The flow of people as an indicator

for the appraisal of HST related strategies and interventions into urban space

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Final Report

HIGHSPEEDTRAINS

Final Report: 12th April / 21st Juli 2007

The flow of people as an indicator
for the appraisal of HST related strategies and
interventions into urban space.
The case of the City - Tunnel Project in Leipzig

Attended by Buiten Consultancy, Utrecht
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Based on the Master Thesis
at the Institute for European Urban Studies
Bauhaus University Weimar
attended by Prof. W. Christ / Jun. Prof. F. Eckardt
January 2007

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Pictures Title:
C. Schaber and http://www.hstimpactstudy.net/

Content

Introduction

This paper divides into a theoretical and a practical part. The former describes the relevance of the flow of people for urban development and the appraisal of HST related issues. Further Space Syntax and its main ideas and measures are introduced, like the role of axial maps and their preparation for example. Part one also contains background information about the collection of data on site in Leipzig (Chapter 1.3). Additionally Space Syntax is related to the current scientific context as regards human locomotion. In doing so user-based approaches are compared with the spatial orientated method of Space Syntax (Chapter 1.4).

The second part exemplifies the case of the City-Tunnel Project in Leipzig, Germany and the practical use of the Space Syntax method. The project stands for the implementation of a future regional train network in the wider metropolitan area of Leipzig and Halle. The layout of the future network and its urban integration are of equal importance. The case study focuses on the role of the City-Tunnel Project as a catalyst for higher pedestrian frequencies in central Leipzig. The measure is accompanied by a set of public and private investments located inside and around the city centre. Public space can be seen as a mediator between transport infrastructure and urban development.

The City-Tunnel will be the core of the future regional train network in the Leipzig - Halle conurbation. Four new underground stations are the principal elements of the new rail infrastructure. The stations function as a interface between the public transport system and urban space. Within the paper Space Syntax is utilised for the analysis of urban space and the simulation of human locomotion. An axial model of the urban layout of Leipzig was used as a basis for the case study. The radius of the model covers approximately 6 km around the city centre and consists of over 7,000 axial lines. The large size of the model enables the use of one model as a basis for examinations on three different levels and scales. At first the relation of different local and regional train network and urban space is examined. The accessibility of stops and stations and the layout of the transport network in relation to urban space are the main issues outlined in chapter 2. The scope of the analysis involves the major areas of the public transport network. The second examination refers to the surrounding of the new City-Tunnel stations in the city centre and covers a much more detailed area. While the former analysis was based on the spatial configuration the focus of chapter 3 lies on the observation of pedestrian flows. The observations were carried out in September 2006 utilising the gate method. The evaluation of the pedestrian data was carried out according to Space Syntax techniques, i.e. *people - space correlations*.

Finally an inner city development area is subject of comparative simulations. The relevance of Interventions into public space is tested by means of axial models referring to the years 2000 and 2015. These simulations aim at strengthening existing spatial potentials and identifying reasons for the disregard of certain areas. As a result areas of prioritised investment in the public realm can be highlighted. Finally an exemplary proposition is made for the better integration of the *Central Station* and the new *Museum Quarter* (cp. chapter 3.5).

Chapter 1
The flow of people

"*The dynamic flow of people is one of the fundamental conditions for a liveable urban environment*" (SEEDA 2006, p.7).

1.1 The flow of people and urban development

If we talk about places that are alive these are often associated with an economic well-being. In contrast segregated places are considered to be less attractive and they might even be a threat for safety. Train stations and their urban surroundings are a very interesting issue in this regard. On one hand they can be implicated to contribute to a high quantity in the flow of people. But then there are also segregated areas in their urban surrounding which often offer a reduced level of safety. As a result the absence of human movement can be seen as a negative factor in station areas. However the flow of people also leads to capacity problems within stations and in relation with connecting public transport services. The accessibility of stops and stations is an important factor for attractive public transport systems. This includes both the last kilometre as well as transfers within a journey. In this regard the term "travel chain" describes the entire trip from a starting point to its final destination. It is assumed that a better understanding of the flow of people contributes to tackle challenges like the missing link from the train station to the city centre, inadequate accessibility, safety problems, the deprivation of surrounding areas and the poor image station areas face in many locations. The research aims at finding answers on questions like, why is the link from the station to the centre underused, why do people avoid certain places, and what can be done to improve the accessibility ?

Another aspect is the increased acceptance of non-motorised transport users like pedestrians or cyclists. Today many cities and towns have produced development plans that prompt walking and cycling. Both modes of locomotion can be used to improve the accessibility of stations and adjacent urban areas. New developments are often marketed highlighting the advantages of nearby public transport links. Thus the last kilometre of the travel chain is very much related to walking and cycling. In recent years many cities and towns have embarked on tourism-orientated strategies. Their aim is to bring more people from outisde into the relevant urban areas. Therefore higher revenues for commercial, cultural and leisure facilities can be generated. However if the accessibility of an area is not enlarged, revenues are likely to be just redistributed. In contrast the improvement of accessibility and the extension of the relevant catchment area is believed to bring added value to cities and towns. The City-Tunnel project in Leipzig, that is part of the case study, is a striking example for that (cp. fig. 10). Generally speaking, a visitor-friendly urban environment requires specific attention to the orientation of visitors in public space. This involves the integration of train stations into the public realm. Yet guidance to the station is not only a benefit for visitors but is also useful for all other transport users. The regional integration of cities and towns in terms of rail-bound transport infrastructure is a current issue that leads to questions about changes of mobility and commuting habits. In terms of urban development in the surrounding of new public transport infrastructure a previous European study named TranSEcon (TranSEcon 2003, p.35 et sqq.) monitored an increase in commercial uses in inner-city locations and simultaneously an increase in housing demand in the surrounding region. The same study that will be addressed in more detail in chapter 3.3 also lists positive circumstances that led to successful public transport investments. One important aspect is the willingness of municipalities to invest into public space in the areas around the new or modified stations. Such investments into the public realm usually aim at stimulating and securing further investment regarding a certain area. Therefore cities need to be concerned about an effective use of public money. In this regard frequented spaces are often associated with liveable places. The flow of people can be a useful measure to find locations for prioritised investments. For example, the provision of new regional train stations improves the accessibility of the station surroundings. The layout of new public spaces connecting station and a nearby future development area is a potential municipal investment. The northern city centre in Leipzig exemplifies this task (chapter 3.4).

1.2 The Space Syntax Method

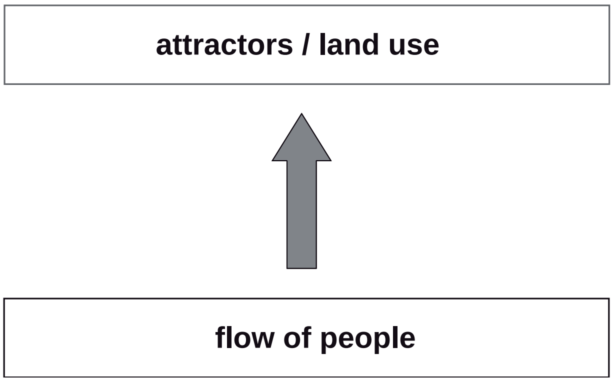
Space Syntax is used as a tool to examine the relation of urban space and its use. It is argued that the collective human behaviour in urban space can be determined and thus predicted. After Space Syntax the use and avoidance of urban areas is due to the spatial configuration of a town or city. In this regard the term *Natural Movement* describes the rate of spatially determined human movement.

Natural Movement

The study of the flow of people is the subject of various approaches. There are for example frequency atlases. In Germany these map the flow of vehicles, public transport and pedestrians. Their use is mainly focused on outdoor advertising and is not yet available for research purposes. Furthermore there are scientific examinations about human locomotion in general and the flow of people in particular that will de discussed later (cp. chapter 1.4). Space Syntax was chosen as an appropriate method for the examination. It is used for more than 20 years and provides powerful tools for research purposes. Finally public space as a municipal domain is the subject matter of the method. The theory of *Natural Movement* belongs to the most fundamental achievements of Space Syntax. There after the use of public space is dependant on its spatial layout. The findings derive from various research projects. The term *Natural Movement* describes the rate of human locomotion that is due to the configuration of urban space.

As one of the protagonists of Space Syntax, Prof Bill Hillier is convinced that this knowledge marks a significant change in the perception of the city. Because It is generally assumed that attractors and not the urban configuration are the most important originator of human locomotion. But It is not the relevance of attractors as such that is in doubt. Space Syntax attributes their position to the urban configuration (Hillier 2005, p.11). The method derives from the University College London (UCL). Since the beginning in the early nineteen eighties further theories and tools to facilitate the use of Space Syntax were developed. Since then the theory of *Natural Movement* has been proven in many cases. In recent years the work of Space Syntax formed the basis for the recrea-

Fig. 1a
Classical relation of movement and land use: It is normally understood that human movement is generated through attractors and land use respectively. (Illustration: C.Schaber)



tion of the Trafalgar Square and the development of the Millenium Bridge in London. Both projects were designed by Sir Norman Foster. The simulation of human locomotion is seen as an important indicator for the future development of public space. The case study in Leipzig will focus on the surroundings of the future City-Tunnels stations in the centre of Leipzig. The analysis will be used to appraise the spatial impact of the City-Tunnel project. The method requires basic mathematical and statistical knowledge as used in the network sciences. Generally Space Syntax does not specify these terms and expressions. Although there is a range of publications in the realm of Space Syntax a manual or starter kit does not exist so far. Today the books The *Social Logic of Space (1984)* by Hillier and Hanson and *Space is the Machine (1996)* by Hillier can be regarded as standard works.

Urban configuration

Space is seen as the origin for examinations to gain evidence about human movement behaviour. In this regard urban space is seen as an intrinsic part of human activity. The social meaning is deduced through spatial analysis. The social logic of urban space can be either studied through the physical layout of urban space or in the way people use and frequent urban spaces (Hillier 2005, p.2). As a result form and structure of the built environment are used as a starting point to elaborate their social aspects.

Public space consists of many single elements like streets, boulevards, alleys, paths, places, parks etc. Space Syntax uses the expression configuration to describe the complex relation between all these spaces. The most important notion is that the essence of urban space cannot only be described through the characteristics of its single elements. The complexity is caused by the interaction of various spatial entities. The dynamic development of real estate prices is used as an example for that. The interactions within a spatial system differ from the result that is just the addition of single elements. This matter is also called *emergence*[2]. The term is not typically used by Space Syntax but helps to understand meaning of configuration. The interpretation and representation of streets, paths and places as mathematical graph enables the calculation and identification of complex spatial relations. For this purpose Space Syntax has developed a set of variables that help to “make buildings and spaces speak” (Agora 2004, p.17). The calculations are usually processed with the help of computers. In this regard every single element in urban space receives

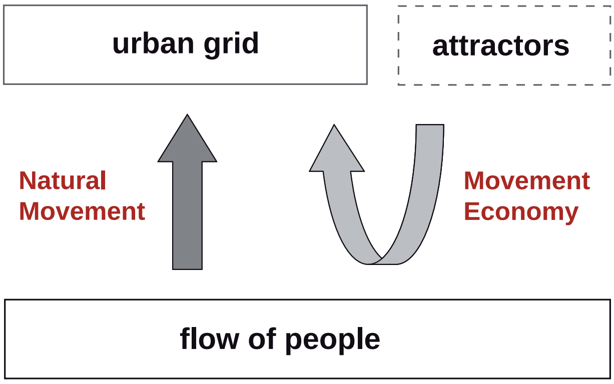


Fig. 1b
After Space Syntax the urban grid plays a key role for the generation of human movement. This is reflected in the notions of Natural Movement and the Movement Economy. (Illustration: C.Schaber)

an individual value called J-graph or justified graph[3]. Dependent on the root from which a system is regarded there is a different Interpretation of the same system. "A spatial layout not only looks different but is different when seen from different points of view in the layout" (Hillier 2005, p.6). One of the earliest and most important variable for calculation is Integration.

After Space Syntax movement and interaction are the two different ways of human spatial behaviour. The distinction of both can be made through their spatial structure. Movement is described as linear process whereas interaction forms a so called geometrically *convex space*[4]. The structures are regarded as a key for the understanding of how urban spaces evolve and how they are used. The different kind of locomotion is reflected in the formation of analytical models. The paper focuses on axial modelling which is suitable for the examination of cities and towns that mainly consist of streets.

Modelling of urban space

In 1998 the consultancy Space Syntax Limited was founded in London. The urban task force was set in place in the same year aiming at practical solutions for vibrant cities and towns. Their list of recommendations involved the improvement of walking and cycling in urban surroundings. The initiatives generally sought to improve the role of planning. Since then Space Syntax offers services such as data collection of human spatial behaviour, the modelling of urban space for simulation as well as advice in Master planning. The following description about the use of the method is based on the technical status of 2006 and is orientated at the practical work of Space Syntax Limited. A four week internship there was a helpful basis for the preparation of this report.

The notion of axial maps is a central element in the work of Space Syntax. The maps involve all the elements of public space within the selected study area. The size of an axial model depends on the way of locomotion to be examined (pedestrians, cyclists, car, public transport). It is recommend using a distance of about 30 minutes around the study area. The preparation of axial maps requires the division of public space into single elements. How can urban space be subdivided ?
The smallest element, the axial line is defined as the longest straight line that can be seen and walked. The principle of creating axial maps is to use the fewest possible number of axial lines that cover the entire study area. The definition is backed by the cognition about human locomotion.

Fig.2 a-e
From street map to graph
(Illustration: C. Schaber)

a Plan of northern city centre   **b** Axial model

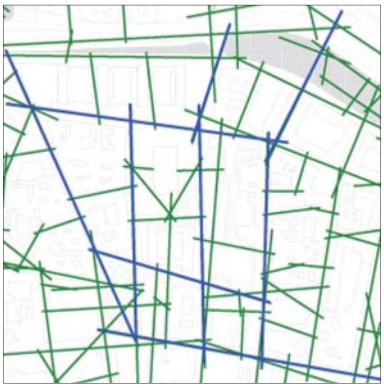
Human beings generally use the shortest path possible to reach a destination. Thereby human orientation is mainly directed by vision. The ring road around the centre of Leipzig is formed by a range of sections. Each of which possesses an individual name. These sections correspond almost precisely to the segments of the axial model.

Syntactic Measures

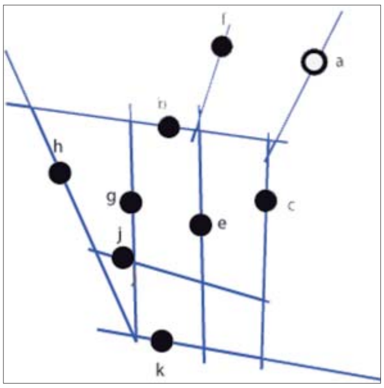
As described, axial modelling permits the calculation of spatial relationships on the basis of the *graph theory*[5]. In this regard Space Syntax uses different quantitative variables referring to the spatial characteristics of an axial model. The variables are called measures and describe those spatial relationships that meet social behaviour and utilisation in the best way. There are numerical, metrical and syntactical measures. The latter are central to syntactic analysis involving the description of spatial relations.

A sophisticated treatment of a study area is enabled through the use of different radia. *Global measures* reflect the relation of a single element to any other element in the system. In contrast *local measures* only reflect adjacent elements that are situated within a certain topological distance. As a result the change from one element to the next marks one step. The radius defines how many topological steps a close-by element can be situated to be involved in a calculation. Each axial line receives different values in dependence of the given radius. *Radius 3*, for example involves all the spaces that can be reached within 2 topological steps. Practice has shown that different radia match certain patterns of use in an urban context. *Radius 3* (2 steps away) corresponds to local, spatially limited activities whereas the global radius Rn corresponds to distant relations and activities of a large scale. The list below indicates the most relevant syntactic measures for this paper:

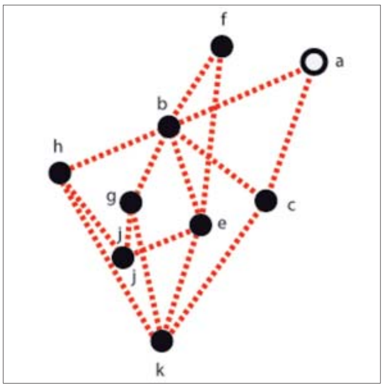
Integration — describes the accessibility of urban space within a spatial system. High *Integration* values indicate a high rates of movement and are often equivalent with vibrant areas. In contrast low *Integration* values indicate low movement rates and are found in segregated areas (Agora 2004, p.35).



c Exemplary selection (blue)



d Each axes represents a node



e Computable model, nodes and edges

Global Integration — *Integration Radius n*
Reflects the spatial relations within the whole system or study area. Global integration often corresponds to the movement of cars. The wide-stretched movements are usually associated with the activity of tourists and visitors.

Local Integration — *Integration Radius 3*
corresponds to pedestrians movements using short trips to nearby destinations. It is usually associated with locals or inhabitants of an area.

The above analogies are based on practical evidence using observation techniques and syntactic calculations. *Integration* is one of the initial and important measures of Space Syntax. It can be stated that the measure is robust enough to meet the criteria of movement and interaction (Hillier and Penn in: Agora 2004, p.35).

