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Phenomenon of urban boundary in a structure of a city. The case of Vilnius

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Abstract. The article presents a theoretical – fundamental study of phenomenon of physical boundaries in a city and their meaning for the existing urban fabric. The paper draws attention to their different nature and possibilities of integration. In terms of its impact, an urban boundary can be both a catalyst and a tool that forces/stimulates/determines some or other conditions significant in formation of an urban structure. The aim of research is to identify/distinguish these boundaries in a city and see their multi-dimensional character, both in terms of positive and negative impacts on the existing environment. The article studies both the theoretical platform for urban boundaries and the practical works/projects, on the basis of which the laws of urban structure resulting from the perception of physical boundaries and principled solutions to eliminate the negative consequences of these boundaries and to promote positive ones are sought. The article moves from theory to practice by identifying the urban boundaries by means of an experiment, for implementation of which a complex city and then a particular district of it are selected. The city of Vilnius and its district Naujoji Vilnia have been chosen for this role. Vilnius is known for its rich topography, which allows the observation of natural boundaries formed by nature. And the selected district perfectly visualises a merger of different physical boundaries that is interesting in its multi-dimensional character and impact on the structure. The authors study the general extent to which physical boundaries have common points of contact in territories of different scale, what they are, where they are located and how they operate in the local context and what principles could be applied in order to highlight them or diminish their effect.

Keywords: structural boundary of a city, natural and anthropogenic boundaries, urban structure

Introduction

The city is a composite complex combination of elements, some of which, by their dominating nature, determine the peculiarities of the urban fabric structure. The physical boundaries of a city are precisely the element determining the peculiarities of the urban structure. They can be observed on a variety of scales (whole city or its individual districts), which generates different scale effects on the urban fabric, its volumetric spatial expression. The phenomenon of physical boundaries is not unambiguous, and its nature in the city can be both natural (formed by nature) and dictated or created by man (anthropogenic). In particular, the boundaries of the latter nature can be considered as a kind of a phenomenon. The famous German philosopher and anthropologist Immanuel Kant called a thing that can happen by using human experience and knowledge to be a phenomenon. An urban boundary created by man could be considered as such, as it often affects not only the further development of the urban fabric, but also people's lifestyles (form, behaviour, etc.). The boundaries of the urban structure in a city can determine the character of the city, its perception, orientation, etc., sometimes they are chosen as a conscious tool for introducing separation. Often, appearance of boundaries is determined by various circumstances and local conditions: social issues not dealt with

(e.g. informal settlements with no pre-design and even no development controls), political sanctions (e.g. the Iron Curtain, the Berlin Wall), economic standards (e.g. business generating clusters, centres), etc.

The topic addressed in the article covers the physical boundaries of cities and their integration into the existing urban fabric of a city, therefore they can simply be called urban boundaries. In terms of its impact, an urban boundary can be both a catalyst and a tool that forces/stimulates/determines different circumstances and conditions for the formation of an urban structure. The aim is therefore to identify/distinguish these boundaries in a city and see their multi-dimensional character, both in terms of positive and negative impacts on the existing environment. The analysis of the phenomenon of the urban boundary uses the following examination route in its recognition process:

To support the study, an illustration of identification of urban boundaries on the city scale and on the district scale is provided. The city of Vilnius and its district Naujoji Vilnia have been chosen for the illustration purposes: Vilnius is known for its rich topography, which allows the observation of natural limits formed by nature; whereas the selected district perfectly visualises a merger of different physical boundaries that is

identification → typology by category and by element → the relationship of the boundary and the environment → potential of the boundary

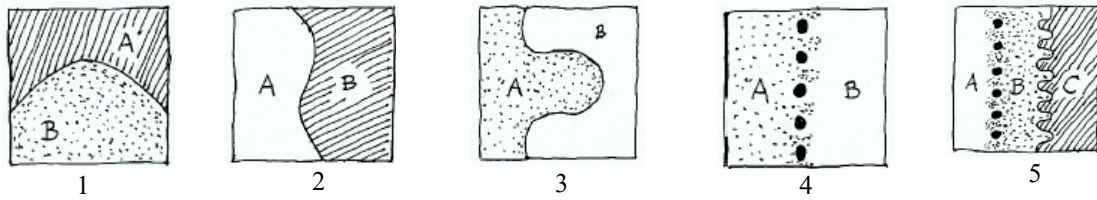


Fig. 1. Structure mergers [1]

interesting in its multi-dimensional character and impact on the structure. The authors study the extent to which physical boundaries have common points of contact in territories of different scale, what they are, where they are located and how they operate. The identification of physical boundaries within the urban structure involves many analysis aspects, and the study of their potential is based on the urban principles and laws of integration into the formed environment, discovered through literature studies.

Study of reference sources analysing urban boundaries of a city

A study of both theoretical and practical works was carried out in the context of studying the phenomenon of urban boundary in the structure of a city, its highlighting, diminishing or even elimination methods.

One of the more prominent theoretical works, explaining existence of a boundary through the method of structural links, is authored by Nikos A. Salingaros, a famous professor of mathematics, a theorist of urban development and architecture. According to him, an urban structure is a system consisting of three elements: nodes, connections and boundaries [1]. All the three elements are important and have their own hierarchy. For their examination, the author uses 8 rules of geometric relations – links, diversity, existence of boundaries, strength (interaction), organization (self-organization), hierarchy, mutual independence and division. According to these rules, Nikos A. Salingaros provides five examples of structure mergers. They can be seen as three-dimensional parts of the city morphostructure (Fig. 1).

They occupy a similar area, are of similar scale, which is illustrative of the first merger rule: only elements of the same scale can merge strongly. A continuous straight line or a pure boundary dividing two districts in a city is rarely found, therefore structures can merge through:

- 1) contrasting materials or the geometry of the junction (1, 2, 4);
- 2) the structure boundaries can be interconnected as puzzle pieces (through penetration) (3);
- 3) structures can connect through the boundary elements (5).

The combination of two elements of a similar scale leads to mutual reinforcement and, when one element is excluded, the other is weakened. The combination of two or more elements makes a whole and grouping, therefore, strengthens the elements, even when one element requires complementing for a stronger connection to exist. The completeness of a structure depends on the strength of the entire boundary, and the aim of an urbanist is to merge different elements into a higher-level structure that acquires new features.

