JAVA-BASED SIMULATION TOOL FOR SHIP MANOEUVRING

Kazuhiko Hasegawa and Yoshimichi Sasaki[1]

Department of Naval Architecture and Ocean Engineering,
Faculty of Engineering, Osaka University
2-1, Yamada-oka, Suita, Osaka, 565 Japan

Abstract: A new simulation programme for the assessment of the IMO Manoeuvrability Standards, and for any arbitrary manoeuvre is presented. The programme itself is based on the well-known MMG model, but is written by Java. One of the merits of the method is to be accessible by anybody, who can access to the Internet with Java-aware browser. Therefore user interface is provided as easy as possible. Some HTML (HyperText Markup Language) links also help users to know the prediction formulae, charts or even references quoted. The procedure is shown through the demo sample.

Keywords : Ship control, Manoeuvrability, Simulation, Internet, Java

1. INTRODUCTION

Manoeuvrability Standards employed by IMO are requesting every shipyard to predict manoeuvrability performance of each ship in her initial design stage. However the Standard doesn't mention about the method, and unfortunately there is no certified standard method for this. Secondary, even if an appropriate mathematical model is chosen, it is hard for each shipyard to establish either of theoretical, empirical or database-based method to tune numerous coefficients for that and then to make their own simulation programme codes.

The authors are proposing a method for this purpose. The simulation programme is developed using Java™, so that anyone can access it anywhere in the world through Internet. Not like other conventional programming languages such as FORTRAN or C, it will run on any platform of computers, as far as they are connected to Internet and have Java-aware browser. Besides not like CGI (Common Gateway Interface) supported by HTML (HyperText Markup Language), the programme codes will be downloaded and computation will be done on each client computer.

In this paper, the method and the interface are discussed and a sample result is shown.

2. SIMULATION PROGRAMME AVAILBALE IN INTERNET

The purpose of the project is to provide a programme which can be used by anybody to predict the manoeuvrability performance of his/her interesting ship(s). IMO Manoeuvrability Standard is the good motivation for this. The authors are considering the following capabilities.

- Modularity
- User capability of choice
- Data-driven computation

Every item listed above will fit the way of Object-oriented Programming (OOP). Modularity of pro-

[1]Nippon Kaiji Kyokai (at the time of research, Course of Naval Architecture and Ocean Engineering, Graduate School, Osaka University)

gramming makes it easy to plug in and out modules both from programmer's side and users' side. User can choose his/her preference of mathematical model, coefficients and tests to be executed. Besides, the authors are trying to develop such a programme available as Internet resource. Java™ meets both features, so is selected as the system language.

For those who cannot provide their own coefficients, easy-to-use way is provided, where almost every coefficient will be automatically estimated from an appropriate method each. User can change any data any time, and computation will synchronise.

3. MATHEMATICAL MODEL AND HYDRODYNAMIC COEFFICIENTS

In the evaluation version, the authors provide so-called MMG model. Other models may be plug-in-ed or even provided from the user's side, although it is not in the evaluation version, but available in the feature version.

MMG model is so popular in Japan, but there exist various implementations. MMG model is a global notation of the way of expressing hydrodynamic forces acting on a manoeuvring ship. In the evaluation version, one of the well-defined implementations defined by Yoshimura (Yoshimura *et al.*, 1995; Kobayashi *et al.*, 1995) was only prepared, but some others may be added later. Fig. 1 shows the menu page of the current version. In the menu, the user

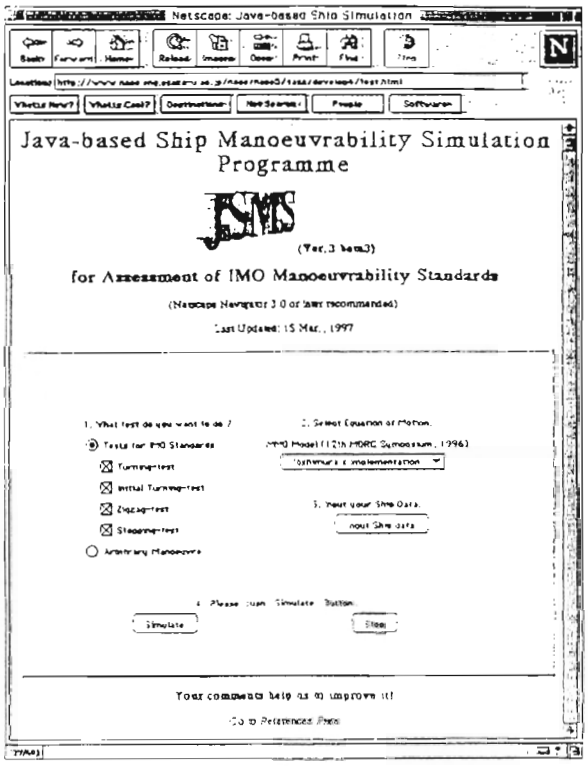

Fig. 1. Menu of the simulation.