Angular Analysis

Over time the continuous enhancement of the method leads to new and complementary measures for the calculation of spatial relationships. The Angular Analysis requires an additional process in generating single measures. In this regard, the axial model is imported into a special computer program. The Depth Map software was exclusively developed at UCL in London and aims at refining the classical axial models. However these remain the basis of each examination. At first the axial lines are segmented. A segment is situated between the crossings of different axial lines. The implication of angles is another important aspect. That way Angular Analysis offers the detailed regard of long axial lines and the use of metric radia. During a conversation about the Leipzig case Prof Hillier stated that Angular Analysis is the norm of Space Syntax research today (Hillier 2006). Thereafter the axial model for Leipzig is split into more than 20,000 axial segments.

Choice *Through-movement*
is an indicator for how often an urban space is used for through-movement. The measure assesses links from each single space to all other spaces in the study area. The calculation refers to the shortest possible link. In contrast to Integration measures, metric radia can be determined. Generally speaking the measure is used to indicate a assumable hierarchy for the use of public space.

Mean Depth *To-movement*
Indicates the average distance of a single space to all other spaces in the study area. The distance can be both topological and metrical. The measure represents the average proximity one space has in relation to all other spaces in the study area. Whereas *Choice* is also described as *Through-movement, Mean Depth* can be explained as *To-movement.*

The use of axial models for simulation
The generation of multiple axial models referring to different phases of urban development gives sound opportunities to compare the different stages. This aspect can be used for either historic analysis or the simulation of future scenarios. The latter is used along with the case study in Leipzig. To this end the current axial model (2006) is altered mapping the years 2000 and 2015 of a particular development area located between the two most important regional train stations in the future. The alterations refer to those schemes that have a spatial impact, like improved ring road crossings for example. The scenario 2015 is built upon municipal strategies for central Leipzig.

The case study shows the creation of improved entrances to the city centre. These new entrances mark a significant interface between the pedestrian orientated spaces in the centre and the surrounding spaces that are dominated by a multi-modal use. The axial models can be used for all modes of locomotion as long as the scope of the study area has been chosen appropriately, i.e. a 30-minutes radius around the area of interest. As outlined above small radia like the topological *Radius 3* or the metric *Radius 400m, 800m* correspond best to pedestrian movements. Whereas expanded movements of *Radius n* or the metric *Radius 2400* and bigger rather correspond to the movement of vehicles.

The Space Syntax colour range
After the calculation of the above measures the non-discursive and complex relations must be retranslated. This process is undertaken by using thematic maps. The maps help to visualize and communicate the syntactic relation of spaces. Thematic maps illustrate syntactic values in attributing all elements to a limited number of colours. For the better understanding of the thematic maps the classical Space Syntax colour range was utilised. This range runs from red to blue. Red means integrated and well accessible, blue means segregated or poorly accessible. The detailed attribution of single colours can be undertaken specifically.

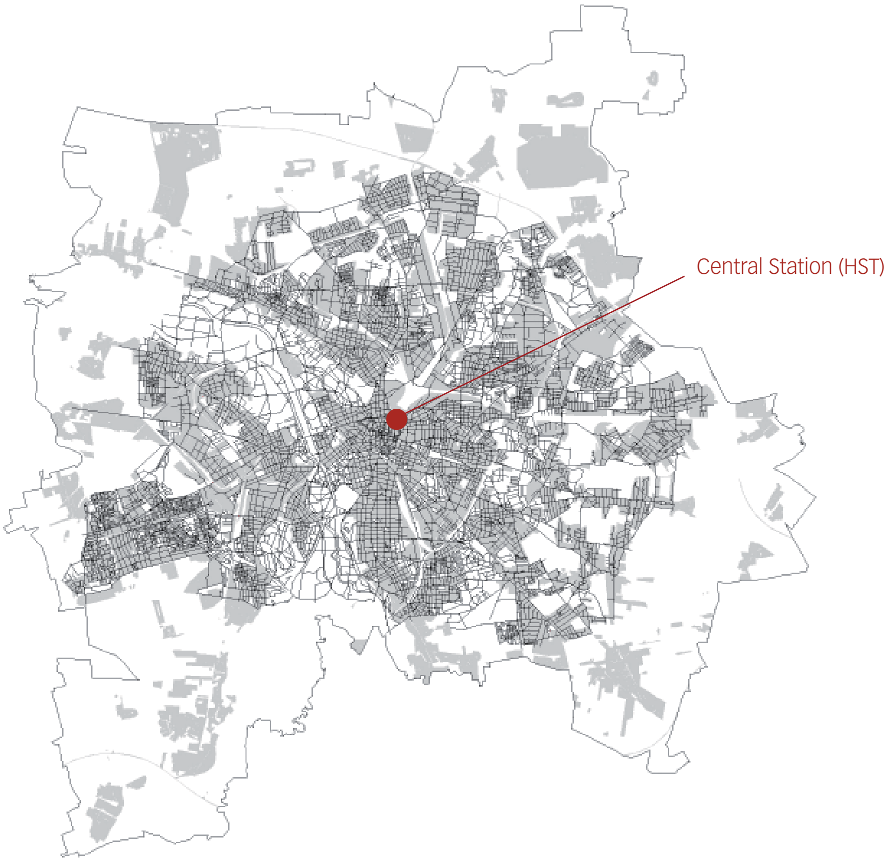


Fig.3
Axial model of Leipzig related to administrative boundaries. (Illustration: C.Schaber)

1.3 Data collection

Observation methods
The collection of data as regards human locomotion in urban space is an important activity of Space Syntax Limited. At first the explication about the purpose of observations appears paradoxical. An internal manual explains: "we observe (..) to see how much we can learn about the environment without taking account of peoples intensions" (Space Synax 2006, p.1).

The quotation shows that the patterns of the collective behaviour matter for Space Syntax rather than the individual behaviour. Generally spoken the aim is to collect objective environmental information. Space Syntax offers a set of techniques and methods that can be adjusted to all kind of needs. The *Gate-method* is a technique that is often used in the urban context. As the term gate expresses those persons are counted that cross an imaginary line. The line is thought at right angle to the street. The *Gate-method* can be called a workhorse among the observation techniques and is widely used also in Germany (EuV 2003). The technique is suited for the count of persons and vehicles in motion. In practice one collects as much different categories as possible. The choice of various categories is dependant on the subject and local circumstances.

The case study involves 26 different gates in the centre of Leipzig. The collection of data took place within 10 days in September 2006. There were no public holidays and larger events during that time period. The gates were selected with respect to their location in proximity of the future City-Tunnel stations. These are *Central Station, Market Square* and *Leuschnerplatz*. Areas with interference of construction activities were excluded from the data collection. The selection of gates requires spaces with a different character. For example, busy shopping streets were involved just as well as quiet side streets or passages. The observations were carried out on weekdays (Tuesday) from 10 am – 6 pm and during the weekend (Saturday) from 11 am – 3 pm. The observations were undertaken in time intervals of two hours each. During one turn a maximum of 14 gates were counted. Within a turn each gate was captured once. The count refers to an interval of 5 minutes. The evaluation then deals with the amount of persons per hour. The collection of data was categorised in age-groups. Cyclists were included in the observations.

Correlations

After the preparation of axial models, the processing of syntactic measures and the collection of data it is about analysing these elements. The essential aim of Space Syntax is to gain evidence about the relation of spatial configuration and the collective human behaviour (Agora 2004, p.43). The evaluation requires the use of statistical tools like scattergrams. These enable studying the correlation of two variables like the syntactic value of an urban space and its correspondent movement rate. After this the regression line is used to identify the quality of the model. Thus the spatial influence on movement can be determined by using the value of *R-squared* (Agora 2004, p.44). A value between 0,6 and 1 accounts for a strong correlation of both variables.
It is understood that correlation does not necessarily prove causal interdependences. The statistical evaluation of this paper has been carried out using the statistical software program JMP. To this end the evaluation contains the results of 20 gates. This amount is enough to account for a robust result. Additionally the results can always be refined by the inclusion of further data. Definitely spends and uses have to be considered at the beginning of an examination.

The paper focuses on *people – space correlations* as described above. However the use of *space – space* or even *people – people correlations* is also a possible evaluation. As mentioned before, the spatially determined degree of movement is defined as *Natural Movement*. The relevance of this statement has been empirically proved in many cases. Therefore it is not the intention of this report to verify this theory. However there are additional factors influencing human movement patterns in urban space. These factors can be the unequal distribution of attractors that may occur in combination with a major event, for example. Another aspect is the arrangement of building entrances and the presence of active building frontages with display windows for example.

1.4 Mobility research, a comparison

"*At first the intention is to reach a given destination on shortest paths possible. Secondly a certain distance to other persons and to obstacles is maintained*" (Molnar 1995, Vorwort).

In the scientific context of mobility research there are either user-based or spatial approaches to examine human locomotion. The comparison of the different approaches complements the understanding of Space Syntax in a useful manner. The relation involves empirical examinations about human locomotion as well a study about the dynamics of the flow of people. The research stems from the fields of urban planning and physics and picks out the most important common aspects of human locomotion. The table in fig.3 displays an overview of the comparison of key aspects.

Direct path and collective behaviour
The most basic notion is that human beings moving from A to B use the shortest possible connection. For Schenk the principle of *energy economy (Energieökonomie)*[6] is a reason for that. His empirical studies show that movement traces of pedestrians derive from the choice of shortest paths, the avoidance of detours and the use of short cuts. Therefore he mentions the formation of trails in parks and housing estates as a good example (Schenk 1999, p. 79). Configurational analysis after Space Syntax is principally based on the use of shortest connections. All three approaches are equally based on the examination of collective human locomotion. However Space Syntax is not interested in individual behaviour (Space Syntax 2006, p.3). In contrast the work of Schenk and Molnar is based on the observation and calculation of individual behaviour. Both determine collective movement patterns from individual behaviour. Schenk proofs general movement behaviour through a range of empirical examinations. He states that the sum of individual movement traces leads to the formation of collective routes (Schenk 1999, p.97).

Complex relations
The examination of human spatial behaviour is certainly a complex issue. Space Syntax uses a spatial approach that is reflected in the configuration of space. For Molnar the complexity derives from multiple interrelations within the flow of people itself and with the environment (Molnar 1995, Vorwort). He uses statistical data and changes in velocity to calculate these relationships. The calculations are undertaken by means of computers with the use of special software. For example, these calculations permit the determination of highly frequented spaces. In this regard the result of Molnar´s approach is quite similar to the syntactic measure of *Integration* as it is used by Space Syntax. However the approach is different. Molnar utilises start – destination algorithms and states that his approach enables the use of subjective criteria such as the degree of well-being (Ibid.). The interesting comparison of the physical approach of Molnar and Space Syntax as regards movement rates in urban space or the rate of frequency in parts of a system cannot be explained here because this would exceed the subject of this paper.

Initially Schenk reflects the complexity of relations in a quantitative way. Using 18 case studies he observed more than 15,000 pedestrian movements. The cases studies involved different locations

Fig.4 a,b
Movement and interaction are considered as the basic principles of human locomotion.
(Source: High Speed Trains http://www.hstimpactstudy.net/ Illustrations C.Schaber)

such as bottle necks and wide open areas. Video tapes formed a basis to carry out the movement observations. During the evaluation phase movement traces are generated on the basis of these tapes. As a result common rules of human locomotion can be determined. Schenk focuses on the selection of pedestrian routes. For him a kind of optimisation process is the reason for the choice of traces. He considers the principle of *energy economy* (ibid.) to be the most relevant of these processes. Interestingly the optimisation processes are independently from the mode of locomotion (Schenk 1999, p.69). This notion underlines the use of axial models for different modes of movement like pedestrians or motorists as it is used through Space Syntax.
Orientation and choice of traces

How does human orientation work ? Vision plays a key role for human spatial orientation and the choice of traces. Schenk states that the selection of traces is a process consisting of orientation, consideration and control. The process is of dynamic nature and can be adjusted at any time.
Space Syntax has got a similar understanding of this notion by using *isovists*[7]. These are defined as a field of sight in reference to a certain point of view. In this regard a linear movement creates continuously changing *isovists*. However it is fundamental to know that the process that leads to the choice of traces applies for different modes of locomotion. The universal validation is independent from kind, velocity and devices. Another aspect Molnar mentions is that orientation is related to the cognition of places. As a result locals are able to use alternative routes in case of congestion. These routes are memorised as *cognitive maps*[8] (Molnar 1995, Wegenetze). The Space Syntax method could only utilise such cognitive maps if these could be part of some kind of observation. Molnar also states that the quality of routes can be a help for orientation. It is assumed as a much simpler way to orientate rather than watching out for points of reference or define individual routes (Molnar 1995, Orientierung). Molnar distinguishes between the orientation of locals and visitors. In this regard he describes the existence of routine tracks. These tracks can be frequented without big efforts. Unlike much more concentration is required to orientate in unknown places. Also Schenk refers to routine tracks. For him they belong to the *principle of conservation (Konservativität)* (Schenk 1999, p.79).

	Molnar Physics	Schenk Emprical examination	Space Syntax Network sciences
Approach	user orientated	user orientated	spatial approach
Subject matter	pedestrians	pedestrians	urban space
Universally applicable (all kinds of locomotion)	n/a*	yes	yes
Selection of direct Route	yes	yes	yes
Based on collective Behaviour	yes	yes	yes
Data collection required	n/a	yes	dependant
Simulation (Software)	yes	no	yes

** not applicable*

Fig. 5 Comparison of different user-based mobility research methods with Space Syntax
Reference: Molnar 1995, Schenk 1999 (Table C. Schaber)

Space Syntax uses indicators like *Intelligibility* to evaluate the orientation within a spatial system. The indicator is thought to create a kind of "perceptual clarity" of an urban system. As a result higher values of *intellegibility* make it more likely that pedestrains can understand the spatial layout of an area and are thus able to navigate successfully within that specific area (Space Syntax 2004, p.44). *Intelligibility* can be determined by means of the statistical tool of correlations. The closer the its values approximate 1 the better the orientation is. The indicator is generated through the use of already calculated syntactic measures and are therefore called *2nd order analysis.* In addition Space Syntax uses a much simpler and more general approach to the movement of locals and visitors. It is stated through empirical evidence that the movement patterns of locals refer to rather small radia whilst the movement of visitors refers to larger radia. Somehow the observation of locals and visitors offers culturally different connotations. For example in Germany it is a much bigger challenge to eliminate the above categories as it is in the UK. There people are used to wear uniforms at many times (school uniform, dress code). Thus the case study in Leipzig refers to different groups of age.

Fig. 6a

Fig. 6b

1.5 The flow of people and rail-bound transport infrastructure

Among the principles of human locomotion the choice of routes works regardless of kind, velocity and devices of locomotion (Schenk 1999, p.78). However do these principles apply for rail-bound transport infrastructure ?

In the field of transportation it is generally accepted that routes consisting of changes and waiting periods are less attractive than non-stop routes (Hässler 2005, p.187). For travellers who are unfamiliar with a place such transfers may result in a loss of time, orientation problems and stress. By contrast there are good examples of non-stop regional transport systems. For example the light rail links in the wider area of Karslruhe, Germany were extended into the region. Since 1992 specially built light rail trains (2-System Stadtbahn) operate on both local transport and regional rail networks. The scheme helped multiplying passenger numbers. In addition new stops have been built along the non-stop routes (3SAT 2006). The so called *"Karslruher Model"* with its fast and direct rail links shows that basic principles of locomotion apply for rail-bound transport infrastructure. This fact underlines the universal character of the principles of locomotion as postulated by Schenk.

Pedestrians move without any device and therefore are very flexible and agile. However they move with the lowest velocity of all road users. Although many rail companies offer door-to-door services for the last kilometre of a journey, walking still plays an important role for rail users. Hence the integration of rail stops and stations into the urban configuration is crucial for the accessibility of rail-bound transport systems. In Leipzig the design of stations and adjacent places is an aspect to improve this integration. Other measures for the layout of stations are the orientation, the supply of information and the quality of connecting paths (NVP 2005, p.27 et sqq.). In Leipzig, for example all urban subareas have to made accessible for public transport use. By definition at least 80% of inhabitants and working places within each subarea have to be located within a 300 m aerial radius around local transport stops. For regional trains and local transport stops in the periphery a radius of 500 m is permitted. Additionally the relevant stops and stations have to meet certain criteria as regards the number of services (NVP 2005, p.42). In a regular urban configuration the above distance is equivalent with a walking distance of 5 to 8 minutes.

Fig. 6a,b & 7a,b
Station area of Leiedal / Harelbeke (left) and Aachen (right) after modernisation (this page)
Platforms in London St.Pancras (left) and Liège (right) on the next page. Source.: http://www.hstimpactstudy.net/

Fig. 7a

Fig. 7b

1.6 General recommendations for HST related issues I

The indicator flow of people

After Space Syntax the basic elements of human spatial behaviour are either movement or interaction. Public space is dominated by linear elements like roads, streets, alleys, footpaths, motorways, corridors, crossovers and underpasses. Even squares and parks offer characteristics for movement. Therefore it is understandable that analysis of urban space mainly consists of movement orientated axial models.

