MARITIME TRAFFIC SIMULATION IN CONGESTED WATERWAYS AND ITS APPLICATIONS

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ABSTRACT

In Japan Ministry of Land, Infrastructure and Transportation is conducting the project so-called "Marine ITS". The authors are engaging in this project. The marine traffic simulation developed by the authors is further utilized for various applications. In this paper the some recent result including the on-land AIS stations are introduced how the simulator is utilized in the actual and future government projects.

KEY WORDS: marine traffic system, AIS, VTS, GPS, safety assessment

INTRODUCTION

Marine ITS is the national project of Japan, aiming for the next generation's marine traffic system, sponsored by Ministry of Land, Infrastructure and Transportation (**MLIT**), Japan.

The first author has been engaged in this area from the first stage. Hasegawa proposes the system using Global Ship Information (**GSI**) system, and points out the possibility to be applied for automatic collision avoidance system[1]. As it was very early stage of this kind, the proposal was rather conceptual. Fig. 1 shows this concept. It was expanded and renamed as Virtual Vessel Traffic Service (***V-VTS***) by the authors[2]. In this system, V-VTS is a virtual Vessel Traffic Service (**VTS**) Center and it automatically gathers information of a ship accessible to ***V-VTS*** via Internet. In return it will deliver information of other ships who are near-by her.

On the other hand, International Maritime Organization (**IMO**) has established Automatic Identification System (**AIS**) in Dec. 2001 and makes it rule to install it for any **SOLAS** ship from July 2002. The date is now postponed to Dec. 2004 for international and to June 2006 for other ships respectively. Now the ***V-VTS*** is physically possible using AIS as shown in Fig. 2[3].

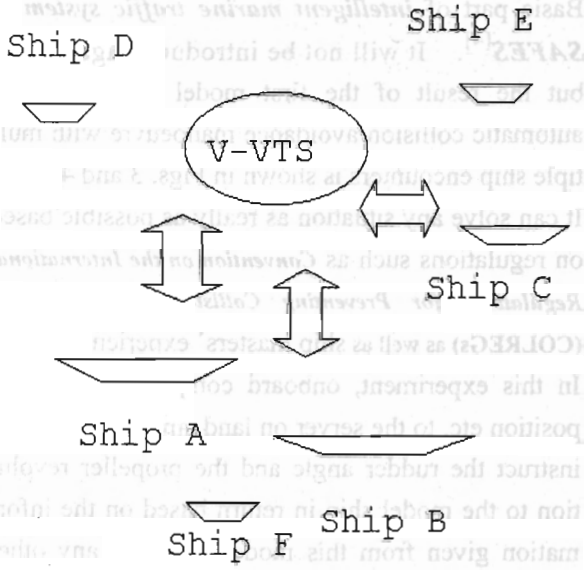

Fig. 1 Concept of V-VTS[1,2]

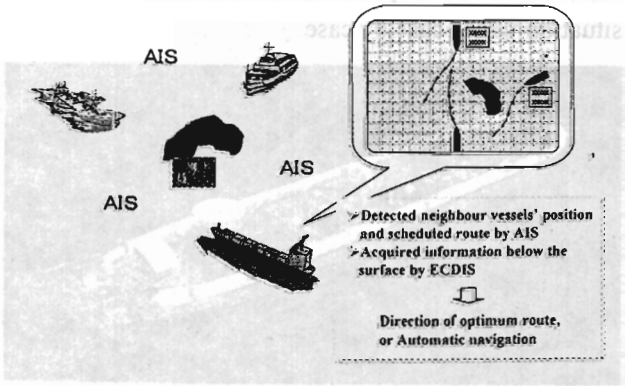

Fig. 2 Concept of AIS Communication

However, it is not confirmed how AIS will work in congested waterways such as Tokyo Bay, because of the limit of its communication capacity (report number or slots). Furthermore Japan Coast Guard is planning to install on-land AIS stations in major congested waterways in Japan. The question then is how many on-land AIS stations are necessary and enough for specified area such as Tokyo Bay.

For these purposes ***intelligent marine traffic simulator*** will play an important role. Once it was developed, it will be useful for assessment or feasibility studies of various projects or systems where natural maritime traffic circumstance is essential for their evaluation.

SAFES – SHIP AUTO-NAVIGATION FUZZY EXPERT SYSTEM[4]

Basic part of ***intelligent marine traffic system*** is *SAFES*[4]. It will not be introduced again here, but the result of the first model experiment of automatic collision avoidance manoeuvre with multiple ship encounters is shown in Figs. 3 and 4[5].