can select items to be executed and the model (if availabe).

There are still many discussions how to determine hydrodynamic coefficients. MMG model defines its structure, but not on each notation of coefficients. Some persons introduce second order non-linear hydrodynamic forces/moment, but the others do third order. Coefficients of interaction forces between hull, propeller and rudder govern the motion significantly, but it is very hard to predict theoretically. Some empirical formulae or diagrams are useful, but normally established only by accumulating experimental data.

The authors are carefully selected the well-defined implementations, so that everybody can follow the method from the published literature. It is not the authors' intention to introduce these implementations, and they will be well defined in the hyperlinked documentations including references and figures.

4 A SAMPLE RESULT

The user interface is especially important for this kind of public domain programme. The programme will ask the user to provide all physical and hydrodynamic data of the ship to be predicted. Some users have their own well-confirmed method to estimate certain coefficients, but some don't. The programme will fit both. In the pre-evaluation version, all coefficients were tabulated with its variable-like name and a user should fill out the column of value. It was nice interface, but the user should be aware of its original name (mostly subscripted by Greek letters) and position in the equation. In the evaluation version 3, it is improved as shown later.

Before going to there, let us show the next page, when the user clicks "input your Ship Data" in Fig. 1. It is shown in Fig. 2. First, all columns are blank, so that the user can input appropriate value. The figure shows the data of "Esso Osaka" after clicking "DEMO" button. There are many publications on this ship. After the user fill out all columns either way of trying DEMO values, alternating certain values from DEMO or filling his/her own ship data, click "Next >>" button. ("Cancel" terminates the programme.)

Fig. 3 is the next page. The user can see the MMG model as it is, except one input window beneath the coefficient x_G'. This is the style of inputting data. User can easily find the coefficient what it is. Each data is already filled out, if appropriate method is available. In case of Yoshimura's implementation, all data are estimated. If the user has any data, he/she may replace them. From now on,

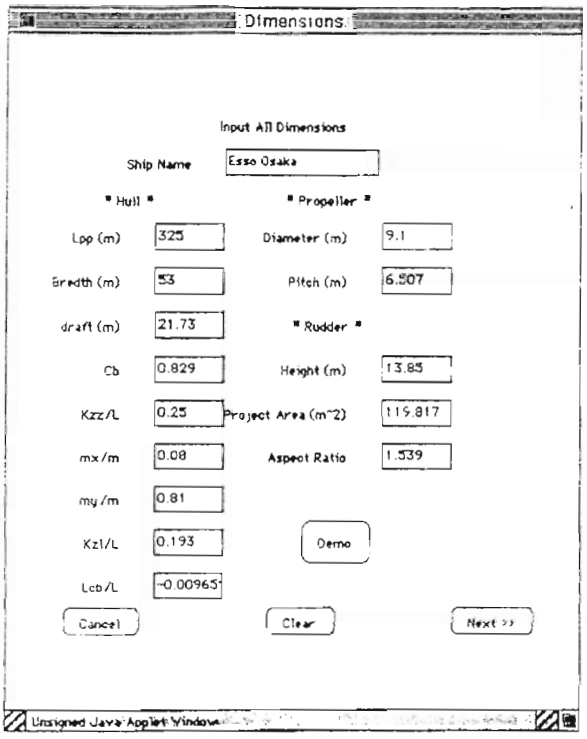

Fig. 2. Input menu.

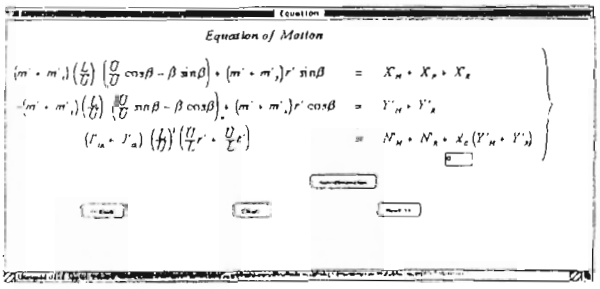

Fig. 3. Equations of motion in sub-menu.