A comparably basic but important knowledge about human locomotion is the choice of direct routes. This selection comes along with visual orientation. Underpasses are a good example to exemplify this. Their use normally requires several turns that cannot be overlooked at the beginning. In contrast street-level crossings permit direct access and enable a visual contact from the start. As a result it is no surprise that the latter will be more frequented if people have the choice. To avoid underpasses some people prefer traversing roads at street level even if there are no pedestrian crossings. The cognition about the choice of direct routes also plays an important role for the layout and design of stations and their surroundings. For example, many train stations are located just outside the historic city centre. Because of barrier effects the stations are often isolated from other parts of the city. These barrier effects are caused by railway tracks on one side and ring roads on the other side of the station. In this regard the integration of station areas into urban space can be improved in both directions. Practice proved that the provision of road crossings for walking and cycling at street level around the station area require to be in line with the wider municipal transport plans.

It is known that visitors and locals as users of public space have different interpretations of the notion of direct routes. For example, visitors prefer direct routes with few turns even if these routes may be longer. For them the choice is convenient and avoids stress. In contrast, for locals direct routes are rather short even if they require many turns. Locals also use so called *cognitive maps.* These resemble mental maps and are used for example to bypass sites of congestion. Walking routes play an important role to upgrade the link from station areas towards the (pedestrianised) city centre. However in the existing urban fabric the creation of new visible and direct routes crossing heavy roads is just one solution. The renewal of streets is another important aspect. The cognition of direct routes may also assist in restructuring existing streets. For example, pavement, illumination and furniture can be used to improve the layout of these routes.

	Leipzig	Reading	Hastings	Dover	London	Stratford	Ebbsfleet	Ashford	Maastricht
Partnership		connect	connect	connect	4i	4i	4i	4i	connect
Characteristics									
Feeder station (2nd network)	●	●	●	●					●
HST station	●				●	●	●	●	
Challenges									
Link station - town centre	●	●	●	●				●	
Deprivation			●		●	●			
Brownfield / rail land	●				●	●	●		
Safety probelms									●
Accessibility	●	●	●	●	●	●	●	●	●
Image problems				●		●			
Competition centre - periphery	●						●		
Insufficient HST connections					●	●	●	●	●
Poor feeder capacity	●		●				●		●
Strategy / Objectives									
Station integration / station	●	●	●	●	●	●	●	●	●
New stops (2nd network)	●								
Non-motorised transport	●	●	●	●	●			●	
Intermodality (accessibility)	●	●		●		●	●		●
Stimulate new developements	●				●	●	●		
Design strategy / Public space	●		●					●	●
HST investment									
Feasibility Study			●	●					
Construction		●						●	

Fig. 8 Relevant objectives of HST-partner cities and regions plus Leipzig. Reference: HST Impact Study, Draft 2006 (Table C. Schaber)

It is known that pedestrians follow chosen paths or pavements if these match with the intended direction because it is easier for them to navigate. If the orientation through direct visual contacts is not possible there is also the opportunity to implement a guidance system that indicates important destinations like stations and helps people to orientate. In doing so it is important to keep the signs well arranged. It makes sense to dispose guidance signs around important locations in walking or cycling distance. This also applies for transfers between trains or different modes of transport. Changing from one line to another can mean stress and a loss of time and it makes public transport less attractive in the perception of people. In contrast tackling the barrier effect of railway tracks and the integration of station backsides into urban space is often much harder to achieve. As the best solution, the tunnelling of the tracks under ground is not feasible in many locations. Therefore pedestrians can either cross over or underpass the tracks. That means there are generally not many options for improved walking connections. In general such measures rely much on planned investments on the backside of railway facilities. However there are many of such areas that have become obsolete for railway companies in recent years. For this reasons there is a remarkable potential for developments at the backside and around train stations. As a

	Den Haag	Heerlen	Armetiéres	Menen	Wevelgem	Kortrijk	Harelbeke	Waregem	Aachen
Partnership	4i	4i	connect	connect 4i	connect	connect	connect 4i	connect	connect 4i
Characteristics									
Feeder station (2nd network)	●	●	●	●	●	●	●	●	
HST station									●
Challenges									
Link station - town centre				●	●	●	●	●	●
Deprivation		●	●						
Brownfield / rail land					●				
Safety probelms	●	●		●					
Accessibility		●	●		●	●	●	●	●
Image problems			●						
Competition centre - periphery					●				
Insufficient HST connections	●								
Poor feeder capacity		●	●	●	●	●	●	●	
Strategy / Objectives									
Station integration / station	●	●	●	●		●	●		●
New stops (2nd network)		●							
Non-motorised transport			●		●		●	●	
Intermodality (accessibility)	●	●	●	●	●				
Stimulate new developements	●		●			●		●	
Design strategy / Public spac				●	●	●			●
HST investment									
Feasibility Study	●			●	●	●	●	●	
Construction			●						

rule new station developments are less spacious than existing ones and most of them permit the continuous flow of urban space to both sides of the tunnelled railway tracks.

Their construction is less complex if they are built on outside of town locations. However the case study of the City Tunnel Project proves that a modern regional train network can be integrated into the centre of a conurbation like Leipzig. Another remarkable measure for the analysis of the flow of people is to differentiate between circumstances people are in. The distinction can contribute to solve capacity problems because within each circumstance people move with a different velocity. For example, working people walk relatively fast with around 1.61 m/s (5.8 km/h or 3.6 mph) followed by commuters with 1.49 m/s (5.4 km/h or 3.3 mph). People doing shopping stroll with 1.16 m/s (4.2 km/h or 2.6 mph) (Molnar 2006, Gehbewegung). Physicists use the velocity to calculate quantitative flows of people related to the spatial layout of a place. Interestingly it is not always the broadening of footpaths or the adding of further paths that helps to solve problems of congestion.

Notes - *Chapter 1*

1 Annual conference held by the German Academy for Urban and Regional Planning (Deutsche Akademie für Städtebau und Landesplanung, DASL) in Ulm, October 2006

2 **Emergence** is the process of complex pattern formation from more basic constituent parts. An emergent behaviour or emergent property can appear when a number of simple entities (agents) operate in an environment, forming more complex behaviours as a collective (Wikipedia 2006a).

3 **Graph** / Justified graph
A graph is the basic object of study in graph theory. Informally speaking, a graph is a set of objects called points, nodes, or vertices connected by links called lines or edges. Although often represented through drawings, graphs are just mathematical structures (Wikipedia 2006b).

4 **Convex space** describes a geometrical figure where two arbitrary points and their link lie within the figure.

5 **Graph theory** is a branch of mathematics that examines the properties of graphs and their interrelations. (Wikipedia 2006c).

6 **Energy efficiency** (Energieökonomie)
After Schenk the principle is fundamental for human locomotion. The minimised use of energy is explained as the reason for the choice of shortest and direct route connections. The principle applies in a universal way for other modes of locomotion including rail transport (Schenk 1999, p.77 et sqq.).

7 **Isovists** describe a field of vision in relation to a fixed position.

8 **Cognitive maps** describe the mental representation of geographical spaces.

Chapter 2

The case of the City-Tunnel Project in Leipzig

2.1 Criteria for a current regional train system

The thematic background of this report is the relationship between the city and railway. The current professional discussion consists of three main topics[1]. These are the handling of disposable railway areas in inner-city locations which constitute a great potential for future urban development. Another important aspect is the changing role of stations as an interface between transport infrastructure and urban space. Furthermore economic and structural aspects require the integration of cities, towns and their surrounding region. This paper intends to analyse a regional train system and its meaning for urban development. The subject matter of the examination is the City-Tunnel in Leipzig. The project is the principal item of the future regional train network in the wider region around the cities of Leipzig and Halle. The project aims at creating a direct link between the region and the city centre of Leipzig. In addition it will function as a feeder to the European high speed train (HST) network.

The definition of the Trans European Transport Network (TEN-T) is composed of a set of major transport axes across the continent. The network contains priority railway axes. In economic terms the construction of the rail network aims at the promotion of a decentralised concentration. A study lead by the University of Vienna found out that the implementation of all the mapped railway lines in combination with a certain standard would reduce regional differences in the European Union. The research focused on questions of accessibility and its economic impact. The study states that the highest benefit can be achieved if resources are pooled together and are concentrated on specific locations. At the same time the European train network has to be accessible for all citizens of the EU. According to the principle of *subsidarity*[1] the access has to be supplied on the national and regional level respectively. The task involves the provision and the layout of secondary rail and road networks and is related to the national and regional legislation respectively. Examples of TEN-T priority rail axes are, for example the routes: Paris–Brussels–Cologne–Amsterdam–London or Berlin-Leipzig-Munich-Rome-Naples or Paris-Stuttgart-Munich-Vienna-Bratislava (EC 2005, p.5).

Another research project, the previously mentioned TranSEcon study, worked on the direct and indirect socio-economic impacts of investments into rail-bound transport infrastructure in 13 different European cities. As a practical recommendation an urban regeneration indicator was conceived. The indicator appraises different public transport modes and their relevance for urban regeneration. S-Bahn[2] (4,0) and underground (3,5) realize the highest values before the tram (3,0) (TranSEcon 2003, p.38). More details about the TranSEcon study will be addressed in chapter 3.3.

Fig. 9 (Next page)
Comparison of urban street network and rail-bound public transport stations. The axial model of urban space shows a hierarchy of Through-movement capacities. (Thematic map C. Schaber)

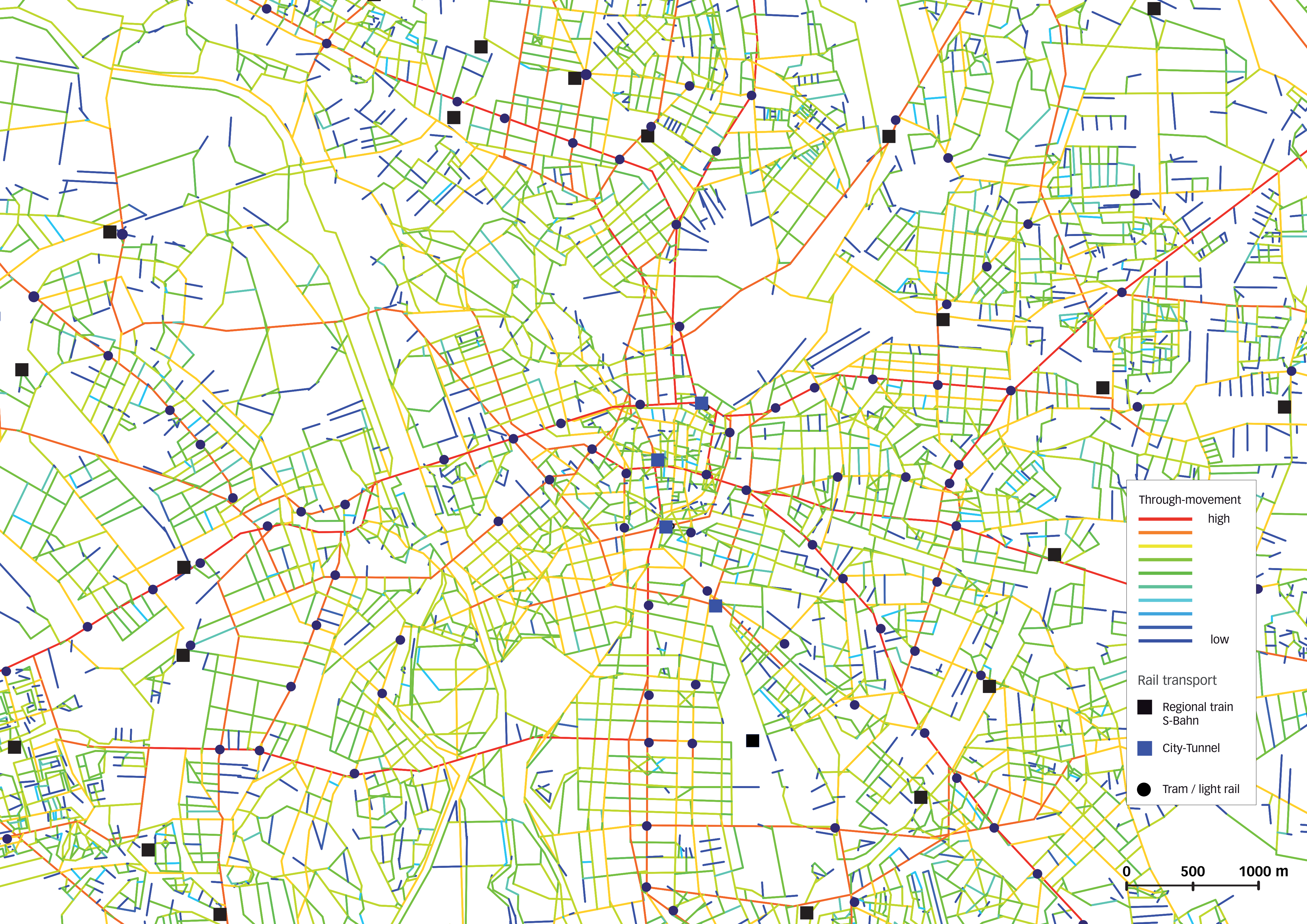

Through-movement
high
low
Rail transport
Regional train
S-Bahn
City-Tunnel
Tram / light rail
0
500
1000 m

Fig. 10 a, b
Urban space around future City-Tunnel stops at Market Square, left and Central Station, right. (Pic.: C. Schaber)

The restructuring of S-Bahn and regional train network in the Leipzig – Halle conurbation provides a useful example for analysis. That way the conception of a regional train scheme feeding into the HST network can be examined. The following statements refer to generalized findings of the examination of local and regional train schemes in the wider Leipzig region and the findings of previous studies like TranSEcon. Rail-bound transport systems can be divided into two different categories. These categories involve *independent* and *integrated* rail networks in relation with urban space (chapter 2.4). *Integrated* rail networks refer to public transport modes that use urban space like for example trams. *Independent* rail networks run on own routes autonomously from urban space like for example S-Bahn or regional trains. The comparison of this ideal type distinction with the urban regeneration indicator developed in conjunction with the European TranSEcon study is remarkable. *Independent* rail networks (S-Bahn, underground) demonstrate higher regeneration effects than *integrated* schemes (tram). A possible reason for that could be human movement behaviour. People prefer direct routes irrespective of the mode of transport. Transferred to public transport the direct path would correspond to a so called "*unbroken*" journey. Users arrive at their destinations without changing trains or modes of transport. If the trip is not only direct but also fast, the attractiveness of the transport system rises. Saving travel time caused through transferless journeys is a quality feature. Within the urban context a rail transport system can be considered fast if it has few crossings with other systems and is yet well integrated into urban space. These characteristics rather apply for S-Bahn and underground than trams as TranSEcon also confirmed. However the selection of a distinct system is not always the only solution. The successful provision of a regional light rail network in the Karlsruhe region is based on light rail trains running on inner-city tram tracks as well as railway tracks. Thus direct connections from the city into the region are provided. The scheme is known as the "*Karlsruher Model*". As a consequence passenger numbers multiplied since 1992 and the scheme was extended further into the region.

Today other medium size towns like Braunschweig or Zwickau are adopting this kind of regional light rail network. The "*Karlsruher Model*" was also surveyed and discussed for the city of Leipzig. However high follow-up costs in relation with new rolling stock and complex reconstructions at major crossings led to the preference of a regional train course under ground. The tunnelling of the S-Bahn and regional train network unlocks the terminus station in Leipzig on the regional level.

2.2 The regional train network in the Leipzig conurbation

Fig. 11
Layout of future City-Tunnel stations related to urban grain and local, regional and national rail networks. (Illustration C. Schaber)

The case of the City-Tunnel in Leipzig, Germany

With 500,000 inhabitants Leipzig is about the same size as Den Haag. The terminus HST station is one of the biggest in Europe and is part of a European rail priority axis (TEN-T). Its role as an important transport hub will be strengthened through the City-Tunnel project. After the modernisation of the regional train network in 2010 the station will be a through station for S-Bahn and regional express lines. Four underground and a station at-grade level will form the key piece of the modernised scheme in the wider Leipzig area. Several S-Bahn and regional express lines will be tied together in a tunnel of 4 km length. There the routes function like an underground system. Three of the four stations under ground have direct accesses towards the city centre and open up essential destinations in Leipzig which are of regionalsignificance.

The integration of regional train lines into the city centre aims at an increase in movement rates there. Today (2006) about half of the people reach the centre by public transport. The improved accessibility plays an important role in the regeneration process of central Leipzig. The new train scheme links scientific centre, the universities, the city centre and the *Central Station* offering services every 5 minutes. In addition the scheme provides faster and more direct rail connections to HST-station, airport and trade fair from the southern region. The construction of a southern rail access to Leipzig *Central Station* has been discussed for more than a century. Finally the City Tunnel project contributes to overcome the terminus station status on the regional level. It was discussed to run also HST trains through the tunnel. Finally the decision was taken in favour of S-Bahn and regional trains. Since Leipzig Central Station is one of the biggest stations in Europe there is enough space to rebuild an area within the HST station as an entrance to the future City-Tunnel. The expected passenger numbers there are 70,000 persons. The regional station will have direct access to the tracks in Leipzig Central Station, to local transport and to the city centre. The economic basis of the scheme was appraised positively by means of a feasibility study (1995) as well as a cost-benefit analysis (1998). The originally estimated costs of approximately 571 million Euros are pooled together from federal, national and European funds (ERDF). Construction works began in 2003 and are likely to be completed in 2010. The use of both S-Bahn lines and regional express lines contributes to the economic well-being of the scheme. Further a so called "S-Bahn-Vorlauf" mode will be established. The mode enables rapid transit trains to run to remote destinations in the region. Thus these trains contribute to attractive, "*unbroken*" journeys connecting Leipzig directly with destinations throughout the region.

