Summary of Transportation Management System for costal ships using Satellite Packet Communication techniques

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ABSTRACT

This paper introduces the development of the transportation management system, which realizes effective transportation by integrating sea and land. The transportation management system serves the transportation status to the transportation management companies, cargo owners, carriers, consignees, etc. on the basis of the data from mobiles installed on such as ships and lorries, for the improvement of safety and efficiency of transportation. It also promotes rationalization of transportation by shearing information among the companies concerned such as cargo owners, carriers, and management companies.

To configure the system, mobile packet communication technology (satellite basis and mobile-phone basis) and digital map, which covers the whole sea and land, were applied.

The operation information of each mobile, such as position, speed, direction, ETA, and other information such as destination, route, schedule to be shared bi-directionally among the mobiles and the companies concerned is transferred on real-time via the ship-shore communication satellite and/or mobile-phone.

The terminals of this system are installed on ships, lorries and transportation management companies and have functionalities to display above information on the combined digital map of land and sea (electronic chart.)

Moreover, real-time database technique and human interface with voice input/output enables to develop safe and efficient transportation management system. The function of the system was tested on real ships and lorries.

Key Words: GIS, Satellite Communication, Voice Input/Output, Electronic Chart, Digital Map, Internet

1. INTRODUCTION

In the marine transportation industries, there has been a difficult situation because of aging seamen, and it is difficult to hand over the important technology such as maneuvering techniques to young generation.

The transportation industry has tried to solve these problems continuously. As one solution to this problem, they have been applying the highly automated onboard system to save manpower and to realize safety navigation. They also have made efforts to establish the standardized maneuvering procedures and an effective navigation support system.

In the results of these efforts, the highly-automation modernized vessels that can be operated with a few crews have been in service recently. The modernized vessels equip ECDIS (Electric Chart Display and Information System,) IBS (Integrated Bridge Systems for Ship,) Machinery Automation System and Cargo Control System, which enable practical application of independent automatic navigation system.

Furthermore, the transportation management system by using data communication between ship and shore has been introduced. These systems are able to realize safety sailing and to improve efficiency of transportation management work.

However, these systems and techniques have been developed for ships and vehicles independently, and the integrated transportation management system including whole transportation at sea and land has not been developed.

In response to the trend of ‘Modal Shift’ [3] [4], we have developed the new transportation management system for seamless management of ships and vehicles.

New developed system has a database server in the new information management center to shear the necessary information among concerned companies such as cargo owners, carriers and management companies. Also, the latest packet data communication techniques by using marine satellite telephone and mobile telephone are applied to this system.

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In this paper, we introduce the new transportation management system for ships and vehicles. The target of this system is coastal ships and domestic lorries, and consists of following element technology.

- Satellite packet communication
- Digital map as human interface
- Voice input/output technique as human interface
- Internet

Fig. 1 shows element technology of this system.

2. BASIC CONCEPT
2.1 Purposes of system

This system was developed to support combined management of marine transportation and land transportation, to improve safety of transportation, to make work order more efficient and to construct foundation of modernization of domestic ships’ transportation management work. It makes the best of mobile communication, GIS (Geographic Information Systems) and IT to manage domestic ships and transportation lorries on real-time base.

The system configuration is shown in Fig. 2.
2.2 Features
At the beginning of development of the system, we set up the following essential items.

- The system must cover not only sea but also land.
- The system must have bi-directional data communication function among mobiles.
- Safety operation must be assured.
- Popular Internet technology shall be key for this system.

To achieve these preconditions, this system provides the following features.

1) Digital map covering land and sea

The GIS technology is one of the most important factors to realize the transportation management system. The various data of the ships and lorries such as positions and status are managed together. The latest position of both ships and lorries are displayed on the digital map with the symbol mark. We developed the unique function to overlay the digital road map on the electronic navigational chart. The JMC map published by Geographical Survey Institute is applied as an electronic map, and the ENC published by Japan Coast Guard as an electronic navigational chart.

In this system, the digital road map data, which are important for management of the vehicles, are converted to Mercator’s data, and then the digital road map can be overlapped on the electronic chart. Fig. 3 shows a sample of an overlaid display screen.

According to this overlaid display function, the users can display the positions of both ships and vehicles without switching the map and the chart, i.e., the positions of both ships and lorries are displayed on the same screen simultaneously.

Electronic Chart (ENC) Digital Map (JMC Map)

Fig.3 Screen image of the overlapping function of the digital chart and digital road map
(2) Mobile Communication

It is essential to apply the suitable data communication tool to realize the seamless management of ships and vehicles. We developed the data communication software by using technology. Between the ships and the ship management company, the satellite packet communication system that is TCP-IP protocol on the basis of packet communication service at April 2000 by NTT DoCoMo, is applied, and between lorries and the vehicle management company, the mobile packet communication system, DOPA by NTT DoCoMo is applied.

The data communication by using the current marine satellite telephone has to repeat the connection and disconnection of telephone line in order to exchange the information every time. However, the packet data communication can communicate continuously without line disconnection. And current telephone is charged according to the consumed time during the line connection, but the packet telephone is charged with the mount of transmitted packets (128bite=1packet). So the packet communication can realize economical data communication even if the communication line is connecting all the time.

