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GATEWAY-PATHWAY HERITAGE AND URBAN GROWTH

Zagreb case study

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ABSTRACT

This paper is a part of on-going research into the typological definition of 'urban gateway-pathways'. This term refers to routes used to connect peripheral settlements to the urban core of contemporary cities. The typology was developed with reference to a sample of 18 Central European cities that were formerly provincial capital cities of the Austro-Hungarian monarchy. This paper provides the first authoritative syntactical description of the city of Zagreb and reports on initial syntactical analysis of its historic pathway typology using the transect method established by Hillier (1999). The results from the transect analysis are then used to provide more refined typological descriptions of the gateway-pathways and their historical transformations, and to frame a future phase of research using segment analysis.

KEYWORDS

Gateway-pathways, space syntax transect analysis, Zagreb, Croatia

1. INTRODUCTION

This paper reports on-going research into transformations of historical 'gateway-pathways' (Maric and Jaksic, 2011; Maric et al. 2014). 'Gateway-pathways and roadways' refer to those routes which lead, or used to lead, into the urban historical core of a settlement. Need for terminological distinction from other historical paths, roads and networks, came out from the importance of these routes in urban formation processes during the growth of the cities. The effort is to suggest a process-driven appreciation of heritage, rather than a static, object-driven approach. To explore these linear processes along specific routes and emphasise the importance of these streets we aim to introduce the name 'gateway-pathways' and typological study.

Research is applied on Central European case studies[1], where gateway-pathways are identifiable from historical maps made under the Habsburg rule (Biszak et al., 2014)[2]. The territory of the Austro-Hungarian monarch was mapped by military surveys using the same technique three times: 1763-1787, 1806-1869 and 1869-1887 (fig. 1). The identification of the historical urban core and historical gateway-pathways in the surveyed cities depends on the date of the first survey (fig. 2). In all cases the survey took place before the rapid urban twentieth-century growth of these cities. The sample of 18 cities selected for exploring historic gateway-pathway as a dimension of urban heritage, were formerly the main provincial cities of the Austro-Hungarian monarchy[3].

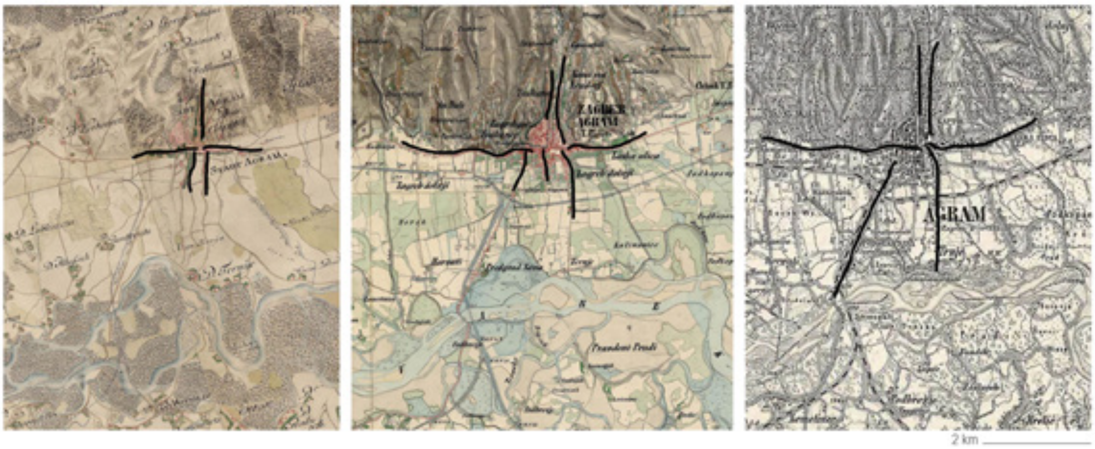

Figure 1 - The city of Zagreb at the end on the 18th, the first half of the 19th and the second half of the 19th century on Habsburg military survey maps with gateway-pathways (black) during the slow historical urban growth before the 20th urban expansion.

An initial typological classification of historical gateway-pathways and their transformations was derived from a comparative evaluation of the routes connecting the urban periphery to the historic core based on two criteria: (a) the relationship of the pathway to the urban core and periphery; and (b) the transformation of the pathway or in other words, the contemporary state of the pathway. Criterion (a) was assessed based on route formation, topography and urban growth processes; and criterion (b) was based on the contemporary status of the pathway, and the changes on the original/historical pathway form and its role for the city.

Based on a comparative examination of the historical military survey maps for 18 Central European cities, the categories of typological classification of gateway-pathways were developed. The types are: a) 'regional direct gateway-pathways' connecting other towns and settlements with the defined walled city; b) 'local direct gateway-pathways' connecting the walled core with northern slopes towards the mountain, and c) 'transit gateway-pathways' leading to the historical core of the built environment beyond the historically defined and walled town. From this classification, the city of Zagreb was selected for further investigation using space syntax in order to evaluate the typological categories of historical gateway-pathways by applying a formal analytical method of spatial-morphological description[4]. In this paper, we will explore the spatial morphological description of the last category – 'transit gateway-pathways' as the dominant gateway typology for Zagreb.

1 On-going research refers to doctoral research undertaken at Vienna Technical University (TUW) by PhD student Tamara Marić that is also part of Heritage Urbanism project at The Faculty of Architecture, The University of Zagreb.

2 Database from Arcanum project (mapire.eu)

3 Vienna, Budapest, Prague, Ljubljana and Zagreb as also state capitals in the 21st century with all three military survey maps are explored in more detales while other cities (Sarajevo, Lavov, Brno, Graz, Chernovitzi, Trieste, Linz, Salzburg, Innsbruck, Klagenfurt, Zadar, Opava, Bregenz) are used only for initial typology identification.

