THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS
and
THE SHIP STRUCTURE COMMITTEE

Paper presented at the Ship Structure Symposium '96
Sheraton National Hotel, Arlington, Virginia, November 18-20, 1996

A Program for Onboard IBM PC Ship Handling in Storms

Alexander Maximadji, PhD[1]

[1]CNIIMF, ul. Kavalergardskaya, 6 193015, St. Petersburg, Russia

Abstract

A number of measures directed to the navigation safety growth on account of the decrease in Human or organization errors (HOE) is considered. It is noted that the most weak link in this chain is a control of the value of the ship response to the excited sea. The a board IBM PC program "Consultant", which can to a certain degree fill this gap is described. Some results of the use of the program "Consultant" for the container ship and tanker are given.

Statistics is as "a lantern column" which throws a dim light but allows to lean on it. So - on statistics it may be confirmed that about 75% of sea accidents are the result of human action or inaction, i.e. the consequence of human or organizational errors (HOE). Meanwhile just a man who will yet stand on the bridge for a long time determines finally the safety of the ship, its crew and cargoes and the extent of transportation economy as well.

Contributing factors for different type ship's accidents induced by HOE may be considered as following (Figure 1):

1. Structural deficiencies,
2. Technological defects,
3. Severe storms,
4. Heavy ices,
5. Shore services errors,
6. Ship crew errors.

The first two factors are defined by the ship quality and HOE take part in their forming through the design and construction errors. The second two factors - weather effect - are connected with errors in information, warning and weather forecasting systems. The last two factors depend on human's behavior and actions and may be directly attributed to HOE category.

All these factors are the links of one chain with which the ship safety may be raised to the higher level. The strength of these links is to be about the same because finally a real chain strength on the whole is determined by strength of "a weak link". So the attention should be reasonably distributed between the science, specialists and finances in order to soften the HOE influence within contributing factors.

Until recently in striving for decrease of HOE influence there was a tendency to pay much more attention to the first four categories of factors and the last two ones were considered with less interest [1].

But in eighth, the situation began to become more equable. The serious measures were taken to smooth HOE effect owing to studying the influence of activity areas which have not been considered previously. Three ways (see Fig. 1) of balancing attention were suggested:

1. Optimizing skill level of operator: education, training, strong control,
2. Development of techniques: improvement of ship structural safety and reliability of all the structures; lower dependence of techniques on man's action,
3. Adaptation of techniques to operator: special technical solutions, IBM programs.

Among three ways mentioned the most attention in the world practice is drawn to optimizing skill level of operator. In such a way a number of international documents on training and certification of sailors [2], principles of ship manning [3] and control [4] were developed and accepted. The appearance of these three documents and systematic mass control of their implementation make a significant contribution to decreasing HOE owing to optimizing skill level of operator.

Improvement of techniques is also a rather popular method. The investigation [5], in which the problem of the decrease in HOE during the design and construction process is considered in all its aspects, is worthy to be mentioned.

A great progress is achieved in the field of investigations and realization of measures directed to improvement of quality and accuracy of forecasting of weather and ice conditions [6,7].

A lot of work has been done in the field of adaptation of techniques to operator (The use of satellites in navigation and devices of observation and control of environmental conditions and etc). However there is a vast field of activity which will give a great additional effect. It implies the means of prompting the possible optimal solutions to the ship operator under special very severe navigational conditions.

Every man has a certain field of activity in which he is not able to extract the maximum use from the environmental conditions analysis. This occurs because he could not notice the contradictory signals, or because he interpret them not in a proper way.

Such behavior is typical to young ship operators who have tendency to observe not what they really see but what they consider must happen in a particular situation. Regarding new circumstances under the aspect of there earlier formulated standard imagination [8].

In this sense the analysis of about 200 accidents reported in [9] is rather demonstrative. The statistic curve obtained during this investigation shows a great dependence of ship safety on length of operator experience (Fig. 2).

The initial phase of experience (insufficient experience) is firstly characterized by a great accident rate, but then with growth of sense of responsibility the accident risk decreases. The accumulation of experience is accompanied by a groundless self-confidence and growth of accidents. When the experience is reached and the confidence is justified the longest and the most safe period of ship operator's activity is coming.

After this period the errors of ship operators may be again increased if a stage of psycho-physical fatigue came.

The most common reasons for errors and non optimal commands are "false hypotheses" which in turn are the consequence of complicated and contradictory environmental conditions, especially if they include the following elements (Fig. 3):

- Novelty (unknown before, new, newly open, insufficiently studied phenomenons),
- Lack of training leads to psychological unbalance, excitation,
- Uncertainties (exactly unstated, not quite distinct, not clear phenomenons),
- Difficulty in estimation leads to incorrect decisions,
- Suddenness (unexpected, suddenly appeared phenomenons),
- Quick change of impressions forces a ship operator- to respond only selectively.

So for a large group of ship operators (see Fig. 2), especially young and poorly experienced operators, the prevention of undesirable consequences of "false hypotheses" under heavy environmental conditions is connected with a possibility of comparison between the subjective perception of environmental conditions and the objective impartial recommendation, for example, that of specialized IBM PC program.

Such comparison assists operator to correct the subjective perception of environmental conditions and to avoid decisions (Fig. 3).

