MASTER'S THESIS

Accessibility Matters.

Socio-Spatial Effects of Inner and Peripheral Development

ausgeführt zum Zwecke der Erlangung des akademischen Grades eines Diplom-Ingenieurs

Thesis submitted for the degree of Master of Science

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To my parents.

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Abstract

Based on debates on how cities will physically grow, this study investigates the impact of inner and peripheral development on the spatial structure of Vienna and its surrounding municipalities. It is argued that people's movement within a complex system might change both the local and global accessibility within Vienna, a continually growing city. The space syntax approach is adopted to examine the potential effects of the influx of people in the urban structure. A segmented axial map of Greater Vienna is manually drawn and processed to highlight the city's urban morphology and spatial configuration. The effects of inner and peripheral development are then modelled under two scenarios: the new main train station with adjacent commercial and housing areas and Rothneusiedl as an experimental schematic model. Analysis of all models in terms of accessibility values reveals the marginal impacts on the global (city-wide) scale. In terms of local impacts, the development zone surrounding the new main train station can benefit from additional links to the 3rd and 4th districts. The peripheral scenario might benefit from a link to adjacent sub-centre Oberlaa and suggests potential for a well-connected neighbourhood. The space syntax analysis provides an efficient method to explore the functionality and accessibility of a complex city system, although more detailed studies are needed, especially with regard to socio-spatial effects on a local scale.

Kurzzusammenfassung

Unsere Städte wachsen, darauf basierend untersucht diese Arbeit den Einfluss von innerstädtischer Verdichtung und peripherer Stadterweiterung auf die räumliche Struktur von Wien und Umgebung. Die Stadt als komplexes, wachsendes System und das Verständnis von Bewegung im Stadtraum, lassen Rückschlüsse auf die lokalen und stadtweiten Erreichbarkeitspotentiale zu. Mit der Space Syntax Methodik wird untersucht, welche Effekte ein Bevölkerungszuwachs in den urbanen Strukturen mit sich bringen können.

Dafür wird händisch eine segmentierte *axial map* des Großraums Wien gezeichnet, um die morphologischen und räumlichen Charakteristiken des Raumes darzustellen. Es wurden zwei verschiedene Modelle entwickelt: Ein Nachverdichtungsszenario am neuen Hauptbahnhof mit angrenzenden Wohn- und Handelsflächen sowie mit Rothneusiedl ein Szenario einer peripheren Stadterweiterung. Beide Szenarien werden hinsichtlich ihrer Zugänglichkeit (accessiblitiy) untersucht. Dabei wird ersichtlich, welch marginalen Einfluss sowohl die Nachverdichtung, als auch die Stadterweiterung auf die Zentralitätswerte (integration) und Durchgangspotentiale, also die Erreichbarkeitswerte, haben. Kleinräumiger betrachtet, profitiert das Entwicklungsgebiet um den neuen Hauptbahnhof von neuen Verknüpfungen in den 3. und 4. Bezirk. Im peripheren Szenario in Rothneusiedl ist eine stärkere Verknüpfung zum Stadtteil Oberlaa erkennbar und zeigt Potentiale für eine intensivere Nachbarschaft auf. Die Space Syntax Analyse ist eine effiziente Methode die Funktionalität und Erreichbarkeit von komplexen Stadtsystemen zu analysieren, jedoch sind detailliertere Studien, speziell bezüglich sozial-räumlicher Auswirkungen auf kleinräumigerer Ebene, notwendig.

INTRODUCTION

1. Introduction

Urbanisation is one of the key phenomena currently affecting the world. According to the UN World Urbanisation Prospects (2014), 54 per cent of the world's population already lives in urban areas, and the number is expected to increase to 66 per cent by 2050. The term “urbanisation” describes the shift of a society - or more generally of people - from a rural to an urban way of life. This shift results in growing urban areas with enormous social, economic and environmental challenges.

One of the changes pertains to the physical growth of our cities. This is a complex phenomenon that is crucial to a better understanding of how cities can physically grow and what effects this will have on the existing urban structure. One negative side-effect of urbanisation has been identified as the *urban sprawl* of a city (Batty et al., 1999), while *urban infill* has been promoted as a remedy to solve the spatial problems of urban sprawl, such as the high degree of land consumption (Brooks et al. 2011). In this context *infill development*[1] can furthermore be seen as a strategy for the development of a more sustainable usage of space[2] within an urban area.

To investigate how urban growth changes the urban system in terms of accessibility and movement, I picked out a major infill development area in Vienna: the new central rail station and the adjacent new housing projects, and compared the spatial changes here with those associated with a theoretical peripheral development project: Rothneusiedl in the south of Vienna.

For this case study, a segmented axial map (model) of Vienna and its surrounding municipalities - named *Greater Vienna* - will be the basis for all analysis. This approach provides a complete representation of the spatial network, defining the basic element as the segment of a street between junctions. It analyses the spatial relations between each spatial segment and all others in the network.

1 SCHOLL, B. (2005), Strategische Planung; In: ARL Akademie für Raumforschung und Landesplanung (2005), p. 1128

2 RICICA, K.; VOIGT, A. (1998), Raumverträglichkeit als Beitrag zur nachhaltigen Raumnutzung; Band 1 - 5, Österreichischer Kunst- und Kulturverlag, Wien

Problem description and research questions

Vienna and its surrounding municipalities form a metropolitan area of approximately 2.64 million inhabitants[3]. Depending on the source there are different statistics concerning population growth in Vienna, but all agree on the prospective situation of growth within the next decades. According to the study *Stadtregion+* (2012), Vienna's metropolitan area will grow by 400,000 new inhabitants. Previous studies expected a lower rate of growth, stating that the city would reach the 2 million inhabitants mark by the year 2047[4]. According to this current study, former forecasts have been revised and the 2 million mark will be reached by 2030.

To cater for these new inhabitants, new settlements and the associated infrastructure are needed. The question for planning authorities is how and where new spatial structures should be developed.

During my internship at Space Syntax Ltd. in London in 2012 I gained theoretical and professional skills in the field of spatial analysis. Additionally, through informal talks with the responsible planner at Vienna City Council[5] I examined which modelling and simulation tools are currently used and how Space Syntax techniques can be implemented in master planning strategies.

To examine the potential effects of the influx of people in the urban structure, the following research question(s) will be explored:

- What impacts on Greater Vienna's spatial structure can be identified?
    - How efficient is the current city in terms of movement potentials?
    - What differences between local and global (city-wide) effects can be measured?
    - How do infill-development and peripheral development differ?

[3] According to the study Stadtregion+ by PGO (Planning Community East) and the States of Vienna, Lower Austria and Burgenland, published in June 2012, Vienna

[4] Source: Statistik Austria, Population forecast 2011, main variant

[5] Interview with DI Augustin, Municipal Dept. MA 18, City of Vienna, 4 February 2013

Approach

With strategic plans, there is an effort to establish key points, tasks and solutions in order to understand the circumstances of spatial developments. Defining and applying these *planning strategies* will therefore enhance the degree of flexibility to better manage changing situations and uncertainty. As a matter of fact, they will give us an *overview* of urban developments (Scholl 2005, C. Yamu 2014). Consequently, in order to solve problems such as increasing land consumption, the effects of political planning interventions and actions are of importance for future cities. Scholl (2005) argues for a minimum strategy of spatial development:

> *"Sustainable land use means inner development versus urban sprawl. Focusing on inner urban development instead of urban growth on greenfield is the minimum strategy for sustainable land management. In cities there are fascinating possibilities for inner development due to commercial and social changes."(B. Scholl 2005).*

This inner development is only possible if there are adequate possibilities for development, renewal and rearrangements. Unfortunately there are no studies that give an overview of inner development potentials, although Scholl (2005) defines the overview as a prerequisite for strategic actions and decision-making as well as for setting strategic priorities.

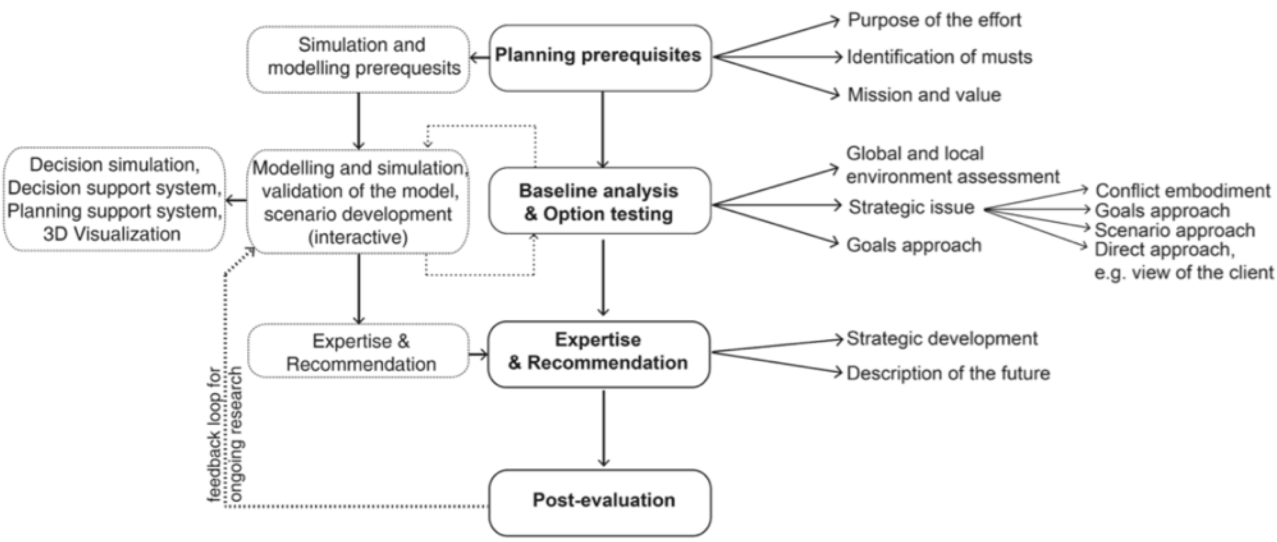

Figure 1. A strategic planning process incorporating a simulation and modelling process, in the Routledge Handbook of Planning Research Methods p. 351(Yamu, 2015)

Modelling and analysis tools help us to understand the effects of planning interventions and obtain an overview. One of their key elements refers to the street network, and space syntax tools analyse the latter's configuration within a system - in this case, a city.

The road network is more than a system in which we can navigate and get stuck in traffic. It has a strong influence on the pattern of movement of pedestrians and vehicles. Conventional (automated) modelling techniques are proven and well established in terms of traffic, route options and travelling on time. However, Penn and Hillier (1998) saw a flaw in the construction of these models: "The models […] are seldom constructed to represent the finest structure of the street network and their performance at this scale is not well understood". They hence developed new approaches to model a "detailed representation of the pattern of space through which pedestrians or cars move" (Penn and Hillier 1998).

Their methods for analysing the spatial configuration measures do not merely localise spatial elements but consider the entire configuration of elements, each in relation to the others.

Based on Space Syntax theory, this paper aims to explain the way in which spatial factors have an impact on a city or region. Analysis of Greater Vienna's spatial structure thus enables us to identify greater or lesser strategic options within a system.

Through analysis of the existing spatial configuration and option testing, this type of modelling creates numerical values for the existing built environment. As already described, with this method the relation of each space to all other spaces can be identified. Changes in the urban system or different planning and design approaches can thus be calculated to show their likely effects on the existing system.

To create a link between theoretical research and practical use, a space syntax model of Vienna has been manually drawn and processed. Using the space syntax method set, three different urban configurations on various scales will be analysed, namely:

1. Greater Vienna Model 2012 (status quo)
2. Model 2014 (Vienna Main Station - infill development)
3. Rothneusiedl Model (peripheral development)

The focus of the analysis will be a segmented axial map of Vienna. Current practices such as specific modelling rules, new configurational measures and techniques will be mentioned, but due to the scope of the thesis they will not be discussed in detail. For further information, the online platform http://www.spacesyntax.net provides a wide spectrum of material from research and professional practice to publications and available software.

THEORETICAL

BACKGROUND

2. Theoretical Background

This chapter focuses on the term “city” and how people move within it, and furthermore on how a city, a space, is configured and how the space syntax methodology can examine a city in its morphological layout. Finally, the space syntax theory will be described, and an explanation will be given of how it will be used for the case study of Greater Vienna.

2.1. The Movement Economy

The city as a complex system

The phrase “the whole is greater than the sum of the parts” reflects the wave of change in the social and physical sciences that started in the late 19th century in biology and engineering. It reflects the need to articulate specific phenomena in generic terms and evolved the “system” approach. A system is defined as “a set of interacting or independent components forming an integrated whole” (Encyclopaedia Britannica).

The city is an element of human settlement and its numbers are increasing worldwide. As stated in the introduction, there is a need to think of cities as systems. Cities are consuming more and more land and it is hard to describe the city as a compact and structured whole entity.
Batty and Marshall (2012) describe this as being consistent with the *complexity sciences* which dominate the simulation of urban form and function. They argue that the city has evolved into a complex and dynamic system.

Moving through the system

Hillier deepens the theory by considering the activities in the city. To place maximum emphasis on this movement, he calls this phenomenon a “movement economy”.

“Every trip in an urban system has three elements: an origin, a destination, and the series of spaces that are passed through on the way from one to the other. We can think of passage through these spaces as the by-product of going from a to b.” (Hillier 1996: p. 126)

Therefore, location in the grid has a crucial effect: “It either increases or diminishes the degree to which movement by-product is available as potential contact. […] Thus there will be more integrating and less integrating areas, depending on how the internal structure of the area is married into the larger-scale structure of the grid, and this will mean also areas with more by-product and areas with less.” (Hillier 1996: p. 126)

He further explains that “such locations will […] tend to have higher densities of development to take advantage of this, and higher densities will in turn have a multiplier effect. This will in turn attract new buildings and uses, to take advantage of the multiplier effect. It is this positive feedback loop built on a foundation of the relation between the grid structure and movement this gives rise to the urban buzz”. (Hillier 1996: p.126)

Hillier’s findings can describe a space as “urban”, if it makes maximum economy of the movement that passes through it.

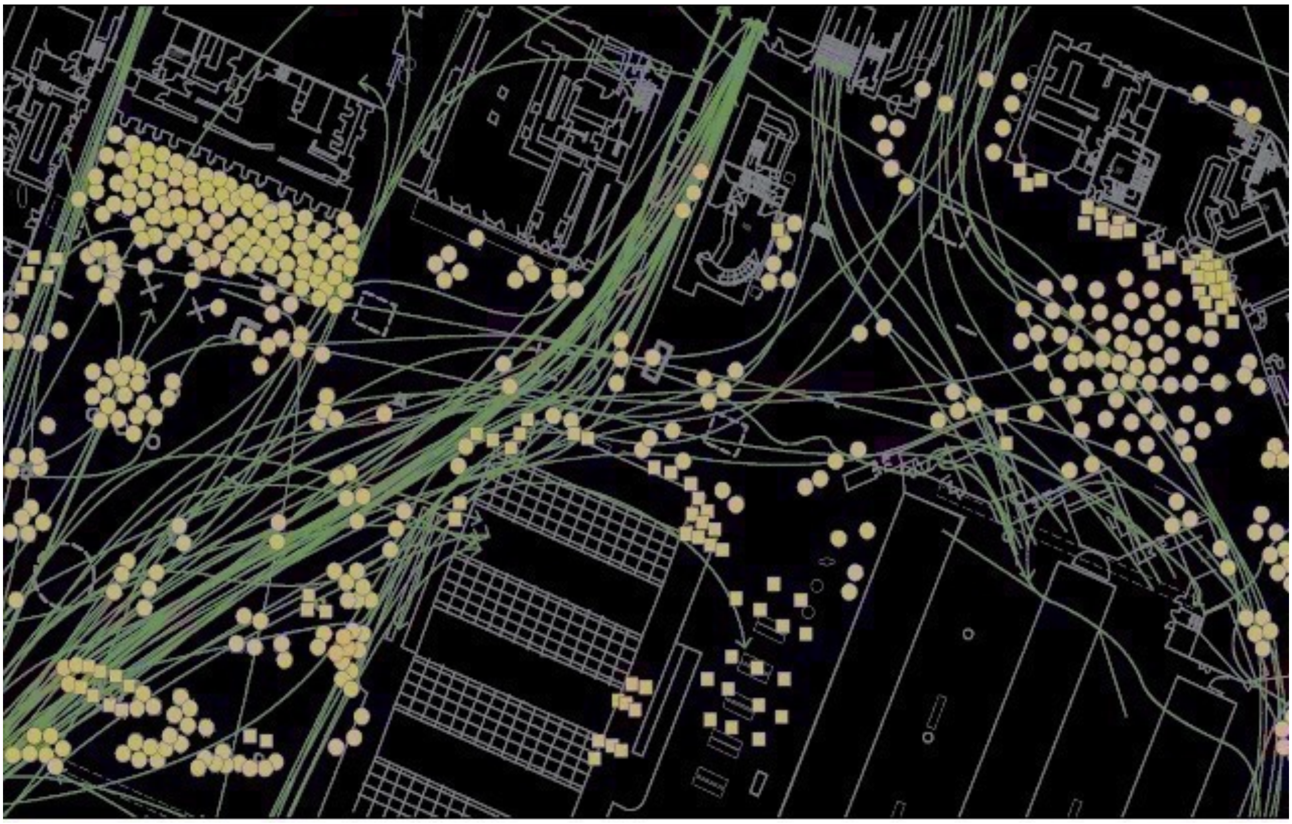

Figure 2. Understanding human activity - stops and moving traces. Designing with movement, source: Space Syntax Ltd. 2014

Configuration of Space

In his theory, Hillier explains that circulation in a city is determined by the configuration of lines into a global hierarchy of *depth*, which he calls *integration*. In his first case study he examined London's major shopping streets and observed their connection in the wider urban (spatial) context.
He investigated whether the shops are the main attractor of movement and if they lie on the main integrators.

His conclusion: "This is of course true. But it does not undermine what is being said about the structure of the grid as the prime determinant of movement. Both the shops and the people are found on main integrators, but the question is: why are the shops there? The presence of shops can attract people but it cannot change the integration value of a line, since this is purely a spatial measure of the position of the line in the grid. It can only be that the shops were selectively located on integrating lines, and this must be because they are the lines which naturally carry the most movement." (Hillier 1996: p. 125).

Hillier and his colleagues proved that there is a connection between the structure of a city and its function, therefore the configuration of the street network has a significant influence on the movement patterns of people.

Space Syntax as Methodology

Understanding the city and the movement within it as a complex system, the configuration of the space using the space syntax methodology is a formal way of looking at cities based on the study of the network of space - the streets and roads. On this basis, Hillier in 1996 proposed "a new universal definition of a city as a network of linked centres at all scales set into a background network of residential space".