4 This work was done as guest research at UCL Bartlett in 2016 and is partially supported by the Croatian Science Foundation under the project *Heritage Urbanism – Spatial and Urban Models for Revival and Enhancement of Cultural Heritage* (HRZZ 2032 project; head of the project Prof.dr.sc. Mladen Obad Scitaroci)

Zagreb occupies a specific topological urban situation with bi-nucleated urban core located on the hills between the mountain of Medvednica and the river Sava (fig.1-3). Two historical settlements were merged into one city together with the main square outside the walled settlements and surrounding houses gathered along the main gateway-pathway routes in 1850. Rapid growth in the second half of the 20th century extended the main urban area to include surrounding village settlements. Zagreb's municipal authority, with a series of architectural and master planning competitions, continuously developed new routes for entering the city in areas without historic pathway network. Consequently, the historical gateway-pathways in Zagreb have kept their distinctiveness to different extents, depending on how they were located in relation to the subsequent development of railway and motorway infrastructure. The main research question addressed in this paper concerns identifying whether syntactical measurements can be used to describe these typological differences, thereby enabling researchers to better understand the definition of 'gateway-pathways'.

The body of research in space syntax theory on central European cities is limited. Dino et al (2015; 2016; 2017) look diachronically at morphogenetic transformation of Tirana (Albania) by contrasting the built form and the road network during two distinctively different political ruling ideologies, while Shpuza (2009; 2014) gives detail comparison of Adriatic and Ionian cities among which are two cities used for typological identification of gateway-pathways in this research. In addition to its primary focus on gateway-pathway, therefore, this paper also provides an introduction to inform spatial-morphological comparison of Zagreb with more commonly investigated UK and Mediterranean examples. It gives insight into preliminary research questions, methodologies and results pertaining to the Zagreb case study, which can be used for developing comparison with other Central European cities. In this context, the paper's specific aim is twofold: (1) to use space syntax measurements, descriptions, and tools to evaluate the typological and terminological notion of gateway-pathways, and (2) to develop a mapping method involving the historical 'decoding' of a syntactic model of contemporary Zagreb using the historical cartographic surveys, in order to identify new possibilities for using space syntax theory and methods in historical research.

2. THEORETICAL AND METHODOLOGICAL BACKGROUND

The development of systematic spatial-morphological descriptions in historical studies is growing as a popular inquiry in space syntax research. Historical urban-scale research using space syntax methods takes a variety of forms (Griffiths, 2012), and includes a series of studies of urban structures that can be considered as gateway-pathways. Such examples are the syntactic descriptions found in the study of transformation processes of the historic cores of Iranian and English cities by Karimi (1998), of the English industrial city of Sheffield by Griffiths (2009), of the London suburban development by Griffiths et al. (2010), as well as in the study of spatial sustainability as an organic process of the street network in cities by Hillier (2012). While spatial-morphological descriptions of city structures in general, and amongst them of city elements that were historically gateway-pathways in particular, have advanced in the context of space syntax historical studies, still gateway pathways – as historically structural routes to and from the urban core – is a theme that has not been either systematically – typologically addressed – or particularly considered in heritage context. This paper aims to explore the theoretical and methodological prospects of gateway-pathway research in historical and heritage studies using a syntactical understanding of cities.

The methodology developed for this paper poses two main questions. The first has a wider context in space syntax approach: namely, to what extent is it possible to identify historical transformation processes in streetscape through a process of 'decoding' axial and segment graphs instead of using the cartographic redrawing method? The second question is case-related: namely 'of what value are the current typologies of gateway-pathways being used in research on Central European cities, and which syntactical measures will be of the most value in developing the typologies?

Research into gateway-pathways involves examining changes in the relation between the urban historical centre and peripheral areas of the city by tracing transformations in the urban tissue of their connecting paths, roads, and centralities. Along these pathways, we can track transformation processes from trail to path, to road and urban street, and finally as part of the 'urban landscape' of streets connecting different public places from the centre to periphery. They have (or ought to have) specific recognition in heritage context because they are not only continuously present (in some form) from the early history of the city but they are also, necessarily, connections to the protected historical centre. For Hillier (1996, 339-345; 1999) what we identify as gateway-pathways comprise a critical generic feature of emergent urban growth, meaning that as cities grow and increase in density at the centre, they preserve a globalising linear structure that carries integration from the urban core to the (segregated) urban exterior. Theoretically, it is this powerful identification and mathematical description of the formative processes of the core structure in the urban landscape by Hillier (1999) that is of fundamental significance for testing typological classification of gateway-pathways.

In explaining 'centrality as a process' Hillier suggests a globally structuring pattern of grid deformation along the main routes and off the main routes, which occurs as local grid conditions adapt over time and the grid densifies by forming smaller scale urban blocks and more trip-efficient routes. Gateway-pathway relates to 'centrality as a process' because it investigates pathway development and transformation of routes along continuous or near-continuous transects with the focus on identifying the particular trajectory of pathway development and historical 'break incidents'. Relying on the fact that integration analyses show live centres (*ibid.*) within transect method, we will attempt in this paper to systematically address the historical emergence of gateway-pathways in spatial-morphological terms by comparison method with other streets in Zagreb network and by adapting Hillier's transect method.

