INTERACTION OF RAILWAY STATIONS WITH CARGO TERMINALS AT THE PLACES OF NON-PUBLIC USE

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ABSTRACT

The authors set a task, using clearly organized service information, to achieve optimization of the process of formation of multi-group assorted trains and freight deliveries at railway stations with a detailed selection of groups of cars by the specified criteria. The suggested model of control of local operations will remove inter alia the problems of spasmodic, uncoordinated delivery of cargo to transshipment points, will optimize the interaction of marshalling yards and freight terminals at the places of non-public use.

Keywords: railway station, cargo terminal, management, places of non-public use, interaction, optimization, multi-group trains, assorted trains, local work.

Background. *One of the reasons for non-optimal interaction of railway stations with cargo terminals is spasmodic and uncoordinated delivery of goods to transshipment points. And here, in fact, we face the emergence of a clear management task, in this situation, to optimize the process of formation of multi-group assorted trains and cargo deliveries at stations with a detailed selection of groups of cars by the specified criteria. This task includes a selection of cars on the stations of the section, areas of local work, access roads and cargo fronts of stations, rolling stock owners, types of rolling stock and its current state (laden and empty), types of filling for empty tanks, types of cargo transported, technical condition of cars (run, year of construction, thickness of a wheel flange), by type of repair of faulty units of the park.*

The analysis shows that at all marshalling yards of the railway network compositions of assorted trains and cargo deliveries include rather a small number of groups (no more than 5–7 in the train) with inclusions of cars without their selection at a number of stations or freight fronts. As a result, the average duration of stay of an assorted train at intermediate stations remains high, and is due to the fact that the processing of a local car flow is transferred from technical to the so-called reference intermediate stations. At the stations of formation of assorted trains, usually, extensive selection of cars within groups, detachable at the section from the assorted train, is not performed. Therefore, at intermediate stations re-sorting of cars is done in order of their placement in the cargo fronts, or in order of transfer to the neighboring intermediate stations. This re-sorting is done in limited gridiron, and in some cases (in the absence of isolated extracts) and with the occupation of the main tracks that leads to an additional reduction in the throughput capacity of the section, to unplanned work of shunting locomotives of intermediate stations.

At the marshalling yards with a large volume of local work, as well as in terms of concentration of processing of local car flows at technically equipped marshalling yards a detailed selection of cars formed in multi-group compositions (10–20 or more groups) is required by stations of the section, access roads and cargo fronts.

The effectiveness of proposed actions is expressed primarily in the form of:

– Reduction of operating costs associated with the formation of multi-group compositions, including two three-time reduction of travel time and reduction of energy costs in the performance of shunting operations;

– Release of additional capacity in the formation of local trains and additional tracks of sorting the parks through the use of computer-aided method of combinatorial sorting of cars;

– Exemption of shunting locomotives of stations from the need for a detailed selection of cars;

– Acceleration of delivery of cars at stations for cargo operations and, accordingly, reduction of downtime of local cars;

– Improvement of the use of rolling stock, reduction of local car traffic at the department.

Objective. *The objective of the authors is to consider interaction of railway stations with cargo terminals at the places of non-public use*

Methods. *The authors use general scientific and engineering methods, comparative analysis, graph construction.*

Results.

Requirements for preparation of information for implementation of a task.

It is necessary to identify stations at which the implementation of the task is urgent, and to set the sequence of its implementation at these stations. For each of them it is necessary to prepare a set of data.

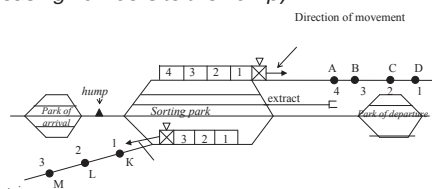*Enlarged scheme of a station and its adjacent areas («in drafts») stating:*

– location of the station parks;

– directions of movement of each assorted train to the section;

– location of all numbers of groups of cars on the circuit of a composition of each assorted train and cargo delivery in relation to sorting devices;

– venues for the sorting of cars (from the hump, from the extract) for each multi-group composition.

Example 1 (see pictures).

A list of all assorted trains and freight deliveries formed at a station is composed, indicating for each of them train destination (or cargo delivery), i.e. the name and code of the destination station. For each assorted train and freight delivery it is necessary to specify the number of such trains formed during shift and day.

