ЗАКЛЮЧЕНИЕ

Предлагаемые методы распределения зон и функций управления между дежурными по техническим станциям, основанные на количественной оценке загруженности оперативно-диспетчерского персонала и длительностей задержек конфликтных передвижений, создают предпосылки к выбору научно обоснованных технических решений по организации рабочих мест при строительстве и модернизации систем железнодорожной автоматики и телемеханики.

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DISTRIBUTION OF MANAGEMENT AREAS AND FUNCTIONS OF OPERATING PERSONNEL

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ABSTRACT

Need to reconstruct the electric centralization of train station creates a problem of rational distribution of functions and management areas between station operators, which requires not to exceed the rate of workload of personnel and to ensure the best conditions for technological operations. Complexity of the problem is exacerbated by the lack of theoretical and practical methods of quantitative assessment of results of alleged use of various options for solving the problem in order to select the best of them. The article contains a summary of the adjusted method of quantitative assessment of station officers' workload at train stations at different ways of organizing their work places and different volume of movement based on the algorithmic description of the contents of the personnel's labor.

ENGLISH SUMMARY

Background.

The authors investigate method for calculation of station officers' workload at train stations, which is based on the algorithmic description of the contents of their work.

Workload of station officers at train stations is determined mainly by following factors:

– Parameters of gridiron of tracks (number and effective length of tracks, design of leads and location of crossover tracks with parks and locomotive depots);

– Technology of yard operation (train composition of different lengths and weights, combining of trains, maintenance of cars);

– Organization of traction service (change of locomotives, crews, diesel and electric traction, connecting the traction current);

– Volume of train, shunting and local operations;

– The level of the station's equipment with railway automation and remote control systems (distribution of management areas, implemented in the construction of the control board and panel, displaying data on the screen);

– Means and quality of technological communication;

– Opportunities and quality of used automated information systems (content, completeness and forms of input and output information, the amount of manual data entry in automated working stations);

– Organization of repair and maintenance of infrastructure.

Objective.

The objective of the authors is to investigate different aspects of a workload of station officers and to propose an appropriate method for its calculation in terms of management areas' distribution.

Methods.

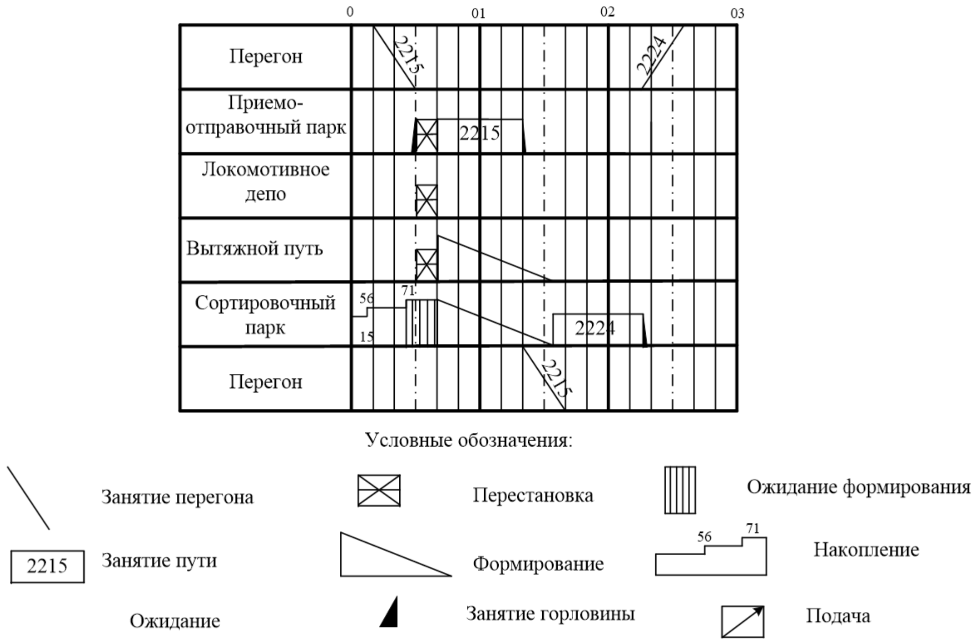
The authors use mathematical method, analysis and descriptive method.

Results.

