Research of vehicle control informative functioning capacity

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Abstract. Harmful influence of human factor upon industrial processes and while vehicles running control necessitates to search for ways of its minimizing or total elimination [1–3]. For this, intellectual technologies are implemented more and more often [4], systems of support in making decisions [4–12], which ensure solving of this problem. For assessment of future characteristics DSS, before initiating projecting it’s extremely important to define the influences to which a person-operator is usually succumbed to. In conditions of railroad transport operation, when the price of incorrect decision or mistake while operation is too high, implementation of such systems is especially actual. Intellectual system will take on itself some certain informative streams [13–15] that’s why it’s necessary to organize spread of information in such a way, that won’t create excessive overload of a locomotive brigade.

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1. Introduction
Harmful influence of human factor upon industrial processes and while vehicles running control necessitates to search for ways of its minimizing or total elimination [1–3]. For this, intellectual technologies are implemented more and more often [4], systems of support in making decisions [4–12], which ensure solving of this problem. For assessment of future characteristics DSS, before initiating projecting it’s extremely important to define the influences to which a person-operator is usually succumbed to. In conditions of railroad transport operation, when the price of incorrect decision or mistake while operation is too high, implementation of such systems is especially actual. Intellectual system will take on itself some certain informative streams [13–15] that’s why it’s necessary to organize spread of information in such a way, that won’t create excessive overload of a locomotive brigade.

While doing his responsibilities in process of locomotive operation a machinist is found in difficult stressful situations and processes a great amount of operative information [16]. Assessment of
a machinist informative functioning capacity is an important value, which influences safe running and utilization of locomotives.

2. Using fuzzy set theory to represent the train control process

The main function of any control system is to develop in accordance with a certain set of rules and to issue, in the necessary form of control, effects on executive mechanisms, which, in the case of systems that advise, is a person. A prerequisite for the correctness of the effects produced is a reliable assessment of the states in which the object of management is located.

The states of the control object can be evaluated by the values of the signs - the recognizable features of the object. For example, let the control object be a locomotive moving with a train. The main requirements for the control system are to ensure traffic safety by detecting dangerous emergency situations and taking measures to exit from them, as well as to ensure the most rational mode of trains in terms of minimizing operating costs.

In this case, the basic states of the control object can be evaluated by the values of the signs "Signal state", "Speed of movement", "Freedom in front of the lying section of the path", "Distance to the traffic light (signal)", "Distance to the obstacle", "Indications of the devices control". The current of traction electric motors "and so on. It is clear that the number of signs (the power of a set of signs) is determined by the objectives of the object management and features of the control system.

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The construction of an intelligent DSS for a locomotive engineer is proposed to be performed using the method developed in [17]. A set of values of attributes describing the state of the control object at some point in time, we call the situation. Let the simple approach be used to construct a decision-making block: a "decisive table" is formed, that is, the correspondence between all possible situations and some set of control decisions. The size of the table is determined by the number of situations, which, in turn, depends on the degree of specification of the values of the signs.

If p is the number of characters, mi is the number of values of the sign yi (i ∈ J = {1, 2,...,p}), then the number of possible situations does not exceed m1 × m2 × ... × mp.

The situation for constructing a decisive table is supposed to be obtained as a result of an expert survey (in our case, an experienced driver). Naturally, when describing situations, the attention of the expert will be focused on the typical "typical" situations that arise when driving a locomotive. The number of typical situations is much less than the total number of situations, but for their description, the expert is most apt to use the verbal values of the features representing the value of the corresponding linguistic variables, for example ("Speed of movement", T1, D1), ("Distance to obstacle", T2, D2), where T1 is the term set of the linguistic variable "Speed", T1 = {"large", "medium", "small"}, respectively T2 = {"large", "small", "medium", "small"}.

Consequently, all possible states of the control object can be described by a set of typical situations, each of which is a set of linguistic values of attributes.

