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NEW APPROACHES TO CREATION OF TRAVEL TIMES
NOVÉ PŘÍSTUPY K TVORBĚ JÍZDNÍCH DOB

Abstrakt

Vývoj železniční dopravy je trvalý a nikdy nekončící proces. Železniční infrastruktura během několika předchozích let prošla zásadními změnami jako např. výstavba železničních koridorů s novými typy sdělovacích a zabezpečovacích zařízení, dále byly realizovány některé dodávky nových drážních vozidel, jako např. řady 680 event. osobních vozů Bmpz, další změny a inovace budou následovat.

Tyto současné dynamické změny v železničním provozu se musí odrazit i v nabídce dopravců formou zkrácení jízdních dob. Bude také možné, v následujících létech určovat jízdní doby, které budou se stanovenou mírou pravděpodobnosti dodržovány po celé období platnosti Jízdního řádu?

Následující článek analyzuje jednu z možných metod tvorby jízdních dob na základě stochastických podmínek. Za použití metod matematické statistiky a pravděpodobnosti prezentuje model determinování míry pravděpodobnosti dodržování jízdní doby.

Abstract

Development of railway transport is an everlasting and never-ending process. Over the last few years the railway infrastructure has passed essential changes, e.g. building of new corridors with new types of communication and security apparatus, some deliveries of new vehicles, e.g. 680 range, event. Bmpz passenger carriages; further changes and innovations are supposed to follow.

These current dynamic changes in the railway traffic should result in the transporter´s offer of travel time shortening. In the coming years will it be possible to state travel times that will be kept at a given rate of probability all the time of the timetable validity?

This paper analyses one of possible methods of travel time creation on the basis of stochastic conditions. Using methods of mathematical statistics and probability it presents a model of determination of probability rate of travel time keeping.

Introduction

In our days, is there any sense to deal with problems of stating regular travel times and delay times to theoretical travel times especially on corridor tracks? After all there should be no irregularities in the railway service operation on the corridor tracks with new modernized vehicles while keeping regular travel times, stated by deterministic models which use deterministic inputs.

This paper deals with an analysis of regular travel times and an amount of delay time to theoretical travel times.

1 METHODOLOGY OF USING DELAY TIMES

Calculation of regular travel times and travel times is essentially problems of train travel dynamics. At present the regular travel time consists of the theoretical travel time and a delay time added to the theoretical travel time.

The delay times added to the travel times are used to compensate irregularities in the railway service operation which can be caused by many reasons, e.g. a planned exclusion, an accidental time need because of obstacles in service caused by other impacts (weather, etc.).

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The regular travel time is stated according to the equation [1]:

$$T_{prav.} = T_{teoret.} + T_{př.} \qquad [\text{min}] \tag{1}$$

where: $T_{prav.}$ ... regular travel time [min]

$T_{teoret.}$ … theoretical travel time [min]

$T_{př.}$ … delay time added to the theoretical travel time [min]

The delay time to the theoretical travel time is expressed by a percentual amount of time added to the theoretical travel time.

Specifying and the amount of the delay time to the travel time have undergone a long time development. From the past we have known the delay time values for starting and stopping expressed by percentual value of the delay time added to the travel time which was $4 \div 6$ % for express and fast trains, $7 \div 10$ % for stopping trains and 10 % for freight trains.

Nowadays, the delay times are used related to the theoretical travel times - 4 % for passenger services and 10 % for freight trains.

The use of 4 % delay time value is generally valid within the Czech Railways, inc. The supplementary delay value to the theoretical travel time is not different for e.g. regional and corridor tracks.

The following analysis deals with passenger services on the corridor tracks.

2 ANALYSIS OF THE REGULAR TRAVEL TIMES AND DELAY TIMES ADDED TO THE THEORETICAL TRAVEL TIMES

In order to objectively set e.g. a regular travel time or a supplementary value of delay to the theoretical travel time on a stochastic basis, it was necessary to analyze as many travels of trains of the same number as possible, to use some of methods of mathematical statistics and probability, to define travel time as a new random variable with some simplifying assumptions:

- traffic according to the railway transport flowchart without any emergencies,
- train weight is constant during train timetable validity and complies with weight normative in accordance with data of a timetable booklet; a type of travel resistance is constant as well,
- motor vehicles of a planned range are used for the train movement,
- adhesive conditions are good or just slightly worse,
- in cases of an electric traction the trolley voltage is equal to the rated value for a corresponding traction system, etc.

