Traffic calming in historic city centres - a case study

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Abstract. The aim of the paper is to compare the existing transport service solutions in the city centers of Bydgoszcz (Poland) and Hasselt (Belgium) that use the widely understood idea of calming the movement. The method of elaboration consisted of analyzes of the literature on the subject of the article, analyzes of available documents and local visits. The solution has been operating in Hasselt since September 2018, and in Bydgoszcz also since September, but 2019. Analyzed solutions in terms of traffic calming goals in these areas, implemented principles, methods used and traffic calming measures that are to lead to a consensus between traffic and the accessibility of the area and making centers living areas. The analyzes carried out confirm that the primary effect of leading to obtain areas centers as areas of “livable city” is to eliminate traffic not associated with a given area, the implementation of restrictions on the availability of cars while maintaining accessibility to public and residential buildings and creating preferences in terms of accessibility for pedestrians, bicycles and public transport. In both cities significant attention was paid to shaping public spaces for pedestrians and development of street fronts with facilities for attractive functions for center users and tourists. Analyzed examples of Bydgoszcz and Hasselt show that the implementation of a separated cycling infrastructure in the historic structure of centers is very difficult. For achievement of “livable city”, special emphasis is placed on functional solutions and forms of pedestrian areas, taking into account the requirements of conservation protection, aesthetics and road safety.

1. Introduction
Transport services for city centres is one of the most difficult challenge in the field of city planning and management. In particularly it is difficult in areas where city centres are also legally protected historic areas, which practically eliminates the possibility of any spatial structure and road system transformation. European city centres are usually historically shaped. They are attributed by low-capacity street systems, which leads to the elimination of car traffic from these areas.

The purpose of this paper is to compare existing transport service solutions for two city centers: Hasselt in Belgium and Bydgoszcz in Poland. The solution applied in Hasselt has been functioning since the nineties of the twentieth century. It is seen as exemplary in the aspect of transport policy and the
The relationship between the street system and the development of the centre area for medium-sized city centres on the scale of Belgium and Western Europe. In the case of Bydgoszcz’s city centre, restrictions on car traffic have been introduced since the beginning of September 2019. Despite the consultation process with inhabitants at the design stage, they still meet with many controversies. Both solutions in Hasselt and Bydgoszcz are based on the concept of traffic calming, which has been successfully implemented in urban structures, including city centres, for almost half a century.

The methodology for developing this article was to review the literature on the subject, visions of local Hasselt and Bydgoszcz centres, to prepare photographic documentation and to compare existing solutions.

A review of the literature on the subject of the article indicates that the idea of traffic calming as a tool for shaping public space was dealt with subjects or analysing road and street networks in urban areas among others Ascher and Apel-Muller [1], Bonanomi [2], Bach and Presman [3], Bach [4], Gawlikowski [5], Gehl [6], Gunarsson [7], Vahl and Gisges [8], Wesolowski [9] and Zalewski [10] as well as scientific institutions including among others: CROW [11] in The Netherlands and in France - CETUR/CERTU [12-14].

The general conclusion resulting from the analysis of the above literature items is that the idea of traffic calming is an urban and transportation concept that has been developed for almost half a century in cities and European agglomerations of various sizes and is a widely used tool for shaping public space in cities.

Traffic calming is "ordering and adjusting the transportation way of servicing the area to its basic functions and functional, cultural and ecological character" [15]. Gunarsson [7] defines traffic calming as "a solution of an organizational, construction and legal nature, reducing traffic nuisance by imposing restrictions on it and changing the transportation service of selected areas, e.g., housing complexes, city centres, shopping streets. These activities assume deviation from the principle of full freedom of car use and reduction of the degree of penetration of the area by traffic car .

The emergence of the idea of traffic calming [10] is associated with:

- counteracting the intensive development of the automotive industry,
- deterioration and threat to road safety,
- environmental nuisances caused by car traffic,
- degradation of urban spaces, especially downtown and residential districts.

Traffic calming causes changes in street hierarchy, installation of barriers and other physical devices that reduce the speed of traffic and / or limit the volume of transit traffic in terms of road safety, legibility of street space and other public purposes. Traffic calming is a combination of, mainly physical, devices and activities that reduce the negative effects of using cars, changing driver behaviour, and improving conditions for non-motorized street users. The reconstructed streets become such "icing on the cake" of public space in cities and agglomerations.

