PRINCIPLES OF THE DESIGN OF URBAN SPACE THAT SUPPORT RAIL SYSTEMS FROM THE ASPECT OF URBAN ELEMENTS AND ELEMENTS OF THE RELIEF

NAČELA ZA OBLIKOVANJE URBANIH PROSTOROV, KI PODPIRAJO TIRNIČNE SISTEME, Z VIDIKA URBANIH ELEMENTOV IN ELEMENTOV RELIEFA

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ABSTRACT

In the multimodal approach to a balanced representation of public and private transportation, rail systems contribute to the solution to the problem of traffic in modern cities. The introduction of these systems in urban units enables the creation of urban transformations that can contribute to livable and sustainable cities, through the rational use of energy, reduction of noise and air pollution, reduction of traffic jams, social interactions in public spaces, functionality of urban totalities and the attractiveness of the urban form. Spatial components of rail systems can be related with the urban elements and the elements of landscape. Through relating these elements at the level of public spaces, and based on architectural principles, it is possible to create functional urban totalities of specific form and urban design.

The objective of this study is to determine the way in which these elements can be spatially related in order to enable the contribution of public areas containing rail systems to the attractiveness of livable and sustainable urban form. The objective is also to establish criteria based on which the configuration of terrain with all its elements will be introduced into the process of designing urban spaces that include rail systems.

KEY WORDS

Urban spaces, rail system, route, geomorphology, landscape, design

IZVLEČEK

Pri multimodalnem pristopu k uravnoteženi zastopanosti oblik javnega in zasebnega prevoza tirnični sistemi prispevajo k rešitvi prometnih težav v modernih mestih. Njihovo uvajanje v urbane enote omogoča urbano transformacijo, ki lahko z racionalno rabo energije, zmanjšanjem hrupa in onesnaženosti zraka, zmanjšanjem prometne gneče, socialno integracijo na javnih mestnih prostorih, funkcionalnostjo urbanih enot in privlačnostjo urbane oblike prispeva k mestu, ki je trajnostno in prijazno za bivanje. Prostorske elemente tirničnih sistemov je mogoče spraviti v ustrezno razmerje z urbanimi elementi in elementi reliefa. Z oblikovanjem odnosov med temi elementi na ravni javnih mestnih prostorov, in sicer na podlagi arhitekturnih načel, je mogoče oblikovati funkcionalne urbane enote posebne oblike in urbane zasnove.

Cilj dela je ugotoviti, kako je mogoče spraviti navedene elemente v prostorski odnos, da bi javni mestni prostori, ki vsebujejo tirnične sisteme, prispevali k funkcionalnosti in privlačnosti za bivanje prijazne in trajnostne urbane oblike. Cilj je tudi ugotoviti, kako konfiguracijo terena, z vsemi njenimi elementi, spraviti v proces digitalnega projektiranja urbanih prostorov, ki vsebujejo tirnične sisteme.

KLJUČNE BESEDE

Urbani prostori, tirnični sistem, trasa, geomorfologija, relief, dizajn

1 INTRODUCTION

The excessive use of cars in transportation in modern cities has caused several problems: serious harm in people socialization, dispersal of activities, environmental pollution and the irreversible loss of energy resources (Vucić, 1999). The introduction of rail systems into the public transportation has significantly changed the urban landscape and the character of public social life in many cities. On one hand, these systems contribute to economic development, they use renewable energy sources, contribute to the reduction of traffic jams and reduction of emissions of harmful gases; on the other hand, by alienating people from the nature, their influence to the elements of cultural development and socialization is insufficient. Life in conurbations requires driving hundreds of miles to get to a natural landscape. However, public infrastructure and public utilities, which serve the daily needs of the population, are the basic and essential prerequisite for life, work and normal development of every society. The indicators of economic and social development are directly related to the level of development of public infrastructure (Rakar et al., 2010). By the introduction of principles of sustainable development as the basic guideline for the formation of strategy of spatial planning of urban areas, it is possible to review the current concepts of designing urban spaces that contain rail systems and to create new concepts. This area represents a vast field of research that should contribute to the improvement of urban public spaces and the quality of life within them. There is a number of papers and books (Lynch, 1960; Appleyard, Lynch and Myer, 1964; Canter, 1977; Gabrijelčič, 1994; Allen, 1999; Alihodžić, 2009) proposing theoretical views on the perception of public spaces in relation to the element of route, where cognitive theories are being considered dealing with the psychological identification with spatial elements and the orientation in relation to spatial elements. There are papers (Adler, 2001; Arentze & Timmermans, 2003, Golledge, Gale, Pellegrino & Doherty, 1992; Wilkniss, Jones, Carol, Gold & Manning, 1997; Abdel-aty, Kitamura & Jovanis, 1997; Allen, 1999; Papinski et al ., 2009; Large, 2001; Kueh, 2006; Sepe, 2009; Raveau, Muñoz & De Grange, 2010, Hillier et al. 2010) dealing with the choice of routes and the wayfinding through the urban structure. Papers dealing with the identification of people with the elements in space (Lipovac, 1997; Eldemery, 2003) are important as well. Through the systematization of these studies and their review in relation to the spatial component of the rail system it is possible to improve the urban structure in relation to the route of the rail system. Therefore, it is necessary to examine the uniqueness of spatial components of rail systems in urban totalities, the possibility of directing the movement through these rail systems and generating a sense of space. Based on the review and analysis of these papers it can be concluded that studies examining the potentials of the terrain and landscape and the positive perceptual experience of space in setting-up routes and achieve the desired effects on the human environment are underrepresented.

Typological systematization and analysis support the objective to identify the ways in which spatial components of the rail system are related to the urban elements and thus, determine the degree of importance of geomorphologic features of the terrain as elements for the identification of criteria of designing urban spaces from the aspect of route of the rail system. The purpose of this analysis is to systematize the criteria for shaping urban spaces that include rail systems. By the use of different methods, specifically digital technology, these criteria represent the basis

on which the terrain configuration and the layout of urban elements are coordinated, which significantly improves the aesthetics of urban landscapes in addition to the basic aspects of sustainable development.

The authors of this paper advocate the view that urban areas that include rail routes are possible to shape by applying architectural principles of spatial shaping, using the theories of spatial perception and defining the relationship between the spatial components of railway systems, the principles of shaping the space and the form of relief.

2 THE POSITION OF KEY COMPONENTS OF RAIL SYSTEMS IN RELATION TO THE GROUND

The term of urban rail systems generally covers light rail system, metro system, monorail system and railways (Dinić, 1998). According to the spatial components, in urban sections, railways – a system of transportation used on extra-urban routes – are compatible with the first two systems. A good example for this is the extension of Karlsruhe light rail transit lines over intercity railway lines (Dinić, 1998, Vucić, 1999).