A transport ship can not be built to sustain any cargo shifting or all the probable actions of the excited sea. So the Rules of Classification Societies provide for certain standard permissible response values which are accepted as the design ones in shipbuilding. The ship, its crew and cargoes safety may be naturally guaranteed only when the design response values are not practically exceeded in service.

Keeping the responses within safe limits is a task the solution of which is completely dependent upon the operator's knowledge, his experience and capability to evaluate the environmental conditions and make correct decisions. So in this case the specialized on board IBM PC programs may be very useful for ship operators (fig. 4). The tasks of these programs may be the following:

- Correction of subjective estimations of environmental conditions,
- Decrease in labor consumption when solving tasks arisen,
- Increased accuracy when solving problems of ship handling.

Programs for onboard IBM PC like "Consultant" capable to solve such tasks have been developed in CINEMA (St. Petersburg) and approved by Russia Sea Register of Shipping and successfully used during ten years in more than

70 ships of Novorossisk and Baltic Shipping Companies of Russia.

Programs are intended to help ship operators when maneuvering in the storm sea and are developed under the following assumptions (Fig. 5).

The wave energy spectrum is assumed to be represented analytically in the form recommended by JSSC II [10]. The closer the real waves are to its mathematical model the more accurate the quantitative program recommendations. The qualitative regularities are practically maintained at any wave spectrum.

The properties of the ship as a dynamic system converting the wave process in the output response processes are presented in terms of response operators, which are determined by the ship motion calculation for the ship considered as a system with six degrees of freedom.

The ship's responses to short - crested irregular waves are expressed in terms of their standards (square root from dispersions) which allow to evaluate both the most probable maximum response value and the tendencies of the response changes when maneuvering.

The ship is also supposed to be a linear dynamic system and therefore there is a linear link between the characteristic wave height and the response value.

The following input data are entered into the program: the mean pitching period (τ), *the heading angle relative to the main-i wave direction (q*) and the ship speed (*v*). These data permit to determine the environmental wave system characteristics if the ship is considered as a measuring instrument. Additionally for quantitative estimations of the most probable maximum amplitude value of reactions a visually estimated characteristic wave height (*h*) must be determined and entered IBM PC.

On the basis of wave system characteristics obtained in such a way and using the calculation results of the ship motion set into the IBM memory, the program can forecast standards and the most probable maximum amplitudes of main responses at any combinations of ship speed and heading.

This program presents the following hull responses and tendencies of their change in dependence on heading angle and speed:

- Midship wave bending moment,
- Vertical and horizontal accelerations at any given potential slamming; green water,
- Rolling motion;
- Resonance zones.

Other responses may be evaluated as necessary with consideration of specific ship and cargo peculiarities.

The program block - scheme is given in Fig. 6.

HOE can be defined as the deviations from acceptable or desirable practice, permit by the person or a group of them, which lead to the undesirable or unacceptable results.

In the first case (the errors of the single person) it is the error of the man. In the second case (the errors of the group of people) it is the error of the organization.

The acceptable or desirable practice in the transport ship handling must be considered as such practice, which provides the safety of ship, cargo, crew and the efficiency of ship exploitation.

From this point of view the efficiency in use of program "Consultant" was estimated in practice during trial trips in the Atlantic and Indian Oceans for two ships: tanker "Antonio Gramsci" and container ship "Captain Konevskiy". During this trip the solutions on ship handling given in the ship log-book and recommended by program "Consultant" were recorded simultaneously.

The basic recommendations of the program "Consultant" are: permissible combinations of course and speed for each pair of cargo shifting and the environmental wave system. This recommendations provides the fulfillment of all norms of Russian Register of Shipping (parameters of pitching, rolling, wave bending moment, the number of dangerous blows under slamming, number of green water, accelerations in the control points and so on).

The ship operators usually try to keep the general course. That is why necessary corrections of moving are fulfilled by the speed changing. During- the trial trips the comparison of the ship speed according to the log-book and recommendations of the program "Consultant" for the maximum safe speed were made. In some cases the recommendations of the program differed from the actual ship speed (see Fig. 7, 8). However for some parts of trips, with the sea force 6 and more, the usage of the program recommendations would have permitted to increase the average speed of the whole voyage approximately on 7% (fig. 9).

The conclusions obtained from the trial trips are fully confirmed by the long term practice of the program usage. The reviews of some of the ship masters from the Novorossiysk and Baltic ship companies clearly indicate it.

Conclusions

1. One of the weak links in the chain of measures directed to increase the ship safety and connected with HOE is the poor control of the value of ship hull response to the excited sea waves.

2. On board IBM PC program "Consultant" developed in CINEMA and approved by Russia Sea Register of Shipping and successfully used in ships during many years is intended to decrease HOE influence on the ship handling in storm.

3. Apart from increasing the navigation safety the application of program "Consultant" allows to increase the mean ship speed in the voyage by about 7% and to decrease the fuel consumption by about 1 - 1.5%.

References

1 "Human Factor and Accidents," Marine Fleet, M., N 11-12, 1995, p 31.

2 International Conference on Training and Certification on Training and Certification of Seafarers, Final Act, 1978.

3 Principles of Safe Manning, IMCO, 1982.

4 Memorandum of Understanding on Port State Control, Paris, 1982.

5 Bea, Robert G., "The Role of Human Error in Design, Construction and Reliability of Marine Structures," SSC - 378, 1994, p.323.