Transect analysis (*ibid.*) was chosen as the most appropriate syntactic method for comparing four case study pathways in the preliminary stage of analysis for two reasons. First, patterns derived from 2-step transects can overlap with the network of 10% most integrated axial lines which should show differences due to different typological categories in the way gateway-pathways initially led to the historical settlements. Second, it allows historical understanding without using cartographic redrawing methods due to careful choosing of the transect axial lines enabled by georeferencing historical maps either scanned (Škalamera, 1994) or used from mapire.eu (Biszak et al., 2012) in ArcGIS, where the axial model of Zagreb was also drawn. Cartographic redrawing methods are now well established as a form of syntactic-morphological analysis (Pinho and Oliveira, 2009; Dhanani 2016). This approach, which involves working backwards from contemporary maps to create syntactical models of past urban environments is time consuming, which explains why comparative case studies are rare.

Following a baseline spatial morphological description of the Zagreb model in chapter 3, axial and segment analyses are used to compare the spatial configuration of gateway-pathways in the overall spatial configuration of Zagreb street system in chapter 4 and table 3. The degree of change in the network is measured by the breaks in continuity and, on the basis of this, the typology is tested in chapter 5 with comparative descriptive approach on a sample of four gateway-pathways transects. The basis for transects as selected lines or zero-step-depth lines were historical lines detected as preserved in contemporary axial map from original gateway-pathway route[5].

This study is focused on four Zagreb transit gateway-pathways as dominant typology with different roles in contemporary urban network. We will call these pathways: (1) Ilica; (2) Vlaska; (3) Savska, and (4) Petrinjska, while noting that they include other streets as well along their historical and contemporary lines. In Zagreb, there are three types of transit gateway-pathways according to placement and transformation degree. The first are Ilica and Vlaska pathways which kept the east-west continuity by keeping the irregular linear character in the layout plan closed to historical center and which together with the main public square create

5 Historical lines are derived from the continuity path on the historical military survey maps, while contemporary lines is continuity direction after route transformations during the urban growth. These differences are measured by the number of breaks between historical and contemporary lines in the table 4.

one axis in the Zagreb urban plan. The second, Savska street, is an avenue type of street which was in part redirected with the new bridge connection in 1981 from its original route layout onto contemporary route as new traffic entrance to the city, while original parts from 18th century have more of a local route character. The last type is Petrinjska Street as the pathway with discontinuities (or 'disappeared gateway'), which is a comparative rare classification in all the analysed cities.

Figure 2 - The city of Zagreb – first military survey map with identification of 'transit gateway-pathways' by numbers 1=Ilica, 2=Vlaska, 3=Savska and 4 = Petrinjska and dashed-white area of historical core: Gradec (west) and Kaptol (east) settlement.

3. SYNTACTIC PROFILE OF ZAGREB

Zagreb is bi-nucleus city with its medieval centres of Gradec and Kaptol located on two hills (fig. 2 and 3). Both centres were walled and at a distance of 2.8 km from the River Sava[6], on the slopes of Medvednica mountain. The Roman settlement and port on the Sava River was Andautonia south-east of Zagreb's historical core and not a part of contemporary fabric of the city. The exact routes of the Roman roads passing through the area of the city have not yet been precisely identified. There are indications of a southern connection from east to Siscia, and possibly east-west connection with Andautonia which was a regional gateway-pathway as Ilica and Vlaska later in history[7]. The difficulties of mapping geolocations of ancient historical pathways are the reason why typological identification was done using high quality military surveys from 18th to the beginning of 20th century. For Zagreb, the areas of original route of gateway-pathways and the historical urban core as the built urban fabric are visible from the first military survey mapped in 1783-84 (fig.2). Typological identification described in introduction and methodology was done before making axial map and syntactical model of Zagreb. Therefore, we decided to create contemporary model for the purpose of finding out if and how original routes can be detected after transformation processes.

This city of Zagreb is one of the 21 counties in Croatia. That defines the city by its administrative area boundary – an area which is not equivalent to the built-up area of the city. Therefore, there were two main criteria in defining the size of the syntactical model: 1) natural topographical boundaries – the mountain to the north and river to the west and south-east[8], and 2) 'hard'

6 This is a distance from contemporary cannal form of the Sava river.
7 http://pelagios.org/maps/greco-roman/
8 Medvednica mountain is under natural park state protection with strict building restrictions which makes clear the boundary of urban area.

Figure 3 - The city of Zagreb – 21st century aerial view with: 1=Ilica gateway contemporary, 1'=Ilica historical gateway-pathway route in contemporary urban form, 2=Vlaska gateway contemporary, 3=Savska gateway contemporary, 3'=Savska historical gateway-pathway route in contemporary urban form, 4= Petrinjska historical pathway traces in contemporary urban form; a=Zagreb central planned axis, b=Vukovarska street (modernistic street), c=Zagrebacka avenue (contemporary western gateway route to the city); A= Maksimir park, B= Bundek park and the hippodrome, C= Jarun recreational park and dashed-white area of Gradec and Kaptol (Up-town, north) and 19th century block planned structure (Down-town, south)

infrastructural boundaries – including the detour motorway to the south and east[9]. The map is approximately 20x10 km in layout size about an equivalent area to the Zagreb Master plan.

The axial model was drawn using ArcMap software and GIS data layers of buildings and transportation network from the city municipality of Zagreb[10]. The map was done from scratch having orthophoto map[11] from 2012 as the basis for drawing and overlapped with the database of vectorised and georeferenced buildings layer distributed with colours by purpose for exact positioning the length of the axial lines and areas of roads from the transportation network which helped in peripheral areas (industrial and retail) as the places where people move. The model includes all main urban public spaces as streets, squares and parks together with pedestrian zone. These pedestrian areas were mapped according to pedestrian traffic layer combined with data from terrain experience and OpenStreetMap ArcMap base layer. Three large-scale urban parks are excluded from the map because they are closed pedestrian subsystems at a different scale from the open street network of the main part of the city. These are: Maksimir park with the zoo area, Bundek park near the Sava river with the lake and the hippodrome area and Jarun park area which is the main recreational area of the city. The Banks of the Sava River with the embankment system are mapped as a part of pathway system. The 19th century blocks are mapped together with the passages and block entrances where the public buildings are inside the block areas. The northern part of the city with Medvednica slopes includes pedestrian stairs which are characteristic connection feature for that area. The steps are drawn with broken axial lines – increasing depth to indicate the difficulty in pedestrian movement.