Light rail system, metro system, monorail system and railways are the necessary technical/technological and functional units, which include transportation means (pulling and pulled, organized into driving units of adequate capacity), routes and stations (partially or completely grade separated, with underground and surface sections, or sections in the level with other traffic routes), IT (information transfer and remote control systems, as well as the passenger information system in vehicles and stations), stable electric traction facilities (used to transmit electrical power and feed pulling vehicles), as well as signaling security systems for traffic regulation and transport organization. Thereby the technical, technological and organizational elements of the transportation processes are complete coordinated (Dinić, 1998).

Figure 1: Position of the route: a) the underground metro tracks in Berlin, Germany (Eric Pancer), b) light rail system at ground level in Phoenix, USA (John Hall & Associates), c) light rail system above ground level (on the viaduct) in London, England (www.funini.com).

Routes and stations are the physical expression of all the above mentioned rail systems through which they fit into the wider urban structure by their various constructive forms, design and visual expression. The basic structural forms which forge a link with the environment can be typologically systematized, with various alternative solutions. These solutions vary regarding the position of main components in relation to the terrain. Constructively, the route of light rail system in different sections may be conducted by combining the position at ground level, under

the ground (or partially underground), and above ground level, on viaducts or dikes, while routes of the metro system are mostly buried in the ground or are situated on viaducts, and routes of the monorail system are exclusively on viaducts. The conclusion is that the light rail system is the most flexible in terms of routing in the environment and setting-up stations, as important nodes for the residents' public meeting.

3 PRINCIPLES OF ROUTING IN SPACE

Throughout the entire history of building, the design of route in the urban structure has significantly been affected by its visual experience. The goal has always been to leave a striking impression on the participants that move through public spaces of the city by using different eye-catching and memorable elements. Through a comparative analysis of the spatial experience of people during their movement in public spaces formed in different historical periods an experience has been acquired, which can be applied to improve routing in modern conditions.

Due to the importance they had for the people, procession routes in ancient Greek polis and Roman cities were taken as examples of visual experience of people on the move. To a certain degree, shaping the public space in modern cities is also influenced by the technological revolution. Therefore, as another example, the effects of technological developments in the route surroundings on the psychology of its users were also analyzed. The active participants' visual experience in perceiving and memorizing the route as one of the striking elements in the panoramic city views has been tested based on the views of Kevin Lynch on the city image (1960). Advanced and critically transformed in various forms by other authors, these views have survived to this day through the analysis of the people's cognitive map, the development of methodology for selecting the route of movement through the city and the wayfinding methodology in the cities.

3.1 The experience of space in terms of visual experience of people moving along the route

Festivities and rituals are forms of communication and a very effective tool to identify and confirm certain social values (Stupar, 2001). The unique strength of rituals affects the society's ability to step above the plane of everyday life. In that moment, the society sees itself from a different perspective, becoming aware of its compactness and strength, and, due to the high levels of emotion, renewing and transferring from the transient and profane state to the state of universality. The power of such events is able to change the cornerstone of an individual's point of consciousness as well, so rituals and festivities can serve as a successful means of mass manipulation, which is often used by authoritarian systems. Periodically repeated festivities moving through the city, remind people to the cyclical nature of life and the infinity of the universe. In this way, the principle of immortality is emphasized and individuals are granted with power they lack in their daily life (Eliade, 1991).

Through their daily migrations, modern people directly experience the cyclical nature of life. The use of subway, buses or trams for the regular communication in daily activities takes two to three hours on average, regardless the degree of compliance of public transportation with the needs (Mijić-Vucković, 2005). In this context, the route where the ancient procession takes

Society according to epoch	The means of control by the governing elite	The level of orientation towards public space	Reasons of orientation towards the public space	Universal character of the path	Purpose of forming the route
Antic society	Procession paths	High	Festivals and rituals, communication and socialization	The cyclic nature of life	Media of communication and relationship between the governing elite and people through stepping above the level of the everyday life
Modern society	Electronic media	Low	Traffic, socialization	The cyclic nature of life	Stepping above the level of everyday life of the society and individual, transition from the state of usual into the state of universal and creation of sustainable and creative life

Table 1: Comparative analysis of the ancient and modern society with the aim to define the principles for route design (Author: Milos Kopić).

Nature of the route	Spatial properties	Architecture and urban issues	Elements	Purpose	Unique principle	Interventions in the relief
Antic procession	Visual continuity and unification were symbols of order and infallibility of the system; orientation, uniformity and wide street profiles	Explicit perspective and gradation of the center line	Obelisks, colonnades, gates and other street scenery	Communications, ritual ceremonies, subordination to the system	Emphasizes the principle of immortality giving the power that an individual lacks in his life	Grade separation of the terrain
Route of a rail system	The three basic structural forms are above ground, in ground-level and buried (partially or completely). Independent on the other modes of transportation or integrated.	Skylines, sights, landmarks, parterre arrangement, route design, station design, use of modern technology and structures, integration of activities in urban tissue, shaping and usage of public space.	Elements of the contact network, rails, pavements, urban mobiliars, stations	Traffic in cities, implementation of technology, sustainable society, orientation of people towards public spaces	Stepping above the level of everyday life of society and individual through a unique experience and perception of space.	Dikes, viaducts, bridges, cuttings, retaining walls, tunnel structures

Table 2: Comparative analysis of the ancient procession route, the route of the railway system, and the engineering interventions in the relief (Author: Milos Kopić).

place may be conditionally compared with modern traffic routes. Since both rely extensively on public spaces, the ancient experience can serve in shaping modern routes using semiological principles. The principle of necessity of shaping the route of the rail system within urban units in the context of geomorphologic features of terrain can be viewed through the comparative analysis of nature of the ancient and modern society (Table 1), and the comparative analysis of ancient processions and the nature of railway route (Table 2).

Ever since Marshall McLuhan published his vision of the "global village" in the 1960s, social and political theorists-mostly coming from a Marxist perspective-have associated globalization with the acceleration of time, the "annihilation" of space, and the expansion of authoritarian control (Fiss, 2009). Antic processions, as interpreted in accordance with these views, were mediums of communication, a step of society above the plane of everyday life, representing the relationship between the governing elite and the people; however, in the modern world, this kind of role has been marginalized. This kind of connotation of route has been transferred to the virtual world and the electronic media: it remained the bearer of urbanization, becoming a high-capacity means of realization of transportation requirements (Kopić, 2009b).