The set of fuzzy values of the characteristics that characterize the states of the control object, we call the fuzzy situation. Formal definition of "fuzzy" situation. Let Y = {y1, y2, ..., yp} – be the set of signs whose values describe the states of the control object. Each sign yi (i ∈ J = {1, 2, ..., p}) is described by the corresponding linguistic variable <yi, Ti, Di>, where Ti = {T1, T2, ..., Tm} – term-set of a linguistic variable, yi – a set of linguistic values of a sign, m – number of values of a sign, D – is the base set of signs yi. To describe the terms Tj (j ∈ L = {1, 2, ..., m}), corresponding to the value of the sign yi, the fuzzy variables <Tj, Di, Cj>, are used, that is, the value Tj is described by the fuzzy set Cj in the base set D:

\[ C_j = \{ \mu_{C_j}(d) : d \in D \} \]  \hspace{2cm} (1)

The fuzzy situation s is called the fuzzy set of the second level:

\[ s = \{ \mu_{s(y_i)}(y_i) : y_i \in Y \} \]  \hspace{2cm} (2)

where:

\[ \mu_{s(y_i)} = \{ \mu_{s(y_i)}(T_j) : T_j \} \]  \hspace{2cm} (3)
An example of a fuzzy situation that characterizes a state that arose when driving a locomotive: 
\{<<0,1/"great">, <0,8/"average">, <0,4/"small" / "Speed">, <<0,6/"great">, <0,8/"small">, <1,0/"average">, <0,6/"small" / "Distance to obstacle" >\.

In the decisive table, in accordance with this fuzzy situation, a management decision can be made: "Apply service inhibition".

Consequently, a limited set of fuzzy situations can describe virtually an infinite number of states of the control object. Now, the simplified functioning of assessment and decision-making blocks can be presented in the following way. The states of the control object are evaluated by the status evaluation unit at some discrete time intervals. The state of the object is presented in the form of a fuzzy situation. The received incoming fuzzy situation is equal to all typical situations stored in the deciding table. A typical fuzzy situation is determined, in some sense closest to the incoming fuzzy situation. Information about this typical fuzzy situation comes into the decision-making block, where the decisive table defines the necessary control decisions in the given state of the object.

3. Analysis of criteria for making managerial decisions in the information situation of "driving a train"

Information Situation U – "driving a train" is characterized by the distribution of probabilities 
\( p=\mathbb{P}\{\theta=\theta_j\}, \sum_{j=1}^{n} p_j=1 \) states \( \theta \in \Theta \) of medium S. This situation identifies the behavior of the environment S under risk conditions and allows us to effectively use the theory of statistical decisions [18]. On the basis of the data on the condition of the train, locomotive, environment and locomotive brigade, an appropriate decision on the control action is taken.

Consider the main criteria for decision making in the information situation U [19, 20]. Let the decision-making situation \( \{\Phi, \Theta, F\} \), be given, in which the estimated functional \( F=\{f_{jk}\} \) belongs to the class \( F' \) or \( F'' \), the sets \( \Phi \) and \( \Theta \) are given in the form \( \Phi=\{(\varphi_1, ..., \varphi_m)\}, \Theta=\{\theta_1, ..., \theta_n\} \).

Bayes' criterion: The essence of this criterion is to maximize the mathematical expectation of the estimated functional. The name of this criterion is mainly related to the transformation of the a priori probability formulas in the a posteriori. According to the criterion Bayes, the optimal solutions \( \varphi_{k_0} \in \Phi \) (or a set of such optimal solutions) consider such solutions for which the mathematical expectation of the estimated functional reaches the maximum possible value [21].

\[
B^*(p, \varphi_{k_0}) = \max_{\varphi_{k_0} \in \Phi} B^*(p, \varphi_{k_0}) = \sum_{j=1}^{n} p_j f_{jk}^* = \sum_{j=1}^{n} p_j f_{jk}^{*}\ (4)
\]