In analysing an urban system, the space syntax methodology and theory will provide a toolset for understanding the morphological logic of urban grids, especially their growth. Space syntax offers a link between spatial structure and the socio-economic factors.

2.2. Space Syntax - Theory and Methodology

The theoretical ideas of Space Syntax are founded on two formal ideas of how space should be seen: first, it is not merely the background for human activity, but an *intrinsic* aspect of daily life. Second, it is not just about individual spaces; it is the *configuration* between many spaces which matters (Hillier and Vaughn 2007).

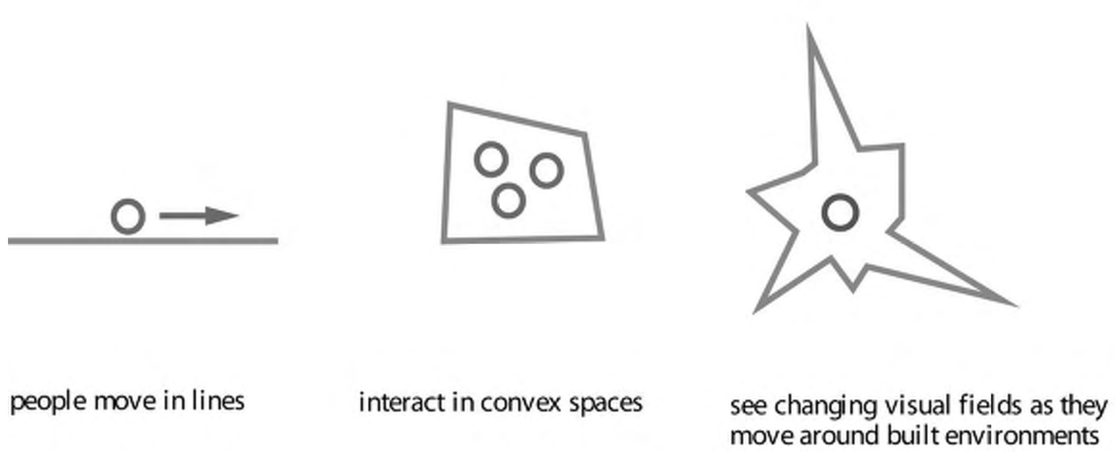

Figure 3. An intrinsic aspect of how we use and experience space: moving, interacting and seeing (Hillier Vaughn 2007)

The technique of space syntax methods is to analyse spatial configurations of all kinds. Especially in buildings and cities, Hillier and Hanson (1984) identified a relationship between the layout of a city (or building) and the movement of its users. Furthermore, they observed that the spatial configuration has a significant effect on human behaviour. This simple but fundamental finding is seen "as a key and necessary resource in organising […] human societies" (Bafna 2003, p.17).

Space Syntax defines the term *configuration* of space "as an act of turning the continuous space into a connected set of discrete units" (Banfa 2003, p.17). In other words, the spatial architecture of the city forms a large collection of buildings held together by a network of space: “the segmented street network.”

The scientific basis for space syntax is provided by graph theory (spatial configuration). Through the arrangement and the topology of each space, graph theory gives a mathematical value to each component within the entire network. Space Syntax describes this value as *depth* (Hillier et al., 1993) and shows the amount of syntactical steps needed to go from one space to the next.

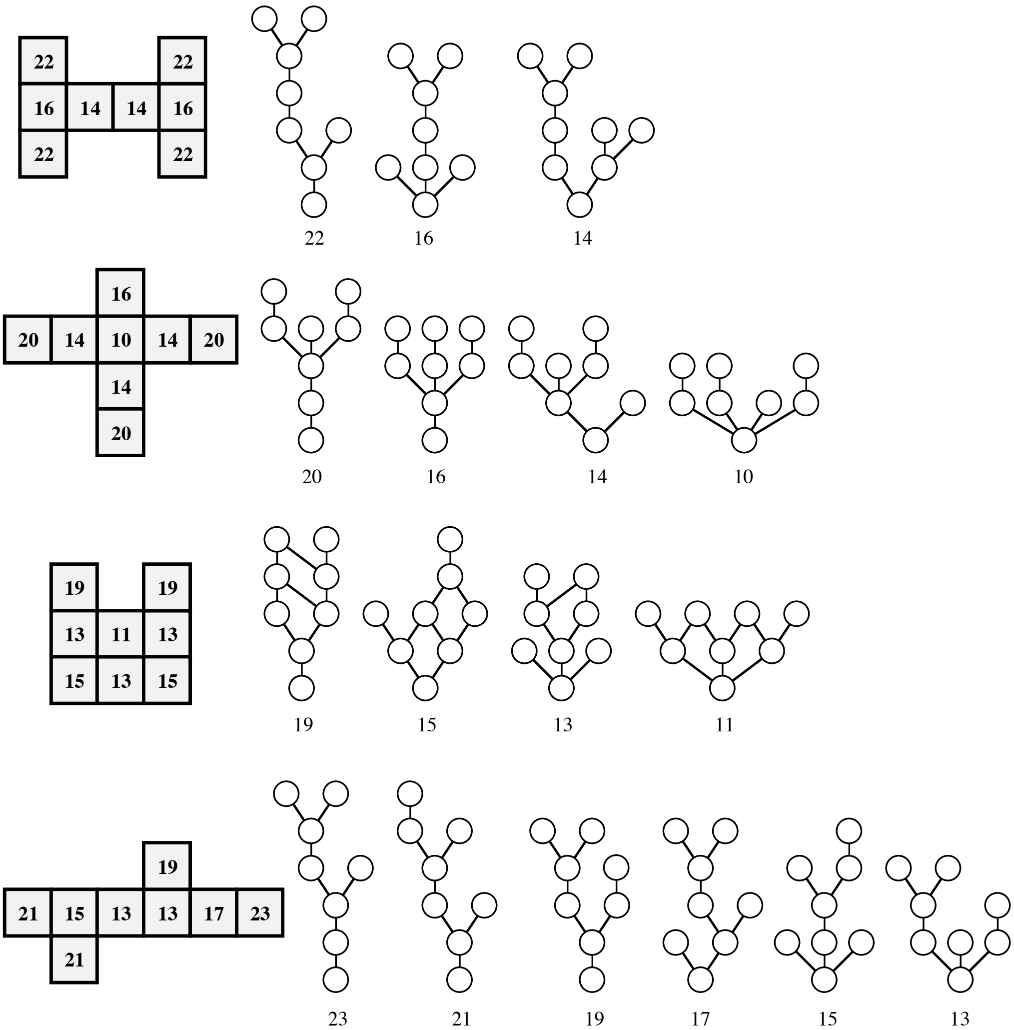

Figure 4. Total depths: a selection of shapes with different amounts of j-graphs (Hillier 1996 e-version 2007, p.76)

For each shape, different graphs are illustrated to show how *shallow* or *deep* a system can be while still representing the same shape, just looked at from a different point of view. A shallow graph is seen as being very *integrated* and a deep graph as very *segregated*, yet both describe numerically how each space relates to all the others.

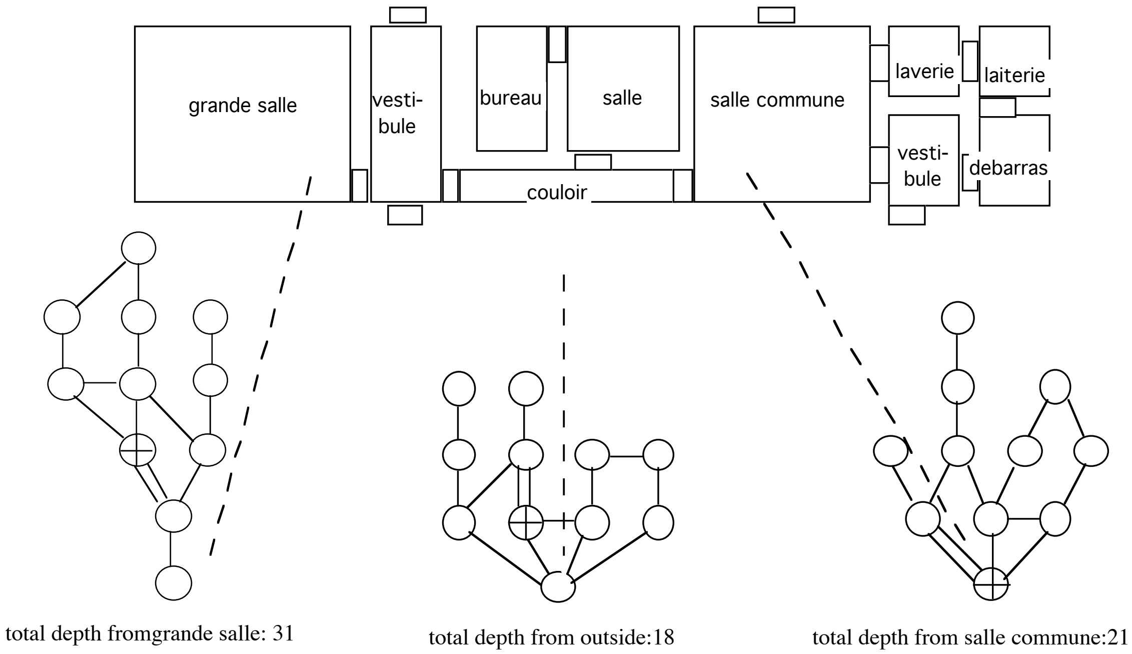

Figure 5: The layout of a house looks more or less integrated from different points of view. Source: Space Syntax Ltd.

As a result, this spatial configuration takes other relations into account, and affects the relations between all the various spaces of a system as well. Finally, it mirrors the hierarchical order of each space (Hillier and Hanson 1984).

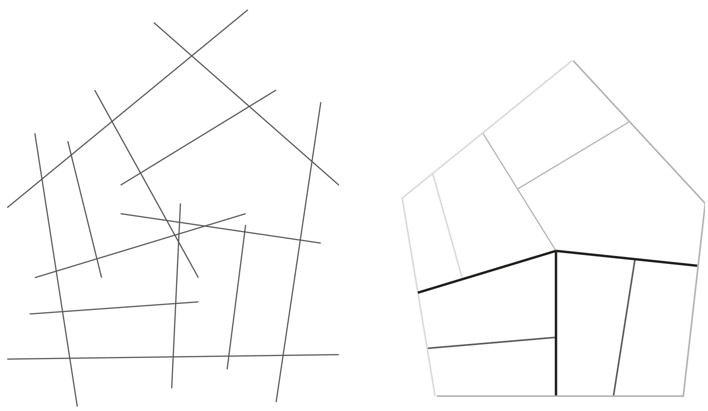

Figure 06: Total depth from different points of view in a system of axial components; black shows very integrated spaces and light grey very segregated spaces. Own adaptation of source: ArchPlus, 10/2008, Rose, Schwandtner, Czerkauer-Yamu, p.33

2.3. Accessibility Values

Within the space syntax theory, the main variable for urban form and movement is accessibility. The research work of Hillier and his colleagues at Space Syntax has provided convincing evidence that urban form and spatial layout have a strong impact on movement patterns.[6] The likelihood of movement is directly influenced by degrees of spatial accessibility and can be measured by *spatial integration analysis*.

Based on the street network, space syntax applies the axial line as the minimum set of longest straight lines of sight. All interconnected lines form the “axial map”, which represents a geometric model of an urban grid. Therefore, the street network helps us to understand how the urban grid actually shapes the pattern of movement (Hillier, 1996; Penn, 2003; Bafna, 2003).

For analysing a city, Hillier (2003) describes the axial map as a set of lines and draws attention to the importance of connectivity and its topological configuration. From the basic topological measures of *total depth* and *mean depth* the main configurational measures of *integration* and *choice* can be calculated; this will be the starting point for our analysis of Greater Vienna.

These measures can help to explain social behaviour and are outlined below:

The **connectivity (degree)** of an urban grid measures the number of immediate elements that are directly connected to a space. This represents the simplest graph measure of Space Syntax.

To indicate how *deep* or *shallow* a node is in relation to the rest of the graph, the **mean depth** is calculated by assigning a depth value to each space according to how many spaces it is away from the original space, totalling these values and dividing by the number of spaces in the system minus one (the original space).

The measure of **integration (centrality)**, or its opposite, segregation, is expressed by the Real Relative Asymmetry or RRA value.[7] This value is obtained by analysing a graph representing the number of changes in direction between one axial line or space to all other lines or spaces. It is based on the number and depth of spaces that must be traversed from one space to all other spaces in the configuration (Hillier 1984).
These values suggest movement and density potentials of a city and are called “to-movement”. This shows how easily accessible a space is or how easy it is to get to a place or an area in terms of syntactical steps. There are correlations with the theory of *central places* posited by Christaller (1933) which helps us to understand the emergent structures and processes[8].

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[6] Known studies by Hillier et al.,1993: correlation of crime and spatial configuration

[7] Mathematically, integration is measured by the inverse of relative asymmetry (RA). This is given by the equation RA=2(MD-1) / (k-2), where MD is the mean depth and k is the number of spaces in the system (Hillier 1984)

[8] Based on a reflection about the catchment areas of different levels of services and hence of social activities in cities

Choice (betweenness) is the other factor; this describes the “through-movement” which permits one to analyse the likelihood of a pedestrian or vehicle going through a specific road. It is based on the angular analysis (Turner 2000) of each space. For all pairs of possible origin and destination locations, the shortest path routes from one to the other are constructed on a metric basis. Frequently used nodes are given high values, while those that fall on fewer paths are assigned low values.

“To-movement” and “through-movement” can be exposed to different radii, giving nearer or further apart streets either more or less weight. Local metrics (i.e. radius 800m and 1200m) will have a smaller radius, which will put a higher weight on the network nearby. A larger radius (i.e. radius N) would be an example of a global measure, which focuses on the grid for a larger part of that area.

The correlation between some of the measures can describe characteristics of an urban grid in terms of way finding (Conroy Dalton, 2000):

Intelligibility, for instance, is a correlation coefficient between connectivity and global integration. It indicates how easy it is to comprehend the global structure from a local position.
Synergy illustrates the relation between smaller and larger radii of integration. This relationship between local and global integration highlights the underlying background network.

2.4. Rules of Application for the Greater Vienna Model

As stated in the introduction, automated models already exist. In contrast to those models and to obtain a better understanding of the logic of axial maps, I have decided to draw every single axial line for the Greater Vienna Model manually.

Space Syntax analyses are processed in 3 steps:

1. drawing the axial map
2. analysing and processing the map
3. displaying and interpreting the results

First of all, and in order to ensure which spatial configuration the model represents and which simulations can be shown, it is important to specify the modelling rules governing how Vienna will be drawn. For this case study the following rules have been established for drawing an axial map of Vienna:

- longest, fewest axial lines
- simplified axial lines along serpentines to avoid *over-modelling*[9]
- no pathways in parks[10]
- main strategic connections for pedestrians and vehicular traffic[11]
- simplified ramps and highways[12]
- no driving directions[13]
- unlinks are set[14]

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[9] Over-modelling: additional costs (spaces) can influence the results

[10] Accessibility matters, therefore only spaces which can be accessed on a 24/7 basis are included.

[11] Straight lines instead of curved streets

[12] To avoid over-modelling

[13] Administrative rules are not a spatial argument; people can still perceive and access the street from both directions

[14] Overlapping lines that may not connect to each other: overpasses, underpasses, tunnels, etc..

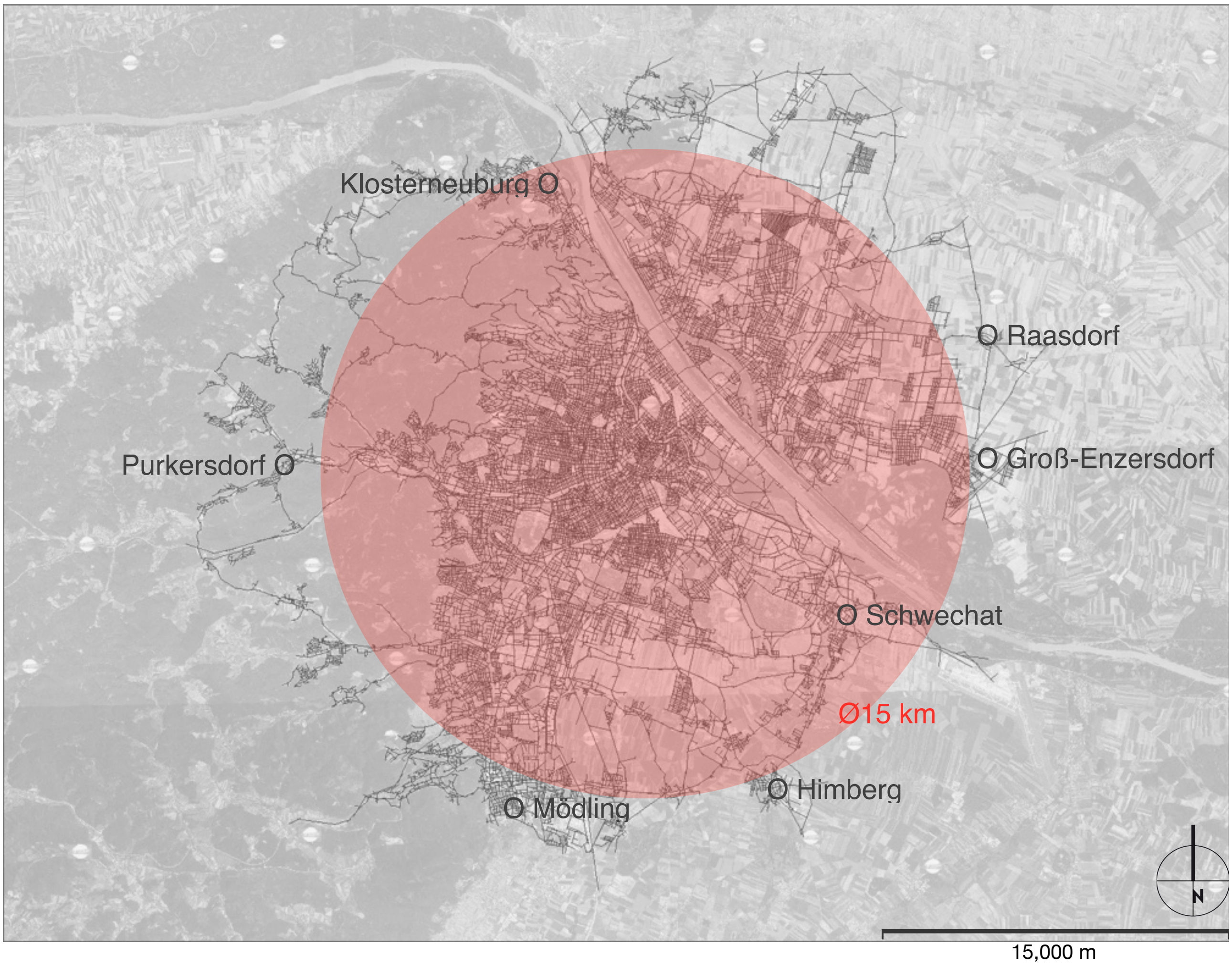

Figure 7. Axial map of Greater Vienna with suburbs and towns at 15km boundary; own model, status 2012, background: orthophoto by Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management

Cities cannot be seen in isolation from their peripheral surroundings; for this research, the borders of the model mainly show the functional relations between existing settlements *around* and *in* the municipality of Vienna. In addition, a buffer of 3 km at a radius of 15 km from the historic, economic and cultural centre of Vienna, St Stephen's Cathedral, was used to delimit the spatial model.