Due to the technological advancement, the power and spheres of influence were formed and preserved through the electronic media. Information and communication technologies present us with a series of paradoxes. On the one hand by aiding the communication process they promise to bring us all closer together, yet all the evidence is that social exclusion rather than inclusion is consequence (Uzzell, 2008). The environment is not a neutral and value-free backdrop to our lives (Moser and Uzzell, 2003). It is constantly conveying menaings and messages

(Uzzell, 2008). The physical world is an integral part of human action and is used to promote identity and to locate the person socially, culturally, and economically. For environmental psychologists, psychological processes are always situated. That is, they are invariably place-related and place-dependent. This is no less true of the digital world (Uzzell, 2008). Throughout the entire history, the purpose of public spaces is to lead to "unexpected meetings" and "daily experiences". The question is, what are the possibilities of "unexpected meetings" and "daily experiences" when living in a digital city (Uzzell, 2008). As the result of the information technology and automation, life is increasingly faster and more complex, and also oriented to confined spaces, where the relation between the user (a certain kind of vassal) and the control system works through the electronic media (Kopić, 2009b). Universal values necessary for the development of sustainable society and the emotions that spaces in the surroundings of railway routes need to arouse in people who are moving along it, should act as a counterweight to the numerous problems and challenges of modern life in a global city (Kopić, 2009a), i.e. they should bring individuals to the level of emotional catharsis or constructive and optimistic thinking, as was the case with the ancient citizen when he moved along the procession route.

Those who believe that there is no alternative to the current expansion of the urban tissue may easily overlook the historical outcome of such an urban concentration of power (Mumford, 1961). They forget that these developments have repeatedly announced the last stage of classical civilization. One reason for the fatal cycle of urban growth, expansion and disintegration that

is constantly repeated lies perhaps in the very nature of civilization (Mumford, 1961). The route illustrates the movement, the speed and the certainty of process. The route is a symbol of organized production, profit earning, and technological revolution without control (Kopić, 2011). Now, this same route should lead to the deceleration of uncontrolled social processes, while the evolution reaches the scale of technological revolution. All the connotations of the route and all the marking factors that led to modern urban routes are subject to critical analysis and systematization. The results of such research can be formulated as the principles of shaping the city of future, i.e. the transformation of the modern city through the resolution of all challenges and problems of the modern society.

3.2 Analysis of influence of the elements of perception in the surroundings of the route on the psychology of users of the route

Many of the sicknesses of modern society are being claimed as the effect of the environment we have built ourselves. Whether it be vandalism or wife-swapping, whether absent workers or confused commuters, there are some who will try to find a cause in the physical fabric of modern cities. The significance of our surroundings, geographical or architectural, is crucial to our sane survival (Canter, 1977). The conceptions which people have of the places in which they find themselves, are frequently the scientific key which will unlock the processes by which those places have their impact. It is interesting to consider that people participate in public areas of the city without being previously consulted regarding the framework they want to live in. This can be explained by the fact that people have the choice to move into space that they feel more or less pleasant, with their mental map of space being formed based on the elements of these spaces. Life in the modern city, with the necessity of complex navigation and site-searching, would be certainly very complicated, if people would not be able to create their own image of movement in space (Canter, 1977).

Psychologists Carr and Schissler have carried out a very useful experiment regarding the ways of creating an image of the space (Alihodžić, 2009). They conducted a survey in which three groups of people participated. The first group consisted of drivers who pass a route through the city for the first time; the second group consisted of passengers that these drivers were transporting; and the third group consisted of drivers who knew that specific route through the urban fabric (passed by the previous two groups), (Alihodžić, 2009). Subjects were shown to have a very similar image of the path and facilities, although only the third group was familiar with given part of the city. This similarity in respondents' perception and memorizing the images of the city has led two psychologists to conclude that the design process in city planning can be simplified. They felt that it is important to achieve the character of essential elements of the project, if they are distinct from the background by their "size or peculiarities". It is highly important to clearly differentiate the "picture from the background". According to this research one can easily orientate in the city when the dominant elements are chosen selectively and can be easily observed from the road, although the road is straight. Here we come once again to pointing out the importance of the dominant landmarks of the city, with important features that are easy to observe and remember. Hence, many buildings have supported some variation of

obelisk, as this form passed the historic test of a successful spatial accent, which is notable since the age of building Stonehenge (Alihodžić, 2009). In their experiment, Winkelman et al. used a visual device, by which respondents were enabled to add or remove (according to their own understanding) some elements on the route they travelled and in the perceived environment. On the first recordings, respondents clearly removed billboards, signs with written information, as well as the cable network over the roadway. Interestingly, in a certain moment respondents said that with the removal of the maximum number of elements the road became monotonous and "depressed". It is known that in many countries highways are equipped with reproductions of artworks placed along the road to prevent the negative effects of boredom in perception, which is especially present in lowland areas (Alihodžić, 2009).

Shaping the roadways is among the most complex tasks in space design. It consists of many elements of the natural and built environment and is influenced by a wide spectrum of social interests (Gabrijelčič, 1994). In the context of forming a visual experience on the highway, Appleyard, Lynch and Myer (1964) have defined clear objectives. The first is to present the viewer with a rich, coherent sequential form, a form which has continuity and rhythm and development, which provides contrasts, well-joined transitions, and a moving balance. This form may be built out of the sensations of space or those of motion (both of self or the external environment). It may be constructed from modulations in light, color, or texture, from roadside detail, or perhaps even via secondary senses such as sound, smell or touch. The second objective of the design is to clarify and strengthen the driver's image of the environment, to give him a picture which is well-structured, distinct, and as far-ranging as possible. He should be able to locate himself, the road, and the major features of the landscape, to recognize those features with surety, and to sense how he is moving by or approaching them. The third objective is to deepen the observer's grasp of the meaning of his environment: to give him an understanding of the use, history, nature, or symbolism of the highway and its surrounding landscape. The roadside should be a fascinating book to read on the run (Appleyard, Lynch, Myer, 1964).

The objectives of providing car drivers with visual experience on the highway can be seen as analogous to the objectives of visual experience on the route of the rail system for the passenger. The advantage of passengers of the rail system is that they can focus their full attention to the recognition and realization of relations with the elements in the near and distant space regarding to the route. Also, the psychological connection with the natural elements and the elements of the built environment continue to establish directly after the travel on the rail system ended, when the passenger becomes a pedestrian in the street or in pedestrian areas along the route. The emotional experience of perception from the route is continued directly by the emotional experience of perception in the surroundings of the route that can be a part of the concept of urban space, which includes the rail systems.