If the maximum is reached on several solutions of \( \Phi \), whose set is denoted by \( \Phi^* \), then such solutions will be called equivalent. The value \( B^*(p, \varphi_{k_0}) = \sum_{j=1}^{n} p_j f_{jk}^{*} \) is called the Bayesian value of the estimated functional for the solution of \( \varphi_{k_0} \in \Phi \). The Bayesian criterion is the most popular criterion in this information situation is that it is closely related to the axioms of utility theory (the axiom of Neumann and Morgenstern), in which the overall utility is defined as atematchyce expectations of individual utilities. If the estimation function is given in the form of \( F' \), instead of the operation max, the mathematical expectation uses min. The corresponding selection rule can be interpreted as follows. The matrix of the estimated functional \( F=\{f_{jk}\} \) is supplemented by another column containing the mathematical expectation of the values of each of the rows. The decision is made from the row of this column, which has the highest value.

The criterion for maximizing the probability distribution of the estimated functional. Set the value of \( \alpha \), which satisfies the next inequality [21]:

\[
a_1 < \alpha < a_2
\]

where \( \alpha = \min_{j} \min_{h} f_{jk}^{*} \),
\[
\alpha = \max_{j} \max_{h} f_{jk} \ (j=1,...,m)
\]
For every solution \( \varphi_{\text{in}} \in \Phi \) we determine the probability \( P(f^*_j k \geq \alpha) \) that the value of the estimated functional is not less than \( \alpha \) for the state of the medium \( \theta_j \in \Theta \) and the solution \( \varphi_k \in \Phi \). The essence of the criterion for maximizing the probability of the distribution of the estimated functional is to find the solution \( \varphi_{\text{in}} \in \Phi \) (or the set of such solutions), for which:

\[
P(f^*_j k \geq \alpha) = \max_{\varphi_k \in \Phi} P(f^*_j k \geq \alpha)
\]  

(5)

The corresponding rule of choice for this criterion can be formulated as follows. The matrix of probabilistic solutions is supplemented by two columns that contain in each row the minimum and maximum values of the corresponding matrix line. Then the third column is formed, in which each line is determined by the difference between a certain maximum and minimum values of the corresponding lines of the additional columns. The solution is selected from the last column by the maximum value of its line.

When using this criterion, the control body Y proceeds from the task of a specific value of \( \alpha \) and those solutions \( \varphi_{\text{in}} \in \Phi \), for which this condition is fulfilled, is considered optimal.

The criterion for minimizing the variance of the estimated functional. For each solution \( \varphi_k \in \Phi \) the mean value of the estimated functional and the variance in the form:

\[
B^*(p, \varphi_k) = \sum_{j=1}^{n} p_j f^*_j k ,
\]

is determined:

\[
\sigma^2 = \sigma^2(p, \varphi_k) = \sum_{j=1}^{n} \left[ f^*_j k - B^*(p, \varphi_k) \right]^2 p_j .
\]

(7)

The dispersion \( \sigma^2 \) characterizes the scattering of the random value of the value of the estimated functional for the solution \( \varphi_k \) of the mean value \( B^*(p, \varphi_k) \).

The choice rule for this criterion is expressed as follows. The matrix of probabilistic solutions is supplemented by another column containing the variance of the values of each of the rows. This column selects the minimum value, which is the best solution.

Modal criterion. The essence of this criterion is that the control body Y proceeds from the most probable state of the environment [19]. Assume that there is a single meaning

\[
p_j = \max_{\theta_j \in \Theta} P(\Theta = \theta_j) .
\]

(8)

When using this criterion, the control body Y believes that the medium is in the state \( \theta_j \in \Theta \) and is optimal \( \varphi_{\text{in}} \) (or \( \overline{\Phi} \)) determined from the condition:

\[
f^*_j k = \max_{\varphi_k \in \Phi} f^*_j k .
\]

(9)