For each assorted train it is necessary to provide a complete list of stations served by train, with the indication:

– Name, station code; group number for this station in order of its service by an assorted train (group number assignment for stations and consignees should be made according to the rule of increasing numbers to the hump).

Example 1.

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If reference intermediate stations are allocated on the site, where uncoupling of cars for this and other stations is made, and the location of cars at the destination station in the detachable group is not essential, then all intermediate stations must have the same group number as the reference station.

Example 2.

If for any of the stations in the area it is necessary to select cars on access roads and cargo fronts, then the list of consignees for each such station with the introduction of the following information is compiled:

– The name of the consignee;

– The code of the consignee;

– Group number for the consignee in order of his service at the station. Thus a number of consignees may have the same group number, for example, if companies needs only be divided into even and odd on their location relative to the station, or if a selection of local cars will only be made on the areas of local work (ALW) of such stations.

Example 3.

For each cargo delivery at the marshalling or cargo station, selected for implementation, the list of all served commercial customers is indicated, including for each of them:

– the name of the consignee;

– the code of the consignee;

– group number for this consignee in order of his service.

If in addition to a selection of cars at stations of destination or the consignee (for assorted train or cargo delivery) it is necessary to perform a selection of cars on any other criterion: by type of rolling stock, on the basis of the sign «laden» and «empty», by type of loading, on type of cargo, by current state of cars, as the thickness of the flange, run, rolling stock owners, etc., that these requirements should be given in the NSI as a structure of such multi-group composition, as represented, for example, in Pic. 1 in the formation of the composition of empty tanks for light pouring from the station Moskovska to the station Kombinatskaya of West-Siberian railway or in Pic. 2 during formation of the composition from the station Moskovska to the station Karbyshevo-1.

For each assorted train and freight delivery information must be given on the maximum permissible values of the train length (in conventional cars) and weight (in thousands of tons).

There should be a list of all sorting tracks of the station, on which cars are accumulated for compositions of assorted trains and cargo deliveries, and all tracks, which can be used in selection of cars. For each track its own number and its total capacity in conventional cars are indicated.

If in the assorted trains cars are included which follow in transit through all stations of the section of turnover of the assorted train, i.e. further than the destination station of the assorted train, then it is necessary to specify the range (or ranges) of codes of destination stations of such cars and the corresponding number of the group so that these cars are included automatically in a separate group, following to the end station of the assorted train. Otherwise, when analyzing the codes of destination stations of such cars, they will be marked by the system with a sign «alien» and will require further clarification from the shunting dispatcher (or hump foreman) on their inclusion in the formed multi-group composition or direction when sorting to a detachable track.
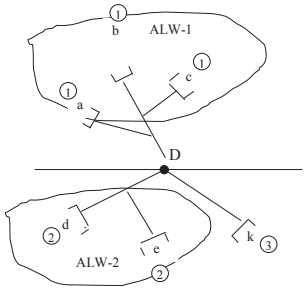
Example 4.

Additional conditions that must be submitted in the service information:

Group umbers
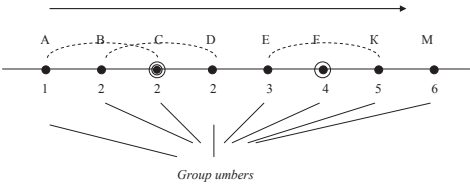
Uncoupling of cars from the assorted train is made at the stations A, C, E, F, M;
Service of stations B, D and K is made respectively from the stations C and F (location of cars in the group, uncoupled at the station C, is not essential, but in the group, uncoupled at the station F, is strictly required).

Example 2.

a, b,. . ., k — consignees of the station D;
1, 2, 3 — group number for the consignee.

Example 3.

– If the car is carried out under the extraction of limited length («short extract»), its length is indicated in conventional cars;

– If in a number of stations (or a number of consignees) there is no strict requirement on the order of location of cars in the composition, it should also be reflected.
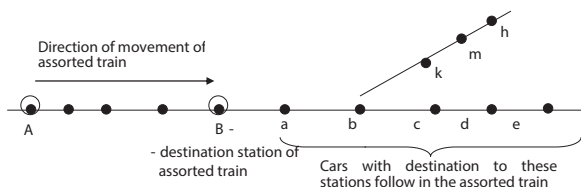
Example 5.

– whether at the same time just two multi-group compositions are formed of the cars accumulated on one sorting track (with the completion of formation of two compositions on two tracks);

– whether one multi-group composition is formed of the cars accumulated on different (two, three) sorting tracks.