It has to be taken into account that the boundaries of the analysed area have a significant effect on the integration values of the model. As Turner and Penn (2007) noted, the *edge effect*[15] has to be considered, because lines closer to the centre of a system will naturally have a higher integration value than lines on the edge. Therefore, a modification is often used: local integration[16] or incorporation of a buffer for analysing specific areas on the edge (Turner and Penn, 2007).

This model can be seen as an example of how space syntax functions and how it can be applied to a specific case of urban development: inner and peripheral development. The respective values represent a range of the integration of a space within a system. A modelling and simulation tool can never show real and absolute values as it is an approximation of the real world.

To analyse the segmented axial map I used the space syntax tool *confeego*[17], which is a plug-in for the GIS program *MapInfo Professional* that combines a suite of tools for investigating the effects of spatial configuration. These include data translation, data collection, map processing, data analysis and data visualisation. After processing the maps, the *choice values* will be normalised with log+2 to enable the comparison of different systems (in terms of size).

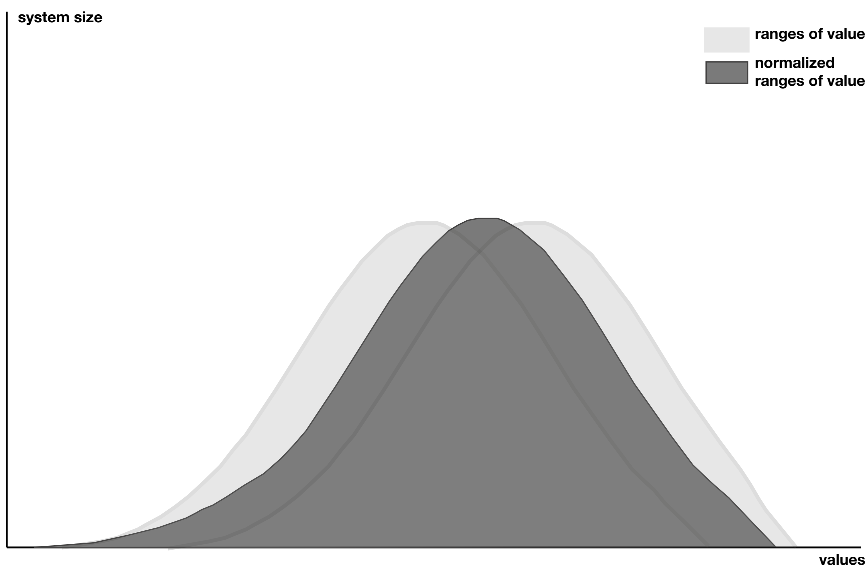

Figure 8. Normalised values of two different metric measures, own sketch.

Technical support was provided by the GIS programs *Mapinfo Pofessional* and *Depthmap*, open sources like *orthophoto (WMS)* with access from the eGIS of the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management, *Vienna City Map (ViennaGIS)*, *Open Street Map* and personal surveys in the real world.

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15 Distortions in values depending on where we choose to draw the boundary of the graph

16 Local integration: "in most studies the best performing spatial variable is radius-3 integration" (Hillier 1998), that is, the integration of a particular line within a system of lines that is up to three lines away.

17 confeego was developed by Space Syntax Limited and is available free for academic use.

CASE STUDY:

Greater Vienna

3. Case Study: Greater Vienna Model

The Greater Vienna Model 2012 is a strategic model. “Strategic” in this context means that it represents the configuration of movements for pedestrians and vehicles on a city-wide (global) scale. This model visualises the connection structure of the street network of Vienna and its surrounding municipalities without the new main train station and with no Rothneusiedl development.

After modelling the axial map, it will be processed according to the topological and metric values of *integration* and *choice*. For each model, the configuration values will be compared on their different radii to show the impact on the system and the results will be interpreted. The following will explain how space syntax can add value to the decision-making process in planning strategies and design to support a sustainable and sustaining built environment in future Vienna.

Processing the segmented axial map of Vienna, the status quo will be analysed using the following multi-scale (from global to local) measures:

- Integration Radius N, which represents the centrality value for each space within the entire network
- Choice, Radius 1200m, Radius N Radius 800m to represents the likelihood of a space to pass through

In order to illustrate and distinguish the low from the high values, I classified the *choice values* into 4 categories (non-equal ranges) on a grey scale. High vales are mapped in black, low values in light grey.

Table 1: Attribute properties of Greater Vienna Model 2012 with amount of axial lines and segments.

Greater Vienna Model 2012

Attribute	Count
Axial Lines	18,066
Street Segments	53,281
Model Boundary Diameter	18.4 km

3.1. Greater Vienna Model 2012

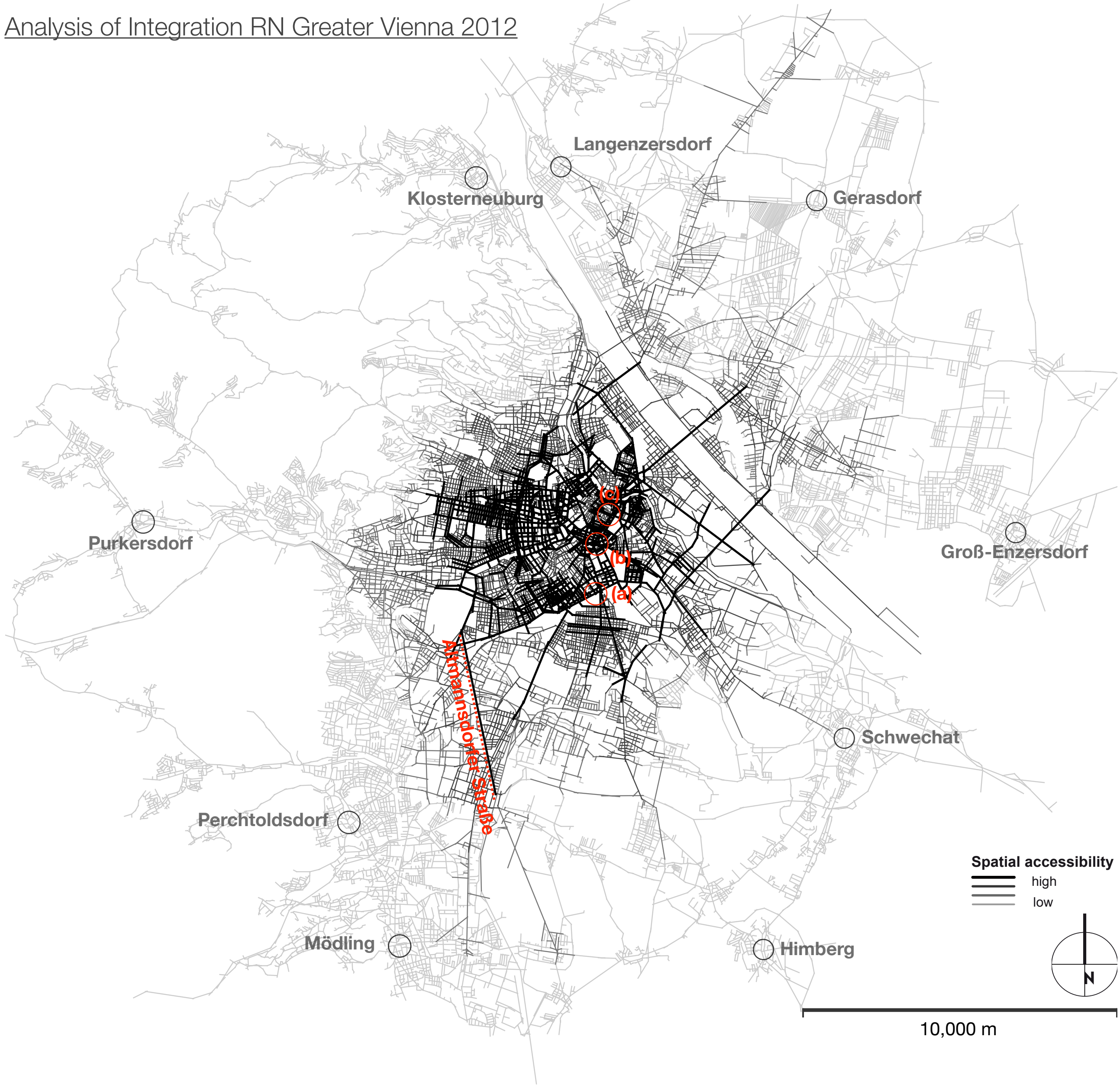

Figure 9. Integration RN; Greater Vienna Model 2012. Vienna and suburbs forms deformed wheel. The most accessible areas (mapped in black) (a) Wiedner Gürtel, (b) Schwarzenbergstraße and (c) Parkring in Historic Core. Major roads like Altmannsdorfer Straße, Triester Straße and Südosttangente Wien are also highly integrated, with the city bridges across the Danube river to the north as a further conduit of access.

Analysis of Choice RN Greater Vienna 2012

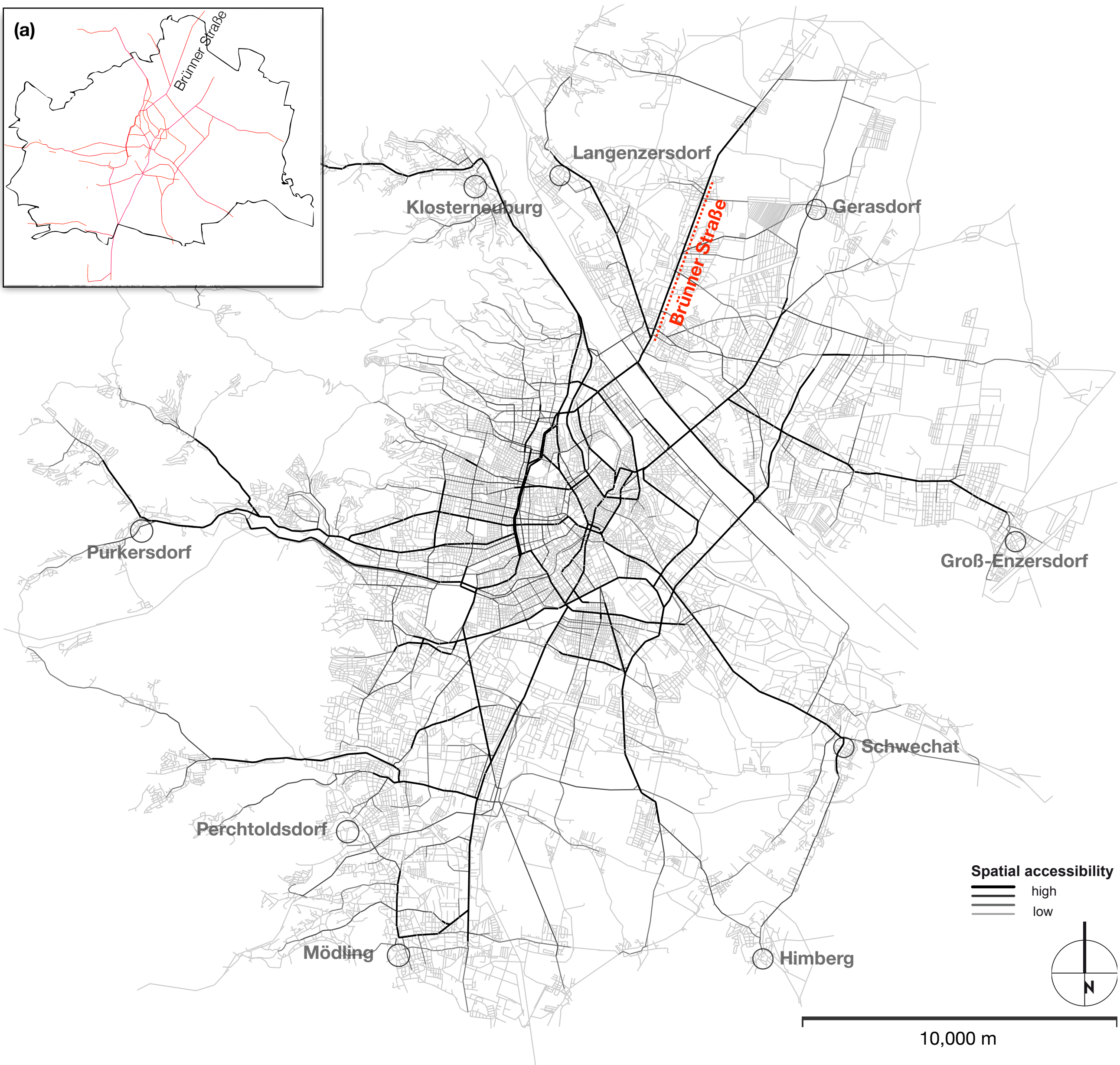

Figure 10. Choice RN; Greater Vienna Model 2012 including Aspern development and excluding the new main train station (Hauptbahnhof); own processing (entire zoom)
(a) Highlights most potential through-movement. Shows segment choice values within the entire network.

Analysis of Choice R800m Greater Vienna 2012

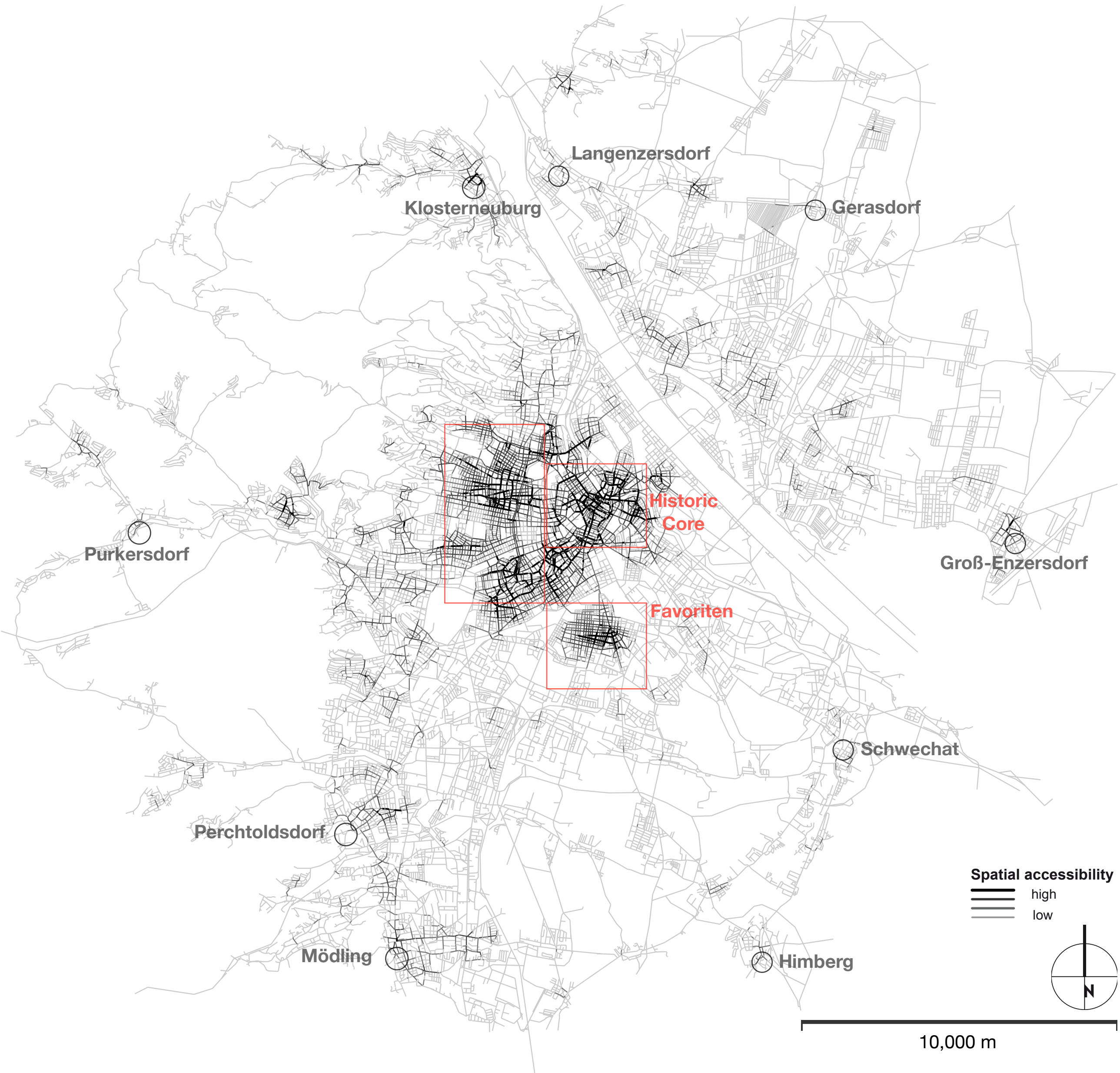

Figure 11. Choice R800m; Greater Vienna Model 2012 including Aspern development and excluding the new main train station (Hauptbahnhof); own processing (entire zoom)
Shows segments choice values within the entire network. (Former) historic settlements such as Währing, Gumpendorf and evidently the first district are highlighted. Furthermore and again, the 10th district (Favoriten) forms a huge local centre.