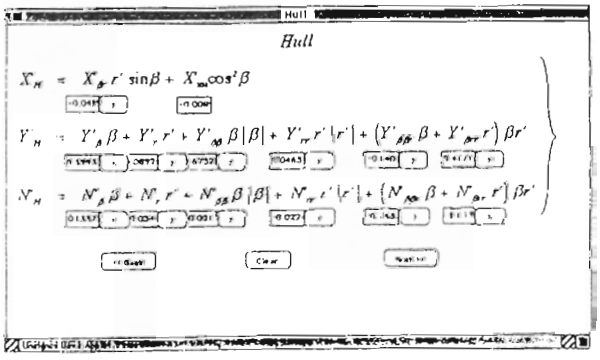

Fig. 4. Expression of hull forces/moment in sub-menu.

there are "<< Back" and "Next >>" buttons, so the user can go forward or backward, as he/she likes.

From Figs. 4 - 7, definitions of hydrodynamic forces are shown and the user is requested to fill out their coefficients, or to rely on the programme's estimate. This is the good feature of data-driven programme. In case of conventional programme or even in case of Excel-like spreadsheet, it is difficult to accept both. Here data column is already data and the rest of programmes doesn't care where it came from.

After clicking "Next >>" in Fig. 7, there still appear some windows concerning to the hydrodynamic forces/moment concerning to the propeller astern, and continuing clicking "Next >>", the user can reach Fig. 8, initial data window. At this version no other

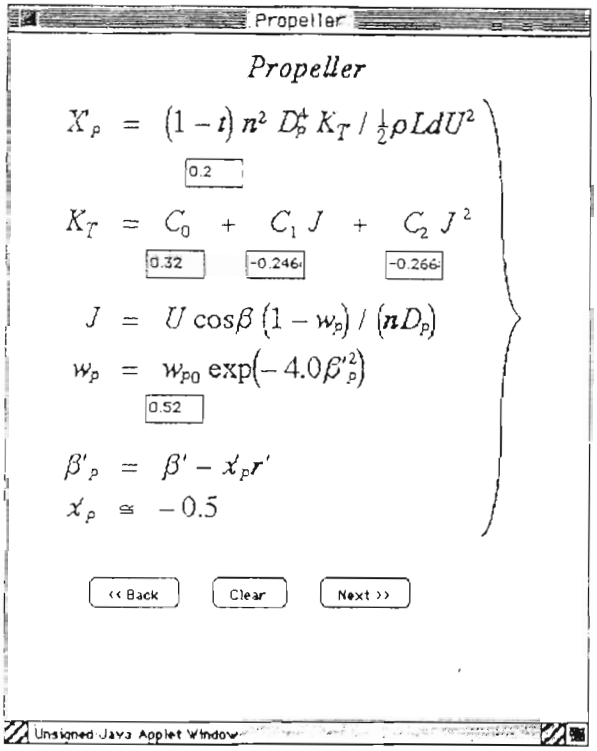

Fig. 5. Expression of propeller forces/moment in sub-menu.

