# MODELING THE INFLUENCE OF NAVIGATORS' WAITING ON PROCESSES MARITIME TRANSPORT OF OPERATION

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**Introduction.** There is the hypothesis that due to the psychological characteristics of the individual at each interval (stage) of the trajectory of his activity one factor-direction is considered to act as a dominan one, being dominant. Moreover, each fragmented trajectory of human activity has three dominants in each direction factor, thereby, forming a triangular structure having non-trivial individual-personality properties. They turn out to have scientific and practical significance for the development of the methodology of social expectations of the individual [1-4].

For the sake of confirming this hypothesis a simulation of the trajectory of a person’s behavior in critical situations is supposed to be performed. One peculiarity is to be made is that independent decision making is required to be based on the three-factor model of ERO-AEA-EAPI.

**Research models and methods.** Suppose, as a modeling environment critical infrastructure (for example, maritime transport) would be chosen to be spoken about and as an operator, a watch assistant of the captain [4-7]. Besides, imagine, the environment where the vessel will be operating and maneuvering is said to be one of the most complicated ones (coming up to the pier and mooring operation). To completely satisfy and meet the requirements such options as experience and professional skills of senior assistant of a captain or other higher positions must be taken into consideration [8-10].

When constructing the Cayley graph the three axes *a*, *b*, *c* would be proposed to be used basing on the reasons that when mooring combinations of control actions rests on three main types of maneuvers:

*a* - maneuvering with a change in the operating mode of the main engine;

*b* - shift pen rudder;

*c* - change of the operating mode of the thruster.

As a rule, taking into account huge number of external and internal factors influencing on, the captain gets used to being guided by combinations of basic maneuvers monitoring the situation in real time mode. Gained experience and mind-motor skills are able to be highly likely the most influential factors on choosing the particular strategy. These items which brings an additional effect that polar influences the final result of the maneuver.

Thus, to identify the path of the skipper's actions a metric space is proposed to be constructed. It would definitely take into account the entire spectrum of options for the those actions in the context of a three-factor model in the form of a Cayley graph basing on the geometric theory of groups.

It must be underlined that this graph, according to the axiomatics of the formal approach, is noticed to be starting from the base point e and to be spreading in three axes [11]. The metric of the graph does not change with its spreading’s, however, for the image to be observed compactly, each level of construction is scaled a multiple $\frac{2}{3}$. So, the Cayley graph obtained in this way could be depicted as following (Fig. 1):

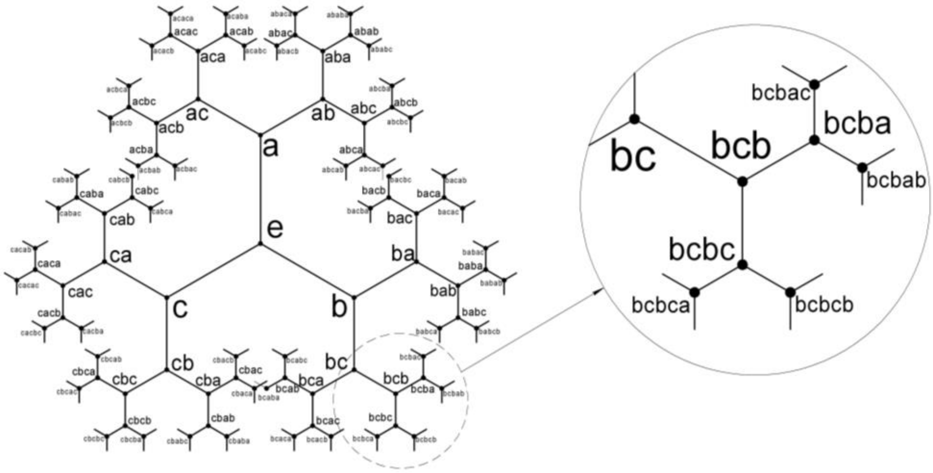


Figure 1. Cayley's graph of the actions of the skipper in the three-factor model

As it can easily be seen from Fig. 1, the Cayley graph is not observed changing structurally. To some extent at any point the principle of the geometric distribution of edges can be functioning in the same way . This tendency confirms the appropriateness of geometric group theory sampling techniques for further development of this study. In order to analyze this approach, an experiment was carried out using the Transas navigation simulator NTPRO 5000 at the Kherson State Maritime Academy (Ukraine) (Fig. 2). Before starting of the experiment students, navigators-to be, had been pre-screened for upcoming behavior pattern with the following analysis of the actions letting us get identified all preferences regarding directional factors during the mooring operation [12-15].

