Assessment of the safety level of a ships' passing manoeuvre in the fairway

Marek Narękiewicz
Maritime University of Szczecin

ABSTRACT

Safe two-way vessel traffic may have some limitations. Fairway width, vessel dimensions, weather conditions, traffic density and other factors must be considered crucial and constraining safe passage of the vessel. The possible sea traffic regulation made by a Vessel Traffic Service (VTS) shore centre, is often based on criteria included in harbour regulations. This may not always be an optimum solution. This paper presents a concept and elements of a method for assessment of safe two-way traffic, based on experts' (pilots') knowledge and experience. The goal is to support the decision making process in a VTS centre. For this purpose tools of knowledge acquisition and representation as well as tools of statistical inference are used. The method is based on the results of the expert research which was performed with the participation of pilots who handle vessels on the Świnoujście-Szczecin fairway.

Keywords : safety of navigation, Vessels Traffic Service (VTS)

INTRODUCTION

Ensuring adequate technical parameters of port waterways as well as the development and modernisation of the port infrastructure are the main issues related to the safety of maritime transport. Although fairway parameters such as depths and widths, different for each port, affect its safety and efficiency, management of waterways is equally important. Safe and effective port waterways management depends on traffic density information and actual meteorological and hydrological conditions.

Improvements in the safety of ports and waterways are necessary for several reasons including demands of growing international trade, the trend toward larger ships and faster loading and unloading operations, the presence of oil and hazardous cargo in congested and heavily populated areas and concerns about maritime accidents that may cause environmental damage. These improvements can be realised through investments both into traditional aids of navigation (beacons, buoys, lights) and advanced maritime information systems like real-time information on weather conditions, pilotage navigation systems and decision support systems for a VTS Centre.

Although the term „Vessel Traffic Service" was internationally used for the first time in the 1970s, systems supporting vessel traffic control were established much earlier [11]. First local initiatives were taken just after the Second World War. Liverpool was the first port in the world to receive (in 1948) a monitoring station and radio equipment. Over the next fifty years such services were introduced by port authorities and coastal state administrations and at present more than 250 such systems ensure regular control in port areas, port approaches and narrow traffic lanes [3].

The VTS idea is based on establishing services for ships' traffic safety and efficiency improvement. The scope of tasks may vary from simple information exchange in ship-land communications to traffic management, i.e. planning such vessels' routes and passages which minimise risk of collision. The assessment of collision risk is based on the information on actual meteorological and hydrological conditions, traffic density, available aids of navigation and technical infrastructure [5].

The creation of VTS systems made it is necessary to define rights, obligations and responsibilities of shore-based centres, vessel masters and pilots. A VTS, with its specialised knowledge of a given waterway is responsible for traffic management in the area. On the other hand, the master, with his knowledge of vessel behaviour and professional skills, is responsible for the safety of the vessel. With taking into account the different- but related - responsibilities, all instructions from the shore centre to the vessel must be result-oriented, while the details of their execution fall on the master and pilot.

KNOWLEDGE ACQUISITION AND REPRESENTATION

Knowledge acquisition can be defined as a formalised, heuristic process of gathering information, data or explanations concerning the domain of relevant knowledge [2]. Experts are the main source of such knowledge. They cannot be usually omitted in the knowledge acquisition process.

The effectiveness of expert system is determined by the process of knowledge acquisition. In this process, the articulation of knowledge is a topic of great importance. In the presented research the method of knowledge acquisition based on examples was used. This is a method of inductive nature, in which a general model is constructed by using induction rules and is based on a set of examples [9].

Experts' questionnaires are one of the most popular heuristic methods of knowledge acquisition. The independence of experts opinion and the anonymity of judgements made by experts working in isolation are distinctive features of this method. The anonymity ensured during the research allows an expert to express an opinion which is not in conformity with the most common one.

The terms „expert" and „expert opinion" do not have a uniform interpretation. For instance, an expert can be considered as a person invited to take part in the research because of his or her knowledge, personality, professional experience etc [4].

An expert can be defined as a very skilful person who has had much training and has knowledge in a specific field. This expert is the provider of an opinion in the process of expert's opinion elicitation. An expert opinion can be defined as a formal judgement of an expert on a matter in which his or her advice is sought. Such opinion is a subjective assessment, evaluation, impression or estimation of the quality or quantity of something of interest that seems true, valid or probable to the experts' own mind [2].

The research subject described in this paper is the part of specific expert's knowledge learned in the training process. It consists of all the particular heuristics and shortcuts that a trained professional has learned to use in order to perform better. His or her practice is anchored in the theory which is also needed but could be only the base [6].

The term „knowledge representation" could be used to define the formalised process of transferring, writing and gathering the knowledge meant as a description of surrounding world, consisting of facts and relations. Such knowledge representation must provide a proper structure of description and interpretation. The process has to be formalised when experts' knowledge is to be used in a decision support system.