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Analysis of Choice R1200m Greater Vienna 2012

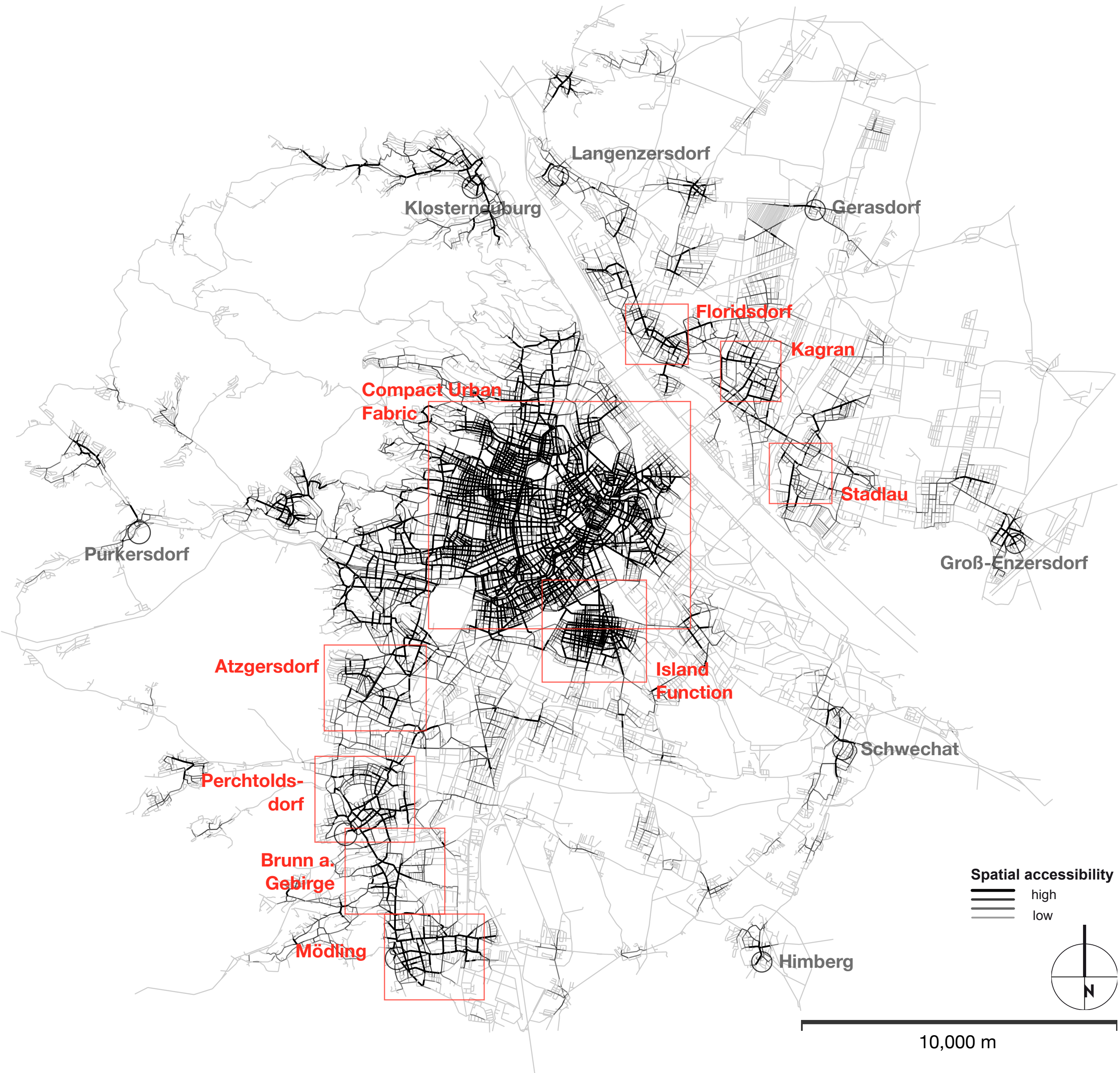
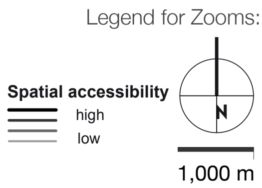


Figure 12. Choice R1200m; Greater Vienna Model 2012 including Aspern development and excluding the new main train station (Hauptbahnhof); own processing (entire zoom)
Shows segment choice values within the entire network. Former very local settlements such as Hütteldorf and Atzgersdorf nowadays form sub-centres. Within the centre of Vienna, existing local centres form a dense urban fabric with highest accessibility values.

Overview with Zooms Greater Vienna Model 2012

Figure 13. Overview map for Greater Vienna Model 2012. Exemplary areas with highest and lowest values based on historical developments and different morphological characteristics.



Analysis of Zooms:

Historic Core | Favoriten (10th District) | Floridsdorf

Figure 14. Integration RN, Greater Vienna Model 2012 with Zooms

Figure 15. Choice RN, Greater Vienna Model 2012 with Zooms

Figure 16. Choice R800m, Greater Vienna Model 2012 with Zooms

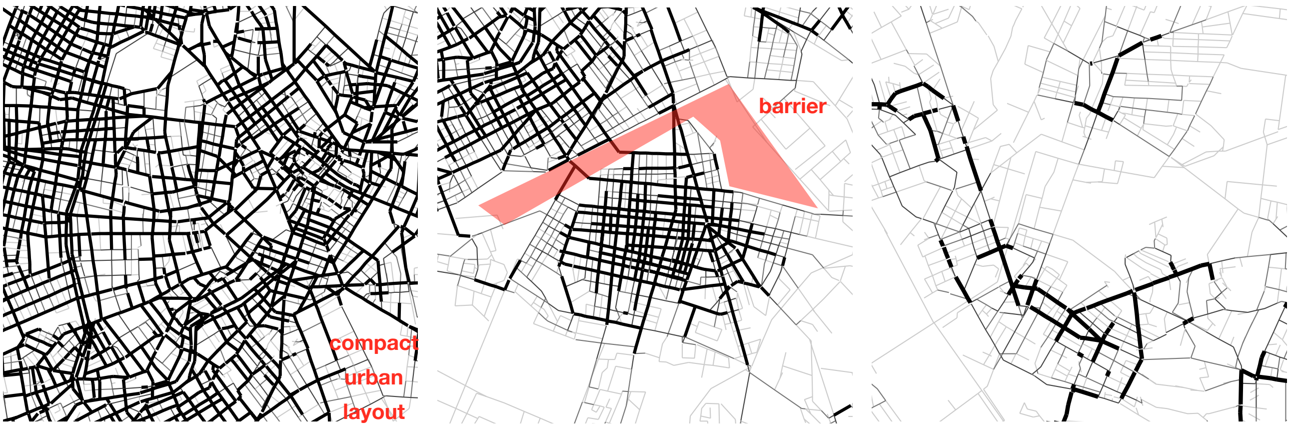


Figure 17. Choice R1200m, Greater Vienna Model 2012 with Zooms

Photo Survey:

Figure 18. Historic Core of Vienna. Most integrated area at (a) Schwarzenbergplatz and along Ringstraße boulevard. Largest number of less integrated minor streets in the 2nd district close to (b) Augarten.

Figure 19. Favoriten (10th district) is highly integrated. Margaretengürtel bordering 4th and 5th districts, is most integrated axes within the 10th district. High potential through-movements at (a) Quellenstraße, Favoritenstraße and Reumannplatz, which are suitable as a local and global centre. This contrasts with the municipal housing area in the west of Favoriten along (b) Erlachgasse.

Figure 20. (a) Floridsdorf in the far north east is characterised by mixed land use along major (historic) roads and residential areas.
Most integrated area at junction of Floridsdorfer Hauptstraße and Brünner Straße. Least integrated and lowest choice values along (b) motorway A22.

Table 2. Attribute properties for Greater Vienna Model 2012. The values show the correlations between local and global accessibility and choice measures.

Greater Vienna Model 2012			
Attribute	**Average**	**Minimum**	**Maximum**
Connectivity	3.733	1	56
Intelligibility (Con/IntRN)	0.877	0.299	1.955
Synergy (R3/RN)	0.586	-0.164	1.243
Mean Depth	30.623	19.042	86.858
Integration RN	0.425	0.135	0.641
Choice RN (normalized)	4.964	0.301	8.565
Choice R800m (normalized)	2.436	0.301	4.538
Choice R1200m (normalized)	2.822	0.301	5.017

Key findings:

The **integration RN** analysis shows a clear shift of the historic centre towards the surrounding districts and away from what was traditionally the historic centre of activities in the city. The reason for this shift is quite clearly identified: huge urban developments during the 19th-century period of promoterism ("Gründerzeit") with its strong grid system. The 16th and the 10th districts, have particularly high integration values and a very high accessibility within the entire Greater Vienna Region.

Investigating the entire network on the global scale in terms of **choice N values**, we can clearly see the citywide street network. Major roads, highways and links like Triester Straße, Westautobahn, the Gürtel ringroad, the Ringstrasse boulevard, the Danube bridges and most (historical) supra-regional roads like Brünner Straße and Prager Straße in the north-east have the highest values in terms of the potential “through-movement”. This correlates with Hillier’s (1993) findings of the foreground and background network theory.

Within the radius of a 10-minute walk **(choice R800m)** historic settlements can be picked out very clearly. This indicates the “walkability” of an environment and reveals suburbs like Klosterneuburg, Mödling or Großenzersdorf. The so-called “island effect” can be associated with the 10th district - rail tracks and two train stations act as barriers to the 3rd and the 4th districts. Main roads have the lowest values due to segment length and low connectivity values (i.e. value of *1* A22 motorway segments).

The expansion of the radius to **choice R1200m** highlights the core areas for sub-centres. Similar to route choice values for 800m, the values change gradually. This illustrates Vienna's compact urban layout and correlates with its mixed land use. Again, the i*sland effect* of the centre of the 10th district (Favoriten) emerges, clearly showing its importance for its inhabitants due to the lack of links to adjacent centres. Additionally, a strongly developed south axis is highlighted.

3.2. Scenario Development

In this research, option testing is to be seen as an approach to investigate the effects of inner and peripheral developments. It can help support the decision-making process, mainly on a strategic level. With this approach it is possible to point out whether new structures are required, where they should be put and what effects these changes will have on the existing system. To understand the different variations of the configuration of space, two main projects in Vienna will be presented.

The first investigates how an urban intensification - and densification - infrastructure project will affect existing structures. And second, a self-made sketch on the border of Vienna state tests potential urban developments in terms of sustainable space configuration.

With planning strategies and design proposals, successful implementation of a design is important, as it allows a stable and continuous development. Space syntax models can adapt the street network quickly and allow an analysis of a range of cases or design proposals[18].

The two options will be modelled separately in order to identify possible effects on the existing system. The analysis will use the following multi-scale (from global to local) measures:

- Integration Radius N, which represents the centrality value for each space within the entire network
- Choice Radius N, Radius 800m and Radius 1200m to represent the likelihood of a space to pass through

[18] Strategic planning and design with space syntax; Czerkauer-Yamu and Voigt, 2011, in City Modelling - eCAADe 29

3.2.1. Scenario - Vienna Main Station (Model 2014)

In 2004, the city council of Vienna, Austrian Federal Railways (ÖBB) and the Austrian Post Office invited international experts to design a master plan for a new central railway station on the site of the formerly segregated south and east railway stations. A combination of the winning projects by architects Hoffmann/Holz and Albert Wimmer was recommended by the jury. Later that year, and after some slight adjustments to take account of the World Heritage site of Belvedere Palace and its main protected line of sight, the city council approved the new “Bahnhof Wien - Europa Mitte” master plan. This will now form a new integrated railway station with adjacent residential area, offices and commercial facilities.

The main goals are to optimise the urban landscape and focus on small-scale structures. The stakeholders also intend to keep the area free from through-traffic and ensure a high quality of recreation in its open spaces. Furthermore, they want to enhance the whole area in terms of connectivity to adjacent districts. New bridges and streets will connect the 10th district with the 3rd and 4th districts, guaranteeing passage through and more freedom of movement[19]. The entire project area can be seen as an example of *grid intensification*[20].

<u>Key Figures:</u>

- 59 hectares between Wiedner Gürtel, Sonnwendgasse, Gudrunstraße and Arsenalstraße, including 8 hectares of park
- Mixed use: approximately 5,000 apartments for 13,000 residents, offices, retail and services, hotel, school and kindergarten on the school campus

The new main station is framed by the main route Wiedner Gürtel, Arsenalstraße, Gudrunstraße and Sonnwendgasse in the 10th district in the south of Vienna. The so-called Sonnwendviertel will provide housing for 30,000 new inhabitants and 20,000 new office jobs. Located on the edge of the 10th district, this project will extend the existing spatial layout and will be analysed here in terms of its impact on choice values of the 10th district.

Table 3. Attribute properties of Greater Vienna Model 2014 (Main Train Station scenario) with amount of axial lines and segments.

	Greater Vienna Model 2014	
Attribute	**Count**	**(Change from 2012 Model)**
Axial Lines	18.092	(+26)
Street Segments	53.281	(+172)
Model Boundary Diameter	18.4 km	

[19] Vienna Main Station overall project; ÖBB Advertising

[20] Space Syntax Ltd. 2012

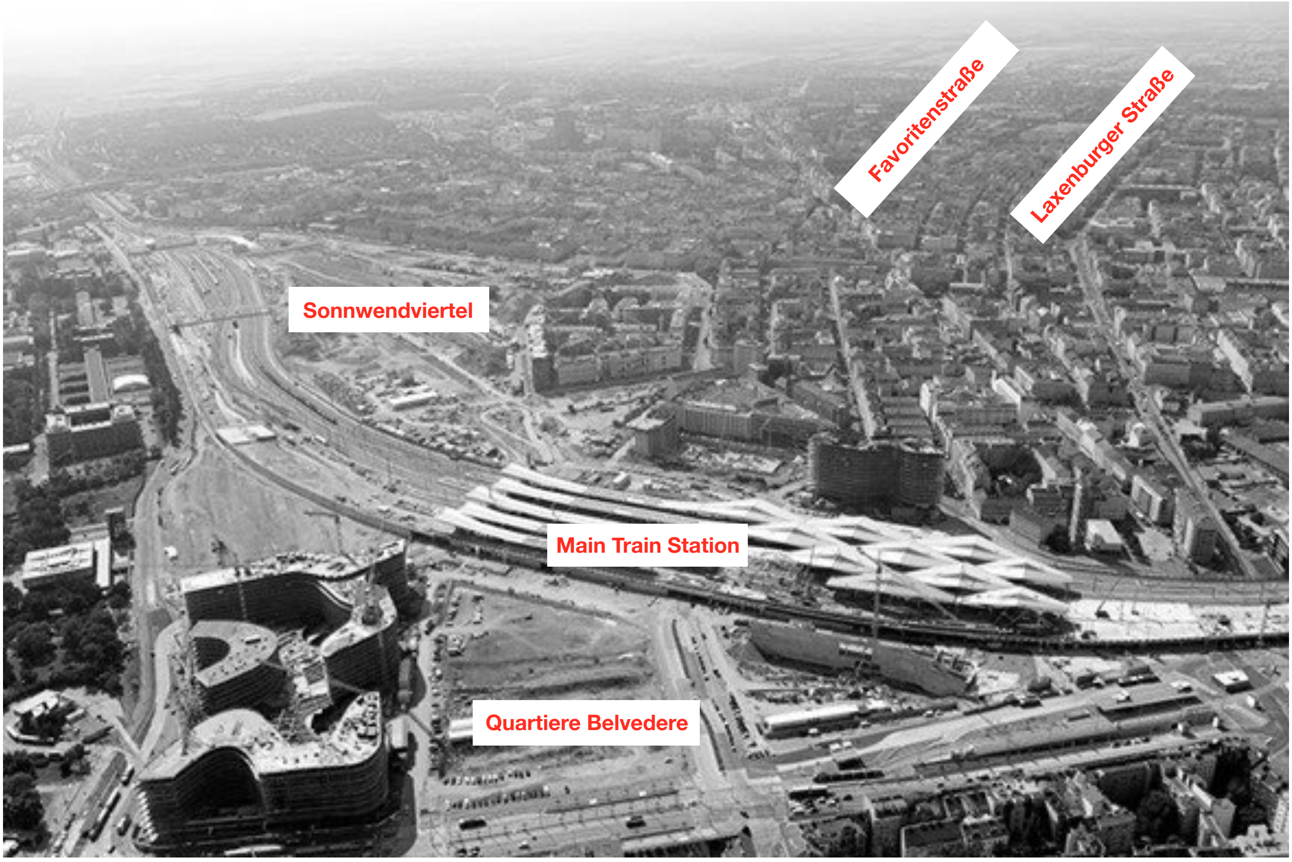


Figure 21. Aerial view of Vienna Main Station and Sonnwendviertel development site, looking south; source: WKO Wien, UHU Project Site

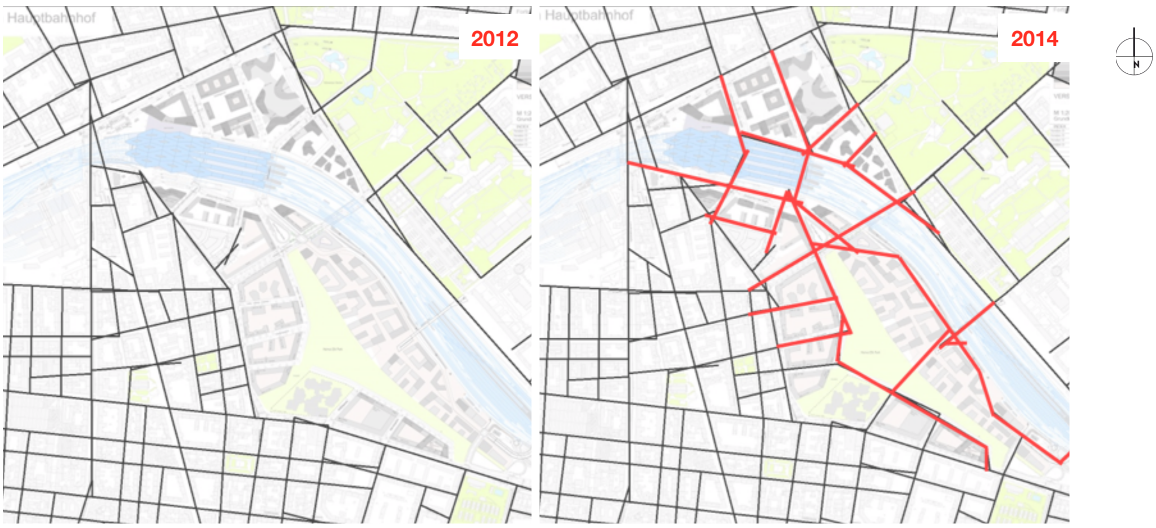


Figure 22. Central Train Station area, Greater Vienna Model 2012 and 2014, own drawing, base map: Masterplan Hauptbahnof 2010, City of Vienna/ÖBB[21]

Grid intensification caused by extension of existing roads and new links between the 10th and 4th districts - in numbers, this means 11 extensions and 26 new links or spaces.

To highlight the different choice values each space has, they were classified into 4 categories. This allows us to identify the differences in the choice values.

[21] Illustration differs from most recent zoning plan dating back to autumn 2014. Current (new) layout is implemented in the Axial Model 2014.

Greater Vienna Model 2014 Overview:

Figure 23. Overview map for Greater Vienna Model 2014 and Main Station scenario with new axes (red lines).

