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The Issue of the Transfer of Persons with Reduced Mobility and Orientation Between Different Modes of Transport

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ABSTRACT

This article deals with the transfer of persons with reduced mobility and orientation between different modes of transport. For these people, the transfer time depends on their mobility and their type of disability, and in most cases their need to choose a different transfer route than the majority of the population. This results in very different transfer times compared to the general population, creating greater time, orientation and physical demands on the persons. Given that this group includes elderly people and mothers with strollers, this issue is very topical. Knowledge of the total transfer time for a particular group can be used to optimize connections, or in Smart Cities applications.

KEYWORDS barrier-free, reduced mobility, transfer time, public transport, transport infrastructure, Smart Cities

INTRODUCTION

Today we can see a clear trend and intent of territorial governments in the field of transport, in their preference of public transport above private car transport. However, people often use different modes of transport and different connections (Integrated Transport System), which is associated with the need to transfer. The transfer time from one mode of transport to another is different for each group of people. Therefore, if a transport application announces a transfer time of 5 minutes between two connections, this is a transfer time that a "regular" citizen can manage on a "regular" route. This means that the information can be used by the majority of the population.

The majority of the population will probably not have an issue with the transfer (except for their knowledge of the transfer route), and will successfully transfer between the connections. In contrast, for people with limited mobility and orientation the transfer speed is undoubtedly different, because it is affected by their disability and the necessity to choose a different - barrier-free route (e.g. elevator, platform, ramp, etc.), resulting in a different time required for the transfer.

Knowing the speed of movement of individual groups with limited mobility and orientation, with regard to various infrastructure elements, can be used to design a transfer hub and during unexpected events, where alternative transportation has to be established to give the "slowest group" a realistic chance for a successful transfer, so they don't have to wait for the next connection.

The transfer process itself is influenced by multiple factors. The factors influencing the transfer speed can be divided into the following types:

- The physical fitness and ability of the person himself
- The influence of technical parameters of the given transport infrastructure element (e.g. speed of the escalator, pavement surface quality)
- The nature of the infrastructure element (e.g. number of stairs, elevator speed and capacity, platform speed)
- The amount of people on the infrastructure element
- The person's knowledge of the transfer route
- Subjective factors affecting the person himself - different for each person

By increasing our knowledge of individual influences, we can better understand the different movement speeds of people on these instrastructure elements, as well as the time loss. By applying them to a particular element, we can determine the difference in delays (speed) for various elements and different groups of people.

Dividing people into groups

For a detailed analysis of the speed (including transfer times or time loss) of individual groups of people, we divided the transferring people into several groups so that they represent both the demographic development in the Czech Republic, and the groups of people with a disability. As a basis, groups of people that are defined by Czech legislation in Decree no. 398/2009 Coll. [1] as „People with reduced mobility and orientation" were used. According to this decree, these are physically disabled persons, visually impaired persons, hearing impaired persons, elderly persons, mentally disabled persons, pregnant women and women with children under three years of age or strollers.

We therefore have defined groups, so that each measured person can be assigned to one group.

The resulting division of transferring people into groups:

- Persons without any apparent movement restrictions
- Persons with oversize luggage
- Older seniors
- Persons with carriages
- Persons accompanying children younger than three years
- Blind and visually impaired with remnants of sight
- Persons using walking aid tools
- Persons in wheelchairs
- Persons in electric wheelchairs
- Persons in mechanized wheelchairs without accompaniment
- **Persons in mechanized wheelchairs with accompaniment**

Determining the transfer time

The transfer route should always be the shortest connection between the point where a person is entitled to a transfer, and the point where his entitlement to a transfer ends. In the case of a transfer between different modes of transport, this is always the route between the modes of transport. The route itself consists of individual transport infrastructure elements that are represented in a different amount and order. Because we have different groups of people, the same route may not

be used for the same transfer (and it often isn't), which is why the structure of infrastructure elements is also different [2].

This includes the following elements in the transport infrastructure:

- Roads (in transfers this is not always a sidewalk, but a general element that connects other elements)
- Crosswalk, place for crossing
- Elevator, platform
- Staircase
- Ramp
- Escalator

Time required for transfer

We can generally define the time required for a transfer as a time loss that occurs on each transport infrastructure element. We should not forget the time required to exit the vehicle and the time required to enter the vehicle.

The total transfer time is therefore defined as follows:

$$T_{transfer} = T_{exit} + T_{transfer} + T_{entry} \quad \textbf{(1)}$$

, where

$T_{transfer}$ - the transfer time is the sum of all time losses on each transport infrastructure element of which the resulting route consists, including "delays" on each element

To determine the total transfer time, it is necessary to perform a detailed analysis of each transport infrastructure element. For example:

For the crosswalk infrastructure element, it is necessary to know the parameters of the crosswalk and measure the actual crossing times for each group [3]. However, the crossing time itself is not enough; we need to take into account the time lost waiting for the "walk" signal at controlled intersections (it is necessary to consider the worst case scenario that the person approaches the crossing just as the "stop" signal lights up), or the time after which the road is safe (median waiting time for all measured persons) for the person to cross.