There is no one, universal, widely accepted way of knowledge representation. Methods of representation must take into consideration a variety of knowledge elements. However future application is also very important. There are only some features that can be required, namely : transparency, accuracy, efficacy, neutrality and adequacy [12].

Some authors use the term „uncertain knowledge representation" for the definition of methods of inference used in decision support systems. Those authors define uncertainty as a lack of information needed for decision making. Sources of uncertainty are : inaccuracy of measuring methods, the existence of parameters omitted as well as the lack of proper experts' knowledge [7].

To define means of interpretation of accepted uncertainty measures is a difficult and important task. The use of probability calculus is one admissible solution. Probability is commonly accepted as a quantitative measure of uncertainty both for premises and for rules of inference.

Statistical methods of analysis (descriptive and inference) are a very useful tool in the perception of structure, interdependence and dynamics of a phenomenon [8]. These methods range from simple explanatory data analysis and significance testing to highly complicated mathematical modelling techniques. Some of them help to summarise efficiently large amount of data while the others help to understand the effects of a number of variables on another variable of interest. One should always remember that statistical inference belongs, besides inference by analogy, to the group of probabilistic inferences, which means that on the basis of true premises we can come to false conclusions [13].

PRINCIPLES OF THE METHOD

The presented method was based
on the following principles :

- ❖ Safety level is the quantitative feature of each manoeuvre. It depends on many factors but mainly on: manoeuvring area parameters, vessel's parameters, executed manoeuvre parameters, and those of actual hydrological and meteorological conditions.
- ❖ Safety level index is the quantitative measure of the safety level.
- ❖ Safety level can be rated by an expert (pilot) because of his or her knowledge and professional experience. The experts' knowledge can be gained by using expert's questionnaires.
- ❖ The questionnaire used in this research was built on the following principles :
  - ✦ The questionnaire contains an expert's opinion which is a subjective assessment (evaluation) that seems true and valid to the expert's own mind.
  - ✦ The expert's opinion expressed by the figure ranging from „1" (safe manoeuvre) to „10" (unsafe manoeuvre), is the quantitative measure of the safety level of ships' passing manoeuvre.
- ❖ Evaluation of the safety level made by experts is based on specific expert's knowledge learned in the training process in order to perform better.

INVESTIGATIONS

The expert research (by using questionnaires) was performed with the participation of pilots handling vessels on the Świnoujście-Szczecin fairway. It aimed at answering two main questions:

- ➲ Is the safety level of manoeuvres of two vessels passing each other affected only by their main dimensions or by actual hydrological and meteorological conditions as well ?
- ➲ Is the safety level of manoeuvres of two vessels passing each other affected also by the section of the fairway in which the manoeuvre is executed? (i.e. are there sections on the fairway where manoeuvre execution is safer not only due to the canal width).

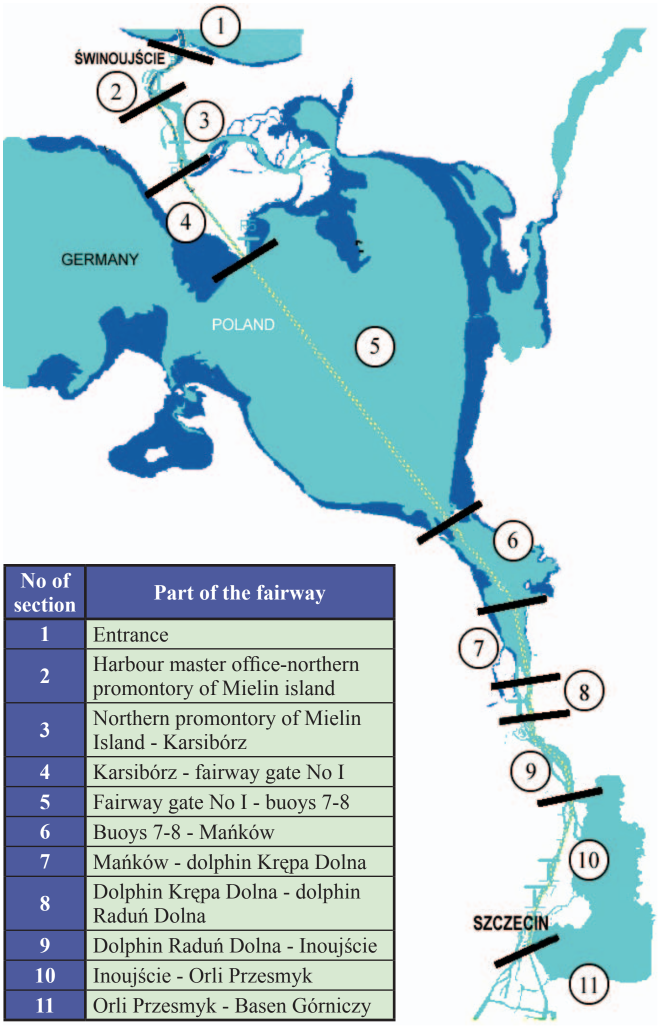
The safety level was based on pilot's assessment with the use of 10-degree scale. Only the vessels frequently calling at port of Szczecin were taken into consideration.