It can solve any situation as really as possible based on regulations such as ***Convention on the International Regulations for Preventing Collisions at Sea, 1972*** **(COLREGs)** as well as ship masters' experience

In this experiment, onboard computer sends ship position etc. to the server on land, and the sever will instruct the rudder angle and the propeller revolution to the model ship in return based on the information given from this model ship and any other ships nearby her. Two other ships were set to disturb this model ship virtually in the server. However, the model ship will send the actual data, the situation varies case by case.

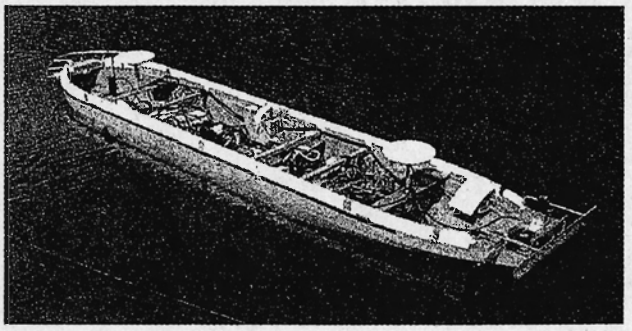

Fig. 3 Photo of the model ship[5]
(Two RTK-GPS antennas were seen)

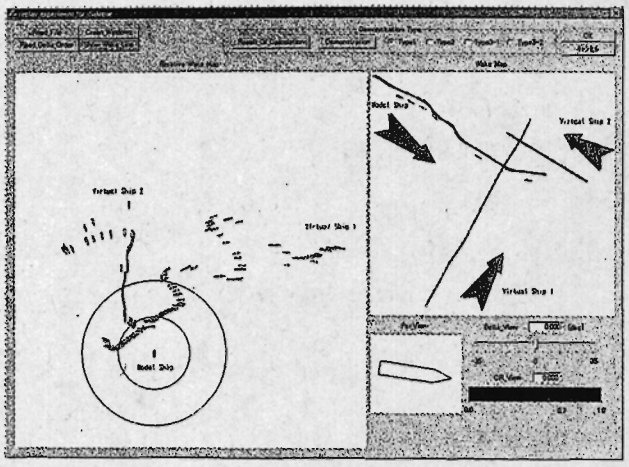

Fig. 4 A result of model experiments of automatic collision avoidance with multiple ship encounters[5]
(Own ship: center (radar) and from upper left to lower right (trajectory), second ship: from middle right to lower left (radar) and from lower left to upper right (trajectory), and third ship: from upper left to near-by center (radar) and from middle right to upper left (trajectory))

SMARTS – EACH-SHIP-WITH-CAPTAIN MARINE TRAFFIC SIMULATION SYSTEM[6-7]

SAFES was originally developed for intelligent ship or unmanned ship project, but during software test or system evaluation, the first author felt it necessary to prepare a simulation system where multiple ships are controlled by ***SAFES***. It can create various situations amongst ships automatically and randomly generated. Several system bugs of ***SAFES*** were found and to check it more intended, more natural traffic generation was requited. It was what ***SMARTS*** can. It can set up arbitrary gates where ships will be generated or finish their missions For each ship, type (cargo, tanker etc.), speed, manoeuvrability indices and destination with arbitrary waypoints can be generated according to the given statistics as well as her arrival (generated) time.. It can generate arbitrary traffic environment. Then each ship will be operated by ***SAFES***, the behaviours of all ships are very looking like the real world. We can change traffic density, waterway configuration and even the level of the ship master's skill.

Fig. 5 shows an example of the simulation done be ***SMARTS*** [5]. It is the case for Osaka Bay, where Kansai International Airport was constructed in the bay, and we needed to discuss the effect of this artificial island and additional high speed crafts servicing to and from this facility.

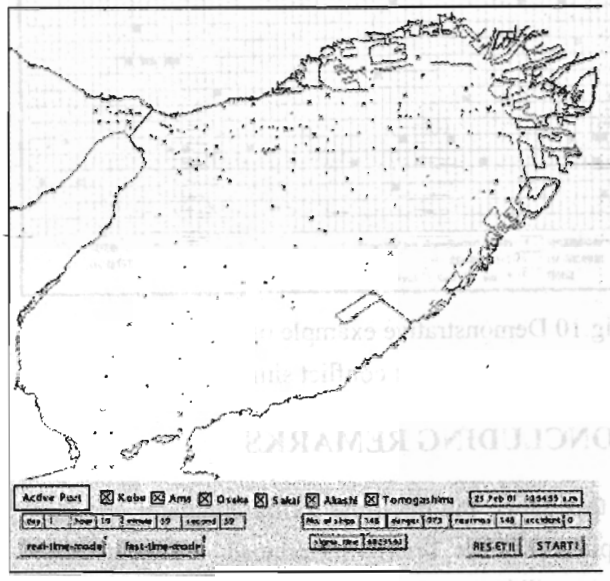

Fig. 5 A sample result of SMARTS[7]

