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UTILISATION OF DECISION TABLES FOR PROPOSAL OF TRANSFER NODE CONCEPTION

ABSTRACT

The key issue in improving the appeal of public mass transport is the optimal arrangement of transfer nodes. The objective is to propose a comfortable, simple and safe environment for both passengers and operators, and a solution which is economical to construct and operate. Although each transfer node is unique and specific, it is beneficial to have a general idea on the layout of a project to construct or reconstruct such a transfer node. This project should, in particular, stem from the traffic intensity of single transport modes, the volume of single transfer links, and the nature and significance of traffic routes. This article presents the methodology for determining the appropriate disposition of mass public transport nodes using modified decision tables (one of the tools of systems analysis) with specific data particularly applicable in the Czech Republic.

KEY WORDS

public mass transport, decision tables, transfer node

1. SIGNIFICANCE AND TIMELINESS OF THE ISSUE

The future of regional railway lines is under discussion not only in the Czech Republic, but also in other European states. The cost of maintenance and operation of trains running on these tracks is constantly growing, hence the capacity utilisation of trains and lines is being monitored more closely. If such railway lines do not perish, but are to be an adequate part of the public mass transport system, it is necessary to increase their appeal at the lowest possible cost. This represents a change both in the vehicle fleet, operational concept (timetable) and traffic control, and in the arrangement and distribution of stations and stops. The railway stations and stops (not only on regional railway lines) should become the core of the public mass transport transfer nodes. Positive examples of this exist in Switzerland, Sweden and Denmark. In this article, therefore, the authors focussed on creating tools that would help with the initial decision-making on the form of the transfer nodes and determine the direction of further discussion and project work on any modifications or new proposals to their form.

There are many opinions on the factors influencing the form of the transfer nodes, especially regarding how they are weighted. Multi-criteria evaluation, evaluation based on expected risk, flowchart and other methods can all be used. In general, however, the most suitable method for practical use is the one that embraces as many decision aspects as possible whilst still being user-friendly. One of the conditions for user-friendliness is simplicity; hence the decision table appears to be the optimum decision-making method for the aforementioned purpose.

2. DECISION TABLES

Decision tables are one of the tools of systems analysis and in their basic form they serve to determine what action (or actions) should be performed under what conditions. The decision table is composed of four parts - quadrants (see *Table 1*):

- List of conditions (upper left quadrant): the quadrant encompasses all the conditions (assumptions) that affect problem-solving and predetermine its possible variants. In the extensive lists, the conditions are aggregated into groups representing one input decision-making variable and the single conditions then represent possible alternatives of this variable.
- Combination of conditions (upper right quadrant): the quadrant encompasses single combinations of condition values that are indicated in the list

Table 1 – Decision table arrangement scheme

Decision table heading	Rules heading
List of conditions: What are the conditions determining the selection of the appropriate action?	**Combination of conditions:** What combination of conditions may arise?
List of actions: What actions must be performed under a single combination of conditions?	**Combination of actions:** What action (or actions) must be performed under a single combination of conditions?

of conditions. This quadrant is divided into a particular number of columns, so-called decision table rules. The meeting of a particular condition is marked with the letter “Y” (yes).

– Combination of actions (lower right quadrant): the quadrant contains, in single columns corresponding to the decision table rules, decisions on which action (or actions) are to be performed under the given combination of conditions. The performance of an action is marked with the letter “X”.
– List of actions (lower left quadrant): the quadrant contains a list of specific activities that need to be carried out, under all the alternatives of the given problem captured in the table.

Working with the decision table is as follows: the conditions that are met under the given situation are selected from the list of conditions. Out of the combination of conditions, the rule that fully meets the given combination of conditions is selected (all the conditions of the given rule are met). The selected rule (column) – one of the options available to solve the given problem - determines the action or combination of actions that are to be performed. The final output is to determine the action (or actions), from the list of actions, that are to be performed.