3.3 The experience of space by conceiving the elements that are related to the route in the urban structure

Our cognitive abilities and personal characteristics shape the way we learn new routes and handle information processing (Adler, 2001; Arentze & Timmermans, 2003, Golledge, Gale, Pellegrino

& Doherty, 1992; Wilkniss, Jones, Karol, Gold & Manning, 1997; Papinski et al., 2009). Critical to route learning is first to establish key landmarks and intersections in the form of a mental map. This is based on personal experience traveling through the urban environment. According to the theory of reinforcement learning individuals explore their surrounding environment and learn from their experiences (Abdel-aty, Kitamura & Jovanis, 1997). Communication designer Paul Arthur emphasised the collaboration between designers and spatial planners , where he stated that the most effective way to approach wayfinding issues was to have arhitects and designers focused on the ways people respodned to the actual environment (Large, 2001; Kueh, 2006). Spatial orientation involves the interaction between the characteristics of passengers and the characteristics of environment (Allen, 1999). For users of urban spaces that include rail systems, the route in its various constructive forms is a part of the perspective, a part of the street facades and a part of the city skyline. Lynch (1960) shows the contents of mental images of inhabitants of Boston, Jersey City and Los Angeles through five basic types of elements: paths and roads along which the observer is moving; edges or boundaries, such as banks, railroad cuts, borders of constructed areas, fence or partition walls; districts or parts of the city; nodes, which are strategic points of the city or the focus of which the observer is moving away or to which he is moving closer; features, which are a kind of landmarks or benchmarks. For most people who participated in defining the mental image of the city, paths were the dominant elements (Kurtović-Folić, 2001).

People who were the least familiar with Boston mostly imagined city through the topographical elements, over large regions, generic features and broad orientation relations. People who were more familiar with it expressed themselves predominantly through the structure of the paths or their mutual relations (Lynch, 1960). When designing urban totalities, relief elements can be used in relation to the urban elements that include rail systems. The construction of route and stations can be used to emphasize one of the forms of relief or the entire totality, and also to supplement or imitate these. If seen as synonyms, the Lynch's element of roadway and the route of the rail system in its various constructive forms, then their equivalent in the relief is the cutting, dike, notch or gradually sloping terrain.

People always remember streets that are either very narrow or unusually wide. The vicinity of the street to the city center contributes to its importance. Sometimes, streets are becoming more visible mainly from the construction reasons (Lynch, 1960). Construction reasons represent a wide range of urban and architectural themes that correspond to the form of route, and the elements and objects in its surroundings.

The main requirement is that the actual route, i.e. the carriageway, goes all the way, the continuity of anything else is not important. Roads that simply have a sufficiently continued lane have always drawn people to cities like Jersey. The Commonwealth Avenue achieves continuity by the uniformity of its facades and alleys consisting of same trees, while the Hudson Boulevard achieves this by its same type of buildings and their surroundings. In addition to their identity and continuity, streets can have their own quality of orientation (Lynch, 1960). By its nature, the rail route has its continuity (Kopić, 2011). It is important to note that the continuity of rail route

is in its feature that corresponds to the one of several ways of wayfinding in an urban structure distinguished by Allen (1999). This is the wayfinding method by following a marked trace. The route may emphasize some relief element, e.g. a dike. The bank can maintain a completely natural form or can be replaced by a brick structure, a facility, or their combination. The structural characteristics of the rail route are such that the grade separated tracks above the ground often can be experienced as either the Lynch's element of road or as the edge element. Orientation is also a principle in defining the ancient processions. In the context of shaping the urban space, orientation can be used in defining the relationship of rail routes and the surrounding elements, buildings and urban totalities.

Edges are often roads as well. Railway tracks elevated above the ground in Jersey City are typical examples of "edges over our heads" (Lynch, 1960). The characteristic elements of the relief that in the interpretation of the route may be noted as edges and constructed as semiologically outlined elements, can be a magnet in the populations' mental image. These are dikes, cuts, notches and a variety of terrain grade separations, from steep and terraced slopes to gently sloped terrain and river banks.

Where the path of movement is followed by a discernable series of road marks, the movement is unfolding by arriving to "secondary goals", passing them by, getting its content and becoming an experience by itself. Then the passenger is impressed by his sense of movement along the path (by turns, climbs and descents). A long downward curve reaching the city center can produce an unforgettable impression and image. That sense of movement consists of the perception of touch and inertia as well, but these are clearly dominated by the visual experience (Lynch, 1960). In finding the way by tracing the features, the passenger relies solely on the sequentially organized knowledge. The feature is associated with the specific information on the direction (or distance) of movement, which leads him to the second feature. The guidance of movement by using features is an effective way of traveling to known or unexamined destinations in a familiar environment and can be a standard method of determining the position of unexamined destinations in an unfamiliar territory. The success in guiding the movement through features depends on their recognition, or on a previous experience and description, as well as on recalling the spatial relations attached to them (Allen, 1999). Equivalent to the element of feature in the context of rail system usually is the station. It may also be the route structure, as well as a range of facilities to which the route, in its spatial disposition, is visually directing us (Kopić, 2011). The equivalence of the rail system components and the forms of relief on one hand, and the element for which Lynch has determined to create a mental image on the other, tells us that they have an important visual role in the perception of urban space. Based on the analysis, a systematized overview of these elements, their equivalent components, certain themes and visually conceivable geomorphologic forms are suggested (Table 3).

Whether viewed as roads, edges and features, spatial components of rail systems can play an important role in different ways of wayfinding in a familiar or an unfamiliar environment suggested by Allen (1999); these are the following: moving with orientation, following a marked trail, guiding with features, the integration of paths, moving out of habit and relying on spatial

relationships. In their analysis of topological model for the selection of subway route, Raveau, Muñoz & De Grange (2010) have found that the users of subway system prefer more familiar routes or routes where they frequently travel, and that route recognition affects the use of specific subway line. The route in the urban structure can be based both on a combination of basic recognizable elements according to the systematization of Kevin Lynch (1960) that interfere with the route and its elements, and different ways of generating paths in the mental map of inhabitants, as outlined by Allen (1999).

Elements in Kevin Lynch systematization	Components of rail systems	Position of the elements regarding the terrain	Type of structure	Architectural and urban issue	Geomorphologic form and engineering intervention
Roads	route	Above ground level, at ground-level, partially buried	Viaduct, at ground level, bridge, tunnel	Arrangement of the parterre, sight, landmark, skyline	Dike, cutting, serpentine, flat terrain, tunnel
Edges	route	Above ground level, at ground-level, partially buried	Viaduct, at ground level, at the level of cutting, retaining wall, tunnel	Sight, landmark, skyline, panoramic view	Dike, cutting in the slope, cutting in the rock, serpentine
	station	Above ground level, at ground-level	Building, station platform with a canopy	Structure typology, fitting the structure into the terrain, design of urban elements and mobiliar and parterre arrangement	Hill, grade separated terrain
Marks	route	Above ground level	Viaduct, on grade separated terrain	Landmarks	Grade separated terrain, rocky ledge
	station	Above ground level, at ground-level	Elevated, at ground level, on grade separated terrain	Landmarks	Grade separated terrain, rocky ledge

Table 3: Analysis of the elements in the systematization of Kevin Lynch in the context of the rail system components and their equivalent geomorphologic forms and engineering interventions in the field (Author: Milos Kopić).

