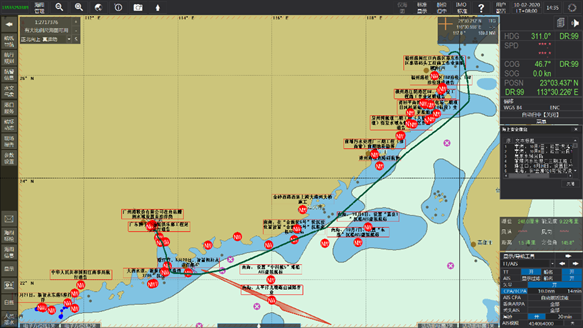
Route exchanges can be implemented through appropriate communication means, including mobile public communication, VDES, etc. When navigating in complex waters, through route exchange, mariners can check the planned routes of other nearby ships to understand their intentions, which can effectively reduce the risk of collision avoidance. The route exchange can be performed by the shore-based system when the mobile public communication is available, or it can also be exchanged directly between the vessels through the VDES. In the shore-based systems and web-based applications, the planned routes of all vessels could be seen, and the mariners can view the planned routes of nearby vessels in the onboard system.



1. Route exchange

2.2 Maritime Safety Information Services

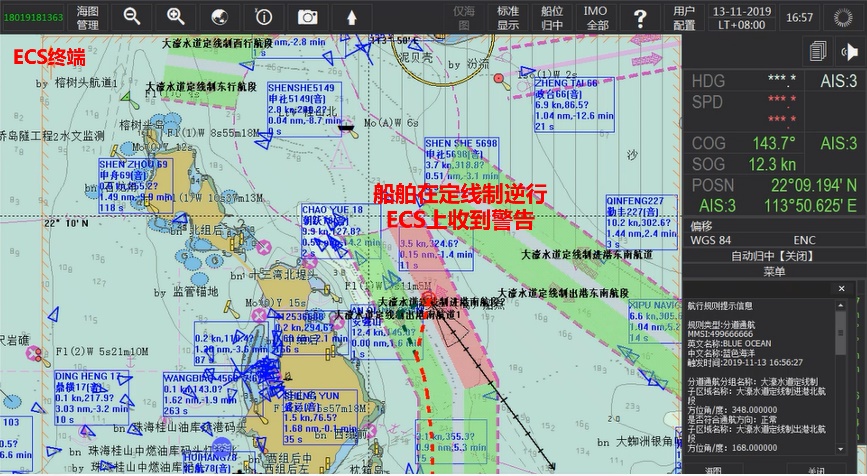
In the shore-based system, navigational warning data is modeled and maintained in accordance with IHO S-124 specifications. The MSI Technical Services are sent to shipboard system and related applications via the Internet and VDES, and will be display graphically. The shipboard system can filter and display the MSI related to the current voyage according to the planned route.



1. Display MSI according to the planned route

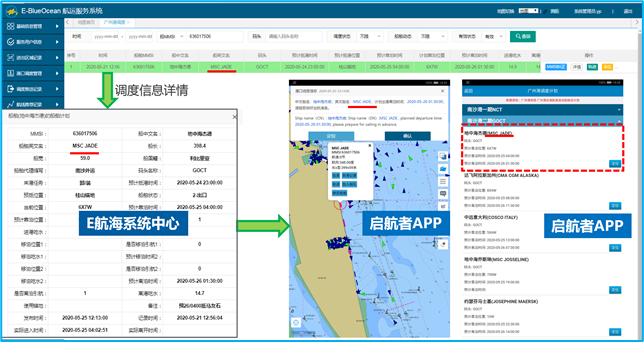
2.3 Navigational Assistance Services

Traffic management information, i.e. recommendations, regulations, restrictions, and nautical information, is modeled and maintained in accordance with IHO S-127 specifications, and related e-Navigation Technical Services have been developed. During the ship's voyage, according to the ship's current position, speed, direction, and planned route, relevant instant navigation assistance messages and warnings will be pushed to the shipboard system.