N.A. Salingaros, in his explanation of the strength of a boundary, distinguishes a road as a linear mathematical element shaped by contrasting or different districts. A road through a single area and dividing the area into two similar parts is ambiguous, as it appears that it can be drawn at any point in that space. The road only makes sense when it coincides with the limit of the territory (Fig. 2). Therefore, in this place, referring to the elements of the city distinguished by K. Lynch, N.A. Salingaros states that the stability of the structure is achieved when one element strengthens the other, because otherwise the forces drive the structure out of balance. This means that two urban elements, i.e. the boundary and the road, strengthen each other only by coinciding and merging, and the divided parts of the structures must complement each other and cannot be the same.

The boundaries in the theory of the sociologist urbanist K. Lynch may be weak or strong [2]. The strongest boundaries are those which are not only perceived visually but also intersect movement. The characteristics of the boundaries between different territories describe the character of the city, determine its perception and orientation. The clearest boundaries relate to distinct, continuous natural or anthropogenic elements: river, slopes, railway or highway lines. A boundary has its own character and is easily remembered. Site accesses and nodes are mentioned as a means of highlighting a boundary, which, because of their impact on the boundary, are named as gateways to the city area. The emphasis is also placed on their hierarchy, depending on the characteristics of the elements of place and structure. *Site access* is a particular element (or a group of elements, perceived as an

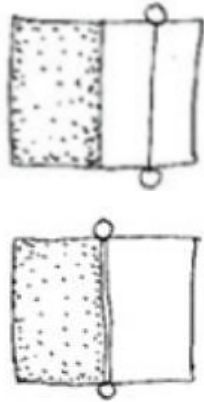


Fig. 2. Structure boundaries and position of a road [1]

architectural composition of larger dimensions), which eliminates an obstacle (between building-up of different types). Such nodes may remove a boundary or, on the contrary, they may emphasize it. They capture and demarcate another structure, often becoming spatial reference points for the territory itself.

In accentuating theoretical works on the urban boundary, importance should be attached to the fringe belt method developed by the English morphologist J.W.R. Whitehand and his colleagues, which identifies the distinctive urban structures that formed on the urban periphery in the course of city development, but then have become a part of it over time [3]. The model of examining the urban periphery is based on the idea that a city, as a physical entity, has developed under the influence of a number of growth impulses or alternating stages of rapid and slow growth. Urban periphery belts usually remain for a very long time as underdeveloped zones in the growing urban fabric of the city, so there is a dual aim for such boundaries: either to integrate them smoothly into the surrounding fabric or to highlight them through significant objects in them (Fig. 3). In practice, these areas are also deliberately formed as green belts.

The treatment of a boundary element or phenomenon in the urban structure in the above-mentioned theoretical works further expands the character of the perception and treatment of the boundary. Looking at the positive or negative significance of the urban boundary, it is proposed to act on the boundary itself: if it is a positive phenomenon, it is to be strengthened, if it is a negative phenomenon (kind of a barrier), it is to be eliminated, overcome, etc.

In the case of practical works in the context of the urban boundary treatment, Venice Architecture Biennale 2018 stands out. During it, an exhibition was opened in the German Pavilion to commemorate the 28 years of the fall of the Berlin Wall. The

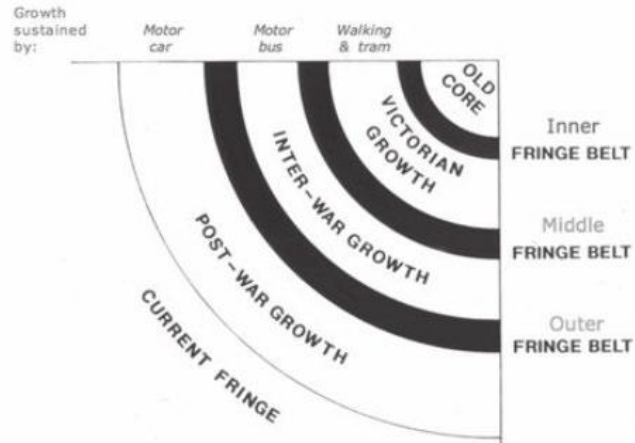


Fig. 3. Models illustrating the city periphery [3]

exhibition was called in a very illustrative manner – *Unbuilding walls. From death strip to freespace*. It presents examples of regeneration of the politically and physically divided territory through implemented projects (Fig. 4) [4]. The information of the exhibition is also presented in an illustrative book with the same title. It consists of two parts: (1) the debating part on the Berlin Wall topic with highly touching texts accentuating the consequences of dividing by the boundary; (2) projects that eliminate this physical object from the urban fabric. As the boundary crossed both the natural areas (parks, squares) of the city and the infrastructure corridors and the built-up areas, the projects respect the former character of the territory that existed until the division, continuing the essential characteristics of the rehabilitated accesses. The projects follow the principles of both highlighting and levelling of the boundary, from areas of particular urban intensity to peculiar sites of pause (kind of reflective islands) formed by natural elements of nature within the urban fabric. Although the wall crossed the entire city, projects also address the hierarchy of the parts of the city.

An example of highlighting an urban boundary would be the Cambridge green belt study published in 2002, where an analysis was carried out on various aspects with a view to developing individual urban areas on the basis of this study [5]. One of its parts provides an analysis of the urban landscape and the general landscape where zones or points of the first view of Cambridge were pointed out on the roads accessing the city, from which those arriving to the city can view the city and perceive its size (Fig. 5). The distance and time of arrival from the countryside to a recognizable city area and the expressiveness of access roads are very important elements which give a person the first impression of the city. The Cambridge green belt study roughly grouped the access roads into green or planted with trees, suburban and roads of commercial areas.

