Systematics in Fishing Navigation Efficiency Increasing

*E.M.Zhidkov** · *E.N.Malyavin**

〈Contents〉

Abstract

On this paper, the methods of optimization research of the fishing navigation using the graph theory are substantiated on the basis of the proposed probable model of the fishing vessel navigator's activity. The graph theory is concerned about the transition from the top graph to the rib one. And the definition of the additional system elements (quasi elements) necessary to provide the effectiveness during the fishing navigation are also substantiated herein.

This approach helps to optimize the structure of any fishing vessel monitoring system.

Introduction

The foremost world-scale level in the fishing navigation is characterized by developing and practicing of the highly-efficient fish-searching and electroradio navigational equipment and complexes, as well as creating of fully automated fishing vessels, wide using of reliable computing technical means, and highly professional education of navigators. The Russian navigation scientists attention is being paid to the decision of the independent certain tasks related to the fishing navigation, its optimization, automation, analyses and advancement of effectiveness. Like this, in the sphere of analysis and advancement of the navigation means and methods (ergonomic questions included) the works of Y.K.Baranov, A.V.Zherlakov, V.P.Kozhukhov, V.M.Lobastov, A.V.Yalovenko and others are known. As for the navigational automation, and promotion of accuracy, and reliability of navigational information processing the following scientists dedicated their works: A.I.Rodionov, A.E.Sazonov, Y.M.Filippov, A.M.Zhukhlin, V.T.Kondrashikhin, Z.S.Kuzin, M.I.Skvortsov. The elaborations of A.A.Andreev, L.P.Gostomyslov, V.E.Olkhovsky,

---

* Prof. of TheFar Eastern State Technical Fisheries University Vladivostok, Russia

V.A.Orlov, A.I.Karapuzov, I.R.Freidzon are directed to the solving of tasks in relation with a ship and fishing gear control automation, engineering and psychological aspects of the fishing industry specialists' business involvement are being researched by R.B.Brandt, V.V. Weikhman and others. Big contribution in the development of simulators and special imitating training device for a preparation of the navigational staff was done by V.V.Konovalov, K.N.Zuev, M.I.Kogon. M.I.Gavryuk, L.A.Zemnukhov, O.V.Nemtsev and others made the foundation to develop the automated system of navigator decision making based on the effective use of modern computing means.

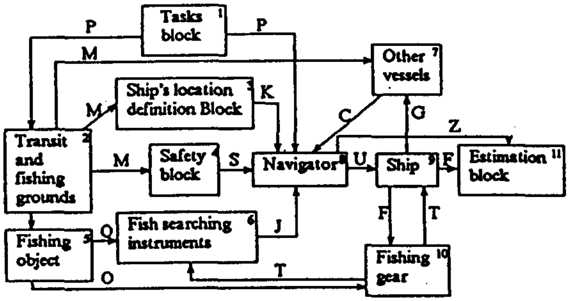
The analogical works are being done in other countries. But the absence of the common approach (from the position of system theory - acc.to our opinion) does not allow to formulate the navigational concept of forming the optimal structure of the fishing vessel monitoring system.

If to explore the fishing navigation system (FNS) based on the methods (V.I.Nechiporenko, 1977) we may come over to results which demand not only to upgrade the basic system, but to develop it by working-out and introducing new system elements.

Such research first of all requires the basic mathematic model of the system which can be obtained for different objects and systems only as result of natural observations or long-time scientific experiment. That's why we consider the introducing of the proposed method on the base of model worked out on results of ergonomic and statistic explorations.

