Scientific Journals
of the Maritime University of Szczecin

Zeszyty Naukowe
Akademii Morskiej w Szczecinie

2015, 43 (115), 65–67
ISSN 1733-8670 (Printed)
ISSN 2392-0378 (Online)

A possible approach for "*human factor*" estimation

Vadim Goncharov

Saint-Petersburg State Marine Technical University
3 Lotsmanskaya St., Saint-Petersburg, 190008 Russia, e-mail: vkgonch@mail.ru

Key words: accident, error, human factor, navigation, operator, risk

Abstract

It is well-known that operator error – "*human factor*" – is the cause of most accidents. This is a great concern to navigators. Recent crashes of ferries with large numbers of human victims have occurred because of navigator errors or because of their inability to make adequate decisions in an unexpectedly arisen emergency.

This paper presents a possible method for quantitative estimation of the "*human factor*" based on analysis of the physical and mental conditions of the operator and the working environment.

Introduction

Operator error – the "*human factor*" – is the reason for most accidents. This is connected with the fact that the operator is subject to his own inner factors and mood which complicate his environmental perception and affect his reactions to incoming information.

In most cases, the concept "*human factor*" is connected with ergonomics where the main problem is the provision of convenient and favorable conditions for the effective work of the operator of any equipment, mechanism, propulsive plant or flybridge, and his maximum health and safety.

Known methods of "*human factor*" estimation conceptually or structurally analyze the processes of human (or collective) interaction with engineering systems and aim to reveal the most critical elements where an emergency is most probable (Stanton et al., 2013). The disadvantage of these methods is the lack of quantitative assessment, the application of which enables the comparison of various situations and control or decision-making structures.

In this study the concept "*human factor*" was considered as a quantity indicator in connection with the risk of accidents. Evaluations of risks are a base for planning navigation and safety. Risk of mistakes while a ship is in unfavorable weather and icy conditions is high. Therefore, it is necessary to evaluate these risks with reference to the specific man and concrete workplace.

Quantity indicators for the "*human factor*" will give possibilities to compare the readiness or ability of operators and navigators to control a ship and select the most effective working conditions.

Suggested approach

The special methods for "*human factor*" estimation suggested are based on analysis of specific features of operator as human and specific working conditions.

Introduced into the analysis is "*factor possible error*" of operator F_{he} that lies in the range: $0 \leq F_{he} \leq 1$.

Situation $F_{he} = 0$ corresponds to the impossibility of operator error. Situation $F_{he} = 1$ corresponds to the inadvertent error of operator and, as a result, accident with damage to the ship's hull, propeller, or oil spill etc.

The operator as a human being is a complicated system with numerous variants of his mental state, subject to the actions of his body at that moment and also to information and impressions that he received during the activity and during the preceding time. Therefore, this factor has an important role for the operator.

Factor possible error of the operator is presented as the sum of *subfactors* F_{si} that characterize separate effects on the mental state of a given operator and have their own weighting coefficients γ_i.

The corresponding formula presents the *factor possible error* of the operator as follows:

$$F_{he} = \sum_{i=1}^{N} \gamma_i F_{si} \tag{1}$$

Each subfactor lies in the range $0 \leq F_{si} \leq 1$. Situation $F_{si} = 0$ corresponds that the effect number *i* on mental state of the operator is absent. Situation $F_{si} = 1$ corresponds that the effect *i* has maximal pressure on the mental state of the operator.

It is appropriate to consider the following effects on the mental state of the operator in the capacity of the subfactor, namely:

1) present state of health;
2) disciplined behavior;
3) work environment (level of workplace comfort and function ability);
4) personal problems originating outside the workplace;
5) operational experience or special training for a given activity and workplace;
6) speed of response, and so on.

It is possible to continue the list of subfactors. For example, it is appropriate to consider the specificity of a given activity (operation) and its difference from other types of activities.

It is required to consider the subfactor as a discrete quantity q_{ij} that possesses a specific value in dependence on concrete type of effect, its intensity and consistency of action and on probability p_{ij} of each variant.

For example, it is possible to consider the methodology to define a subfactor that characterizes "*present state of health*" of the operator. Table 1 was created for this purpose.

Table 2 defines the subfactor "*work environment*" that has effects on attention and speed of response to incoming information.

Table 3 defines the subfactor "*personal problems*" that has effects that can disturb the operator from control of the work at hand.

It is necessary to take into account the complexity of work performed by the operator and his preparedness to react to unexpected situations.

For example, in the operator's workplace, control and monitoring devices can be intended only for observation, for permanent regulating, or for fast correction of undesirable processes to avoid an emergency situation. This means that each activity demands different levels of attention, creates various loads on the operator and tires the operator differently.