One of the main tasks of the research was to determine the influence of vessels' dimensions and hydrological and meteorological conditions on safety level (pilots' assessment). Nine following factors (independent variables) were assumed :

- ✶ length, width and draught of the vessel entering the port
- ✶ length, width and draught of the vessel leaving the port
- ✶ visibility
- ✶ wind force
- ✶ time of day (daylight or night).

The factor not taken into consideration was a kind (dangerous / non-dangerous) of the cargo on board. The results of previously performed studies show a very low priority of this factor for pilots. This factor must of course be implemented in harbour regulations but its influence on pilot's assessment cannot be considered significant. Pilots' opinion in this matter may also be affected by his or her professional experience (e.g. gained in handling oil and/or chemical tankers) [10]. The research task was to find out if the influence of all above mentioned factors is equal in all fairway sections.

According to the Regulation of Ministry of Infrastructure [14] Świnoujście-Szczecin waterway should have the width of 90 m with the depth of 10.5 m (with the exception of a part of the port of Świnoujście and one branch of the waterway near the port of Police where the required width is 150 m). It is not, however, a uniform waterway. It consists of canals, dredged stretches of rivers (Odra, Świna) and the Gulf of Szczecin. For the purpose of this research the waterway was divided into 11 sections shown in Fig.1.



No of section	Part of the fairway
1	Entrance
2	Harbour master office-northern promontory of Mielin island
3	Northern promontory of Mielin Island - Karsibórz
4	Karsibórz - fairway gate No I
5	Fairway gate No I - buoys 7-8
6	Buoys 7-8 - Mańków
7	Mańków - dolphin Krępa Dolna
8	Dolphin Krępa Dolna - dolphin Raduń Dolna
9	Dolphin Raduń Dolna - Inoujście
10	Inoujście - Orli Przesmyk
11	Orli Przesmyk - Basen Górniczy

Fig. 1. *Świnoujście-Szczecin fairway and its sections .*

Each questionnaire consists of assessment of several manoeuvres. Thirty two pilots took part in the research. Nine the same manoeuvres were assessed by all the pilots.

When establishing the range of vessel dimensions two restrictions were considered. On the one hand the assessed manoeuvres should be those permitted by harbour regulations (slight violations can be accepted). Firstly this restriction is due to the fact that manoeuvres not permitted by the regulations could be considered by pilots as unsafe, secondly because only such manoeuvres can be considered as performed by pilots in the past. On the other hand the results of trial questionnaire showed that the assessments of manoeuvres of small vessels (about 80 m in length) never exceeded „2" in 10-degree scale regardless of the waterway section. This may lead to the conclusion that for such vessels traffic control is not necessary.

THE RESULTS

Assessing the safety level of a passing manoeuvre the pilot must take into consideration a number of factors. To find out how pilots' assessment is performed, one must answer several questions regarding the significance and influence of particular factors. What is the effect of vessels' dimensions ? Which dimensions can be considered as influential ? Could the same manoeuvre executed in different meteorological conditions be assessed at a different safety level ? Is the visibility restricted to 5 Nm an influential factor ? How does the night time affect pilot's opinion ? To answer questions like these the regression analysis, the most widely applied of all statistical techniques, can be used.

The regression model aims to determine how a set of variables (in this research : vessels dimensions, hydrological and meteorological conditions) is related to another variable in question (safety level). Like other models it represents a simplified description of reality, i.e. that neglecting elements non-essential for the researcher. Such simplification makes the problem easier to understand, but one should bear in mind that an excessive simplification needs unrealistic presumptions.

An equation or equations of the model are usually represented in a standardised form containing the looked-for (dependent) variable and influencing (independent) variables (predictors).

$$Y = b_0 + b_1X_1 + b_2X_2 + ... + b_nX_n \qquad (1)$$

where :

Y – dependent variable

X_1 , X_2 ... X_n – independent variables

b_0 , b_1 ... b_n – equation coefficients.

To select the best set of predictors is an important problem. Such variables should take into consideration the aim of the research – descriptive or prognostic one, and assure a sensible interpretation and description of the dependent variable with sufficient accuracy.

The approach chosen to solve the problem of the variable selection is sometimes called the experiment planning or backward elimination. Such an approach is convenient when the best-fitting regression equation is not needed, but only to find out the significance of independent variables in predicting the dependent variable (pilots' assessment) is needed. The vessel's dimensions and parameters describing hydrological and meteorological conditions were assumed the independent variables. Almost all variables are of qualitative nature. The only categorical (dummy) variable is a part of the day : day or night. To identify its significance it is denoted as follows :

0 – day

1 – night.

According to the taken presumptions the description is important only when it confirms statistical relations between the predictors and pilot's assessment. Such relation can be confirmed by using the *t-Student* test used to verify a hypothesis concerning regression equation coefficients. The assumed significance level was 0.05.