Comparison of scales in the main axial measurements of Zagreb with the data of Greater London was done in order to understand the scale of the city better in syntactical measurements (Table 1). Zagreb's district area is almost two and a half times smaller in scale than London (641km2 Zagreb and 1572km2 London area). In terms of population London is more than ten times larger (790.017 – Zagreb; 8.673.713 – London), and when it comes to density, it is four and a half

9 which means that until that scale transformations of historical gateway-pathways are observed.

10 City Office for the Strategic Planning and Development of the City / Gradski ured za strategijsko planiranje i razvoj Grada, Sektor za strategijske informacije i istraživanja

11 https://geoportal.zagreb.hr/PopisServisa.htm

times denser (1232 per km2 – Zagreb; 5.518 per km2 – London). The syntactic analysis shows that Zagreb has seven and a half times fewer axial lines in system size. Both models are drawn within the motorway system as a 'hard' boundary, but while administrative boarders of London are within M25 area, Zagreb's administrative border is wider than the model size and motorway system half-ring, with a lot of natural and empty areas in between.

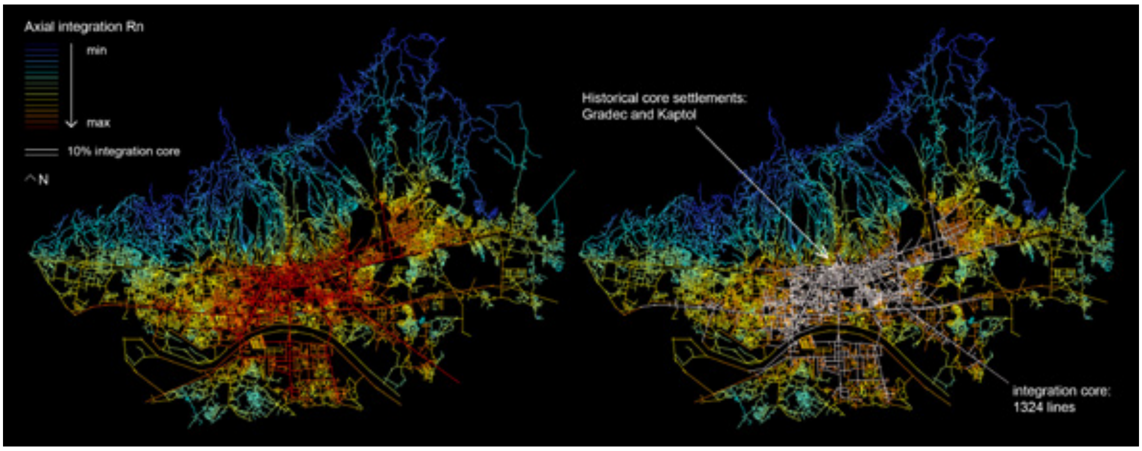

Figure 4 - Zagreb axial integration Rn and marked in white lines 10% most integrated lines as integration core

From the table 1 we can see that London overall has higher connectivity values in both the entire systems and 10% integration core. Line length max and mean is larger for the entire system in London while Zagreb has a bit larger lines length in 10% integration core. Situation is more complex for integration, at Integration HH Zagreb has higher values, while London has higher values for Integration HH R2.

Zagreb's axial integration (fig. 3) shows that its historical nuclei of Gradec and Kaptol (up-town) are not part of top integration values or 10% integration core. Instead 10% integration core of Zagreb is covers entire the 19th century block structure (Down-town), central axis connecting New Zagreb area across and south from Sava River with the areas along the Savska diagonal and its complementary street on the east (Radnicka road and Drziceva avenue). These diagonals and east-west connection streets in the 10% integration core are contemporary entrances or gateways from periphery to city central areas.

	Zagreb				London			
	City (Number Of Lines = 13236)		10% Integration Core (Number Of Lines = 1323)		City (Number Of Lines = 98927)		10% Integration Core (Number Of Lines = 9893)	
	Max	Mean	Max	Mean	Max	Mean	Max	Mean
Connectivity	47	2.63780	47	3.86	110	3.54429	110	5.09127
Integration HH	0.78411	0.47274	0.78411	0.67626	0.535	0.34741	0.535	0.47497
Integration HH R2	8.80606	1.61026	7.31579	2.40183	8.165	2.0479	8.165	2.77801
Line Length	5885	172	5885	281	6270	231	5729	234

Table 1 - Comparison of axial analysis values for connectivity, integration and line length between Zagreb and London in the overall system and 10% integration core.