As noted in [1], taking into account such a wide range of significant factors in quantifying workload of station officers is only possible on the basis of formal algorithmic description of their actions to manage traffic process.

By analyzing technological processes, which are carried out at train stations, a list of management tasks that can be solved by station officers is determined: assessment and prediction of state for the controlled system F_{21}; receiving a freight train F_{22}; departure of a freight train F_{23}; receiving and departure of a passenger train F_{24}; reception and departure of a service train F_{25}; handling of transit freight trains F_{26}; placement/displacement of cars to approach lines F_{27}; moving of a train to a humping track F_{28}.

With induction of an assistant of a station officer (at control desk of electric interlocking), this station officer gets a duty to give him instructions and check their performance, and the assistant at the control desk of electric interlocking also gets a task: receiving and execution of orders, given by station officer F_{31}.



Pic. 1. Fragment of a daily schedule, when priority is given to a change of a transit train locomotive.

I.e. coordination of actions between them is required in the process of solving management problems.

Additional tasks of a station officer include traffic organization by works of repair, maintenance and restoration of technical facilities' failures, shutdown of centralization arrows and isolated areas, deenergisation of a catenary system, in emergency situations, etc.

For algorithmic description of solving management problems it is proposed to use the language of LSA [2], as amended by entry format [3], which simplifies recording algorithms and calculations.

Features of the content of personnel's work make it possible to restrict the set of following algorithms: D – talks through all forms of communication; S – reading information from the clock, remote-board, monitors ACS, journals and notes; R -recording of data and its input in the ACS; E – remembering information; C – calculation and comparison of information; A – making decisions on management of a system depending on fulfillment of a logical condition P; W – transmission of a management command of a technological process through technical means (control, automated working station); K – number of repetitions of an algorithm block in brackets.

In [4] a method for calculating the workload of operating and dispatching personnel is proposed for the general case of many branches in the algorithm for solving management task, based on the raising the matrix of logical conditions to the sequentially increasing the power.

The proposed rules for constructing algorithms, created with due regard for features of work tasks of operating dispatching personnel, greatly simplify calculations and analysis of the dependence of workload from the most significant factors.

Rule 1. *Each logical condition P_i, i = 1, 2,..., n has two outcomes: compliance with the conditions with probability q_i and failure to comply with probability $1 – q_i$*

Rule 2. *When logical condition Pi is met, the next block of algorithm operators G_i, i = 1, 2, ..., k is executed.*

Rule 3. *Failure to comply with logical condition Pi leads to execution of the block of algorithm operators G_j, j = 1, 2, ..., m, specified by operators of transition B_i and (B_i G_j) and co-located with one of them in brackets.*

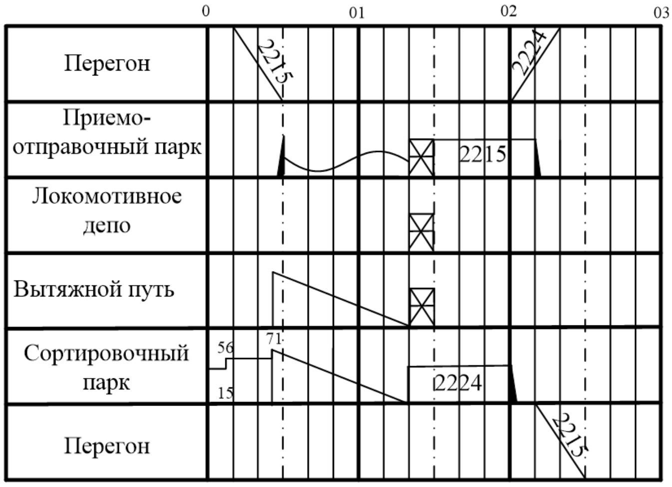
Rule 4. *Block of operators G_i must precede the block of operators G_j.*

Rule 5. *Logical condition Pi should be formulated so that when it is met, an additional block of algorithms G_i, i = 1,2,..., k is to be performed and in particular prior to the main block of an algorithm G_j, j = 1, 2, ..., m only under conditions that hinder execution of algorithms of the main block.*

Rule 6. *Simultaneous use of algorithm operators are not permitted, as workload of operating dispatching personnel should be calculated only in sequential involvement of algorithm operators in the process, which corresponds to normal operating conditions.*

Algorithm fragment illustrates the use of the rules of its construction: $D_i E_i C_i A_i P_i B_i G_i (B_i G_j)$.