APPLICATIONS OF SMARTS

Intelligent ship handling simulator[8]

For background traffic environment SMARTS can be used. Manned ship (own ship) is operated by a human and he/she should avoid background traffic, if necessary. If the trainee fails the operation, background traffic itself will take proper reaction according to the trainee's operation. No instructors' behind-screen operation needed.

Harbour and waterway design and evaluation

Previous example of Osaka Bay is one of them. The authors have conducted the similar study for the runway expansion project of Haneda Airport in Tokyo Bay. To assess the expanded runway design the effect of the expansion was evaluated by the numbers and area of near-miss points. Fig. 6 shows one of such expansion plan. The navigation lane crossing the prohibited area was forced to modified as shown in this figure. The effect was qualitatively and quantitatively shown comparing between Figs. 7

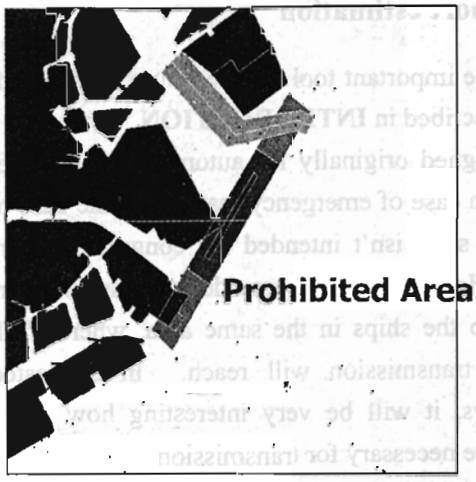

Fig. 6 One layout of runway expansion project of Haneda Airport and the alternation of navigation lane due to the prohibited area to be cleared out

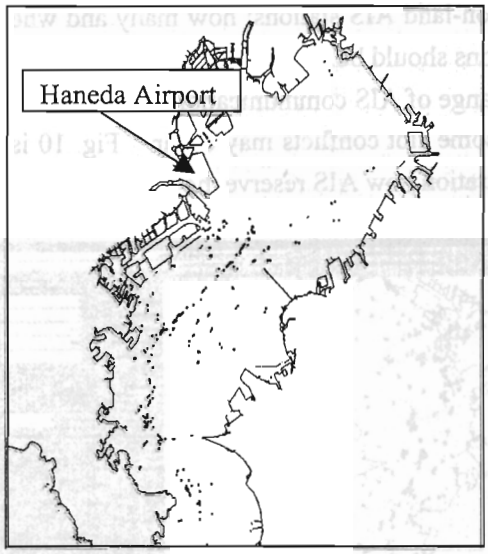

Fig. 7a Near-miss points of present status (Tokyo Bay)

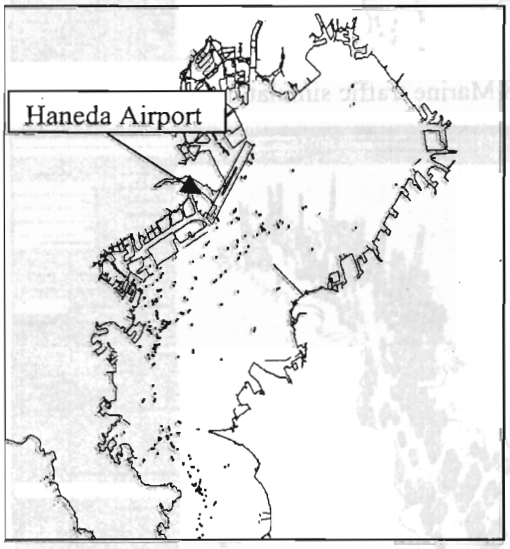

Fig. 7b Near-miss points after the runway expansion layout of Fig. 6 (Tokyo Bay)

AIS report estimation

AIS is the important tool for the future marine traffic as described in **INTRODUCTION**.