For a new random variable defined in this way is then set a rate of probability of keeping stochastically stated regular travel times by means of distribution function, which is expressed in the basic equation [2]:

$$F(x) = \mathrm{P}\ (X \le x) \qquad -\infty < \mathrm{x} < \infty \tag{2}$$

Where: P … probability [1]

X … random variable [1]

x … real quantity [1]

Distribution function expresses probability that a random variable X will be less or equal to x for every real x. Basic properties of distribution function $\mathrm{F}(x)$ are:

A. $0 \le F(x) \le 1$ for every real x, as $\mathrm{F}(x)$ expresses probability of the random variable $\mathrm{X} \le \mathrm{x}$,

B. $F(x_1) \le F(x_2)$ for every pair of real numbers $x_1 < x_2$, i.e. distribution function $\mathrm{F}(x)$ is not falling,

C. $\lim F(x)_{x \to -\infty} = F(-\infty)$ $\lim F(x)_{x \to \infty} = 1$

D. distribution function $F(x)$ is continuous from the right side and has at most finite number.of discontinuous points.

Distribution function was chosen just for these properties applicable to a complex of real travel times.

The same methodology is applicable to a sum of theoretical travel times with a proper size of delay time so that the regular travel time stated in this way is kept at a required level of probability.

Another possible mathematical method of processing the travel time complex achieved on the stochastic basis is synergetic regression [Široký, 2001, p. $85 \div 88$]. Synergetic analysis applied to travel time complex will be a topic of a separate publication.

The same methodology can be applied to a sum of theoretical travel times and a proper delay time so as to keep the regular travel time determined in this way at a required rate of probability.

The analysis of the regular travel times itself was carried out on Ostrava Svinov – Hranice na Moravě corridor track section. This section is passed at the highest track speed of 160 km/h, longitudinal track profile keeps slope and pitch values within 4 ‰. Statistical processing was based on electronic travel records of the highest quality trains - IC 142/143 Odra and IC 146/147 Hradčany during the period of July – August 2006.

Regular travel time stated on the deterministic basis by means of information system of the timetable setting by computer engineering (next IS SENA) was stated at the value:

- trains of even direction have sum of the theoretical travel times of 25 min, 4 % delay time value added to the sum of the theoretical travel times is 1 min which is the regular travel time of 26 min according to the relation [1],
- trains of odd direction have the sum of the theoretical travel times of 26 min, 4 % delay time value added to the theoretical travel time is 1,04 min., which means the regular travel time of 27 min according to the relation [1].

The final results by means of mathematical statistics and probability methods are shown in figures 1 a 2:

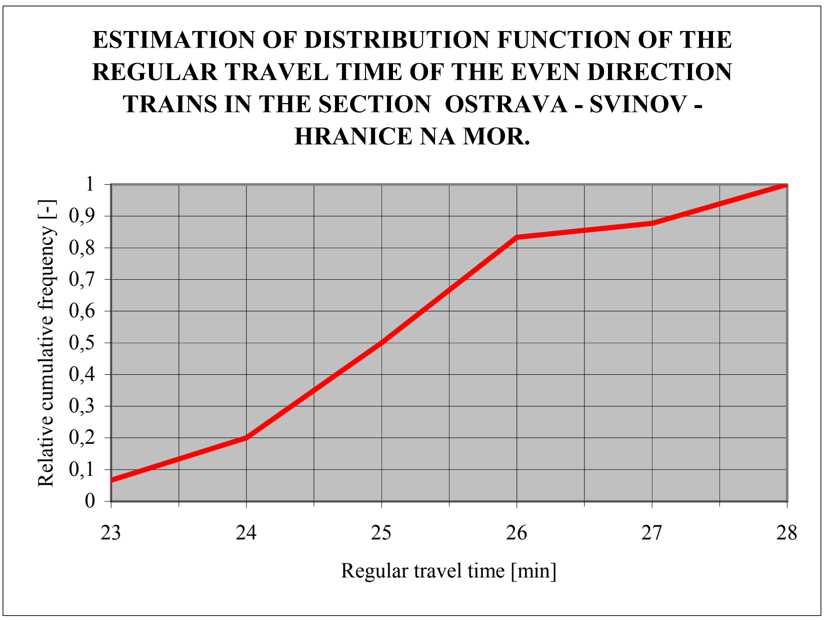

Figure 1: Estimation of distribution function of the regular travel time of the even direction trans.

