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Problem of trespassing railway property as an accompanying effect of suburbanization

Ivo Dostál^a, Marek Havlíček^a, Pavlína Skládaná^{a*}, František Nantl^b, Pavel Skládaný^a,
Pavel Tučka^a, Jan Perůtka^a

^a CDV Transport research centre, Líšeňská 33a, 636 00 Brno, Czech Republic

^b UUR Institute for Spatial Development, Jakubské nám. 3, 602 00 Brno, Czech Republic

Abstract

Railway trespassing is very common, though risky and illegal behavior in the Czech Republic. Number of victims of train-person crashes is about 200 fatalities every year. We can find several types of risk localities where unauthorised access to the railway tracks occurs, with various motivations, users, layout, risk rate, and intensity of trespassing. Field research revealed, in addition to other facts, that localities with very high intensity of trespassing are often situated at local connections between origins and destinations of everyday trips (housing, factories, schools, offices, services, shops, recreation, and sport facilities). This aspect was further explored in the context of land use development. This paper illustrates how risk trespassing sites are formed in the areas affected by suburbanization, either due to imperfections in master plans, or by improper implementation of the master plan in practice.

Keywords: Railway trespassing; suburbanization; barrier effect

* Corresponding author. Tel.: +420 541 641 351; fax: +420 541 641 712.
E-mail address: pavlina.skladana@cdv.cz

1. Introduction

High number of train-pedestrian collisions remains a serious problem of railway safety in the Czech Republic. Every year, there is about 200 fatalities (The Rail Safety Inspection, 2017) on 9564 km of railways (Ministry of Transport, 2017). Although some of the fatalities are proved to be suicides, substantial part of the accidents is the result of trespassing, which is very widespread phenomenon in the Czech Republic.

This paper is aimed to causes and spatial context of railway trespassing. Unlike the train-person crashes, that have been studied sufficiently and regarding many various aspects, trespassing itself hasn't been the subject of many studies.

Frequency, motivations, and opinions of trespassers at selected problematic sites were the subject of two Finnish studies (Silla and Luoma, 2008, 2012). Main reason for trespassing was taking a short cut; half of respondents believed that trespassing is safe and 15 % considered trespassing to be legal. Also other works mention the desire to shorten the distance from point A to point B as the prevailing motivation for trespassing (Lobb et al., 2001; Burkhardt et al., 2014; RSSB, 2014).

Other reasons include recreation (strolls, walking dogs), socializing, vandalism, theft, and risk-seeking (Burkhardt et al., 2014; RSSB, 2014), while the conditions contributing to trespassing occurrence include accessibility (insufficient or no fencing, absence of landscaping, proximity to frequently visited destinations), poor visibility (site located behind a curve or bump, poor visibility from the nearest road), and possibility to take a short cut to one's destination (DaSilva, 2011). Another study (Ozdogan et al., 2006) cites as a crucial cause of trespassing the fact that a substantial proportion of the population lives at the peripheries of large municipalities in proximity to railways but without adequate pedestrian infrastructure. Under such circumstances, trespassing inevitably becomes an everyday activity. Existing knowledge was utilized in recent RESTRAIL project aimed to prevention (Havarneanu et al., 2015, 2016).

Social context of railway trespassing was highlighted by Savage (2007). His study of historical data about train-person crashes in the United States proved that the number and character of crashes are influenced not only by demographic changes in population and the progress of railway traffic but also by economic and political events. In the Czech Republic, serious situation in train-person collisions encouraged initiation of two research projects. AMELIA (Skladana et al., 2016) has described the current situation of railway trespassing in the country and provided an overview of basic preventive principles. One of the main output of the project was the typology of risk localities. Six types of risk localities were specified (Skladana et al., 2016): trespassing at stops and stations, everyday short cuts apart from stations (for these first two types, the dominant motivation is the effort to shorten the way between points A and B); short cuts and lingering at rails in recreation localities (in addition to shortening a tourist trail, the motivation here is also use of the space near rails or even railway infrastructure itself for recreational purposes); places of interest (e.g. urban explorers, railway aficionados, but also vandals and graffiti artists); places of meeting or lodging (places in proximity to railways sought out by users of alcohol and drugs or as hideaways for homeless people); and trespassing at level crossings (time saving as motivation). The project emphasized that although trespassing is always considered to be users' error from legal point of view, insufficient, missing or inconvenient infrastructure for pedestrians, disrespecting existing logical pedestrian routes, is often the circumstance contributing to the occurrence of the offence.

