

SPECIFIC CHARACTER OF SMS AND ITS IMPACT ON THE OPERATING MECHANISM OF THE SYSTEM

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Abstract: Safety Management System in Shipping in simplified variety can be presented as result of interaction between multimedia subsystem "ship's bridge" (technical element, contains multi technical devices of navigation) and social element – bridge team on watch. In social element the leading role playing duty officer, as far as he receive and manipulate whole incoming information on the ship and take decision to choice for optimal safety management and remain bridge team on watch is executer only of the management leading it to multi technical ship's devices.

Functioning mechanism of organizational and technical system can be consider as generalized information model of production process exist in duty officer's awareness, which is created independently and which is improved through acquisition of skills production. In case when the model of functioning mechanism is used as choice for whatever different class ship's operation management, then can conduct formalization and algorithmization of the choice function.

Requirement for management activity of the duty officer is fundamental for realizing of functioning mechanism in safety management system in shipping. If can be implemented information and power connection in structure it will arise real possibility for improving realization effectiveness of functioning mechanism and management effectiveness of safety management in shipping as well.

Keywords: SAFETY MANAGEMENT SYSTEM IN SHIPPING; FUNCTIONING MECHANISM

1. Introduction

Under the International Safety Management Code (ISM Code) Part A – Implementation, paragraph 1.1.4. *Safety management system* refers to a structured and documented system enabling company personnel to implement effectively its policy on safety and environmental protection. The term *Company* is defined in the same section in 1.1.2. the Code, such as: *Company* means: Shipowner or any other organization or person such as manager or operator who has assumed responsibility for operating a ship from the shipowner and who on assuming such responsibility has agreed to assume all duties and responsibilities imposed by the Code. The set of objects and relations between them, which is considered as a whole is defined as a *system*. A link can connect two or more objects. It can be information, material or energy. The set of relationships defined Structure:

- The systems have a *structure* defined by their parts and their structure;
- The systems have a behavior that includes input and output processing of materials, energy, information and data;
- The systems have interconnection: the different parts of the system are connected both functional and structural;
- The systems have detached functions or groups of functions;

Open system is one that can be influenced by external factors (factors beyond the limit set for the system). *Closed system* is one that can not be influenced by external factors. *Dynamic system* contains parts or connections or both, changing the system from open to closed and vice versa all the time.

2. Specific character of structure and its impact on the operating mechanisms

Organizational and technical Safety Management System in shipping in a simplified version can be presented as a result of interaction between multimedia sub - system "ship's bridge" (technical element, comprising a number of technical means of the navigation) and the social element, consisting of officer on watch (OOW) and subordinated watchkeeping team of the ship and is inherently a dynamic system. Further more, in the social element first playing role assumed by the officer on watch, as he accepts and processes all incoming information on the ship and takes decisions on the optimal management of safety of navigation and the watchkeeping team is the only performer of these controls, leading them to the many technical devices of the ship.

To study the characteristics of the Safety Management System can be made a model of organizational-technical system, asking for this purpose the following structure:

$$\eta = (Q, I, X, R, U, G) \quad (1.1)$$

In the given structure under the following names:

Q - set of elements of organizational - technical system, including technical means of navigation, the social element (officer on watch and watchkeeping team at his disposal) and the controlled element, the vessel;

I - system of organizational activities, rules and relationships to ensure safety of navigation;

X - a multitude of trajectories of the state of processes in the system;

R – the purpose of the Safety Management System;

U - law (Plan) of ship's management;

G - management resources needed to realize the set goals with the ship.

In the structure (1.1) triple multitudes of $\xi = (R, U, G)$ forms a mechanism for the functioning of organizational-technical system, which in case of current information on the status of all systems enables the OOW to select a current safety controls condition of the ship $u \in U$, realizing in the structure η put down aim of management R .

Of a formal viewpoint within the structures of $\xi = (R, U, G)$ mechanism of the system (1.1) can be written as

$$\Sigma : R \times U \times G \rightarrow \Phi = M_x \quad (1.2)$$

where M_x is the mechanism of functioning of the organizational and the technical system Safety Management in Shipping. If the mechanism of functioning of the organizational and technical system considered as a summarized information model of the production process contained in the OOW consciousness, self – created and improved by the acquisition of production skills, then this model will become serious problems in formalization. In simple cases where the model of operation mechanism (1.1) is used to select control of any single class of ship's operations, then may take place as formalization and algorithms function selection as well. The resulting formalization and algorithm selection mechanism in the form of software projected (the anticipation mechanism) can be introduced into the composition of mathematical expert systems, which make recommendations on Saafety Management in Shipping.

The expert systems in Safety Management in Shipping are typical in that they allow to given value $u \in U$ to make assessment of the status of safety in the manufacturing operation in perspective and aspirations of this safe state in the goal of management R .