4 THE ROUTE OF RAIL SYSTEMS IN THE CONTEXT OF GEOMORPHOLOGICAL PROPERTIES OF TERRAIN AND PARCELLATION

Spatial planning as a thoughtful process in the line with sustainable development is highly important for preserving space as a limited resource and for good quality of life. In order to

take into account both social and personal interests while preserving the existing spatial values, the public needs to be included in all levels of spatial planning (Fridl and Urbanc, 2008). The responsibility of dealing with space must be shared between the individuals and the society (Urbanc et al., 2004, Fridl and Urbanc, 2008). The sustainability of any place depends on a number of factors that contribute to its liveability, quality and identity. An action such as walking, which is clearly 'sustainable', may become unsustainable if the environment in which it is unfolding fails to include requirements for a quality living (Sepe, 2009). The visual quality of natural totalities to which the railway route is directed may give priority to rail transit over private cars, contributing thereby indirectly to sustainable development. Thus, at the level of public and general interest, space shaping increases individual's awareness of the unique and authentic natural environment and improves life quality. It is also a way to improve the quality of life in modern cities (Kopić, 2011). Urban space is locally metric but globally topo-geometric. It might be conjectured that there is some threshold above which human being use some geometrical and topological representation of the urban grid rather than the sense of bodily distance to making movement decisions, but this is unknown (Hillier et al. 2010).

The geomorphological structure of the soil gives rise to the morphology of the city, despite the fact that nowadays constructions and built elements are less dependent on natural conditions, which prompted the following conclusion: "With the full utilization of elements of relief, water and vegetation, the significant functional and compositional values of the city were achieved " (Radović, 2003). Not many of the planners take the importance of the place into account when designing some plan in order to establish a proper planning process that would save the character of the entire place (Lipovac, 1997). A kind of planning process, that has been mostly forced by the demand of economic growth, undoubtedly leads to a new phenomenon in planning practice: placelessness – making of standardized landscapes and built environment what unavoidable results in bringing insensitivity to the significance of some particular place (Lipovac, 1997). Rapid urbanization and technological advances have resulted in more and more standardization of built environments, depriving human habitats of cultural and regional identity, in which the trend of standardization is becoming an international malaise as the same building methods, materials, and styles are applied (Eldemery, 2009). As cities begin more and more to resemble each other, it often leads to false conclusion that cultural particularities, identities and differences are all lost in the process of globalization (Šaban, 2005). A global city is created in the way to play back all that occurs locally in any city throughout the world (Šaban, 2005). Indeed, the formation of the route in the context of topography can be characterized by this "local" in terms of shaping urban forms. In order to define the principles of shaping the rail route, it is necessary to analyze the urban context of the route and its elements, depending on conditions in the relief.

The nature and potential of the route is considered in terms of parceling, topographic aspect and the degree of urbanization of the terrain. The emphasized features of the relief can be translated into a means of shaping space, rational use of space, application of technological advances and a visualization tool. The route is often functionally a compromise with the configuration of the terrain and influence of natural forces, and thus may suggest an urban form. The upgrade of natural forms can be pure engineering form; rational, and a reflection of modern technology with

emphasized natural characteristics of the terrain, geomorphologic shape, and relief structures. The integration can be a contrast in terms of the engineering design defying the action of forces which the terrain is inclined, thereby achieving the effect of emphasizing certain forms. The route and its elements can also imitate forms of the relief.

4.1 Rail route as a separate totality in the urban morphology in the context of parceling and relief

Routes of rail systems in cities are separate totalities of urban morphology according to their elements, structure, shape of the route, route position, materials, arrangement of the ground floor, parceling, position in the structure of the city, the relation towards elements of historical heritage and public spaces dedicated to social integration (Kurtovic-Folic, 1995). Baseline road-lines need to contain some special quality that distinguishes them from other local routes: some concentration of a particular kind of activity or some particular spatial quality, special texture of the pavement or the facades, something special in the way of illumination, a unique combination of odors or street harmony, a typical, imaginative outlook of vegetation (Lynch, 1960). These special features should be disposed as to ensure the continuity of the roadway (Lynch, 1960). The route over a viaduct corresponds both to the element of the edge and the elements of the road, as classified by Kevin Lynch. In this case, the route has the necessary characteristics of continuity of the road. Viaducts, standing free in space, can follow the course of a main roadway and thus its direction may be shaped by regulation lines on both sides of the roadway. With their free-standing course of direction, viaducts may cut the urban fabric and intersect with the direction of other roads (Figure 2c). In this case, the viaduct stands and neither has a contextual relationship with the surrounding buildings and urban totalities nor can form a distinct spatial relationship, given its distance from the buildings. However, in examples (Figures 2d and 2e), it is obvious that the overhead route penetrate the densely constructed urban fabric. In the example from Chicago, the route is a reminiscent of cutting between the peaks, which does not penetrate the lower floors of buildings, passing them by instead, forming thereby an 'elevated floor'. In the example of Tokyo, the route obviously passes through the building and in structural sense it is the extension of the route through the station. The route in Cerb re (Figure 2a) follows the organic and irregular parcelation, while the viaduct in Chicago highlights the orthogonally regular structure of parceling. In contrast, the viaduct of Tokyo cuts the urban fabric and structures without respecting regulation lines, using their own constructive privilege of grade separation.

The perception of familiar regions where the road runs by entering and leaving them, represent a powerful tool of experiencing the direction and proportions along the road (Lynch, 1960). There are examples of rail routes in the ground level, which is not manageable at short distances. This is an area with characteristic elements and it can be stated that it cuts the city tissue, forming spatially close but functionally remote urban totalities. This can be illustrated by examples in the French city Cerb re (Figure 2a) and the Japanese city Chiba (Figure 2b). Although the urban fragments are separated by these routes, making them functionally and spatially distant, they also have some certain similarities with them in terms of the character of architectural

typology and urban morphology. In the case of Chiba, the geometrically regular surface of the route which dominates the space imitates the regularity of the street network, the regularity in the arrangement of objects and their forms. It can be concluded that the route respects proper parceling through its continuous, straight direction at ground level. This is an intensive direction which may lead to the effect of co-linearity with a series of parallel lines.