Broader context of the railway trespassing is investigated in frame of the research project NEOS (Skladana et al., 2018). The project handle the problem regarding the media coverage, attitudes and opinions of public, and the context of land-use development. Previous knowledge about trespassing motivations was brought together with data from topographic maps in order to determine the impact of land-use development on the formation of selected sites with frequent railway trespassing.

The results demonstrated two ways of trespassing formation. First, the restriction of territorial permeability for pedestrian movement in the territories where the railway was introduced into existing settlement structures; original spatial relationships were severed and this originated the functional and spatial conflicts as described by Sas-Bojarska and Rembeza (2016).

Second, in cases when the railway was introduced outside of built-up areas, proximity of railway stations and accessibility of transport infrastructure often encouraged the construction and development of industrial sites,

accompanied consequently by building of residential complexes and services. These results are compatible with the findings about the influence of physical barriers (including railways), on land use patterns and socio-spatial differentiation within towns, described by Noonan (2005). He claims that physical barriers that mitigate the externality of neighbours' characteristics should be expected to have important differential effects on urban land use patterns. From our point of view, the relevant output is that the mosaic of various functional area types, namely the combination of housing areas with shopping, industrial, and public services infrastructure, became the crucial factor shaping motivations for railway trespassing.

This study concentrates on the above mentioned second type of trespassing localities - the sites resulting from gradual development of built-up areas with different functions alongside existing railways, specifically as the accompanying effect of suburbanization. The major wave of suburbanization in the Czech Republic started after 1990 and still continues, rather uncontrolled due to constantly changing relevant legislation.

Suburbanisation is understood as the spatial growth of cities into surrounding rural and natural landscapes. However, not every urban expansion is suburbanisation. Provided the expanding city maintains a compact form, the matter is one of continuing urbanisation. However, if new developments occur at a distance and spatially separated from the core of the city, what is occurring is suburbanization (Sykora, 2003). Suburbanization – the shift of population, activities and some functions from the central areas of the cities to their suburbs – is an important phenomenon of the second half of 20th century and the beginning of 21st century. In the post-communist countries, suburbanization began later (second half of the 1990's) with more dynamic deconcentration of non-residential functions, and soon became the dominant process that is changing the spatial organization of cities (Sykora, Ourednicek 2007). The process and its economic, social, and environmental consequences, as well as the influence on mobility and the demands on transport infrastructure, has been described in many studies (e.g. Sykora, Ourednicek, 2007; Dostal et al., 2010; Colonna, 2012; Cervero, 2013; DeVos, Wittlox, 2013; Krejci et al., 2016). One of its side-effects, i.e. formation of new pedestrian relationships and links that may result in railway trespassing, is highlighted in this paper.

The study also deals with another aspect of the problem, the influence of the intensity of barrier effect on the extent of the risk of trespassing. The barrier effect of railway may be increased e.g. by fencing and similar measures aimed to prevent the access; but the effect also grows with increasing speed and intensity of railway traffic.

2. Method

To assess the process of suburbanization in proximity of railways in the Czech Republic, the maps of built-up areas defined out of the basic maps 1: 10 000 from the 1990s, and from the actual aerial photographs of the Czech Office of Geodesy and Cadastre were used according to the methodology developed by Skalos et al. (2011) and Havlicek et al. (2013). The processes of suburbanization in the relation to railway trespassing were followed within the hinterland of the selected main railway lines with high intensity of traffic, all TEN-T lines and railways of the national importance. Regional railways were not included.

Using the geographic information system analysis, the area of 1 km radius around the railway was identified. Within this area, such origins and destinations of mobility can be found, that generate the railway trespassing. To be able to assess the dynamics of the growth of built-up areas, and to check the processes of suburbanization, the whole railway net was divided into sections of 500 meters, and thus 9407 zones were created, interdigitated with layer of newly created built-up areas. The percentages of these areas were calculated for each zone. The zones with high percentages of newly built-up areas (more than 15 % of the zone) were further subjected to the detailed investigation of aerial photographs, to be able to specify concrete category of suburbanization.