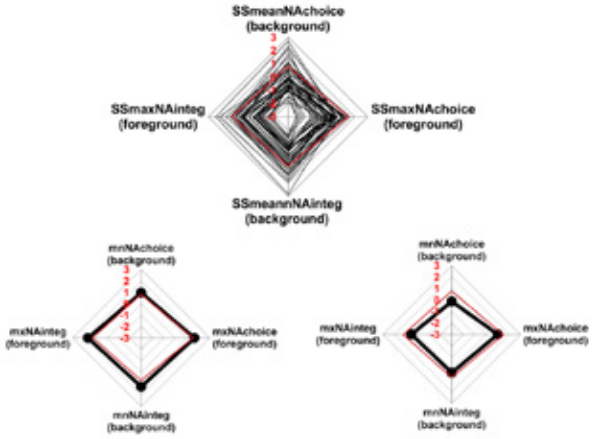

Figure 5 - Zagreb star model in red overlapped with: 1) 50 cities
2) Barcelona and London from a study by Hillier et al. (2012)

Table 1 gives inside to axial analysis measurements for the entire Zagreb system, and this was used for comparison with gateway-pathways in Table 3. Segment analyses were used according to Hillier's star model (2012). In comparison with other cities Zagreb shows balanced foreground-background numbers in star model. Its star model diagram is similar to Barcelona and numbers are in between Barcelona and London diagram model (fig. 5). The biggest differences are in the mean choice value where London has the lowest value. This could be interpreted in combination to Integration HH values whose mean value is more higher for the 10% integration core than for London that Zagreb core stands out more in the overall system, the same relation of choice shows star diagram in Barcelona whose core morphological is very contrasted to the block system network as the foreground pattern.

When star model was done for four case study gateway-pathways the results were too similar to the star diagram for Zagreb overall system Rn, therefore the decision was to include in this study transect overlap with 10% integration core derived from axial measurements.

4. SYNTACTICAL PROFILE OF GATEWAY-PATHWAYS

In order to understand urban growth processes in the city of Zagreb we compared historical gateway-pathways (1 Ilica, 2 Vlaska, 3 Savska and 4 Petrinjska) with mentioned new entrances of Vukovarska, Central axis and Slavonska-Zagreb avenue since they are also a part of 10% integration core (fig.2). Research questions for the comparison methodology were: (1) 'can historical pathways be identified as such and how?', and (2) 'can typological differences be detected in the contemporary axial measurements through this comparison'?

Historical pathways were identified through selection process in ArcGIS by comparing syntactical model to the georeferenced historical maps. For the gateway-pathways case studies the historical and contemporary axial lines measurements were taken into the table 2 for detail comparison.

The elements of the comparisons in table 2 are basic axial measurements: max and mean in integration HH, integration HH R2, connectivity and line length. They are columns together with the number of lines and their sum value. If we look at rows of the table 2 the situation is more complex to show the identified historical and contemporary differences.

In the first row, there are the measurements for the entire system of Zagreb and all other rows are values for parts of the city. These parts are selected as axial lines representing the streets which are being compared: four historical gateway-pathways and three new planned avenues from 20th century. Solid lines between the rows in table 2 separate information for each of the city part or entrances whether it is historical gateway-pathway or not, while selections related to the same route are separated with dashed lines. Also, there are selections where the historical and contemporary layouts of the route do not match due to some breaks in the original line length and its transformation processes. Therefore, historical gateway-pathways are selected in three ways, depending on which one was possible to detect: 1 – as lines of contemporary routes in the city as they are in the 21st century (marked as cont.*[12] in the table); 2 – as streets in the length as they are today (marked in the table as st.); and 3 – as historical pathways where selection was mostly discontinuous because the criteria was to select axial lines which remained from the initial historical gateway-pathway as they were on first or second military survey maps depending on which had better correlation to the contemporary map after georeferencing.

	Integration Hh		Integration Hh R2		Connectivity		Line Lengths And Number			
	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Sum	n
THE CITY	0.784114	0.472746	8.806067	1.610261	47	2.637806	5885	172	/	13236
Ilica cont.*	0.708715	0.601971	4.942303	3.169653	18	6.789474	3450	651	12375	19
Ilica hist.	0.708715	0.556018	4.942303	2.92262	18	6	1224	434	12598	29
Vlaška hist. and cont.*	0.713009	0.637859	5.392927	3.687394	23	8.5625	3658	812	12995	16
Savska cont.*	0.777606	0.702064	6.742888	3.452692	47	11.8333	3062	1161	9966	6
Savska st.	0.777606	/	6.742888	/	47	/	2965	/	/	1
Savska hist.	0.777606	0.56021	6.742888	2.303676	47	5.56	2965	386	9646	25
Petrinjska st.	0.732009	0.712289	4.2445	3.503451	12	8	717	459	919	2
Petrinjska hist.	0.732490	0.68711	4.2445	2.952853	12	5.857143	717	296	2074	7
Vukovars-ka st.	0.784114	0.722218	6.523021	3.954004	43	12.66667	3883	1117	6699	6
Central axis**	0.752811	0.716057	5.327157	3.624651	21	8.428571	4427	1024	7168	7
Zagrebač-ka av.	0.757334	0.674180	4.570052	3.239125	13	6.428571	3860	1670	23394	14

Table 2 - Axial measurements for the city of Zagreb and its streets

The table 2 enables multiple comparisons. Firstly, we can compare linear parts of the cities (streets, pathways) with the entire urban system of Zagreb. Secondly, there is a comparison of those routes which have historical background from before 20th c. and planned axis introduced in the 20th c. (in the table: Vukovarska st., Central axis** and Zagrebacka av.). Thirdly, comparison is possible for the historical gateway-pathways between the form of its historical and contemporary route which appeared during urban growth and spreading of the urban fabric.