Solution of a task of formation of multi-group compositions.

This task is included in the AWS of a shunting dispatcher (or foreman on the hump) and allows for minimal time for shunting operations for sorting and assembly of cars on any, even limited, number of sorting tracks or ends of these tracks to form multi-group compositions in accordance with a predetermined criterion of selection of cars:

– For all stations of the section, and for areas of local work, access roads and cargo fronts of these stations;

– By type of filling for empty tanks (dark-light filling) with separation into separate groups of cars for specific kinds of cargo transported;

– For rolling stock owners (own cars, leased, cars of operating companies and cars of inventory fleet of JSC Russian Railways);

– For types of rolling stock and its current state (laden and empty);

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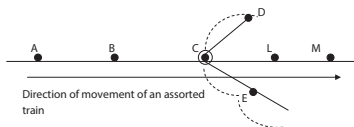
Example 4.

As it follows from this example, it is necessary to specify a range of codes of destination stations of cars and the corresponding group number:
1) code of station a − code of station e;
2) code of station k − code of station h.

Is determined the group number for each range or one group number for all ranges

If the order of service of station D or stations E, K is not severe and can be any (D – then E, K; or E, K – and then D), it is important to only choose cars for these stations, and the order of cars arrangement composed on these stations will be determine d by the PC, based on the minimum number of trips on a selection of cars in the marshalling yard for a particular location of cars in the accumulated composition. Similarly, it is necessary to specify all the driveways and cargo fronts, the sequence of service of which is not strictly fixed. An example of such a composition is also train of the tanks for light loading, shown in Pic. 1.

Example 5.

– The technical condition of cars, including the thickness of the wheel flange, mileage, year of construction;
– By type of repair for faulty cars;
– On the basis of «with customs» – «without customs», etc...
In accordance with different criteria different detailization on the number of selected groups can be obtained.
As for the number of groups in the train their arrangement is not strictly fixed, the PC finds such version of their location, which for the actually accumulated composition is obtained with a minimum number of shunting operations for sorting and selection of groups of cars. Such groups in the pictures are indicated by an arrow «↔», which means the condition of «nonrigid ordering»; such groups of cars are carefully chosen, but may be in any order relative to each other.
Taking into account the technological features of the stations, software package was designed that allows to solve a problem for the conditions when:
• formation of a multi-group (i.e., sorting and selection of cars) is carried out at a sufficient number of sorting tracks and it is required to determine their optimal number according to the number of cars selected in groups;
• formation is conducted on a limited number of sorting tracks (2–3 tracks, including the track, in which the original composition is located);
• formation is carried out in conditions of insufficient capacity of sorting tracks or ends of these tracks («short tracks»);
• formation is carried out in case of insufficient length of turnout track («short shunt-back») and emerging at the same time the need for the division of the composition and its formation part-wise;
• formation in circumstances where there is any combination of the above restrictions (limited number of sorting tracks, lack of capacity, the short shunt-back);

• formation of multi-group compositions in the absence of the requirements of a rigid ordering of groups of cars on their position in a train (i.e. groups of cars should be selected, but may be in any order relative to each other).
In the process of solving the problem in the AWS of the foreman on the hump a track is chosen, on which cars are accumulated for the formed composition. The accumulation is displayed on the screen showing all the required attributes: the destination station of cars, codes of cargo, consignee, remarks. After selecting a destination of a formed composition there is an automatic check of compliance of cars in the accumulated train with the destination of the local train or cargo delivery. Cars that do not meet a specified purpose, i. e., non-selected cars, are labeled with «to non-selection».
For the calculation of the optimal sequence of shunting operations for sorting of cars it is necessary to specify the numbers of used sorting tracks or ends of these tracks, and the computer gives a recommendation to the foreman on the hump about the optimal number of them. The selected number of tracks can be any, including a minimally limited.
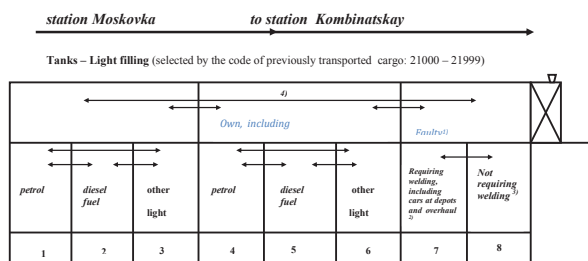*After selecting the tracks and performing calculation on the basis of conditions that require minimal time on the formation of multi-group composition on the screen is displayed and then printed trip-wise plan of shunting operations for sorting and selection of cars, the so-called sorting sheet, as well as the calculated standard time to perform all the maneuvering trips which can serve both for control over the execution and planning of work of the hump and sorting devices.*
Timing of formation of a multi-group composition is conducted by simulation of all locomotive movements with cars on the tracks of the station in accordance with the regulations for performance of shunting operations, real data on the location of cars in the initial train and received sorting sheet. Version for printout of a plan of shunting operations is adjusted in accordance with the requirements of each station and can be arranged with any degree of detailization (car-wise, with only the numbers of the tail and the head cars in uncouplings, etc.).
The task is designed for use at stations with large volume of cargo work to improve the use of rolling stock and, accordingly, reduce the local car traffic by department by optimizing delivery of cars and selection of rational prioritization and the order of service of places of non-public use and cargo fronts.
The basis for the solution of the optimization problem on delivery is implemented in ACS of local work continuous numbered account of the presence, location and status of cars on station tracks, loading and unloading fronts.
As a criterion of optimality may be set minimum costs in car-hours of downtime of cars while waiting for their delivery to cargo fronts. This criterion ensures the lowest loss, but does not account for performance of cargo points and therefore does not reflect the total