6 Proceedings of the Tenth International Ship and Offshore Structures Congress. Issued by Department of Ocean Engineering Technical University of Denmark, Lyngby, Denmark, 1988, p. 46 - 50.

7 Proceedings of Eleventh International Ship and Offshore Structures Congress. Edited by Hsu P.H. and Wu Y.S., Elsevier Applied Science, London and New York, 1991, p.p. 67 - 69.

8 Veresofskiv R.S. and Parohin U.N., "Labour and Rest of Seafarers," Transport. Moskow, 1986, p. 215.

9 Daniijuk M-J., "Dependence of Navigation Safety on Captain's Length of Service," Proceedings of LHIMS, Transport, Leningrad, v.18, 1976, p. 87-90.

10 Proceedings of Second International Ship Structures Congress, Issued by Ship Structures Laboratory, Delft, The Netherlands, v. 1, 1964, p. 8 - 10.

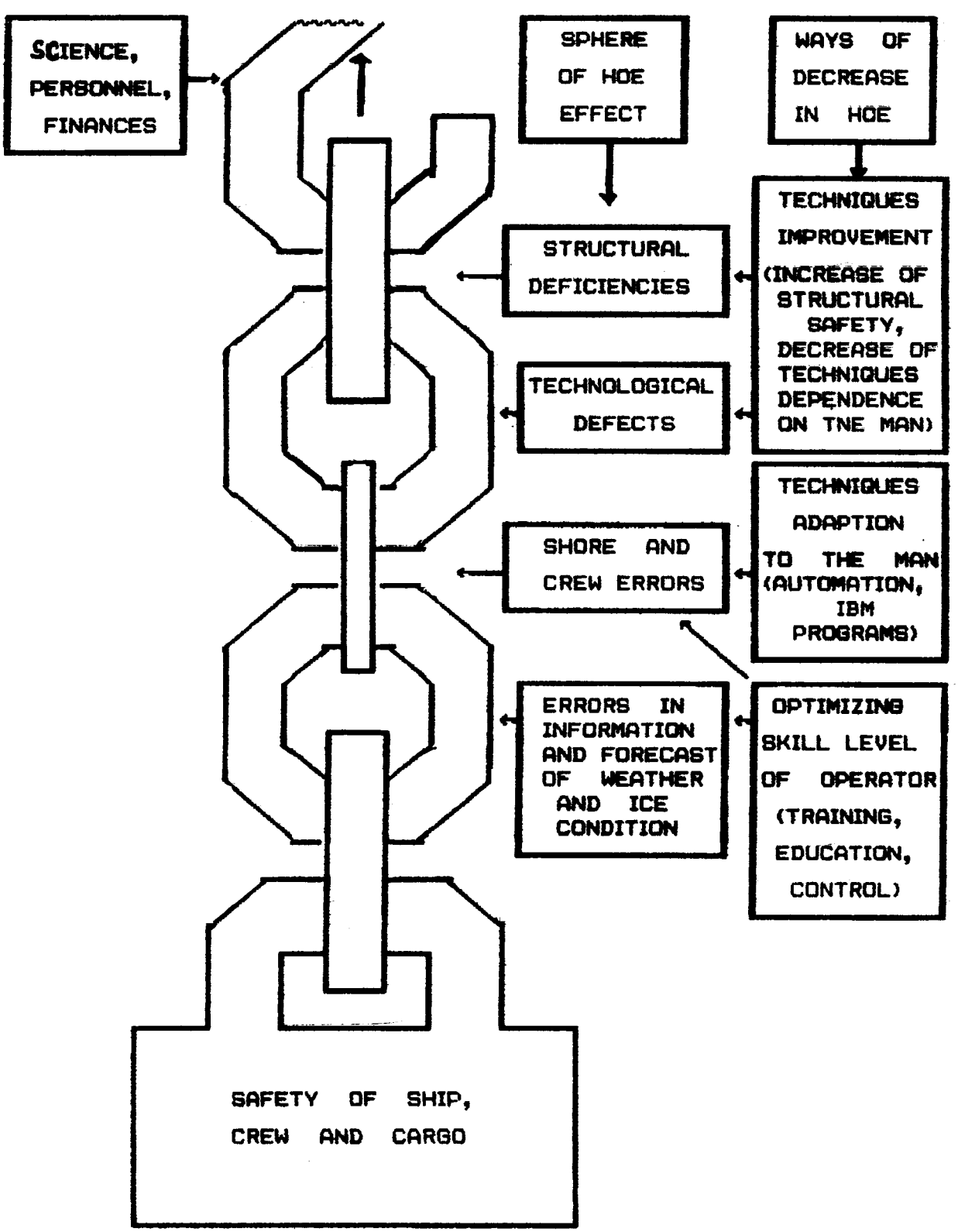

Figure 1
HOE Effect and Ways of Decreasing HOE

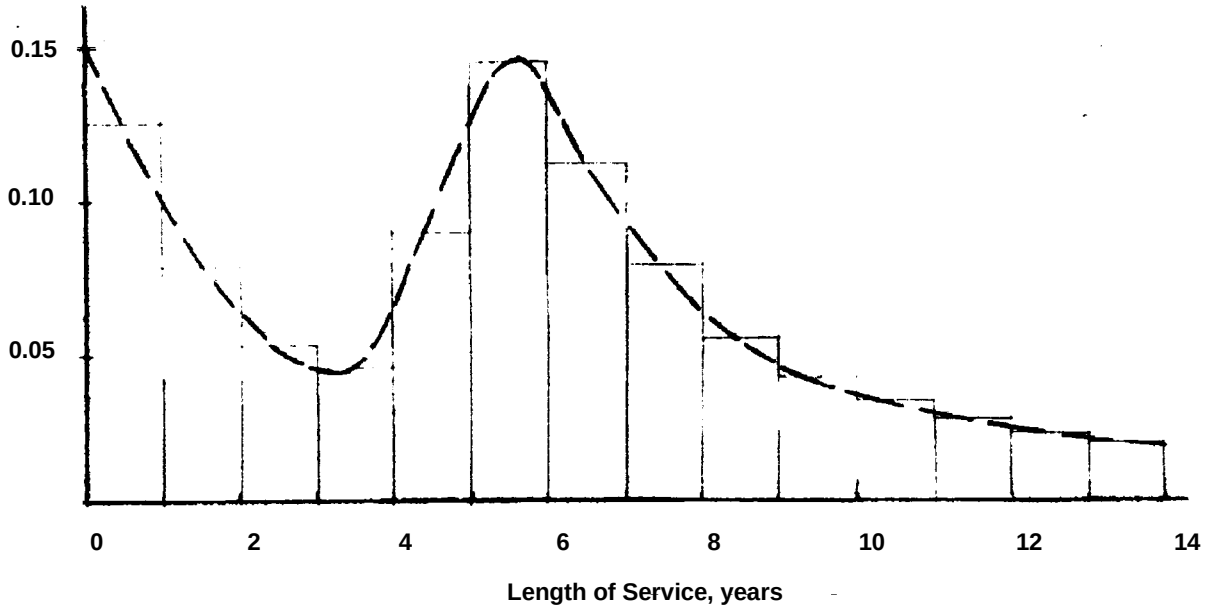

Figure 2
Number of Accidents as a Function of captain's Length of Service
(on the basis of 198 accidents, Pn - number of accidents in year - n)

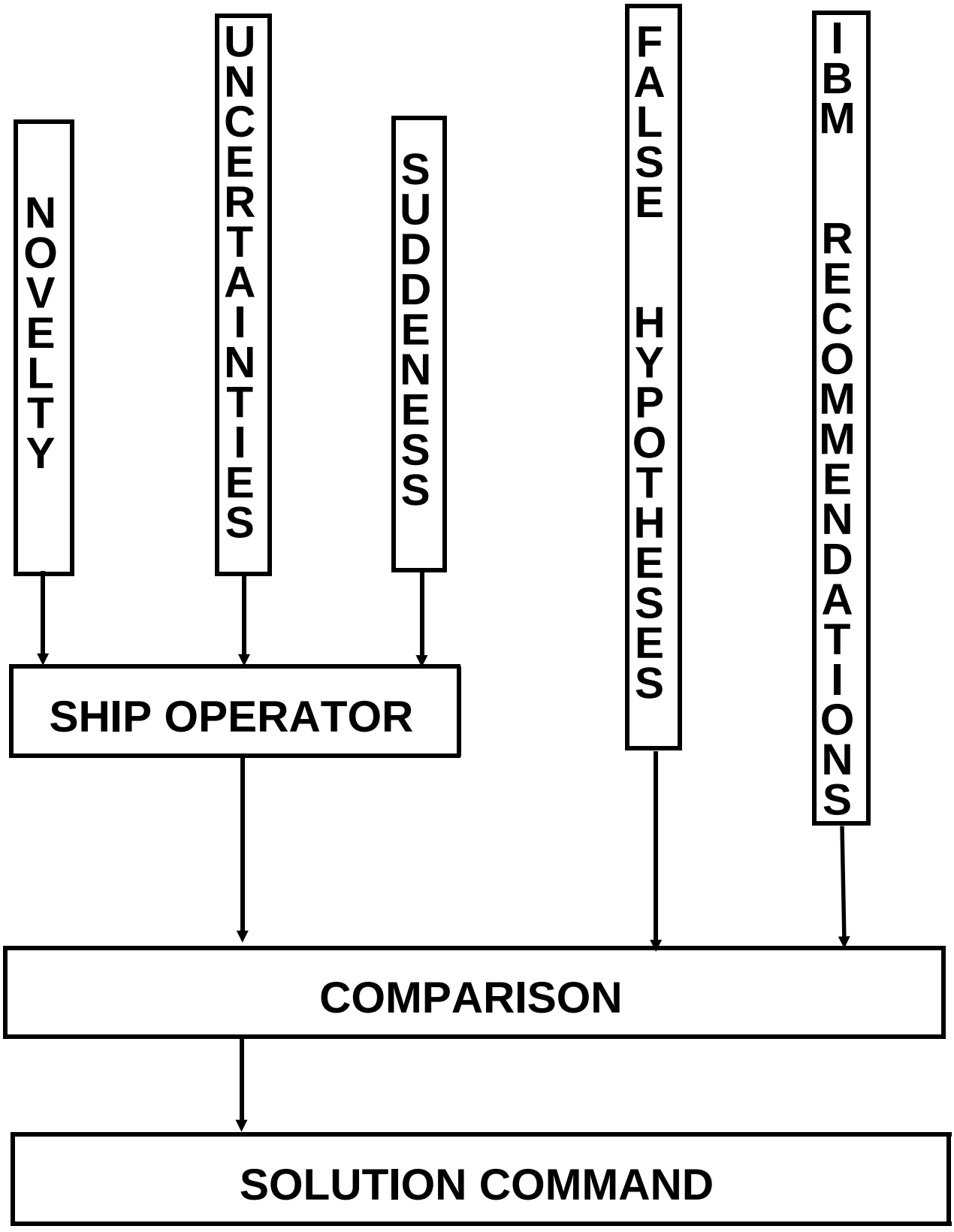

Figure 3
IBM Role in decreasing Undesirable Consequence of “False Hypotheses.”