In the table the highest values are marked in red and the lowest in blue. Both historical gateway-pathways and analysed 20th century arterial streets in the table 3 show similar characteristics when compared to the whole urban network: high maximum values of Integration HH – very

12 Ilica cont.*= Ilica contemporary gateway-pathway consists of Ilica street and Avenue Bologna; Vlaska cont.*= Vlaska contemporary gateway-pathway consists of Vlaska street, Maksimirska road and Avenue Dubrava - this pathway is historical and since the 2nd mil. survey its route layout was not transformed significantly (this is layout plan criteria for transformation; urban design and building structures were not considered here); Savska cont.*= Savska contemporary gateway-pathway consists of Frankopanska street, Savska road, Jadranski bridge and Jadranska avenue; Central axis ** = axis that evolved through Zagreb regulations (fig. 2).

close or the same as maximum in the system (taking into consideration the whole system = Rn) and above the system average mean values for all measurements – Integration HH, Integration HH R2 and Connectivity. This confirms the fact that those streets are significant in the whole urban network, but does not give clear answers to questions on how or why.

All three historical gateway-pathways have lower mean values both for integration and connectivity. This is not surprising since here we characterised the historical routes based on what was preserved in the contemporary axial map. More interesting is the fact that maximum values are the same for the historical and contemporary selections, which means that the new areas appearing in contemporary routes have not increased the syntactic values. This brings us to the potential inquiries for future research: specifically, to the question whether the results would be the same if we compared different segments across the city for streets with and without historical background, and whether, in that way, we can detect heritage and historical layers.

To elaborate the table further within the context of explained gateway-pathway typologies we can consider connectivity. Two streets which significantly transformed their routes and characters in contemporary urban network are Petrinjska and Savska pathways. They both have marked differences between the mean connectivity value from historical route selections and new route selections. Vlaska has null difference because its transformation preserved the route continuity while Ilica had two significant breaks by the railway line but still its character remained parallel to the railway on the north and south, with the difference below 1. For these observations to be meaningful, further comparisons with other streets within network are needed, or even a comparison with gateway-pathway transformations found in other cities.

5. TESTING HISTORICAL GATEWAY-PATHWAY TYPOLOGY THROUGH TRANSECT METHOD

To obtain a deeper insight into networks of historical gateway-pathways all of them were compared in transect method. Since the historical gateway-pathways were defined as the pathways which used to lead from periphery into the historical urban core we decided to compare transect overlaps with the 10% integration core and overall network to see if there are syntactical differences.

2-step transects were made for all four analysed historical pathways (Ilica, Vlaska, Savska and Petrinjska pathways). Transects represent the historical route and its immediate surroundings on the contemporary map (black in fig. 6 and 7). In figure 8 the traces of the historical gateway-pathway on the contemporary map or zero step-depth axial lines are marked in black while the immediate surrounding streets (axial lines which are 1-step and 2-steps away from the selected traces of gateway-pathway) are marked in grey.

In this way, the transect comparison involves information about both the initial historical situation and the transformation processes during urban growth because we selected trances of historical (original) route from contemporary model.

'Visual-graphical descriptive' analyses of the transects and the superimposed 10% integration core on figures 6 and 7 reveal important characteristics of gateway-pathways. Combining transects integration core form is recognisable. This overlap includes 472 lines out of 1324 (fig. 6 and 7). Therefore, 36% of the axial lines comprising the 10% integration core of the Zagreb contemporary street network are lines that belong to historical gateway-pathways (black lines in image 6 and 7) and immediately adjacent streets (up to two steps away from the gateway-pathway – grey lines in image 6-8). This could indicate that the city's growth happened along these lines and that they are distinctive in the overall urban network which is a basis for forming a syntactic gateway-pathway definition.

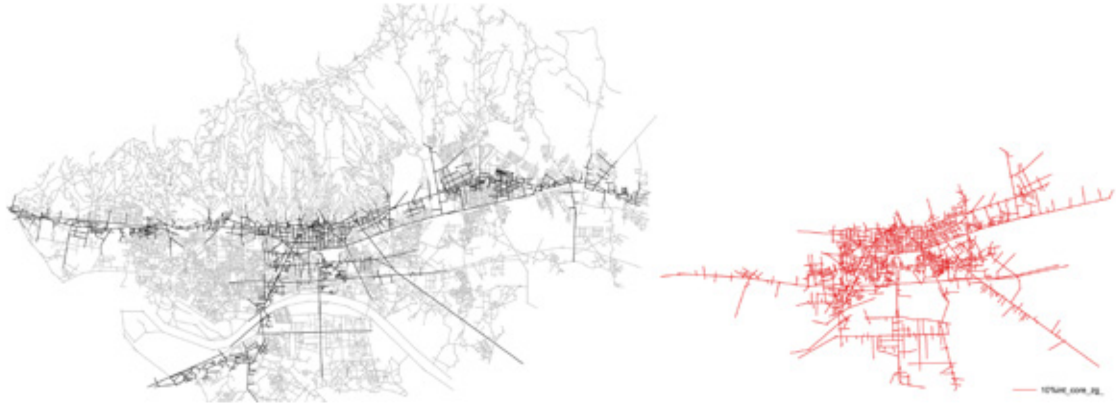

Figure 6 - Merged four two step transects of case study pathways (black, left) and 10% integration core (red, right).

