

# Innovative methods of an assessment of physical condition of a person as a factor of ensuring the effective management of a moving object

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**Purpose:** to establish the basic provisions of influence of a human factor on reliability of functioning of the system “the person – the object of management – the activity environment”.

**Materials & Methods:** The general scientific methods of the analysis, analogy, deduction, comparison, statistical information processing. The methods of a statistical control of sample statistics on an alternative sign. The computer data processing with the use of Excel and Turbo Basic.

**Results:** the method of an individual control and an assessment of influence of a human factor on safety of functioning of the system “the person – the object of management – the environment” is developed.

**Conclusions:** The general provisions of the construction of the sign semantic spaces are established, which allow estimating the current functional state of a person–operator during his direct performance of the professional activity that provides control of its sufficient quality.

**Keywords:** Human factor, safety of movement, semantic spaces, norm of physical condition.

## Introduction

The international symposium on the applied questions of a human factor and ergonomics passed in June, 2015 in Las Vegas. The wide range of questions was considered, disclosing the importance of a role of a human factor in all types of professional activity, in which a person enters as an element of the system «the person– the object of management – the activity environment» in the program of a symposium [1]. A rapid development of a technique representing in this system the component «the object of management» allowed broadening the sphere of the carried-out professional activity significantly. It led to the fact that a person was the weakest link in the considered system «the person – the object of management – the activity environment». Inconsistency of functioning of its elements leads to different incidents which attract emergencies, and in some cases come to the end with accidents. The statistics of the happened accidents indicates that 87% from them occur because of a person [2].

The requirement of development of the system of continuous control of a condition of a person and an assessment of sufficiency of his functionality for a performance of the necessary professional activity, and also the creation of intellectual computer systems for a duplication of functional activity of a person in the conditions inaccessible for his stay acts as the uniting factor of all directions of the research of influence of a human factor.

The most convenient object of the research of this problem are technical sports, and in particular races on motorcycles with a sidecar in which all existing problems are combined, which are connected with optimization of work of the system «the person – the object of management – the activity environment» [3].

## The purpose of the research

To establish the basic provisions of influence of a human factor on reliability of functioning of the system “the person – the object of management – the activity environment”.

## The task of the research

To establish the most general provisions which define the decrease in efficiency of the functional activity of a person. To define the physiological reasons of the decrease in efficiency of a person. To establish the general and special making reliability of a human factor depending on specifics of the professional activity and conditions of the environment in which it proceeds. To define the possible control methods and estimates of the current functional state, admissible for performance of a concrete level of complexity of professional activity. To establish borders of the allowed mistake measure depending on conditions of the carried-out professional activity.

## Material & Methods

General scientific methods of the analysis, methods of analogy, deduction, comparison, static information processing. Methods of a static control of a sample statistics on an alternative sign. Computer data processing with the use of Excel and Turbo Basic.

## Results and discussion

The efficiency of a performance of the system «the person – the object of management – the activity environment» depends on the coherence of interaction of its compound components providing the level of reliability of the exercised control.

The control of the happening changes in the environment and the corresponding external managing directors of actions of object of management acts as the operating factor in the coherence. This process demands manifestation of an adequate attention (observability) from the person-operator. The problem of finding of conditions of the controllability and observability connected with a possibility of definition of indicators of a state by results of measurement of physical variables in the system which is making the basic requirements in ensuring operability of the system, was put only in the second half of the last century, approximately in the century of emergence of the theory of regulation [4].

In turn, the concept of observability or attention which is carried out by a person-operator has a rather generalized character and demands definition of the structure of a condition of the attention which is providing observability and also the physiological mechanisms which are opening the reasons of its easing. The decrease in attention attracts the increase in an error of assessment of physical variables that leads to a violation of accuracy of the operated actions also, as a result, creates emergencies [5].

The general theory of dependence of size of the made mistakes and possible complexity of the organization of management was developed by V. N. Samsonkin [6; 8]. The main essence of this dependence is stated in proved to them direct and return theories about complexity of the structure of the functional organization of the system in tolerant spaces. The essence of their statement is reduced to the fact that «any functional system has a finite-dimensional complexity of the organization in a tolerant space». Or «the complexity of the possible organization of the system is limited at the set tolerance of the forming space». The converse consists that «the creation of the object or the process of the set complexity is possible at the certain tolerance which isn't surpassing some positive number». On the basis of these statements the consequence follows that «at aspiration of tolerance to zero the complexity of the system or the process can increase beyond all bounds and their stability to aspire to zero» [7].