If it turns out that the maximum \( P(\Theta = \theta_j) \) is reached on the a priori probabilities \( p_{j1}, p_{j2}, \ldots, p_{js} \), then the optimal solution \( \varphi_{\text{in}} \) (or \( \overline{\Phi} \)) is determined from the condition:

\[
\frac{1}{s} \sum_{j=1}^{s} f^*_j k = \max_{\varphi_k \in \Phi} \frac{1}{s} \sum_{j=1}^{s} f^*_j k .
\]

(10)

In accordance with this criterion, the rule of choice can be interpreted as follows. Each element of the matrix of the estimated functional is subtracted from the largest value of its line. New differences form the matrix of residues, which is supplemented by the column of the largest values in rows. From this column, the maximum value is chosen, which is a sought-after solution. The main disadvantage of this criterion is the possibility that if two solutions are taken \( \varphi_{\text{in}} \) and \( \varphi_{\text{in}} \) for which \( f^*_j k > f^*_j k \), then this criterion will predominantly be a solution \( \varphi_{\text{in}} \), that is \( \varphi_{\text{in}} > \varphi_{\text{in}} \). However, it may be that

\[
B^*(p, \varphi_{\text{in}}) < B^*(p, \varphi_{\text{in}}) .
\]
The main advantages of this criterion are:

- the adequacy of the detection of only the most probable environmental conditions. At the same time it is not necessary to know the quantitative values of the probabilities themselves of the realization of these states,
- the definition of the estimated functional only for the most probable states of the medium, which increases the rate of decision-making many times.

The criterion for the minimum entropy of the mathematical expectation of the estimated functional. Assume that $f_{jk}^+ > 0$ for all $j$ and $k$. Then the entropy of the mathematical expectation of the estimated functional $\varphi_k \in \Phi$ for a solution can be determined as follows [21]:

$$H(p, \varphi_k) = -\sum_{j=1}^{n} \left( \frac{p_j f_{jk}^+}{\sum_{j=1}^{n} p_j f_{jk}^+} \right) \ln \left( \frac{p_j f_{jk}^+}{\sum_{j=1}^{n} p_j f_{jk}^+} \right).$$  \hspace{1cm} (11)

The essence of this criterion is to find a solution $\varphi_{h_{m}}$ (or $\overline{\Phi}$) of the condition:

$$H(p, \varphi_{h_{m}}) = \min_{\varphi \in \Phi} H(p, \varphi).$$ \hspace{1cm} (12)

Modified criterion. In the modified criterion, it is necessary to fix the value of $\lambda$, which evaluates an event and satisfies the condition $0 \leq \lambda \leq 1$. For each value $\varphi \in \Phi$ the value [14]:

$$\chi(p, \varphi) = (1-\lambda)[B^{\star}(p, \varphi)]^2 - \lambda \sigma^2(p, \varphi),$$ \hspace{1cm} (13)

is denoted:

$$B^{\star}(p, \varphi) = \sum_{j=1}^{n} p_j f_{jk}^+,$$ \hspace{1cm} (14)

$$\sigma^2(p, \varphi) = \sum_{j=1}^{n} [f_{jk}^+ - B^{\star}(p, \varphi)]^2 p_j.$$ \hspace{1cm} (15)

The essence of the modified criterion is to find a solution $\varphi_{s}$ (or a set of solutions $\overline{\Phi}$) of the condition:

$$\chi(p, \varphi_{s}) = \max_{\varphi \in \Phi} \chi(p, \varphi).$$ \hspace{1cm} (16)

The choice of the decision on this criterion can be interpreted as follows. The matrix of the estimated functional consists of the entropy of each solution. After that, it is complemented by another column containing the minimum values in each row. Then, from each matrix element, the appropriate value for the row in this column is dropped. The differences form a new matrix of residues. Then on each line the mathematical expectation is determined and a new column is formed. The decision is made at the smallest value of the row of this column. It should be noted that in two separate cases, $\lambda = 0$ and $\lambda = 1$, this criterion coincides with the Bayesian criterion and with the criterion of the minimum dispersion of the estimated functional.