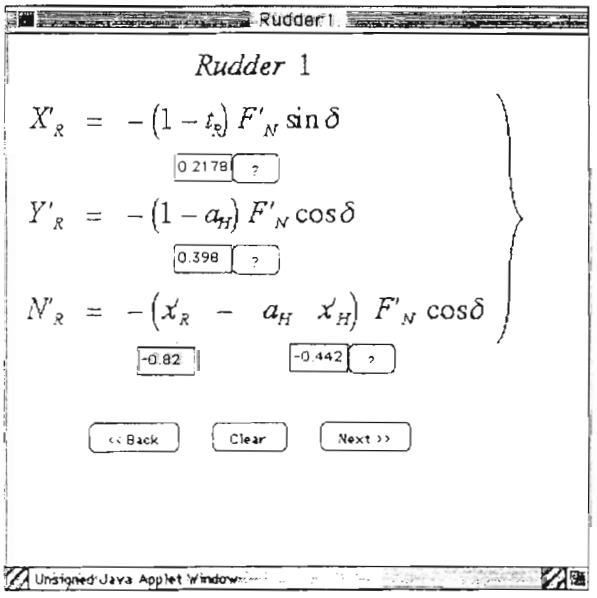

Fig. 6. Expression of rudder forces/moment (Part 1) in sub-menu

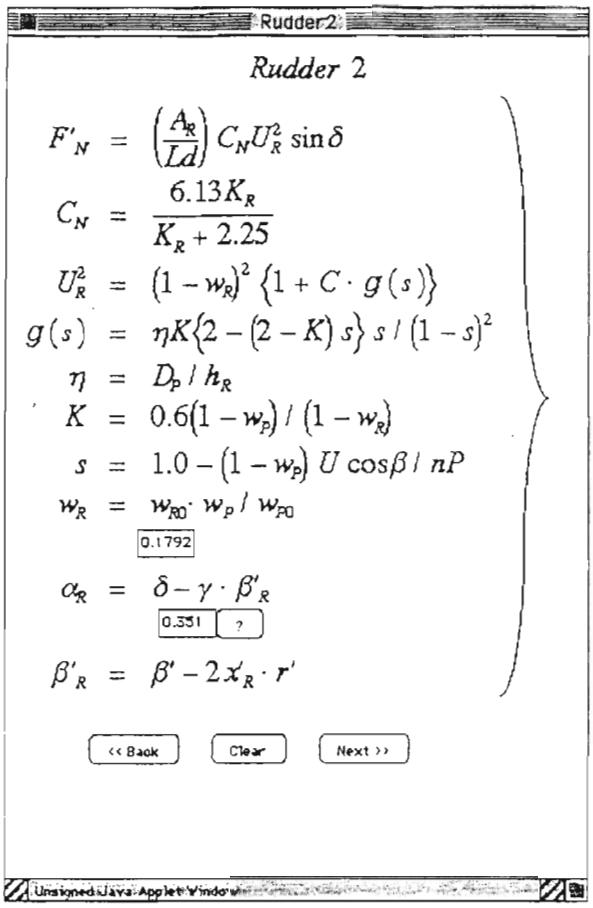

Fig. 7. Expression of rudder forces/moment (Part 2) in sub-menu.

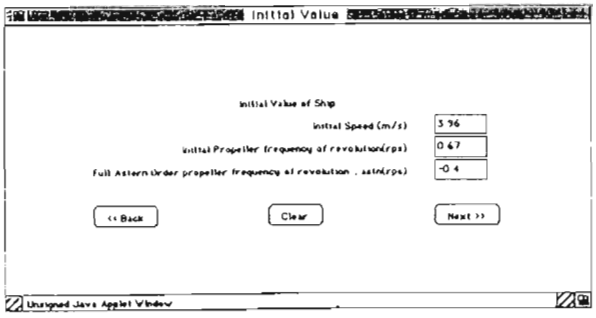

Fig. 8. Initial condition sub-menu.

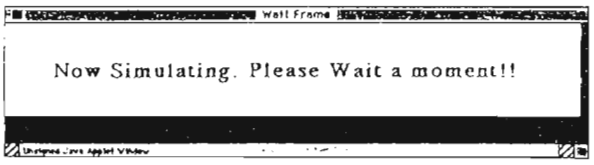

Fig. 9. Waiting window.

initial data will be accepted from the user. Clicking "OK", the programme will go back to Fig. 1. After ticking "Test for IMO Standards" with appropriate test boxes (normally all of them), click "Simulate" button. Then waiting window shown in Fig. 9 will appear, blinking. Please remember, every calculation up to now and onward is carried out in the user's computer. It really depends on the power of the client computer, but will finish within a few minutes by pentium machines to get the result as shown in Fig. 10. In the figure, the IMO standards are shown, so the user can easily figure out his/her ship meets the standards or not. From the second trial, including changing the test ship completely, or just modifying any of principle dimensions or some hydrodynamic coefficients, the calculation time improves drastically. It is easy to compare their trials to find the altered effect. Although "Print" button is prepared, it won't work, because the current version of Java™ doesn't support it. The user should make the hard-copy. The "Close" button will close this window to go back Fig. 1.