Analysis of Integration RN, Greater Vienna 2014

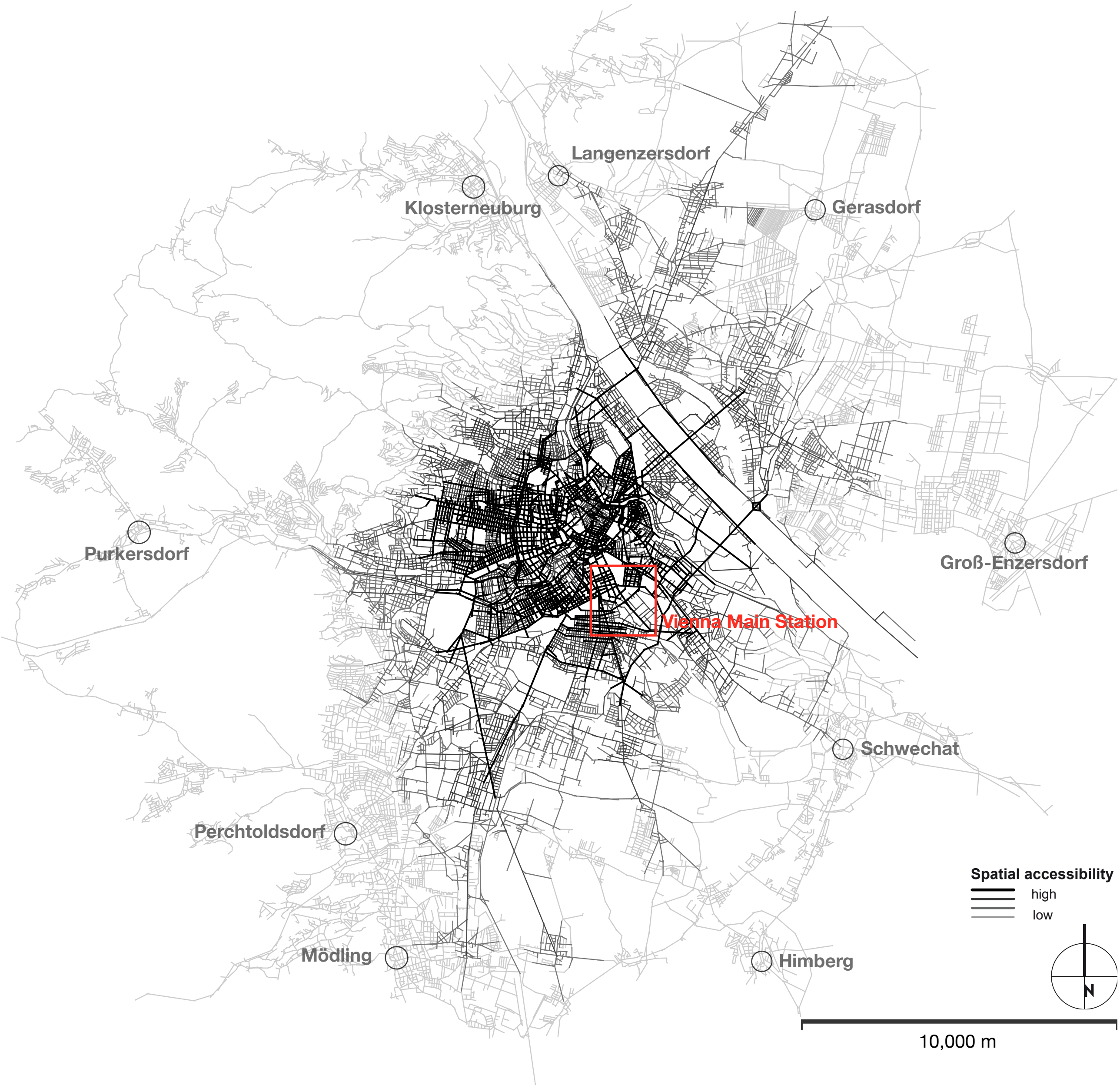


Figure 24. Integration RN; Greater Vienna Model 2014 including the new main train station (Hauptbahnhof). Shows most integrated axial lines within the entire network. Suburbs of Vienna are less integrated into the city. However, Schwechat and Mödling have access to parts with highest values.

Analysis of Choice RN, Greater Vienna 2014

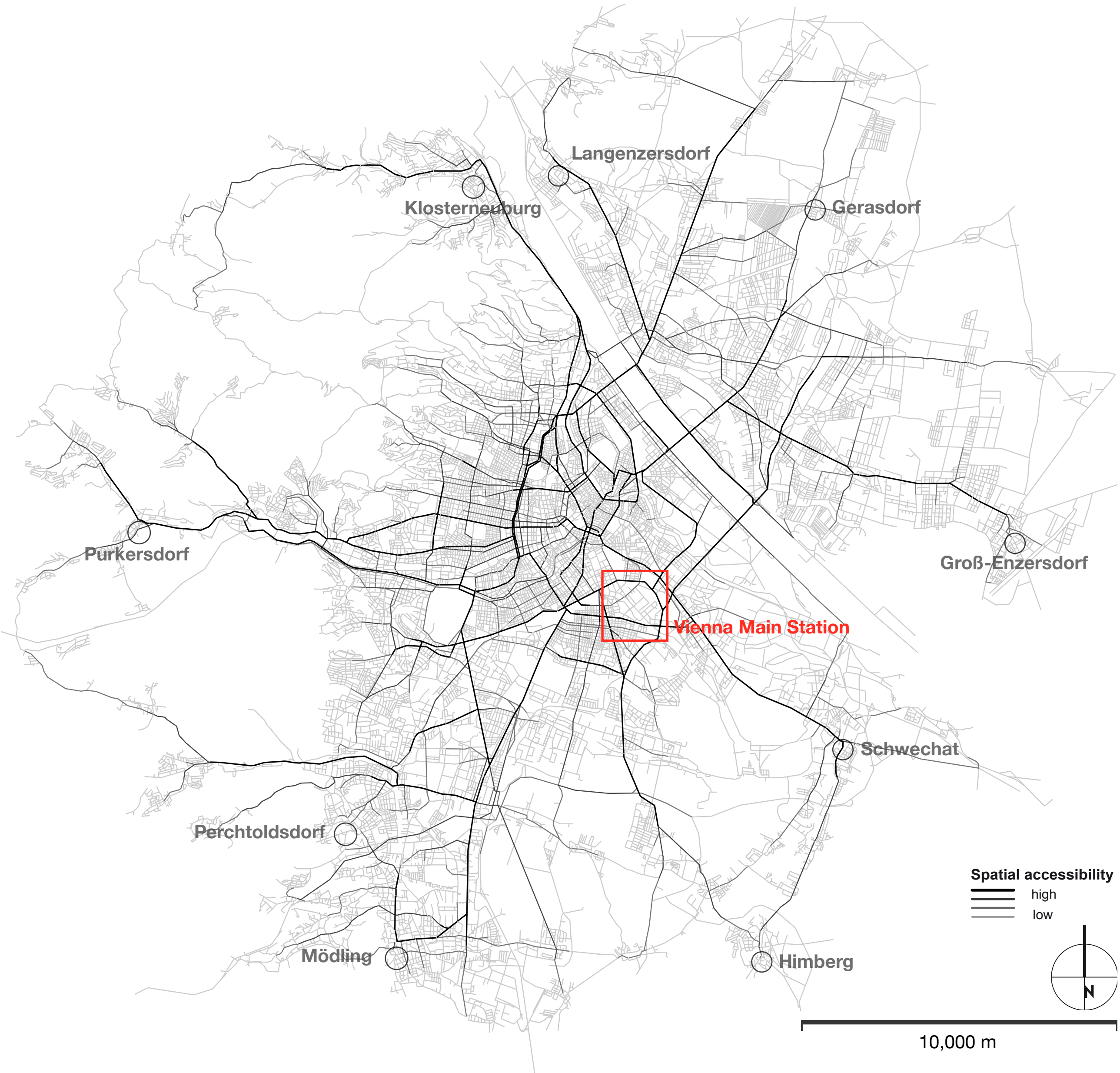


Figure 25. Choice RN; Greater Vienna Model 2014 with new Vienna Main Station; own processing (entire zoom). Shows most integrated segments within the entire network. Vienna Main Station is framed by two main roads - the Gürtel ring road and Gudrunstraße.

Analysis of Choice R800m, Greater Vienna 2014

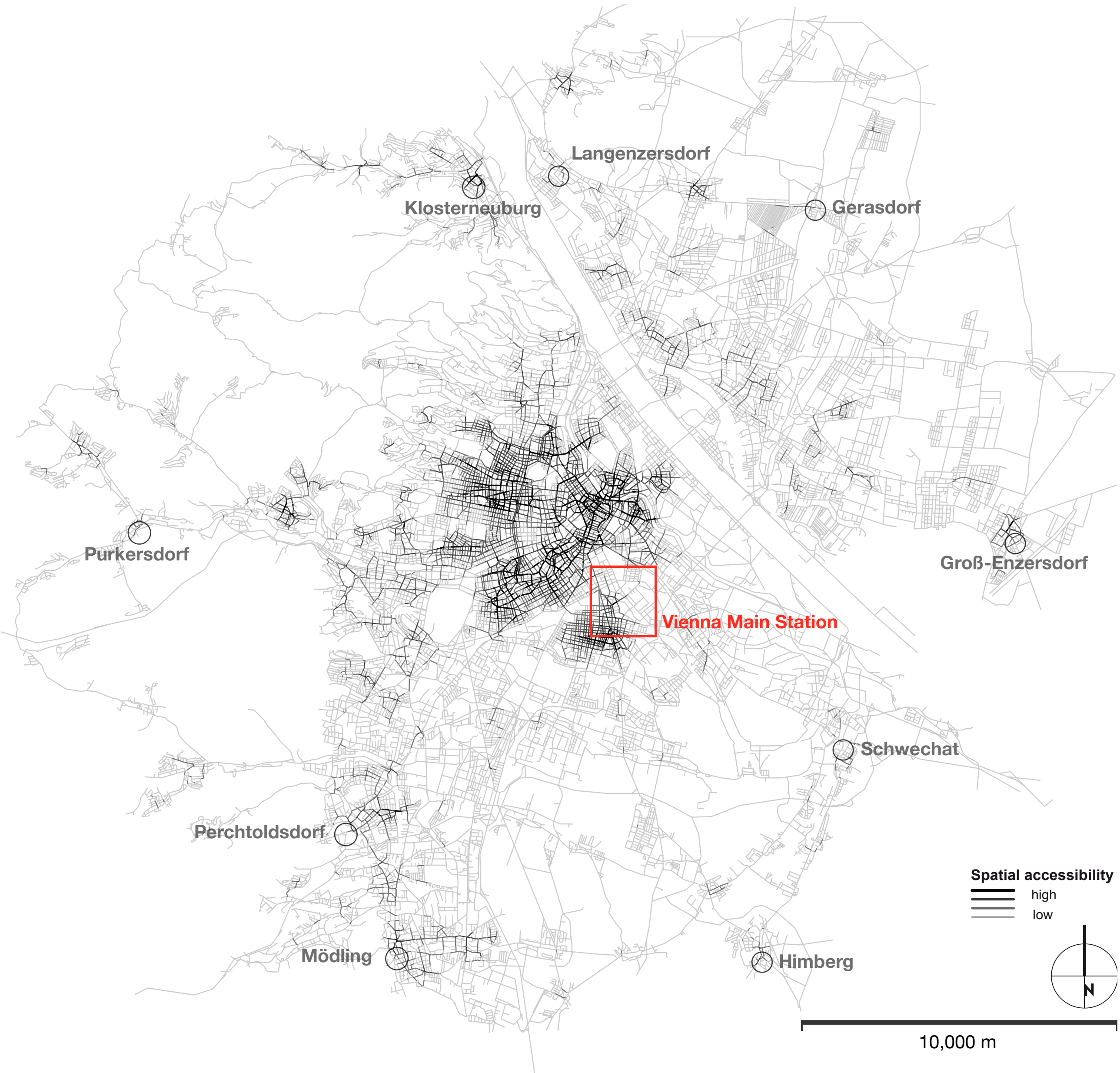


Figure 26. Choice R800m; Greater Vienna Model 2014 including the new Main Train Station (Hauptbahnhof); own processing (entire zoom.) Shows segment choice values within the entire network.

Analysis of Choice R1200m, Greater Vienna 2014

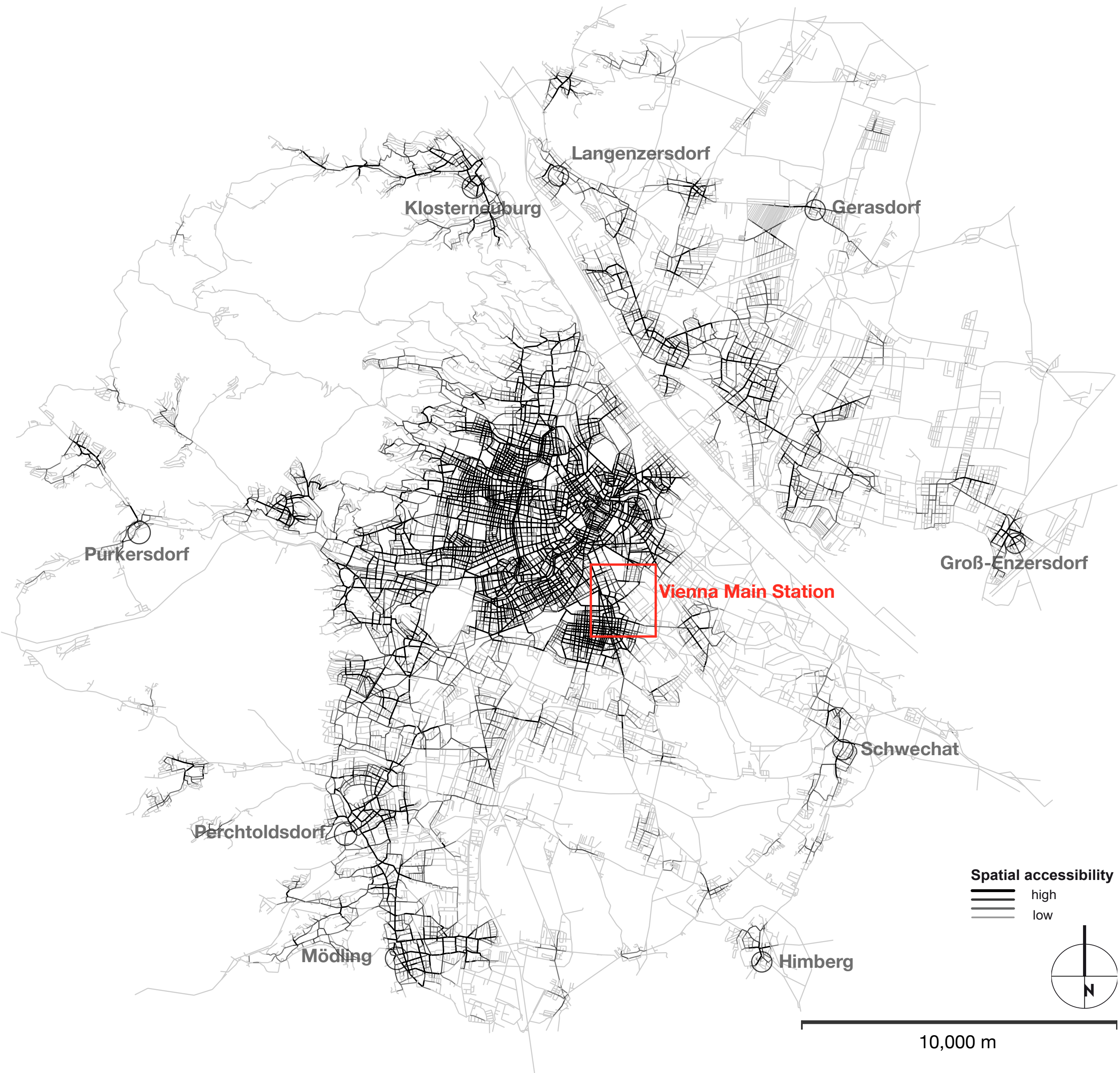


Figure 27. Choice R1200m; Greater Vienna Model 2014 including new Main Train Station (Hauptbahnhof); own processing (entire zoom). Shows segment choice values within the entire network.

Comparison of Zooms, Greater Vienna 2012 and Greater Vienna 2014:

Model 2012 | Model 2014 (Main Train Station)

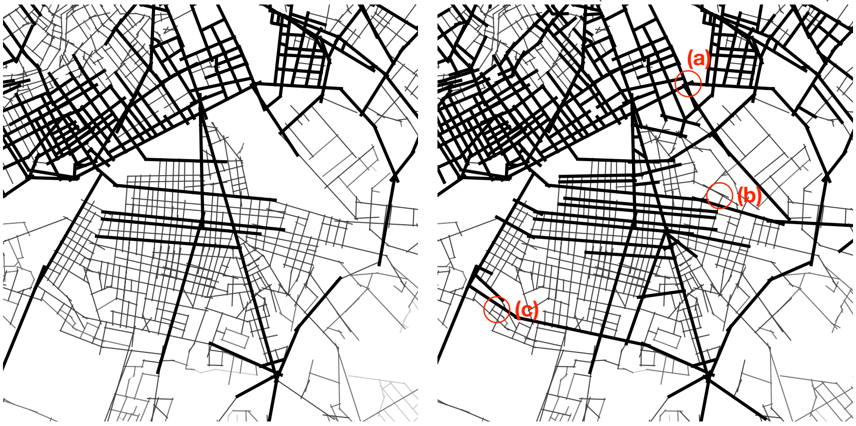


Figure 28. Integration RN, Greater Vienna Model 2014 with Zoom

Wiedner Gürtel ring road (a) with highest integration values. Infill development strengthens existing major roads like (b) Gudrunstraße and (c) Raxstraße.

Figure 29. Choice RN, Greater Vienna Model 2014 with Zoom

No highlight of (a) Favoritenstraße in 4 th district. Therefore, new development area has no effect on a citywide scale in terms of potential through-movement.

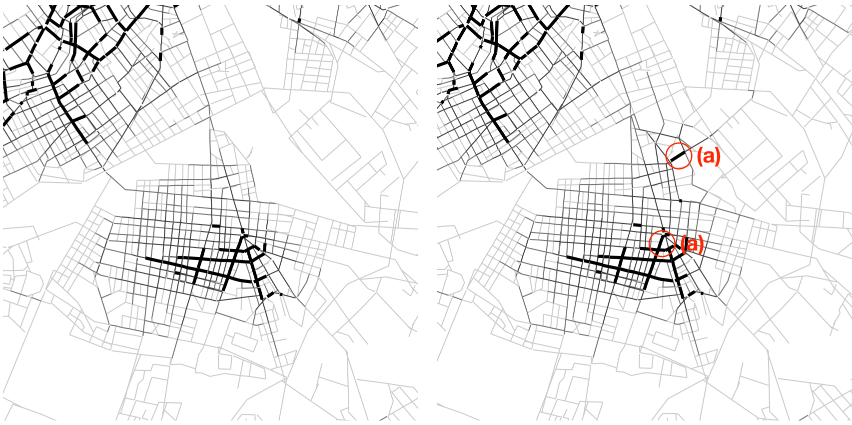


Figure 30. Choice R800m, Greater Vienna Model 2014 with Zoom

The local centre of Favoriten remains at (b) Reumannplatz and new residential area Sonnwendviertel will form a local centre at (a) Alfred-Adler-Straße and brings opportunities for business.