To be able to assess relationship between suburbanization and railway trespassing, also other conditions were investigated, using detailed aerial images and field inspections: the presence of walking trails and ways over tracks, and limitation of possibilities to overcome the tracks (great watercourse, sloping, inaccessible terrain). The analysis of the real impact of trespassing at given place was done with help of the electronic map of train – person crashes, created in frame of AMELIA project. The map (Kubecek, 2015) contains the dates, accurate locations and consequences of train – person crashes in the Czech Republic during the period 2005 – 2014 that can be related to basic operating parameters of railways in the investigated localities. The maximum train speed and intensity of traffic at each of the followed sections were obtained from the official documents of railway infrastructure administrator (Tables of track's situations, Diagrams of train traffic 2016/17).

3. Results

3.1. Overall results

The input layers of maps were the built-up areas from the 1990s and from 2015-2016. Overlay of these maps created the layer of changes of built-up areas during 25 years period. This period matches with the era of the intense suburbanisation in the Czech Republic.

Another map layer included into analyses is the layer of 9407 zones of 500 m long sections of national railways, representing areas of radius 1 km from the tracks. Among these zones, 9052 contains the built-up area at least during one time period, 355 zones are without built-up area. Significant proportions of the increase of built-up areas (more than 15 %) were observed at 228 zones (see Table 1). These zones were then checked with regard to suburbanization and railway trespassing. Significant changes were found also in another 548 zones, with 10 – 14.9 % of the area newly built up. Also in these localities, influence of suburbanization on railway trespassing can be expected.

Table 1. Percentage of newly created built-up areas in the zones along the railway tracks.

Percentage of built-up areas	More than 15 %	10.0 to 14.9 %	5.0 to 9.9 %	2.0 to 4.9 %	0.0 to 1.9 %
Number of zones	228	548	1933	3425	2918
Representation in %	2.5 %	6.1 %	21.4 %	37.8 %	32.2 %

Evaluation of concrete impacts of suburbanization on railway trespassing was applied on all zones with percentage of newly built up areas higher than 15 % during the period 1990 – 2016. For the purpose of more detailed evaluation of problem localities, the zones were merged into model areas that include the complex spatial and territorial links and connections with regard to the motives of trespassing and imperfections of urban planning.

The localities were selected that fulfil following conditions: the presence of suburbanization, terrain conditions appropriate for walking over the tracks, existing paths and shortcuts over the tracks, optionally the accident records in the railway section. In total, 19 following cases were selected with characteristics listed in Table 2 (location see at Figure 1).

Table 2. Localities with impact of suburbanization on trespassing in the Czech Republic by the percentage of the newly created built-up areas.

No	Name of locality	Percentage	Newly built up areas
1	Liberec - Ruzodol	37.87	Industrial estates, shopping centres, individual housing
2	Brno - Cernovicka terasa	36.37	Industrial estates, individual housing
3	Plzen - Bory	33.57	University, services
4	Hostivice	29.26	Logistic centres, industrial zone, individual housing
5	Olomouc - Holice	27.31	Industrial estates, shopping centres
6	Teplice - Sobedruhy	26.97	Shopping centres, individual housing
7	Brno - Ivanovice	26.65	Shopping centres, individual housing, gardens
8	Liberec - Doubi	24.41	Shops, stores, individual housing
9	Minkovice u Liberce	22.40	Individual housing, apartment houses
10	Prostejov - south	20.68	Individual housing
11	Melnik	20.41	Stores, shops, individual housing
12	Roudne, Vcelna	19.94	Individual housing
13	Tisice u Neratovic	19.44	Individual housing
14	Kladno - south	18.60	Industrial estates
15	Tabor, Sezimovo Usti	16.63	Shopping centres
16	Karvina	15.79	Industrial estates
17	Bystrovany, Velká Bystrice	15.39	Shopping centre
18	Dobroviz	15.15	Logistic centre
19	Hradec Kralove	15.05	Shopping centre

Number of fatalities and serious injuries was found in each locality, as well as train speeds and intensity of railway traffic (see Table 3). The strong link between the number of casualties/injured and the maximum train speed, respectively the daily intensity of railway traffic, in each of model areas is documented in the charts below (see Figure 2).

