DETERMINING PARAMETERS OF SCHEDULED MAINTENANCE WORK-INTERVALS WITHIN THE ASSESSMENT OF FUTURE TRANSPORTATION CAPACITY

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ABSTRACT

The article contains a description of the simulation method, required for a quantitative study of modernization stages and repairs of the railway infrastructure. Its use is particularly important in the development of growing traffic volumes with the expectation of long-term perspective and subject of lengthy work-intervals (breaks in traffic for maintenance works), reducing the capacity of lines operated.

Keywords: *railway infrastructure, modernization, repair, carrying capacity, simulation.*

Background. *The task of quantifying opportunities of handling promising cargo volumes on railroad lines compared with options for infrastructure development in the long- term perspective of 5, 10 or more years is decided today on the basis of simulation of transportation process [1], developed and constantly modified by the community of scholars in academic, industry and university research.*

Modernization and repair of rail infrastructure require the provision of long-term work-intervals (breaks in traffic), reducing the capacity of single-track lines, according to expert estimates, by 15–20%, and of double- track lines – by 12–15%.

Railway specialists, so it is accepted, prepare plans to upgrade and repair the infrastructure only for the next year that can reliably take into account the possibility of providing workforce, equipment and materials [2] only for a limited period of time. Therefore, the relevance of the simulation method to study the stages of modernization programs is still high, and taking care of minimizing the costs of development of the projected traffic volumes in view of optimizing the parameters of breaks is gaining more weight on the background of the economic problems in recent years.

Objective. *The objective of the authors is to present a simulation method, required for a quantitative study of modernization stages and repair of the railway infrastructure.*

Methods. *The authors use analysis, comparative method, evaluation, simulation and mathematical methods.*

Results.

I.

The greatest number of breaks is available for track facilities of railways as complex in technology and duration works are carried out by the complex of track machines and service trains. On the other infrastructure facilities there are enough technological intervals, provided for by regulatory train timetable for engineering works. It is logical to assume that in this case the number and duration of intervals in the long term should be defined according to the needs of track operations.

Performance of track works is regulated by technical conditions [3], which apply to the sections with handling of freight trains with axle loads of up to 25 kN / axis, speeds of up to 140 km / h and passenger trains at speeds of up to 200 km / h. Types of repair and its implementation scheme are determined depending on class, group and category of the railway track.

The main type of repair is assigned for the current year if the running time of tonnage (G_C) reaches the norm (G_{CH}), or if it is time for such repairs in the calculation of inter-repair cycle in years. For railway directions relating to the first class, group A, categories 1–3 and C, Gсн = 700 million tons. The intermediate repairs are distributed evenly between years or missed tonnage.

The main types of repair include:

1. Modernization (reconstruction) of railway track.
2. Overhaul on used materials.
3. Replacement of switches.

Intermediate repairs include:

1. Mid-life repair.
2. Preventative maintenance.
3. Complete interchange of rails and metal parts of switches.
4. Grinding of rails.

After determining the timing of repairs for each of their kind schedules are formed for provision of work-intervals showing locations, dates and duration of interruptions in motion.

Long-term work-intervals with the involvement of station track machines (STM) are available for the following types of work:

1. Modernization (reconstruction) of railway track.
2. Overhaul on used materials.
3. Mid-life repair.
4. Interchange of switches.

Technology of formation of schedules of work-intervals for modernization and overhaul on used materials are identical and apply to all infrastructure facilities: track, man-made facilities, signaling, technological communication, electrical power supply, etc.

To replace switches work-intervals are provided, the duration of which is determined by the rules with account of local conditions. Opportunities to carry out works simultaneously with modernization or enhanced mid-life repair are checked, if their terms coincide with each other, and operations on replacement of switches do not interfere the movement of track equipment.