The processes of interaction in the set of the elements of the organizational and technical system (1.1) are described as follows: technical element formed a production flow of events I of the current state of Safety Management in Shipping, a social element (OOW and the subordinate watchkeepin team) by handling received messages, transforms them into a stream of power control commands for safety management of the vessel as an object of type I_o . Furthermore, we'll assume that management u is chosen by OOW of a limited number of U and is sent to the object (the vessel) without inertia line connection. Such lines of connection are provided in the organization of watchkeeping, such as the International Convention STCW 74/95 for immediate implementation of these controls on Watchkeeping crew on the ship's technical equipment.

From the topological viewpoint this processes of interaction can be represented as a cycle of transformation of production data in power managing actions. So within a multipart above model description of the the organizational and the technical system, will introduce the following symbols and we'll consider that the flow of production and navigational messages I entered to the social element according to the dependence $F_m(\lambda, t)$.

Moreover, the social element by handling the resulting a multitude of messages, translates them into flow control through instant execution I_o of the law $P(\omega, t)$, where: ω is the average number of messages converted the safety management of shipping, over the span of time t . To determine the properties of *observability* and *controllability* of the organizational and the technical system, we'll introduce the concept of *order* realization in the process of converting messages from stream flow I in I_o and u command to immediately management of many U . In general, the probability of occurrence of the series $L(\lambda, \omega)$ depends of two parameters:

λ - an average number of messages in the stream I , entering to OOW from integrated information and expert systems.

ω - an average number of transformations of single message in immediately command $u \in U$ for safety management of shipping by the flow I_o .

Namely the proportion of the parameters for the appearance of series $L(\lambda, \omega)$ will determine the properties of observability and controllability at the organizational and technical system. If the proportion of the parameters λ and ω in the expression $L(\lambda, \omega)$ is such that it is effective:

$$L(\lambda, \omega) = 0 \quad (1.3)$$

then the loss of controllability and observability characteristics of the organizational-technical system theoretically is completely impossible.

For example, from Theory of the systems is known that the observed system is not always controlled, and each managed system is always monitored. Maintaining the state controllability and observability of the state respectively in the structure "watch" should be associated with the operation targeted variation of parameters λ and ω therefore achieve the conditions defined by the expression (1.3). Consider the possibility of realization of the conditions (1.3) in steady state operation of socio technical Structure "watch" and give an assessment of the behavior and transformation of production relations coming to the OOW from ship's multimedia sub system "command bridge" in power control actions. We'll introduce the admission for this purpose that to the

OOW enters not simple Poisson stream of the multimedia messaging system, whose intensity is inversely proportional to the number contained in its navigational messages. Further more, each message that enters to the OOW, is converted to an exponential law with parameter ω in purposeful action. Using the mathematical apparatus of queuing theory allows us to establish that the terms of the type (1.3) may be satisfied if the inequality is valid:

$$\lambda < \omega \quad (1.4)$$

That attitude, providing in the structure (1.1) observability and controllability properties, enables full-scale time to realize the sequence *identification - classification - management* and to the social element (the OOW and Watchkeeping team), with power impacts on object of management (the vessel), to support Safety Management System in shipping according to international standards.

No less important for system is a property *stability* which, in organizational and technical structures of the type (1.1) is related to characteristics of the nature of the *mechanism of choice* of OOW. Let the mechanism of choice to correspond to the behavior of OOW as defined in the structure, which is presented in series of seven sets and recorded as follows:

$$< S, t, X, f, \Omega, \Psi, \Gamma > \quad (1.5)$$

$\Gamma \subset \Omega$ - complete set of messages used by OOW to solve navigational tasks. If the intensity of the characters accompanying each alternative is measurable, then the result can be obtained points $f(s)$ of the set X . As a set of points $x = f(s)$ can enter the combination of all navigation risk's assessments and each evaluation in turn will corresponds to some status.

For set Ω in the structure (1.5) we'll consider a combination of sub sets of the abstract set Θ , whose elements ω will be called *messages*. When selecting individual alternative, providing the safety management of shipping a given level, each message ω is a "statement" which in itself or in combination (in range), with some other messages allows to compare the elements of X under pairs. With multiplated Ω sets of messages is determined in principle possibility for immediately receiving of these messages from the media system "command bridge" in the process of solving the task of selecting the required individual alternative.