$\mathbf{H_0} : b_i = 0$ and the alternative hypothesis $\mathbf{H_1} : bi \neq 0$

The optimum decision allows to reject $\mathbf{H_0}$. This confirms the significance of the variable. The acceptance of $\mathbf{H_0}$ means that the dependent variable is not affected by this predictor or that the influence of this predictor cannot be precisely determined. The confirmed significance of the predictors allows to incorporate them into the equation. In the regression model the correlation between independent and dependent variables is important, but it is also important to select such variables which are not mutually correlated.

Predictors which describe vessels should take into consideration dimensions of both vessels because one can not assume safety level of passing manoeuvre of vessels knowing length, breadth and draught of one vessel only. However it is possible to include into the equation the variables which are sums of corresponding dimensions, but first it must check if there is no correlation between the variables.

When verifying if a correlation between independent variables does not exist the correlation factors matrix shown in Tab.1 can be used. These factors are measures of correlation between pairs of independent variables. If two variables are strongly correlated it can affect estimation procedure of regression parameters.

The results presented in Tab.1 show strong correlation between two variables: *sum_of_lengths* and *sum_of_breadths*. This result makes it impossible to include into the equation the variables which are sums of corresponding dimensions (length and breadth). They can be replaced with a new predictor, i.e. sum of the products of the two dimensions, called the *sum_of_waterplanes*.

$$\text{sum\_of\_waterplanes} = L_1 \cdot B_1 + L_2 \cdot B_2 \tag{2}$$

where :

B_1 , B_2 – breadths of considered vessels
L_1 , L_2 – lengths of considered vessels .

Tab. 1. *Correlation of pairs of variables .*

VARIABLE	Sum_of_ lengths	Sum_of_ breadths	Sum_of_ draughts	Night	Visibility	Wind force
Sum_of_ lengths	1.0000	0.9124	0.7222	- 0.0000	0.0000	0.0000
Sum of_ breadths	0.9124	1.0000	0.7394	0.0000	0.0000	- 0.0000
Sum of_ draughts	0.7222	0.7394	1.0000	- 0.0000	0.0000	- 0.0000
Night	- 0.0000	0.0000	- 0.0000	1.0000	0.0542	- 0.1259
Visibility	0.0000	0.0000	0.0000	0.0542	1.0000	- 0.3937
Wind force	0.0000	- 0.0000	- 0.0000	- 0.1259	- 0.3937	1.0000

Acceptance of the five variables: *sum_of_waterplanes*, *sum_of_draughts*, *night, visibility, and wind force* allows to create the following testing hypotheses :

$$\mathbf{H_0^1} : b_{sum\_of\_waterplanes} = 0$$
and alternative hypothesis
$$\mathbf{H_1^1} : b_{sum\_of\_waterplanes} \neq 0$$

$$\mathbf{H_0^2} : b_{sum\_of\_draughts} = 0$$
and alternative hypothesis
$$\mathbf{H_1^2} : b_{sum\_of\_draughts} \neq 0$$

$$\mathbf{H_0^3} : b_{night} = 0$$
and alternative hypothesis
$$\mathbf{H_1^3} : b_{night} \neq 0$$

$$\mathbf{H_0^4} : b_{visibility} = 0$$
and alternative hypothesis
$$\mathbf{H_1^4} : b_{visibility} \neq 0$$

$$\mathbf{H_0^5} : b_{wind\,force} = 0$$
and alternative hypothesis
$$\mathbf{H_1^5} : b_{wind\,force} \neq 0$$

In Tab. 2 are shown the results of the tests of significance of the predictors for the section no. 4 and 6 of the waterway. The results of the tests for the other sections are similar.

Tab. 2. *Results of tests of significance of predictors for the section no. 4 and 6 .*

Section no. 4			
PREDICTOR	**b**	**$t_{(204)}$**	**p**
Sum_of_waterplanes	0.000223	2.20254	**0.028747**
Sum_of_draughts	0.346985	3.45112	**0.000678**
Night	0.096538	0.35815	0.720601
Visibility	- 0.113797	- 3.06849	**0.002444**
Wind force	0.008238	0.40967	0.682481
Section no. 6			
PREDICTOR	**b**	**$t_{(204)}$**	**p**
Sum_of_waterplanes	0.000266	3.08243	**0.002337**
Sum_of_draughts	0.416491	4.85477	**0.000002**
Night	0.001524	0.00662	0.994721
Visibility	- 0.066313	- 2.09560	**0.037351**
Wind force	0.021087	1.22893	0.220513

The presented results confirm that the three predictors: *sum_of_waterplanes*, *sum_of_draughts* and *visibility* are significant. $\mathbf{H_0}$ hypotheses for the other variables cannot be rejected. This may lead to the conclusion that *wind force* (because of a short time of manoeuvre) and *the time of day* does not affect pilots' assessment.