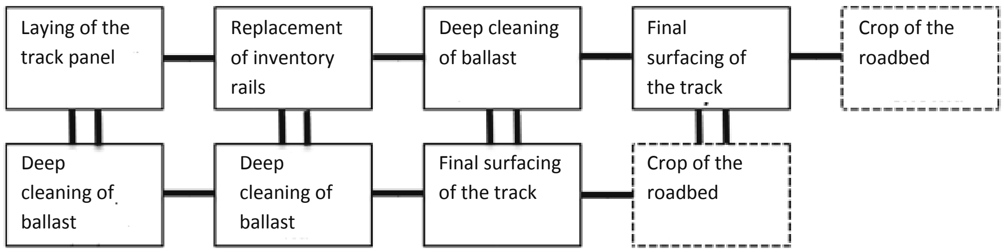
Long-term work-intervals are available for main repairs and preparation and final (finishing) works fit into the technological intervals.

An exception is the crop of roadbed, which follows the final surfacing and dynamic track stabilization. Such a finishing operation is performed during technological breaks, combined with a final surfacing, but partly also requires the use of long-term work-intervals.

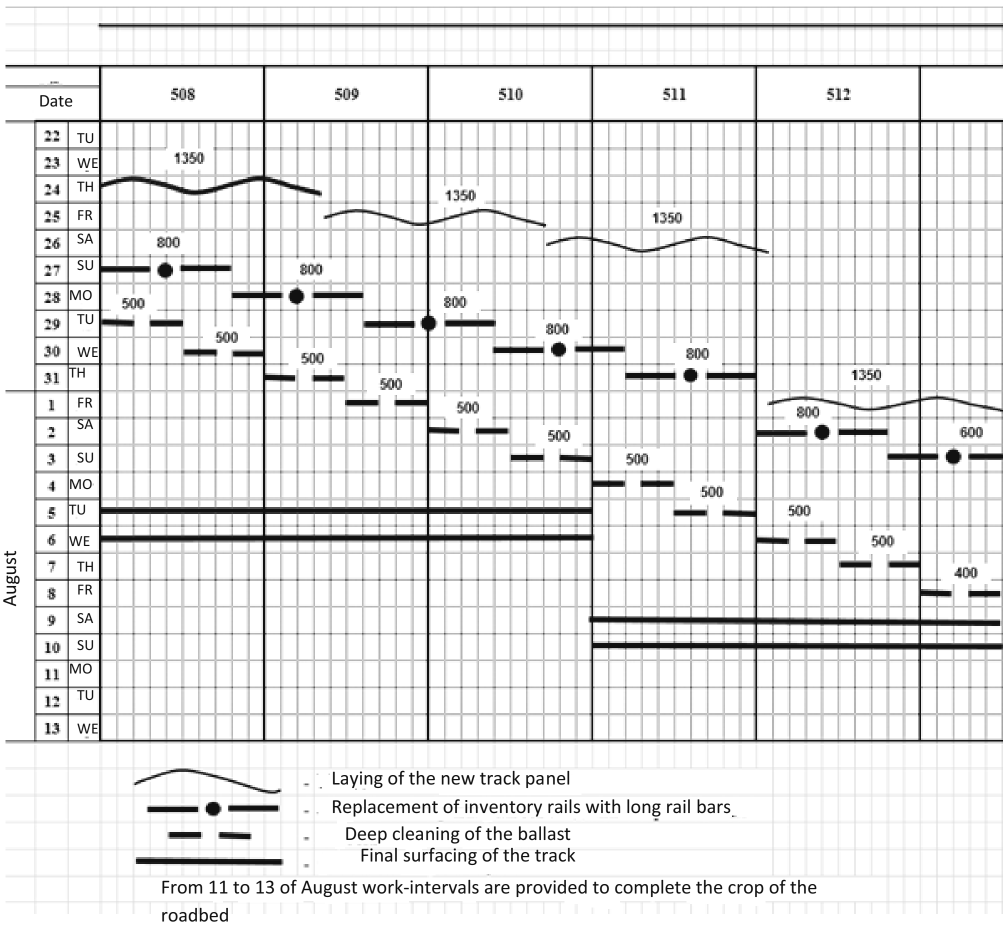
Table 1

Regulatory and average performance of track works, m

Types of works	Duration of work-interval, h			
	Regulatory value		Average value	
	8 h	10 h	8 h	10 h
Laying of the track panel	1350	1500	1150	1350
Replacement of inventory rails	800	1200	600	800
Final surfacing of the track	700	900	700	900
Final surfacing of the track (TM "Doumatik")	3 km/shift			
Crop of the roadbed	300–1500	500–1700	300–1500	500–1700