Table 1. Definition of the subfactor "*present state of health*"

No.	Situations for subfactor F_{s1}	Level of affect	Probability
1	Normal state of health	0	p_{11}
2	Weariness	q_{11}	p_{12}
3	Needing sleep (sleepy)	q_{12}	p_{13}
4	Unwell (cold, stomach pain, etc)	q_{13}	p_{14}
5	Weariness and sleepy	$q_{11} + q_{12}$	p_{15}
6	Weariness and unwell	$q_{11} + q_{13}$	p_{16}
7	Sleepy and unwell	$q_{12} + q_{13}$	p_{17}
8	Weariness, sleepy and unwell	$q_{11} + q_{12} + q_{13}$ $\Sigma q_{1i} = 1$	p_{18} $\Sigma p_{1i} = 1$
Result $F_{s1} = \Sigma q_{1i} \cdot p_{1i}$			

Table 2. Definition of the subfactor "*work environment*"

No.	Situations for subfactor F_{s2}	Level of affect	Probability
1	Temperature, humidity and level of noise optimum	0	p_{21}
2	Heat (or cold)	q_{21}	p_{22}
3	High humidity (or precipitation)	q_{22}	p_{23}
4	High noisiness	q_{23}	p_{24}
5	Heat and high humidity	$q_{21} + q_{22}$	p_{25}
6	Heat and high noisiness	$q_{21} + q_{23}$	p_{26}
7	High humidity and noisiness	$q_{22} + q_{23}$	p_{27}
8	Heat, high humidity and noisiness	$q_{21} + q_{22} + q_{23} = 1$	p_{28} $\Sigma p_i = 1$
Result $F_{s2} = \Sigma q_{2i} \cdot p_{2i}$			

Table 3. Definition of the subfactor "*personal problems*"

No.	Situations for subfactor F_{s3}	Level of affect	Probability
1	Personal problems are absent	0	p_{31}
2	Relations with friends	q_{31}	p_{32}
3	Family relationships	q_{32}	p_{33}
4	Financial problems	q_{33}	p_{34}
5	Family and friends relationships	$q_{31} + q_{32}$	p_{35}
6	Relations with friends and financial problems	$q_{31} + q_{33}$	p_{36}
7	Family relationships and financial problems	$q_{32} + q_{33}$	p_{37}
8	All problems together: family, friends and finance	$q_{31} + q_{32} + q_{33} = 1$	p_{38} $\Sigma p_i = 1$
Result $F_{s3} = \Sigma q_{3i} \cdot p_{3i}$			

The operator can have special training for an activity in an emergency, have experience of previous ways out of an emergency, or designers of the workplace and the unit under control may not have examined the possibility of any emergency. There is especially a multiplane subfactor; therefore, it is required to restrict the set of possible variants on the data stage.

Table 4 defines the subfactor "*complexity and readiness*".

Table 4. Definition of the subfactor "*complexity and readiness*"

No.	Situations for subfactor F_{s4}	Complexity of activity	Training, experience
1	Status under control unit monitoring and information about uninominal situation	q_{41}	p_{41}
2	Status under control unit monitoring and correction in abnormal situation	q_{42}	p_{42}
3	Control unit parameters and variation to change regime	q_{43}	p_{43}
4	Continuous regulating of operational regime	q_{44}	p_{44}
5	Continuous control unit parameters, selection optimal and maintenance of ones	q_{45}	p_{45}
6	Continuous control unit parameters and prevention of emergency due to internal causes	q_{46}	p_{46}
7	Continuous control unit parameters and prevention of emergency due to external causes	q_{47}	p_{47}
8	Liquidation of accident effect or rescue operation	q_{48} $\Sigma q_{4i} = 1$	p_{48} $\Sigma p_{4i} = 1$
Result $F_{s4} = \Sigma q_{4i}\, p_{4i}$			

It is possible to create the same tables for other subfactors and add other unfavorable effects on the operator to the presented tables.

Further, it is necessary to estimate values of individual subfactors using such tables and then calculations by the above presented formula which permits the evaluation of *factor possible error* for an operator for any workplace and activity.

Conclusions

The above stated approach is one of many possible variants. Determination of the proposed *factor possible error* for some specific person, specific point of time and workplace is impossible because all the necessary information cannot be received.

Therefore indirect analysis is required. Such analysis can be based on information about circumstances of concrete accidents that have occurred as a result of any error of the operator.

However, it is very difficult and almost impossible to find such material in enough volume at present. Expert estimations based on personal experiences and conceptions will be more reasonable. Special study is also required to define the weighting factor for each type of effect on the operator whilst performing the task and previously in the course of his normal life.

It is possible to combine the developed approach with known methods for "*human factor*" analysis and assessment.

Acknowledgments

Studies were implemented within the project WINOIL – "*Winter navigation risk and oil contingency plan*". The project was co-funded by the European Union, the Russian Federation and the Republic of Finland.

References

1. Stanton, N.A., Salmon, P.M., Rafferty, L.A., Walker, G.H., Baber, C. & Jenkins D.P. (2013) human factor methods. A practical guide for engineering and design. Second edition. Ashgate Publishing Limited.