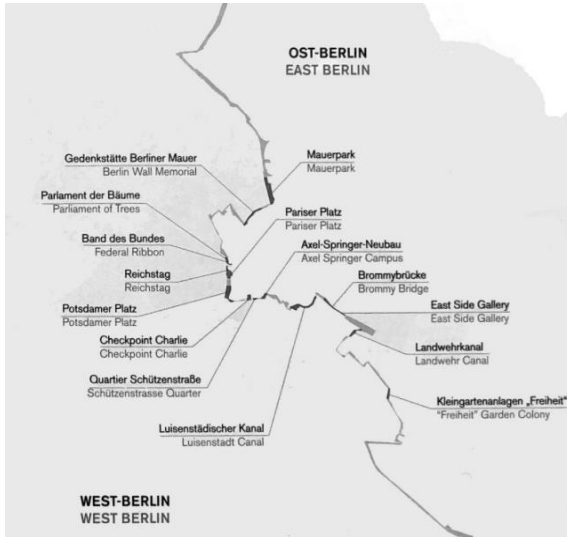


Fig. 4. 26 projects have been implemented along the Berlin Wall trajectory, eliminating this element in the urban structure [4]

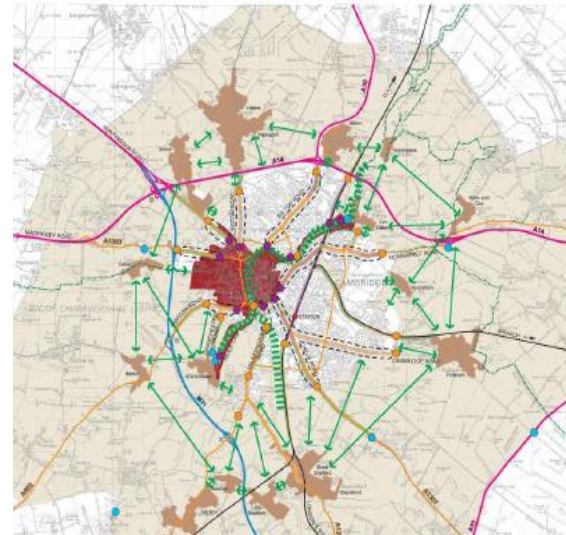


Fig. 5. Cambridge green belt study [5]

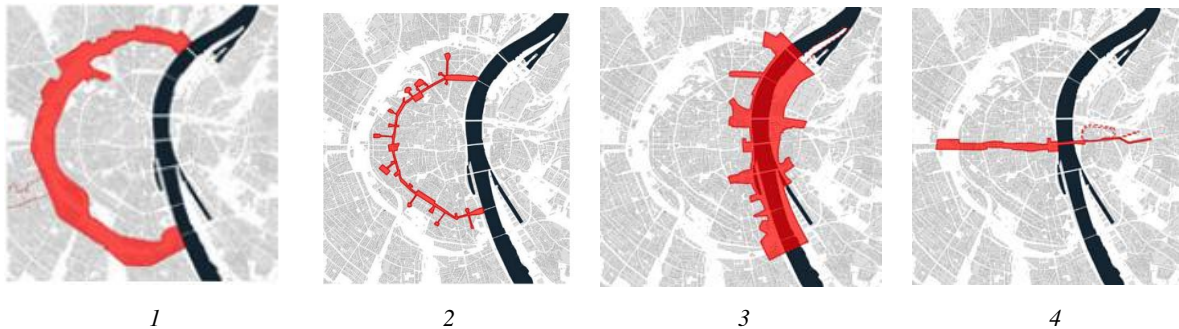


Fig. 6. Highlighting urban programs in the central part of Köln city: 1 – green belt (parks, squares, other greenery) surrounding the central part of the city; 2 – the system of public spaces surrounding the historical nucleus; 3 – integration of the river Rhine through public spaces and new functions; 4 – main spatial channel in the central part of the city as a connection between the East and the West [6]

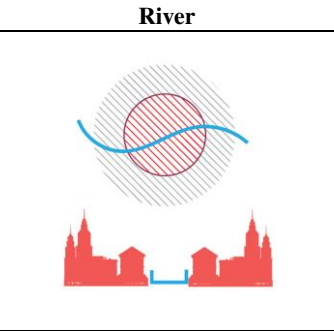
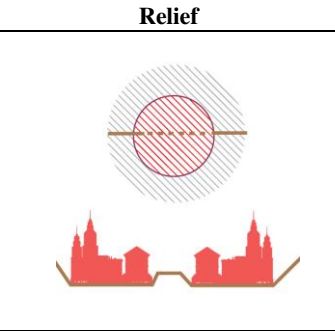
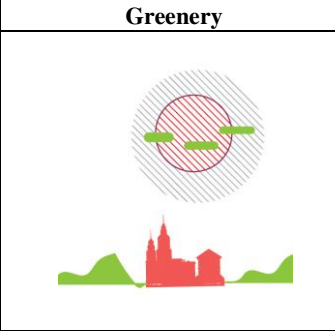
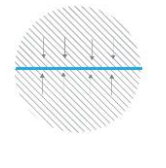
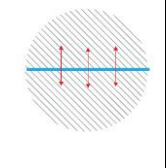
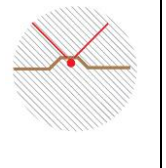


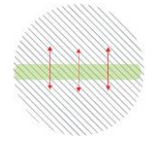
The entry length was measured from the city gateways to the gateways of the most characteristic Cambridge zone. On that basis, three types of city gateways were identified: the first Cambridge view (sight-point when entering the city), the city gateway (a node where a built-up territory of the city begins) and the gateway to the characteristic Cambridge (a node where a visitor feels that he has already arrived in the city). These were informative landmarks highlighting individual parts of the city.

Analysis of the master plan solutions of Köln city in Germany [6] shows a clear separation of the peripheral building-up characteristic of Köln from the central area of the city by creating a green belt (Fig. 6). The boundary of the central area is examined as an integral spatial structure. Transverse connections are developed, connecting both city zones. The main nodes of the spatial structure are distinguished. A higher building-up is formed, tracking the parameters of the space along the structure boundaries. Higher hills are created upon the establishment of the zones of visual shadows from the historical part of the city. The park structure

is divided into separate parts – parks and green zones with different features and characteristics. Building-up is formed by separating a park from the highway. New functions and human activities are created in the park. The inner ring surrounding the city nucleus is the legacy of the 19th century, when the inner ring of defensive reinforcements was broken in order to be able to open the city for the development of the so-called new city. It was then that the creation of the spatial structure of public spaces consisting of boulevards, streets and squares started, which today is difficult to recognise, therefore it is expected to return to the original concept by the solutions of the master plan. Understanding the separating character of the river Rhine, a program for the development of public spaces on approaches to the river is planned. The aim is to integrate both the sides of the river into the active life of the city. The eastern-western axis crosses the whole central part of the city and is the backbone of the territory, and it is, therefore, envisaged to reshape the image of existing squares, to resolve the functional issues of the light railway, etc.