For the escalator infrastructure element, it is also necessary to take into account the time spent on the escalator, as well as the waiting in the "crowd" of passengers before boarding the escalator (depending on the width and number of escalators).

For the staircase infrastructure element, it is necessary to consider the direction and intensity of the flow of passengers going up and down and their necessary evasion (the width of the staircase plays an important role), or the decreasing walking speed when moving up the staircase, if the staircase has more than 6 steps. There is a great number of such "details, and they must be recorded when time losses are measured. This, of course, makes the measurement more difficult and time consuming.

The influence of other parameters on the transfer time

The transfer time is also affected by influences that have not been explicitly mentioned. These are subjective influences. These influences can be different for each person, and they cannot be precisely measured in most cases. These influences include:

- Psychological influences (stress from walking up the stairs, crossing the crosswalk, fear of big crowds of people, ...)
- The weather
- Etc.

All of these factors may play a role in a change in the walking speed of people in a certain group, affecting the total transfer time. However, it is almost impossible to determine these influences without asking a specific person; this is why we do not take them into account in the measurements, but we do mention them for completeness.

Practical example of differences in transfer times

To demonstrate the difference in transfer times for different groups of people, we've chosen the transfer from a tram at Florenc stop (Křižíkova direction) to a line B metro (Zličín direction) in the prominent Florenc transport hub. We only measured the transfer time $T_{transfer}$, excluding the time required to exit the tram, and excluding the time required to enter the metro.

This is a typical example of when some of our defined groups cannot use the same transfer route. The main transfer route (direct transfer) leads from the tram stop straight to the metro station; however, it contains an escalator infrastructure element, and this route can therefore only be used by the following groups:

- Persons without any apparent movement restrictions
- Persons with oversize luggage
- Older seniors
- Persons accompanying children younger than three years
- Blind and visually impaired with remnants of sight
- Persons using walking aid tools

An alternative route that is longer but fully barrier-free must be used by the following groups:

- Persons with carriages
- Persons in wheelchairs
- Persons accompanying children younger than three years

It is no exception that the alternative route is also used by elderly people or people with a walking stick.

The following tables (Tables 1 and 2) show the individual infrastructure elements that each route consists of, including the time losses on these elements. The resulting transfer times for each route are therefore a sum of time losses on each infrastructure element.

TABLE – 1
Main Route for General Population

ID	Part of route	Infrastructure element	Lost time [hh:mm:ss]
1	Tram mark - escalator	road	0:00:53
2	Waiting to board the escalator		0:00:00
3	Riding the escalator	escalator	0:00:41
4	Escalator - escalator	road	0:00:12
5	Waiting to board the Escalator		0:00:00
6	Riding the escalator	escalator	0:00:42
7	Escalator - platform	road	0:00:20

The total measured transfer time $T_{transfer}$ for the main route was 2:48 minutes, and the distance of the transfer was 103 meters.

TABLE – 2
MAIN ROUTE FOR GENERAL POPULATION

ID	Part of route	Transport infrastructure	Lost time [hh:mm:ss]
1	Tram mark - crosswalk	sidewalk	0:01:35
2	Waiting for "walk" signal		0:00:35
3	Crossing	crosswalk	0:00:16
4	Crosswalk - elevator	sidewalk	0:01:21
5	Waiting for elevator		0:02:10
6	Elevator ride	elevator	0:00:47
7	Elevator - elevator	sidewalk	0:00:36
8	Waiting for elevator		0:00:08
9	Elevator ride	elevator	0:00:16
10	Elevator - platform	sidewalk	0:00:40

The total measured transfer time $T_{transfer}$ for the barrier-free route was 8:24 minutes, and the transfer distance was 334 meters.

The results clearly show that the barrier-free route is 5:36 minutes (300% more) and 231 meters (more than 300%) longer than the main transfer route that the general population can use.

The example shows that certain groups of people have no choice and they have to use a different transfer route that offers a barrier-free transfer. However, such routes are likely to contain infrastructure elements that do not allow mass utilization (elevators and platforms), which is the case of our example; specifically, the use of two elevators. Each elevator can only carry one wheelchair user (or mother with a stroller). If a group of wheelchair users traveled together, the resulting transfer time for each person would be much greater, which we must realize.

CONCLUSIONS

This article deals with the issue of transfer times between different modes of transport, with regard to the ability of a specific group of people to use the given (main) transfer route. The main route is not always barrier-free, and certain groups of people (e.g. wheelchair users) must therefore use a different - alternative route. If we breakdown the route into individual infrastructure elements of which the route consists, and we know the time losses on each element, we can determine the total time required for the transfer. Within the research, detailed mapping of each transport infrastructure element of which the transfer route consists is performed. The time losses are measured on these elements with regard to the wider context, such as waiting times required for entering and exiting the elevator, the amount of people, direction of transfer, etc.

Knowing the transfer times for specific groups of people can be widely used in transport and logistics, and especially in Smart Cities applications.

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