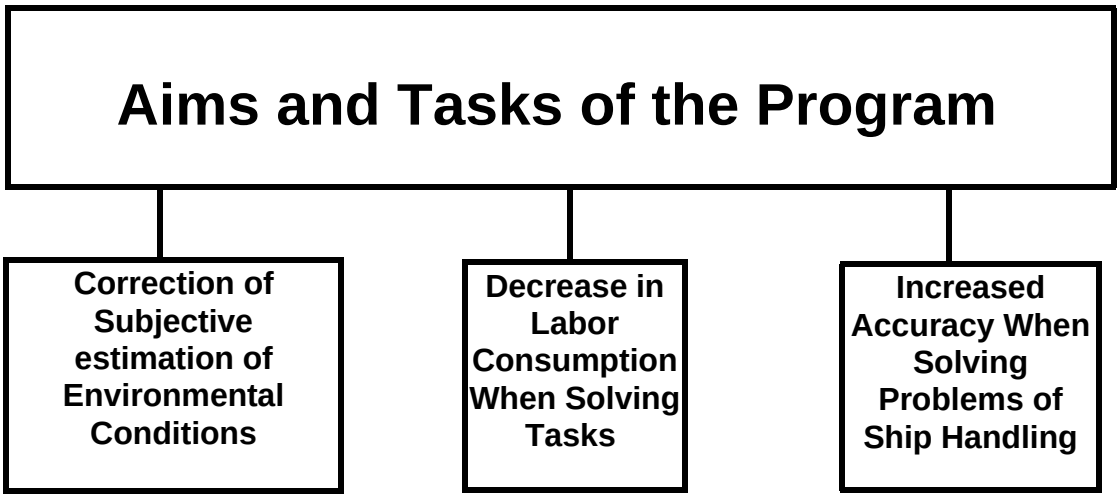

Figure 4
Aims and Tasks of the Program

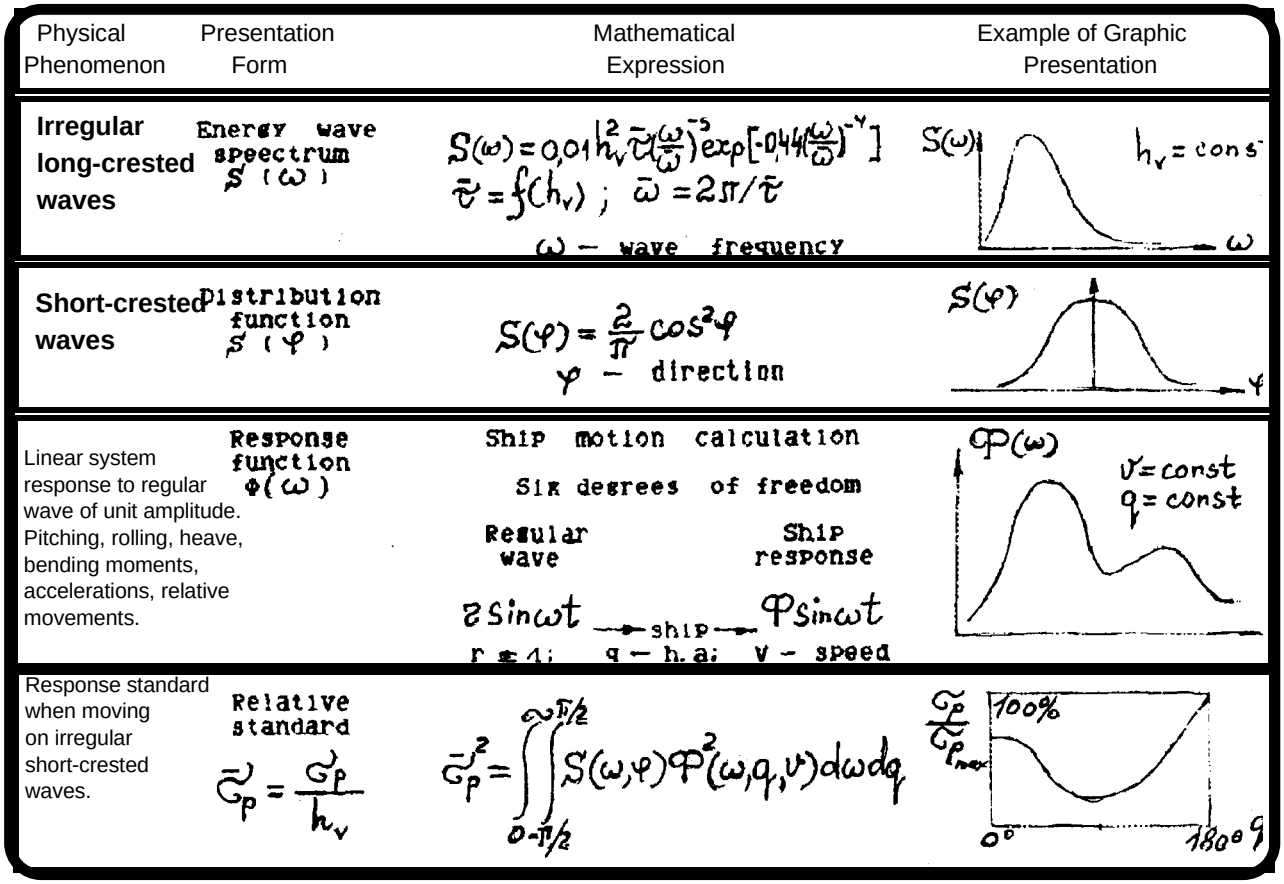