By using of packet communication, the system can transmit the necessary data such as operation order, cargo lording order, any information from the company’s office to ships and lorries, and transmit the confirmation of the received information, report, etc. from ships and lorries to the company’s office.

(3) Voice Input/Output

To operate mobile system, voice input/output function can be used. The user can be operated the system without dangerous situation caused by looking at the monitor to keep the nautical or driving safety. And the system can be output important information by voice message, so usually operator does not watch the monitor. Moreover, digital map control such as scroll or zoom up/down can also be operated by voice, the operation of the system become easier.

To construct this function, we used speech recognition software and voice synthesis software on the market.

(4) Information supply service via Internet

The WEB server supply the information of ships and lorries such as their position or status through the inter net for specified users who are given the identification code. At the branch office of carrier or the transportation management company, the users can get the desired information such as mobile’s position on the electronic map all the time by using of the Internet and the HTML viewer.

And the WEB server has the security function that can manage and control user’s accesses from each company through Internet, so it can prevent illegal accesses from unexpected users.

2.3 Exploitation of IT (Information Technology)

Adding IT mechanism and its functions to conventional technology expedites construction of innovative system. As developing this system, we worked the following items to exploit IT.

Ⅰ. Construction of WEB server
Ⅱ. Adoption of packet data communication for mobiles
Ⅲ. Utilization of information server in the transportation management information center

(1) Construction of WEB server

We developed information service system that offers operating status of target vessels and connection with homepage style via Internet. With this system, users such as agents of vessels and cargo owners at remote locations can get operating status on real-time base by the browser software installed in personal computers.

This system adopted Internet service offered by commercial Internet provider. Operating status of ship’ positions and another information are collected into database periodically and presented on the homepage by WEB application program with CGI (Common Gateway Interface) tools.

This function enables the users to confirm the latest operating status on Internet homepage with their own computers at home or i-mode mobile phone, and acquires good reputation for its convenience.
(2) Adoption of packet data communication for mobiles

Satellite packet communication service and mobile packet communication service (DOPA) by NTT DoCoMo offer TCP/IP data communication. With this service, we developed application software of data communication used by both satellite phones and mobile phones in common to achieve efficiency of system development and improve ease of maintenance of software.

The principal particulars of the satellite packet communication service and the mobile packet communication service are shown on Table 1.

Table 1 Principal particulars of the satellite and mobile packet communication service

<table>
<thead>
<tr>
<th>Method</th>
<th>Satellite packet communication service</th>
<th>Portable packet communication service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum data transfer rate</td>
<td>(Uplink) 4800bps (Downlink) 64kbps</td>
<td>28.8kbps or 9600kbps</td>
</tr>
<tr>
<td>Area of service</td>
<td>within 200 nm from shore</td>
<td>Whole of Japan island (same as portable phone service area)</td>
</tr>
<tr>
<td>Unit of charge</td>
<td>0.4yen/packet (In case of &quot;Satellite basic plan S&quot;)</td>
<td>0.2yen/packet (In case of &quot;Right plan S&quot;)</td>
</tr>
<tr>
<td>Protocol</td>
<td>PPP (TCP/IP)</td>
<td>PPP (TCP/IP)</td>
</tr>
</tbody>
</table>

Uplink: From ship to land
Downlink: From land to ship

(3) Utilization of information server in the transportation management information center

We set up the information server of transportation management center in Nagasaki Shipyard of MHI and installed an information server (database server) and a WEB server. We are carrying out offering database server for the users company involved in ship management and lorries management work. This service aims to minimize the user companies’ initial cost at system installation.

3. SYSTEM CONFIGURATION

This transportation management system for mobiles consists of the following five (5) sub systems. Fig.3 shows the system configuration.

1. Transportation management information center system
2. Ship management system
3. Vehichles management system
4. Shipboard system
5. In-vehicles system

3.1 Transportation management information center system

The transportation management information center system consists of two (2) personal computers that work as the information server and the WEB server. The information server can save transmitted data from each sub systems and send the management data to each sub system. The WEB server can supply the transportation management information to the specified users through Internet.

3.2 Ship management system

Ship management system consists of a personal computer, data communication equipment and modem in order to support management work for target ships at shore. By using this system, users at the ship management company can confirm the voyage situation on the digital map easily and issue voyage order to the vessel.

3.3 Vehicles management system

The vehicles management system works in combination with the in-vehicle system. It consists of a personal computer and data communication equipment in order to support the management work for target vehicles. The system has a function to confirm vehicles’ situation and to issue the service order to the vehicle from the vehicle management company office.

3.4 Shipboard system

The shipboard system consists of a personal computer, a GPS receiver and a satellite packet communication phone, which are equipped in wheelhouse. By using this system, onboard users are able to send the navigational data to shore and receive various information data such as a voyage order from shore through the satellite communication.

The voice input/output function is also applied to achieve easy operation, so the users can operate the system by voice and get important information without disturbing continuous watch.