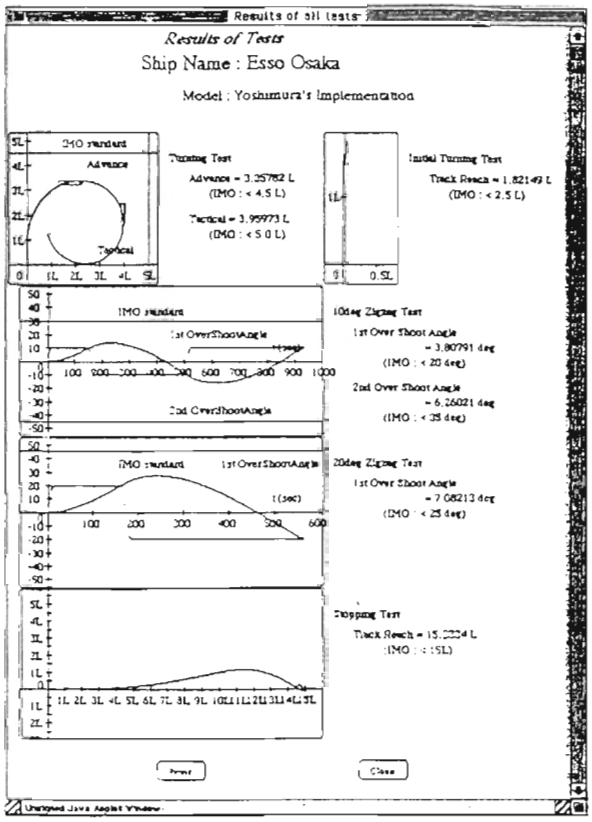

Fig. 10. Result window.

5. HYPERLINKED HELP WINDOWS

There are many buttons such as "?" in previous windows. They are linked with various help windows. Let us show some examples. If the user click "non-dimension" button in Fig. 3, there appears the definition of non-dimensionalization. If the user click the first "?" in Fig. 4, Fig. 11 appears. In the window, there is a button "Reference" and it is linked with the reference window shown in Fig. 12. Further links are set in the window and some are linked with even to the original chart in the reference quoted such as shown in Fig. 13.

These are nice features of HTML (hypertext markup language), and has good relationship with Java™ programme.

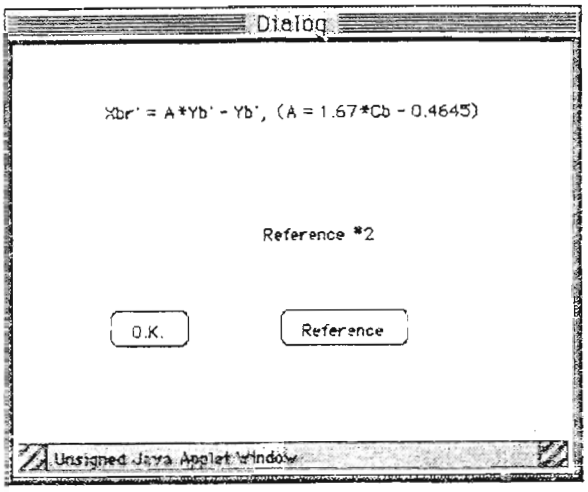

Fig. 11. A help window.

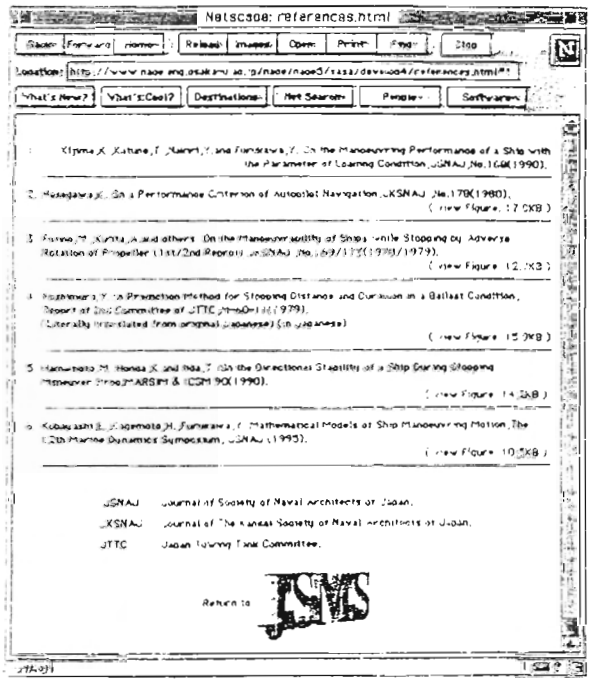

Fig. 12. Reference window.