Pic. 1. The sequence of works, requiring the provision of long-term work-intervals in the modernization of railway track and the possibility of their combination.



Pic. 2. Schedule of modernization of the railway track with the provision of eight-hour work-interval.

Table 2

Dependence of working time from the organization of repair works

Duration of works, h	Three work-intervals of 8 hours	Closing the haul
Repair works	15	15
Nonproductive operations	9	3
Total duration of operations	24	18
Occupation of equipment	72	18

Performance is dependent on the profile of the roadbed and is measured in m^3, so when transferred into meters of railway track its performance based on local conditions vary over a wide range from 300 to 1500 m in the eight-hour work-intervals.

The possibility of partial implementation of crop of the roadbed during the technological work-intervals complicates calculation of the required amount in the preparation of their work schedules. Therefore, based on the real experience it is offered for sections of less than 12 km to allocate for crop of the roadbed additional three eight-hour or two ten-hour intervals. With a section length of more than 12 km it is possible to perform this work only in the technological and combined work-intervals without allocation of long work-intervals.

II.

The main types of repair work in the modernization of the railway track are [4]:

1. Preservation of long rail bars.
2. Laying new track panels.
3. Change of inventory rails on long rail bars.
4. Deep cleaning of ballast.
5. Final surfacing of the track.

Recently long rail bars are not kept, thereby reducing the number of available intervals. Rail bars are cut into pieces of 25 m and taken together with the old track panel, and in its place a new one is laid with new inventory rails.

After that, during technological work-intervals a rail-carrying train delivers and unloads inside the gauge long rail bars, which in the coming long work-intervals replace inventory rails. New rail bars are welded and fixed, creating a continuous welded rail.

The next step is the deep cleaning of ballast using reclamation plants. After completion of sufficient works the final surfacing of the track is performed, at the same time its dynamic stabilization is carried out. In the final crop of the roadbed is made, giving it the form in accordance with the project.

After the full range of track works a track measurement car moves, on the basis of which the decision on the amount of permissible speed of trains on the site is made.

To reduce the number of work-intervals a part of the repair operations is permitted during combined work-intervals. The condition for this is to create a sufficient distance between the end of the first and beginning of the second field of operations to avoid delay of track equipment moving in the same direction of, to ensure security and efficiency of the process.

Regulatory and average performance of track works is listed in Table 1.

When closing the final haul the performance of railway track modernization on all types of works and expert evaluation is in the range of 1, 25 to 2 km / day.

The consistent performance of works, requiring the provision of long-term work-intervals is shown in Pic. 1 by horizontal lines, and the ability to simultaneously produce them in the combined work-intervals – by vertical lines.

The performance of deep cleaning of ballast is the minimum among other types of repairs (see. Table 1). Therefore it is necessary to perform this operation as much as possible in the combined work-intervals that will have a schedule with a minimum number of intervals.

To begin the final surfacing of the track a section is required after deep cleaning of ballast with the length of no less than 3 km, because this work is done with the highest performance.

The fragment of schedule of work-intervals, lasting 8 hours for the modernization of the railway track, is demonstrated in Pic. 2.

In the schedule in the eight-hour work-intervals the first is the field of operations with the length of 1350 m on laying of the track panel. After completion of the section of 4 km works on replacement of inventory rails begin, the performance on the stage of the eight-hour work-intervals is 800 m.