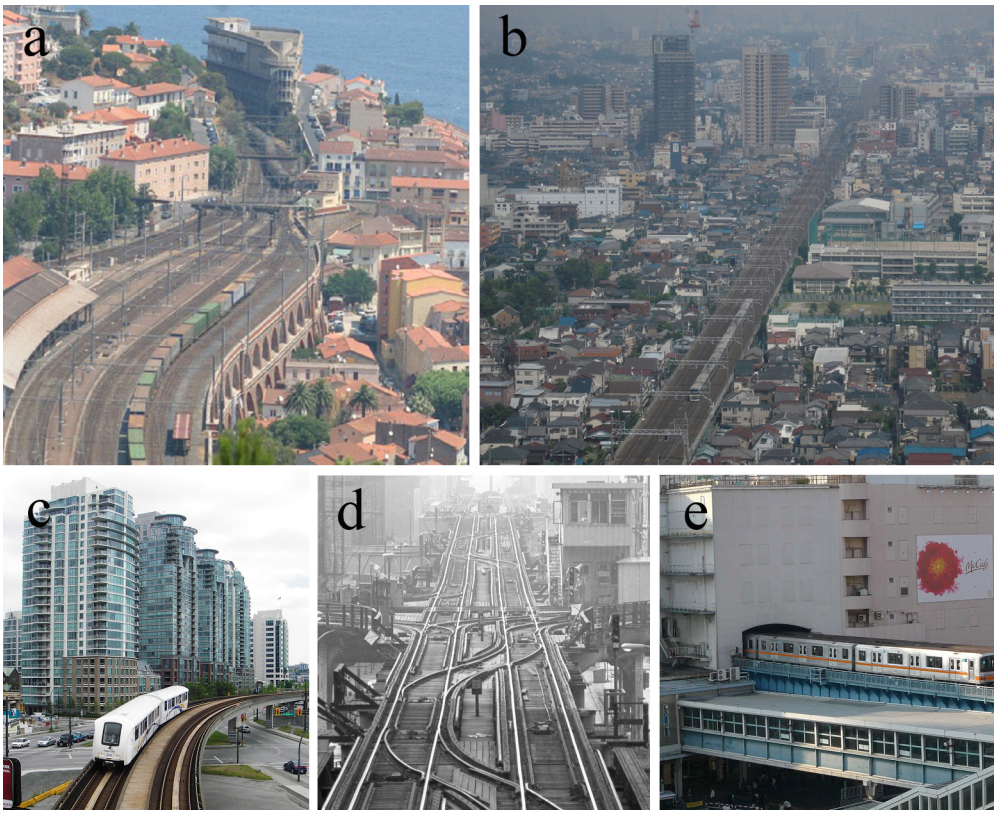

Figure 2: a) rail route in Cerbére, France (Pierre Phaneuf); b) rail route in Chiba, Japan (Picture TYO); c) light rail viaduct in Vancuver, Canada (Mike Martin Wong); d) rail route in Chicago, USA (Pete Hackney); e) railway viaduct in Tokyo, Japan (http://www.funini.com).

If we look for patterns in the section of Tokyo, the first thing the eye notes are line continuities. What we are seeing in effect are sequences of lines linked at their ends by nearly straight intersections with other lines, forming a visually dominant pattern in the network. Intuitively, the value of these in navigating urban grids is obvious (Hillier et al. 2010). If we have already found that some road has the property of orientation, then we can ask whether there is some co-linearity, i.e. whether its direction may be associated with some larger system (Lynch, 1960). In the case of Cerb re, in the constructive sense, the route is deformed while replicating the cascade descent of terrain and the organic form of street network. At the same time, it integrates the architectural elements in the form of arcades on the side of the retaining wall structure. It can be concluded that the route follows geometrically irregular organic structure of parceling, directed by the contours of the terrain.

4.2 Rail route that follows the inclination of the terrain

In some examples of construction activities in the relief, a formal potential of the route is perceived to be an aesthetic moment, providing the urban landscape with identity and upgrading it rather than degrading. This structural intervention may be a historical or modern engineering structure, such as bridges, dikes, viaducts, serpentines, retaining walls, etc.

Places, settlements and regions create their spirits through their geographic features that are so specific (Lipovac, 1997). Mastering the steep landscape in stages provide cities with a distinctive shape. The orientation of streets and regulation lines follow the terrain contour lines, forming thereby an organic built structure descending in a cascade down towards the lower parts of the terrain. These are mostly coastal cities and routes (Figure 3a), although they may be inland towns on a steep configuration. Constructive solutions in terms of combining the viaduct, cuttings on the slope and the shape of the retaining wall define the different forms representing visually unique totalities that have the potential to initiate the development of urban structures. Regarding its shape, the materialization of the retaining wall and floors of cuttings covered by rails, the grade separated route in Strasbourg represents a typical urban totality (Figure 3b). Retaining walls on both sides of the track are covered by embossed arcade reliefs, testifying on the sophisticated combination of purely engineering interventions in the relief and architecture aiming to shape the space visually.

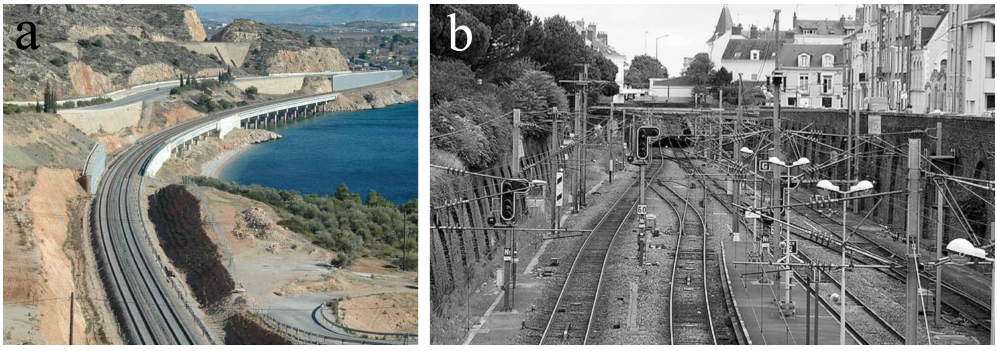

Figure 3: a) railway route Korinthos-Athens, Greece (George Togias); b) route near the SNCF station, Strasbourg, France (Christophe David).

Edges are linear elements that are not considered roads; they are usually the borders between two types of urban areas (Lynch, 1960). They act as lateral landmark lines, and the strongest are the edges that are not only visually distinct, but also continuous in their form and impassable for transverse movements (Lynch, 1960). According to Lynch's classification, cuttings with side retaining walls on slopes and cuttings in a flat terrain can be identified as edges.

Explicit natural shapes (conical, pyramidal, tunnel, canyon, completely flat, slightly sloping etc.) provide the ability for the functional decomposition of the city as a consequence of the chosen location (Radović, 2003). Thus, constructed buildings are in close relation with the forms of nature, emphasizing and expressing the topographic characteristics of the area (Radović, 2003). The route should be linked with geomorphologic conditions in its form, and reflects them

through its form. The inclination of the terrain suggests dynamism of urban form. Through the contour lines of the terrain and forms of the relief, the potential energy of the terrain highlights the kinetic energy of the route.

4.3 Relief emphasizing through rail route modeling

Relief emphasizing can be observed through the principles of implementing the route into the terrain in the form of several rows of arcades. The rail viaduct on the example of Cerb re (Figure 2a and 4a.) is an organic structure built into the slope. As structural principle with its own shaping character and environmental value, it is a reminiscent of the principles of construction in the ancient civilization of Egypt, where burial temples were built in the rocks (Figure 4b.). The similarity is both in the principle of incorporating the object into the natural configuration of the terrain and in shaping the front part of the structure by perforations that replicate arcades or colonnades.