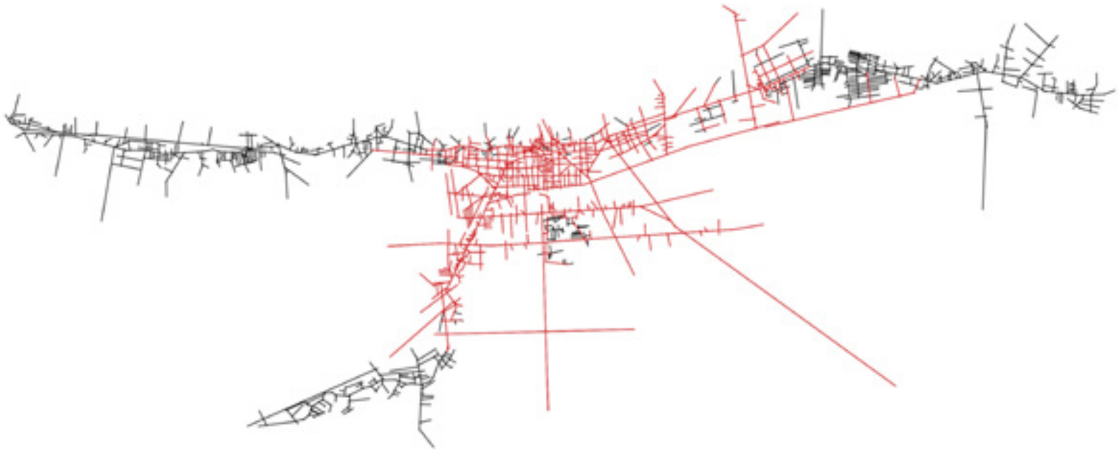

Figure 7 - Overlap marked in red of merged transects with 10% integration core.

Further, if we look at transects individually (fig. 8), already by 'visual-graphical descriptive' comparison, there are differences in percentage of pattern overlaps (red line shows 2-step transect lines which also belong to the 10% integration core). By the amount of red overlaps Petrinjska pathway (no. 4) is quite different from others and this method seams enough to detect the disappeared typology of gateway-pathways, which was transformed with significant breaks in its route layouts and therefore is incorporated into urban fabric of the city by urban growth. Pathway Ilica (no. 1) also is another extreme from these four but not in correlation with the typology identification and therefore numerical analysis is done in table 3.

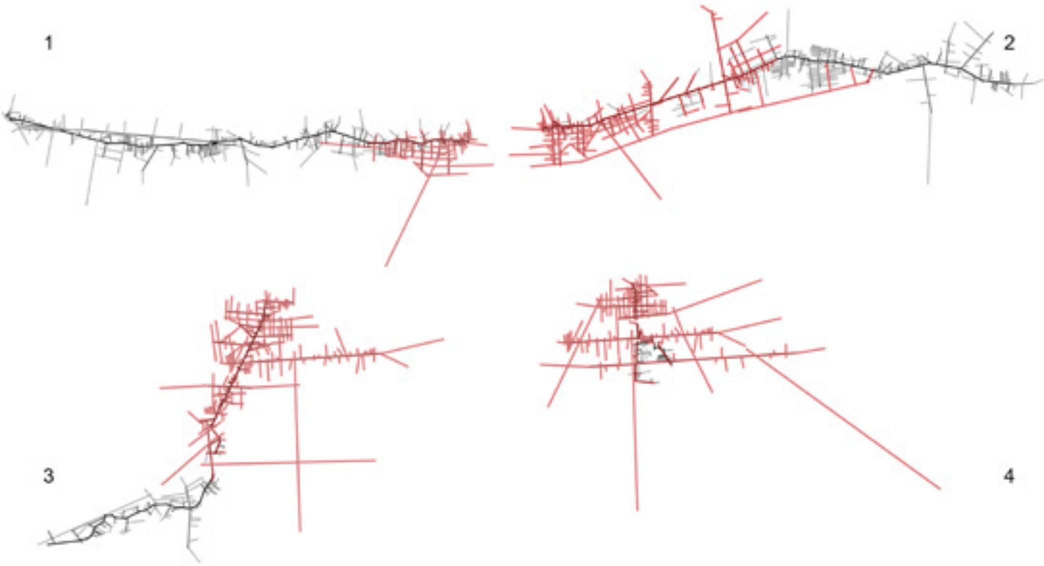

Figure 8 - Transects of case study pathways with 10% core overlap – 1) Ilica, 2) Vlaska, 3) Savska and 4) Petrinjska. Key: black = the historic pathway trace; grey = the transect lines one or two-steps away from the historic pathway trace; red = axial lines of transects that are also part of the 10% integration core

This table 3 presents four observed pathways in four columns with four groups of information (table rows): 1) numbers of lines[13] 2) overlap percentages[14], 3) values for integration and 4) connectivity. In order to interpret results from the table 3, the percentages are compare with data from table 4, which is a summary for four gateway-pathways of Zagreb through the number and character of the breaks in continuity of historical route. Breaks are important for analysing the changes through time because they are the evidence of 'historical incidents' in urban growth.

Vlaska pathway is the 2-step transect with the biggest in the number of axial lines, Ilica follows, then Savska and Petrinjska. Petrinjska as disappeared gateway type expectedly has the smalles number of lines in 2-step transect, while Ilica and Vlaska show quite similar number of lines, but the overlap percentages and other data shows differences although in the typological identification they are the same type.

13 Numbers of lines are given for the:
Step 0 (zero) = selected lines in Depthmap program for step depth calculation;
step 1 = one step away axial lines from selected;
step 2 = all two step away axial lines from selected

14 Overlaps are the percentage interpretations of numerical data of counting lines. The first overlap shows how much of the pathway transect is a part of the 10% integration core calculated by dividing number of overlapped lines with total number of transect lines.
The second overlap is how much of the integration core is occupied by the gateway-pathway. This is calculated by dividing number of overlapped lines form each transect with total number of lines in integration core which is 1324.
The third percentage overlap gives the relation between the transects and the city of Zagreb as information of how much of the overall city is occupied by transect which is calculated by dividing total number of transect lines with total size of Zagreb axial map which is 13236.