1. Warning messages about failure to comply with traffic separation schemes

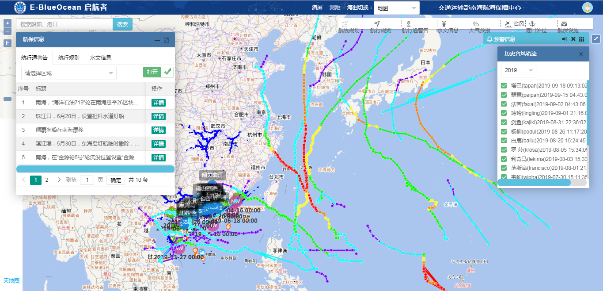
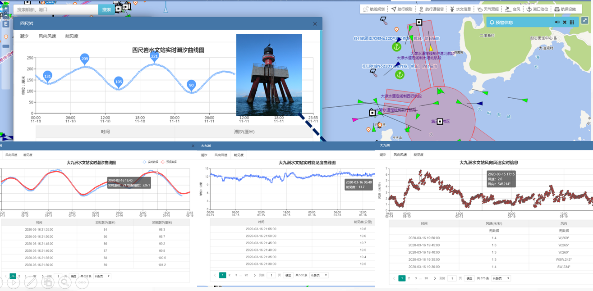
The harbour plan and schedule can be viewed in shipboard system and related applications, and the voyage can be arranged according to the harbour plan and schedule.



1. Harbour plan and schedule

2.4 Hydrological and Meteorological Information Services

Modeling water level data in accordance with the IHO Water Level Information for Surface Navigation Product Specification (S-104), and surface current data in accordance with the IHO Surface Current Product Specification (S-111), and Technical Services were developed based on the above specifications. These data include real-time and forecast water level, current, wind, visibility, etc. The real-time data is collected by coastal hydrometeorological observation stations and offshore buoys, and weather forecasts and warnings are from meteorological authorities. Similarly, through Technical Services, these data can be displayed and used in the related systems and applications.



1. Hydrometeorological information services
2. Application of the project

As of February 2021, there are about 14,440 monthly active users of e-navigation apps and more than 3,000 average daily login users (only one is counted as repeated login) in the Guangdong-Hong Kong-Macao Greater Bay Area, more than 17,000 registered vessels. Time of users online for more than 100 years in total. Users called routes services more than 83,000 times and adopted recommended routes more than 47,000 times, with a total mileage of more than 4.11 million km. We pushed 17.12 million navigation rules and guidance, 3.4 million navigation warning information, 5.681 million hydrological and meteorological information.

|  |  |
| --- | --- |
| **Content** | **Statistic** |
| Monthly active users | 10.5 K |
| daily login users | 3000 |
| Vessels registered | 17.536 K |
| Total online time of users | 105.81 Years |
| Times of routes services | 83.12 K |
| Times of adopted recommended routes | 47.12 K |
| Total mileage of recommended routes | 41.09 K |
| Times of navigation rules and guidance services | 17.12 M |
| Times of navigation warning services | 3.4 M |
| Times of hydrological and meteorological services | 5.68 M |

1. Application statistics from September 2019 to February 2021

ANNEX 2 China's domestic VDES system completed its first long-distance application test

In September 2020, the China Maritime Safety Administration successfully carried out the VDES communication capability test and achieved the expected results. It completed the 60 nautical miles long-distance VDES equipment application test for the first time in China. This document shows the test data of a single voyage on September 9.

1. test objectives

1.1 Test the image transmission effect at sea site to verify the performance of VDES products.

1.2 Verify the range and accuracy of ASM message transmission between ship and shore.

1.3 Test the bandwidth and success rate of image data transmission between ship and shore.

1.4 Test the performance of the VDES network and the packet loss rate of data transmission between ship and shore.

1. Test method

This test uses one shore station and one ship platform. The VDES shore station system is set up at the top floor of Dalian Aerospace Building (point B, about 140 meters above sea level), the distance between the two points A and B is about 90 nautical miles, and deploy a set of shipboard VDES terminal on the M/V"Huludao"(about 20 meters above sea level).



Figure 1 Test site location diagram

During the test, the M/V "Huludao" station was used as the information transmitting terminal, and points B was the receiving terminals. The ship-to-shore communication capabilities of VDES, especially the picture transmission capabilities, were continuously tracked.

1. time of the test

September 9, 2020, M/V Huludao from Dalian to Weihai. Transmitter: ship station; Receiver: point B

1. test records

*Table 1：Test records*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Time | Test object | Content (picture size) | sending times | test result | Note |
| 22:20:00 | ASM | Are you ok? | 3 | YES | Mutual confirmation |
| Yes | 3 | YES | Mutual confirmation |
| 22:25:00 | VDE | picture 50K | 10 | ALL YES | about 12nm |
| 22:35:00 | picture 200K | 5 | ALL YES | about 13nm |
| 22:50:00 | picture 500K | 3 | Failed 1 | about 15nm |
| Temporary decision | picture 50k | 2 | ALL YES | about 24nm |
| 23:50-0520 | packet | 100 | See packet loss rate test results for details |  |