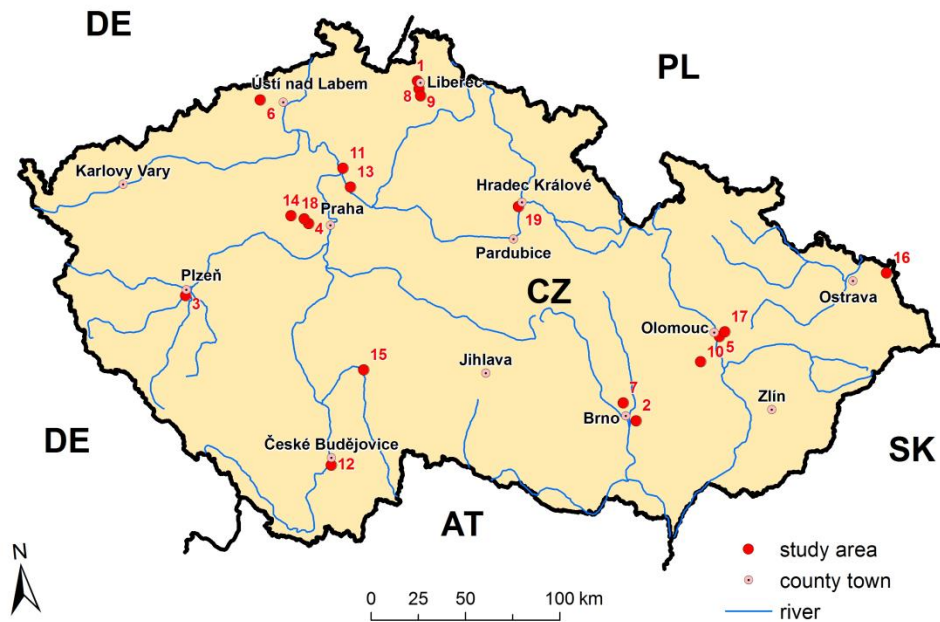


Fig. 1 Map of selected model localities with impact of suburbanization on trespassing in the Czech Republic

Table 3. Number of fatalities and injuries of persons related to speed and intensity of railway traffic in selected model areas.

No	Name of locality	Fatalities	Injured	Train speed	Number of scheduled trains
1	Liberec - Ruzodol	2		100	123
2	Brno - Cernovicka terasa	1	1	100	122
3	Plzen - Bory	1	1	80	38
4	Hostivice		1	80	159
5	Olomouc - Holice	9		120	275
6	Teplice - Sobedruhy	5		100	114
7	Brno - Ivanovice	2		100	150
8	Liberec - Doubi	3		90	49
9	Minkovice u Liberce	2		90	49
10	Prostejov - south	3		100	56
11	Melnik	3	1	120	186
12	Roudne, Vcelna			70	30
13	Tisice u Neratovic			100	69
14	Kladno - south		1	70	91
15	Tabor, Sezimovo Usti	3		140	84
16	Karvina	2		100	130
17	Bystrovany, Velka Bystrice			70	69
18	Dobroviz			60	38
19	Hradec Kralove	5		100	91

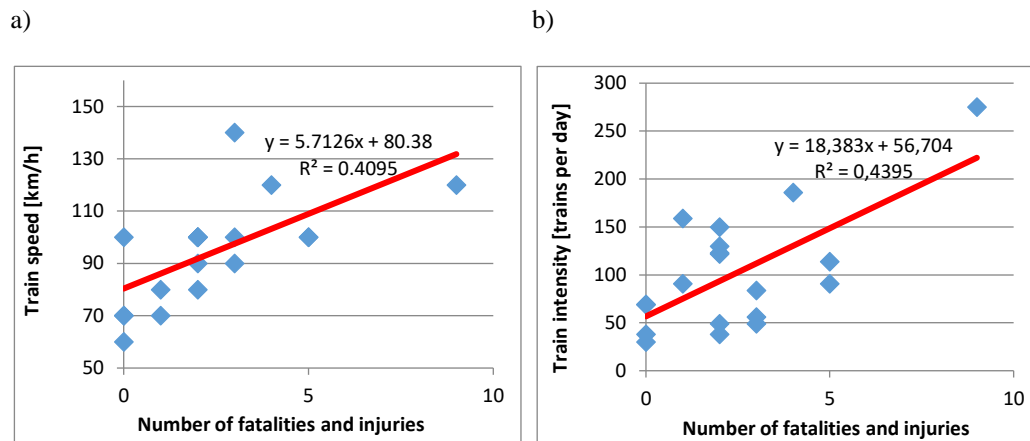


Fig. 2 Number of victims by train speed (a) and intensity of railway traffic (b)