It is designed originally for automatic position reporting in case of emergency just like in the case of aircrafts, so it isn't intended for congested waterways. However, it will provide importance information to the ships in the same area, where VHF wireless transmission will reach. In congested waterways, it will be very interesting how many reports are necessary for transmission.

The estimation is carried out for Tokyo Bay and for Ise Bay in Japan[9].(Fig.9)

The above simulation result was used for the planning of on-land AIS stations; how many and where the stations should be.

As the range of AIS communication is limited by its power, some slot conflicts may occur. Fig. 10 is a demonstration how AIS reserve the slot.

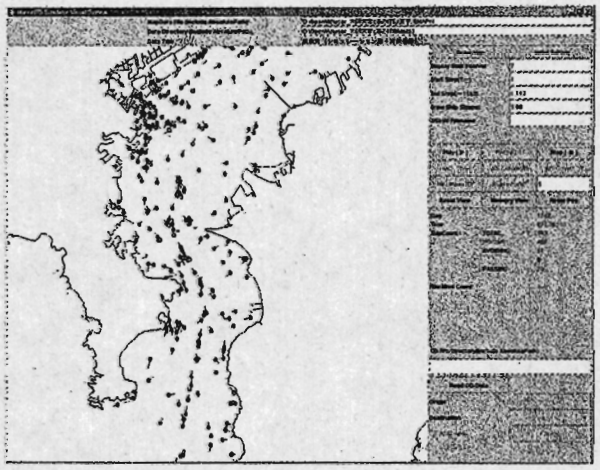

Fig. 8 Marine traffic simulation in Tokyo Bay[9]

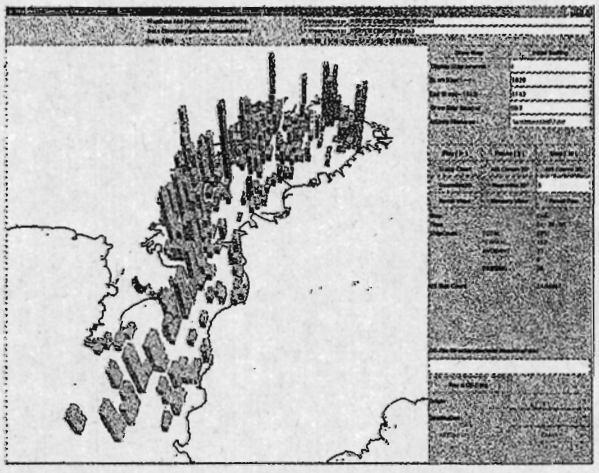

Fig. 9 AIS report number distribution in Tokyo Bay[9]

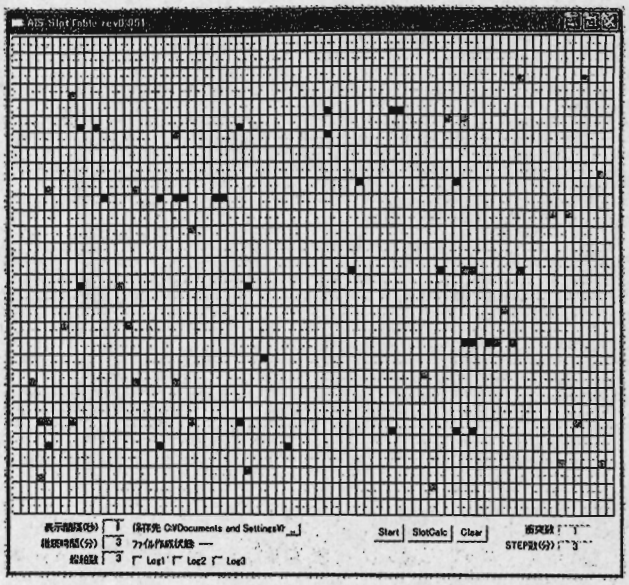

Fig.10 Demonstrative example of AIS slot reservation and conflict simulation

CONCLUDING REMARKS

In this paper, the maritime traffic simulator and its applications are briefly introduced. Conclusions drawn will be summarized.

1. Automatic navigations system ***SAFES*** is the kernel of maritime traffic simulation system. It is confirmed by model experiment for the first time with multiple ship encounter situation.

2. Maritime traffic simulation system ***SMARTS*** will be an important tool for various systems or project in congested waterways.

3. Several applications for harbour and waterway design were introduced partially for the cases of Osaka Bay and Tokyo Bay. ***SMARTS*** as well ***SAFES*** were found work properly and promising.

4. Application for AIS related-project is still going on. Further investigation is required, but this kind of new technology will help safety increase. Urgent development is expected.

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