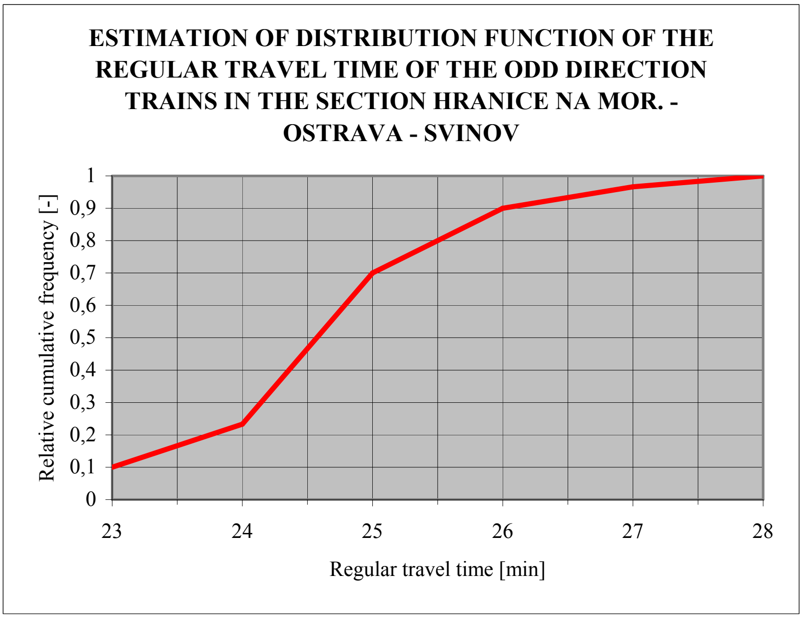

Figure 2: Estimation of distribution function of the regular travel time of the odd direction trans.

3 DISCUSSION OF THE ACHIEVED RESULTS

1. The regular travel time fixed by means of IS SENA at the value of 26 min for the even direction trains is kept with 84 % probability.
2. The regular travel time fixed by means of IS SENA at the value of 27 min for the odd direction trains is kept with 96 % probability.
3. On the basis of the presented stochastic model the regular travel times, eventually the delay time added to the sum of the theoretical times can be fixed at a required probability rate, e.g. for chosen train categories. Real regular travel times can be used as entry data as they are continuously monitored and recorded by means of Information System of Operating Control (ISOŘ).
4. All the trains involved in the analysis of the regular travel times have the mass standard of 750 tons in the Timetable Booklet. This mass standard involves a certain mass size as a reserve. According to the service quide Passenger Trains, Part 1- Express and Fast Trains which includes ordering of the passenger trains, the monitored services regularly consist of 6 ÷ 10 carriages which means a mass standard range between 285 ÷ 472 tons. Such dispersion of the entry values (regardless the mass standard normative 750 tons) significantly affects calculations of the theoretical travel times. An evidence for this can be a low percentage of the regular time keeping by even direction trains in the track section of Ostrava Svinov – Hranice na Moravě.

4 CONCLUSION

A permanent higher precision of regular travel time calculations is an important target of all the railways authorities. Current calculations do not miss sufficient precision of the calculating procedure but they are affected by changeability of entry data for individual services as it is presented by carriage mass example.

To beat a dilema between complexity of the entry values and precision of regular travel time setting is possible in real time by means of methods of mathematical statistics and probability. Without exaggeration we can believe that if the trains are not delayed, the travel time as a transport time will be one of very interesting and demanding parametres of the timetable.

LIST OF RESOURCES

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