TABLE 1

Peculiarities of a natural boundary [created by G. Žukaitē]

Element	River		Relief		Greenery	
Shape in a plan, section (geometry of the shape)						
	continuous line		fragmented (dotted) line		territorial area (guessed boundary)	
Meaning	One of the most important natural axes in the city; until the beginning of the 20 th century, a factor that generated the economy of the city		Often determining the formation and expansion of the urban fabric		Integral part of the formation of public and recreational spaces in the city	
Relationship with the city (positive/negative) (model in the plan)	“+”	“-”	“+”	“-”	“+”	“-”
	Water resources, navigation, fishing, recreation; river as an object of attraction	The image of the boundary is enhanced by wild banks of the river.	Panoramas opening due to the expressive relief, a big number of sight points	Zones unfavourable for building-up, difficulties in forming building-up	Recreational spaces, parks, squares	Territories of abandoned greenery are not only a visual but also a physical boundary.
						
Boundary solution methods / boundary potential	Development of links and connections; integration of the river into the common urban fabric of the city: improvement of river banks, adaptation for recreation		Integration of relief into the urban fabric of the city (by terracing, formation, etc.)		Management of abandoned greenery; formation of parks, squares; fragmentation of greenery in the urban fabric of the city	

Practical examples show different principles of highlighting or eliminating an urban boundary: the central boundary of the city is perceived as a park system, the boundary of the nucleus – as a system of public representative spaces, different urban areas have nodes corresponding to the rank of the area and marking the boundary, which also perform the territories bridging function. For solution of the natural boundary, the principles of merging are employed (public spaces, bridges, the introduction of new functions in the existing built-up structure). When observing the character of the boundary continuity, it is considered to be continuous, dotted, fragmented or only guessed in view of the surrounding situation. However, regardless of its category, character or geometry, the provided study of theoretical and practical works

illustrates that the physical boundary usually operates both as a tool and as a catalyst in process of further improvement of the urban fabric.

Urban boundaries in a structure of a city




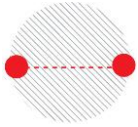

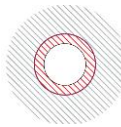
Boundaries in relation to a city

Based on the analyzed sources, urban boundaries are primarily identified in relation to the city itself [7]. Today, cities are generally perceived as complex combinations of individual parts of a city. Most European cities have developed from the historic nucleus as radial structures (radial plan). According to peculiarities of historical development and building-up intensity, the following structural parts of a city are distinguished: the historical

TABLE 2

Peculiarities of an anthropogenic boundary [created by G. Žukaitė]

¹E.g. high-rise buildings in accesses to the city centre

Element	Spatial channels (transport infrastructure)		Building-up			
	Railway	highway/ motorway	Defensive wall		Complexes	
Shape in a plan, section, geometry of a shape						
	continuous line		fragmented (dotted) line		territorial area (guessed boundary)	
Meaning	One of the main transport lines between cities and countries		Important part of the city, a significant historical legacy		A part of the identity of the city or its fragment	
Relation-ship with the city (positive/negative) (model in the plan)	“+”	“-”	“+”	“-”	“+”	“-”
	Mobility lines are developed, connecting important elements of the city.	Clear boundary, dividing the territories, breaking existing links	The limits of the historical nucleus of the city are highlighted.	In some cases, visual and other discomfort is caused by abandoned fragments of a structure.	The boundary is perceived visually; it is weak, does not break existing ties; in individual cases it highlights different parts of the city ¹ .	Poor quality, abandoned building-up of industrial territories can serve not only as a visual limit but also as a physical barrier.
Boundary solution methods / boundary potential						
	Development of links, connections (bridges, structures above tracks, underground passes)		Defensive walls are a historic heritage that must be preserved.		Pulling down of buildings of low architectural value and reshaping of the territory; integration into the common urban structure, structuring of the boundary	

nucleus of a city, the central area and the urban boundary separating extensive suburbs from more intensive city areas. The main radii of radial cities (usually, the main city streets) – accesses to the city, cross these boundaries, and points of intersection, i.e. nodes, are perceived as gateways to a more intensive building-up zone. On this basis, a distinction can be made of physical boundaries in relation to the city:

- *The boundary of the historical nucleus of the city*, the formation of which used to be determined by the historical development of the city, the geographical situation of the city. For defence purposes, the territory of the city used to

be surrounded by defensive walls and the suburbs were built at a distance. The suburbs continued to be formed without any more or less clear urban structure until the 19th century (Vilnius, Riga, Tallinn, Krakow, Bremen, Vienna, Wroclaw, Leipzig, etc.). Today, a defensive wall can be detected in different forms according to its degree of survival: continuous, fragmented or simply guessed. Elements forming it may include building-up, system of public spaces or transport infrastructure spatial channels.

- *The boundary of the central area of the city*, usually surrounded by the corridor of highways

and often accompanied by the problem of their humanization [8] [9], as nodes significant for the city are created at the main accesses to the central area, with a prominent architectural expression on the background of the city. This territory is characterized by intensive building-up, high quality of public spaces, etc.

- *The legal boundary of the city* usually marks the transition between different regimes, i.e. from the city to the countryside. It is a boundary between the old/new industrial and agrarian culture. This boundary is often of irregular shape and is not clearly distinguished, especially if it is not formed by significant natural environment (sea, mountains, etc.).

Classification of boundaries

The typical character of a boundary is the image of a linear object dividing/separating two areas. Boundaries can be crossed easily or with difficulty, which determines the existence of weak or strong boundaries. The strongest boundaries are those which are not only perceived visually but also intersect movement. The characteristics of the boundaries between different territories describe the character of the city or its part, determine its perception and orientation. The clearest boundaries relate to distinct, continuous natural or anthropogenic elements: river, slopes, railway or highway lines. A boundary can be of natural (related to elements of nature) or forming nature and is, therefore, classified as natural or anthropogenic.

Natural boundaries are most often elements of a unique natural environment, in which the city developed (river confluence, sea coast) for military-defence or transit purposes. Although some of them have remained, their significance has now changed, the possibilities of converting them into public recreational urban spaces are addressed. In most cases, natural boundaries relate to more significant water bodies, such as rivers, ports or wetlands. In this case, boundaries are such elements as coastline or marinas, whose means of expression may also vary considerably, depending on the way water is used and the degree of urbanization of accesses to it (e.g. even the coastline themselves are divided into several types: hard, soft, perforated edge, built-up, etc. [10]). In cities with a more prominent topography, slopes and valuable greenery become natural limits (Table 1). At the same time, the boundary of greenery is often created instead of a former defensive wall. This trend is typical of European cities, where the historic part of the city is highlighted by surrounding it with a continuous system of public spaces and parks or separate park fragments.