6. ARBITRARY MANOEUVRE MODE

This programme is also capable for simulating arbitrary manoeuvres. After confirming standard performance of the tested ship's manoeuvrability, for example, the user can go back to Fig. 1 again. In this situation, the programme still holds all the data of the tested ship, so the user can continue to click "Arbitrary Manoeuvre" and click "Simulate". Then arbitray manoeuvre mode starts.

Fig. 14 is the first window in this mode. From the menu bar, drag "Ship" and select "add Ship" (Fig. 15). Then the initial condition window appear, and the user can set the tested ship at any point with any combination of propeller revolution and rudder angle.

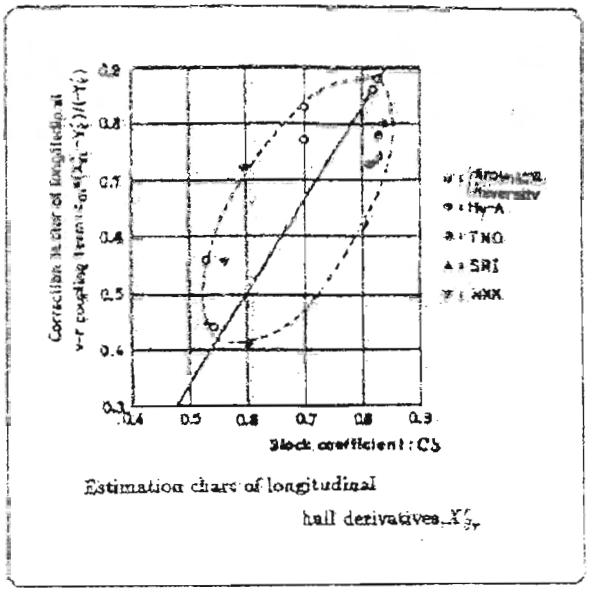

Fig. 13. A chart window.

Clicking "Start" button in Fig. 14, a solid-box representing the 'ship' appears at the point given by the user (Fig. 16) and it will move according to the given propeller revolution and rudder angle. If the user wants to change either of them, click the 'ship' box in the chart (Fig. 17), then command window (Fig. 18) appears. The user can either drag the slide bar or directly input the value to be changed in the window.

The user can add/clear arbitray shaped lands by selecting "add/clear Land" sub-menu from "Land" in the menu bar (Fig. 19). The user can add as many as he/she wants. This is the merit of OOP. Besides, the user can add/remove also arbitray number of ships

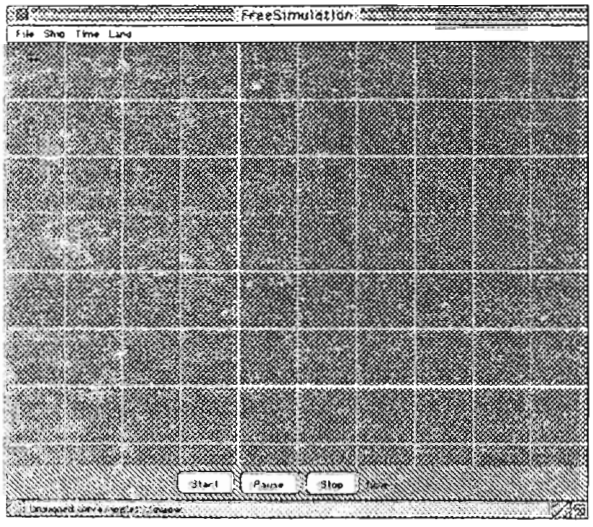

Fig. 14. Initial window for arbitrary manoeuvre mode.

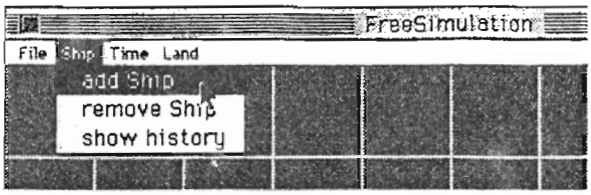

Fig. 15. Pull down menu "add Ship".