An obvious way to assess the regression equation is to assess how well a set of independent variables correlates with the dependent variable. Measures of fitting are the variance and standard deviation of the rests, and the coefficient of determination. Measures of accuracy are standard deviations of the coefficients.

The coefficient of determination $\mathbf{r^2}$ is the percentage of total variance explained by the model. It is an indicator of the model fit [1] :

$$r^2 = \frac{SSE}{SST} \tag{3}$$

where :

SSE – sum of squares of errors
SST – total sum of squares .

This coefficient can be also adjusted with the number of degrees of freedom; it has the following form :

$$r^2_{(adj)} = 1 - \frac{n-1}{n-k-1}(1-r^2) \tag{4}$$

where :

n – number of observations
k – number of predictors .

Another measure of model fitting is the root mean square error (or mean standard error) :

$$s = \sqrt{MSE} \tag{5}$$

where :

MSE – the mean square error.

$$MSE = \frac{SSE}{n-(k+1)} = \frac{\sum_{j=1}^{n}(y_j - \hat{y}_j)}{n-(k+1)} \tag{6}$$

where :

y_j – actual value of dependent variable
$\hat{y}_j$ – predicted value of dependent variable .

Tab. 3. Coefficient of determination, adjusted coefficient of determination, F-statistic and mean standard error, for the equation of three variables : sum_of_waterplanes, sum_of_draughts and visibility .

Number of section	r^2	$r^2_{(adj)}$	$F_{(3.206)}$	p	s
1	0.34344	0.33387	35.91831	< 0.00001	1.81659
2	0.25954	0.24876	24.06834	< 0.00001	1.64267
3	0.22717	0.21591	20.18418	< 0.00001	1.89743
4	0.23437	0.22322	21.02033	< 0.00001	1.90984
5	0.29764	0.28741	29.09912	< 0.00001	1.84703
6	0.34136	0.33177	35.58822	< 0.00001	1.63436
7	0.32367	0.31382	32.86169	< 0.00001	1.69795
8	0.31178	0.30176	31.10757	< 0.00001	1.63894
9	0.32447	0.31463	32.98172	< 0.00001	1.56115
10	0.31313	0.30312	31.30318	< 0.00001	1.60150
11	0.40054	0.39181	45.88091	< 0.00001	1.51395

Tab.3 shows values of the coefficient of determination, the adjusted coefficient of determination and the mean standard error for the equation of three variables : *sum_of_waterplanes, sum_of_draughts and visibility*. It also shows an F-statistic analysis of variance, which confirms the relation between the dependent variable and any of independent variables. The equation is based on 210 examples assessed by different pilots.

The obtained values of the coefficient of determination show that only a small percentage of total variance can be explained by the model. Nevertheless, obtaining the best-fitting prediction was not the purpose of this part of research; it was the confirmation if the predictors affect the dependent variable. Due to such factors like the inaccuracy of measurement (expert's assessment based on specific professional experience), existence of neglected parameters of the phenomenon in question (i.e. water current, ship's speed) or the lack of a proper expert's knowledge, the used model is not able to account for everything, thus errors are unavoidable.

The equation fits the data better when the set of three variables the significance of which was confirmed by tests, is included in the equation and mean values of all pilots' assessments are taken into account. Tab.4 shows values of the coefficient of determination, the adjusted coefficient of determination, the F-statistic analysis of variance and the mean standard error for the equation with the three variables. The equation is based on nine examples, each assessed by all 32 pilots. The mean values of assessments are taken into account.

Tab. 4. Coefficient of determination, adjusted coefficient of determination, F-statistic, and mean standard error, for the equation with three variables : sum_of_waterplanes, sum_of_draughts and visibility. Mean values of all pilots' assessments are taken into account .

Number of section	r^2	$r^2_{(adj)}$	$F_{(3,5)}$	p	s
1	0.92816	0.88506	21.53373	0.00274	0.52673
2	0.96134	0.93814	41.44007	0.00059	0.28332
3	0.94253	0.90804	27.33268	0.00158	0.43437
4	0.91715	0.86744	18.45003	0.00390	0.46360
5	0.88738	0.81981	13.13251	0.00831	0.61021
6	0.95045	0.92072	31.96948	0.00109	0.48449
7	0.92279	0.87646	19.91910	0.00328	0.54660
8	0.92991	0.88785	22.11112	0.00258	0.53383
9	0.93428	0.89485	23.69487	0.00220	0.48674
10	0.92943	0.88709	21.95142	0.00263	0.52384
11	0.92411	0.87858	20.29546	0.00314	0.57119

Tab.5 shows the constant and coefficients **b** attributed to the variables: *sum_of_waterplanes, sum_of_draughts* and *visibility* for all eleven sections of the Świnoujście-Szczecin fairway. Fig.2 shows the coefficients **b** attributed to the same three variables for all eleven sections of the Świnoujście-Szczecin fairway.