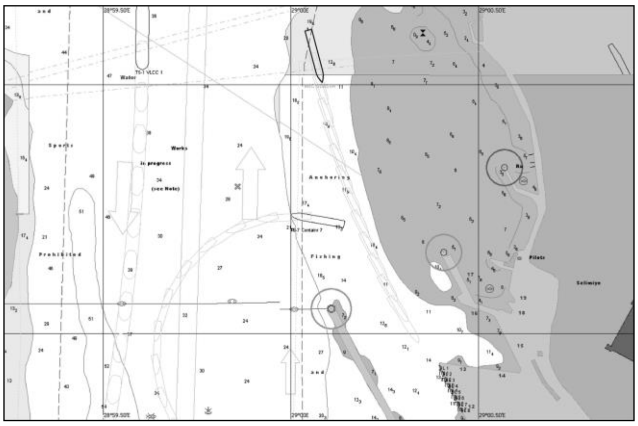

Figure 2. A fragment of the operation on the NTPRO 5000 simulator

In order to improve the experiment quality and leveling random factors a mooring operation is reported to have been performed in three stages. In each of the stages an extremum was determined by three directional factors towards particular captain. Consequently, three trajectories were obtained mapped onto fragments of the Cayley graph (Fig. 3).

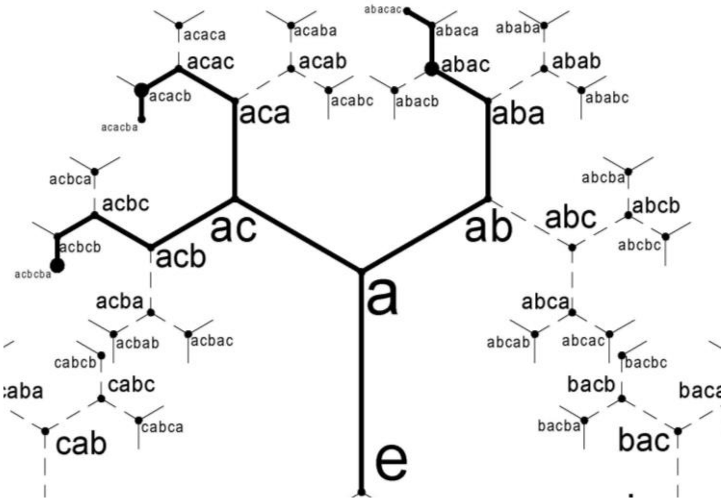


Figure 3. The set of trajectories on the Cayley graph

Figure 3 shows that all three trajectories begin with a factor-direction $a \in A$ indicating the fact of navigator's having already been formed by the carrying out moment stages action plan. To a certain point, this is real truth due to the fact that the skipper is experienced and has well-established behavior algorithms in cases typical to this situation. Having highlighted and connected the extremum points (*acbcba*, *acacb*, *abac*) we get a geometric figure forming a triangle. Attention must be paid to the evidence of functioning each extremum point as a determiner of the length of the trajectories of different sizes (usually from 4 to 6 stages).

**Research results.** The resulting structure is defined by the central a-ac geodesic segment limiting the outgoing trajectories within a constant $c_a$, such (1):

$$f\left(x_g\right)\exists c_a : \forall a \in A, \exists p \in F\left(X_g\right) : d_a\left(a, p\right) \le c_a \quad (1)$$

Thusly, this structure is not said to be anything more than $c_a$ - bounded quasi-isometric mapping of the image describing the metric of social expectations of the skipper in a set of typical situations. The introduced constants are not noticed to distort the essence and linear dependence of the three-factor model of the ERO-AEA-EAPI. This data deliver us the possibility of getting generalization the observed properties of the formation of behavior trajectories. The obtained for each trajectory data is fragmented and displayed in Table 1. and according to it, the main extremes turn out to be analyzed and, as a result, it is individual resurfacing of the navigator's social expectations is highly likely to happen.

*Table 1.*

**The data of the trajectories of the geometric structure**

| № | Trajectory | Trajectory stages | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | *acbcba* | $a_1$ | $ac_1$ | *acb* | *acbc* | *acbcb* | *acbcba* |
| 2 | *acacba* | $a_2$ | $ac_2$ | *aca* | *acac* | *acacb* | *acacb* |
| 3 | *abacac* | $a_3$ | *ab* | *aba* | *abac* | *abaca* | *abacac* |

Further observation of the specifics of the manifestations of factor directions makes us notice our moving away from the straightness of the Cayley graph due to the scatter of the values determined by its points.