Number of fatalities and injuries related to train speed and train intensity was analyzed. These parameters characterize the intensity of the barrier effect of the railway in the locality. The method of the linear regression was used. Both for the speed and the intensity, the coefficients of determination $R^2 = 0.4095$ (Figure 2a - train speed) and $R^2 = 0.4395$ (Figure 2b - train intensity) indicated close relationship. In spite of relatively low number of localities, we can state that the number of victims increases with growing train speed and even more with increasing train intensity. While the occurrence of trespassing itself in suburbanized areas is given by the character of land use in the surroundings, the occurrence of trespassing's consequences, i. e. train – person crashes, is influenced also by the extent of barrier effect of the railway.

3.2. Three examples of suburbanization and its impact on railway trespassing

Liberec- Ruzodol

The highest percentage of newly built up areas was observed in the locality Ruzodol in the outskirts of the City of Liberec, where the industrial park with production of automobile components and electronic parts was constructed. In the proximity of this industrial zone, the important shopping centre was built. On the opposite side of the railway, the residential quarter was completed with new individual houses. Everyday trips between residential zone and shops, or to work in industrial area became the source of railway trespassing. Two illegal paths over the railway can be found in the locality, and two train – person crashes with fatal consequences were recorded during the monitored period (both in 2014). The train speed limit is 100 km/h, and the railway traffic is intensive – 123 timetabled trains per day. Regarding urban planning, insufficient legal connection between residential area and shopping and industrial areas, both for pedestrians and public transport, seems to be the crucial imperfection. Current master plan of the town Liberec does not include any new underpasses, pedestrian bridges or level crossings in the locality.

Hostivice

The municipality is situated close to Prague and the airport Ruzyně. Most of newly built up sites are used as logistic centres or industrial estates, residential houses to a lesser extent. Logistic centres are connected to the main railway with industrial tracks, illegal pedestrian paths are not currently observed in their close proximity. Illegal shortcuts can be found in the vicinity of residential houses; they are used for recreational purposes, walking to nearby wood. The legal connection between residential neighbourhood and recreational zone was not planned in current master plan. During the monitored period, one train-person crash resulting in serious injury was recorded. The train speed is quite low - only 80 km/h but intensity of railway traffic is relatively high (up to 159 scheduled trains per day).

Holice

Holice is situated at the outer border of Olomouc city. After 1990, new industrial, logistic, shopping and educational (university) areas were built here (see Figure 3). The zones are separated from each other by important railway with high intensity of traffic. The railway tracks run through the centre of the territory. Since 2003, when some of the new industrial and shopping estates were opened, new (illegal) pedestrian paths over the tracks gradually appeared (see figure 3 on the right). Two legal possibilities, level crossing and bridge, 1.5 km distant from each other, do not satisfy the needs of pedestrians. Also new bus terminal (2010) became important source of trespassing (Figure 4). Trespassing is formed by regular trips to work, school, and shops. At the problematic section of the railway, 9 fatal accidents were recorded from 2005 to 2014; three of them, in 2010, 2011, and 2012, happened at the shortcut leading from bus terminal (Figure 4).

a) 2003

b) 2015



Fig. 3 Signs of suburbanization in Olomouc – Holice; aerial images 2003 (on the left) and 2015 (on the right)



Fig. 4 Location of frequent railway trespassing with accident records (bus terminal in Holice) – excerpt from electronic map of train-person crashes (AMELIA project)

The investigated localities demonstrated imperfections in town planning documents. The passages for pedestrians and cyclist were either not planned at all, or the concrete measures were planned but not realized. This is the case of the Master plan of the city Olomouc of 2014 (Master Plan Olomouc, 2014) that includes two underpasses for pedestrians and cyclists in the places of trespassing occurrence in proximity of bus terminal Holice (Figure 5 –

pedestrian routes are displayed in blue dots, links to other parts of transport infrastructure is solved). While the areas for development of commerce and industry (pale blue) as well the areas for public spaces (orange) are actually gradually filled with buildings, the construction of underpasses has not yet started (December 2017).