4. Experimental investigation of the control process

During trials of ergatic system "locomotive brigade - train" assessment of a machinist informative functioning capacity is done with the use of experimentally-statistic method. The ground for using of such approach is a method, which doesn’t impose any restrictions on the view of entering stream and the law of maintenance time distribution.

There were held analysis of locomotive brigades in freight traffic from the point of informative loading view. The total time of watching made 67 hours. In time of doing work LB receives variable information. For formalization of the task it’s necessary to express the quantity of information in the quantity of signals, which a person gets. Any new information or updating of any old information was considered as a new signal. Signal distributed in groups are given in a table 1.
Table 1. Groups of signals incoming into locomotive brigade for processing.

| Name of group                     | Characteristics of group                                                                 | General quantity of signals which arrived | Quantity of signals, which characterize abnormal state of system |
|-----------------------------------|------------------------------------------------------------------------------------------|------------------------------------------|---------------------------------------------------------------|
| Preparatory operations            | Passing through medical examination, getting of documents, instructing, getting of task | 60                                       | -                                                            |
| External factors                  | All signals which externally influence train operation such as state of rails surface, part of a day, current and following cutout and plan of railway track, weather and climate conditions | 1550                                     | -                                                            |
| Technical state of locomotive     | Is defined by a locomotive brigade during locomotives acceptance and their stay for job waiting | 150                                      | 5                                                            |
| Technical parameters of a train   | Are defined during connection of a locomotive with a train, trial of braking equipment and getting of documents for a train | 80                                       | -                                                            |
| Parameters of locomotive operation and state of train while moving | Are defined by means of all measuring and signaling devices control in the cabin of locomotive, accessible to locomotive brigade in process of moving, control of braking main state and inspection of a train composition while passing through bent areas | 10200                                    | 110                                                          |
| State of a rail section on the station | Is defined from the information about movement of maneuverable warehouses along station rails, from position of arrows, control of free rails, availability of overall dimensions, people transition | 3500                                     | 25                                                           |
| State of rail section during overdrive | Is defined from the control of railway free state and the condition of upper superstructure of track on significant distance | 1400                                     | 10                                                           |
| Position of signals               | Is defined from control of traffic lights, signal indicators, information from radio connection, manual signals | 510                                      | 5                                                            |
| Negotiation schedule              | Quantity of signals, which obtained by a brigade during execution of negotiation schedule | 2500                                     | 10                                                           |
| Other                             | All other signals, not connected with a train movement and a locomotive maintenance       | 50                                       | -                                                            |

In compliance with provided research the total number of signals which influences a locomotive brigade during movement constitutes approximately \( N_{\text{sig}} = 20000 \) for one trip, and quantity of signals, which denote abnormal situation \( N_{\text{ab}} = 165 \) for a trip.

One of important indicators in a machinist’s work is a time of signal processing \([22]\) – \( t_{\text{oc}} \). This time points upon the period between getting of signal by a person and completion of actions, which are enforceable to execution after given signal. For example, when getting a signal "busy passage" a machinist must move a handle of controller in a zero position and activate brake of a train –
depending on the situation use emergency or service brake and apply sand under the wheels. For these operations from 1.1 up to 8 seconds (dependently on kind of brake) are applied. In other case when getting signal "free passage" a machinist needs less than 1 second for processing of this information, evaluation of situation and decision taking about further train movement without control actions application. Generally during a train movement period of signal processing lays in the interval $0.3 \, \text{sec} < t_{oc} < 11 \, \text{sec}$.

When considering other groups of signals, we see that $t_{oc}$ is distributed as it is shown in a table 2. The laws of $t_{oc}$ values distribution for each group require additional research, but in further calculations we will come from the normal distribution processing periods distribution for signals with mathematical expectation in the point, which is an arithmetic average from the limits of time interval. This will not influence significantly on the procedure of further calculations.