Replacement of inventory rails for two such work-intervals allows deep cleaning of ballast in combined work-intervals. It is impossible to start works earlier due to insufficient distance to place track equipment.

After the replacement of inventory rails at the field of works with the length of 4 km another work-intervals is provided to lay a track panel and two work-intervals to replace inventory rails, which are combined with the deep cleaning of ballast.

The final surfacing of the track with capacity of 3 km during the work-intervals is performed twice. Two work-intervals with the final surfacing and the dynamic track stabilization are combined with works on the deep cleaning of ballast.

For the crop of the roadbed three additional work-intervals of 8 hours are provided.

III.

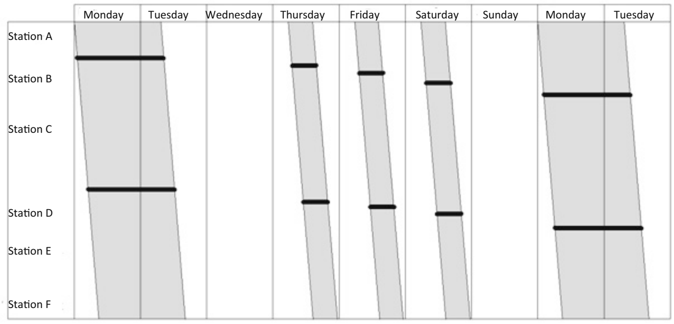
On the railway network of the Russian Federation three technologies to organize track repairs are used:

1. Execution of the program in the work-intervals of 8, 10 and 12 hours.
2. Closing the haul for the period of repair work (5–6 days).
3. Repairs on a seven-day schedule.

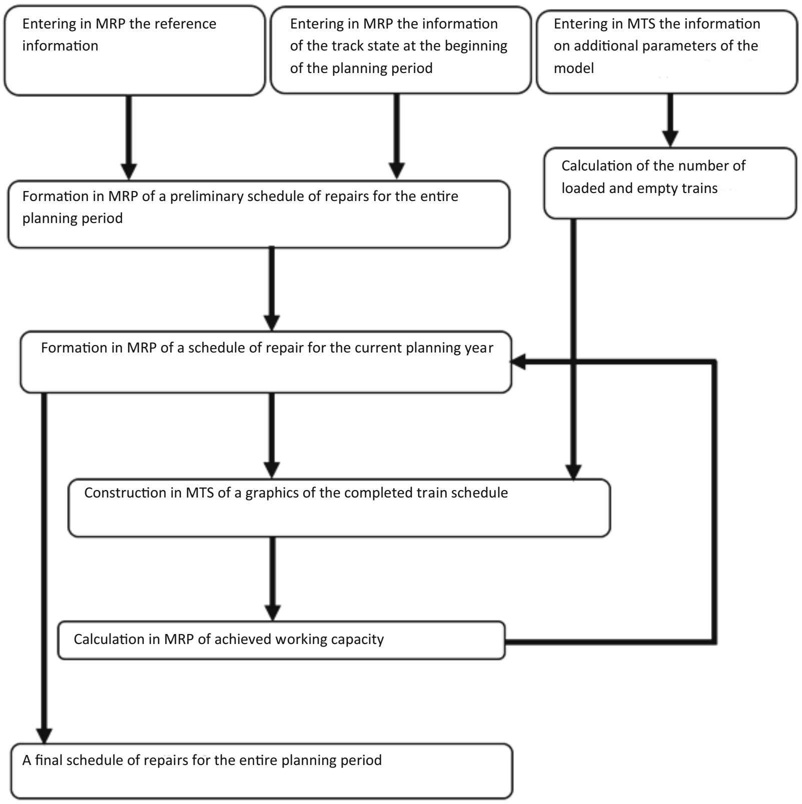
The choice of the option is related to the level of carrying capacity usage, the presence of parallel rail lines, technical equipment (presence of bilateral auto-lock) and the operation of the railway section (handling of heavy, long and combined trains).