Fishing Navigation System

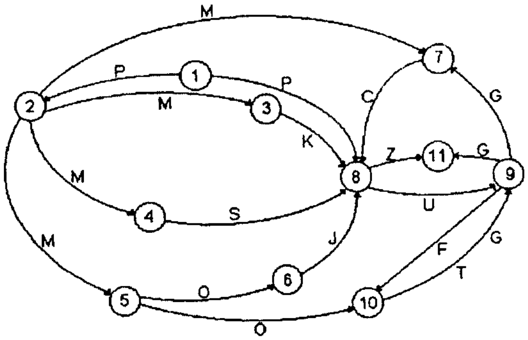
So, at present there is no mathematic model reflecting properly the special activity of fishing vessel's navigator. Because of this it's being proposed that on first stage it's necessary to form such model on a stochasic-systemal (probable) approach considering functional and probable interactions between all links of the model. The fishing navigation system for big-size stern trawling fishing vessels (big-size sea-going trawler, fish freezing trawler, super trawler, etc.) is taken for analysis. This system has being researched by the authors since 1966-1970. After summing up the data of big systems (A.A.Denisov, 1982, P.Johnson, 1971) with a consideration of the fishing navigation tasks hierarchy (V.E.Olkhovsky, 1979, 1980) and taking into account the expert navigational estimations of FNS as a whole, the probable FNS model has been worked-out. It looks like the block schematic given on drawing 1 (E.M.Zhidkov, E.N.Malyavin, 1989).



Drg.1 FNS complex structure

Influences in system: P - voyage tasks, M - area characteristics, K - current co-ordinates data, ship's course, S - current safety estimation, O - influence of fishing object and gear, J - fishing object information, C - information from other ships, Z - given criterion, U - governing influences, G - cargo amount (made product) information, F - influence of vessel on fishing gear, T - fishing gear influences.

Let's draw FNS structure for its optimal structure as a top graph (Drg.2) and follow the above given symbols: tops (digits) - system corresponding blocks; ribs or arches (letters) - influences.



Drg.2 Top graph of FNS

Demonstration of FNS as an orientated top graph is not enough because physical content of separate elements and logical conditions of their realisation are combined in the same elements-graph tops.

Transition from top graph to rib ones is giving an opportunity to attach all system elements physical features to the graph ribs and all logical conditions to concentrate in the tops.

To build the rib graph equivalent to the initial top graph shown on Drg.2 let's write the relation matrix for the latter, as follows:

$$\|l_{ij}\|_1^{11} = \begin{array}{c||ccccccccccc||} & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 \\ \hline 1 & & 1 & & & & & & 1^{*} & & & \\ 2 & & & 1 & 1 & 1 & & 1^{*} & & & & \\ 3 & & & & & & & & 1 & & & \\ 4 & & & & & & & & 1 & & & \\ 5 & & & & & & 1 & & & & 1 & \\ 6 & & & & & & & & 1 & & & \\ 7 & & & & & & & & 1 & & & \\ 8 & & & & & & & & & 1 & & 1 \\ 9 & & & & & & & 1 & & & 1^{*} & 1^{*} \\ 10 & & & & & & 1 & & & 1 & & \\ 11 & & & & & & & & & & & \end{array} \quad \cdot\cdot(1)$$

Based on matrix $\|l_{ij}\|$ (1) and using the quasiconical matrix theorem we build matrixes $\|S_{ij}\|$ and $\|C_{ij}\|$. Elements of matrix $\|S_{ij}\|$ are defined according to formula

$$S_{ij} = l_{ij}\left(\sum_{i=1}^{11} l_{ij} + \sum_{j=1}^{11} l_{ij}\right), \quad \cdots\cdots\cdots (2)$$

where $\sum_{i=1}^{11} l_{ij}$, $\sum_{j=1}^{11} l_{ij}$ are sums of units in lines and columns of matrix $\|l_{ij}\|$.