*Tab. 5. The coefficients **b** attributed to the variables: sum_of_waterplanes (b_1), sum_of_draughts (b_2) and visibility (b_3) for all eleven sections of the Świnoujście-Szczecin fairway (b_0 - constant). Mean values of all pilots' assessments are taken into account .*

Number of section	b_0	b_1	b_2	b_3
1	2.253766	0.000615	0.115413	- 0.169931
2	2.117815	0.000429	0.056652	- 0.157979
3	0.564922	0.000479	0.229381	- 0.139367
4	0.369852	0.000415	0.196733	- 0.128929
5	- 1.287264	0.000308	0.342393	- 0.154076
6	- 0.067514	0.000548	0.322482	- 0.152738
7	- 1.034664	0.000375	0.381633	- 0.142633
8	- 0.213562	0.000371	0.414399	- 0.137965
9	0.243243	0.000429	0.274761	- 0.168543
10	0.489656	0.000457	0.295718	- 0.157638
11	- 0.206354	0.000388	0.452058	- 0.099156

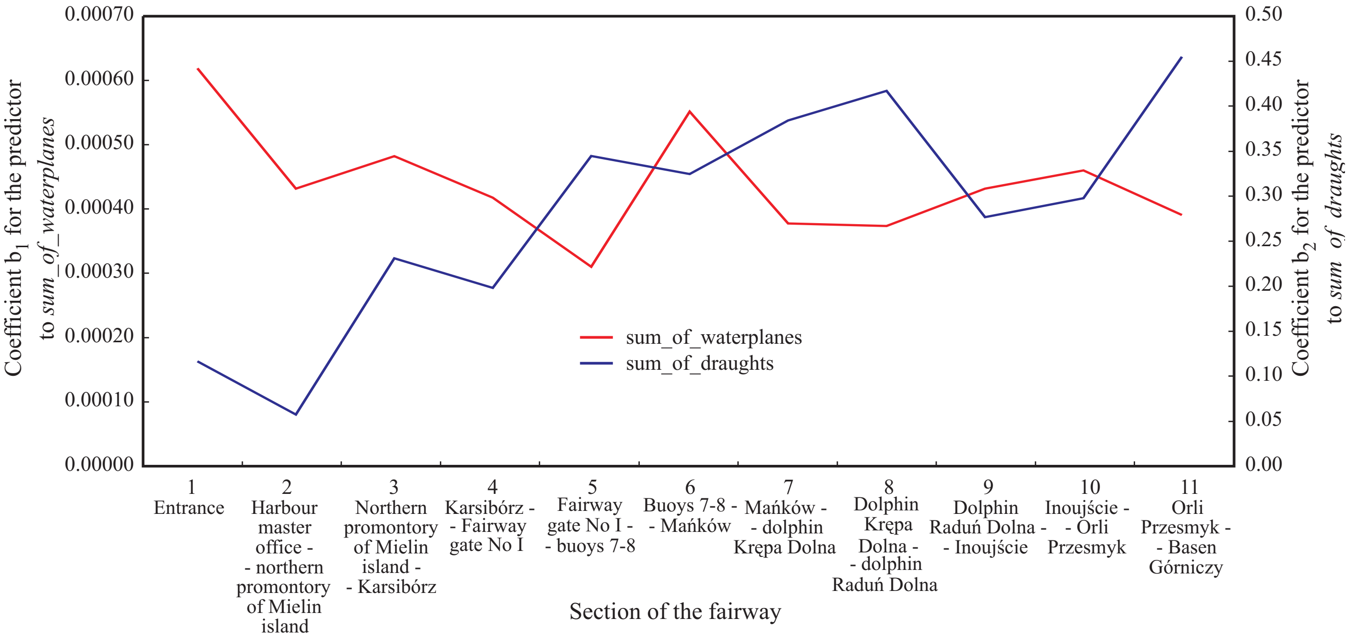


*Fig. 2. The coefficients **b** attributed to the variables : sum_of_waterplanes and sum_of_draughts .*

The values of coefficients for different sections are similar except for the sections no.2 and 5. In the section no.2 which includes the fairway of the port of Świnoujście with the depth of 14.3m, the value of the coefficient **b** attributed to the variable *sum_of_draughts* is distinctly lower, compared to those related to the other sections. In the section no.5 which leads through the Gulf of Szczecin, the value of the coefficient **b** attributed to the variable *sum_of_waterplanes* is distinctly lower than for the other sections, while the coefficient **b** attributed to the variable *sum_of_draughts* can be regarded as affecting the pilots' opinions.