Render in account of characteristics of the structure (1.5), from multitude management responses of the OOW, may be select such behavior, where its function of individual choice $\psi(\omega)$ in each $\omega \in \Omega$ will have properties R^* , called *quasi series*. In such case, if the message ω is a binary message in respect to X , then for it a top limited function ψ^* of individual choice will be stronger, bringing X to a quasi transitive closure of messages ω , that can be represented as:

$$\psi^*(\omega) = E \cup T_r[\omega] \leq R^* \quad (1.6)$$

$$\text{if } \omega \subseteq \Gamma \subset \Omega$$

The resulting expression (1.6) can be used as the basis for sustainable management-related behavior of the OOW, which takes him to manage the safety of navigation. The peculiarity of this behavior is that in the performance of his duties as a "control" element in the structure (1.5) in OOW is formed stereotype to select an alternative $\psi^*(\omega)$, which will be "stronger" (majority) for each sequence of the function of individual choice $\psi(\omega)$, subject to the condition $\omega \subseteq \Gamma \subset \Omega$. The resulting condition (1.5) and the requirement of management activity of OOW (1.6) are fundamental for the realization of the *mechanism of operation* (1.2) in organizational and technical system. Moreover, if in addition to

(1.5) and (1.6) is achieved optimization of information and power connections in the structure (1.1) will show a real opportunity to improve both the effectiveness of implementation of the mechanism of the operation, hence the effectiveness of safety management in navigation.

A distinctive feature of the structure (1.1) than that used in the research performance of organizational and technical system is the fact that its composition and enters series G, by which we can understand *management resources* necessary to achieve the goals set with the ship, ie the *safety management in shipping*. Therefore it will be necessary to examine the specifics of creating a mechanism (1.2) of the functioning of organizational-technical system. The management of organizational and technical systems in companies is done with the ultimate aim of preventing the occurrence of emergency situations on the basis of well-organized work teams. Prevention of emergency situations, however, with internal management of safe operation is impossible without an *appropriate and sufficient resources*. Availability of this resource is provided in Part A, section 6 of the ISM Code - *Resources and Personnel*, but virtually all national documents defining the operation of Safety Management System (SMS) of ships, not prejudice or passed over in silence the issue of management resource of the companies.

Let us define the SMS of the company by using the function of risk, which is expressed by a discrepancy between the actual company ship's condition and the international requirements, such as the type $R(Y, Z)$. The average indicator of the risk of non-conformity ships of the company with international norms in summary form we can write as:

$$J(Z) = M_Y \{R(Y, Z)\}$$

If the mean function of the risk of non - compliance is differentiable and has only one extremum, in *co-ordinated approach* to resource for SMS can always choose such matter $Z = Z_{01}$ which will provide the condition for optimal

$$J(Z_{01}) = \min J(Z) = J_0 \quad (1.7).$$

Under the subordination of the designated person appointed by the ship's owner significantly more common variant is another resource – non conformity, ie administratively apointed and landing from head of the company . Naturally, in this case the resource will be determined by elements of subjectivity, which allows it to be regarded as a random variable X governed by the law of distribution with density distribution $f_X(X)$. For definiteness we'll assume that the law belongs to a class of distribution, which is known with an accuracy of some magnitude, $f_X(X) = f(X, Z)$.

In general, management resources Z_{02} elected on the principle of non-conformity will be different from the management resources Z_{01} , resulting from the agreement between the designated person ashore (DPA) and the shipowner. Furthermore, the resource Z_{02} determined only optimal density of probability distribution, which has an optimal solution $X = X_0$ in non-conformity resource.

The optimal solution is characterized by a minor function of the average risk of non-conformity. The subjectivity of the shipowner, which can be modeled by randomness, affects the quality of resource management appointments. The assessment of this influence is a practical interest and it allows to determine what benefits and harms brings non-conformity between the shipowner and DPA in those cases where the risk function is differentiable and has only one extremum. Further we'll assume that non-conformity in the selection of resources does not affect the optimality of solutions. Minor value of average function of the risks in non-conformity choice of resource management can not be less than the minimum value of the average function of risk in a co-ordinated choice of this resource. From here derives the conclusion that involvement in the company SMS noncoordinated resource increases the average minimum value funtion of the risks and that

means deterioration of the overall quality of SMS of the company. Will clarify the impact of non-conformity in the appointment of resource management $Z = Z_0$. Clean administration by the shipowner for appointment of SMS resource can both reduce and increase the rudeness of the optimal solution Z_0 . The conditions ensuring the rudeness of the optimal solution for noncoordinated approach to determining Z_0 , are determined solely on the basis of detailed assumptions about the behavior of risk functions $J(X)$, or more precisely, on the third derivatives $J(X)$ and the density distribution $f(X, Z)$. These conditions, however, have not the same value as their a priori distribution, which no ships owner controled or DPA the company. If later make some hypothetical assumptions, we can make appropriate conclusions about management resources which have designated only by the owner and will gives us grounds to assert that noncnformity in the assignment of resource management is able to reduce the rudeness of the decision $Z = Z_0$ and hence reduce its optimal to zero. The analysis of the two possible scenarios for the appointment of management resource allows to infer the existing advantages of co-ordinated choice than non-conformited. So there is a need to further consideration of the conditions under which the company is able to achieve co-ordinated and optimal choice of management resources. For this purpose, let's separate in company SMS DPA and to unite with the owners .In this way we'll obtain series pairs of W type:

$$W = U \times V = \{(u, v) \mid u \in U, v \in V\}$$

where: U - ship owner; v – DPA

Elements in series W of pairs are connected, first, with the obvious relation "owner - DPA," we can write this:

$$u, v \in W, (u, v) \in \alpha_1 \Leftrightarrow v \prec u \quad (1.8)$$

That ratio (1.8) is a source that is capable to produce non-conformity selection of optimal resource management Z_0 . On the one hand, the ship owner may consider the value of management resources in the light of unproductive losses and its natural desire is to minimize the magnitude of Z . On the other hand, the DPA appears to be responsible for ensuring compliance of SMS with international rules and is interested in the maximization of the value Z . Therefore, there is a conflict situation, the solution of which depends on the choice of the optimal value of management resources Z_0 . Let's assume that in such situation any of the players can not simply act "out of the game." Furthermore, under the requirements of the ISM Code nobody can interfere in this conflict. Then complete and a summary description of the interests of elements in W pairs will be the target function $g_i(k_i)$, $i = 1, 2$ for each of these elements. Further, if the event that the participants in the conflict situation is not governed by no considerations other than their desire to make meaning of the maximum objective function, then taking into account (1.8) we get the condition under which the choice of place and inconsistent management resource:

$$g_1(k_1) > g_2(k_2) \quad (1.9).$$

where: $-g_1(k_1)$ – the owner of the target function, $g_2(k_2)$ – target function of DPA; k_1 and k_2 - behaviour strategies of shipowner and employee, in the case - DPA, respectively. To realize a co-ordinated choice of management resources the shipowner must refuse to use the levers of administrative pressure (1.8) and is governed by totally different relation in series W . *Desired relationship between elements u and v we can write this:*

$$v \in W, (u, v) \in \alpha_2 \Leftrightarrow u \sim v \quad (1.10).$$

The expression (1.10) defines partnership relationship between the shipowner and DPA. That partnership relations are able to make the conflict situation in a sustainable compromise agreement between both parties. The existing practice in SMS shows that the optimal choice of coordinated resource management, in spite of its

significant advantages in comparison with administrative appointments resource, meeting stiff resistance from the shipowners. So one option for solving this problem may be developing elements of culture in relationships in set W . Using these elements we can create a list (inventory) of operations $R^*(x,y)$. Analysis of the resulting algebraic system $(W, \alpha_i F_j)$

with an indicative list of operations shows that can outline the range of actions of the pair "shipowner - DPA" If then detach these acts and join them, then we can get a new culture C in relationship, typical of the company SMS. The appearance of such a culture will contribute to a "reasonable" transition relations of the type (1.9) to the relations of the type (1.10). In turn, the relation (1.10), supported by a culture system C is able to transform the conflict

situation in compromise $\Sigma : AS \xrightarrow{u-v} CS$ where AS - conflict situation; CS - compromise agreement. Ratio (1.10) establishes conditions ensuring the process of making a compromise choice for the value of the coordinated SMS resource management Z_0 pair of conflicting $(u, v) \in W$. In turn, the relationship culture C is the output when compiling a complete set of strategies $k = (k_1, \dots, k_n)$, by which each participant pairs $(u, v) \in W$ may rely on the following result:

$$Z_1 = \underset{i \in K}{\text{Max}} \underset{j \in K}{\text{Min}} g_1(k_1, k_2, \dots, k_n), i \neq j$$

The final selection of coordinated resource management will be implemented if

$$Z_0 = IR \quad \text{при} \quad IR = Z_1 \cap Z_2 \neq \emptyset$$

where: IR - outlined a set of individually rational outcomes.

The value of the coordinated resource management Z_0 can not accept the norm as it depends on the individual provide the ship owner and the designated person (DPA), responsible for managing the safe operation of ships at the time of concluding the agreement.

3. Conclusion

Summarizing said above we can make the following conclusion. Organizational - technical model of Safety Management System in the simplified version can be presented as a result of interaction of multimedia subsystem "command bridge" and the social element, including the OOW and watchkeeping team, and ship - the sophisticated engineering equipment presented in the system as a controlled device. Description of the processes of interaction of set elements in organizational - technical system is reduced to that technical element formed a production flow of messages for the current state of safety of navigation, a social element by handling received messages, translates them into commands flow of power control of the ship as an object. Feature of presented organizational and technical system is that in its structure introduces an additional set of items corresponding to the term "resource management", which is required to achieve the set targets for the ship to ensure safety of navigation. The selection of the parameters (members) of management resources shows the advantage of the method of "coordinated resource", although its value can not be considered as norm, since it depends on the relationship between the shipowner and the designated person ashore (DPA), and from the concept of options for the company Safety Management System.

Used Literary:

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