Computing according (2) we obtain matrix $\|S_{ij}\|$, as follows:

$$\|S_{ij}\|_1^{11} = \begin{array}{c||ccccccccccc||} & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 \\ \hline 1 & & 3 & & & & & & 7 & & & \\ 2 & & & 5 & 5 & 5 & & 6 & & & & \\ 3 & & & & & & & & 6 & & & \\ 4 & & & & & & & & 6 & & & \\ 5 & & & & & & 4 & & & & 4 & \\ 6 & & & & & & & & 6 & & & \\ 7 & & & & & & & & 6 & & & \\ 8 & & & & & & & & & 4 & & 4 \\ 9 & & & & & & & 5 & & & 5 & 5 \\ 10 & & & & & & 4 & & & 4 & & \\ 11 & & & & & & & & & & & \end{array} \quad \cdot\cdot(3)$$

Elements of matrix $\|C_{ij}\|$ are being computed based on formula

$$C_{ij} = l_{ij}(\triangle_{j/i}S_{ij} + \triangle_{i/j}S_{ij}), \quad \cdots\cdots\cdots (4)$$

where $\triangle_{j/i}S_{ij} = (S_{ij} - \min S_{ij})_i$ is sum's excess of data-in and data-out half-extents for element $l_{ij} = 1$ in i-line in comparison with element having minimal value $S_{ij} \neq 0$ in this line;

$\min S_{ij}$ is minimal data-in and data-out half-extents sum value for elements $l_{ij} = 1$ in i-line; $\triangle_{i/j}S_{ij} = (S_{ij} - \min S_{ij})_j$ is sum's exceed of data-in and data-out half-extents for element $l_{ij} = 1$ in j-column in comparison with element having minimal value $S_{ij} \neq 0$ in this column;

$\min S_{ij}$ is minimal value of data-in and data-out half-extents sum for elements $l_{ij} = 1$.

Let's define elements of matrix $\|C_{ij}\|$:

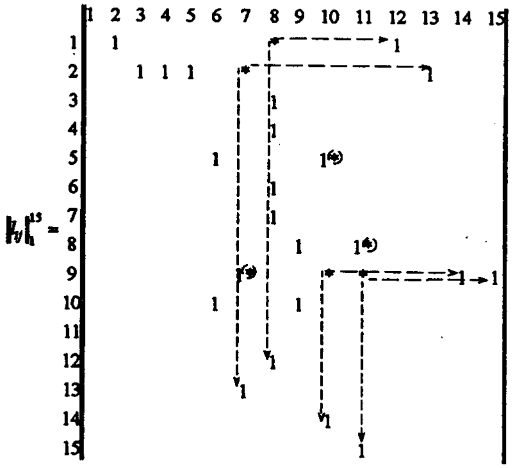
$$C_{12} = l_{12}(\triangle_{2/1}S_{12} + \triangle_{1/2}S_{12}) =$$
$$= l_{12}[(S_{12} - \min S_{12})_1 + (S_{12} - \min S_{12})_2]$$
$$= 1[(3-3)+(3-3)] = 0;$$
$$C_{18} = l_{18}(\triangle_{8/1}S_{18} + \triangle_{1/8}S_{18}) =$$
$$= l_{18}[(S_{18} - \min S_{18})_1 + (S_{18} - \min S_{18})_8]$$
$$= 1[(7-3)+(7-6)] = 5;$$
$$C_{23} = l_{23}(\triangle_{3/2}S_{23} + \triangle_{2/3}S_{23}) =$$
$$= l_{23}[(S_{23} - \min S_{23})_2 + (S_{23} - \min S_{23})_3]$$
$$= 1[(5-5)+(5-5)] = 0\ldots$$

If to continue calculations we shall define the rest elements C_{ij} of matrix $\|C_{ij}\|$, or finally:

$$\|C_{ij}\|_1^{11} = \begin{array}{c|ccccccccccc|}
 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 \\ \hline
1 & & 0 & & & & & & 5 & & & \\
2 & & & 0 & 0 & 0 & & 2 & & & & \\
3 & & & & & & & & 0 & & & \\
4 & & & & & & & & 0 & & & \\
5 & & & & & & 0 & & & & 0 & \\
6 & & & & & & & & 0 & & & \\
7 & & & & & & & & 0 & & & \\
8 & & & & & & & & & 0 & & 0 \\
9 & & & & & & & 0 & & & 1 & 1 \\
10 & & & & & & 0 & & & 0 & & \\
11 & & & & & & & & & & &
\end{array} \quad \cdots(5)$$