Operators of an algorithm D_i E_i C_i inform a station officer on the presence or absence of free track to receive a train. Logical condition P_i in the task «receiving of a train to the station» should be formulated as a «free track to receive a train is missing» and the block of an algorithm G_i must contain a sequence of actions of a station officer in the absence of a free track (taking measures to accelerate to free a track, departure delay of the train from neighboring station, etc.). In the presence of free track logical condition P_i is not met. Therefore, operators of transition B_i and (B_i G_j) exclude performance of algorithms of the additional block G_i and ensure performance of algorithms of the main block of operators Gj, corresponding to the actions of a station officer in case of presence of a free receiving track.



Pic.2. Fragment of a daily schedule, when priority is given to departure of a train of its composition.

The proposed rules of writing algorithms simplify programming calculations of personnel's workload and allow using tables Microsoft-Excel, as shown by the example of the algorithm F_i:

$F_i = D_i E_i C_i A_i P_i B_i G_i (B_i G_j) D_{i+1} E_{i+1} C_{i+1} A_{i+1} + P_{i+1} \ldots$

If operators of an algorithm are replaced with relevant duration of operations' performance t_i with their numbers and logical conditions – estimates of compliance probability q_i and $1 – q_i$, then the time spent on solution of a management task will be:

$TF_i = t_{Di} + t_{Ei} + t_{Ci} + t_{Ai} + q_i t_{Gi} + (1 – q_i)\, t_{Gj} + t_{Di+1} + t_{Ei+1} + t_{Ci+1} + t_{Ai+1} + q_{i+1}\, t_{Gi+1} \ldots$, *where t_{Gi} and t_{Gj} – total time spent on performance of block of algorithm operators Gi and Gj.*

Based on the above the following procedure for calculating the amount of time spent by an operative employee on solving a management task is proposed:

1. The time spent on the execution of the algorithm operators is summarized from the beginning of the recording to the first logical condition $P_i B_i$.

2. The time spent on the execution of additional block of the algorithm t_{Gi}, located behind the first logical condition $P_i B_i$ is summarized.

3. This sum t_{Gi} is multiplied by the value of probability assessment of compliance with the first logical condition q_i.

4. Resulting sum is added to the sum of paragraph 1.

5. The time spent on execution of the main block of operators of the algorithm G_j, located in brackets together with a pointer of transition of the algorithm B_i to actions in case of non-compliance of P_i with the first logical condition ($B_i G_j$).

6. This sum t_{Gj} is multiplied by the value of probability assessment of non-compliance with the logical condition ($1 – q_i$).

7. Resulting sum is added to the sum of paragraph 4.

8. Calculation continues similar to paragraphs 1–7 for all following elements of the algorithm.

Workload of an operative worker T_{oi} is determined by time spent on resolving all management tasks during one shift with duration of 12 h (720 min) depending on the time spent on solving each task T_{Fei}, T_{Fpi}, T_{Fmi} and the number of tasks of each type N_{ei}, N_{pi}, N_{mi}...

$T_{oi} = T_{Fei} N_{ei} + T_{Fpi} N_{pi} + T_{Fmi} N_{mi}$,

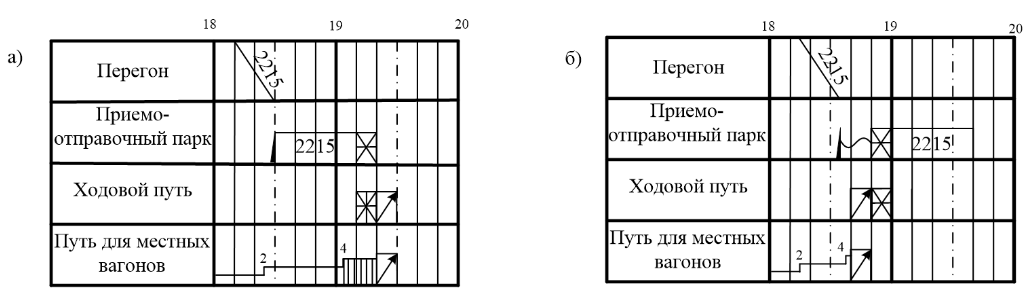
Sources of information about the maximum number of movements, organized by station officer during day and night shifts, are timetables, station logs, and statistics.