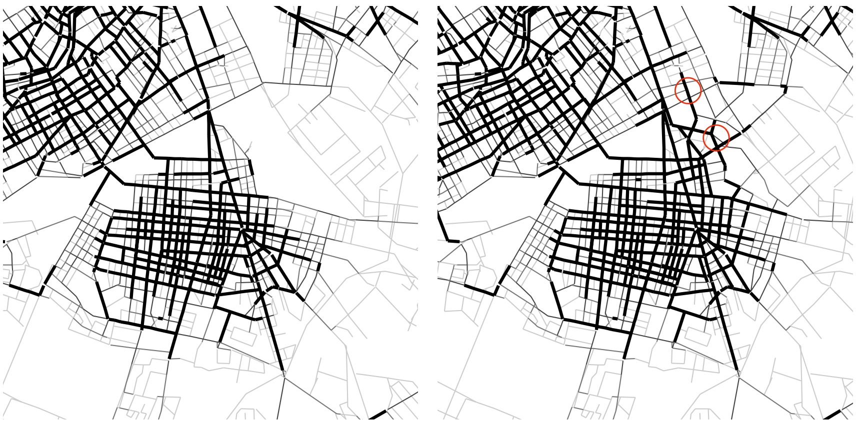


Figure 31. Choice R1200m, Greater Vienna Model 2014 with Zoom.

New link roads enhances potential-through values to the 3rd district, whether in or out of train station for local business. Possibilities for mixed land-use and cultural institutions are likely.

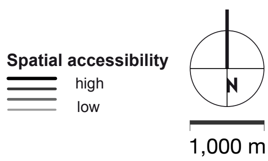


Photo Survey, Main Train Station Scenario:

Figure 32. New link roads to neighbouring 4th district enhances accessibility on local and global scale (a) Gertrude Sandner Straße and (b) Karl-Popper Straße.

Figure 33. (a) Favoritenstraße is the most integrated and most accessible axis within the 10th district. It remains a local and global centre, especially Reumannplatz (b) in particular serves as the main local centre.

Figure 34. (a) Gudrunstraße and (b) Sonnwendgasse serve mainly for housing and local shops and services.

Table 4. Attribute properties for Greater Vienna Model 2014. The values show the correlations between local and global accessibility and choice measures.

Greater Vienna Model 2014			
Attribute	Average	Minimum	Maximum
Connectivity	**3.739**	1	56
Intelligibility (Con/IntRN)	0.877	0.229	1.954
Synergy (R3/RN)	0.586	-0.165	1.243
Mean Depth	**30.597**	19.023	86.860
Integration RN	**0.426**	0.135	0.641
Choice RN (normalized)	4.968	0.301	8.567
Choice R800m (normalized)	**2.439**	0.301	4.538
Choice R1200m (normalized)	2.825	0.301	5.017

Figure 35. Comparison of major numerical changes (average values)

There is a logical relationship between connectivity and integration: the more joints, the more integrated the system. The correlation of connectivity and integration is intelligibility which shows the comprehensibility of the system as a whole. This value does not change. Although the system is better integrated (through higher connectivity and integration values), the legibility of the system does not increase much.

The *route potential* increases, which means the system shows a higher accessibility although the size of the system and its legibility remain constant.

Key findings and impact evaluation:

On the global scale, Alfred-Adler-Straße and Landgutgasse serve as major links between the most global roads, Wiedner Gürtel/ Landstraßer Gürtel in the north and Favoritenstraße/ Laxenburgerstraße in the west. Gudrunstraße will remain the second most important west-east link for the 10th district.

At this point, Landgutgasse at the intersection with Sonnwendgasse mainly serves for housing. In future more demand for commercial use is very likely, especially when Alfred-Adler-Straße becomes operational and new offices are constructed on the development site to the east.

On the local scale of **choice R800m**, a new small centre can be identified at the intersection of Landgutgasse and Sonnwenndgasse. Despite that, there are no high values in the whole area. The most accessible areas for the 10th district remain more to the south towards Reumannplatz.

Looking at the **choice R1200m** radius, there is a clear shift of major road status to the new Alfred-Adler-Straße, which serves as a link to Arsenalstraße across the railway tracks to the east. There are very segregated housing areas south of Sonnwendgasse due to the fewer connections, as well as a new park and bigger block sizes.

Comparing the Greater Vienna Models 2012 and 2014, the spatial structure shifts to a more integrated 10th district towards the 3rd and 4rd districts. Movement potentials will focus on the 10th district. However, the island effect of the 10th district remains.

3.2.2. Scenario - Rothneusiedl

After gaining an understanding of the existing spatial layout and the effects of infill development, the question remains of how new settlements can be designed and located in a spatially sustainable manner. What are the differences between grid intensification and peripheral developments in terms of integration and choice values?

To investigate where my peripheral area of interest is located, or could be located, my starting points were based on 3 factors:

1. Statistics - population growth forecast on micro-scale
⇣
2. Administrative planning intentions - STEP2025 and Stadtregion+
⇣
3. Accessibility - based on Greater Vienna Model 2012 choice values

Rothneusiedl is an experimental schematic model. Based on an immanent principle, the location was also chosen because of historical rail and road links to Hungary.

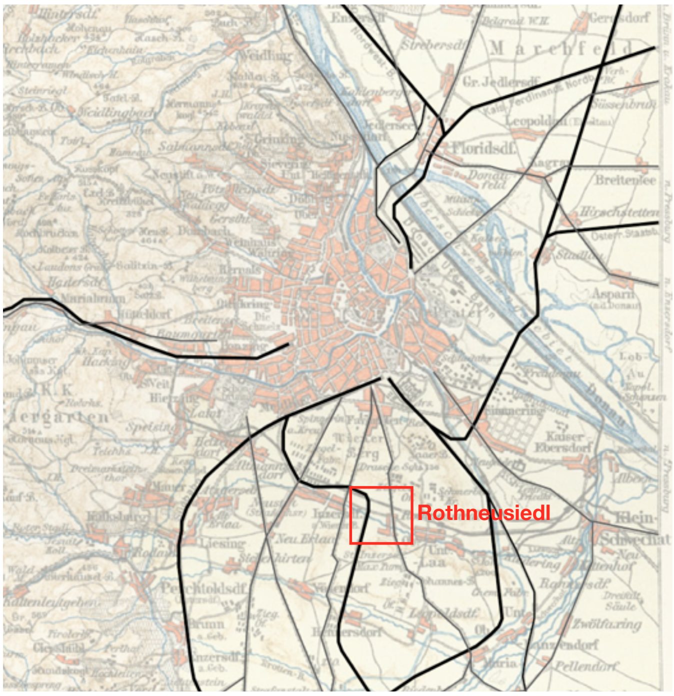


Figure 36. Historical railway lines (black) and major roads (grey). Own adaptation based on source: wikimedia.org/Umgebung von Wien 1888

The sketch of the Rothneusiedl Model is based on political proposals and the urban design study by Ganahl IFSITS Architects. The main connections (axes) are extensions of existing roads, proposed new connections and intersections from the study and own adaptations.

The main modification is based on a *grid system* and additional smaller spaces to generate a local centre on the periphery.[22]

Figure 37. Urban design study by GANAH IFSITS, 2007, source: http://www.ganahlifsits.at/projekte/staedtebau/rothneusiedl.html

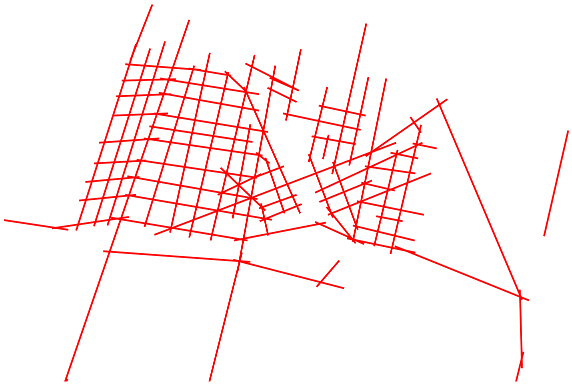


Figure 38. Rothneusiedl sketch with new axes (red lines)

Table 5. Attribute properties of Greater Vienna Model, Rothneusiedl scenario with amount of axial lines and segments.

Greater Vienna Model Rotheusiedl

Attribute	Count	(Change to Model 2012)
Axial Lines	18.149	(+83)
Street Segments	53.281	(+536)
Model Boundary Diameter	18.4 km	./.

[22] Model Rothneusiedl without Main Train Station, to limit the work.

Rothneusiedl Overview:

Figure 39. Overview map for Greater Vienna Model and Rothneusiedl scenario with new axes (red lines).

Analysis of Integration RN, Greater Vienna and Rothneusiedl

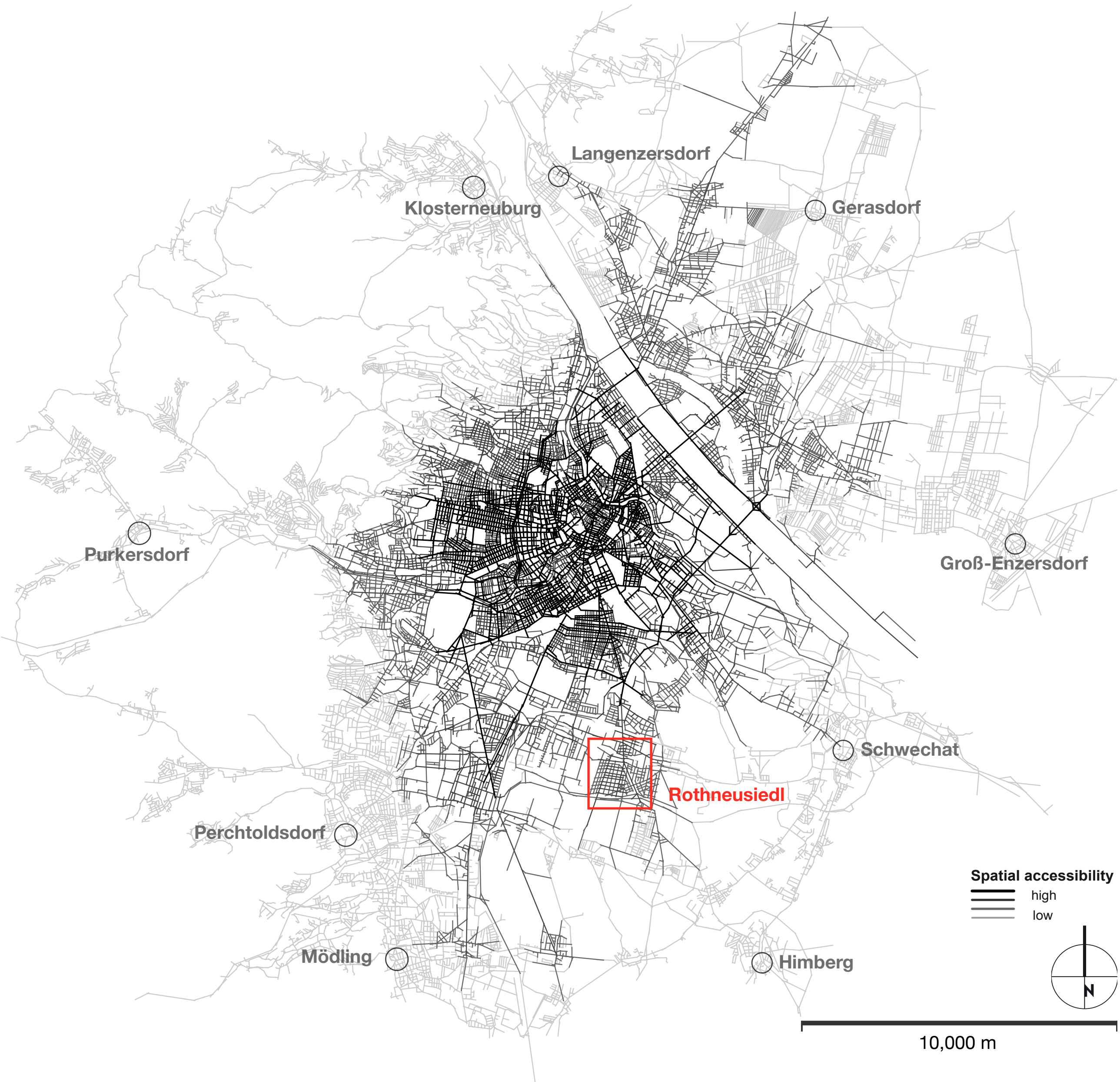


Figure 40. Integration RN; Greater Vienna Model and Rothneusiedl. Shows most integrated axial lines within the entire network. Suburbs of Vienna are less integrated into the city. However, Schwechat and Mödling have access to parts with highest values.

Analysis of Choice RN, Greater Vienna and Rothneusiedl

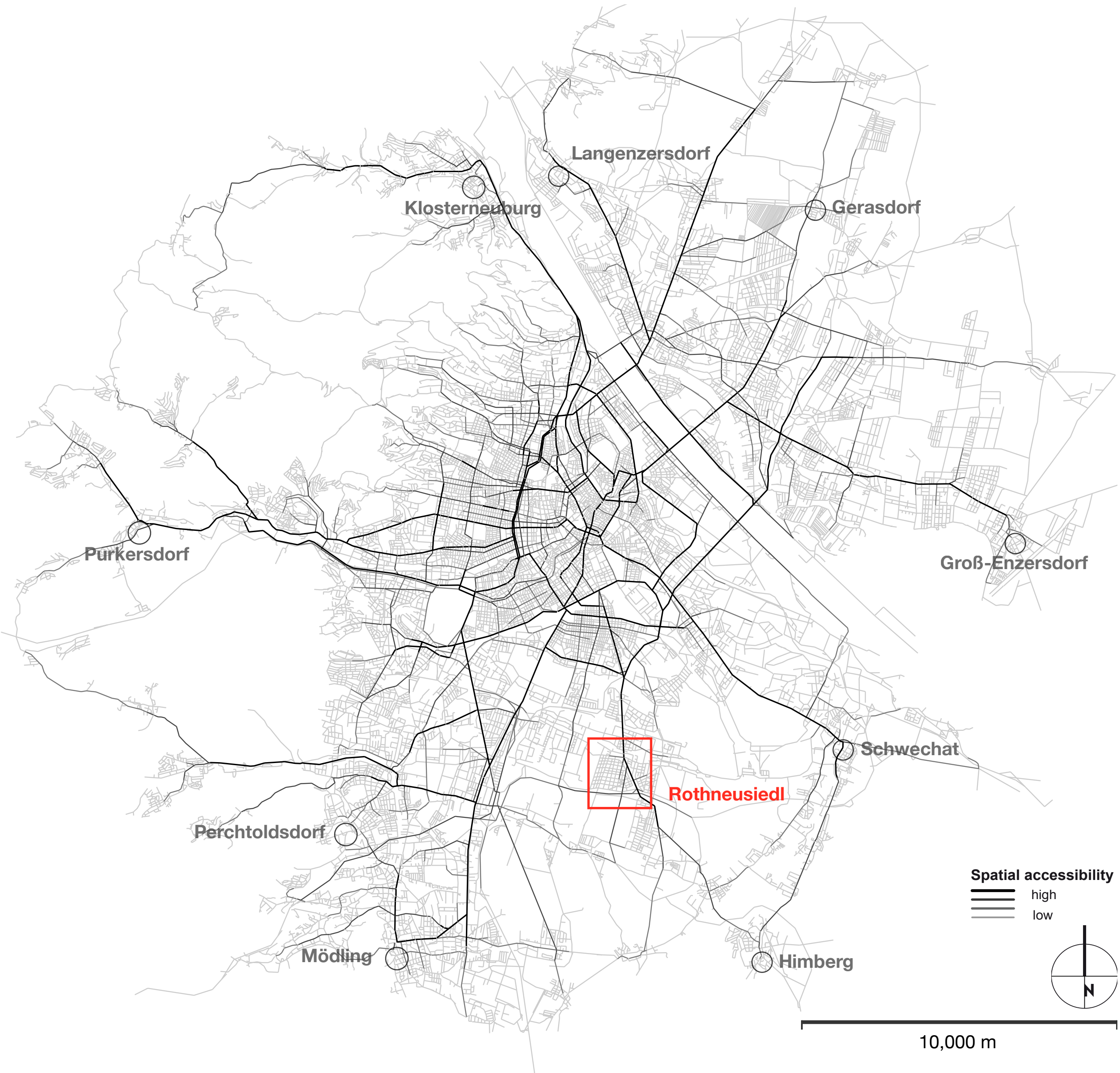


Figure 41. Choice RN; Greater Vienna Model 2014 with new Vienna Main Station; own processing (entire zoom). Shows most integrated segments within the entire network. Rothneusiedl lies on major road to the south.