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station Moskovka   to station Kombinatskay

Tanks – Light filling (selected by the code of previously transported cargo: 21000 – 21999)

						Requiring welding, including cars at depots and overhaul [2]	Not requiring welding [3]
			Own, including			Faulty [1]	
petrol	diesel fuel	other light	petrol	diesel fuel	other light		
1	2	3	4	5	6	7	8

Pic. 1. Structure of a multi group composition of empty tanks for light filling in cargo delivery from the station Moskovka to the staition Kombinatskaya of West-Siberian railway with a detailed selection of cars up to 8 groups.

Note: 1) faulty cars are allocated on the code «9» in the 1-st special mark and record «FORWARD» in the note; 2) faulty cars that require during repair welding operations, are allocated in a separate group in accordance with fault codes (from ACS PTO); this group includes cars, sent to depot and overhaul (all of them will be immediately delivered to elevated structures of washing and steaming station); 3) similar faulty cars are allocated, which do not require welding operations; 4) arrow «↔» indicates those groups of cars, the location of which in the train is not strictly fixed («nonrigid order»); these groups of cars are carefully selected, but may be located in any order relative to each other.

operation loss of the total downtime of local cars. Since to a large extent the downtime depends on acceleration of unloading (loading) of goods, as the second criterion is used minimum total car-hours spent on delivery of cars and conduct of cargo operations.

Organization of delivery of local cars at the station must be linked to the work of assorted, transfer or export trains; so one of the optimality criteria should provide such an order of service of approach roads and cargo fronts, which will allow a locomotive to deliver most cars and return to station with removed from the front cars to the specified time under the relevant «thread» of schedule for assorted (local) trains.

The result of solving the problem in AWS of a shunting dispatcher must be agreed by the dispatcher work card for a shunting master to serve approach lines and cargo fronts indicating the prioritization of service and standard time on the implementation of all operations on delivery and removal of local cars at the station.

Requirements for preparation of information for implementation of tasks.

It is necessary to define the station, at which implementation of tasks is acute, and set the order of its implementation at these stations.

For each station it is necessary to prepare a scheme of places of non-public use and cargo fronts of the station with breakdown into its local work areas.

It is necessary to compile and fix:

– A list of all areas of local work of the station indicating priority in their service (if available) and the number of shunting locomotives, exercising delivery of local cars.

– List of places of non-public use and cargo fronts for each area of local work.

– The length of each haul in the transport scheme of non-public use and cargo fronts of the station (which will lead to the calculation of time of following to each cargo front in accordance with the number of cars in the cargo delivery and standards for performance of shunting operations).

– Allowable speed on the hauls of the station transport network and the presence of speed limits.

– Restrictions on weight and length formed on cargo deliveries.

For each cargo front it is necessary to prepare the following data:

– Front capacity in cars;

– The number of cars that can simultaneously be under cargo operations;

– Front operation indicating the start and completion of the work;

– A list of the cargo front customers (owners of branches, counterparties, one-time customers);

– Time performance of the freight front (standard time to perform cargo operations for loading and unloading, depending on the nature of the goods and the car type, the average arrival time of shunting locomotive with cars to the cargo front, and the average time of departure from the front);

– The priority in serving cargo fronts.