Figure 4: a) railway route in Cerbére, France (Thierry Ilansades), b) the burial temple of queen Hatsepsut (Paul Mannix), c) aqueduct in Qerétaro, Mexico (Diego Materazzi), d) Slaithwaite Viaduct, England (Tim Green).

When space feels thoroughly familiar to us, it becomes place (Tuan, 1975; Lipovac, 1997). What does it mean familiar? (Tuan, 1975; Lipovac, 1997). Individual's psychological sense of place identity can be understood in many ways: as an experience, a convergence of cognitions, how residents feel towards their town, or an assessment of the extent to which they agree with the sentiment "this is not the place for me" (Eldemery, 2009). Place identity is sometimes described

as an implicit psychological structure. It is also considered a cognitive structure that contributes to global self-categorization and social-identity processes (Eldemery, 2009).

The space can be familiar to us due to an architectural element or the relationship between that element and the relief. Identification with a familiar and widespread element in the architecture, which is integrated into the relief of unknown regions, may lead to the impression of identification with the entire landscape. The relationship of the route to the aqueducts as historical elements of construction of the concrete examples, may be diverse: from the cases the aqueduct is a historical legacy when the emphasis is on the route and it can also be a city gateway (Figure 4c), and the examples from Slaithwaite (Figure 4d), where the same form, i.e. a spatial hypertrophied arcade, is the route of the rail system.

4.4 Spaces of rail routes as morphologically diverse totalities

The perception of space is enhanced if the road reveals the traveler some other elements of the city as well; by cutting them through or running over their edge, and revealing the symbols it is passing by. The road can also be formed with its course being sensory evident; ramps or spirals with continuously running traffic are stimulating our thoughts. All these techniques intensify the observer's visual experience (Lynch, 1960). Few parts of the urban totalities in the cities are diversified regarding the combination of different structural elements, topographic features and urban elements as the space by which rail systems are supported. This is reflected through many grade separations, different constructive solutions of viaducts and girders, bridge structures, tunnels, retaining walls, dikes and vegetation on a relatively small area (Figures 5a, 5b, and 5c).

Figure 5: a); b) and c) routes of rail systems, Tokyo, Japan (http://funini.com).

Dominant lines in space with the visual role of lateral edges are meant to be noticeable grade separated slots. In the context of the route and public urban spaces which support the traffic, they can be identified as traffic-space edges. Traffic in terms of characteristic elements of rail routes, such as the contact network on the grade separated route (Figure 5b), construction of cabin systems (Figure 6a), the combination of these elements and a dike as a highly elevated lateral edge (Figure 5c), mutual combination of multiple routes (Figures 5a and 6b) or even a mutual combination of multiple routes in regard with some elements, such as a dike (Figure 5c) or a river bed (Figure 5a and 5b).

In these examples, the diverse treatment of the river bed in the context of the rail route is obvious. In the example of Wuppertal, due to the characteristic girder, the route is running over the river, while banks are intact in the architectural sense and under dense vegetation. This can be

understood as a kind of ecological route. In the example from Tokyo (Figure 5a), the route is set by the very edge of the river bed, perpendicular to the river bed, completely urbanizing the spatial segment. By its position and the higher structure of that side of the river bed, the route around the perimeter of the river bed highlights the lateral nature of the edge. In contrast, in the example of Ljubljana (Figure 6c) the character of the river as a route may be accentuated by upgrading the banks of its bed and by the rhythmic arrangement of columns and arches which, as a totality, replicate the stylistic context of the surrounding architecture. River banks are completely constructed. Performed as a grade separated route with two levels and highlighted by an arcade and colonnade, this upgrade enhances the visual effect of the coast. The case is quite the opposite (Figure 6b) when the colonnades are not set in rhythmic regular series, lacking columns of uniform dimensions, and when an engineering structure follows the contours of the terrain. This series, together with the horizontal structure of the continuous grade separated girder of monorail system, represent a natural obstacle which is upgraded by engineering. The bank is partially constructed, without an overemphasized architectural dimension, which is the case for the examples in Ljubljana and Tokyo.

Figure 6: a) monorail system in Wuppertal, Germany (Dandelion and Burdock), b) monorail system in Chong King, China (Dennis Deng), c) the bank of Ljubljanica river near Tromostovlje, Ljubljana, Slovenia (Kopić Miloš).

4.5 Routes of the rail systems as urban canyons

The essence of place lies in the largely unselfconscious intention that defines places as profound centres of human existence (Relph, 1976; Lipovac, 1997). There is a deep association with place and consciousness of the places where we were born and grew up, where we live now, or where we have had particularly moving experience (Relph, 1976; Lipovac, 1997). The identity of a specific place becomes interesting when it brings about a certain experience, evoking associations or memories (Eldemery, 2009). The grade separated route of the rail system in the densely built fabric of the city brings the vehicle to the level of the higher floors of buildings (Figure 7a). The drama of this concept and the character of the route as a canyon have its analogy in natural conditions, where the route is cut in the walls of the gorge (Figure 7b). The organic architecture, impressing with its sheer audacity and elegance, speaks more about the visual quality of these spatial totalities. This route has the character of a very strong edge, highlighting the impressive relation of walls and the grade separated route.

In geographical way of speaking, space is not uniform and homogeneous (Relph, 1976; Lipovac, 1997). It has its own name, sense and experience. The place has to be recognized and considered

as a phenomenon of direct experience (Relph, 1976; Lipovac, 1997). Edges can become more than dominant barriers, provided that they are dynamically or visually penetrated (Lynch, 1960). If a significant edge is with a sufficient number of visual and traffic elements of connection, by which the connection to the rest of the city structure is achieved, then it becomes a factor that easily aligns everything else (Lynch, 1960).

Figure 7: a) the Ginza metro line in Tokyo, Japan (http://funini.com), b) Taroko Gorge, Taiwan (Robert Hruzek).

4.6 Natural forms in the context of landmarks on a rail route

A very good discussion of the place concept in geography can be found in an article by Fred Lukerman where he is revealing six major components of the concept of place (Lipovac, 1997). Place involves an integration of elements of nature and culture (Lukerman, 1964; Lipovac, 1997). Although the places are unique, they are interconnected by a system of spatial interactions and transfers, part of a frame of circulation (Lukerman, 1964; Lipovac, 1997). Routes which are both prominent landmarks and spatial edges give identity to the space; also, they are elements of orientation and recognition. The route can be set in relation to the landmark, which is an important and prominent structure, or alternatively, a part of the route can be a landmark. Hypertrophied geometric shape that replicates a grade separated natural form can be a landmark in the urban structure, enriching thereby the urban morphology.