2.3 Rail-bound public transport and urban development in Leipzig

The impact of rail transport for urban development

Years before one of the first German railway lines from Leipzig to Dresden started operation in 1839, there was already a conception about a German railway network. Friedrich List, the author of the plan granted Leipzig the role of an important railway hub. The economic, industrial and site conditions justified Leipzig´s role within the conception of the German railway network. List said "*the number of people travelling in and out and through the city Is higher than in any other city or town in Germany*" (DB 2004, p.15). The railway was supposed to go where the people were. In the following years several stations were built just outside the medieval city centre. As an economist List considered the railway as a profitable investment. During this period train companies were privately owned and there were rather limited aspirations concerning potential urban developments caused by railway constructions. This changed first decades later.

The construction of the Central Station in Leipzig (1909-15) instead of several smaller terminus stations was used to kick-start the modernisation of the medieval city centre. Beforehand it had been discussed to relocate the several existing station buildings to a place further outwards. However, the then director of town planning Strobel stated in 1911: "*the completion of the Central Station will cause major changes in the historic city centre"* (DB 2004, p.30). His aspirations focused on the formation of a new kind of city shifting land uses from housing to commercial uses of the tertiary sector. The shift implied trade fair buildings, banks, hotels und administrative buildings. An under ground rail connection, an ancestor of the current City-Tunnel, was planed but not built between the new *Central Station* and another station southwest of the city centre. The scheme was not meant as part of a regional train network but as a direct station link. An important justification of the scheme was the provision of additional stops at the entrances of the two busiest streets around 1910 (DB 2006, p.36). Interestingly, today both shopping streets belong again to the most frequented places in the city, as own observations in 2006 demonstrated.

The improvement of regional transport infrastructure investments can in fact influence land uses in the surrounding areas. In this regard the TranSEcon study reports that a very common pattern is the increase in the number of businesses in inner-city areas. At the same time higher rents lead to a reduced numbers of inhabitants there (TranSEcon 2003, p.37). Additionally, a higher centrality also impacts on the regional scale mainly in small and medium size towns where locations around the new infrastructure schemes benefit most from private investments. The major City-Tunnel stations will be located at the most frequented places in the centre. The station Market Square (South) will be directly placed at the crossing of the two most frequented shopping streets in Leipzig.

From a municipal point of view the regional integration of central Leipzig is a unique opportunity to strengthen the competitive position the inner city compared to out-of-town shopping centre locations (SKS 2006, p.2). The construction works of the City-Tunnel project begun in 2003. From 1996 until then the amount of floor space for retail in the centre of Leipzig has already doubled

Retail / City centre	in m²	Change
1996	73.000	
1999	92.000	26%
2003	144.000	56%
2006 (estimation)	180.000	25%

Spatial distribution 2002	in m²	proportion
City centre South	105.000	77%
City centre North	13.000	10%
Central Station	18.000	13%
Total City centre	**136.000**	100%

Retail / Comparison	in m²	year	car parking	location
City centre Leipzig (incl. Central Station)	144.000	2003	5.500	City centre
Nova Eventis	76.000	2006	7.000	out-of-town
Paunsdorf Center	87.000	1994	7.300	out-of-town

(cp. fig.8a). However it is hard to detect to which degree the increase can be associated with so-called *anticipating land use development*[3] in terms of the City-Tunnel Project. It is certain that the increase of retail floor space in the city centre goes on. In 2006 several major retail projects like the *Market Gallery (Marktgallerie)*, a house of trade (*Messehaus*) and the *Karstadt* department store will be completed. The growth of retail facilities is clustered around the traditional shopping streets *Grimmaische Strasse* and *Peterstrasse* in the southern part of the city centre. There 75% of all inner-city retail floor space can be found. The only larger central retail facility outside this area is the Central Station Arcade that opened in 1997. However private commercial investments are only one part of the current investments in the centre of Leipzig. At the same time as the City-Tunnel Project, reconstruction works at the central University buildings and the hospital complex close to the centre are realised (cp. fig. 10). These measures include investments around 300 million Euros and are scheduled for completion in 2009 (IHK 2006, p.4 et sqq.). All of these investment projects are located within the City-Tunnel catchment area.

In line with the City-Tunnel Project the municipal strategy aims at prompting pedestrian-friendly schemes and at upgrading frequented public spaces in and around the city centre (SKS 2006, p.2). A declared goal is the increase of pedestrian movement rates. The concept is based on tourism-orientated measures to regenerate public spaces in central Leipzig. It is the kind of concept that has been implemented successfully in Barcelona, London, Lyon and Berlin. TranSEcon listed a set of accompanying measures that contributed to successful public transport investments. Among the most important ones is the political will for regeneration, civic pride and most notably the municipal willingness for investments into public space (TranSEcon 2003, p.39). A fast and direct regional train connection extends the catchment area and reduces travel times to and from the city centre. Today the access to the inner-city in Leipzig already depends to around 50% on public transport connections. The total proportion of public transport in Leipzig adds up to around 20% (NVP 2005, p.19).

The increase of movement rates is seen as a key for a successful urban development in the city centre. The flow of people is associated with economic well-being of public and private facilities. Further it is anticipated that higher movement rates safeguard current investments. In this matter

Fig. 12 a, b (previous page)
Growth and distrubution of retail floor space. References: Stadt Leipzig 2004a, p.48 ; IHK 2002, p.5 et sqq.

Fig. 13 (previous page)
Comparison of retail floorspace. Reference: BMW 2004, Nova Eventis 2006, Paunsdorf Center 2006, Stadt Leipzig 2004a

Fig. 14 a, b (right)
Tables about investments parallel to City-Tunnel construction. Reference: IHK 2006, p.45-46 (All tables C. Schaber)

Leipzig	in Mill. Euro	until
City-Tunnel Leipzig	572	2010
Total Inner-city	521	2009
Total City-wide	289	2014
Total Logistic area A14	1.700	2010

City centre (selection)	in Mill. Euro	until
University (central)	140	2009
Hospitals (university)	214	2008
Karstadt "shopping galerie"	100	2006
Messehaus Marked Square	60	2006

the far side of the ring road around the centre can also benefit from higher movement rates. The Urban Development Plans (UDP) outline measures to improve the accessibility around the ring in both directions. Therefore at-grade crossings for pedestrians and cyclists have been proposed (Leipzig 2004b, p. 69). Although the new City-Tunnel stations were located in busy places there are still derelict areas between the new stations. These areas offer high potentials for regeneration. A very central development area is located between the two most frequented City-Tunnel stations Central Station (South) and Market Square (North). The north-western centre is a focal point of urban regeneration for the next decade. From the municipal point of view constructions around the *Brühl* are seen as a key for the future of the area around the Museum Quarter and the northern city centre (chapter 3.4).

2.4 Examinations 1 & 2 - Public transport Networks

Three of four future City-Tunnel stations will have direct access to downtown Leipzig. Prognoses predict that these stations will account in large part (85%) for the use of the new regional train scheme. There pedestrians using the public spaces between the three stations obtained priority. Accordingly the impact of the City-Tunnel Project on urban space is examined particularly in these areas. The axial model that is used as a basis for the analysis maps an area with the radius of 6-7 km. The model is made up of over 7,000 axial lines is used as a basis for the calculation of different kinds of syntactic measures after Space Syntax. The relatively large study area was chosen to map all relevant stations of the local and regional transport networks.

The first set of examinations refers to the position of local and regional train stations as interfaces between public transport network and urban space. The analysis involves the accessibility of stations for pedestrians and the layout of the public transport network in relation to the urban street configuration. The examination is based on existing stops plus the new City-Tunnel stations. The below figures show that Leipzig is a good study case for rail-bound public transport schemes. 77%

EXAMINATION 1 - Fig.15

Station accessibility for pedestrians

Syntactic measure:
Local Integration (Int R3)

Study area / radius: 6 km
(Pic.: C. Schaber)

of public passenger transport in the city is conducted by rail-bound carriers. About 80% of rail-bound transport is taken on by the tram. The rest is shared by S-Bahn and regional trains. The operation of the City-Tunnel from 2010 on will shift these figures towards an increased use of S-Bahn transport. If we consider the interface between rail-bound transport schemes and public space about 25% of the 500 tram stops and all 34 S-Bahn stations are relevant for the study model. Local transport offers about 150 stops with a daily passenger emergence higher than 2,000 persons. The selection of stations was carried out with subject to the currently available Local Transport Plan (NVP 2005). Afterwards syntactic measures are used to draw conclusions about the relation of integrated and segregated transport carriers to urban space. Therefore the syntactic measure of *Local Integration (Int R3)* is utilised.

The map examines the pedestrian accessibility of all mapped stations within the study area of about 6 km around the city centre. Therefore the syntactic measure of *Local Integration (Int R3*) is utilised. The measure determines the integration of every single element to all other elements in the study area. The chosen *Radius 3 (R3)* assesses only elements that are two (topological) steps away from any single element (axial line) and accounts for local routes like those of pedestrians. The displayed thematic map uses the classical Space Syntax colour range from red to blue. Red stands for a high integration a blue means low integration and segregation respectively.

Result Examination 1

The existing rail networks demonstrate fundamental differences between local (tram/light rail) and regional (S-Bahn/regional railway) schemes. For example, the more than 100 mapped tram stops mostly offers high values of integration regarding pedestrian accessibility. In contrast most of the 34 S-Bahn and 19 regional train stations show generally lower integration values and poor crossovers for pedestrians between station and urban space. This is even true for the Central Station. Further some of the stations are also distant from travel demand. This applies in particular for stations that are located at the urban fringe within low frequented industrial areas (NVP 2005, p.32). The layout of the tram is almost identical with the major through-roads and enables direct pedestrian access from most places in the study area.

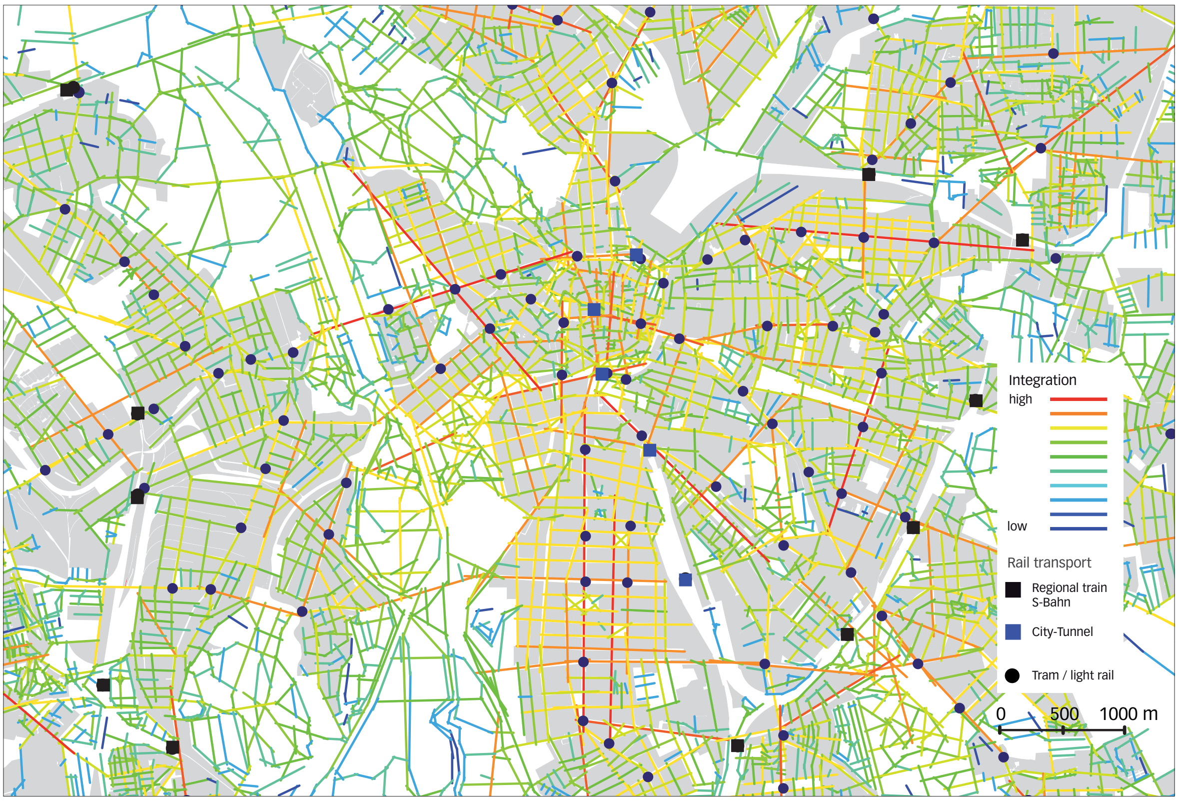


Fig. 16 Axial map showing the syntactic measure of Local Integration (Int R3) in relation to important local and regional train stations. The measure indicates the accessibility for pedestrians using the classical Space Syntax colour range. (Thematic map C. Schaber)

There are a few exceptions like the post war housing estates to the far west and northeast of the centre. The public or semi public spaces around theses estates have a specific layout. Their access from inner streets and buildings to the public transport stations usually requires many topological turns. Thus most of the housing estates are more segregated from the important transport axes than other urban spaces. It is striking that the Central Station is also relatively segregated in terms of pedestrian accessibility. There is a quite simple reason for that. The extended railway facilities and tracks around the station create a barrier effect that isolates the Central Station from the urban context. This effect is exceptionally strong in relation with pedestrian and local distances. As a result, the Central Station globally contributes to higher movement rates and locally rather locks movements. The new City-Tunnel stations make a difference in terms of accessibility and their relation with urban space. Except for the new Central Station stop the other stations are accessible for pedestrians (cp. fig. 11,12). Beyond their regional significance the new City-Tunnel stations *Market Square (Markt)* and *Leuschnerplatz* are highly accessible for pedestrians because of their good local integration. The *Market Square* station will be the first rail-based public transport station inside the historic centre of Leipzig. The future City-Tunnel stops Central station, *Market Square*, *Leuschnerplatz* and *Bayrischer Bahnhof* form the core of the regional and S-Bahn network in the conurbation. About 140,000 people are expected to use the four stations each day. More than 75% of the expected passengers will board and get off the trains on the northern stations Central station and Market Square. The area between both most frequented City-Tunnel stations

EXAMINATION 2 - Fig.17

Relation of street layout an public transport network

Syntactic measure:
Through-movement Rn (Choice)

Study area / radius: 6 km
(Pic.: C. Schaber)

is seen as a future development area. The area will be addressed more detailed in chapter 3.4. Generally, for all the new stations the integration into urban space is an important issue. To sum up it can be stated that the attractiveness of the new City-Tunnel stations is based on their good accessibility and services running every 5 minutes.

In contrast to the tram current S-Bahn and regional train schemes run to a large extend independently from urban space. The later have an autonomous configuration. An ideal type distinction of rail network has been made: In relation to public space tram / light rail (local transport) tends to be an integrated system whereas regional / rapid-transit railway operate rather independent from urban space. After the Local Transport Plan (NVP) 2005 the term accessibility is defined as an indicator for an area-wide access to public transport networks (NVP 2005, p.24). The plan defines specific criteria for accessibility. Thereby the distance towards the next public transport station matters. The linear distance should not exceed 300 metres for ocal transport stops and 500 metres for regional train stations. The syntactic measure of *Local Integration* used for examination one is based on topological distances (steps). Therefore a comparison of both measures is difficult. However the *Point Depth* tool of Space Syntax would be able to determine metric catchment areas around specific points like stations. The tool is helpful if the course of streets is not regular and the use of linear distances would be imprecise.
The local and regional transport line network in the study area can be examined with the syntactic measure of *Choice*. *Choice* or *Through-movement* indicates how often an urban space is used for through-movement. In doing so a potential hierarchy for the use of routes can be detected (chapter 1.2).