A person, being in various conditions under which his professional activities are carried out, with the development of exhaustion reduces the observation (attention). Depending on conditions of the environment and preparedness to work, duration of performance of professional activity in these conditions is defined in it.

The experimental check of a period of operation depend-

ing on intensity of its course shows that this dependence is described exponential which reflects the development of an appropriate level of exhaustion. Thus, tolerance of an assessment of perception, which is flowing on a strict regularity, gives the instrument of control of the made mistake in an assessment of coordination of managing directors of actions with the required results. Therefore, the environment in which the management process takes place, defines requirements of what is necessary for interaction with it.

Having the communication of tolerance of interaction of elements of the system with the accuracy of implementation of the operating actions and regularity of change of tolerance in the course of performance of professional activity, it is possible to determine duration of safe implementation of management of the object with a rather high precision. At the same time the physiological reasons which cause exhaustion completely are defined by intensity of the carried-out activity.

Insufficiency of oxygen for ensuring processes of a metabolism (deterioration process); accumulation of products of an exchange (process of a contamination); exhaustion of an energy potential (process of exhaustion) relate to such reasons. Intensity of work defines individual share of the reasons of exhaustion. The special place in the structure of development of exhaustion causes the mode of monotonous work which proceeds against the changes of the internal environment which aren't overstepping the bounds of its deviation, which are capable to cause protective reactions for counteraction to exhaustion. In this case it is about the local center of braking which arose in the central nervous system. All four factors causing exhaustion always participate in its course, but their share importance in each case has various ratios depending on the character of the experienced strain [9].

The mechanism of the central braking develops as a result of local violation of regional blood circulation. The nature of such violation of the internal environment in direct control methods of its state isn't feasible. Only the existing control method of the development of the central braking is observed violation of accuracy of an assessment on indicators of force, time and spatial characteristics of the performed operations. The most effective method of fight against this kind of exhaustion is switching on other kind of activity as which active recreation acts [10].

In general it is necessary to exercise control of an admissible mistake on the end result of correctness of performance of the operated actions. A standard of comparison has to be for these actions. The previous experience of performance of a task and its step-by-step comparison with the current performance can act as such criterion. Or comparison from results of a double in a joint management with establishment of the allowed limit of discrepancy of the performed operations is.

The most perfect monitoring system behind the current functional state is its representation in special sign spaces. The essence of this advantage is that the high-quality division of structure of response of the operated actions into the stationary basic tension providing the level of necessary functional activity, and on its background of the pulsing adaptation behavior which is directed to the arising deviations in the environment of stay as reciprocal managing directors of the actions keeping an equilibrium condition of the system «the person – the object of management – the environment» is carried

out in the sign semantic spaces.

Such submission of the qualitative characteristic of work of any functional system is that the oscillatory process has a step of transition of accuracy of regulation from the previous state to the subsequent in the range of the shown functional activity from a minimum to a maximum and vice versa. The transition from one state to another is a pulse step (amendment amplitude). Therefore, there is the current value of maximum and minimum (max-min) that is characterized by a pulse difference or a step of the made amendment. In that case average value, rather control, a fluctuation of variation of activity occurs, will be defined as  $(max - min)/2$ . This size in the course of the exercised control can remain a constant or will change multidirectional both towards a maximum, and towards a minimum that is characterized as a pulsation of its trend.

The feature of representation of the structure of result of the characteristic of high-quality changes of functional activity consists in the determination of compliance to each level of functional activity or its intensity of step-by-step regulation of the made amendments to change of the current level of amendments. Such regulation of the functional activity can be observed concerning the level of its orientation, duration of manifestation of this intensity and prevalence of observed activity.

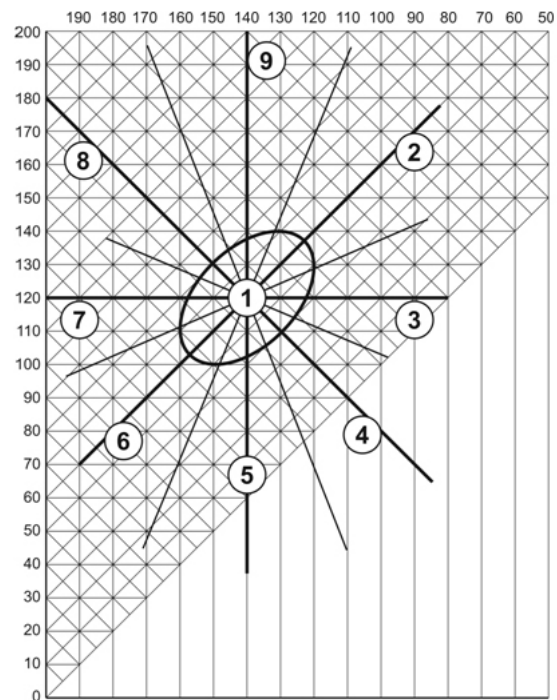
Each of the noted characteristics of the functional activity has the independent morphofunctional mechanism of manifestation which provides the relevant operational adaptive amendments to the relations with the environment of a stay.

