COMPUTERIZED FREIGHT TRAIN SCHEDULING

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SUMMARY

This report deals with the development of interactive graphic models for the operational planning of longdistance freight trains in the network of German Federal Railways (DB).

The intentions and the methodology are described as well as the experiences gathered from practical applications of computer aided train scheduling at high performance marshalling yards.

Special regard is given to the advantages of the man-machine dialog which is part of the optimizing and decision making process.

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1. Operational requirements for the operational planning of long distance freiht trains (stating the problem and setting the goals)

Considerable difficulties in operational planning of public transportation are caused by the irregularities in transportation demands (transportation demand fluctuations). Therefore the fluctuations in the level of demand for daily goods wagons, noted in practice, as well as the random longer term and seasonal-periodical changes set limits for the application of conventional methods of tracked freight traffic planning.

In general, the following (first only qualitative mutual dependencies between economic operational planning on the one hand and marketable transportation production on the other) can be considered as starting points for model developments:

- A reduction of production costs requires, in itself, the minimization of the number of freight trains, since each train - even without consideration of its actual loading - is responsible for a definite portion of operating costs. One should however take into account that a limitation of the transportation supply would mean, at least potentially, a reduction of transportation quality for the customer of the transportation enterprise.

- Despite the irregularities in transportation demand, a division of transportation supply into regularly offered services as well as those according to need is effective for large transportation enterprises like, for example, the railways.

- If one first only considers the different figures of the daily transportation volume with respect to long distance transportation of goods over a given sche-

dule period, one will undoubtedly discover that the transportation of goods will be uneconomical, if too many regular trains are scheduled due to the fact that the loading ratio must be low in this case. However, the scheduling of too few regular trains will also prove to be uneconomical, due to the fact that the resulting necessary increase in special transports is more expensive than the regular transports.

It is therefore to be expected that ratios in standard and special transportation exist which are monetarily most feasible and which form the basis for a suitable planning project.

- Not only do the greatest difficulties in operational detail planning arise due to the fluctuations in the daily level of transportation volume, but the monetarily most feasible ratios of standard and special trains and the transportation quality from the customer's perspective are influenced as well, when the fixed conditions of departure of the standard trains cannot be optimally adapted to the demands for irregular transporation. A methodical planning instrument is therefore needed for the direction of demand-oriented and simultaneously economic freight train management. In consideration of the above deliberations, the newly developed model complex for long-distance freight traffic includes two major points of emphasis:

(A) Realisation of mathematic-statistical procedures for the investigation of fluctuations in transportation volume;

(B) Realisation of a planning model for the determination of the most economically feasible ratios of standard and special freight trains as well as the optimal departure times of all long distance trains.

2. O. R. solution approach

2.1 Analysis of Traffic Demand

In step 1 of the model the traffic demand can be analyzed with the help of statistical methods, in particular the so called treeanalysis.

This traffic data analysis serves the following purposes:

- to define homogenious planning time intervals for which a uniform operational planning of long-distance freight trains can be programmed,

- to analyze the causes for possible changes in demand from which a prognosis for subsequent time periods are to be deduced.

2.2 Economic division of long-distance freiht trains into regular and special trains

In step 2 of the model a first approximation of a calculation of the economy of the operational planning of long-distance freight trains is conveyed. It has been taken into account that different fixed costs are incurred in the course of determining the allotment of regular long-distance trains and/or special trains scheduled only in case of need. For the special trains, the costs for the train personnel, the depreciation and maintenance of the tractive units as well as the costs of empty running vehicles are about 50 % higher than for regular trains.

2.3 Scheduling of long-distance freiht trains

The resources for the operational planning of long distance freight trains, which have been available up to now are based exclusively on the application of the so called "sum-line-method". Our knowledge of this practical method comes mainly from railway experience and literature.

Like the "sum-line-method", the newly developed method also considers the actual use of train capacity depending upon the influx of the freight wagons into the set of reception sidings according to the time of day, as an essential criterion for the determination of the time table of the freight trains.

The capacity of the marshalling yard, particularly the available track system in the set of sorting sidings, is referred to as a further basic criterion for the determination of the times of departure.

The heuristic method developed for the methodical operational planning can be simply described as follows:

Planning: Regular trains

Earliest departure conditions (use of train capacity)

The most financially feasible delivery of the traffic volume during one day is reached when the smallest number of trains is put into operation, ie. when all trains are loaded to their respective capacities with respect to freight and length. This results in the fact that the earliest departure time for each train to be planned should be scheduled when the expected traffic volume at its depar-

ture time is for the rest of the day at least as large as the transportation capacity of the minimal number of trains necessary. If the departure time were scheduled earlier, some leftovers would necessarily remain, which would have to be transported by a special train. In this case the transport expenses would deviate from the minimum costs to the extent of the fixed costs for a special train.

Latest departure conditions (track capacity)

One must assume that there are limitations on the influx of transport units belonging to the different tracks of the sorting and departure sidings which can be received. These limitations are due to track capacity and suggest that the departure of a special train is always supposed to be scheduled whenever the transport units waiting at the sorting sidings have reached twice the delivery capacity of a train. The same limit arises from the conditions of operational quality for which an analogous situation is present, namely that the time interval between two deliveries as opposed to the normal interval should not do more than double.

If for other reasons a later departure of the regular train is necessary, a special train will have to be scheduled. This train will increase the costs of transportation by the amount of the fixed costs of a special train delivery, similar to the case of not attaining the earliest recommended departure condition.

All in all, there is a cost increase function from which one can derive an optimal temporal range for the delivery of a certain regular train with respect to the progress of demand of a certain day.

The scheduling of regular trains, however, should not only be optimal for the progress of demand of one particular working day but should also be optimal for

an entire planning period. It follows that the various demands of all working days of a planning period should be individually analyzed according to the optimal range of the regular train in consideration, so that this information can then be used to estimate a certain demand situation.

Planning: Conditional Trains

In connection with the fixation of a departure condition for regular trains, the transports made on all days of the selected test period in the respective time interval of the regular train schedule are examined in order to find out if a special train should be put into operation. This principally results when, according to the criterion for the limitation of the late departure condition, an excess of available track capacities due to special deliveries is to be avoided.

A further criterion becomes effective when the regular train functions as a transport chain.

Strictly speaking, transport chain trains should not leave any leftover wagons behind, if the desired transport quality (ie. a transport duration of a maximum of 36 hours in middle to long-distance range) is to be reached. Therefore special trains have to be scheduled when the number of wagons needed exceeds the capacity limits of a fully loaded regular train before the departure of a transport chain train.

General description of the WRB-model

Concept of the Model:

System analysis/System definition

- graphic presentations of the transport volume
- statistical evaluation of the demand fluctuations
- tree analyses (homogeneous planning periods)

Limitation of the economical inter marshalling yard train supply

- approximation of transportation costs for alternative production strategies (regular/special trains ratios)
- determination of economical numbers for regular trains (basis: data of daily transportation volume)

Mathematical optimization

- determination of feasible departure conditions for regular and special inter marshalling yard trains (basis: daily temporal distribution of transportation volume)
- calculation of transportation costs and determination of the most economical ratios of regular to special inter marshalling yard trains.

Methodical development of a basis for decision-making concerning a demand-oriented and economical production regulation on the inter marshalling yard train sector.

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