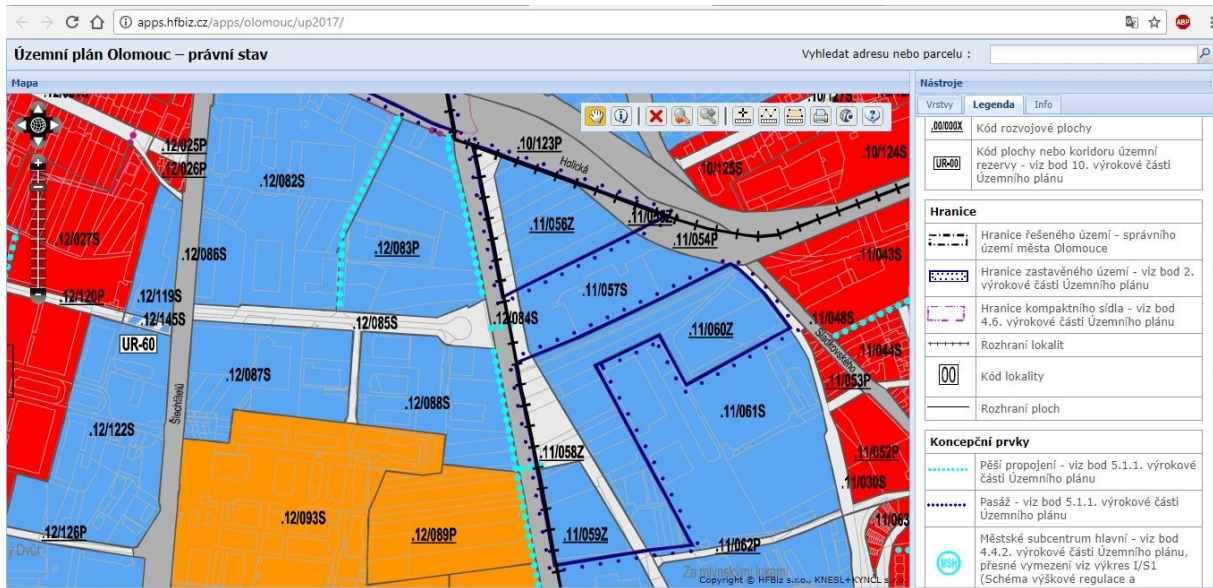


Fig. 5 Master Plan of Olomouc with bus terminal Holice in the middle of map



Fig. 6 Trespassing site in Olomouc-Holice (photo 2017)

Flat landscape is typical for the region of Olomouc, so that characteristic mode of transport is cycling. Inspection of the trespassing site in Olomouc-Holice revealed that the illegal shortcut is used mainly by cyclists (prints of tires at Figure 6). Frequent crossing of people carrying heavy bicycles necessitated implementation of technical measure protecting the track ballast.

4. Conclusions

The analysis presented in this paper has shown the significant occurrence of railway trespassing in the areas affected by suburbanization. The total of 19 risk localities situated in suburbanized areas over the whole country were identified and analysed in detail, using the statistics of train-person collisions and characteristics of the railway traffic.

In all but four localities, one or more accidents were recorded between 2005 and 2014, including the site Olomouc-Holice being at the top with 9 casualties. Four sites with no accident record were located at the single-track, less important lines with lower speed of trains and mild intensity of trains, while others, highly risk sites, are located

at railways with high speed of trains and high intensity of traffic. The barrier effect increased by high speed and intensity does not prevent the access, but remains one of the factors contributing to the danger of trespassing. All sites have in common that providing of legal, safe, and pedestrian friendly connection between various parts of newly built up territories, when railway tracks forms the dangerous barrier, is omitted. From the viewpoint of urban planning, there are two completely different approaches to the pedestrian problem in valid master plans. Either there are no new passages through railway planned, so the existing trespassing is obviously the result of bad planning; or the master plan includes proposed new passages but these were never built. Then the trespassing occurrence is caused by improper implementation of the master plan in practice: the construction permits for new built-up areas does not include obligation to include legal walking paths as a part of construction and/or new passages were not included into project due to economical reasons during the (re-)construction of railway in the case of TEN-T lines.

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