Solution of the optimization problem of delivery of local cars.

In the automated system normative reference information of a calculated test area is formed, including all areas of the local work of the station and for each of them, the scheme of places of non-public use and cargo fronts, as well as their main characteristics.

The scheme of places of non-public use specifies the length of each haul, which allows to calculate time of movement to each cargo front, in accordance with the number of cars in the cargo delivery and standards for performance of shunting operations.
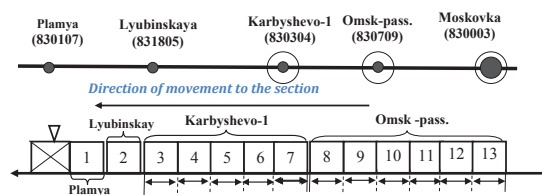
The characteristics of each cargo front include: a list of all commercial customers, performing cargo operations on this front, front operation, indicating the start and end of work, front capacity, its specialization, regulatory and actual times for freight operations taking into account the type of cargo and rolling stock. Timing on the alignment and removal of cars at the front is made operation by operation in accordance with the regulations and the amount of delivered and removed cars.

Operational data for calculation are the real number-wise information on availability of cars at the station in the address of freight fronts and information on the state of the cargo fronts at the time of calculation. For cars under loading (unloading), the calculation is carried out of the forecasted time of the end of freight operations. Forecasted time is calculated based on processing with statistical methods of the actual data on the work of each front over a long period of time (quarter, year). Forecasted time is displayed in red and can be corrected by a shunting dispatcher if necessary. A list of cargo fronts, on which calculations on prioritization of delivery and removal of cars will be carried out, may be adjusted.

After setting by the shunting dispatcher of departure time of cargo delivery the calculation of

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Selection of car groups in a formed train is carried out acording to the following criteria:

Group number	1. By stations of the section	2. By the current state of cars (laden, empty)	3. By types of rolling stock, cargo fronts, work with customs, with allocation of faulty cars
1	PLamya		
2	Lyubinskaya		
3	Karbyshevo-1	laden	customs
4	Karbyshevo-1	laden	without work with customs
5	Karbyshevo-1	empty	covered
6	Karbyshevo-1	empty	grain carriers
7	Karbyshevo-1	empty	all other types of rolling stock, exept for allocated in separate groups
8	Omsk-pass.	laden	cargo client — «River port»
9	Omsk-pass.	laden	cargo client — JSC «Omskoe»
10	Omsk-pass.	laden	all other cargo clients
11	Omsk-pass.	empty	faulty
12	Omsk-pass.	empty	in good order — grain carriers
13	Omsk-pass.	empty	in good order — all other types of rolling stock, exept for allocated in separate groups

Pic. 2. Structure of a multi group assorted train from the station Moskovka to the station Karbyshevo-1.
Note. The arrow «↔» indicates those groups of cars, the location of which in the train is not strictly fixed («nonrigid order»); these groups of cars are carefully selected, but may be located in any order relative to each other, e.g. Group 3, 4, 5, 6, 7 may be selected in any sequence relative to each other, but they all must be in the «Karbyshevo» part of the composition; faulty cars are allocated on the code «9» in the 1-st special mark and record «FORWARD» in the note;
The cars allocated to a group to work with customs, are chosen in accordance with the presence of signs and code of ECP station of transfer of a car to the Russian Railways on interstate division points.

optimal prioritization of service is carried out as areas of local work of the station, and cargo fronts and approach lines. As optimization criteria for the calculation are taken either minimizing of the car-hours of downtime of cars awaiting their delivery to cargo fronts, or provision of maximum loading (unloading) to the time specified by the dispatcher.

Conclusion. *Organization of delivery of local cars from the station must be linked to the work of assorted, transfer or clean-up trains; therefore one more optimality criterion is introduced when calculating the prioritization of service of approach lines and cargo fronts, which provides a maximum delivery of cars and the return of the locomotive to the station with the maximally removed from front cars to the time specified by the dispatcher under the appropriate «thread» of schedule for assorted (local) train.*

For each option of calculation on the screen are displayed graphics of dynamics of delivery and removal of cars, as well as completion of cargo operations.

For the option selected by the shunting controller for delivery of local work card for the shunting master

to serve places of non-public use and cargo fronts cars is formed and printed.

Implementation of all the above set of measures will allow more fully optimize joint work of railway stations with cargo terminals in the non-public areas.

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