Result Examination 2

The routing of the tram line networks is almost identical with the major through-roads. According to the classical colour range the major through roads are indicated red in the map (cp. fig. 5). The major through-roads pass by the previously mentioned post war housing estates where rail carrier stops have a reduced pedestrian accessibility in comparison to other parts of the city. Globally the Central Station is located at one of the most important through-roads. In addition the

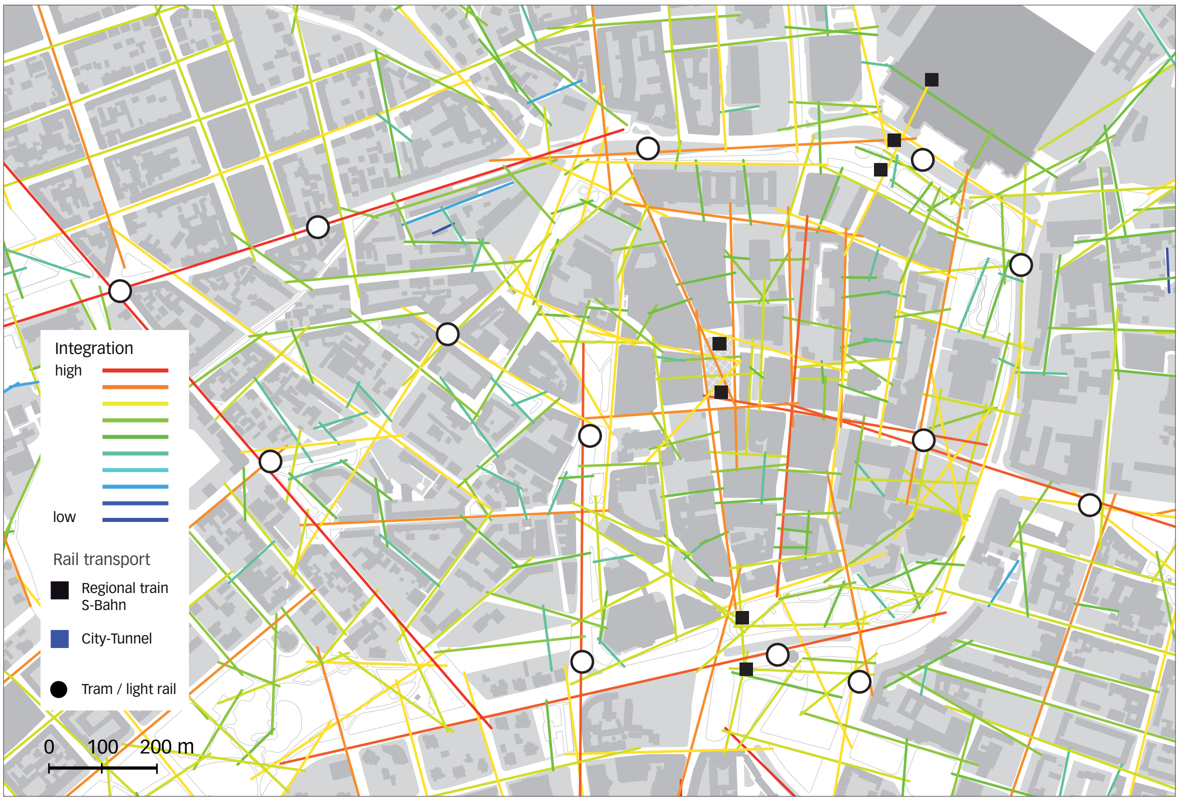


Fig.18 Axial map indicating pedestrian accessibility of local transport stops and City-Tunnel stations in the inner-city. (Illustration C. Schaber)

extended ring road, where the station is located is part of the *Integration Core*. The core consists of the most accessible spaces within the entire study area. The result underlines the global (entire study area) meaning of the station accesses within the network of urban space. The significance of the *Integration Core* is reflected in the course of the tram line network as principal part of the local transport scheme. All 13 tram lines are tied together around the extended ring road (*Promenadenring*).

The modernisation of the regional train network leads to a significant change of the described relation to urban space. The new stations will be situated at the most important inner-city locations. As a result the focal point of future rail-bound transport will be the entire city centre instead of just the Central Station. Comparing trough-movements with the regional train network in terms of the *Choice* measure also results in big differences between the current and the future course. Today the regional train network runs independently from urban space. Both networks form autonomous structures. These structures are not always aligned at major intersections and through-roads. The most important intersection today is the Central Station. With 70,000 persons, It is expected that the station will also become the most frequented regional train station in the future. For the current regional train network, the other new City-Tunnel stations will be untypically well integrated into urban space. And if these are not yet well placed like the station at-grade *Semmelweisstraße*, a new road connections will improve the link with the urban street network. That way different modes of transport get access to all City-Tunnel lines. In addition the set of stations offers direct access for different transport modes (cp. fig.7).

	Central Station (Hbf.)		Bayr. Bahnhof
Entrances	3		2
Estimated users / daily	**70.000**		**10.000**
Platform length / m	215 (400)		140
Space Syntax	NORTH	SOUTH	NORTH / SOUTH
Pedestrian Rate / hourly			
Workday (WT)	n/a *	1.989	n/a
Weekend (WE)	n/a	5.184	n/a
Local Intergration	●●●	●●●●●●	●●●●●●●●
Global Integration	●●●●●●	●●●●●●●●	●●●●●●
Through movement	●●●●●●	●●●●●●●●	●●●●●●
** not applicable*	I low high I	I low high I	I low high I
Accessibility (integration)			
Car parking		**1.300**	n/a
National railway	Yes		
Regional / S-Bahn trains	Yes		Yes
Local transport	Yes		Yes
Land use	Tranport Hub, shopping centre		Hospitals, health care
Retail	●●●●●●●●	●	●●●
Housing	●●●	●●●	●●●●●●
Offices, hotels	●●●●●●	●●●●●●●●	●
Leisure	●	●	●
Public services	●	●	●●●●●●
Land availability	●●●	●●●	●●●●●●●●
	I low high I	I low high I	I low high I
Strategies /Public Space			
SKS ** relevance	Restructuring of northern ring road		Structural Plan
Status	Preliminary planning		1998
Funding	City of Leipzig		Leipzig / railway
Problems	Barrier effect northern ring		Vacancies
*** Municipal Strategy for public space*	Development area northern centre		

2.5 Summary public transport networks

The examinations one and two focused on rail-bound carriers. As a "city of trams" that hosts one of the biggest train stations in Europe, Leipzig makes up a good example for the examination of rail-bound transport. Both large scale examinations with Space Syntax provide useful information about the pedestrian accessibility and the layout of public transport networks. First, the ideal type distinction of *integrated* and *independent* transport networks matters. Both categories describe the relation between a rail-bound transport network und the grid of urban space. Secondly, the analysis stated a fundamental change in the layout of the regional train stations. There after the relation of the future regional train network and urban space can be improved substantially.

So far stations and line networks have been outlined without significant transitions towards urban space. In the future the most frequented regional train stations will be located at the best acces-

	Market Square (Markt)		Leuschnerplatz	
	2		2	
	40.000		**20.000**	
	140		140	
	NORTH	SOUTH*	NORTH*	SOUTH
	n/a	2.500	1.400	n/a
	n/a	4.000	1.500	n/a
	●●●●●●	●●●●●●●●	●●●●●●	●●●●●●●●
	●●●●●●	●●●●●●	●●●●●●●●	●●●●●●●●
	●●●	●●●●●●●●	●●●●●●●●	●●●●●●●●
	I low high I	I low high I	I low high I	I low high I
		400	**1.080**	
	Yes		Yes	
	Yes		Yes	
	Urban "parlour" of Leipzig, shopping, culture		Multiple choices	
	●●●	●●●●●●●●	●●●●●●●●	●
	●●●	●●●	●	●●●
	●	●●●	●●●	●●●
	●●●●●●	●●●●●●	●●●	●
	●	●●●●●●	●●●●●●●●	●●●●●●
	●●●●●●	●	●	●●●●●●●●
	I low high I	I low high I	I low high I	I low high I
	Renewal Market Square (Markt)		Restructuring of soutthern ring road	
	Execution Plan		n/a *	
	City of Leipzig		Administration union (ZVNL)	
	Development area northern centre		Barrier effect ring road	
			Vacancies	

Fig. 19 Table showing relevant characteristics of the four future City-Tunnel Stations.
References: DB 2004, p.7; Stadt Leipzig 2006a, p.9 et sqq.; BMW and Stadt Leipzig 2004 p. 1-2
(Observation data and table C. Schaber)

sible and highly frequented places. In addition several transport modes will have direct access to the City-Tunnel lines. The regional trains become a kind of local transport element because of frequent services and the grouping of several lines in the City-Tunnel. The focal point of public transport will shift from the Central Station alone to the entire city centre. Layout and design of the new stations as interfaces to the city obtains a specific meaning. This meaning is about the integration of stations under ground into the public realm. The conception of the future regional train network in the Leipzig conurbation combines advantages of both ideal type categories of rail networks. The direct and *independent* regional network will be *integrated* into central inner-city areas.

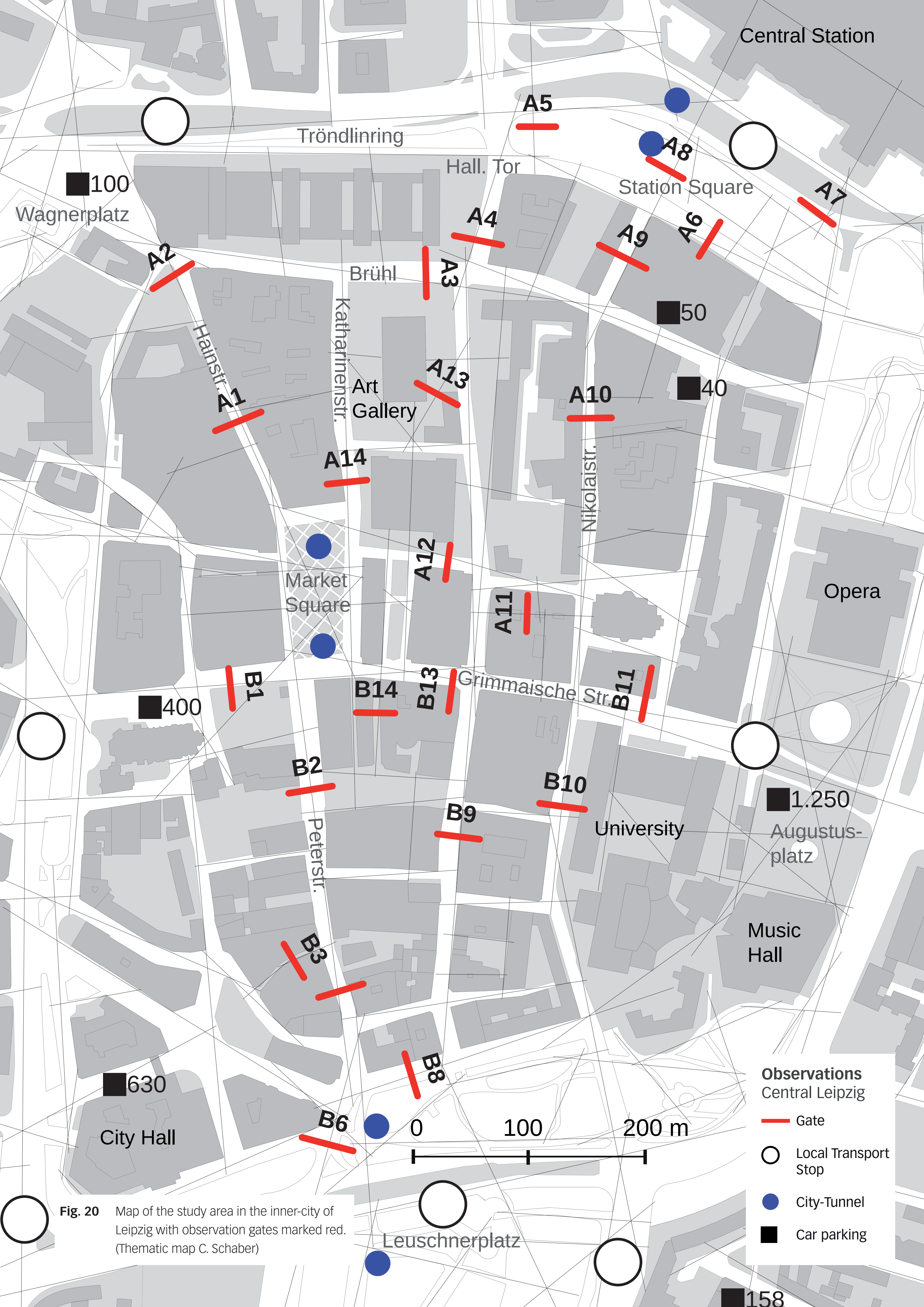


Fig. 20 Map of the study area in the inner-city of Leipzig with observation gates marked red. (Thematic map C. Schaber)

Fig. 21a

Fig. 21b

Chapter 3

The flow of people in central Leipzig

Already today urban space in the area of the future City-Tunnel stations is dominated by non-motorised transport, primarily pedestrians. Generally the share of walking persons in the centre lies well above average. The compact city centre with its dense network of streets, alleys and squares and the insertion of regional train stations within this network are just two reasons why Leipzig is a opportune study case for the examination of urban space, rail-bound transport and the flow of people. Civic pride and the willingness of the municipality to invest into public space are evidently basic conditions of successful transport infrastructure investments (TranSEcon 2003, p.39). Additionally the fact that large parts of public transport run within the system of the urban grid eases the use of axial models based on urban configuration.

The notion that urban space has a cultural dimension is a very general cognition of Space Syntax. However the definition is helpful to understand the connection between urban spatial structures and their social dimension. The way societies form spatial structures through streets, buildings, boundaries and zones etc. is defined as their spatial order. There after the spatial order of administrative cities and cities of trade is very different. Hillier believes that the difference is caused through the layout of the street network and important public buildings and functions (Hillier 1984, p.21). According to this he describes two fundamental characteristics of public space. Thereby the number of entrances plays an important role.

The first category is marked by everyday houses, facing public space with multiple entrances. The second category is related to public buildings and functions. Their characteristic is reverse to the first. The public building typically does not form urban space. On the contrary, space floats around the building that offers only a limited number of entrances towards urban space. Hillier claims that the proportion of the two categories indicates whether we deal with a city of commerce or an administrative city (Hillier 1984, p.27). The definition of *spatial order* derives from the early Space Syntax era and it clearly demonstrates the ambition to relate urban space and social meaning.

Fig. 21 a,b Flow of people around Market Square, left and in the northern centre, right. (Pic.: C. Schaber)

EXAMINATION 3
Fig.22

Integration Core
The most integrated urban spaces

Syntactic measure:
Integration Core

Study area, radius: 6-7km
(Pic.: C. Schaber)

However, the spatial category that is considered typical for cities of commerce is very similar to what we understand as the European city. The spatial order of administrative cities very much resembles post-war constructions. There buildings are also withdrawn from the through-roads and have comparatively few entrances. The author assumes that after more than two decades of empirical experience the observation of people has found to be a more hands-on solution to combine spatial configuration and social behaviour.

At this point it must be stated that each era in the history of the city used to have a principal mode of transport. For example walking was a common locomotion in the medieval cities and towns. Then during the 19th century the railway became the means of transport for the masses. After 1950 onwards cars dominated collective movement and the layout of cities and towns. Today besides the car walking, cycling and new a kind of trains become increasingly important. Although the use of cars is still dominant, the current challenge is to combine many different modes of transport. In this regard city centres and train stations are very complex issues because all kind of transport modes have to be integrated into rather limited spaces. If the study area was chosen wide enough, axial models are a suitable tool to analyze the multitude of transport modes. Their use is not directly limited to a certain mode. Thus axial models can be used universally. As we learned before (cp. chapter 1.4) human movement behaviour, like the choice of direct routes for example, also applies for different types of human locomotion. However there is the opportunity to distinguish different modes. Thereby the radius and length of routes is used for differentiation.

3.1 Examination 3 - Integration Core

The best integrated spaces in Leipzig are not located in the historic centre but just outside along the extended ring road (*Promenadenring*). Several streets that run perpendicular to the ring road are also very well integrated. Space Syntax calls a figure of this kind *Integration Core*. Thematic maps that use the classical Space Syntax colour range display these areas in red. Commonly this is the place of the live centre with retail shops on both sides of the street (Agora 2003, p.53). In real terms there are no shopping facilities except from the Central Station Arcades. In Leipzig most shops are located within the historic centre.

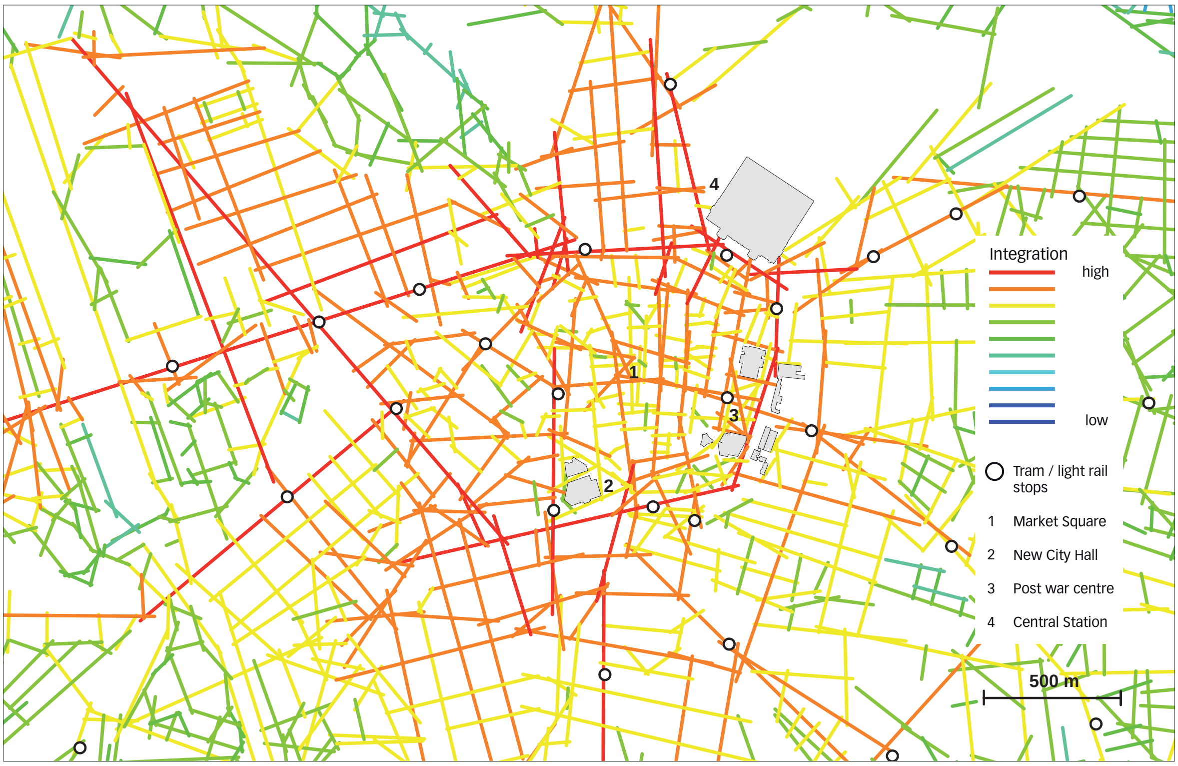


Fig. 23 Axial model of Global Integration (Int Rn) showing the best accessible elements of urban space (red lines). (Thematic map C. Schaber)

In terms of local transport the *Integration Core* really contains busy places. All 13 tram lines are tied together here. These tram lines carry out more than 70% of public transport cases and make both sides of the extended ring road accessible (NVP 2005, p.17). In addition all major local, regional and national rail interchanges are also located there. The live centre that is found along the *Integration Core* usually offers commercial land uses, like retail facilities. In this regard the case study results are unexpected. Although the uses along the most integrated streets are rather mixed, it is striking that public buildings of different kinds and at different times have been placed around the extended ring road. In the early 20^{th} century these were the City Hall (1905) and the Central Station (1911). Both buildings today still belong to the largest of their kind in Europe. During the socialist era a new centre was conceived at the eastern fringe of the historic centre. From 1960 – 81 several new building complexes including post office, hotels, university buildings and concert hall were grouped around a big open space that was used for political manifestations.