The significant role of traffic calming in actions for the benefit of transport and urban policy, as well as reducing the traffic risk has been noticed in official documents of the European Union (EU), among others [16] and is currently a binding idea in shaping public space in cities of EU member states.

2. Traffic calming in city centres

Traffic calming on the scale of the functional area and the urban unit consists in considering at the stage of the local land use plan the boundaries of the calmed traffic zones, the geometry of intersections and street routes inside the area should be determined. Rules for traffic calming should be laid down, along with methods for transforming interiors of streets and squares and the level of traffic restrictions. At the
same time, the consequences of introducing sedation in the road and street system should be analysed, due to the common phenomenon of traffic migration and threats outside the calmed area [10].

The city centres are extremely susceptible places to introduce traffic calm zones. The areas with central and downtown functions were, next to residential areas, regions of cities where historically the earliest attempt was to implement traffic calming.

Therefore, to ensure their proper functioning, the introduction of restrictions on access to these areas is required, and at the same time, access to all objects located in these areas must be guaranteed. The traffic calming inside them seems to be the perfect idea to achieve this goal, which in turn will reroute some traffic flows into alternative arteries located outside of this areas.

For traffic calming in city centres, the most important is as follows:
- definition of so-called environmental capacity of the area in terms of transportation,
- mapping routes and traffic that will take over part of the traffic previously passing through the centre,
- definition of the scope of possible transformations in the urban aspects, i.e. changes in functions and their intensity as well as necessary streets reconstruction.

The main activities are focused on the elimination of traffic not related to the calmed area and the creation of an internal centre bypass. This internal centre bypass should be joined with loops of local streets, with possible connectors providing access to most buildings and public facilities. Pedestrian zone should be located inside of each central area, which is a representative promenade of the city. In the zone closed for private cars, bicycles usually have the right to access it, and they supply transport during not heavy pedestrian traffic.

The most important premises for achieving the desired transformation of urban territory into a traffic calmed zone and obtaining synergies resulting from it can be formulated as follows:
- vehicle traffic not related to a given area must be completely eliminated and routed through arteries or main streets running outside this area, which is achieved by creating street systems in the form of one-way connectors and loops;
- traffic with granted access to the zone should be speed limited to a maximum of 30 km/h;
- parking lots should be comprehensively organized for the entire zone;
- a dense and efficient network of pedestrian and bicycle traffic, as well as convenient public transport services should be provided to encourage residents to give up their own car, especially on short trips;
- all measures that physically direct and organize car traffic and shape street space should be implemented consistently and in a coordinated manner for the entire zone.

It should be noted that the implementation of the above premises in relation to the functional area or urban territory must consider its functions, and the layout of the spatial structure and forms of the road and street network.

3. Traffic calming in the centre of Hasselt
Hasselt (Belgium) is an example of a comprehensive traffic calming solution on the scale of the entire city (Figure 1). It is a medium-sized city with about 70 thousand residents, and it is known as an important administrative and academic centre. The rate of motorization in Hasselt is estimated at 1.14 private car per a household in the second decade of the 21st century [17]. The city is organized with a radial-bypass system of spatial structure and a concentric centre location. The scale of a medium-sized city has potentially created opportunities for traffic calming both across the city and its individual parts (see Figure 1).
Figure 1. Road-street network in Hasselt (Belgium), which implements the principles of traffic calming in the city and the area of the historic centre; internal bypass with one-way car traffic and speed limits 30-50 kph;
[source: Hasselt tourist map of 2018]
legend: red - motorway; yellow - the basic road and street network with speed limit 30-50 km/h; green – cyclists infrastructure (roads for bicycles, roads and zones for pedestrian and cyclist); dotted line - street sections accessible to pedestrians and cyclists.

The size of a city, in which, as a rule, all or a significant part of it can be served by walking and cycling, has created premises for the implementation of calming throughout the city and brings the best results among urban areas of various types. On this scale of cities, traffic calming can be introduced in areas with the various spatial development functions, including centres, downtowns, residential districts, and mixed-use areas. Moving through traffic from the city to its outside is the biggest transportation problem.