The current value of the maximum and minimum size of the functional activity, their average value and step-by-step change of accuracy of regulation of a pulsation are connected by the simultaneous representation of the generalized point in uniform sign semantic space which allows to track regularity of behavior of a trend and pulsation of accuracy of the operated actions in the corresponding condition of intensity of the system.

As an example this regularity can be observed in the course of regulation of a local blood pressure. The objective registration of indicators of a local blood pressure allows establishing its maximum and minimum values. Pulse reaction or pulse pressure (P) is defined as a difference systolic (S) and diastolic (D) pressure. The average arterial pressure (AAP) is equal to a half of the sum of systolic and diastolic pressures  $AAP=(S + D)/2$ . This characteristic is the most stable and represents energy of the continuous movement of a controlled stream of blood (the existent process).

If to make a sign semantic space which can be presented as two combined coordinate systems in one of four characteristics of which changes of the top and lower borders of pulse fluctuation of rather some state (systolic and diastolic change of pressure) are reflected, and in another – the condition and size of pulse fluctuation, then the only point connecting them will describe a trend of a condition of system in the generalized zone of this space. The feature of creation of a semantic space consists that coordinate systems are turned by 45 degrees relatively each other (pic. 1, 2).

The presented sign semantic space is applicable for all cases of the description of processes when the adaptive step-by-



**Pic. 1. The nomogram of dynamics of measurement of arterial pressure defining a characteristic orientation of change of arterial pressure:**

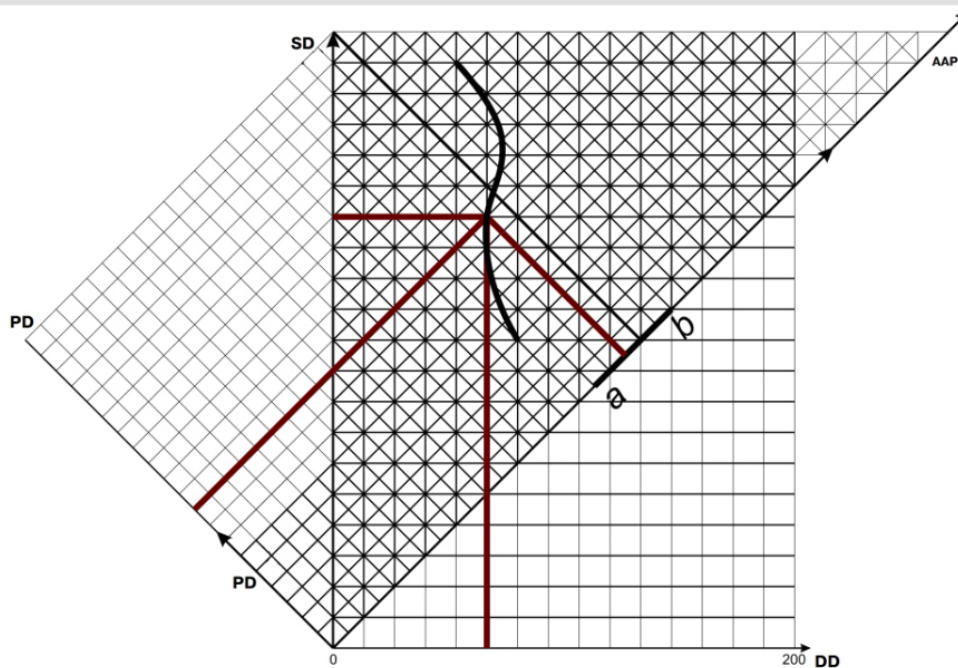
1 – norm; 2 – the general hypertension; 3 – diastolic hypertension; 4 – pulse hypotonia; 5 – systolic hypotonia; 6 – general hypotonia; 7 – diastolic hypotonia; 8 – pulse hypertension; 9 – systolic hypertension.

step regulation of its equilibrium relations with the environment proceeds against any condition of the system. The constancy of their relation and the constancy of occurrence of these relations are established in spaces of this kind on the basis of absolute units of measure of controlled signs.