Today the former university tower is still an essential part of the skyline of Leipzig. Eventually the City-Tunnel Project demonstrates the current importance of the ring road as *Integration Core*. Two of four new stations are located there. However these new interventions will not create any physical presence along the ring. The tunnel project connects the city centre with current major projects. These are for example the airport extension, the new logistic hub, new trade fair and car manufacturing sites. The ring road does not only contain superlative buildings, the ring itself is very wide at many places. As a result it creates a disturbing barrier effect particularly on its northern side (chapter 3.4). Although the ring forms a continuous open space around the historic centre

Access point	Leuschnerplatz	Augustusplatz	Central Station	Wagnerplatz	Hallisches Tor
Observation Gate / pers. p. hour	**B6**	**B11**	**A8**	A2	A4
SAT 10am - 6 pm	**1.032**	**2.634**	**1.989**	993	402
TUE 11am - 3 pm	**1.146**	**3.072**	**5.184**	846	438
Car parking	1.080	1.250	1.300	261	270
Public Transport					
Local Transport	●	●	●	●	
S-Bahn / Regional trains	●		●		
National rail network			●		
Cyclists	●	●	●	●	●
Pedestrians	●	●	●	●	●

Fig. 24 Comparison of important inner-city entrances as regards movement rates and modal accessibility
Reference: data collection C.Schaber 2006, BMW 2004 (Table C.Schaber)

single parts have quite different characteristics. Therefore the ring is not perceived as an entity. Anyhow the squares at the fringe of the historic centre are important open spaces for the compact centre. Each of the previously mentioned major projects along the ring features an adequate square or large open space. These (*Augustusplatz*, *Station Square* and *Leuschnerplatz*) are highly integrated into urban space and are strategic locations to access the historic centre.

The ring road is highly integrated and is also an important route for through-movement. Together these potentials add up to a high volume of traffic that complicates access to the historic city centre and the connections towards the surrounding areas. The layout of public space in the inner city shows a linear structure that seems to be optimised for the flow of people and goods. Most access routes lead to the historic market square. The square is the only larger open space within the city centre. Around the market square a network of semi-public alleys and passages permits crossings and short cuts. Although most passages have been unattended for decades, their role as an important element within the historic street network is appreciated today. As a result many of them were preserved even new passages have been built.

3.2 Examination 4 & 5 – Observation and Evaluation

Whereas the previous examinations one to three dealt with axial models using the spatial configuration for analysis, the following examinations focuses on the collection of data, their evaluation and the combination of both spatial and empirical information. The evaluation of movement rates and syntactic measures is usually done with the statistical instrument of correlations. For practical reasons the scope of observations is usually reduced to a certain area of interest like the city centre of Leipzig.

Observations and counts of human movement rates respectively permit the cognition of frequented and isolated areas (cp. chapter 1.3). It is no surprise that the two major shopping streets and the Central Station access belong to the most frequented places of all observed gates. *Grim-*

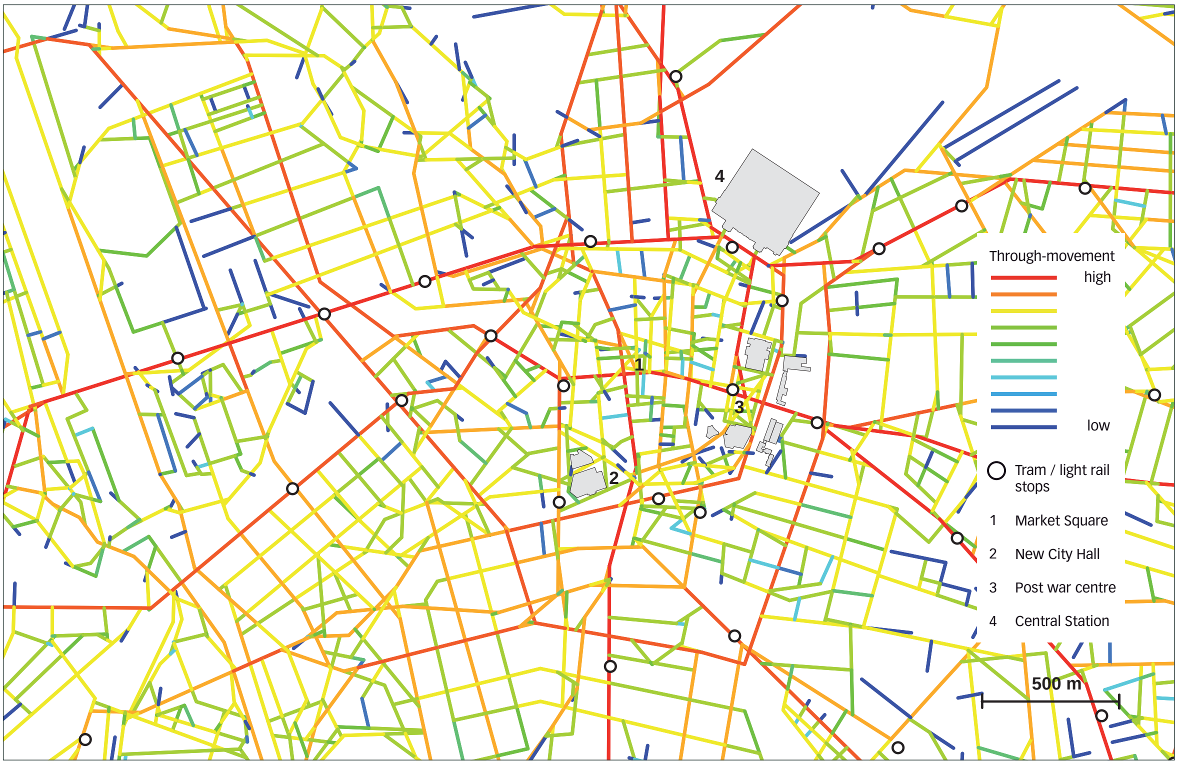


Fig. 25 Axial map of *Choice* determines a hierarchy of through-movement 2006. (Thematic map C.Schaber)

maische Strasse and *Peterstrasse* would even be among the 20 most frequented shopping streets in Germany according to a ranking of shopping streets of German cities from 2001 (EuV 2003). The main access to the Central Station partly exceeds these numbers on Saturdays when many visitors arrive in Leipzig by different modes of rail-carriers. However through a set of counts for each place a more differentiated picture can be obtained. For example, the western gate of the Central Station generally has the highest movement rates of all counted accesses to the station. Whereas this gate accounts for the highest movement rates during the weekend (Saturday), the flow of people during a workday can be different from that.

Observation techniques are used to collect objective environmental characteristics. In this regard the gate-method is a very applicable technique for counts of persons and vehicles in motion. The data collection on site involved 26 different gates. These were chosen according to their position in the surrounding of the future City-Tunnel stations. Thereby intervals of two hours were counted, on workdays between 10 am – 6 pm and on Saturdays between 11 am – 3 pm. Exemplary for the observations in the surrounding of the future City-Tunnel stations the analysis of entrances to the historic centre is discussed below. The examination focuses on three of the most important accesses. All of the locations were previously described (cp. chapter 3.1). In terms of comparability, the places required to have similar characteristics. First, the chosen routes have public transport connections along the ring road. Secondly, there is a big open space and an important public building around the entrance point. At two of them future City-Tunnel stations will be located. An overview about these and further entrances is provided in the enclosed table (cp. fig. 16).

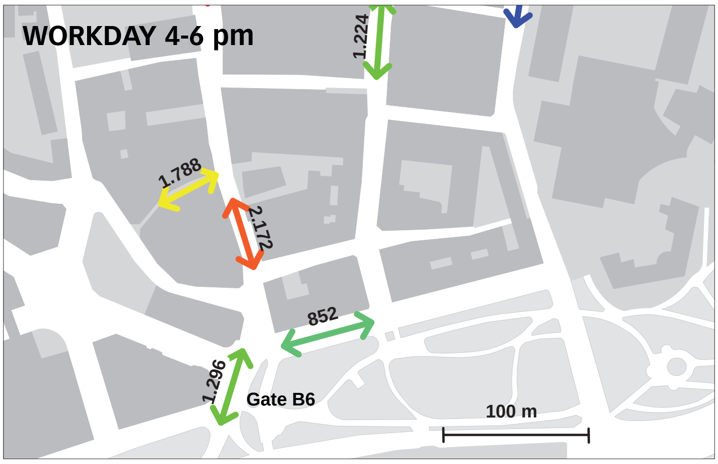


Fig. 26 a

Fig. 26b - *Around GATE B6*

Gate B6 - Peterstrasse III

Leuschnerplatz / New City Hall / Local transport, S-Bahn (2010) (cp. fig.13)

Highest rate (workday 4 to 6 pm)	1.296 persons per hour (ranked: 11.)
Lowest rate (workday 10 to 12 am)	816 persons per hour (ranked: 13.)
Variance: 1,6	

Located at the southern access *Peterstrasse* is an important shopping street. *Leuschnerplatz* is a large open space stretching to both sides of the ring road where the future City-Tunnel station is under construction. The spatial configuration of this area proves that the place is highly integrated into the urban space and belongs to the Integation core, the areas with the hightest Integration values city-wide (cp. fig. 14). However *Peterstrasse* is also an important through-road to the centre from the southern districts. If we take the average movement rates the favourable position in terms of configuration does not match with the effective numbers of people there. Gate B6 ranks in the middle of all observed gates as regards movement rates. As a result other than the spatial configuration must have a strong influence on movement there. There are two possible explanations for the disparity. First, several large construction sites disordered the usual configuration of the public realm. These are the City-Tunnel construction site *Leuschnerplatz* and the partial closure of the southern *Peterstrasse* because of the renewal of the *Karstadt* warehouse in 2006. Another aspect could be the spatial separation of different transport modes at the access to the centre. Cars are not allowed to enter at this point. The required parking facilities are located below the *Burgplatz* square, an underground garage round the corner behind the New City Hall. From there pedestrian use a recently built passage to access *Peterstrasse*. Interestingly the passage accounted for movement rates that had almost the same numbers of people like *Peterstrasse* (South) itself. Furthermore as long as the construction sites exist, it is likely that people are tempted to use other routes to the centre. This includes also the use of alternative tram stations. For pedestrians arriving from southern districts the area is not very attractive because people are obliged to cross a huge and windy open space that does neither provide shelter nor any kind of functions. The area of the wider *Leuschnerplatz* at the southern edge of the ring road is a potential site for future developments.

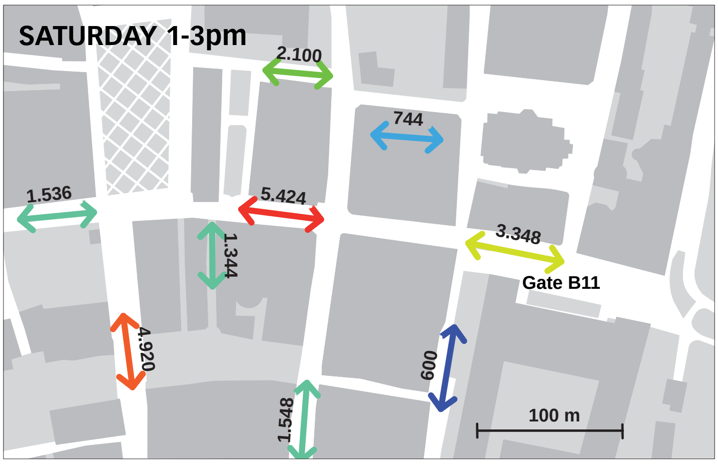


Fig. 27 a (Thematic maps C.Schaber)

Fig. 27b - Around GATE B11 (Pic.: C.Schaber)

Gate B11 - Grimmaische Strasse II

Augustusplatz square / University / Local Transport (cp. fig. 13)

Highest rate (weekend 1 to 3 pm)	3.348 persons per hour (ranked: 6.)
Lowest rate (workday 10 to 12 am)	2.244 persons per hour (ranked: 1.)
Variance: 1,5	

Grimmaische Strasse is the second important busy shopping street in the city centre. Gate B11 is located in proximity to the square of *Augustusplatz*, adjacent to the Central University complex. The area has high potentials for through-movement and belongs to the important eastern access link to the city centre. The global accessibility is comparably lower than at the two other exemplified places. Gate B11 is highly integrated locally and has therefore a high potential for pedestrian movements. The counts well reflect the syntactic properties of gate B11. Although the gate can only be crossed by people walking or cycling the total number of people is comparably high and through-movement potentials are not interrupted there. The transition from public and motorised individual transport is organised on the basis of direct access. For example, the biggest inner-city car park and a tram station are located right at the beginning of the pedestrian area. Further more the ring road crossings for pedestrians and cyclists are at-grade and enable a direct access to *Grimmaische Strasse* and further on to *Market Square*. The change-over from all modes of transport to walking and cycling is organised in a direct and fast way. Thus the through-movement potentials of the eastern access to the centre are safeguarded.

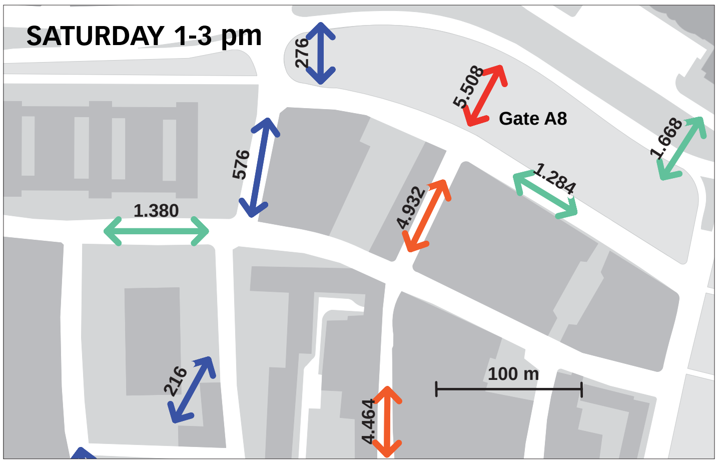


Fig. 28 a (Thematic map C.Schaber)

Fig. 28b - *Around GATE A8* (Pic.: C:Schaber)