Figure 5

Program Scheme

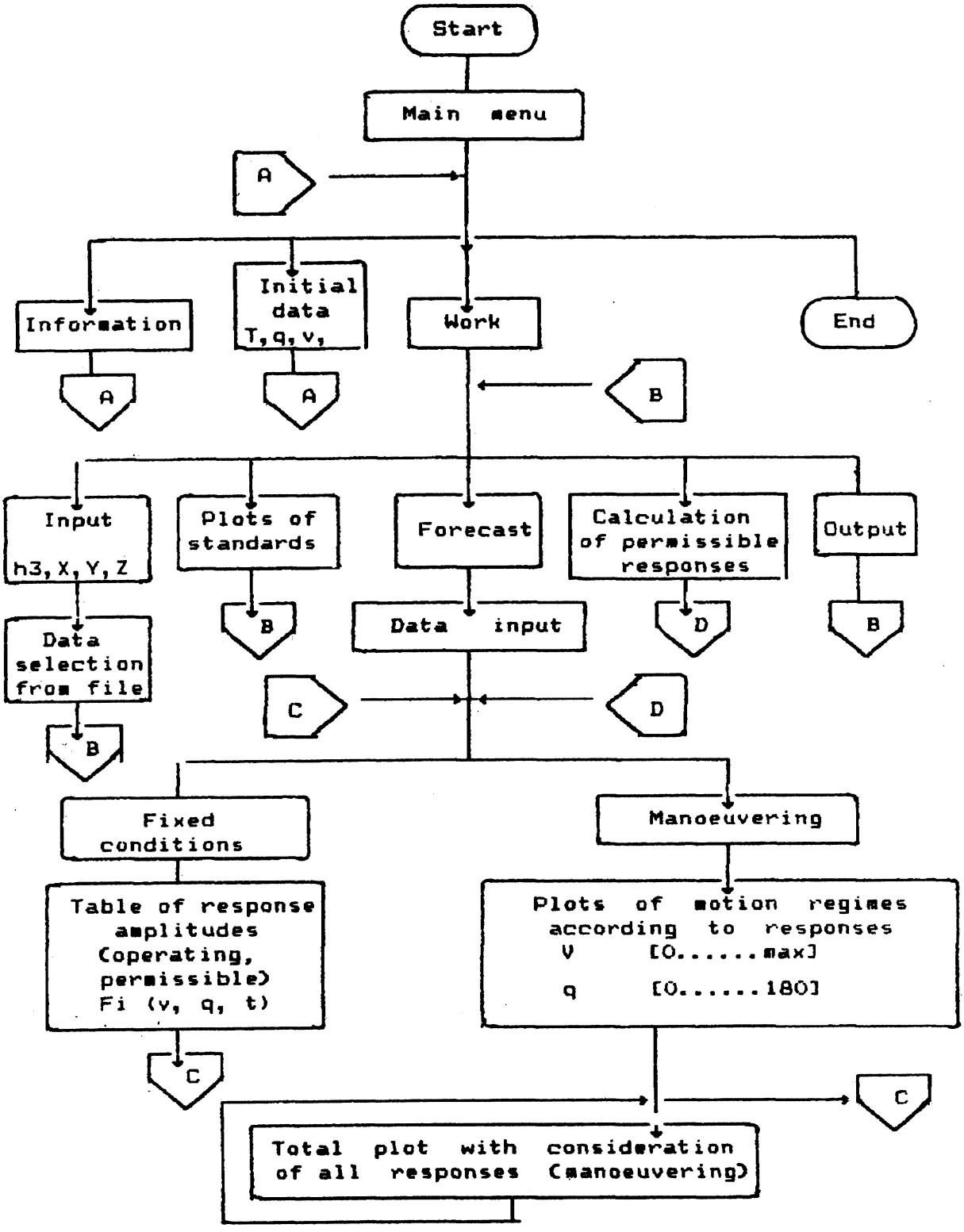

Figure 6
Block Scheme of Program “Consultant”