These compliances of the ordered representation of parameters allow establishing the analytical description of a trend of a condition of the system that gives the chance of forecasting of its behavior taking into account specific features of the considered interaction with the environment of a stay.

The most effective use in this regard is the control of a person-operator not on separate indicators of any functional system, and on their integrated indicator which is the equifinal result of the carried-out professional activity. Regardless of a type of the arising exhaustion, its final impact on the carrying-out professional activity is shown in the increase in an error of the introduced operating amendments [11]. It is led to increase in tolerance of space of the interacting components of the system «the person – the object of management – the environment» and to decrease in complexity of solvable problems of management of the object that follows from theoretical developments of V. N. Samsonkin [12].

The control of the accuracy of performance of operations of management of the object doesn't demand carrying out the test control of physiological processes and use of additional hardware providing which has probabilities of refusal and a random error of an assessment of the current state of an operator.



**Pic. 2. The combined nomogram of dynamics of measurement of arterial pressure reflecting interdependent behavior of all characteristics AP:**

*SP* – systolic pressure; *DP* – diastolic pressure; *PP* – pulse pressure ( $SP - DP$ ); *AAP* – average arterial pressure  $(SP + DP)/2$ .

The current physical state will act as the forming condition in which it is carried out at control of direct result of the performed operated operations. The level of the current weariness will be the defining factor in an assessment of a physical state. As a certain accuracy of performance of the operated actions (their pulsation) corresponds to any state and borders of this pulsation are known, on the course of performance of operational professional activity in the system of the sign semantic space which was described above, the trajectory of movement of a trend of a working condition will be formed. The established limits of admissibility of an error of management in real time define a possibility of continuation of the performed work. We will exercise such control both at an assessment of prestarting preparedness, and in the course of direct activity [13].

The implementation of such control allows: to establish the most difficult conditions of interaction with the environment of elements of the system «the person – the object of management – the environment» which influence a working condition of the operator; to establish the level of proficiency and learning ability of a person-operator and duration of preservation of his working capacity; ensuring timely inclusion in work of the double or automatic control system. The accumulation of results of such information will promote the improvement of the automated management process and the creation of self-training system of the automated management of the object. The solution of the last point will allow excluding participation of a person in the management of object in the conditions which are inaccessible for his stay that increases safety of management of the system «the person – the object of management – the environment» in especially dangerous conditions of finding of the system «the person – the object of management – the environment».

## Conclusions

1. The decrease in efficiency of the professional activity is connected with the increase in inaccuracy of an assessment of the made amendments to the operated actions that is defined by the blown process of exhaustion. The development of exhaustion increases tolerance of the corrected actions and reduces complexity of the solvable tasks. The analytical dependence connecting these factors allows to predict the approach of maximum permissible inaccuracy in the carried-out operated actions and to carry out the necessary amendments anticipating them.
2. The specifics of the professional activity define the development of the process of exhaustion of those functional systems which experience the highest strain. The transferable intensity of this loading causes the corresponding form of manifestation of exhaustion that causes the decrease in the general physical state and decrease in availability of performance of a certain complexity of the professional activity. The corresponding accuracy of an assessment of change of the environment is inherent to the level of a physical state and pulsation of a step of the made amendments to management of the object for each level.
3. The communication of the current state, the borders of a pulsation made at it amendments and the tendency of a trend of a state which are obligatory components of any functional system has the close analytical inter-conditionality which is revealed in the special sign semantic space reflecting constancy of the relations. The existing analytical communication of interdependent behavior of the considered signs allows exercising individual control of availability of performance of the professional activity.

4. The most effective method of safety of management of the object is not control of certain functional systems, but control of their integrated indicator which is reflected in the accuracy of performance of the professional activity and submits to the determined consistent patterns of behavior of a trend of a state and the related accuracy of the performed work.

5. The existence of the regularities reflecting inter-conditionality of the growth of inaccuracy in the operated actions; the exhaustion and the general physical state which are inherent in any functional system allow to carry out a model creation

of these processes and to expand borders of opportunities of the automated control systems for the object, excepting participation of a person in the conditions which are inaccessible for his professional activity.

## Further researches

In this direction will be connected with the development of intellectual automated control systems for the object with participation of the person who is out of the object.

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