3. MODIFICATION OF DECISION TABLES

In order to use the decision tables as a tool for decision-making on the conception of mass public transport transfer nodes, the authors of this article propose their modification in the following manner:

1. Division into two levels: the first factor is the form of the transfer links, and the subsequent recommendation about the platforms in the railway station that are core to the transfer node. The second factor is conditioned by the required transfer link as not all the basic conceptions allow for the application of the respective required form of a transfer link resulting from the first decision-making level. Selecting the optimal arrangement is a sophisticated task which must take into account many criteria.
2. More solutions offered: the standard decision tables usually assign a unique problem solution to a combination of conditions. Because the resulting form of a transfer link reflects the local conditions and its entire functionality is important, the decision-making process offers more solutions under a particular combination of conditions. The resulting decision depends on the user, assuming a familiarity with the physical conditions, both current and future operational requirements and the prevailing needs of passengers and transport operators. For this reason, in the decision table quadrant “Combination of actions” the usage of letter “V” was introduced, which stands for exceptional selection, i.e. the marking of an alternative that otherwise meets the given conditions, but is applicable only in exceptional and justifiable cases.

4. FIRST LEVEL DECISION TABLE

The first level decision table (*Table 2*) assigns the optimal form of change between single transport systems based on the intensity of the transfer link and the physical conditions of a station forecourt. The output of the decision-making in this table is one of the input variables of the second level decision table.

The input variables of the first level decision table are the following:

– Intensity (significance) of the transfer link: the number of passengers changing between the backbone and follow-up transport system determines the requirements for pedestrian transfer. The higher the number of passengers regularly using the transfer, the higher the emphasis that should be placed on the shortest route with minimum recurring changes in elevation.
– Future number of mass public transport stops connecting to the backbone transport system (most often buses connecting to trains): this factor must correspond to the physical conditions of the station forecourt space, whether it is, for example, possible to allocate the stops for the connecting transport on the far side of a railway platform and thus create an “edge-edge” transfer, or whether only the construction of a sophisticated bus station in the area should be considered.
– Horizontal arrangement of the traffic routes of single transport modes: the mutual elevation location of the transport routes excludes or conversely offers certain alternatives to the transfer node arrangement.

Table 2 – First level decision table

Form of transfer links – first level	I	II	III	IV	V	VI	VII	VIII	IX
weak transfer link	Y	Y	Y						
medium transfer link				Y	Y	Y			
strong transfer link							Y	Y	Y
need for up to 2 bus stands		Y	Y	Y			Y	Y	
need for up to 5 bus stands		Y			Y			Y	
need for 6 and more bus stands						Y			Y
suitable area by the passenger building		Y			Y			Y	Y
traffic routes crossing in more levels			Y	Y			Y		
edge-edge “P-HH”, “P-PT”, “P-HJ”		X			X			X	
vertical link “P-VV”			X	X			X		
standard bus stands						X			X
remote stop	X	V	V						

Y – meeting of a particular condition (see Chapter 2)
V – exceptional choice (see Chapter 3, point 2)
X – performance of an action (see Chapter 2)
The abbreviations of the transfer links types are explained in Chapter 6.

5. SECOND LEVEL DECISION TABLE

The second level decision table (*Table 3*) combines the condition arising from the conclusion of the first level table, i.e. the optimal form of transfer, with the railway track category and operational requirements. In addition to the outputs of the first decision table, further criteria are:

- Railway category and number of main tracks: these aspects are the key to the options in carrying out certain modifications of the railway stations because they must take into account the safety of railway operation and must be in line with the valid technical norm [7].
- Passage of the train through the station without stopping: because trains expected to pass through the station without stopping must not be limited by passenger flows, a central foot level crossing must not be proposed.
- Length of the train: if the train is composed of four and more cars of classic construction, the passengers stepping out from the outermost doors (away from the locomotive) must take a more than one-minute-long walk to the central foot level crossing situated in front of the locomotive, therefore a semi-island platform arrangement with a central foot level crossing is not suitable.
- The required form of the transfer link: the output of the first decision level comes into compliance or conflict with other aspects.

A key aspect that is seemingly unenclosed in the decision tables is the overall functionality of the terminal, i.e. the combination of all variables taken into consideration. The transfer node cannot be considered from one viewpoint only, even two basic criteria would be insufficient for decision-making. The transfer node functionality itself results in the ambiguity of certain columns in the lower right quadrant of both level decision tables, because the result of the combination of the decisive conditions in the project proposal must conform to the one actual considered location, so the result would be a transfer node suitable for the operational requirements, safety and the target user – the passenger.