The perceptions of transport users regarding available route alternatives are such that they do not always choose what the modeller would consider as the "lowest cost" option. In their study, Raveau, Munoz and Grange (2010) have evaluated the impact of non-traditional factors that influence the transport users' decision-making in selecting the route. Conceiving the certain aspects of route environment (the physical characteristics of subway stations) also points to the route selection (Raveau, Munoz and Grange, 2010). Well-established fact suggest that transit user decision-making is affected by psychological considerations such as aesthetics, comfort and travel-time reliability (Papinski et al., 2009). Every single space or place can be

identified by different forms that are within (Lipovac, 1997). They can be natural or manmade one (Lipovac, 1997). A vast valley, with nothing to be seen for miles around would bring to the observer a different picture then the valley that is surrounded with mountains in distance (Lipovac, 1997). A series of landmarks along the route may provide the identity to the route and the entire city. These can be only stations along the route, a combination of stations and structural totalities along the route, or a combination of both with the landmark elements of the urban structure. Any of these elements can be either a natural form or a natural form upgraded by engineering structures (Alihodžić and Kurtović-Folić, 2009). A consecutive series of features, where the occurrence of first feature warns the observers to the other, main features, sharpens the observers' attention (Lynch, 1960). We have found that many people direct their movement through the city in this way (Allen, 1999). Where the terrain is flat, through the diversity of their forms, through structures and totalities imitating natural forms, engineering structures largely compensate for the shortcomings in geomorphological shapes. Where the terrain is inclined, the same effects can be achieved by upgrading natural elements or their underlining in concert or the contrast with the terrain.

Component of the rail system	Character of the terrain	Position of the component regarding the terrain	The shape determined by the character of the terrain	Specific engineering structure	Specific equivalent form of the relief	Relation with parceling
Route	Flat	Above ground level, at ground level, beneath ground level	May be part of the cut and dike or the river bank	Viaduct, bridge, tunnel, cutting, dike	River bed	Part of the public area, but partially may be also on a private parcel
	Mountain	Above ground level, at ground level, beneath ground level	Follows the terrain contours, penetrates the mountain massif, built into flanks of the massifs, canyons or river beds	Viaduct, bridge, tunnel, cutting, retaining wall	Explicit edges of canyons, river beds and of the cascade sloping terrain	Part of the public area, but partially may be also on a private parcel
Station	Flat	Above ground level, at ground level, beneath ground level	May be the expansion of a cutting or a dike, or an upgrade to the river bank	Viaduct, bridge	Slight hill	Part of the public area, but partially may be also on a private parcel
	Mountain	Above ground level, at ground level, beneath ground level	Expansion of the contour line field, part of the mountain ranges and built in the massifs, canyons or river bed	Cutting, retaining wall	Forms in the rocky massif, suggesting the form of a portal, expansions in cuttings	Part of the public area, but partially may be also on a private parcel

Table 4: Characteristics of the route and the station of the rail system in the context of the topographic features of the terrain and parceling

A systematic review of the characteristics of the route and stations of the rail system in the context of topographic features of the terrain and parceling is given in Table 4.

5 CONCLUSION

Urban public spaces can be formed through the element of the rail route using historical architectural principles in shaping the space. This is confirmed by theories of perception of space at the level of route elements. Also, based on the given analysis it can be concluded that public space in the vicinity of the rail route can be shaped through the relationship between the spatial components of rail systems, urban elements and elements of the relief, thus confirming the hypothesis of this paper.

There is equivalence between street procession, route of a rail system and its elements, the principles of shaping, forms of the relief and the engineering structures. This is concluded based on the comparative analysis of antic procession, the route of rail system and the engineering interventions in the relief. The systematic review is given in Table 2.

Based on the analysis of elements in the systematization of Kevin Lynch in the context of the rail system components and their equivalent geomorphological forms and engineering interventions in the field, it has been concluded that there is an equivalence of shapes in architecture and urban design, of spatial components of rail systems, modern architectural and urban topics, and urban elements, forms of relief and engineering structures in the field. The systematic review of this is given in Table 3. Based on the analysis of research on cognitive mapping, wayfinding in space and selecting the route of traveling in space, it can be concluded that elements in contemporary urban forms that characterize traffic totalities affect the creation of the population's mental map. Reverse conclusion suggests that the equivalent spatial components of rail systems can visually affect the participants of urban spaces that include rail systems.

Based on the summary of characteristics of the route and stations of the rail system in the context of topographic characteristics of the terrain and parceling (Table 4), it can be suggested that that the route, by its structure, position, grade separation in the field, its relationship with the surrounding elements and geomorphologic forms, induces the same feelings in the viewer as those aroused by the forms of relief. These feelings can be understood through the identity element of space which is defined by the shapes of relief and their spatial relationships. The route can replicate these forms and interpret their visual effects on the viewer through a variety of design approaches and spatial relationships. By relying on civil engineering structures such as dikes, cuts, serpentines, (at different levels of processing, fitting with the construction, materialization and technology) the route can effectively direct the point of views, to form panoramic views of the urban totalities and become the element of identity throughout the urban series or the city skyline. By its structure, in terms of basic geometric shapes, the route is equivalent and replicates the forms of the relief such as riverbanks and various grade separations and supports a variety of engineering structures such as cuts, dams, dikes, tunnels, serpentines and the cascade regulated terrain. The route is meant to follow the contours of terrain; it also has rich architectural possibilities to develop individual totalities. This is important, because when designing urban

space with rail systems, interventions are not radical in terms of removing natural shape. Instead, the route can upgrade the elements of the topography, and coexist with them or replicate them in the context of various engineering structures. Some totalities of the route, such as stations of different storey heights, capacity and structural characteristics regarding the field are equivalent to the element of portal and the term of landmark in urban design. They are also compatible with the forms of relief such as rocky structures, various grade separated types of terrain and different engineering structures. In this way, in terms of design, they may be their formal logical extension or they may replicate them in the absence of these forms in the urban structure.

The route is a form in the relief resulting from natural processes, but also a shape in the urban structure and in the mental map of an individual as a result of social processes. All connotations of paths in a variety of natural shapes and forms can be used as a principle of design of space that includes rail systems both in visual and functional terms. It can be concluded that forms of the elements of a rail system, through the absorption of kinetic energy and the potential of natural forms which they imitate or upgrade, are directing that energy to the stream of social processes and social media. Such a direction of energy in the domain of spatial perception and the realization of mental interaction with elements in space may suggest regenerative and creative processes in the society, which are necessary for its sustainable functioning. In addition to this, the absorber of this energy is both the user and the observer of the space. Based on all the above, it can be concluded that in physical terms, rail systems, particularly light rail system, metro system and monorail system, due to their attractiveness, design and spatial structure, are compatible with the elements of urban structure, equivalent to the relief elements and suitable for the arrangement of urban space and form the shape of the city.

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