The elimination of the external through traffic creates great opportunities for shaping urban spaces to make them friendly to residents and the environment. Comprehensive implementation of traffic calming creates possibilities to achieve the intended goals, including improvement of road safety, reduction of private vehicles traffic volume, and thus much better qualitative and quantitative shaping of public spaces. The scale of a medium-sized city allows the use of various traffic calming techniques, both a construction nature and a traffic engineering technique. If the traffic calming cannot be
implemented in the scale of the whole city, selected areas with different functions and spatial attributes can be chosen for implementation.

At the end of the second decade of the 21st century Hasselt can be called a resident friendly. Systemic activities in the field of transformation of the city's transport service system have been carried out for almost 50 years, intensified 30 years ago, and cover the entire city. Today's look of a living and user-friendly city is due to the bold decision of the city authorities, which decided to move away from the policy of a "pro-car city" towards a city policy with sustainable urban mobility. This city policy is focused on pedestrians, cyclist, public transport, as well as implementation restrictions for car traffic and road safety improvement. In addition to this activity, the free of charge public transport service for the city’s residents was started in 1997. Moreover, the selected tourist transport lines were served free of charge either. In 2014, the public transport fare system was partly restored, however, it has not reduced the use of public transport by residents.

The implementation of a traffic calming zone in the centre of Hasselt resulted in significant changes in the distribution of transport modal split in 2000-2013 (a significant increase in public transport trips was observed from 4% to 41% of all trips, from 9% to 26% as a pedestrian and a reduction in motorized trips from 71% to 23%) \[17, 18\].

The road and street system in Hasselt was categorized and hierarchies. The two-bypass system was implemented, a one-way traffic system on the inner beltway of the historic centre, inside of which pedestrian and cyclist traffic are prioritized (limited access for cars in the form of loops, 30 pace zones, bicycle streets \[19\] and pedestrians’ zones).

So-called bicycle-car streets are an interesting solution, where mixed bicycle and car traffic is accepted. However, in this solution bicycles have right of way on the road and car traffic must yield two-wheelers. Two-way bicycle traffic (contraflow traffic) operates in bicycle-car streets with one-way car traffic. This solution perfectly fits the historic spatial structure and street network in Hasselt improving transport efficiency and road safety. Selected public transport bus lines penetrate the centre area of the city and their last stops are in the historic Market Square. This solution allows to obtain continuity of the bicycle road network and creates the environmentally friendly central zone. It also improves the quality of public spaces (Figures 2-5).

**Figure 2.** Hasselt (Belgium) - view of the downtown beltway with calmed one-way traffic; for the opposite direction there is a one-way service street with an approved bicycle traffic; in the middle lane a pedestrian and bicycle promenade

**Figure 3.** Hasselt (Belgium) - a traffic calming zone in the historic centre - a view of a bicycle-car street with two-way bicycle traffic and one-way car traffic
4. Traffic calming in the historic part of the centre of Bydgoszcz

Bydgoszcz is a city of 354,000 inhabitants [20]. It is an important regional centre with administrative, industrial, academic, and cultural facilities. The level of individual motorization is estimated according to the official statistics data in 2017 at 1.60 pp / business home [21]. The layout of the spatial structure has a form like a rectangular grid with an extension towards the East-West.

The shape of the spatial structure of the city is determined by the Brda river passing through the city centre, which gives a special atmosphere and charm. The main road network in the centre and downtown of Bydgoszcz is currently underdeveloped. As a result, intra-district routes are heavily loaded with traffic run in the immediate vicinity of the historic centre. There is no possibility of traffic rerouting it into alternative arteries, especially in the East-West direction. A significant part of the city centre is located outside the restored historic part of the city.

Without the construction of the new East-West arteria, alleviating the problems of transport service, it is not possible to further expand the traffic calming zone in the entire downtown of Bydgoszcz and to make this area user-friendly. Traffic calming in the centre of Bydgoszcz includes streets inside the area bounded by routes, which form the basic road network of the city (main arteries and collective streets). The area covered by the traffic calming zone is shown in Figure 6.