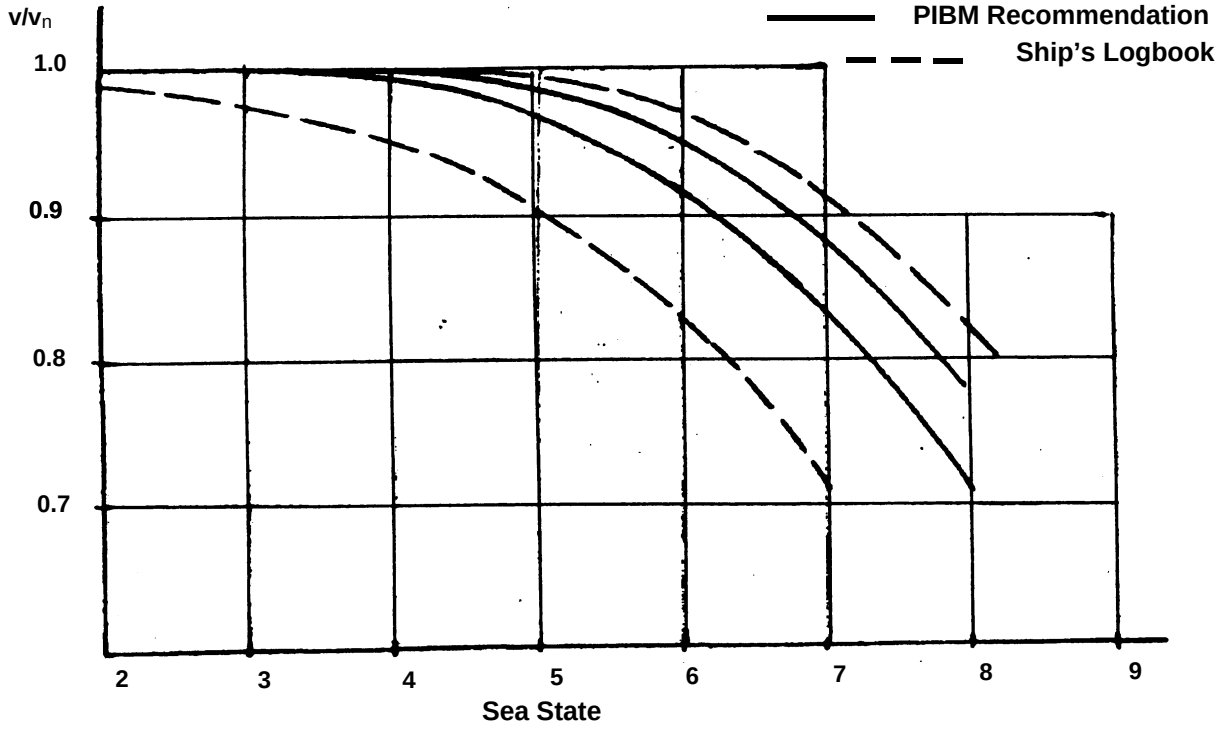

Figure 7

Relative Speed for Tanker "Antonio Gramsci";
L = 183 m, V_n = 16.5 knots in the Atlantic Ocean

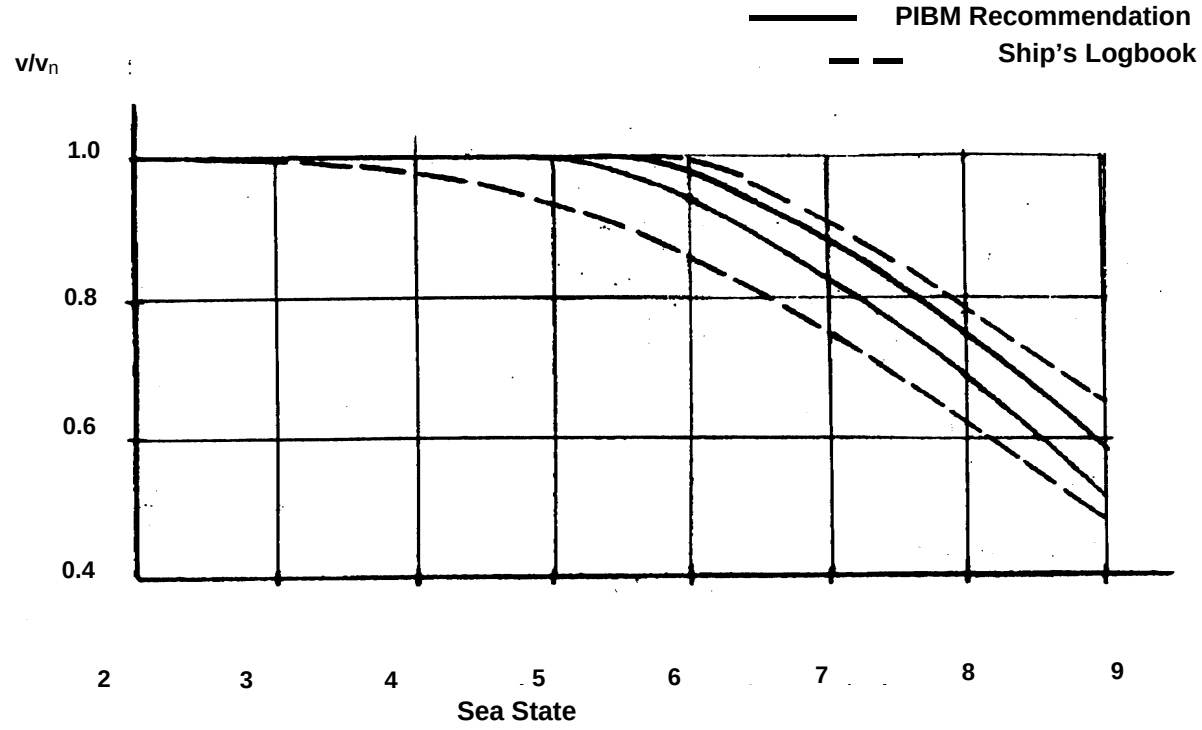

Figure 8

Relative Speed for Tanker "Antonio Gramsci";
L = 194.4 m, V_n = 18 knots in the Indian Ocean