Anthropogenic boundaries in cities are man-made boundaries: some of them are formed by

building-up (defensive wall, high-rise building complexes), others often are transport infrastructure elements – highway and railway routes [8]. In many cases, the latter even have strategic implications not only for the city, but also for districts (both physically and visually), creating negative barriers by slowing down the path of movement from one location to another. As a result of intensive highway, railway traffic, people must go under or above them in order to cross the barrier, additional solutions are created for them, restricting movement patterns (Table 2). Meanwhile, the boundaries formed by building-up usually separate areas of different profile, which differ both by their character and social, economic and other aspects.

Practical illustration of urban boundaries – the city of Vilnius and its district Naujoji Vilnia

Boundaries on the city scale

As it is often a case with a large city, Vilnius has enough physical boundaries in its urban fabric. Their location in the city is not accidental and often leads to problems of connection of individual territories. The river and the railway are among the most obvious in Lithuanian cities. It is namely the location of these boundaries in Vilnius city that divides the districts or even causes a lack of integrity in their inner structure. Physical boundaries were identified for the whole city, later – for selected districts. This helped to understand the different scale of boundaries and their impact on the structure of the city.

In order to identify the main areas of Vilnius city that are most affected by the boundary problem, to determine the effects of the boundaries and the need for their elimination or consolidation, an urban analysis of Vilnius city has been carried out covering administrative structures (legal boundaries of districts), analysis of Vilnius development models (applied to Vilnius city in 1995 and 2015), topographical situation, transport infrastructure, urban transport flows and their influence on boundary problems, a plan of physical boundaries of Vilnius city has been prepared.

In studying the administrative structure, the years of formation of individual administrative sub-districts (elderships) and their joining the city have been determined. The legal boundaries in Vilnius city are not physically felt or visually visible. However, when examining the urban development strategies prepared after the restoration of Lithuania's independence (1990), attention was drawn to the emphasis on the application of the polycentric urban model, which would be successful due to the very uneven distribution of the urban centre environment. The lack of that environment is felt in the residential areas on the right bank of the river Neris (Fabijoniškės, Pašilaičiai, Verkiai,



Fig. 7. Schemes of the city of Vilnius: (1) natural boundaries; (2) anthropogenic boundaries; (3) parts of Vilnius city affected by the boundaries [created by G. Žukaitė]

Karoliniškės, Šeškinė, Pilaitė) and in Naujoji Vilnia. These areas house about 45% of the total population of Vilnius, and the districts themselves are very different from the Old Town in terms of architecture, planning and functional composition. The residents of the remote districts are doomed to daily commuting to the historical part of the city for cultural, recreational, household or work purposes. Over 50% of all jobs are focused in the city centre. This apparent functional grouping and the separation of the rest of the city from the centre identifies a clear task of achieving a balanced distribution of services, jobs and housing in the city. This would result in a more even distribution of functions and “removal of heavy weight” from the central area of the city [11]. In order to optimize the allocation of functions, the convergence of districts should be avoided and, in line with the principle of balance of functions, a polycentric urban development model for the city of Vilnius was proposed, which would help some districts, somewhat distanced from the central area (including Naujoji Vilnia), in their smooth integration into the full-fledged system of city districts and becoming its constructive participants. It would be all the more so if strategically some functions generating the economy of the city were moved from the central area of the city to the city parts mostly separated by natural and anthropogenic boundaries.

The analysis of infrastructure and city transport flows has revealed the lack of transport lines enabling elimination of exclusion of districts. In the study of significant locations of natural boundaries, three main elements were identified in the city of Vilnius: the river Neris and the river Vilnelė and their valleys, as well as large plantation arrays belonging to regional parks (Fig. 7). Almost the most striking anthropogenic boundary in Vilnius city is the railway line. The busiest Vilnius streets (Ukmergės St., Geležinio Vilko St., Laisvės Ave. and the western bypass) can also be classified in the category of anthropogenic boundaries. Based on the

findings of the urban analysis, a plan of physical boundaries of the city has been drawn up, clearly highlighting the division of the city by the boundaries.

On this basis, six separate parts of the city and three Vilnius city zones mostly affected by urban boundaries are pointed out (Fig. 8):

- *The suburbs* with an industrial area in the East, where two boundaries are found: the Neris tributary and the railway. The degree of urbanization in the area is low, the vast majority of the railway is in the woodland zone, therefore the railway area does not have a significant impact or does not cause substantial changes in the area, and the river tributary does not influence the formation of the district, so the existing number of connections across the boundaries is fully in line with the use of the area, besides, with regard to the local topography, it is a rather flat area.
- *The city centre* (central area) is the most urbanized zone from all the three indicated areas. It is dominated most clearly by the only anthropogenic boundary, i.e. the railway, with accesses of industrial functions in the area. In relationship with the environment, the historically formed links that have been cut and city districts that have been separated from each other are to be pointed out. Six connections are found in this zone, but they are formal, operating only as infrastructure elements, but not as fully-fledged connections between districts, all the more so that accesses to them involve enclosed territories forming a section that is not fully used. Although both the sides of the railway are characterised by vivid relief, however it is not felt in the overall urban structure due to the degree of urbanization in this zone.
- *A separate district* of Naujoji Vilnia, which formerly was an autonomous town. Even four boundaries are identified in this zone. They are all of a different nature: two natural boundaries