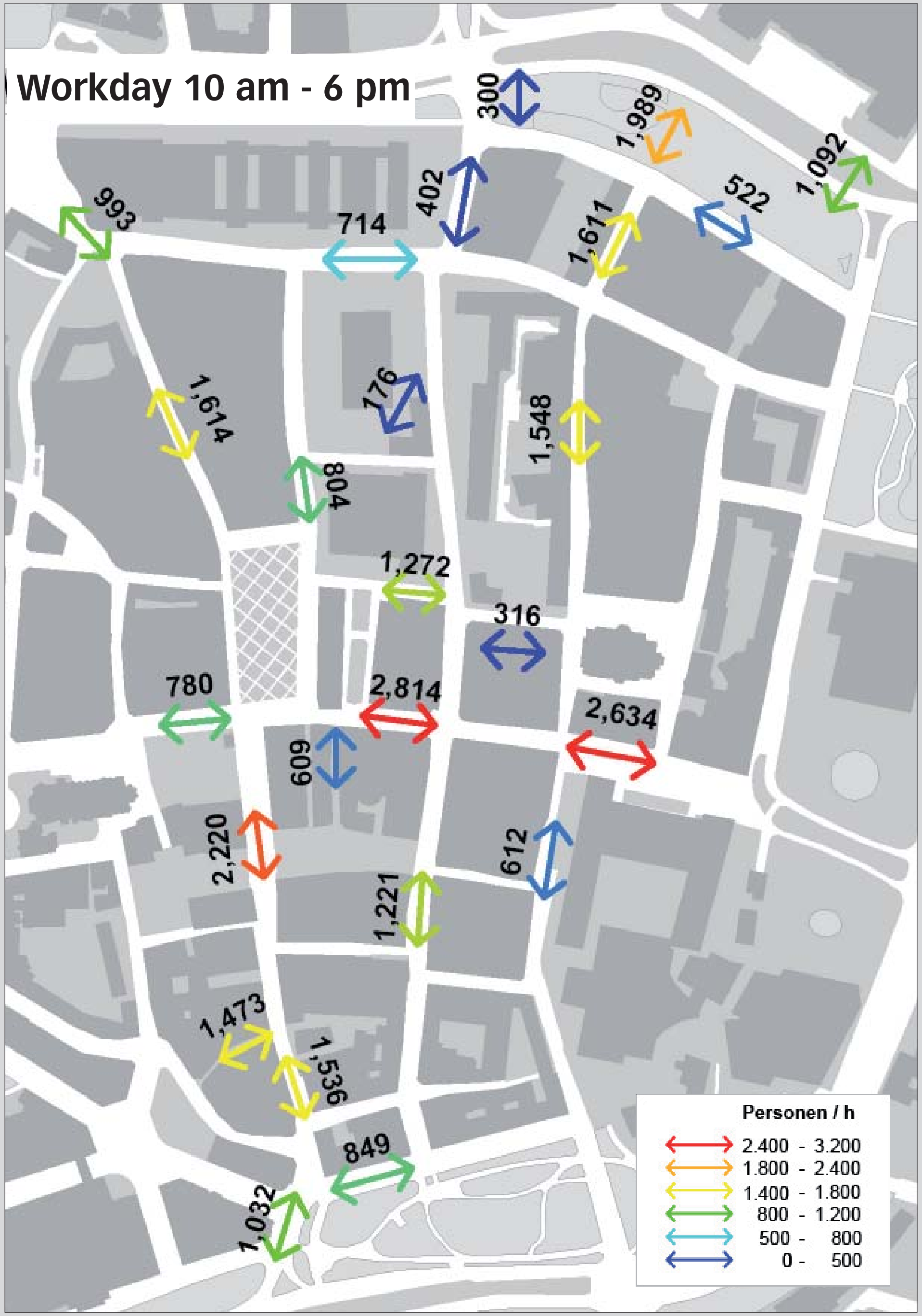
Gate A8 - Central Station (West)
Station Square / Central Station / Local, Regional and National transport (cp. fig.13)

Highest rate (weekend 1 to 3 pm) 5.508 persons per hour (ranked: 1.)
Lowest rate (workday 4 to 6 pm) 1.536 persons per hour (ranked: 9.)
Variance: 3,5

The western entrance of the Central Station is the shortest link from the station to the city centre. Since 1997 the spacious main building of the Central station contains also a shopping centre with about 18,000 m^2 of retail floor space. Gate A8 is located opposite the western gate on the way from the station to the inner-city. The syntactic potentials there mainly lie in a high accessibility for long routes (*Global Integration)*, like car or public transport journeys. In fact the place is located adjacent to the most important local, regional and national public transport lines. As discussed before, station area and surrounding rail grounds create a large barrier effect (cp. chapter 2.4). As a result direct pedestrian access to the station is limited. Although the overall through-movement capacity of the near by ring road is high, the potentials of gate A8 are reduced in this regard because the street terminates at Central Station. The observed movement rates generally reflect the high accessibility of the station square. At weekends gate A8 accounts for the highest movement rates of all 26 observed areas. However the proximity of the station also leads to high variances of single movement rates. Lowest and highest counts there differ with a factor of 3,6 whereas the previously described gates B6 and B11 only differ by 1,6 and 1,5 respectively.

Evaluation of observation data

The evaluation of movement rates aims at combining two important elements of Space Syntax research, i.e. the number of people and the spatial configuration represented through syntactic measures. The analysis is based on the statistical tool of correlations. For the determination of the *person – space correlations* scattergrams have been utilised. The previously undertaken comparison of different city entrances involved such kind of procedure in a simplistic way.



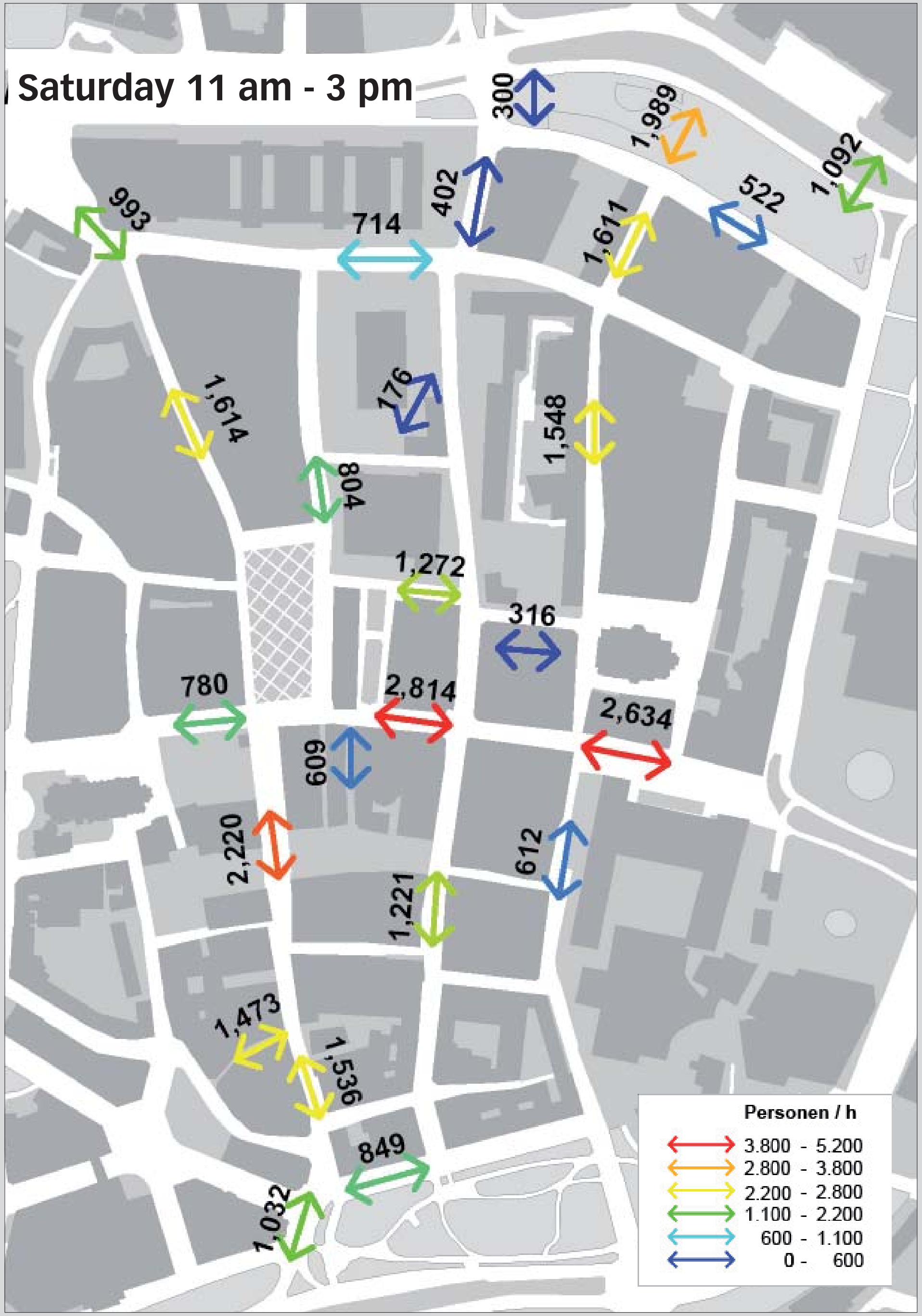


Fig. 29 Quantitative flow of people adjacent to City-Tunnel Stations in the centre of Leipzig 09 / 2006. Reference: Data collection and thematic map C. Schaber.

INTEGRATION / To - movement

Time period	WT 10-12	WT 12-14	WT 14-16	WT 16-18	WE 11-13	WE 13-15
Int Radius 3	52%	59%	42%	53%	25%	26%
Int Radius 5	55%	57%	46%	58%	32%	30%
Int Radius 7	51%	46%	48%	59%	31%	31%
Int Radius n	20%	12%	43%	28%	38%	39%

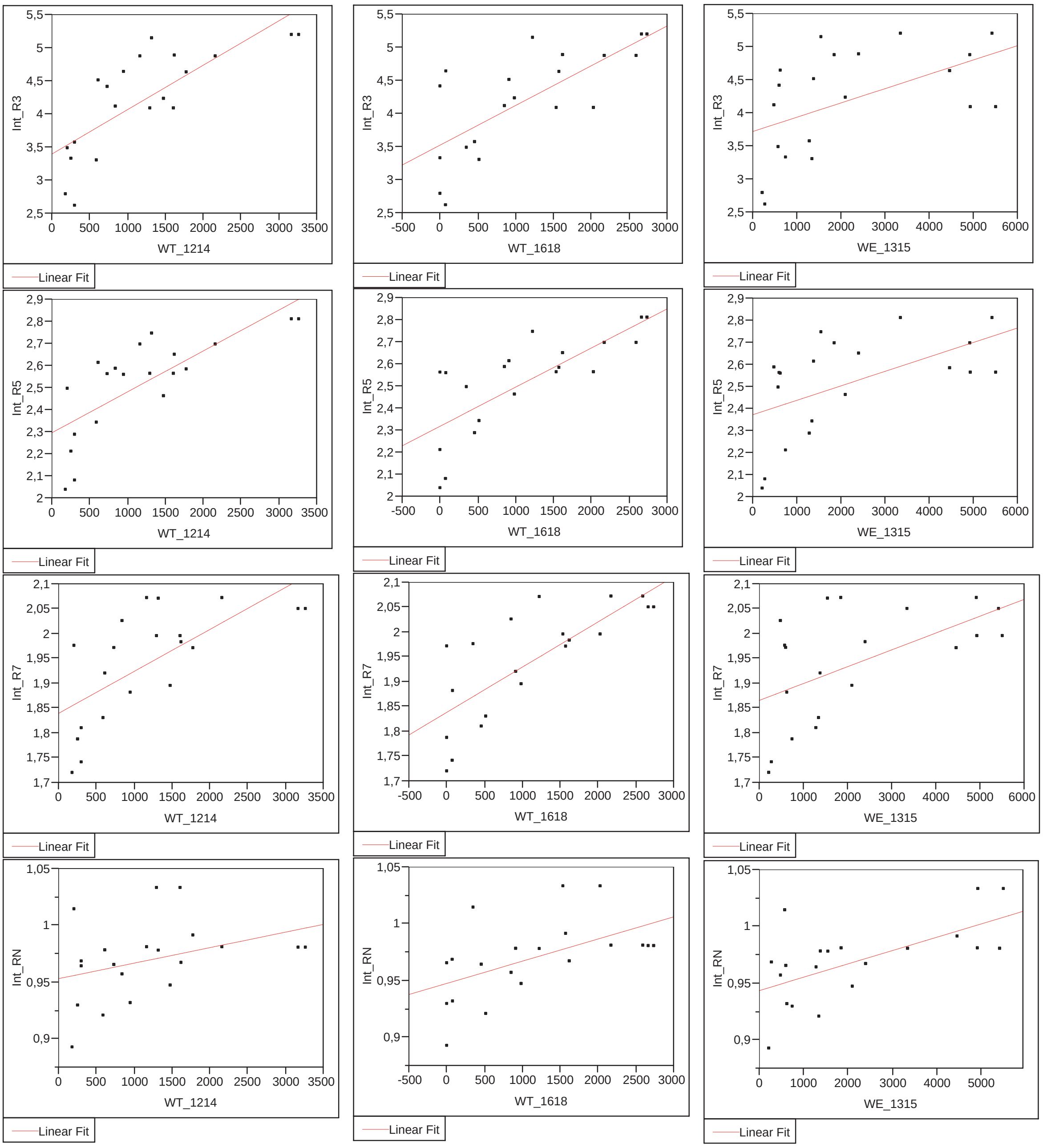


Fig. 30 a,b - The *Integration* measure - Data and Illustrations: C. Schaber

a (top) Overview of space - people correlations for the Integration measure. The red numbers indicate the highest correlation for each time period of observations.

b Scattergrams determine the relevant space - person correlations. Therefore the statistical tool, R-squared, is used. The chart shows scattergrams for the time periods 12 am - 2 pm, 4 - 6 pm on workdays and 1 - 3 pm on Saturdays.

EXAMINATION 5

Statistical evaluation: *people – space correlations*

Syntactic measures:	*Integration, Choice*
Radia	R3, R5, R7, Rn, 400m, 800m, 1200m, Rn
Observation	Total number of pedestrian and bicycle movements
Time period	Workday 10-12 am, 12am–2 pm, 2-4 pm, 4-6 pm
	Weekend 11am–1 pm, 1-3 pm
Gates	all
Study areas:	Station surroundings City-Tunnel

The analysis about the importance of urban spatial configuration for the flow of people is driven by two main intensions. What is the proportional impact of the urban grid on the movement rates of passers-by ? This impact can be determined for each observed time interval (10 - 12 am, 12 am - 2 pm, 2 – 4 pm etc.). As a result the strength of the correlation between movement rates and spatial configuration can be analysed. Therefore the coefficient of determination, *R-squared* has to be calculated. Per definition in statistical literature a *R-squared* value above 0,6 is considered as a strong correlation between two variables (cp. chapter 1.3). Another relevant aspect is related to the radius of dominating movements. *People - space correlations* can identify whether people collectively used rather short routes or longer routes for each available time period. At the same time the radius can be associated with certain modes of transport. The movement rates of six different time periods were correlated with the syntactic measures of *Integration* and *Choice*. Thereby the evaluation involved four different radia. For *Integration* these are the topological radia R3, R5, R7 and Rn, for the *Choice* measure these are the metric radia 400,800, 1200 and Rn respectively. The results of the correlations can be found in the particular table (cp. fig. 20 & 21).

Findings

Generally, the share of *Natural Movement* in the centre of Leipzig is only around 40% on weekends. By contrast both syntactic measures demonstrate almost strong correlation values during workdays. Then up to 59% (*Integration*) and up to 54% (*Through-movement*) refer to the urban spatial configuration. The most striking difference between workdays and weekends is the above average increase in movement rates at the Central Station access (cp. gate A8). It is therefore argued that the existence of a single, large transport hub like Central Station reduces the spatial impact on movements during peak hours. In Leipzig where the centre has got a stronger retail and leasure uses than offices, Saturdays can be considered as a peak time. Space Syntax explains this effect with an uneven distribution of attractors that is expected to reduce the notion of *Natural Movement*. The radia or length of routes people collectively complete in the course of a day differ from one another. For example, the shortest routes have been recorded between 12 am and 2 pm. In the late afternoon routes become longer and during the weekend they achieve the longest radia possible. This applies for the measure of *Integration* just like *Through-movement (Choice)*. More detailed findings are provided in the exemplary description of certain time periods below. In addition the table in figure 25 shows an overview about the attribution of measures to all observed time periods.