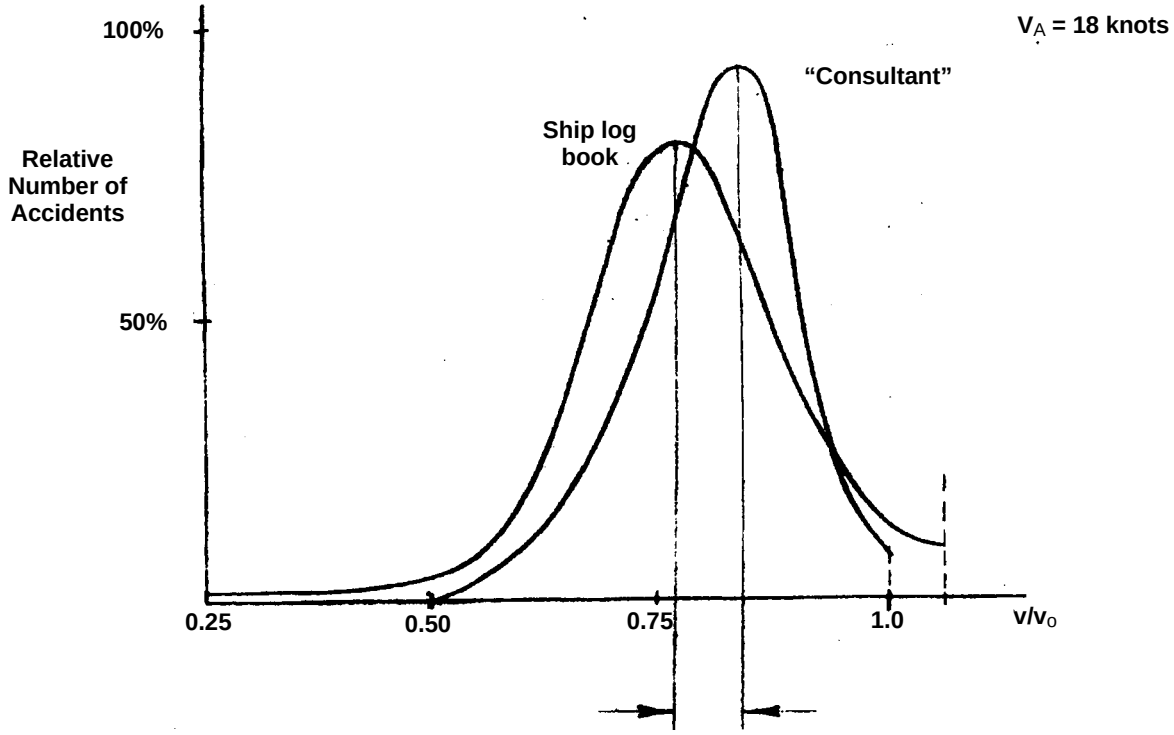

Figure 9
Speed Distribution at Sea State More Than 6 for Containership "Captain Kanevskiy"

Discussion

by Captain P.I. Tkachenko
m/s "Marchal Konev"

The program is intended to help the ship operators to choose the ship course and speed in the storm sea. The program allows determining the traffic regime at which slamming, green water, accelerations, motion and ending moments will be within permissible limits specified by the Russian Register Rules. The simple application of the program and the prompting system allow using the program immediately without any preliminary training. The check of the program by test examples performed during the trip over the Atlantic Ocean has shown that its recommendations do not contradict good sea practice. The application of the program permits using more accurate estimations when choosing the ship speed and course in strom conditions. The programs are thus recommended for practical use**.**

by Captain V.D. Artemjev
m/s "Marchal Udennyi"

The program is intended to choose the ship speed and course relative to the main wave direction in the storm sea. The program is simple, suitable for practical use and may be a useful guide for a captain to accept maneuvering solutions in storm conditions. The spot check of the program recommendations during ocean navigation has shown a good agreement with a good sea practice. The program may be recommended for use with long-distance vessels.

by Captain A.N. Alexeev and Chief Mate P.P. Kubilyus
m/s "Captain Kanevskiy"

The crew of navigating officers of the ship "Captain Kanevskiy" attended the lecture "Ship Handling in Storm" read by Professor A.I. Maximadji with the demonstration of the computer program "Consultant" specially developed by CNIIMF to the order of the Baltic Shipping Company for "Captain Gavrilov" type ships. The discussion has shown that the recommendations of the program "Ship handling in Storm" are in a good agreement with the general practice, investigations of specialists and comparisons with the ship log data for a long operational period. During discussion it was suggested to display and to print the forecast table with the additional indication of the time and date as well as to speed up the development of the ship traffic schedule. The check of the program was performed during the voyage several times at sea state and gave positive results. As a whole, the program "Consultant" (Ship Handling in Storm) for onoard IMB PC may be recommended for use in the "Captain Gavrilov" type ships when navigating in storm conditions.