Analysis of Choice R800m, Greater Vienna and Rothneusiedl

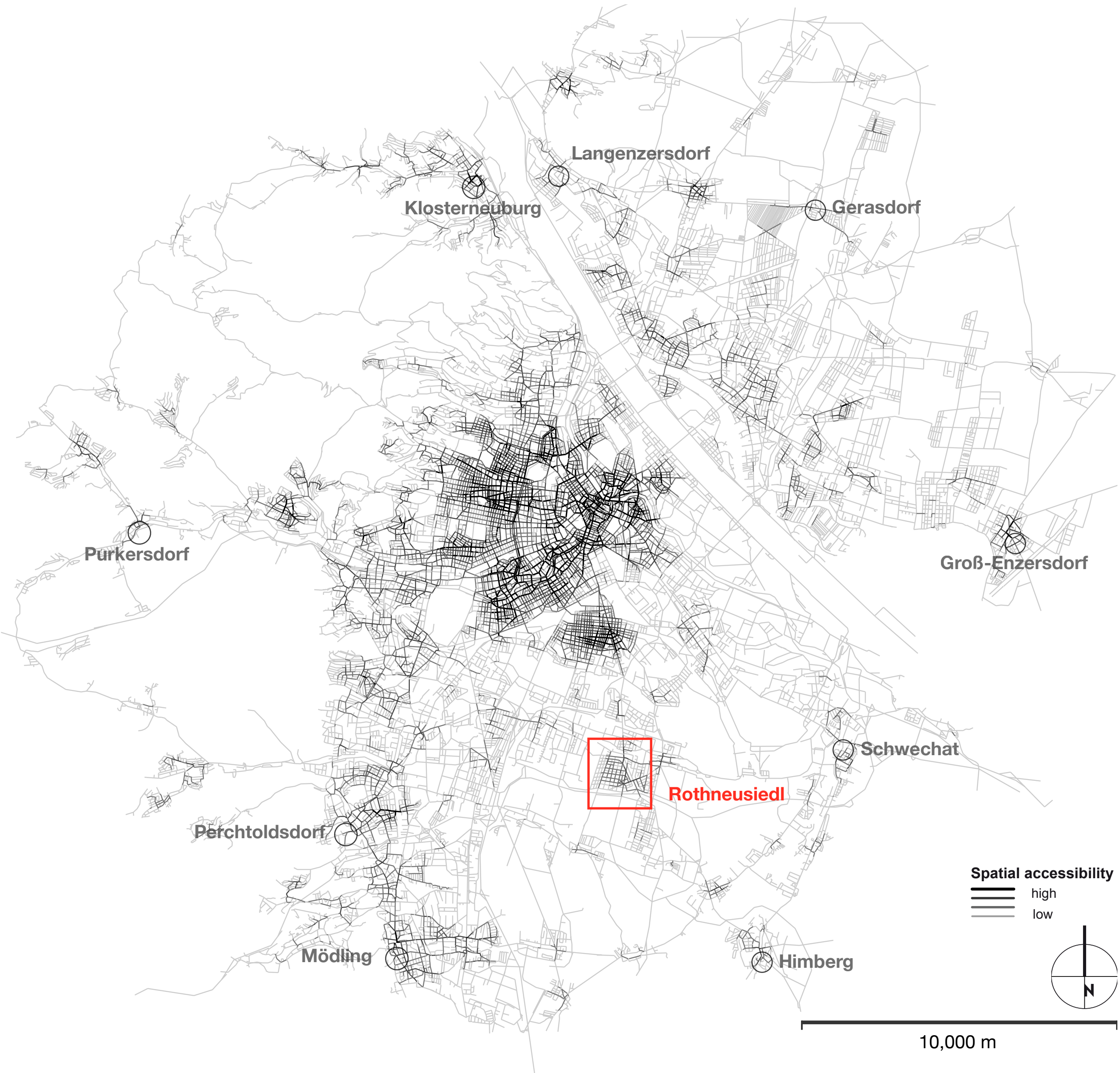


Figure 42. Choice R800m; Greater Vienna Model including Rothneusiedl; own processing (entire zoom). Shows segment choice values within the entire network.

Analysis of Choice R1200m, Greater Vienna and Rothneusiedl

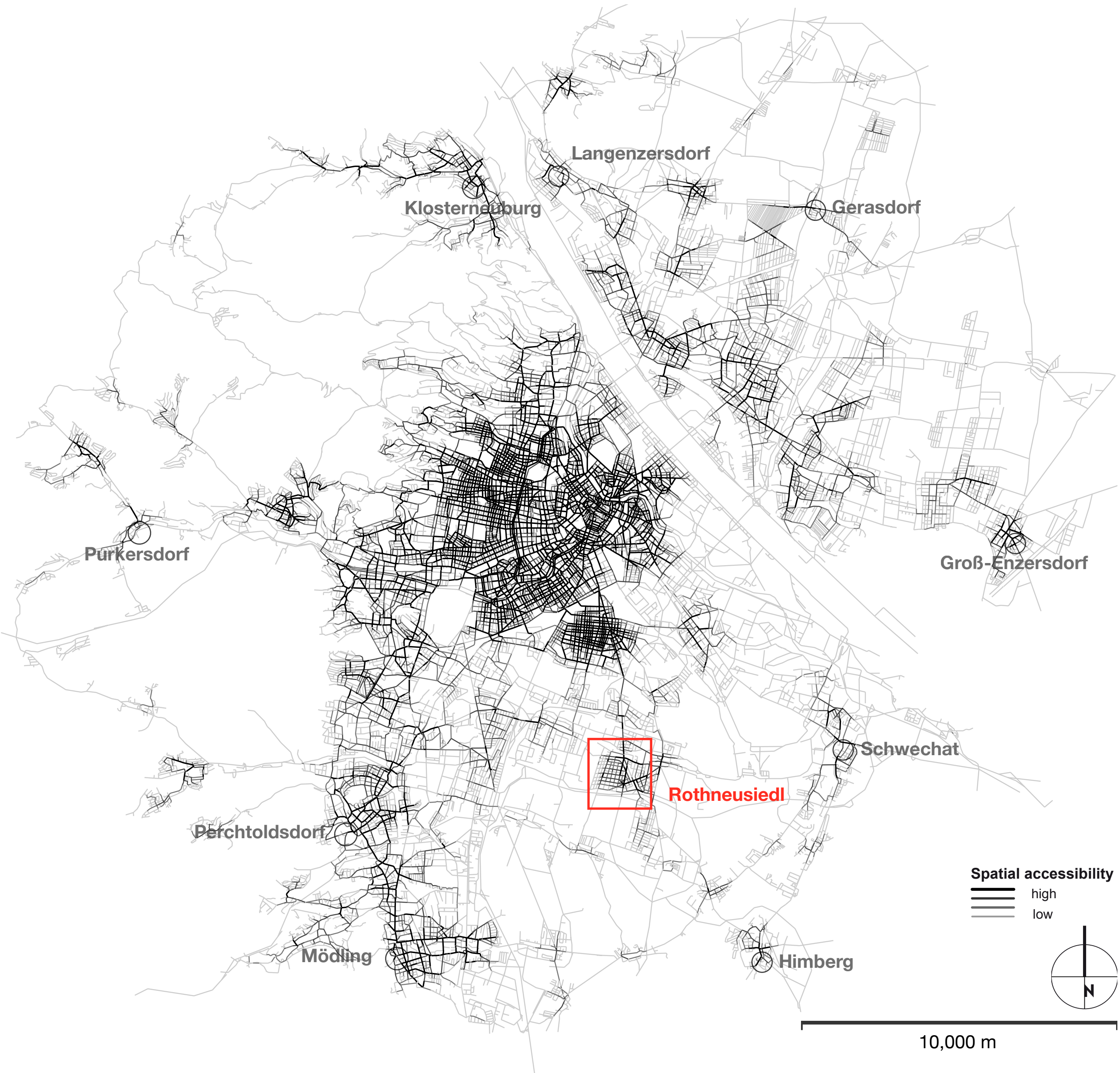


Figure 43. Choice R1200m; Greater Vienna Model and Rothneusiedl (entire zoom). Shows segment choice values within the entire network.

Zooms:

Figure 44. Integration RN, Rothneusiedl Model, Zooms

Peripheral development implies joining of existing major roads to form continuous axes. (a) Higher integration values for Favoritenstraße and Altmannsdorferstraße. Furthermore, (b) Raxstraße and Süd-Ost Tangente motorway form a continuous axes.

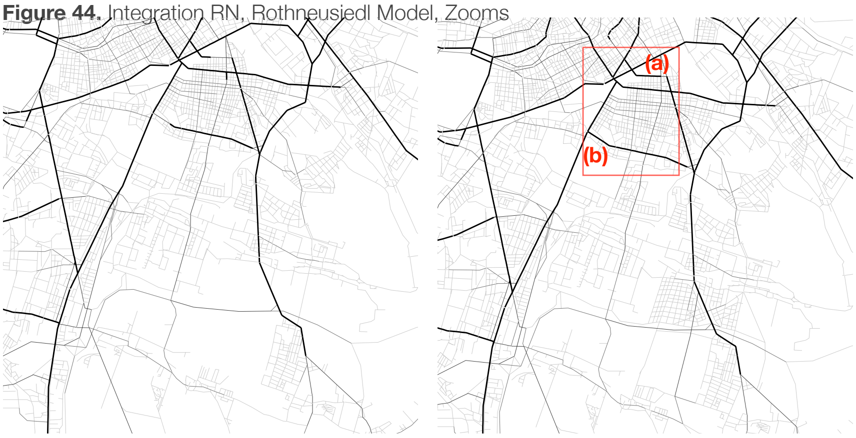


Figure 45. Choice RN, Rothneusiedl with Zoom

The location of Rothneusiedl scenario, along historic main road to the south (Himberg), remains most accessible part in the citywide system. New development results in better connected 10th district along (a) Landgutgasse and (b) Raxstraße.

Figure 46. Choice R800m, Rothneusiedl with Zoom

Grid system and generated local centre clearly show high potential through-movement values. Neighbouring Oberlaa is within walking distance, which indicates that existing urban structure of Oberlaa will benefit in terms of local accessibility to new Rothneusiedl development.

Figure 47. Choice R1200m, Rothneusiedl Model, Zooms

Rothneusiedl creates new subcentre and can function as a *stepping stone* in the south of Greater Vienna.

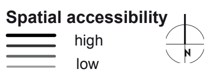


Photo Survey, Rothneusiedl Scenario:

Figure 48. New link roads to neighbouring suburb (a) Oberlaa at junction of Himberger Straße and Rosiwalgasse (b).

Figure 49. (a) Motorway S1 in the south connects main regional commercial zone Vösendorf, (b) future commercial areas along S1 motorway, suburb Schwechat and Vienna airport.

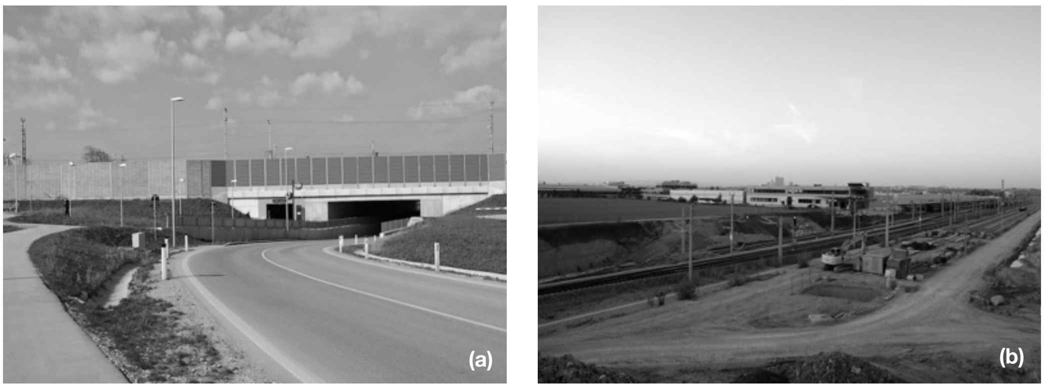


Figure 50. (a) Rosiwalgasse and Wien-Blumental station with (b) Inzersdorf industrial zone as barrier to Rothneusiedl.

Table 6. Attribute properties for Greater Vienna Model and Rothneusiedl. The values show the correlations between local and global accessibility and choice measures.

Greater Vienna Model - Rothneusiedl

Attribute	Average	Minimum	Maximum
Connectivity	**3.750**	1	56
Intelligibility (Con/IntRN)	0.877	0.228	1.953
Synergy (R3/RN)	0.586	-0.166	1.243
Mean Depth	**30.533**	18.979	86.868
Integration RN	**0.427**	0.135	0.643
Choice RN (normalized)	4.972	0.301	8.570
Choice R800m (normalized)	**2.439**	0.301	4.538
Choice R1200m (normalized)	2.825	0.301	5.017

Figure 51. Comparison of major numerical changes (average values) Model 2012, 2014 and Rothneusiedl Scenario. The connectivity values (global effect) rise due to higher amount of new axes (spaces). In terms of local choice values no effect at all can be identified.

Key findings and impact evaluation:

On the global scale, Himberger Straße clearly remains the most accessible route for the wider urban system. It forms a continuous link to Favoriten in the north and is connected to the Südosttangente motorway. On this scale, the S1 motorway shows high values as well. However, S1's potential *through-movement* is higher thant that of Himberger Straße. This correlates with real-time car traffic figures for Vienna[23].

On the **local scale**, almost the entire settlement benefits from *walkability*. Even links to adjacent Oberlaa can be identified. The intersection of Himberger Straße and the new *central axis* will form the local centre in this draft. Furthermore, it creates its own sub-centre as well as linking to the adjacent commercial zone along Oberlaaer Straße and the grid system is clearly highlighted.

When comparing Greater Vienna 2012 and 2014 and Rothneusiedl, however, Rothneusiedl primarily affects the existing structures to the north. The western and southern parts show no change in their values for potential *through-movement*. This indicates that more strategic connections are needed to link local centres such as Maria Lanzendorf or Himberg in the very south. *Stepping stones*[24] within walking distance could improve the functionality of Rothneusiedl, which is currently isolated from other sub-centres.

[23] cf. ASFINAG Traffic Statistics Report, 2013

[24] Space Syntax Ltd. 2012

CONCLUSION

OUTLOOK

4. Conclusion and Outlook

This study has investigated the impacts of infill and peripheral development on the spatial structure of Vienna and its surrounding municipalities (Greater Vienna).

4.1. Summary and Conclusion

All of these local centres have more in common than just their high potential in terms of accessibility; they also serve as popular shopping areas for the neighbourhood. This corresponds with *natural movement* findings (Hillier et al, 1993), in which the author identified a relationship between spatial configuration and movement.

Highways do not have the highest values generally, even though they represent major connections within the Vienna Region. The reason is rooted in the way highways are designed, i.e. for high-speed vehicular traffic. They therefore have controlled access, fewer intersections and are free of any at-grade crossings. In terms of accessibility they are thus less integrated into the city system.

More interesting though are settlements with low local *choice values*. They represent completely isolated areas which cannot pick up on the benefits of *through-movement*. Within all Greater Vienna Models, districts such as Donaustadt and Floridsdorf in the north and east of Vienna and some parts of Meidling along Grießergasse and Am Schöpfwerk in the south-west can be identified as such areas. Settlements of so-called local *choice value* are of greater interest.

In contrast to Favoriten, some sub-centres form continuous linked paths to neighbouring sub-centres; for example, a clear string of sub-centres in the south can be identified: Atzgersdorf, Perchtoldsdorf, Brunn am Gebirge and Mödling. Along this line of villages, huge residential, commercial and industrial areas correlate to the accessibility values.

Areas with low potential *through-movement* values can be identified in the south-east and beyond the Danube. These are mono-functional areas with the focus either on industries (south-east, next to Rothneusiedl) or on huge housing developments. In contrast to the 800m radius, local sub-centres like Floridsdorf (centre), Kagran and Stadlau across the Danube (Floridsdorf and Donaustadt) even show high values on this scale. This correlates with recent and upcoming upgrading programmes by the City of Vienna[25].

[25] Cf. Urban Development Plan *STEP 2025*, City of Vienna

As the results suggest, inner and peripheral developments have marginal impacts on the global scale in terms of *accessibility* values. Concerning the local accessibility values, inner and peripheral developments have only a minor impact on the system, if at all. More detailed investigation is necessary to understand the impacts on the local scale.

However, comparing the Vienna Main Station and Rothneusiedl models, the higher effects of peripheral developments can be identified on the local and global scale. The *grid intensification* in an already very highly integrated and well-connected part of the city must have more substantial spatial interventions in its configuration. The project area of the new rail station and the Sonnwendviertel development zone complement existing urban structures and create new strategic connections between the 10th, the 3rd and 4th districts.

Favoriten (the 10th district) remains in its island-like position: although very integrated into the wider city system, it can benefit from new connections of Alfred-Adler-Straße to the 3rd or 4th districts on a local scale.

Reviewing Rothneusiedl's strategic location along the main global routes of Himberger Straße and the S1 motorway, the new peripheral structure hardly enhances or affects existing segments on a global scale. Himberger Straße remains the most global major connection to Greater Vienna (Model). However, links to the adjacent settlement of Oberlaa indicate a high potential for well-connected neighbourhoods on a local scale. This new walkability could be the starting point for a vital urban structure.

In Hillier's paper *A theory of the city as object* (2001) he examined a large number of axial maps to establish that socio-cultural factors generate differences on a certain local urban layout. The different geometry also reflects syntactic differences, so Hillier identified syntactic average values for 58 cities (subsamples). He compared the values for connectivity, local and global integration and intelligibility and detected different characteristics for American, European and Arabian cities.

When comparing these values with the Greater Vienna Model, Vienna shows a lower local integration than the average for European and American cities. However, global integration and intelligibility are hardly comparable due to the different system sizes. The consideration of municipalities on the Vienna city boundary implies spaces that are less connected to the whole system and reduces the average values - the so-called *edge effect*.

Socio-spatial effects of inner and peripheral developments can be identified using space syntax theory and serve as a useful tool set for model-based decision-making in urban planning.

However, a space syntax model could link with the precondition of an overview to create a composite model of urban assessment. Furthermore, the applied analytical model helps to evaluate design options and effectively inform and enhance the decision-making process for new urban developments.

4.2. Outlook

Space syntax theory mostly analyses the urban morphology in two dimensions. The question of the third dimension when modelling an urban system seems very interesting. Are there effects in terms of route choice and orientation because of building heights? How can graph measures capture a more realistic description of the real world? Research into these questions is currently being carried out by Mavridou (2012).

The intention of proposing a space syntax analysis is not to make a designer's work redundant. It is a technocratic approach that provides for a good result in terms of a mathematical evaluation – and one that delivers immaculate results that would be unlikely to be achieved through drawing methods performed by hand.

In terms of practical usage, the majority of inner development potentials within Vienna are obvious. Currently, municipal department MA 18 (Urban Development) is intensifying infill development throughout Vienna. However, government officials still do not see space syntax analysis as a source of reliable data. They have faith in their own wide range of different analysis tools, mainly based on automated traffic models with a very detailed degree of information.[26]

At the moment, the Vienna metropolitan region faces difficulties due to different development dynamics and the lack of formal instruments for cooperation. Therefore, cross-border cooperation is essential. Vienna already works with Lower Austria at SUM[27] and gives guidelines for spatial development. Rothneusiedl lies directly on the Vienna state border, and with the findings regarding its potential for linking adjacent settlements for a walkable friendly neighbourhood and its potential as a *stepping stone*, it can fulfil a role in the sustainable development of the future South Vienna and Lower Austria Region.

However, taking Vienna's surrounding municipalities into account, the metropolitan region level becomes more important on account of the competition among municipalities. This research argues for an analytical approach to urban development based on spatial configuration. Space Syntax methodology provides an efficient method of analysis to explore the functionality and accessibility of the Greater Vienna Region as an urban system. For more detailed study, especially with regard to socio-spatial effects, further data and surveys are needed.

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[26] Interview with DI Augustin, Municipal Dept. MA 18, City of Vienna, 4 February 2013

[27] Metropolitan region management of Vienna and Lower Austria developing informal planning strategies of future cross-border developments.