Example :

with three predictors assumed, the equation for the section no.7 is as follows :

$$(assessment) = -1.03466 + 0.00037 \cdot (sum\_of\_waterplanes) + 0.38163 \cdot (sum\_of\_draughts) - 0.14263 \cdot (visibility)$$

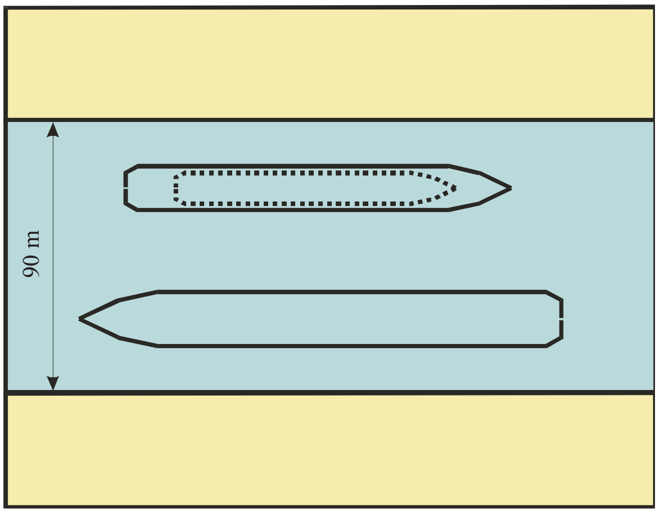


Fig. 3. *Passing manoeuvre .*

The manoeuvre of two ships passing each other and having the parameters : L_1=150 m, B_1=18 m, T_1=7 m; L_2=120 m, B_2=15 m and T_2=5 m, respectively (shown in Fig. 3 with solid line), in the visibility of 10 Nm, was assessed by the pilots at the value of 3.81 in 10 - degree scale. The same manoeuvre in the visibility reduced to 0.5 Nm was assessed at the value of 5.16. Also, can be compared two manoeuvres given with the same mark in two different visibility conditions, i.e. the good visibility (10 Nm) and that reduced to 0.5 Nm. The assessment value of 3.81 calculated for the above described manoeuvre can be assigned to the manoeuvre in the reduced visibility only when the dimensions of ships are adequately smaller. With the draught unchanged, the length and beam of one of the vessels should be equal to L_2= 88 m and B_2 = 10 m (shown in Fig.3 with the dotted line).

CONCLUSIONS

- Assessing a given situation, when manoeuvring in restricted areas, the pilot must take into consideration a great number of factors. The creation of a decision support systems based on experts' knowledge and experience, seems to be a useful and helpful solution. Such systems can solve complex problems of a very specific nature with results comparable to those provided by an expert, for example a pilot.
- When a traffic regulation is established in a specific area, decisions related to planning the passage of vessels are not made by the pilot but by a person who has no such professional shiphandling experience. His or her decisions are based on harbour regulations or internal procedures which must be a simplification of pilots' experience.
- The knowledge acquisition process is laborious and long-lasting, so the creation of decision support system is reasonable only when it has to be used by a great number of users and for a long time.
- There are opinions that the main task of an expert is to tackle identification of a hazard or risk. Anybody with great professional experience can easily point out situations connected with hazard or risk. The results presented in the paper show that an expert opinion can be also used for risk classification.
- Finally, all activities undertaken by all the persons engaged in safety matters in restricted waters can be treated as the activities undertaken within one system which needs interdependent decision - making and operations. The system in which decisions made by persons in charge of the vessel and a shore-based VTS centre interact each other, really exists. The interaction must be taken into consideration by all parties because decisions made by one party affect the other parties in an intended or unintended manner.

NOMENCLATURE

b – equation coefficient
B – vessel's breadth
F – F-statistic
L – vessel's length
p – significance level
r^2 – coefficient of determination
$r^2_{(adj)}$ – adjusted coefficient of determination
s – mean standard error
t – t-statistic
T – vessel's draught
VTS – Vessels Traffic Service
Y – dependent variable
X – independent variable.

BIBLIOGRAPHY

1. Aczel A. D.: *Statistics in management* (in Polish), Scientific Publishers (Wydawnictwo Naukowe) PWN. Warszawa, 2000
2. Ayyub B. M.: *Elicitation of Expert Opinion for Uncertainty and Risk*, CRC Press LLC. Boca Raton, 2001
3. Boisson P.: *Safety at sea – Policies, Regulations & International Law*, Bureau Veritas. Paris, 1999
4. Cieślak M.: *Predicting in economy. Methods and applications* (in Polish), Scientific Publishers (Wydawnictwo Naukowe) PWN. Warszawa, 2001
5. Filipowicz W.: *Problems of ship traffic management – PLA* (Population Learning Algorithms) *approach* (in Polish), Reports of Navigation Department, Gdynia Maritime University (Prace Wydziału Nawigacyjnego Akademii Morskiej) No. 13. Publishing House of Gdynia Maritime University. Gdynia, 2002
6. Klein M. R., Methlie L. B.: *Knowledge-based Decision Support Systems with Application in Business*. John Wiley & Sons Ltd. Chichester, 1995
7. Korbicz J., Kościelny J. M., Kowalczuk Z., Cholewa J.: *Process diagnostics. Models. Artificial intelligence methods. Applications* (in Polish). Scientific Technical Publishers (Wydawnictwo Naukowo-Techniczne). Warszawa, 2002
8. Luszniewicz A., Słaby T.: *Statistics. Theory and applications* (in Polish). 2nd ed., C.H. Beck Publishers. Warszawa, 2003
9. Mulawka J.: *Expert systems* (in Polish). Scientific Technical Publishers (Wydawnictwo Naukowo-Techniczne). Warszawa, 1996