The new satellite packet communication network supplied by NTT DoCoMo and the public telephone network supplied by NTT are applied for data communication between the ship management system and the shipboard system.

3.5 In-vehicles system

The in-vehicles system consists of a personal computer, a GPS receiver and a mobile packet communication phone, which are installed on the driver’s spare seat. By using this system, the driver can send the driving information to the vehicle management office and receive various information data such as the transportation order from the office. The voice input/output function is also available as same as the shipboard system.
4. Functions

Mobile transportation management system is roughly divided into two systems, i.e., ship management system and vehicles management system.

The difference between these two systems is the way of packet data communication. Ship management system uses packet data communication by satellite vessel phone, and vehicles management system uses communication by mobile phones. They are similar in basic concept and functions, so in this section we introduce the functions of ship management system.

Ship management system consists of the system equipped at shore office and onboard system. Fig.6 shows function diagram of ship management system.

![Fig.6 Function diagram of ship management system](image-url)

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**Fig.5 System Composition**

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**Fig.5 Function diagram of ship management system**
4. FIELD TEST AND RESULT

Following development of the system, we carried out the field test on the real management work for about two months with cooperation of some management companies to evaluate availability and practicality. The number of tested ships and vehicles are 4 each. Fig.7 shows the outline of test equipment onboard. Fig.8 shows the outline of test equipment on trailer truck.

![Fig. 7 Picture of the test equipment for ship](image1)

![Fig.8 Picture of the test equipment for trailer trucks](image2)

The main items and results of the filed test are as follows.

(1) Management efficiency of ships and vehicles

Table 2 shows the comparison table of time data for communication work between truck drivers and vehicle management system operators. As this table shows, this system could shorten communication time and this means that adoption of this system achieves efficiency better than conventional methods, by telephone or radio.

(2) Availability of GIS

According to questionnaire survey to the system users, we confirmed that by the overlaid display the users could confirm current mobiles’ position faster and more precise than by the conventional measures such as FAX and telephone.

(3) Stability and economical efficiency of satellite packet communication

Satellite packet communication covers Japanese 200 nautical miles territorial water sea. Therefore, data communication, e-mail services and Internet were so stable between systems at shore office and systems on domestic ships servicing in the area. This system adopts always-on service of packet data communication and toll is charged for communicated data volume. As for periodic transmission of constant volume data, this always-on service is more efficient than call switching service charged for on-line time.

Table.2 Comparison table of information transmission task

<table>
<thead>
<tr>
<th>Information</th>
<th>Information flow</th>
<th>Unit: Sec.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Marine phone</td>
</tr>
<tr>
<td></td>
<td></td>
<td>/FAX</td>
</tr>
<tr>
<td></td>
<td></td>
<td>/Mobile phone</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Packet</td>
</tr>
<tr>
<td>Current position</td>
<td>ship to center</td>
<td>190</td>
</tr>
<tr>
<td></td>
<td>trucks to center</td>
<td>140</td>
</tr>
<tr>
<td></td>
<td>ship to office</td>
<td>190</td>
</tr>
<tr>
<td></td>
<td>trucks to office</td>
<td>140</td>
</tr>
<tr>
<td>Operation order</td>
<td>office to ship</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>office to truck</td>
<td>180</td>
</tr>
<tr>
<td>Notification</td>
<td>ship to office</td>
<td>140</td>
</tr>
<tr>
<td></td>
<td>trucks to office</td>
<td>130</td>
</tr>
<tr>
<td></td>
<td>office to ship</td>
<td>140</td>
</tr>
<tr>
<td></td>
<td>office to truck</td>
<td>130</td>
</tr>
</tbody>
</table>

![Table 2: Comparison table of information transmission task](image3)

![Time(Sec.)](image4)
5. CONCLUSION

(1) Commercialization of the system

Through the field test, we confirmed that this system reached practical level. Also, the satellite packet communication service for domestic ship’s radiotelephone system started at March 2000, so we have commercialized the system and have introduced it to domestic shipping companies.

At the moment the system is equipped on 3 (three) domestic Roll-On/Roll-Off vessels. In addition, we are planning to apply this system to new market such as control and management business of working ships in ports and harbors.

(2) Expansibility of the system by interfacing with existing marine companies’ system

Ship management system can be interfaced with existing marine companies’ ship management and control system. We are constructing integrated transportation management system including followings.
- Shipping schedule, route planning, and cargo planning at shore
- Data communication function between ship and shore
- Ships allocation and accounting system of marine transportation companies.

(3) Exploitation of satellite packet communication service

Mobile data communication function is essential for integrated ship and shore transportation management system.

NTT DoCoMo placed new satellite packet radiotelephone on the market and started satellite packet communication service at March 2000. By exchanging old satellite phone with packet phone and equipping a computer onboard, ship and shore network can be constructed easily and Internet and e-mail service are available onboard just same as services by ISDN ashore.

We are expecting that in the near future complete ship and shore network will be constructed and safety management system including ship management system will become more efficient by making the best of it.

6. ACKNOWLEDGEMENT

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7. REFERENCE