6. TYPES OF TRANSFER LINK AND STATION ARRANGEMENTS

Transfers specifically have various transfer link constrictions. The term transfer link constriction is, for the purposes of this article, understood from a construction point of view, i.e. from the point of view of the time needed to transfer passengers from one connection to another. The “P-HH” edge-edge scheme represents a transfer link with the shortest distance between traffic routes of single transport modes and the zero amount of recurring changes in elevation completed. One platform edge is designated for trains to stop and the bus stands/stops are located on the reverse edge. The “P-HJ” one-way edge-edge scheme stems from the previous scheme, but in addition to the edge-edge platform (used for trains going only in one direction) there is an island-platform to/from which the passenger can get to exclusively through an underpass and thus completes a change in elevation recurrently.

The “P-VV” vertical link scheme is an alternative solution with limited possibilities for establishment because of the projected location of the transport routes

Table 3 – Second level decision table

Station arrangement – second level	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
railway track included into the European railway network	Y	Y	Y	Y	Y	Y										
national railroad			Y	Y	Y	Y	Y	Y	Y	Y	Y					
regional railroad												Y	Y	Y	Y	Y
one main track	Y	Y	Y			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
two and more main tracks				Y	Y	Y										
train passage without stopping				Y	Y		Y					Y				Y
regular train crossing		Y		Y	Y				Y	Y	Y		Y			Y
train with more than 4 cars				Y	Y			Y						Y		Y
crossing or centre station						Y									Y	
edge-edge		Y	Y	Y		Y	Y		Y			Y	Y			
vertical links	Y				Y	Y	Y	Y			Y					Y
standard bus stands	Y				Y	Y	Y	Y		Y		Y	Y	Y	Y	
remote stop	Y				Y	Y	Y	Y		Y		Y	Y	Y	Y	
"N-PPE", "N-HPE"	X	X			X	X	X	X		X	X				V	V
"N-VPE"				X	V											
"N-POO", "N-POJ"	V	V						V	V	X		V	X	V	X	
"N-VDV", "N-VJE"									X			X	X	V		
"N-VND"				X										X		
"N-VNJ"			X				V	X				V				

Y – meeting of a particular condition (see Chapter 2)
V – exceptional choice (see Chapter 3, point 2)
X – performance of an action (see Chapter 2)
The abbreviations of the transfer links types are explained in Chapter 6.

of different transport systems (such as railways and roads) at different height levels and their mutual crossing. The same goes for the "P-PT" weaving scheme as for the "P-VV" scheme, and on top of that a suitable space to establish a transfer node must exist. The traffic route of a single transport system is, in this case, surrounded from both sides by another transport system traffic route, and both traffic routes before and behind the transfer node must cross at a grade separation.

The "N-PPE" scheme is common for the two-track railroad stations, at larger train stations, and for the node and crossing stations. It represents the existence of platforms with a grade separation access exclusively, as the case may be with a direct access from the passenger building, i.e. island and outer "high" platform (this means a height of the platform edge of 550mm above the rail top). Usually two island platforms are proposed that always have one of their edges by the main track and the other by the overtaking track.

The "N-VPE" island and outer high platform by the passenger building with one two-way travel overtaking track scheme represents an economical modification of the "N-PPE" scheme (overtaking tracks reduction) and its advantage is leading one main track in front of the passenger building. It is an alternative for the stations with low intensity of regular overtaking by trains, but it is not viable where there is simultaneous train overtaking in both ways. The "N-HPE" island platform between the main tracks scheme, or other outer high platforms is again an economical modification of the "N-PPE" scheme and is usually proposed if the station is situated in an arch.

The "N-VND" advanced platform scheme is a suitable solution where two overcoming tracks need to be maintained and at the same time the site situation does not allow establishment of a grade separation access platform in the station. If a two-edge platform is sufficient, advanced positioning is suggested (a new stop de facto). This solution can be used with a one-track rail also – the "N-VNJ" scheme.

