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ANALYSIS ON MECHANISM OF HUMAN FACTORS AND COMPLEXITY IN SHIP TRANSPORTATION MANAGEMENT

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ABSTRACT

This paper elaborates the human factors in ship management, and analyzes Liveware-Liveware interface and Liveware- Environment interface based upon the SHEL model. And the measures to reduce human error in marine transport has also been proposed. This paper also has made systematic analysis on the complexity of Shipping Transportation System, construct system model, and analyzes Synergy Mechanism of Shipping Transportation System .

Keywords: *Human Factor, Shel Model, Ship Management, Shipping Transportation System*

1. INTRODUCTION

The rapid development of world economy and the expansion of international trade have greatly promoted the prosperity and progress of the shipping industry. At the same time shipping industry has developed into an important pillar of the national economy. Safety, efficiency, and energy-saving are the targets of the shipping industry, among which safety is the primary. How to make navigation safer has become the focus of the shipping industry. According to recent statistics of IMO[1,2,3], more than 80% ship accidents were caused by human error, so human factors is the main reason causing the marine accidents. How to reduce human error in ship management is becoming the hot topic in shipping industry.

2. REASON OF HUMAN ERROR

Human errors are those mistakes which respond to stimulations by mistake and violate the design, operating procedure or crew's common practice and thus lead directly or indirectly to accidents. These mistakes make the system in failure or occur dysfunctional events. There are many factors influencing human error, which requires systematic study. The human factor in ship management are mainly composed of the following aspects.

Firstly, psychological and physiological factors. Crew's psychological abilities have subtle effect on their psychology state and behavioral competence. As far as physiological is concerned, the main factors affect the action are fatigue, disease, and biological rhythms.

Secondly, technological and skillful factors. Technology and skills, which are the main basis on measuring the crew's operational capacity, mainly depend on the crew's expertise, operating skills and experience.

Thirdly, environmental factors. The environment that the crew's in mainly refers to the human environment. Good environment can provide the effective protection for finishing the complex tasks. As one part of the social environment, whether managers or frontline staff, they both affect and are affected by enterprises culture and atmosphere.

Finally, management factor, which Includes management guidelines, group morale, individual motivation, coordination and communication.

3. SHEL MODEL IN SHIP MANAGEMENT

SHEL Model[3,4] was firstly proposed by Professor Edwards in 1972, and then modified by Professor Hawkins (figure 1). Now, the model is widely used in studies on the framework of human factors. SHEL Model includes Software, Hardware, Environment and Livewire. Human is the center of this model, which is considered as the most important segment in the system. The inter-relationship among human and software, hardware and environment, we call them Liveware-Liveware(L-L)interface, Liveware-Software(L-S) interface, Liveware-Hoftware(L-H) interface and Liveware- Environment(L-E) interface separately. The errors are caused by the mismatched element of the interface. So we can analyze human errors in each interface.

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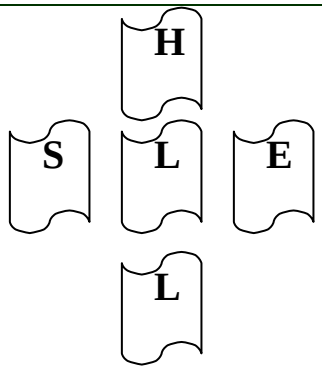

S—Software
H—Hardware
E—Environment
L—Liveware

Figure 1:SHEL Model

Liveware-Liveware（L-L）interface：It refers to the activities between humans in the system, that is, the relationship of leadership, management, communication and cooperation. For example, the management of captains, crews' cooperation; the safety management of shipping companies, department coordination, information management, ship security supervision and safety monitoring; etc.

Liveware-Software(L-S) interface: The relationship between human and software . Whether the data required in shipping is complete, reasonable or not; whether shipping-related laws and regulations, systems, rules, protocols, standard operating procedures, customs and practices, are compliance with transport safety management requirements or not, and whether it is scientific and effective or not.

Liveware-Hoftware(L-H) interface: the relationship between human and the physical part of the system, which mainly refers to the relationship among crews ships and goods. For example, the science of ship design conditions, equipment maintenance conditions, overloading, cargo stowage situation. In essence, the design of hardware should be crew-centered and achieve the goal of safety, efficiency, and convenience. Crews have to adapt to hardware devices so as to improve efficiency.

Liveware-Environment(L-E) interface: the relationship between human and environment(including social environment and the natural environment). For example, whether the navigation environment affect the crew's judgments and whether the ship condition limits the crew's behaviors. What's more, whether the environment which the crew's are living in affect the crew's status or not.