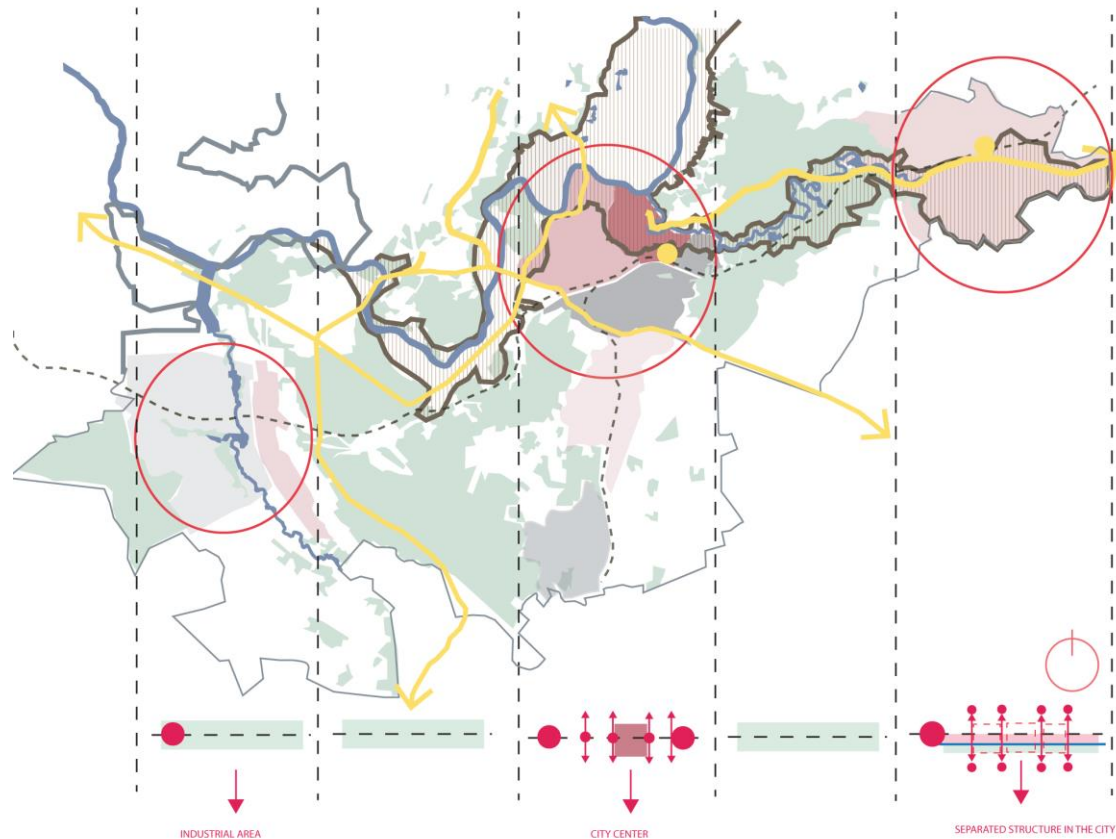


Fig. 8. Territories mostly affected by boundaries [created by G. Žukaitė]

(a river and massive greenery) and two anthropogenic boundaries (the railway and an industrial area established nearby in the Soviet times). Being close to each other in the urban structure, they form a complex multi-stage boundary, which becomes an obstacle in the urban structure of the district, while the existing connections across the railway section do not resolve the boundaries integration issue. The exceptional situation is also dictated by the local topography, which is quite prominent.

In view of the complexity of the identified urban boundaries, Naujoji Vilnia district was selected for the study, which would allow demonstration of the miscellaneous phenomenon of physical boundaries in the urban structure on a district scale. The natural situation in the district itself created conditions for emergence of this phenomenon, which in itself has led to the adjacency of the natural boundaries, and the effects of these boundaries on the district have been further strengthened by human activity.

Boundaries on the city district scale

Naujoji Vilnia today has no clear role either in the overall structure of Vilnius city or in the internal urban composition: it is a district of weak character with few identified and respectable elements capable of representation not only in the context of the district but also in the context of Vilnius as a whole.

Although the district can be very independent, as at its beginning it was an autonomous town that joined Vilnius only in 1957, this district counts already the 7th decade (63 years) within the city in Vilnius but, in spite of that, it is still isolated from the rest of the city area both physically and functionally. The district itself is grateful for its natural situation and has a number of significant historical facts, but the complex combination of different types of boundaries that formed in it is probably the most prominent cause of the fragmentation of the urban structure.

Therefore, in order to explain the nature of the urban boundaries and its advantages and disadvantages in the district, a much more detailed urban analysis was carried out on the scale of Naujoji Vilnia district compared to that of the whole city: by revealing the formation of the boundaries through the urban development of the district, the laws and principles of the natural frame and the structure of public spaces and the very character of building-up.

The contemporary Naujoji Vilnia district is a relatively new urban formation, which emerged in the middle of the 19th century, at the intersection of railway lines connecting St. Petersburg and Warsaw, also Liepaja and Romny [12]. For some time, Naujoji Vilnia acted as a separate town independent of Vilnius. The first elements of Naujoji Vilnia

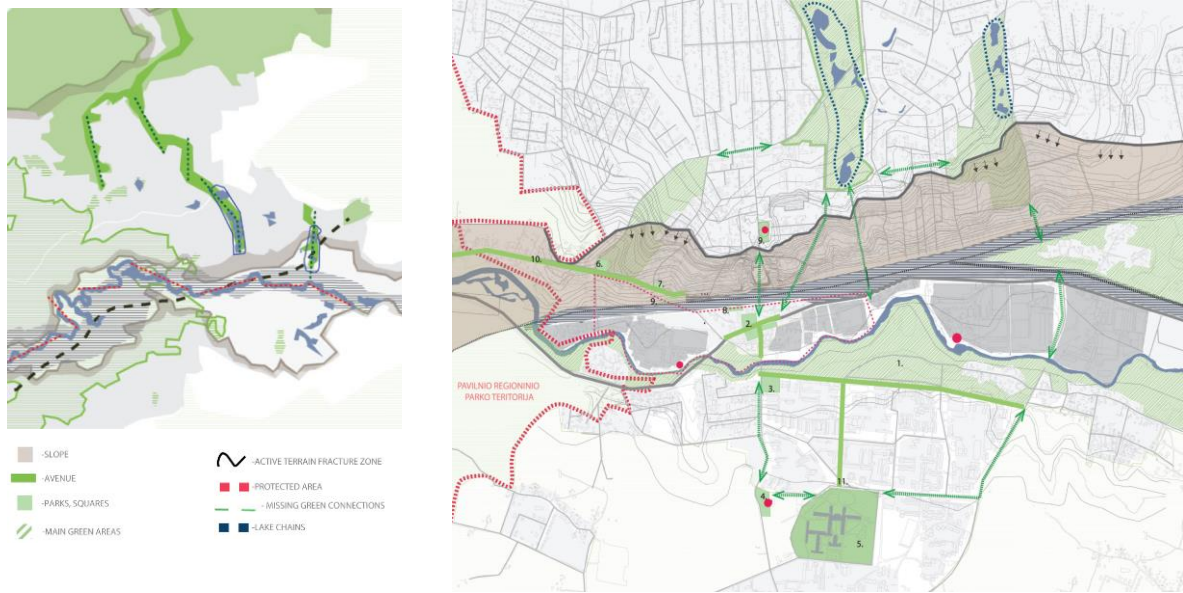


Fig. 9. Naujoji Vilnia natural frame and system of green spaces and possible connections [created by G. Žukaitė]