The "N-POO" double-sided semi-island platform scheme represents an adjustment of intermediate railway stations on regional railroads where the double-sided semi-island platform is inserted at an abolished station track site. The access from the passenger building that is ideally connected to the station forecourt is carried out by the central crossing. The "N-POJ" one-edge outer and semi-island platform scheme is an alternative to the "N-POO" scheme – it requires lesser space and only half of the passengers must cross the traffic rails.

The "N-VDV" two outer high platforms by the passenger building scheme is specific to passengers not crossing the tracks towards any of the platforms. This alternative can be recommended only if the railway stations are sufficiently oblong because it looks in a way that in the centre of the station the overtaking track turns from the main track and the outer platform is situated by both tracks. The "N-VJE" oblong outer two-edge platform scheme is a modification of the "N-VDV" alternative. One long platform edge is separated by a switch to two platform edges, the trains from both directions stop in front of the signalling device securing the passage through this switch.

	Form of transfer links – first level	I	II	III	IV	V	VI	VII	VIII	IX
inputs	weak transfer link	Y	Y	Y						
	medium transfer link				Y	Y	Y			
	strong transfer link							Y	Y	Y
	need for up to 2 bus stands		Y	Y	Y			Y	Y	
	need for up to 5 bus stands		Y			Y			Y	
	need for 6 and more bus stands						Y			Y
	suitable area by the passenger building		Y			Y			Y	Y
	traffic routes crossing in more levels			Y	Y			Y		
output	edge-edge "P-HH", "P-PT", "P-HJ"		X			X			X	
	vertical link "P-VV"			X	X			X		
	standard bus stands						X			X
	remote stop	X	V	V						

Station arrangement – second level	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
railway track included into the European railway network	Y	Y	Y	Y	Y	Y										
national railroad			Y	Y	Y	Y	Y	Y	Y	Y	Y					
regional railroad												Y	Y	Y	Y	Y
one main track	Y	Y	Y			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
two and more main tracks				Y	Y	Y										
train passage without stopping				Y	Y		Y					Y				Y
regular train crossing		Y		Y	Y				Y	Y	Y		Y			Y
train with more than 4 cars				Y	Y			Y						Y		Y
crossing or centre station						Y									Y	
edge-edge		Y	Y	Y		Y	Y		Y			Y	Y			
vertical links	Y				Y	Y	Y	Y			Y					Y
standard bus stands	Y				Y	Y	Y	Y		Y		Y	Y	Y	Y	
remote stop	Y				Y	Y	Y	Y		Y		Y	Y	Y	Y	
"N-PPE", "N-HPE"	X	X			X	X	X	X		X	X				V	V
"N-VPE"				X	V											
"N-POO", "N-POJ"	V	V						V	V	X		V	X	V	X	
"N-VDV", "N-VJE"									X			X	X	V		
"N-VND"				X										X		
"N-VNJ"			X				V	X				V				

Scheme 1 – Example of the decision table usage

7. CASE STUDY

The method described in this article is applied to the following real life situation and aims at proving practical utilizability of the method and its benefits. The article deals with the description of an intermediate railway station Týnec nad Sázavou on the territory of the Czech Republic, located about 50 kilometres from the capital city, Prague on the regional railway line with intensive recreational traffic. Nowadays, there are three level platforms in unsuitable condition – their edge heights are only slightly above the rail top level. Passenger entrance and exit is enabled by two foot level crossings. Access to passenger building and platforms is barrier-free, though, due to height difference between platform surface and railway vehicles floor level, the barrier-free entry and exit are not possible. Some 50 meters from the passenger building, a drop shape bus station with ten bus stands is situated – a transfer between train and bus change is realized on unpaved and rugged station forecourt. The entire station forecourt, adjacent bus station, platforms with their entrances are completely unsuitable for passengers' safety and comfort.