Table 2. Signal processing time in groups.

| Name of group                                      | Minimum value $t_{oc}$, с | Maximum value $t_{oc}$, с | Calculated value $t_{oc}$, с |
|----------------------------------------------------|---------------------------|---------------------------|-----------------------------|
| Preparatory operations                              | 5                         | 90                        | 47.5                        |
| External factors                                    | 1                         | 2                         | 1.5                         |
| Technical state of locomotives                     | 0.5                       | 650                       | 325.25                      |
| Technical parameters of a train                    | 3                         | 300                       | 151.5                       |
| Working parameters of locomotive and state of a train during the movement | 0.5                       | 4                         | 2.25                        |
| State of railway section on the station             | 0.3                       | 15                        | 7.65                        |
| State of track section on train overdrive          | 0.3                       | 11                        | 5.65                        |
| Position of signals                                | 0.3                       | 11                        | 5.65                        |
| Negotiations schedule                              | 0.3                       | 2                         | 1.15                        |
| Other                                              | 1                         | 90                        | 45.5                        |

For assessment of informative loading on locomotive brigade during movement it is necessary to define thickness of intake stream of a certain group of signals using the formula:

$$\lambda_e = \frac{N_e}{T} \quad (17)$$

where $N_e$ – quantity of signals of the group named $e$, which came to a locomotive brigade; $T$ – total time of locomotive brigade in run, min.

Overall thickness of intake stream for a locomotive brigade will be:

$$\lambda = \sum_{e=1}^{k} \lambda_e \quad (18)$$

where $k$ – quantity of groups of signals.

During the research procedure it was found that quantity of signals in different groups changes with time. As an example in the figure 1 there given alteration $\lambda_e$ of signals in 0.5 hour of a trip. Here you can see, that in process of a train running along the span total quantity of signals, which comes to a locomotive brigade, makes approximately 75 per minute, and while following the station reaches up to 150 per minute. Thus it is possible to say, that LB works in a highly loaded informative space and not always may respond and evaluate all scale of signals incoming from outside.

Quantity of information, which comes to a machinist is possible to evaluate with help of informative theory methods in binary units per second [23]:

$$I(x_i) = - \log_2 p(x_i) \quad (19)$$

where $p(x_i)$ – probability of the event named $i$. 
Figure 1. Alteration of incoming stream thickness during trip: 1 – parameters of locomotive operation and condition of train in process of movement; 2 – condition of track section on the station; 3 – condition of track section on the overtake; 4 – location of signals; 5 – negotiations schedule.

Probabilities of concrete signals emergence are different. So, for example, probabilities of a green signal from anadromous traffic light makes \( p(x) = 0.33 \), because three readings – green, yellow, red are possible. When lessening of \( p(x) \) value the quantity of information from \( x \) event increases [24, 25]. But there exists a series of signals with very high occurrence probability and in some cases approaches to unit one: freedom of track on the stretch, actual state of upper superstructure of a railway track and a contact hanging, visual signs of carriages composition integrity in a train.

Figure 2. Dependence of quantity of information, got by LB per second from the thickness of signal with a different probability.

Assumption of the fact that probability of each signal emergence is 0.5 makes it possible informative loading of locomotive brigade in dependence on the quantity of signals per minute (figure 2).

5. Development of an information model of the management process

In general view the seed of information receiving is possible to identify using the formula:

\[
V_{\text{inf}} = -\log_2 p(x) \cdot \lambda / 60, \text{ bps}
\]  

(20)

From the data given it’s clear that informative loading of locomotive brigade in calculations with given assumptions approaches to limiting possible values, which make 2–4 bps.

For attaining of more exact information loading of locomotive brigades data it’s necessary to develop improved calculation method.
According to (19) quantity of information depends on the probability $p(x_i)$ – probability of event named $i$. Events may be divided in groups up to the quantity of results. Events which may lead to two mutually exclusive results we will name as elementary (for example, position of arrow may be correct or incorrect). Events, which lead to several results, may be named as events of grade named $n$ depending on the number of $n$ outcomes. So event "yellow signal of traffic light" is an event of the 3$^{rd}$ grade, because there exist three variants of signals – red, yellow, green.