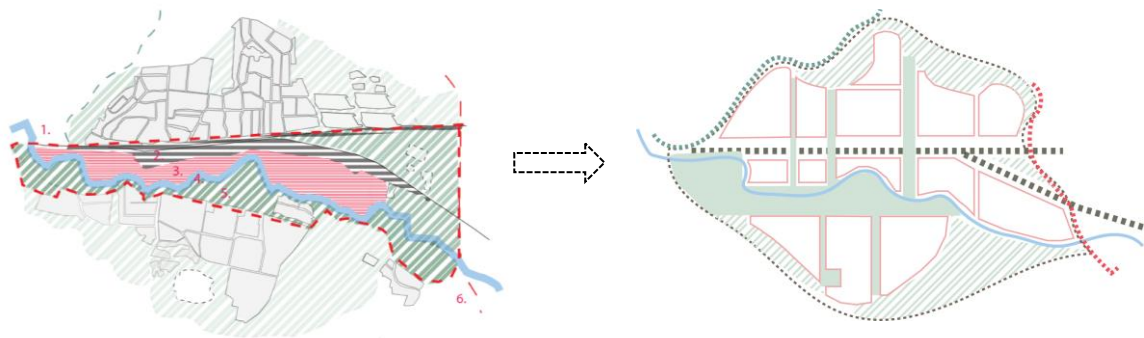


Fig. 10. Model of the existing and forecasted situation in Naujoji Vilnia district [created by G. Žukaitė]

building-up came in the middle of the 19th century, and the main driver of the settlement development became the railway lines and later the railway station. Given the topographic parameters of Vilnius surroundings, the valley of the river Vilnelė was the only way to build a railway line from Vilnius to the East and the place at Naujoji Vilnia was the place to create its branch to the South-East. It can therefore be assumed that it was the topographical situation of the area that determined the emergence of the Naujoji Vilnia railway station, from which the history of the district starts. The railway line was not only a catalyst for the district creation, but it also played an important role in the formation of the urban fabric in the district. It was on the northern and southern sides of this line that the first building-up of the area appeared. The river Vilnelė also played an important role here as the main natural axis in the area in the East-West direction. In this case, it was involved in the development of the urban structure as a natural barrier, limiting the expansion of the district building-up to the South. Naujoji Vilnia started to expand to the southern side of the river Vilnelė only after a mental hospital

complex was built here at the beginning of the 20th century, but the urbanization of the southern valley of the river Vilnelė of a larger scale has been only taking place since the middle of the 20th century.

It was initially a railway workers' settlement consisting of small wooden buildings, the building-up character of which was that homesteads, located along the railway line. After the railway station was constructed, the area transport conditions improved and Naujoji Vilnia became economically attractive. With a possibility of exports, industrial objects started to emerge here. It should be noted that industrial objects appeared and developed on the southern side of the railway line on the right bank of the river Vilnelė. This zone acquired its industrial purpose, which it maintained until the end of the 20th century. The first multi-apartment residential houses of the perimeter building-up character appeared at the main transport route to Vilnius (Polocko St., currently A. Kojelavičiaus St.). When a church was built on the right slope of the Vilnia river valley (at about 1911), the settlement building-up expanded to the northern part of the territory, the formation of the town centre started,

also isolated fragments of satellite homestead-type building-up appeared. For some time, Naujoji Vilnia acted as a separate town independent of Vilnius, it became a part of the city of Vilnius only in 1957.

A part of the territory between the railway line and the river Vilnelė became a zone of large-scale industrialization. The free planning industrial building-up that prevailed here before World War II became even more widespread, a different nature of volumetric-spatial organization became more apparent: industrial complexes built before the war were low, were extensively distributed as small scale buildings in the area, whereas the objects that appeared during the post-war industrialisation were higher and of a much larger scale.

After analysing the natural structure of Naujoji Vilnia, two prominent natural wedges into the urban fabric of the district were identified (Fig. 9). Other important natural elements include a clear slope, the river Vilnelė with its valley, a broad green zone along the river. All of them act as a strong boundary, which lacks integrity and interconnections. The river with its banks also acts as a boundary dividing the district: there are no formed accesses to the river, the banks are abandoned, with little integration into the urban fabric of the district. The river acts not as the main natural axis of the district, but as a strong barrier.

As regards the system of public spaces in the district, these do not constitute a smooth network, at best, they stop at the complicated section of boundaries. The expressive relief of the territory gives rise to a number of sight points, but the visual identity of the district is negatively affected by free planning territories with chaotic building-up of homestead type and a broad zone of visual pollution – abandoned industrial territories, standing out from the general district building-up by their scale.

The railway section and the industrial area within the district are perceived as a whole indivisible zone. The first element divides Naujoji Vilnia district longitudinally into two parts. The infrastructure line is very wide and not used properly, while the second part is the industrial area almost merged with the railway, abandoned and aggressive in the general context of the district by the scale of its building-up (Table 3).

Thus, the area is affected by both natural and anthropogenic boundaries. The situation is also aggravated by the fact that all of them form kind of a single section, with a few formal links, but in general the section is regarded as a physical barrier and an obstacle for the territorial development of the district. In principle, it can be identified as a multi-stage physical boundary, the effect of which is negative rather than positive. Based on the study of literature sources and projects (Lapėnienė, 2005; Salingaras, 2005; Birthler, 2018), strategic options for this complex boundary are therefore presented, capable of complementing the entire urban fabric of Naujoji

Vilnia, as well as contributing to the creation of the identity of the district and a new image of the district (Fig. 10).