The following input parameters such as intermediate railway station, middle scale of loading and unloading, non-existing train passage without stopping, possibility of bus station relocation at station forecourt closer to railway yard, regional transfer node, passenger count increase potential, operation of trains with variable length are crucial for the application of the methodology based on the decision table usage, and out of these the following columns such as the first level decision table – *column V*, the second level decision table – *column M* have been chosen. For our case the option "*N-POO*" has been chosen. New 135-metre long double-sided semi-island platform with the edge of 550mm above the rail top is projected instead of one removed station track. The access between this new platform, the passenger building and the station forecourt is realized through a central foot level crossing. In order to improve the train-bus transfer connection an extensive reconstruction of the station forecourt has been implemented: The bus station has been moved directly in front of the passenger building; its appearance has been projected in the form of open-end terminal with the number of bus stands changed to four stands for getting on/off and one stand for parking. To sum up, due to the modifications proposed in the article that enable comfortable, safe, fast and non-barrier transfer from trains to buses the railway station Týnec nad Sázavou ranges among the modern regional transfer nodes of public mass transport.

The procedure of the decision table usage for the railway station Týnec nad Sázavou is shown in *Scheme 1*. The output of the decision tables are four options for the station arrangement ("N-POO", "N-POJ"; "N-VDV", "N-VJE"), from which the selected option is "N-POO".

8. CONCLUSION

The utilisation of the modified decision tables and their contents oriented to the public mass transport transfer nodes, whose core is a railway station, is considered as a tool to support decision-making at the engineer's offices, of the traffic engineering project investors, regional administration and mass public transport coordinators. It can be assumed that after adjusting it, based on initial practical experiences, they will become a popular supporting tool in planning the modernisation of mass public transport transfer nodes.

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ABSTRAKT

Jeden z klíčových problémů, jehož řešení vede ke zvýšení atraktivity veřejné hromadné dopravy, je optimální uspořádání jejích přestupních uzlů. Cílem je navrhnout příjemné, jednoduché a bezpečné prostředí pro cestující i dopravce a řešení levné na výstavbu i provoz. I když každý přestupní uzel je originál se svými specifiky, tak k projektu jeho rekonstrukce nebo novostavby je vhodné získat nejprve obecnou představu o jeho dispozici. Ta by měla vycházet zejména z intenzity provozu jednotlivých druhů dopravy, síly jednotlivých přestupních vazeb, významu a charakteru dopravních cest. Článek představuje metodiku určení vhodné dispozice uzlů veřejné hromadné dopravy s využitím modifikovaných rozhodovacích tabulek (jednoho z nástrojů systémové analýzy) s konkrétními údaji využitelnými především v prostředí České republiky.

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veřejná hromadná doprava, rozhodovací tabulky, přestupní uzel

LITERATURE

[1] **Fiedler, J.**: *Bahnwesen*. Edition 5th reworked. Werner Verlag, München, 2005. 538 pages. ISBN 3-8041-1612-4.

[2] **Jacura, M.**: *Dopravní obslužnost území* [*Traffic Service in Region*], Ph.D. thesis, CTU in Prague, Faculty of Transportation Sciences, the Czech Republic, 2010.

[3] **Kubát, B.** et al.: *Městská a příměstská kolejová doprava* [*Urban and Suburban Rail Transport*]. Wolters Kluwer ČR, Praha, 2010. 352 pages. ISBN 978-80-7357-539-7.

[4] **Lübke, D.** et al.: *Das System Bahn*. Edition 1st. DVV Media Group, Hamburg, 2008. 680 pages. ISBN 978-3-7771-0374-7.

[5] **Taufer, I.**, **Hrubina, K.**, **Taufer, J.**: *Algoritmy a algoritmizace. Vývojové diagramy. Sbírka řešených příkladů* [*Algorithms and Algorithmization. Flow Diagrams. Solve Exercise Collection.*]. University in Pardubice, 2001 [online, 2009-10-04]. Available from WWW: <http://krpvt.upce.cz/files/algoritmy/kap1.pdf>.

[6] **Týfa, L.** et al.: *Moderní trendy v dispozičních a provozních úpravách regionálních dopravních uzlů* [*Modern Trends in Operational and Layout Modifications of Regional Traffic Nodes*]. Edition 1st. CTU in Prague, 2010. 341 pages. ISBN 978-80-01-04520-6.

[7] Czech Technical Norm ČSN 73 4959. Platforms and Roofs of Platforms of Nation-wide, Regional and Industrial Railway Lines. 2009.