The image of the graph itself can *b* regarded as an image on a curved surface formed by a matrix of values when forming the trajectories of the real actions of the skipper. To a certain point, the formed surface is said to be an individual imprint of his social expectations in the situation under consideration (2) [16-18]:

$$(M,d):\forall x_g, y_g, z_g \in M,\ \exists \gamma:[0,r] \to M \qquad (2)$$

The curvature determination of this surface contributes to providing the representation of the impact degree of dominant factors on the situation and to displaying of individual habitual preferences being performed in a typical situation. As a result, possible future behavior pattern of the skipper is highly likely to be predicted. However, taking into account the complexity of this process, an indirect feature is proposed to be used due to the fact of getting real reflection of the deviation from the average indicators of the points. This indirect issue is noticed to be based on the ratio of the area formed by three points of the flat and the actual obtained surface.

The comparative analysis of the area of the flat $S_1$ = 4210.04 mm$^2$ and the surface area $S_2$ = 9531.18 mm$^2$ is equal to 2.263. Thus, a surge of factors regarding the situation turns out to have double time exceeding average experience which is considered to be treated as true indicator of skipper's mental state.

Therefore, the goal points of social expectations are able to be determined for all three factors-directions of the model of the ERO-AEA-EAPI.

So, the formed space is $\delta$ hyperbolic [19] because (3):

$$\forall x_g y_g z_g \in M, \forall [x_g, y_g], [y_g, z_g], [x_g, z_g] \to M\delta \qquad (3)$$

Being proved by the fact that all the geodesic segments in our case are located in the same neighborhood surroundings common trajectory fragments are vividly seen. This issue is confirmed by transition properties (4):

$$\exists \delta : \forall geodesic\square \to \delta narrov \Rightarrow \exists \delta : geodesic\square \to diam\{center\ points - a,b,c\} \le \delta \qquad (4)$$

It can be observed from formulas (3) - (5) that the this way formed geometric structures have a central space being limited by points ($c_{x_g}, c_{y_g}, c_{z_g}$), so called $\delta$ neighborhood. In our case it will have a diameter equal to the edge *a-ac* being completely appropriate for the *c* - limitation condition mentioned above (Fig. 4).

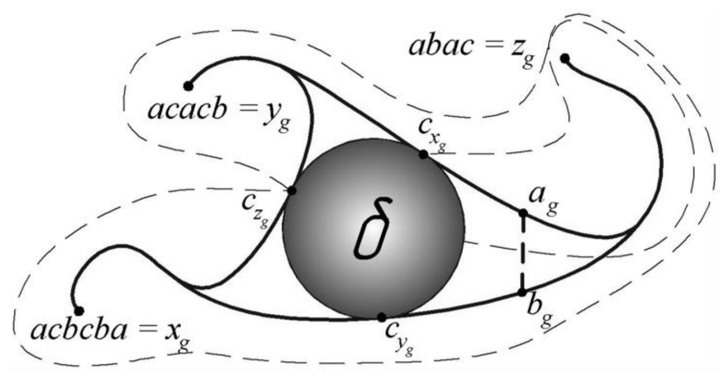


Figure 4. Is $\delta$ -neighborhood surrounding on the geodetic triangle ERO-AEA-EAPI

Depicted in Fig. 4. a geodesic triangle is quasimetrically embedded being a fragment of the Cayley graph into a hyperbolic space as its $\delta$-fineness $\left[x_g, y_g\right] \cup \left[x_g, z_g\right] \cup \left[y_g, z_g\right]$ in the metric space $(M, d)$. This situation can easily be determined by the following condition: for the vertex z and for any two points $a_g$ and $b_g$ on its sides $\left[z_g, y_g\right]$ and $\left[z_g, x_g\right]$ the next coming item is observed:

$$d\left(z_g, a_g\right) = d\left(z_g, b_g\right) \le \frac{1}{2}\left(d(z, y) + d(z, x) - d(y, z)\right) \Rightarrow d\left(a_g, b_g\right) \le \delta, \delta > 0$$

**Conclusion.** Consequently, that presented in the scope of this study three-factor model of ERO-AEA-EAPI on this Cayley graph group happens to be mentioned a hyperbolic one basing on the definitions of Gromov-Rips [19,20]. From the spoken above the conclusion can be made about existing $\delta$-neighborhood surroundings for a finite system of generators where the union of any two sides occur (Fig. 3). As it can be clearly seen, the curvature of the space ERO-AEA-EAPI seems to be situational one and depends on its generators. These studies will help to build automated models of ship control in situations where a negative human factor is manifested [21-24]. The result of this as follows: the problem of revealing the pattern of its formation as well as the complication of making classification of the navigator's mental states regarding to extreme points happen to surface.

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