The boundary of the district in the East coincides with the city boundary, whereas in the West it borders with the Pavilniai regional park. The boundaries *are to be reinforced by emphasising them* by use of contrast elements/materials:

- a) the city sign or a plastic sculptural composition of the city symbol is suggested at the city boundary, which is usual in such cases. The boundary may also be visualised by infrastructure elements (entry roundabout, slow-down lanes, etc.);
- b) the boundary at the regional park is the intersection with the district area and is therefore considered as an access to the district, where it is proposed to create the character of a district gateway by urban means – extending the building-up with low residential houses to the point where the regional park starts.

The railway effects are to be mitigated by the use of the juncture geometry:

- a) eliminating some of the tracks that are no longer used and narrowing of the railway section itself;
- b) creating vertical links joining different parts of the city in certain zones;
- c) developing a horizontal system of interconnections in the accesses to the railway, covering a part of the railway and creating public spaces above it.

The river is to be integrated by means of joining of structures through elements of the boundary:

- a) forming spatial channels towards the river from both the southern and the northern parts of the district, merging into the system of public spaces being developed on both the sides of the river;
- b) upgrading the building-up on the banks.

The industrial area is to be converted using its own territory for integration as elements of the boundary:

- a) forming the building-up of the scale specific to the district, development of its polyfunctional nature;
- b) priority is to be given to complexes generating the economy of the district.


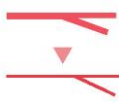








The green zone is to be developed as a structural boundary able of connecting as puzzle pieces or using its own territory for integration as elements of the boundary:

- a) continuing green connections towards the existing district squares and parks, integrating this zone in this way;
- b) as the area is big, suggesting a recreational function in some of the area, which would connect the southern and northern parts of the district.

Urban boundaries in a city are one of the structural components of the city. Depending on the situation of the city, the identified boundaries most often coincide with structural parts of the cities: the historical nucleus, boundaries of the central area and the legal boundary of the city. With very different

TABLE 3

Peculiarities of a natural boundary [created by G. Žukaitė]

No.	Element (type of boundary)	Shape (geometric expression and plan)	Relationship with the district	Boundary solution methods
1	Railway (anthropogenic boundary)	Continuous boundary 	“+” mobility lines are developed, connecting important elements of the city	The boundary is to be partly eliminated by narrowing the rail tracks, developing communications and connections (bridges, structures above the section, underground passes) 
			“-” a prominent boundary, dividing the territories, breaking existing pedestrian connections	
2	Abandoned industrial zone (anthropogenic boundary)	Territorial area 	“+” active industrial function – it is generating the district economy and raising its economic level	Territories of low architectural value, of contrasting scale are to be integrated into the urban fabric, converting them into a structure useful for the district, with relevant functions. 
			“-” poor quality, abandoned building-up of industrial territories serves both as a visual and physical barrier	
3	The river Vilnelė (natural boundary)	Continuous line 	“+” water resources, fishing, recreation, river as an object of attraction	The river is to be integrated into the common urban fabric of the city by means of public spaces and new functions in the accesses to it (improvement of the river banks, adaptation for recreation, formation of new connections). 
			“-” the image of a boundary is enhanced by wild banks of the river	
4	The green zone (natural boundary)	Territorial area 	“+” recreational spaces, parks	Green connections are to be developed with major parks and green areas of the district – the territory is to be exploited for recreational purposes, structured, abandoned greenery are to be managed and new ones are to be formed. 
			“-” the territories of abandoned greenery are not only a visual but also a physical barrier	
5	The regional park and city boundary (legal boundary)	Continuous line (guessed) 	Legally regulated	The strengthening of the legal boundary is possible by framing it, so a building-up line of certain intensity inside the city is to be newly developed, whereas on the outside, the boundary may be marked. 

degrees of survival of the nucleus boundary, the boundaries of the historical nucleus can have different geometry: continuous, dotted, fragmented or only guessed. In the meantime, the boundaries of the central area are distinguished by a belt of parks, fragments of public spaces, nodes of high-rise buildings, infrastructure elements. The city boundary is marked by vertical points, their groups or large complexes. When analysing the means of expressing urban boundaries, they can be categorized by nature (natural and anthropogenic), by natural and man-made character, by scale, by relationship to the environment, etc.

The study of reference sources analysing the urban boundary has revealed that the most common natural boundaries are analysed as a single structure, adapted for recreation, the nodes of the boundaries are distinguished according to the hierarchy of transverse connections, the number of connections is increased. A similar situation exists with anthropogenic boundaries, which are also examined as a single structure in creation of transverse connections and distinguishing the hierarchy of nodes.

If the perception of the urban boundary is simplified down to the elementary geometric elements, three principles of connection are possible: (1) two morphostructures are joined by contrast materials or geometric properties; (2) a structure is wedged into / interconnects with another one or overlaps; and (3) two structures are joined together through a third element.

An applied experiment has been carried out to identify urban boundaries, which involves overall observation of the lack of attention given to urban boundaries, the problems they cause, leading to greater exclusion and segregation. In addition, different parts of the urban fabric do not complement each other, are not in contact, remain unconnected, which is reflected not only in the urban structure but also in social and economic models. Therefore, after a comprehensive urban analysis at the scale of the selected city of Vilnius, the elements of the city that are significant in separating urban

territories are identified. The same elements forming urban boundaries are found after the analysis on the city district scale – in Naujoji Vilnia. In order to reduce the district's exclusion from the rest of the city, the strategy for a polycentric city model is proposed, improving both its economic situation and functionally integrating the district into the common system of districts – moving some of the functions from the city centre in order to make the district more attractive to other citizens of the city. The internal urban structure of the district identifies a specific phenomenon of the boundary – a complex combination of boundaries, consisting of several different boundary components: the railway, the river, the industrial territory and the green zone. The analysis carried out has highlighted the importance of connections between different structures of the district. Therefore, observing the negative effects of the existing boundaries, methods of elimination/integration of the boundaries are proposed, based on the performed study of theoretical references and practical work. The proposed new vision for the development of the district is linked to the creation of hierarchical urban public spaces, which would structurally combine isolated parts of the district and the main objects forming the district identity. A number of strategies are suggested for the development of the urban fabric: natural elements are to be used to make the structure not so big, the building-up structure is to be extended towards the natural element, elements of the formed building-up are to replicate the natural form (contour lines, water line) and continue the natural elements.

According to the references studied and the experiment carried out, urban boundaries should be highlighted in the urban structure, adding uniqueness to the character of the city and reinforcing its identity. Depending on the situation and the character of a physical boundary, it can be both a tool and a catalyst in the urban structure of the city.

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