Reduction of car traffic, improvement of traffic conditions for pedestrian and cyclists, and the quality and accessibility of public space were the main goals of a traffic and parking reorganization in this area. The area of the Old Market Square and streets reaching this square have been excluded from car traffic, except for periodic availability for delivery traffic (Monday - Friday 6-10). In addition, the section of one of the streets not directly reaching the Market Square was total excluded from car traffic, and which has very high functional and aesthetic values and is an attractive route for pedestrians and cyclists (Figures 7-10). Mention above street sections form a pedestrian and cyclist zone. The other streets in the area forming the traffic calming zone and a residence zone (with a speed limit of up to 20 km/h) or as a "tempo 30" zone (with a speed limit of up to 30 km/h).
Figure 6. Traffic system scheme in the Old Market area in Bydgoszcz – the traffic calming zone [22]

Figure 7. Grodzka Street - departure from the residence zone

Figure 8. Intersection of Dluga and Jan Kazimierz Streets, section of Dluga Street, intended for pedestrians and cyclists - visible lowered bollards limiting accessibility
Figure 9. Podwale Street- residential area, one direction for car traffic and both-directions bicycle traffic (contra-flow traffic)

Figure 10. The north-east corner of the Old Market Square with a parking lot for bicycles after revitalization (pavement surfaces, roadways and market slabs made of stone of varying texture and colour)

The previously functioning system of loops and one-way streets with full access from the basic city road network was adapted. It enabled to introduce of restrictions on accessibility. Direct access to the city centre is limited to residents, deliveries (with allowed parking up to 30 minutes), police and other municipal services, as well as vehicles for the disabled users. Public (paid) parking lots are located on the outskirts of the traffic calming zone. They can be accessed from the streets of the basic road network system limiting the above-mentioned zone.

Public transport service (buses, trams) is organized by the routes and lines of urban public transport connecting the centre with other parts of the city. Transformations of the road network and parking system in the city centre resulted in a significant improvement in the quality of public spaces. The Old Market gained new decor, where the entire surface of the square and the roadways and pavements surrounding the square were replaced. The Struggle and Martyrdom monument was moved to the edge of the square. A public bike station was built in the Market Square. This way, the city gained an aesthetic square and an excellent place for various city events.

The solution presented above has been in operation since September the 1st, 2019, and the authors do not yet have numerical research results of traffic counts and transportation inhabitants’ behaviour. Opinions of the residents in Bydgoszcz indicate their positive reception. They fully accept the new look of the Old Market Square. Critical voices, but in the opinion of the authors unreasonable, come from users of public institutions located in this area. And it is because access to these institutions is limited and at the same time retaining the possibility of temporary parking (Area of the Cathedral and the Episcopal Curia). Also, users of commercial and service facilities and numerous catering facilities complain. And this is mainly due to temporary restrictions on the availability of more efficient management of supplies of goods necessary for their operation.

Car access and parking restrictions enabled to reduce internal traffic and vehicle speeds, and that way to improve accessibility for pedestrians and cyclists. The one-way street system, the pavement renovation of selected streets and the above-mentioned the Old Market Square total pavement replacement gave a new look to this area. As a result, the historical centre of Bydgoszcz, after the introduction of traffic calming solutions, became a user-friendly area for its inhabitants and tourists (Figures 11-12).
5. Conclusions

1) The traffic calming solutions in Hasselt (Belgium) and Bydgoszcz (Poland) centres presented in this paper show great possibilities of shaping transport service and improving the quality of public space in central areas of cities. The undertaken actions are strongly embedded in the spatial and transport policy of both cities.

2) Creation of user-friendly zones and improvement of the operating conditions of these areas enabled much better quality of public spaces in central areas.

3) In both cities the traffic calming effect in the central areas was achieved by reducing through traffic, limiting private cars accessibility, zoning accessibility through a loop system and one-way streets, limiting parking lots and parking tolls. Moreover, some means of traffic calming were used, among others legal measures like speed limits, appropriate vertical road marking, surface reprints, posts (automatic) as barriers to accessibility.

4) The traffic calming solution in Hasselt covers the entire city centre, while in Bydgoszcz only part of the centre with the most historic values. This is the result of different spatial structures of these areas and the size of both cities.

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