10. Pietrzykowski Z., Narękiewicz M.: *Implementation of marine regulations in decision support system for vessel traffic services*. Maritime Engineering & Ports. WIT Press. Southampton, 2002
11. Wawruch R., Śniegocki H.: *System of ship traffic surveillance as a body for control and organization of ship traffic at sea* (in Polish). Reports of Navigation Department, Gdynia Maritime Academy (Prace Wydziału Nawigacyjnego Wyższej Szkoły Morskiej w Gdyni) No. 4. Publishing House of Gdynia Maritime Academy. Gdynia, 1997
12. Zieliński J. S.: *Intelligent systems in management. Theory and practice* (in Polish). Scientific Publishers (Wydawnictwo Naukowe) PWN. Warszawa, 2000
13. Ziembiński Z.: *Practical logics* (in Polish). Scientific Publishers (Wydawnictwo Naukowe) PWN. Warszawa, 1994
14. Polish Ministry of Infrastructure. Official Journal No 4, item 41. Warszawa, 2003 .

CONTACT WITH THE AUTHOR

Marek Narękiewicz, M.Sc.,Eng.
Department of Marine Traffic Engineering,
Institute of Marine Traffic Engineering,
Maritime University of Szczecin
Wały Chrobrego 1/2
70-500 Szczecin, POLAND
e-mail : marekn@am.szczecin.pl

Conference

SHA 2005

On 16-19 May 2005 at Puck, a Polish town on the coast of the Gulf of Gdańsk, was held 5th in Poland

European Acoustics Association (EAA) Symposium on Hydroacoustics.

It was organized by Polish Naval University, Gdynia. As usually, the main topics of the scientific meeting were the following :

- ★ Acoustics in fisheries
- ★ Acoustics in marine environment
- ★ Non-linear acoustics
- ★ Sound propagation in the sea – modelling
- ★ Radiated and ambient noise
- ★ Sonar systems
- ★ Signal and data processing
- ★ Transducers and instrumentation.

34 submitted papers were devoted to research results and theoretical considerations presented by scientific workers from 11 Polish scientific research centres including Gdańsk University of Technology (10 papers), and 8 foreign centres including 4 Russian ones (4 papers) and those of Austria, Canada, Turkey and United Kingdom (1 paper each). All the papers have been very carefully published (in Polish) as the Symposium's proceedings by Polish Acoustical Society, Gdańsk Division, in the Annual Journal „Hydroacoustics", vol.8, Gdynia 2005.

Conference

A sailing conference

The next successive
Domestic Scientific Conference on :

Scientific and technical problems of professional sailing

was organized by the Faculty of Motor Cars and Heavy Machinery, Faculty of Mechanics, Energy and Aeronautics of Warsaw University of Technology together with the Faculty of Mechanical Engineering of Gdynia Maritime University.

It was held on 2-9 April 2005 on board the sailing yacht *Pogoria* during its voyage on the route : Naples – – Castellamare – Civittaveccia – Livorno – Geneva, and its programme contained the presentation of 25 papers prepared both by scientific workers and students. The papers were divided into four topical groups :

❖ ***Calculation methods, measurements and materials***
10 papers including 3 prepared by students :

- ➢ *Measurement of hull form by using tachimetric methods* – by A. Klawikowska and B. Puchowski under supervision of J. Kozak, D.Sc. (Gdańsk University of Technology)
- ➢ *Numerical analysis of a keel-rudder system by using Fluent software* – by A. Sentkowska and J. Broniszewski (Warsaw University of Technology)
- ➢ *Analysis of influence of spreader inclination angle on magnitude of compressive force acting on the mast and stress distribution within the mast* – by M. Zagożdżon (Warsaw University of Technology) .

❖ ***Construction, building and general arrangement***
6 papers including 4 prepared by students :

- ➢ *A fast water craft driven by human muscles* – by W. Leśniewski and K. Niklas (Gdańsk University of Technology)
- ➢ *Design study of a small yacht* – by Z. Madej (Silesian University of Technology)
- ➢ *Tests of a prototype sailing yacht* – by D. Markuszewski and M. Wędołowski (Warsaw University of Technology)
- ➢ *Flybridge as an element of Sunreef 60' turistic catamaran* – by E. Perzyk (Warsaw University of Technology) .

❖ ***Safety and operation*** – 6 papers

❖ ***Mechanical drives*** – 3 papers

The greatest number of papers (8) was prepared by representatives of Warsaw University of Technology, 4 papers by authors from Mining- Metalurgical Academy, and 2 papers by authors from Gdynia Maritime University. Authors from Gdańsk University of Technology, Koszalin Technical University, Silesian University of Technology and Technical-Humanistic Academy of Bielsko-Biała presented one paper each.