4. THE STRUCTURE OF HUMAN FACTOR SYSTEM

In the theoretical framework of SHEL model, we summarized the human risk factors as follows: L-L factor, L-S factor, L-H factor and L-E factor. Now we can build up the ship management index system model as shown in figure.2.

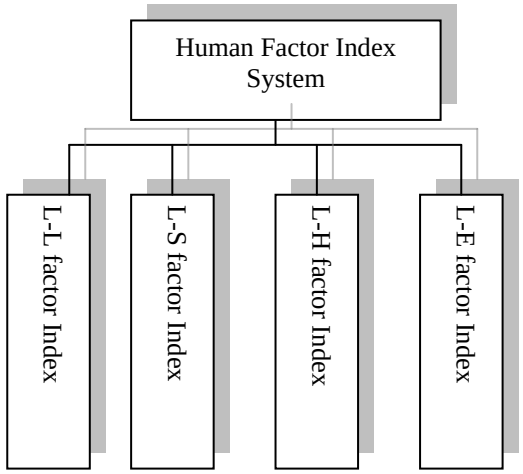

Figure 2: Ship management index system model

So we can cut down ship accidents through taking measures in above four interfaces.

4.1 Strengthen The Coordination Among Crews

The safety of the ship depends on the crew's sense of responsibility, and depends on whether each crew tries his best. For each crew's error can give the entire ship with disastrous consequences. So shipping companies should be concerned about the crew team-building actively, expand the links and communication channels between the company and crews, discover the gap in the crew team.

4.2 Strengthen The Coordination Between Crews And Machines

With the application of new computer technology and consolidation of intelligence, the management of ships, in nowadays, takes the trend of rationalization, intelligence and automation. It makes higher demands on the crews in the theoretical knowledge, technology, operational control, maintenance management and other aspects. The crews should learn professional knowledge, and the company should strengthen

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training through the use of simulators, test equipment and other practical operation, in order to help the crews make further understanding of the working principle of the ship and its performance. And thus finally eliminate the hidden danger caused by equipment factors in navigation.

4.3 Strengthen The Coordination Between Crews And Rules

In order to help the crews improve the understanding of the regulations and rules, shipping companies should establish a comprehensive safety education and training system. Crews safety awareness and sense of responsibility are to be improved through laws and rules education, safety and theoretical education, etc.

4.4 Strengthen The Coordination Between Crews And Environment

Large number of studies have shown that the psychological characteristics of the crews' change with the internal factors and external conditions. So shipping companies should help the crews to enhance knowledge of various external factors affecting the navigation, then the crews can grasp the safety measures in severe environment.

5. SHIPPING TRANSPORTATION SYSTEM BASED ON COMPLEXITY

In recent years, the complexity of the science has attracted many researchers of different fields, Although it is not consistent with the understanding of the complexity of some of the problems，many researchers have formed a consensus: the study of complexity is inseparable from the system. For what is a complex adaptive system, there is no strict definition.

Many studies on the complex adaptive system have shown that different areas of complex adaptive system have some of the same attributes. Usually, people can determine whether a system is a complex adaptive system or not based on these attributes. The nature of the ship transportation system will be examined in the following parts with reference to the features of complex adaptive system.

5.1 Hierarchy

The ship transportation system has obvious hierarchy. From the point of view of the static structure of the system, the transport fleet of the world, regardless of its level of automation, and management, almost all of the ships adopt the classification of the deck and cabin structure, each one has corresponding hierarchy: sailor, three, two, the first mate, captain attaching to the deck department; mechanic, fourth engineer, third engineer, second engineer, chief engineer establishing cabin system. Operations under the system of hierarchical management system must be hierarchical in nature.

From the view of the dynamic structure of the shipping system, the dynamic behaviors of shipping system are divided into river transport, offshore transport, ocean shipping, which can be further divided into passenger, tanker shipping, bulk shipping, container transport, special transport behaviors.

5.2 Nonlinear

The interaction between the various elements of the shipping system is nonlinear. Elements complete their tasks according to their own state; the state of the surroundings and global rules. Behaviors and patterns of behavior for each element depend on each other.

The nonlinear interaction between shipping elements arise out of the properties of the crew in the decision-making process, the interference in the decision-making process, course selection and the assessment and adjustment of shipping environment.

5.3 Non-Balanced And Orderly

Defined from thermodynamics, equilibrium means an isolated system, which does not change over time, and is in uniform chaotic state. The system can't achieve the evolution of the development process until it leaves the equilibrium Open systems move from the balance, nearly balanced toward far from equilibrium through the exchange of matter, energy and information with the external environment, thus forming the ordered structure of non-equilibrium.