Historical Pathways transect system	Ilica	Vlaska	Savska	Petrinjska
Number of lines:				
N Total	355	390	305	186
N step depth 0	29	16	25	9
N step depth 1	116	106	85	45
N step depth 2	210	268	195	132
N overlapped lines with 10% integration core	88	162	205	138
Overlap percentage:				
% of historical pathway transects that overlaps with 10% integration core N overlapped / N total	24.79%	41.54%	67.21%	74.19%
% of overlapped lines in the 10% integration coreN overlapped / 1324 lines	6.65%	12.24%	15.48%	10.42%
% of overlapped lines in overall city network N total / 13236 lines	2.68%	2.95%	2.30%	1.41%
Integration HH:				
Rn MAX	0.777606	0.770287	0.784114	0.784114
Rn MEAN	0.564767	0.613456	0.651852	0.686311
R2 MAX	6.742888	7.315790	6.742888	6.742888
R2 MEAN	2.225436	2.548053	2.653397	2.799870
Connectivity:				
MAX	47	26	47	47
MEAN	3.909859	4.474359	4.295082	5.016129

Table 3 - Axial syntactical profile of the historical gateway pathways two step depth transects.

Historical Pathways transect system	Ilica	Vlaska	Savska	Petrinjska
Stretching of the zero-step-depth selection	East-west connection (from the main square to east)	East-west connection (from the main square to west)	North-south diagonal connection (east from central urban axis)	North-south diagonal connection (first street to the west of central axis)
Number of breaks in zero-step-depth lines and continuity:	2	0	2	4
Reasons for the breaks:	railway		Bridge; elevated roundabout	Rail and Historical transformation of the route; railway main station placement with industrial area; and east-west dominant streets connections from regulation in 1953

Table 4 - Comparison in the transect breaks at zero-step-depth selections of historical gateway-pathways from overlapping in ArcMap georeferenced historical maps and transects.

The two north-south connections – Sava and Petrinjska – both have the highest values for integration (0.784114) and connectivity (47), which are due to presence of Vukovarska east-west street in their 2-step transect networks (from the table 2 we can see that Vukovarska has the highest values in the overall Zagreb axial lines). Differences between Savska and Petrinjska 2-step transectsare in percentages. Petrinjska occupies only 1.41% of the overall city network, but with the high percentage of lines (74.19%) being a part of the integration core and having in mind that this high number is still revels only 10.42% of the integration core lines. All this together additionally confirms typological identification for Petrinjska. The reasons for this are listed in the table 4, where Petrinjska pathway is with the highest number of breaks in the continuity of its historical route.

The Savska transect shows that more than a half of the transect lines are a part of 10% integration core with 15.48% out of integration core from overlapping lines as the biggest percentage in this category. The percentage of overlap with the overall urban network is 2.3%, which may indicate that Savska remained important as a gateway. The two breaks in the continuity of Savska historical route and descriptive analysis of this pathway no. 3 in the figure 8 shows that a 'historical incident' happened causing the split of Savska gateway-pathway – this was the new traffic regulation with new bridge position accross the Sava and redirection to form a different gateway system – motorway as the south-west regional entrance to the city of Zagreb. The comparison and value in differences between measurements of historical and contemporary selection in the table 2 confirm that this redirection caused significant difference in the role of two parts of original historical route for the city.

Vlaska and Ilica transects are identified as the same type according to the placement in the topography and transformation processes. They are east-west continuity line through main city square with partially irregular linear characters and mixed used shopping areas. The space syntax comparison shows hidden differences, although the numbers in the table 2 are quite close in values for the contemporary selection. According to the placement in topography they are both boarders between hill slopes of Medvenica and Sava river plain, but Ilica street leads to west and Vlaska to east from the main square. Vlaska is parallel and distanced from the railway while Ilica has two crossings with the railway. Therefore, Ilica had two breaks in the continuity of historical route and Vlaska is the only gateway-pathway in Zagreb without breaks in continuity.

The observed gateway-pathways are those which were classified as 'transit gateway-pathways' which led into historical core but outside of the walled part(s). The integration core should be in the place where dominating historical pathways used to lead into because it was the crossroad where the city developed through the growth process in 19th and later 20thcentury. Space syntax approach shows a possible way to test typologies numerically (as showed on Petrinjska), but more than that it gives us the way to perceive better differences in the same typologies (as showed on Ilica and Vlaska).

6. CONCLUSIONS AND NEXT STEPS

As a part of an on-going PhD research and research project, the paper gives insights into the syntactical description of Zagreb city and the methodological points for testing and developing a typological definition of 'gateway-pathways' in the context of urban growth studied on contemporary axial map. The heritage notion, which is explored through the analyses of Hillier's transect method and star model, becomes measurable value which could lead in further exploration into route preservation and urban matrix criteria in planning the urban networks.

Methodology and presented results in this paper partially answer the two research questions investigated, which means that the study sets the basis for future research. Results of gateway-pathways comparison in Zagreb (tab.2) show that the selection process, of choosing axial lines for the transects, is a way of decoding historical layers in contemporary syntactical model. Transect analysis and comparisons were applied in GIS software. It is worth to further explore this transect comparison method (summarised in table 2) by adding more street examples. Also, regarding the second question related to testing the typological identification, to draw conclusions it is crucial to apply comparisons of streets on other cities. The percentage of overlaps with 10% of most integrated axial lines in the city systems clearly shows types of gateway-pathways which stopped being entrances or connections to the periphery due to significant breaks in continuity. For the Zagreb case study, this is also another way of showing the change in local grid conditions. This 'disappeared gateway' type over time became fully part of the integration core of the city, which is one of the ways we can look at the centrality problematics.

Overall, this paper identifies an important link between urban heritage studies and space syntax theory. Space syntax enables an active understanding of spatial heritage in terms of historical processes, while transect analysis introduced in the paper opens new methodological prospects for historical studies of street networks.

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