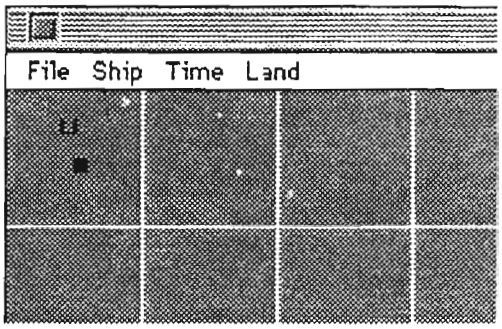

Fig. 16. Start of arbitrary manoeuvre.

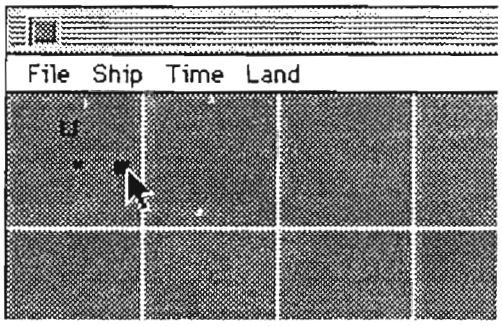

Fig. 17. Change command by clicking the ship.

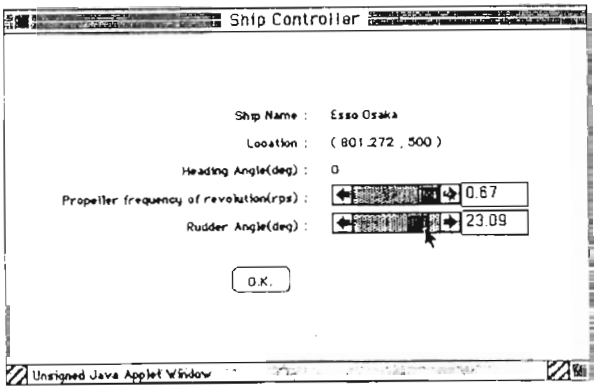

Fig. 18. Command window.

with different coefficients.

From the 'Time' menu, the user can change the time interval and total simulate time.

Although the speed and of Java™ and the network is not sufficient and this is just on an experimental stage, it will be an important direction for the future way of simulation.

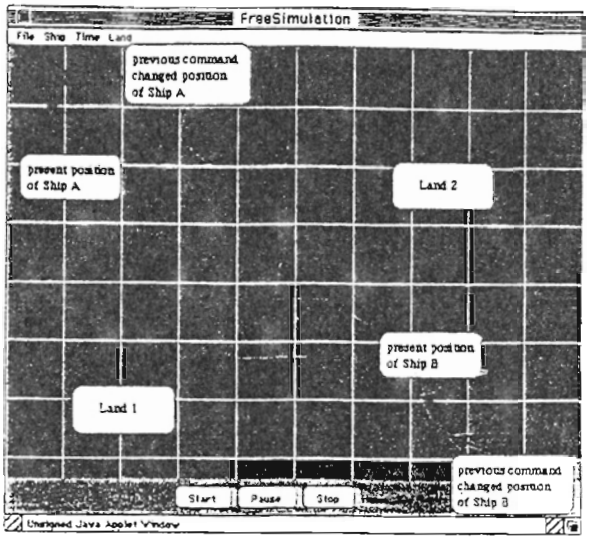

Fig. 19. Two ships added with two lands.

7. CONCLUSIONS

The evaluation version of "Java-based Ship Manoeuvrability Simulation Programme for Assessment of IMO Manoeuvrability Standard" was introduced as an example of network simulation tool for ship manoeuvrability. The authors will summarise the conclusions as follows.

(1) Ship manoeuvring simulation programme was developed using Java™. The current version is available in Internet at
URL http://www.naoe.eng.osaka-u.ac.jp/hase/ShipSim.html

(2) A sample user interface suitable for Internet user is developed. Any user without programming experience can 'run' the programme with his/her coefficients.

(3) Importance and future trend for Java-based scientific calculation is shown.

REFERENCES

Kobayashi, E., H. Kagemoto and Y. Furukawa (1995). Mathematical Models of Manoeuvring Motions, ibid., pp.23-89, Tokyo.

Yoshimura, Y., T. Ishiguro, S. Tanaka (1995). Prediction of Full-scale Manoeuvrability in Early Design Stage (in Japanese), in Proc. of 12th Marine Dynamic Symposium, pp.91-133, Tokyo.