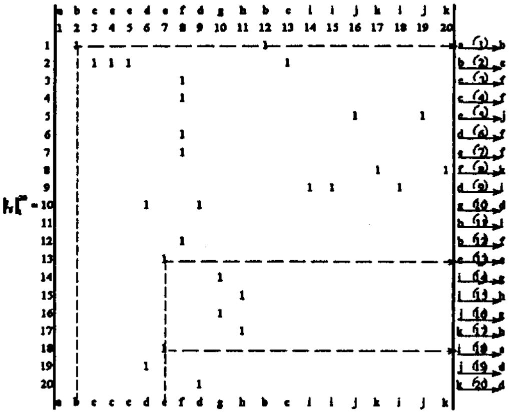
We mark with asterisks those elements in matrix $\|l_{ij}\|$ (1) for which elements C_{ij} in matrix (5) don't equal to 0. These elements are $l_{18}; l_{27}; l_{910}; l_{911}$.

Let's extend matrix (1) adding to it four lines and columns and each of marked elements we change by couple of new ones. We shall obtain matrix $\|l_{ij}\|_1^{15}$, (6) on which principle of matrix $\|l_{ij}\|_1^{11}$ (1) extension is shown. For example, element l_{18} (asterisk $\|l_{ij}\|_1^{15}$, shown in its place) is being changed by two elements: l_{112} and l_{812}. In analogy with above extension of matrix $\|l_{ij}\|$ is done with lines and columns 13, 14, 15.

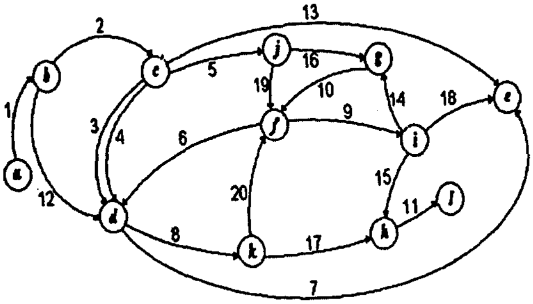

... (6)

Based on matrix (6) and using (2) and (4) let's build matrixes $\|S_{ij}\|_1^{15}$ and $\|C_{ij}\|_1^{15}$. The latter again indicates necessity of matrix (6), (see mark*) extension.

If to repeat same procedure for matrix $\|l_{ij}\|_1^{18}$, we shall define the final relation matrix $\|l_{ij}\|_1^{20}$ (7).


... (7)

Method of rib graph tops numeration is shown in (7) according to given one (O.Ore, 1968, V.I.Nechiporenko, 1977), thus it's clear that FNS equivalent rib graph is like one shown on Drg.3.



Drg.3 FNS equivalent rib graph

Additional symbols for Drg.1: 12 - regulating factors analyses device, 13 - fishery strategy choosing block, 14 - fishery strategy implementing block, 15 - navigation and ship monitoring block, 16 - fishery object recognition block, 17 - monitoring criterion working-out block, 18 - ship monitoring block at fishing time, 19 - interinfluencing factors analysis block, 20 - optimization block; a - start of system activation; b=P, c=M, d=T, e=G., f=(P,D,S,J,C) - information for ship's navigator, g=j=0, h=(Z,U) - influences of navigator, i - information on target function, k - monitoring decisions of navigator, 1 - end of activity.

So, in comparison with 11 initial FNS elements the additional ones (quasielements) have appeared in the system structure, they are shown as new fictional ribs on Drg.3. Not parametres shown on Drg.1 but new logic connections meaning functions obtained from initial parametres have become the tops, i.e. links between FNS elements or functional interconnections.

Results

New elements and links obtained as a result of FNS structural analysis are shown below in table 1.