The ship transportation system is an open system, and its openness manifest in the internal open and opening to the outside world. The internal open is the links between the various subsystems of the ship within the system. Each of the crew during the voyage must have good collaboration between each other and between machinery and equipment. Opening to the outside world is the exchange of matter, energy, information of shipping system between their environments.

The ship transportation system is an integral part of the transportation system, its establishment and maintenance must rely on the external environment which can provide human, material financial and information support. Marine Systems, in turn, contributes to the economy and adopt the

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destruction to the environment. On the behavior of the nature of the system of the ship, it is a far from equilibrium behavior.

5.4 Self-Adaptability

Self-adaptability is a description of the evolution of the system from the perspective of system interaction with the environment. It emphasizes the emergence of a new structure, status or function after the adaption to the environment. Under certain environmental stimuli of the outside world, environment is bound to react to the embodiment of the system, which shows the ability of adapting to the environment.

The adaptive behavior of ship systems mainly reflect on the adjustment of their course according to changes in the marine event and ship fuel. In navigation process, each system is complex and changeable. Crews usually reduce the chance of a failure occurring to a ship, increase the safety of the ship systems through continuous monitoring real-time status of the ship, to. This self-adaptability, in fact, is a learning process and the accumulation of experience of crews and the ships

5.5 Self-Organization

The persistence of adaptive mechanisms make the systems tend to have a self-organizing nature. The self-organizing means system, without external command and interference conditions, constitute joint action to achieve a result relying on mutual understanding and coordination of behavior within the system, which is a new stable structure. As far as the ship transportation system is concerned, its goal is to minimize the cost of time of reaching the port of destination, which is to reach coordinated property of shipping system under the common efforts of each elements.

6 . THE SHIP TRANSPORTATION SYSTEM MECHANISM

The transportation system[6,7] consists of the crews, ship, and navigation environment, which are usually called as “people-boat-environment” system. Its most important feature is that the people, boats and the environment are seen as three elements within a system. It emphasizes the general characteristics of the whole system. Through the information transmission and control among the system ,the system has a “safe, efficient, and economic” performance. Ship transportation system, as a large system, has internal complex subsystems in which factors interact and influence each other. Constituted model as shown in figure 3:

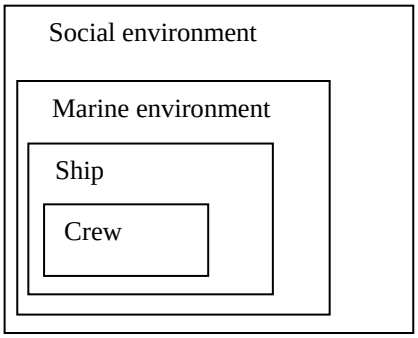

Figure 3:Constiute Of Shipping Transportation System Model

Transport system include: crew subsystem, shipping subsystem, sea transportation environment and social environment subsystem. So, we should not only be concerned with the change of every subsystem, but also with the relationship among every subsystem. Behavioral matrix is an effective instrument for describing the relationship of every subsystem. Supposing the behavioral matrix of shipping transportation system at some time is as following:

$$M = \left[M_{ij} \right] = \begin{bmatrix} m_{11} & m_{12} & m_{13} & m_{14} \\ m_{21} & m_{22} & m_{23} & m_{24} \\ m_{31} & m_{32} & m_{33} & m_{34} \\ m_{41} & m_{42} & m_{43} & m_{44} \end{bmatrix} \quad (1)$$

When i=j, it means state and property state of every subsystem at certain time; when $i \neq j$, it means the influence of subsystem j on the subsystem i in the shipping transport system.

Other subsystems affect the whole shipping transportation system through their influence on this subsystem. Supposing four subsystems, denoted by $b_i, i = 1,2,3,4$; the behavioral matrix of subsystem a_1 is denoted by M^{b1}; M^{bi} means the influence of every subsystem $b_i, i = 1,2,3,4$ on the subsystem b_1 which include behavior, property, state. The other three subsystems' influence on subsystem b_1 are M^{b2}, M^{b3}, M^{b4}. So, the general behavior model of shipping transportation system is as follow:

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$$M = M^{bi} + \sum_{i=2}^{4} M^{bi} = \begin{vmatrix} m_{11}^{b_i} + \sum_{i=2}^{4} m_{11}^{b_i} m_{12}^{b_i} + \sum_{i=2}^{4} m_{12}^{b_i} \ldots m_{14}^{b_i} + \sum_{i=2}^{4} m_{14}^{b_i} \\ m_{21}^{b_i} + \sum_{i=2}^{4} m_{21}^{b_i} m_{22}^{b_i} + \sum_{i=2}^{4} m_{22}^{b_i} \ldots m_{24}^{b_i} + \sum_{i=2}^{4} m_{24}^{b_i} \\ \ldots\ldots \\ m_{41}^{b_i} + \sum_{i=2}^{4} m_{41}^{b_i} m_{42}^{b_i} + \sum_{i=2}^{4} m_{42}^{b_i} \ldots m_{44}^{b_i} + \sum_{i=2}^{4} m_{44}^{b_i} \end{vmatrix} \quad (2)$$

7. THE SHIPPING TRANSPORTATION SYSTEM COORDINATE MECHANISM

The shipping transportation system coordination means synergetic. In the view of the originator of synergetic, it means the coordinate, collaborate and collective action. Because the person-ship- environment system composes of three subsystems, the synergetic is the necessary requirement for the shipping security.

The substance of coordination mechanism of shipping transportation system is to search for external function N. In the action of N, the total effectiveness $E(x)$ is more than the sum of each subsystem's effectiveness $\sum_{i-1}^{4} E(X_i)$:

$$E^g(x) = E\left\{N\left[f(x_1, x_2, x_3, x_4)\right]\right\} = E\left[\mathrm{g}\ (x_1, x_2, x_3, x_4)\right] \rangle \sum_{i=1}^{4} E(X_i) \quad (3)$$

So we say N is the coordinate mechanism for the shipping transportation system S. the set of coordinate mechanism denoted by N.

8. CONCLUSION

Ship management is an important part of maritime security. Based on the SHEL model and analysis of the human factors, a series of effective measures are proposed so as to prevent the generation of human error, and finally achieve maritime security objectives. The ship transportation system is a complex system, the mutual cooperation, coordination and development of each subsystems will cause the entire system to malfunction. Analysis from the point of view of system theory of identifying the relationship among shipping transportation subsystems, are going to provide new ideas and methods for water traffic safety research

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REFRENCES:

[1] Y. Tana, M. Sata, "Asymmetric fingerprinting based on 1-out-of-n oblivious transfer", Proceedings of International Conference on Computer Application in multimedia, IEEE Conference Publishing Services, February 25-28, 2010, pp. 622-632.

[2] International Maritime Organization (IMO). SOLAS consolidated edition, International Convention for the Safety of Life at Sea 1974, as amended, 2009.

[3] Otto S, Pedersen PT, Samuelides M, Sames PC. Elements of risk analysis for collision and grounding of a RoRo passenger ferry .Journal of Marine Structures, Vol. 15, No. 4 ,2002

[4] HiokoItoh, "An Extension Of m-SHEL Model for Analysis of Human Factors at Ship operation", Japan CCGS2004, pp. 118-122, 2004.

[5] Trucco P, Cagno E, Ruggeri F, Grande O. A Bayesian belief network modelling of organisational factors in risk analysis: a case study in maritime transportation. Reliab Eng Syst Safety, in press.

[6] Flin, R., Mearns, K., O'Connor, P., Bryden, R, "Measuring safety climate: identifying the common features", Safety Science, Vol. 34, No. 1-3, 2000, pp.177-192.

[7] O'Neil, W. A., "The human element in shipping". World Maritime University Journal of Maritime Affairs, Vol.2, No. 2, 2003, pp. 95-97.

[8] Guofei Jiang, George Cybenko, Functional Validation in Grid Computing, Autonomous Agents and Multi - Agent Systems, Vol. 8, No. 2, 2004.

[9] Tobias Robert, Carole Hofmann. Evaluation of free Java-libraries for social-scientific agent based simulation, Journal of Artificial Societies and Social Simulation, Vol. 7, No. 7, 2004, pp.266-273 .

[10] Gell-Mann, M. Consciousness, reduction, and emergence. Some remarks, Annals of the New York Academy of Sciences, Vol. 929, No. 1, 2001, pp. 41- 49.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[11] Nicholas R. Jennings, Katia Sycara, Michael Wooldridge, A Roadmap of Agent Research and Development, Autonomous Agents and Multi - Agent Systems, Vol. 1, No. 1, 1998.

[12] Ersan Basar, Investigation into Marine Traffic and Risky Area in the Turkish Straits System Canakkale Strait, Transport, Vol. 25, No. 1, 2010, pp. 5-10.