This method determines all elements of time costs of a station officer depending on these factors.

Example of calculation of time spent on solving each management task and workload of a station officer of a train station is shown in Table 1.

The size of management area of an operative worker must be set so that his workload does not exceed permissible level established in [5, 6], for workload coefficient

$K_з = (T_{oi} + 72) / 720 \times 100\% \le 95\%$, *where 72 min – time allocated for an operative working during the shift to relaxation and personal needs.*



Pic.3. Fragments of a daily schedule in case of distribution of management areas at rail bottlenecks.

Table 2 shows the results of calculations for workload of a station officer, taken as an example, for day and night shifts, depending on the volume of movement of transit freight trains at constant volume of movement of passenger and commuter trains in the conditions of studied options for the allocation of functions and management areas.

N1, N2, N3 – number of pairs of transit freight trains in the shift from the existing to the maximum; in the numerator there are parameter values for the day shift, in the denominator – for the night.

Calculations show that the maximum number of transit freight trains can be handled during one shift, not exceeding the permissible workload of a station officer, in the allocation of their management areas on the station parks.

Distribution of management areas between station officers due to the norms of their workload creates conflict movements, due to the need to use elements of gridiron of tracks, which are located in the management area of a neighboring station officer. In connection with it, a method is proposed for assessing the impact of the distribution of functions and traffic management areas between station officers on the performance indicators of a station, which are based on computer modeling and analysis of situations that arise in the process of constructing daily schedules. The approach is illustrated by examples of priority selection for conflict movements.

In the distribution of management areas between station officers in the station parks and simultaneous need to change a locomotive of a transit train № 2215 and composition of a train, it is necessary to occupy a turnout track, which is in the management area of a station officer of receiving-departure park.

If the turnout track is first taken by the train locomotive, directed at the depot, and then train locomotive, which is moved from the depot to the train № 2215 (Pic. 1), a train, subject to composition, will be idle waiting for the possibility of movement from classification yard to turnout track. As a result, composition of a train № 2224, which will depart from the station at 02.18 is delayed. Change of a locomotive of the transit train № 2215 takes minimal time and the train will depart at 01.20.

If turnout track is first occupied by a train to be composed (Pic. 2), the change of a train locomotive is delayed and the train № 2215 will depart at 02.10 with a delay of 50 minutes, and the train number of its composition № 2224 at 02.00.

Thus, when such a conflict arises, station officers should make a choice – to keep a transit train for 50 min or to send a train of its composition later in 14 min.

In case of division of management areas to rail bottlenecks common elements of gridiron of tracks (open track, etc.) appear. In case of simultaneous need to move a train locomotive to the depot and a train to approach line, a need to use open track appears. If priority is given to the movement of the locomotive (Pic. 3a), layover of a train in anticipation of movement will be 17 minutes, and if train (Pic. 3b) first begins to move, layover of a locomotive will be 15 minutes.

Criterion for priority selection for conflict movements is to minimize cost of losses due to delays, quantitative assessment of which depends on a complex set of factors. Therefore, decisions about priorities of conflict movements on the station are made based on expert assessment of their importance for achieving the goals of the management area and the station.

Attention should be paid also to the fact that distribution of management areas to the parks of the station, turnout track will be in the management area of station officer of receiving-departure park and priority will be given to accelerated departure of transit trains with a change of locomotive and not to local operation. A similar situation arises in the allocation of management areas at rail bottlenecks. For decision-making to a greater extent consistent with the objectives of the station, it is advisable to transfer functions of a shift supervisor to a shunting dispatcher and provide him with information on the situation at the station and the approach of trains.

Conclusion. *Proposed methods of distribution of areas and management functions between station officers at train stations, based on quantifying workload of operative dispatching personnel and duration of delays of conflict movements, predetermine selection of scientifically based technical solutions for the organization of work places in the construction and modernization of railway automation and remote control.*

Keywords: railway, train stations, traffic management areas, algorithms, functions, operating personnel, workload calculation, methods of organization.

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