Grouping of influences and new elements of obtained FNS by probabilities of their decision,

Contents of Quasielements and New Links in FNS Structure

Quasielements, new links (prescription and name)	Symbols (Drg.3)	Tasks being solved	Ways of effectiveness increasing	
			main	secondary
1	2	3	4	5
1. Regulating factors analysis device	12	Computing ones	Automated system of decision (ASDM)	Automation of navigation, Training
2. Fishery strategy choosing block	13	Computing ones	ASDM	Training
3. Realization block	14	Technical and computing ones (technical and economical and computing means of decision making)	ASDM	Automation ship's control at fishing. Training
4. Navigational and ship monitoring block	15	Technical ones	Automation of navigation	ASDM.Automation of ship's control when fishing.Training.
5. Recognition block	16	Technical and computing ones	Automation of ship's control when fishing	Training
6. Block of monitoring criteria choosing	17	Computing ones	ASDM	Automation of ship's control when fishing
7. Ship's control block when fishing	18	Technical and computing ones	Automation of ship's control when fishing	Training
8. Fishing object and gear interinfluences estimation block	19	Technical and computing ones	Automation of ship's control when fishing	Training
9. Monitoring optimization block	20	Technical and computing ones	ASDM	Automation of ship's navigation when fishing
10. System activation start	a	Start of system	Technical ones	

1	2	3	4	5
11. Information for navigator on nav.tasks	f	Computing (indication of current voyage tasks, coordinates and ship's safety, fishing object)	ASDM	Training
12. Fishing object influence on fishing gear and fish-search instruments	g	Technical ones	Training	ASDM
13. Navigator's monitoring influences	h	Technical ones	Training	ASDM
14. Information for navigator on purpose function (fishing) parametres	i	Computing ones	ASDM	Training
15. Certain fishing object influences on fishing gear and fish-search instruments	j	Computing ones	ASDM	Automation of ship's control when fishing. Training
16. Monitoring decisions (navigator's actions)	k	Technical ones	Computing and technical ones	ASDM
17. End of system action	l	Technical ones	ASDM	Training

creation and application comes to the conclusions of the whole system functioning quality increasing:

- creation and application of navigator decision on board vessels where automated systems are existed;
- automation of navigation and ship's control when fishing;
- special training.

Analysis of graphs 3, 4, 5 of table 1 also comes to one more essential conclusion: about 80% of new elements and links in FNS are being solved and can be solved with the use of modern means of computing technique, this clears the necessity of fishing navigation computerisation.

Conclusion

The given approach allows to optimize the structure of any fishing ship's control, which is different from the one on Drg.1. Besides, as shown by authors (Zhidkov, Malyavin, 1992, 1996) in a similar manner one can obtain the structural optimization of educational plans for the specialists being prepared and solve other tasks how to increase the system efficiency when the correct choice of initial model is done.

Biblography

1. A.A.Denisov, L.N.Kolesnikov. Theory of big systems monitoring, L. Energoizdat, 1982, 288 p.
2. R.Johnson, F.Cast, D.Rosentsweig. Systems and management, M. Soviet Radio, 1971, 648 p.
3. V.I.Nechiporenko. Structural analysis of systems. M. Soviet Radio, 1977, 212 p.
4. V.E.Olkhovski and others. Mathematical security of automation for trawl and seine fishery. M. Pischevaya Promyshlennostj, 1980, 168 p.
5. V.E. Olkhovski. Fishing navigation. M. Pischevaya Promyshlennostj, 1979, 544 p.
6. O.Ore. Graph theory. M.Nauka, 1968, 124 p.
7. A.I.Rodionov, A.E.Sazonov. Automation of navigation. M. Transport, 1992, 392 p.
8. E.M.Zhidkov, E.N.Malyavin. The systemal

approach to the increasing of fishing navigation. 7-th Conference on Socialist countries fishing fleet and fishing industry development. Report No 50.L, 1989, 18 p.

9. E.M.Zhidkov, E.N.Malyavin. The Structural analysis of the fishing industry navigator model. Regional Higher Ed.Institues Conference, Report thesis. Vladivostok, 1992, p.49-50.
10. E.M.Zhidkov. The system analysis of fishing vessel control's automation. Scientific works of Dalrybvtuz, edition 7, Vladivostok, 1996, p.24-36.