Grade increase causes its informative value growth (figure 3).

![Figure 3. Dependence of informative quantity on event grade.](image)

Analysis of events (signals) quality, which enter locomotive brigade denote absolute majority of elementary events in comparison with other: 2$^{-}$nd grade – 17800 surveillances; 3$^{-}$rd grade – 1990 surveillances; 4-th grade – 630 surveillances; 5-th grade – 200 surveillances; 6-th grade – 220 surveillances; 7-th grade – 80 surveillances.

Besides, informative functioning capacity is influenced with a result of signal getting by a machinist. In dependence with one or the other event a machinist must accept a decision about control actions correction or about absence of necessity to make such correction. Then the quantity of information $I(x_i)$ from the event $x_i$ will be a complicated function, which depends on the quantity of information, which a machinist gets supplementary before the eventual decision taking.

The model of machinist’s actions in time of event emergence, which requires acceptance of control decisions, is given in the figure 4.

![Figure 4. Informative model of control decisions taking by a locomotive machinist.](image)

Thus speed of information receipt to a locomotive brigade from one group of signals may be calculated as:

$$V_{inf.e} = \lambda \left( - \log_2 p(x_i) - \sum_{j=1}^{n} \log_2 p(x_j) \right) \frac{V_{inf.e}}{60}$$

(21)
And in general the information gets a locomotive brigade with a speed:

\[ V_{inf} = -\sum_{i=1}^{k} \left( \log_2 p(x_i) + \sum_{j=1}^{n} \log_2 p(x_{ij}) \right) \cdot \frac{\lambda_e}{60} \]  

(22)

where \( p(x_i) \) – probability of the main event named \( i \); \( n \) – quantity of signals, which should be obtained by a machinist supplementary for decision on correction of control actions taking when event \( x_i \) emerges; \( p(x_{ij}) \) – probability of supplementary event named \( j \), which is considered by a machinist when event \( x_i \) emerges; \( \lambda_e \) – thickness of intake stream of a certain group of signals, 1/min; \( k \) – quantity of groups of signals.

Thus there was got an expression to define informative expression to define informative functioning capacity in process of train control loading. Its difference lays in consideration of supplementary scale of information, which accompanies acceptance of each control decision. According to calculations, taking into account the number of decisions, which are taken by a person during the trip, real informative functioning capacity is 25–32 % more, than it was considered in existing method of calculation.

6. Conclusions

In the process of driving the train to ensure traffic safety, the locomotive brigade has to face the choice and making sound decisions based on information situations with varying degrees of uncertainty. For the formalization of such situations and human actions, a method is proposed for evaluating the adoption of rational management decisions in conditions of uncertainty. Evaluation is carried out with the help of an estimating functional, which is a matrix of quantitative estimates of the decision and can express such concepts as efficiency, utility, loss, risk, etc.

In conformity with conducted researches the general quantity of signals, which influences a locomotive brigade in process of movement makes approximately 20000 for a trip, and quantity of signals, which indicate abnormal situation reaches 165 for one trip. In process of a train movement the period of signal processing lays in the interval \( 0.3 \) sec \(< t_{oc} < 11 \) sec. It was defined that informative functioning capacity of a locomotive brigade in calculations with given assumptions approaches to boundary values which are 2–4 bps.

Obtained in process of work expression (22) allows to estimate parameters of informative functioning capacity on a locomotive brigade. Unlike to existing models represented approach allows to take into account supplementary information, which should be taken into account when taking control decisions. This gives possibility to define ways to reduce informative functioning capacity on a locomotive brigade. The main measures for this should be complex automation of locomotive control: transference of technical state locomotive functions control during the trip on the automated system, which should signalize just only in cases, when parameters deviate from the norm and the system is unable to correct them independently; development of intellectual system, which gives advices to a machinist about the most efficient positioning of locomotive control in a certain train situation, that may partially avert informative streams from a machinist.

7. References

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