The highest performance is achieved by repair work on the closed haul, and the lowest – in terms of work-intervals of 8 hours. This is due to the fact that with increasing duration of the work-intervals reduce loss of time and energy delivery of track machines to the scene and back, the organization and maintenance of the production processes themselves.

The situation with the performance is easily seen in the deep cleaning of ballast, which determines the duration of the full range of track works. With total investment of time of three hours on the movement of track equipment back and forth, as well as the preparation and conduction of work operations are



Pic. 3. The seven-day schedule of repairs.



Pic. 4. Flow chart of interaction processes of MRP and MTS.

obtained depending on the length of work-intervals duration, presented in Table 2.

Since each work-intervals is available in some day, in case of haul closing not only the total duration of repairs reduces, but also the number of days when the track equipment is at the repair area (from 72 to 18 hours). This technique allows increasing productivity by using it in the other sections.

In case of haul closing operations are conducted twenty-four-hour, usually involving several STM. Operating expenses decrease by 1,5 to 2 times, by 70% – the need for locomotives for service trains, by 1,5–2 times – the costs of empty runs of service trains [5]. The disadvantage of the technology used is the reduction in the capacity of the railway section caused by the long handling of trains on the same track of double-track haul in both directions.

Specialists of Kuibyshev Railway recognize as an intermediate option the organization of works on a seven-day schedule, which they proposed. This technique (Pic. 3) provides at the same weekdays alteration of work-intervals of large (14–32 h) and low (8 h) length with days without intervals, that allows to handle a predetermined number of trains per week in intervals between the work-intervals [6].

On the graph inclined lines show the location of work-intervals and horizontal – the venue of repairs, and at the section A-B the first STM operates, and at the section B-E – the second.

On Wednesday (field day) work-intervals are not available, and the alternate schedule provides handling of the maximum number of freight trains. From Thursday to Saturday work-intervals of 8 hours are offered, and on Sunday a field day is planned.

The advantage of this technology is a fixed number of handling trains for a week due to the cyclicality of works that smoothes uneven movement on different days and provides handling of the planned number of trains [7].

The duration of large work-intervals is calculated based on the need to handle the entire train stream on the repaired section and parallel lines.

The analysis of planning, organizing and carrying out repairs is a basis of computer technology, determining the need for work-intervals with projected traffic volume. It is necessary to assess the adequacy of carrying capacity in the implementation of the proposed options for the infrastructure development with the help of rail transportation process simulation [8–9].

A system basis of this technology is a flow chart (Pic. 4) of interaction processes of modernized due to the adoption of new technological conditions of the module of repairs planning (MRP) and module of transportation simulation (MTS) [10–11] in the formation of the schedule of work-intervals of large duration.

To start MRP it is necessary to enter the reference data of classes, groups and categories of tracks, regulations and schemes of repairs, performance of work, parameters of loaded and empty trains, as well as data on the state of the track at the beginning of the planning period.

On the basis of such information MRP gives graphics of repairs for the entire planning period, containing information about the places, the amount, duration of provided work-intervals and additional restrictions of train speed. Graphics settings are entered in MTS, together with promising traffic volumes.

As a result of simulation MTS builds the schedule of the completed train traffic schedule, calculates capacity and carrying capacity in terms of intervals. This information is exported to MRP where working capacity is calculated at the end of the year of the simulation beginning, a plan of work-intervals is adjusted, which is then transmitted to MTS.

Modeling and adjustment of schedule for repair works is going on all the specified planning period. If the date of completion of the work in any area goes beyond the last day of the last month of repairs, it is planned to use an additional STM.

If there are no conditions for the handling of the required number of freight trains on the repair area the deflection of the train stream to parallel tracks is tested.

Conclusion. *The study resulted in development of a method of simulation of processes of rail traffic that takes into account possibility to combine different maintenance and repair works in order to better define parameters of scheduled lengthy work-intervals, and that is suitable to numerically substantiate sufficiency of modernization stages of rail infrastructure to enable growing transportation for a long future period.*

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