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List of Figures and Tables:

All figures, visualisations and tables are the work of the author, except for some additional sources. The basic map for modelling, the aerial map of Austria, was provided by GDI of the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management by WMS-Account, July 2012. The City of Vienna , Municipal Department MA 18, supplied additional maps and documents.

List of Tables:

Programs for modelling and empirical analysis:

Adobe Illustrator
Adobe InDesign
depthmapX, University of London
MapInfo Professional, Pitney Bows Software
Space Syntax Confeego, University of London & Space Syntax Ltd.

APPENDIX

Appendix
A) Values for Specific Street Segments

Main Train Station:

In order to see how the system changes when it expands through grid-intensification, the following figure and table illustrate the effects on specific segments of the new developments at Vienna Main Station

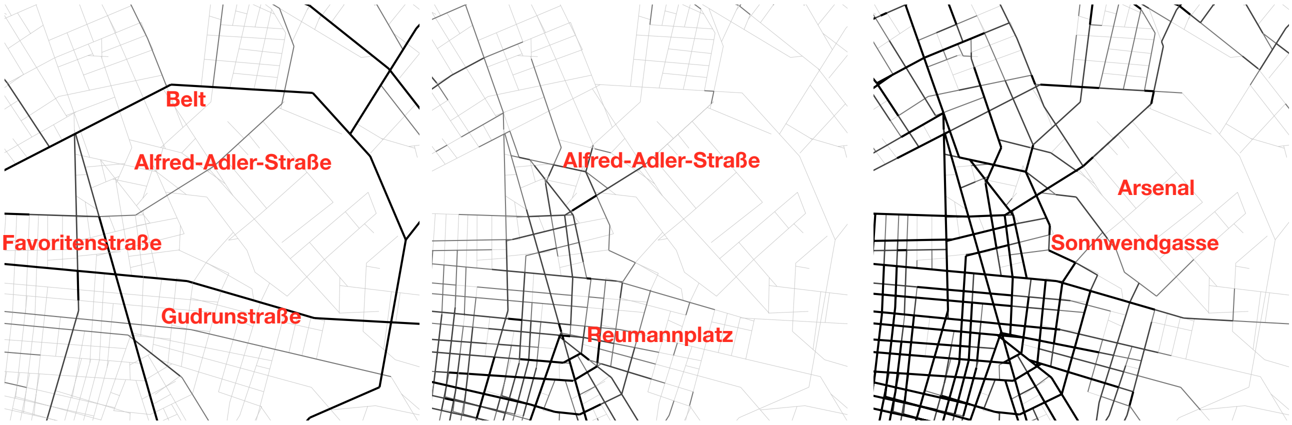

Figure xx. Choice N, 800m and 1200m ZoomVienna Main Station

Figure xx: Effects on specific segments due to grid-intensification, choice 1200m; Greater Vienna Model 2014

Model 2012 | Model 2014			
segment (street)	**attribute ch_800m**	**attribute ch_1200m**	**attribute ch_N**
Sonnwendgasse	2.86 | 3.51	3.54 | 3.89	5.23 | 5.75
Landgutgasse	3.11 | 3.60	3.45 | 4.07	5.92 | 6.73
Arsenalstraße	0.78 | 1.26	2.02 | 2.68	6.16 | 6.13
Gudrunstraße	2.83 | 3.21	3.44 | 3.74	7.84 | 7.84
Favoritenstraße	3.54 | 3.57	4.20 | 4.30	7.64 | 7.64
Wiedener Gürtel	2.78 | 2.97	3.49 | 3.68	8.09 | 8.09

Figure xx: Effects on specific segments due to grid-intensification, choice 1200m; Greater Vienna Model 2014

Rothneusiedl.

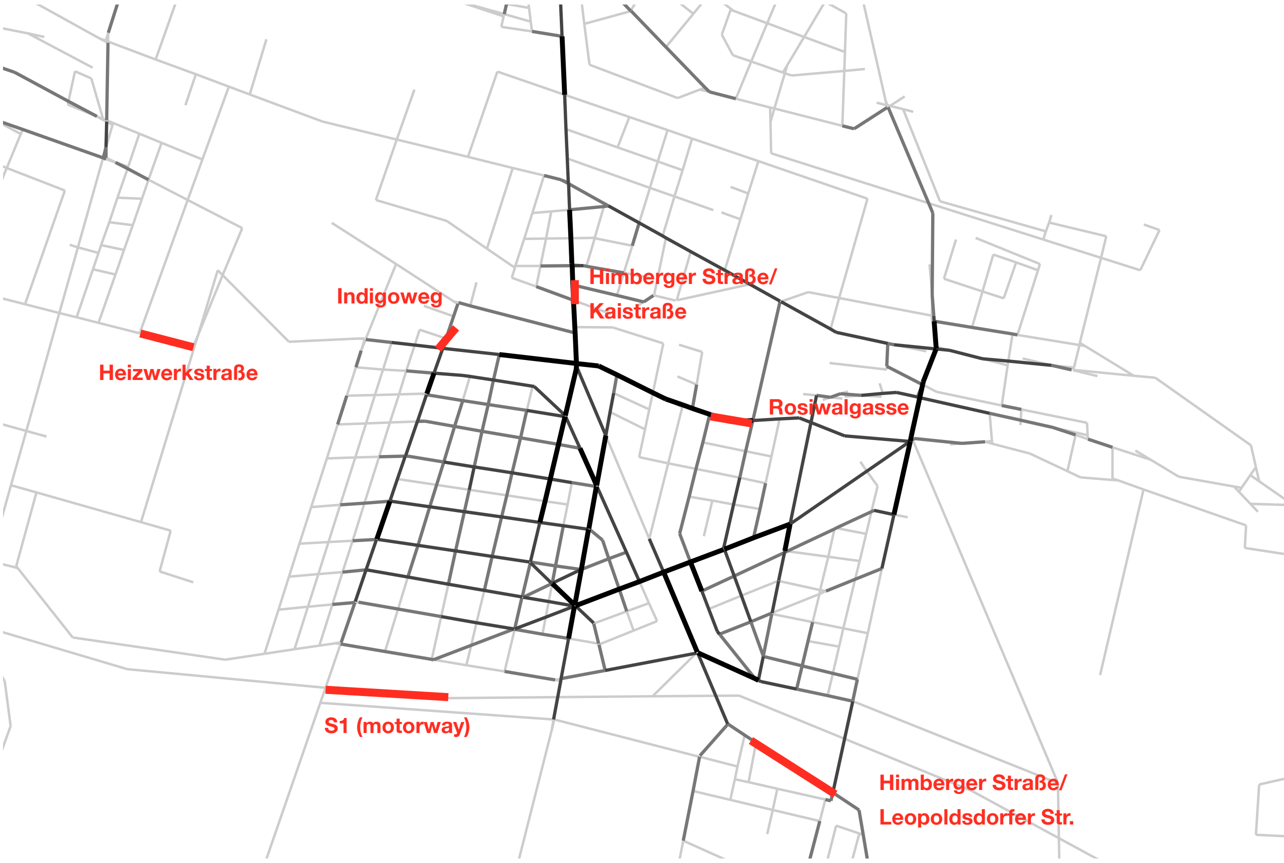

Figure xx: Effects on specific segments due to peripheral expansion, choice 1200m; Rothneusiedl, own processing

Model 2012 | Model Rothneusiedl

segment (street)	attribute ch_800m	attribute ch_1200m	attribute ch_N
Himbergerstr./ Kaistraße	3.17406 | 3.49707	3.61194 | 4.10058	7.91004 | 8.15351
Rosiwalgasse	2.40993 | 3.01368	3.01745 | 3.72107	5.92833 | 6.89663
Himbergerstr./ Leopolsdf.	2.0607 | 2.39445	2.49831 | 3.01953	7.82979 | 7.72354
S1 (motorway)	0.30103 | 0.60206	0.30103 | 1.62325	7.14598 | 7.16292
Heizwerkstraße	2.19033 | 2.19033	2.7167 | 2.71349	4.9113 | 6.17268
Indigoweg	2.1057 | 2.97589	2.48001 | 3.45209	4.35056 | 5.17923

Table xx: Choice values of specific segments in comparisons of Model 2012 and Rothneusiedl Model, own processing

No effects can be measured on the local scale for minimum and maximum values. However, raised average values can be identified for both developments (inner and peripheral developments). This seems to be because of additional elements within the system.

Slight effects on the system are marginal; the global values are raised because of additional elements in the system, but no effects on minimum attributes can be identified.

B) Why Rothneusiedl?

1. Statistics: Population growth at registration district level:

(Kleinräumige Bevölkerungsprognose für Österreich 2010 - 2030 ÖROK Forecast, total population beginning year 2009=100, highest %, districts which are covered by Greater Vienna Model 2012)

District	2010	2020	2030
	NÖ		
Schwechat	101.4	115.3	127.9
Korneuburg	101.0	111.6	121.8
Mödling	100.7	109.1	116.9
Baden	100.9	111.2	120.4
Wien-Umgebung	101.2	113.6	125.0
	Vienna		
Stammersdorf			
Großjedlersdorf			
Kagran			
Breitenlee			
Hirschstetten			
Aspern			
St. Marx			
Kaiserebersdorf			
Rothneusiedl			
Atzgersdorf			

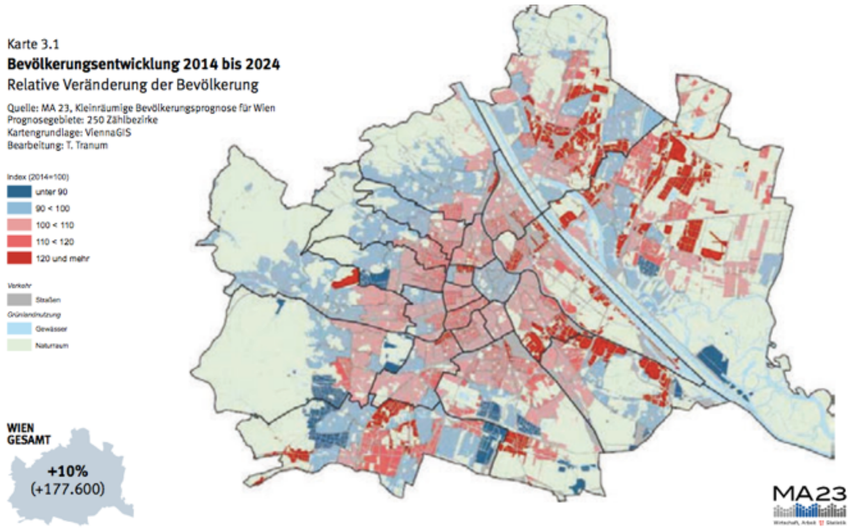

Table xx. Statistics, population forecast Greater Vienna Region, source: ÖROK, City of Vienna, p. 114/115; date: 2010

As stated in the introduction, the Greater Vienna Region has the highest population growth among all major European capitals. Statistics clearly show high population growth forecasts for Lower Austria and Vienna.

Planning interventions based purely on statistics give no guidance as the potential new development areas, especially when the population growth forecast almost exclusively predicts growth for the whole Greater Vienna Region. Therefore, further factors are needed:

Stadtregion+ *(Cityregion+)*

Initiated by Planungsgemeinschaft Ost (PGO), Stadtregion+ focusses on strategies for spatial developments in the eastern region of Austria. This project involving the states of Vienna, Lower Austria and Burgenland places the emphasis on future settlements, options for action and guidelines for spatial developments at state level for Vienna and its surrounding municipalities.

STEP 2025

The Urban Development Plan 2025 (STEP 2025) is an informal planning instrument that has been formulated in a broad-based discussion, information and participation process in Vienna. It deals with the entire city and formulates strategies and guideline concepts. The plan sets out the administrative vision for urban development of settlement structures and highlights potential areas for housing and workplaces.

2. Administrative Planning Intentions - Stadtregion+ (PGO) and STEP 2015 (Vienna)[28]

District	PGO / STEP 2025
	Lower Austria (NÖ)
Schwechat	focus on urban development
Korneuburg	focus on urban development
Wien-Umgebung (Gerasd.)	n.n.
Mödling	focus on urban development
Baden	focus on urban development
Wien-Umgebung (Süd)	regional development
	Vienna
Stammersdorf	area with development potential
Großjedlersdorf	development potential and sub-centre upgrading
Kagran	potential; upgrading; priority zone
Breitenlee	n.n.
Hirschstetten	area with development potential
Aspern	potential; upgrading; priority zone
St. Marx	development potential and priority zone
Kaiserebersdorf	development potential and sub-centre upgrading
Rothneusiedl	area with development potential
Atzgersdorf	development area and established sub-centre

Table xx. Administrative planning intentions, source: STEP2025 and Stadtregion+, date: 2014 and 2011

[28] Stadtregion+ p. 49; STEP2025 p.67

3. Analysis of Accessiblity:

To delimit potential development areas, factors such as peripheral location, development potential and upgrading of sub-centres are necessary. The most interesting areas can be identified as Schwechat in combination with Kaiserebersdorf; Stammersdorf in combination with Großjedlersdorf, and Rothneusiedl because of its closeness to Oberlaa (development potential and sub-centre upgrading)[29]

Major projects such as Aspern, for which a space syntax analysis by G. Hartl (2010) based on a model by C. Yamu (2007) already exists, and very urban areas such as Kagran and St. Marx are not relevant as peripheral development areas for the purposes of this research.

In combination with statistics, the analysis of accessibility values (global and local scale) of defined sub-centres is an appropriate starting point.

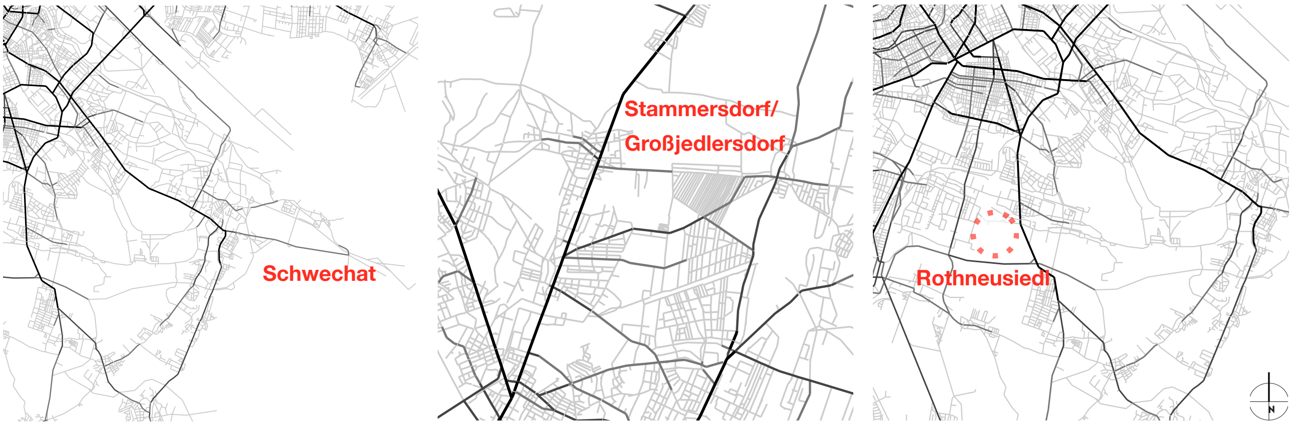

Figure xx. Coice_RN; Greater Vienna Model 2012

Spatial accessibility
high
low

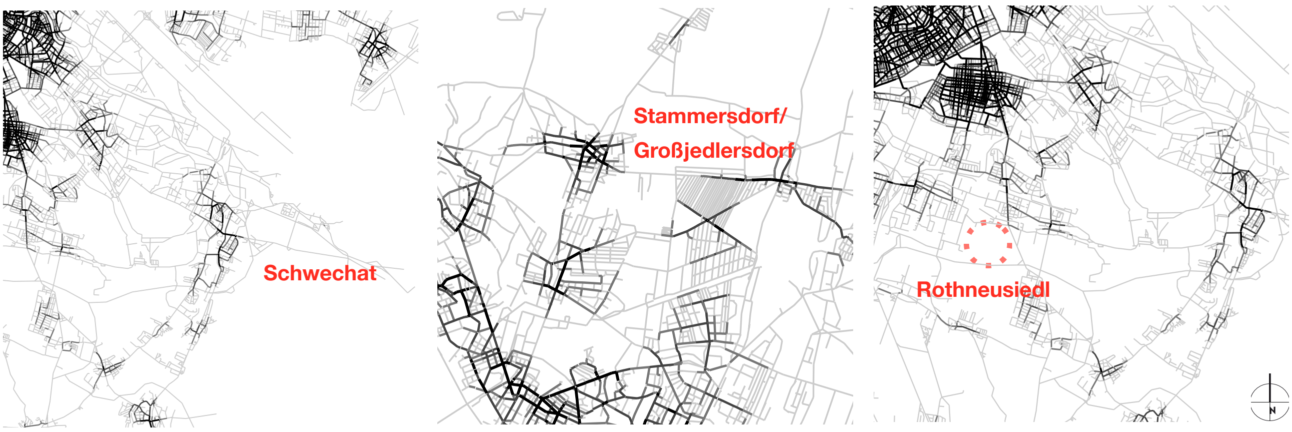

Figure xx. Choice_R1200m; Greater Vienna Model 2012

[29] See map: Mission Statement for Urban Development, STEP2025, p.67

Schwechat is already located on the very global route Simmeringer Hauptstraße and shows high local values, indicating an existing sub-centre. However, it has low choice values on the local scale of 1200 m.

Stammersdorf lies on the main route Brünner Straße and is quite well connected on the global scale. On the local scale, historic Stammersdorf can be clearly identified; however, there is an obvious lack of links to Großjedlersdorf to the south.

Finally, Rothneusiedl is framed by the main road Himberger Straße and the S1 motorway and shows highest values on the global scale. At this point there is no sub-centre in close proximity, though Oberlaa to the north-east shows minor sub-centre tendencies and could possibly be connected through new developments

Briefly summarised:

District	Statistics (2030)	Planning intentions	Accessibility
Schwechat/ Kaiserebersdorf	+27.9%	development area and sub-centre upgrading	higlhly on global scale weak on local scale
Stammersdorf/ Großjedlersdorf		development area and sub-centre upgrading	highly on global scale high on local scale
Rothneusiedl/ Oberlaa		development area and sub-centre upgrading	highly on global scale high on local scale

There are equal reasons to choose each of them. The decision in favour of Rothneusiedl was because of the possible connection to Oberlaa. Additionally, design ideas are already available for Rothneusiedl and the city officials have planned an extension option for underground line U1.

Furthermore, Rothneusiedl has less restrictions at the environmental level: Schwechat faces onto the Danube wetlands; Stammersdorf - Bisamberg is a planned new recreation area. Finally, Rothneusiedl has been under discussion for years for upgrading and developing as a sub-centre in the very south of Vienna.