*Table 2：Packet loss rate test records of VDE*

|  |
| --- |
| 23:50:19-00:10:24: send： 100 receive： 39 packet loss rate： 61.0% (27nm) |
| 00:10:25-00:26:34: send： 100 receive： 87 packet loss rate： 13.0%(32nm) |
| 00:26:34-00:35:34: send： 100 receive： 100 packet loss rate： 0.0%(35nm) |
| 00:35:34-00:44:34: send： 100 receive： 100 packet loss rate： 0.0%(37nm) |
| 00:44:34-00:53:43: send： 100 receive： 100 packet loss rate： 0.0%(39nm) |
| 00:53:44-01:02:55: send： 100 receive： 100 packet loss rate： 0.0%(41nm) |
| 01:02:56-01:12:10: send： 100 receive： 99 packet loss rate： 1.0%(43nm) |
| 01:12:10-01:22:41: send： 100 receive： 92 packet loss rate： 8.0%(45nm) |
| 01:22:41-01:33:55: send： 100 receive： 83 packet loss rate： 17.0%(47nm) |
| 01:33:56-01:46:31: send： 100 receive： 71 packet loss rate： 29%(50nm) |
| 01:46:32-01:58:43: send： 100 receive： 73 packet loss rate： 27.0%(53nm) |
| 01:58:44-02:10:05: send： 100 receive： 85 packet loss rate： 15.0%(56nm) |
| 02:10:05-02:19:31: send： 100 receive： 100 packet loss rate： 0.0%(58nm) |
| 02:19:32-02:30:07: send： 100 receive： 90 packet loss rate： 10.0%(60nm) |
| 02:30:07-02:42:05: send： 100 receive： 77 packet loss rate： 23.0%(62nm) |
| 02:42:05-02:55:27: send： 100 receive： 67 packet loss rate： 33.0%(65nm) |
| 02:55:27-03:08:17: send： 100 receive： 66 packet loss rate： 34.0%(68nm) |
| 03:08:17-03:23:48: send： 100 receive： 38 packet loss rate： 62.0%(71nm) |

*Table 3：Packet loss rate test records of ASM*

|  |
| --- |
| 23:50:19-00:06:51: send： 100 receive： 97 packet loss rate： 3.0%(27nm) |
| 00:06:51-00:24:00: send： 100 receive： 90 packet loss rate： 10.0%(32nm) |
| 00:24:00-00:40:54: send： 100 receive： 95 packet loss rate： 5.0%(35nm) |
| 00:40:54-00:58:19: send： 100 receive： 90 packet loss rate： 10.0%(37nm) |
| 00:58:19-01:15:26: send： 100 receive： 91 packet loss rate： 9.0%(42nm) |
| 01:15:26-01:32:14: send： 100 receive： 96 packet loss rate： 4.0%(45nm) |
| 01:32:14-01:49:17: send： 100 receive： 92 packet loss rate： 8.0%（48nm） |
| 01:49:17-02:06:40: send： 100 receive： 94 packet loss rate： 6.0%（52nm） |
| 02:06:41-02:23:42: send： 100 receive： 93 packet loss rate： 7.0%（56nm） |
| 02:23:43-02:41:58: send： 100 receive： 81 packet loss rate： 19.0%(60nm) |
| 02:41:58-02:58:40: send： 100 receive： 94 packet loss rate： 6.0%（64nm） |
| 02:58:40-03:15:29: send： 100 receive： 94 packet loss rate： 6.0%（68nm） |
| 03:15:30-03:33:20: send： 100 receive： 79 packet loss rate： 21.0%(72nm) |
| 03:33:20-03:50:42: send： 100 receive： 90 packet loss rate： 10.0%（75nm） |
| 03:50:42-04:07:42: send： 100 receive： 92 packet loss rate： 8.0%（78nm） |
| 04:07:42-04:24:21: send： 100 receive： 91 packet loss rate： 9.0%（82nm） |
| 04:24:21-04:42:27: send： 100 receive： 83 packet loss rate： 17.0%（85nm） |
| 04:42:28-04:59:49: send： 100 receive： 88 packet loss rate： 12.0%(89nm) |
| 04:59:49-05:22:41: send： 99 receive： 39 packet loss rate： 60.61%（91nm） |

1. the test results
   1. VDE

Picture transmission: within 24 nautical miles from the shore, 50Kb picture transmission is stable; the larger the picture and the farther the distance, the lower of the transmission success rate.

Data packet transmission: 27 nautical miles from the shore, the packet loss rate is 61%, 32nautical miles from the shore, the packet loss rate is 13%, 35 to 41 nautical miles from the shore, the packet loss rate is 0, then the packet loss rate starts to increase as the distance increases. At 60 nautical miles, the packet loss rate is 10%.

* 1. ASM

The packet loss rate has always existed and is unstable. Within 60 nautical miles, the packet loss rate does not exceed 10%.

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