CHOICE / Through - movement

Time period	WT 10-12	WT 12-14	WT 14-16	WT 16-18	WE 11-13	WE 13-15
Radius 400m	40%	43%	11%	19%	9%	12%
Radius 800m	**45%**	**50%**	28%	42%	22%	21%
Radius 1200m	41%	45%	34%	48%	26%	24%
Radius Infinity	34%	32%	**45%**	**54%**	**34%**	**38%**

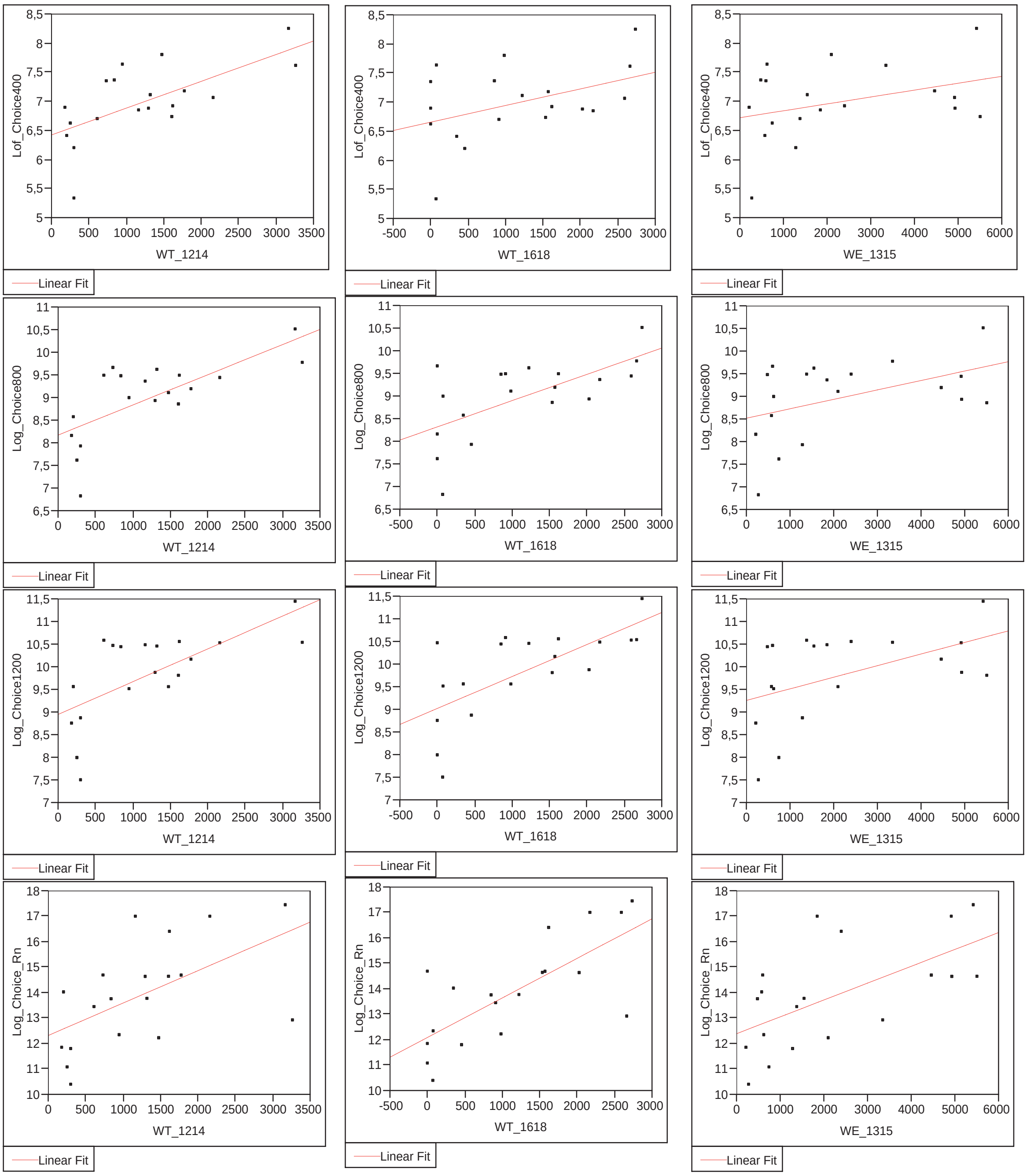


Fig. 31 a, b - The *Choice* measure - Data and Illustrations: C. Schaber

a Overview of space - people correlations for the Choice measure. The red numbers indicate the highest correlation for each time period of observations.

b Scattergrams determine the relevant space - person correlations. Therefore the statistical tool, R-squared, is used. The chart shows scattergrams for the time periods 12 am - 2 pm, 4 - 6 pm on workdays and 1 - 3 pm on Saturdays.

Example A

Time Period:	Weekday 12 am – 2 pm
Syntactic measue	*Local Integration (Int R3)*
Natural Movement	59%

The spatial determination of 59% is achieved when the collective movement in the examined area is dominated by short trip lengths. Therefore it can be stated that people predominantly use short routes to local destinations between 12am and 2pm. As a result the flow of people is mainly dominated by walking within the centre itself. There after the dominating collective movement radius can be represented as an axial map modelling the respective measures like Integration in the example. Again the classical Space Syntax colour range is utilised. According to the correspondent axial map (*Integration R3*) Grimmaische Strasse is used more often than other routes. The *Museum Quarter* to the north has a similar potential for high pedestrian movements between 12 am and 2 pm. However practically this is not the case as the observations demonstrate. In contrast to *Grimmaische Strasse* this area offers a lack of functions. The same procedure can be applied for each interval of observed movement and for various syntactic measures.

Example B

Time Period:	Weekday 4 – 6 pm
Syntactic measue	*Trough-movement*
Natural Movement	54%

Between 4 – 6 pm on workdays the quantitative flow of people results in the spatial determination of movement of 54%.Thus it can be stated that the correlation can be considered as almost strong. The value of 54% is achieved when the collective movement in the study area is dominated by very long trip lengths. Therefore it can be claimed that between 4 and 6 pm people use predominantly long routes to move towards their destinations. As a result movement mainly starts and determines outside the city centre. It can be concluded that people use either the car or public transport for these routes. The mobility index for Leipzig shows that 53,1% of public transport routes are longer than 5,1 km (SrV 2003, p.11). The axial model of *Through-movement* indicates the course of the principal routes for this kind of movement (cp. fig. 5).

Example C

Time Period:	Weekend 11 am – 1 pm
Syntactic measue	*Global Integration (Rn)*
Natural Movement	38%

The variable of *Global Integration (Rn)* accounts for the highest correlation value at the weekend between 11am and 1 pm. Reasons for the comparably low correlation of 38% were given previously. Anyhow very long radia or routes length dominate the collective movement at this time. Therefore it can be stated that between 11am and 1 pm people arrive at the city centre either by car or public transport. Both transport modes account for long routes within the study area of 12 km diameter. The correlation analysis enables the elimination of single observation gates. This makes sense to study the importance of certain spaces. Gate A4, a northern entrance from the ring road to the city centre is used to exemplify this matter. During the weekend the coefficient of determination *R-squared* for urban configuration is around 40% for *Integration* measures (cp. fig. 23). This rather medium value partly derives from very low movement rates at gate A4, named *Hallesches Tor*. The street is an important northern access to the historic centre. For several reasons this entrance is currently locked for certain kinds of movement. As a consequence a disparity between movement rate and syntactic potential appears.

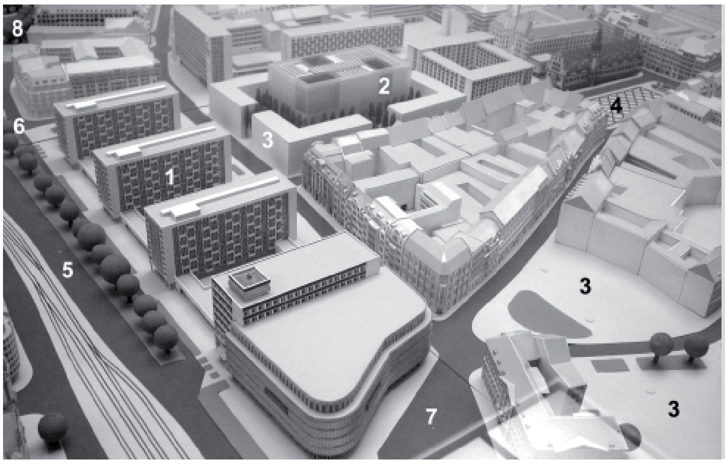


Fig. 33

Development Area northern City centre

1 Vacant housing estate / Future mixed-used development
2 Art Gallery
3 Disposable premises (2007)
4 Market Square
5 Northern ring road
6 Hallesches Tor
7 Wagnerplatz
8 to Central Station
(Pic.: C.Schaber)

3.3 TranSEcon Study

Urban regeneration through transport infrastructure

Some useful findings that have been addressed previously within this report derive from the European TranSEcon research project. The study from 2003 analyzed direct and indirect impacts of investments in relation with rail-bound carriers. The analysis involved public transport infrastructure projects in 13 different European cities[4]. The cases involved underground, tram, S-Bahn[5] and light rail schemes. The Institute of Transportation at the University of Vienna was the lead partner of the project.

In concrete indirect, long term socio-economic impacts were examined. The basis of the research comprised of a broad mixture of economic and social issues including the promotion of development areas, mobility of disadvantaged persons, improved access to basic needs of supply, transport safety and the quality of the public realm. The general recommendations and the issues of urban regeneration and regional development have been of interest for this work.

The final report of the study provides recommendations for action as well as background knowledge for municipalities and regional partners in terms of transport planning and infrastructure development. The amount of qualitative and quantitative data collected for TranSEcon offers a comprehensive basis for general insights that are used to initiate the appraisal of the City-Tunnel Project. In terms of urban regeneration TranSEcon examined urban areas that benefited from an improved accessibility. The evaluation of all 13 cases was carried out through hard and soft factors. Hard factors were real estate prices, rental prices, land use patterns and current investments. The soft factors considered indicators like the attractiveness of an area elaborated through interviews and questionnaires (TranSEcon 2003, p. 35).

According to the study the improved rail-bound transport infrastructure accounts for:

1 An increase in the number of businesses (retail, services) in central inner city areas. At the same time a reduction of population through out-migration to the suburbs was monitored.
2 Both aspects were regarded as a contribution to strengthen centrality in a regional sense. Across the region private investments tended to take place around areas with an improved accessibility.
3 The availability of space or construction sites in relation with local conditions was crucial for the development of an urban area.
4 The urban regeneration indicator (cp. chapter 2.1) showed the importance of different rail carriers for urban development (TranSEcon 2003, p.38).

Already today the City-Tunnel stations *Market Square, Central Station* and *Leuschnerplatz* are located at busy places. The operation of the City-Tunnel from 2010 onwards is likely to increase movement rates around the station areas and in the historic centre. There are two important preconditions for that. First, the restructuring of the S-Bahn und regional train network in the Leipzig conurbation extends the catchment area of central Leipzig. Second, the municipal strategy aims at improving the accessibility of the centre particularly along the ring road. There the first measures, for example at-grade crossings for pedestrians and bicycles have been implemented recently. Except Central Station with three, each new City-Tunnel station will offer two separate accesses. Although there are estimations about passenger numbers for each station (cp. fig. 7) the distribution of these numbers among the individual entrances is not known.

Experiences of the TranSEcon study claim that the availability of construction sites and derelict land in the surrounding of public transport stations matter. According to this, well-conditioned urban areas experience only gradual changes. In contrast, areas like the northern city centre are likely to experience bigger changes. The area is located between the two most frequented future City-Tunnel stations and has yet substantial vacancies and fragmented urban spaces. Therefore the northern centre is considered as a future development area (SKS 2006, p.3). For comparable cases TranSEcon found out that similar circumstances acted like a catalyst for urban regeneration. The studies refer to top-quality projects with mixed uses (TranSEcon 2003, p.35 et sqq.). The area between the two pedestrianised shopping streets *Nikolai*- and *Hainstrasse* in the northern city centre is characterized through vacancies and fragmented urban spaces without active frontages. Single municipal interventions like the construction of the *Art Gallery* 2004 and the removal of a pedestrian crossover for example, prove that the area is in transition. However, the own observations from 2006 demonstrated that movement rates are still low there and the regeneration process has just begun.

3.4 Reasons for the isolation of a central development area

The role of public transport

About half of all people arrive in the centre of Leipzig by public transport. The Central Station and the inbuilt shopping centre are used by 150,000 travellers and visitors daily according to the Deutsche Bahn (DB 2006). The important role of the *Central Station* as local, regional and national transport hub has spatial implications for the city centre. It can be demonstrated that the northern part of the centre adjacent to the Central Station has a higher dependency on public transport than the southern area. The daily use of different transport modes indicates unequal curves and peak hours respectively for public transport and car use (MIV). Both can be compared to the number of people counted in exemplary spaces. In the north it becomes evident that movement rates decrease significantly after 3 pm like the use of public transport. In contrast movement rates in the southern centre still rise after 3 pm and remain constantly on a high level just as well as the use of cars (cp. fig. 22-24).

The dependency of the northern centre from public transport is enforced through the absence of parking spaces that are clustered around the shopping streets to the south and on both sides of the Central Station (cp. fig. 13). In this regard the close relation of retail facilities and parking spaces is evident. In 2003 the northern centre only accounted for about 10% of the total retail floor space in the entire centre inclusive Central Station (IHK 2002, p.46) and 14% of the total car parking spaces (BMW 2004, p.2). In fact structural weakness and spatial isolation of the northern centre is not new. The place is considered as an important future development area.

What are the reasons for the lagging behind of the northern city centre ?
In fact the area is situated in an opportune and central location between *Central Station* and *Market Square*. From the author´s point of view there are two main reasons for the decline of the northern city centre. One aspect are the structural interventions during the post-war era. These led to a substantial disruption of the regular urban fabric in the historic centre. Existing structures like alleys or passages were removed others were added. The absence of active frontages and the dominance of wide open spaces partly create a kind of urban no man´s land. The opening of the public *Art Gallery* in 2004 has not yet changed the isolated character of the area. Today the segregated appearance of public space is still existent. Positive incentives are expected from the demolition and the new construction of a post war housing complex. However further investments are required to improve the quality of public realm. Despite its central position the area suffers from an inadequate accessibility.

Access to the northern city centre is complicated by functionally segregated traffic modes and the barrier effect of the wide ring road. Additionally the northern ring (*Tröndlinring*) is among the busiest roads like syntactic analysis *(Through-Movement)* affirms (cp. fig. 5 & 32). As a result unattractive crossovers and underpasses isolate pedestrian movements from other kinds of locomotion. That way the selection of direct routes is hardly possible. *Wagnerplatz* and *Hallisches Tor* are two links between the centre and the areas on the other side of the ring road. The latter was considered noticeable in the previous chapter because of a disparity between movement flows

Fig. 34

Vacant housing complex and City-Tunnel information box.

Northern city centre Leipzig, 2006
(Pic.: C.Schaber)

and syntactic potentials. There after *Hallisches Tor* is believed to play an important role in the accessibility of the northern development area. Movement rates at gate A5, an underpass, were generally among the lowest of all 26 observation gates.

Why do people avoid the Hallisches Tor, the area of Gate A4 and A5 ?
The answer is quite simple. The street is hard to access. Except for bicycles the place is either unattractive or locked. Despite the importance of public transport for the northern centre there are no stops or stations around *Hallisches Tor*. Even if several public transport stations are only some hundred meters apart, the flow of people uses other routes from there to the inner-city. As a result only bicycles can pass *Hallisches Tor* unobstructed. In fact during workdays 50% of all passers-by there are cyclists. Hence gate A4 also accounts for the highest proportion of cyclists in relation to all observation gates. For comparison, the city-wide proportion of cycling is around 12% (SrV 2003, p.8). The construction of the Central Station in 1912 led to modifications of the street network within the historic centre. Thus the then new link at *Nikolaistrasse* directs the flow of people away from the development area. Furthermore the high dependency on public transport fuels this issue. For example, on Saturdays between 11 am and 3 pm more than 4,000 people per hour take the route to and from *Nikolaistrasse*. At the same time 150 metres distant just about 600 people per hour pass *Hallisches Tor*. There the today isolated crossing *Hallisches Tor / Brühl* used to be the place where the ancient channel of trade *Via Regia* (via regia 2006) and *Via Imperii* met (Riedel 2005, p.71).

3.5 Examination 6 & 7 - Prognoses about the flow of people

Empirical studies have demonstrated that the municipal willingness to invest in the quality of public space is an important precondition for successful (public) transport infrastructure projects (TranSEcon 2003, p.39). It can be supposed that the municipal willingness for investment into public space is high in Leipzig. One reason is the rather symbolic municipal contribution to the finance of the City-Tunnel project. The project is mainly financed by federal, nation and European (ERDF) funds. Another aspect is the municipal strategy for public space. Among other aspects the strategy involves the following directives[6] :

Fig. 35

View towards Central station

The area was proposed as a potential municipal investment site for public space. 2006 (Pic.: C.Schaber)

- Encourage pedestrian-friendly environment
- Eliminate barrier effects and create pedestrian and bicycle crossings at-grade (ring road)
- Increase movement rates
- Prompt tourism-orientated urban development
- Activate development areas through spatial integration (Art Gallery investment)
- Selective investment into public space

Currently the city is working on a concept to prompt a pedestrian-friendly environment in conjunction with the upgrade of highly frequented public spaces in the historic centre (SKS 2006, p.2). A fundamental issue is the increase of movement rates. It is believed that higher numbers of passers-by will contribute to the economic well-being of the city. The historic centre faces a strong competition with out-of-town shopping centres in and around the city boundaries (SKS 2006, p.3). The attraction of visitors into the city centre is accompanied by reduced travel times on national train routes since 2006 and on regional train routes from 2010 onwards. Urban regeneration in the centre thereafter has to reflect tourism-orientated measures. However the strategy also aims at attracting more people from the city itself. Therefore the accessibility for pedestrians and cyclists shall be improved substantially.

The sixth examination carries out a comparative simulation of the northern development area in central Leipzig. The simulation contrasts axial models from 2000 and 2015. The frames of figures 30,32 mark an area where the accessibility to and from the northern centre will be improved substantially. Two entrances will be transformed into pedestrian friendly and highly integrated places. The simulation focuses on these two connecting streets passing through the northern centre. It can be demonstrated that unlocking the mentioned access points will lead to a much better accessibility. There after large parts of the northern city centre will be part of the *Integration Core*, spaces with the highest *Integration* values city wide. As a result the intended measures form three highly integrated entrances. The opportunity is given to unlock the northern centre for different modes of transport. The simulations shown in fig. 31 and 33 also indicate an effective improvement of accessibility for the City-Tunnel station Market Square (North). The second highest passenger numbers are assigned to both stations entrances there. After the interventions both

Fig. 36

City centre access at Hallisches Tor.

View from ring road southwards Northern City centre Leipzig, 2006 (Pic.: C.Schaber)

entrances will be highly integrated. Higher values of Integration are associated with higher movement rates (cp. chapter 1.2). The simulation underlines the aspiration that adjacent districts on the other side of the ring also benefit from the interventions along the northern ring road. This can be demonstrated at the crossings *Hallisches Tor* and *Wagnerplatz*. A better external and internal access, as shown in the model, is thought to determine higher movement rates in the development area. External access will be improved through the restructuring of ring road crossings whereas a better access from within derives from the City-Tunnel station Market Square. A highly accessible *Museum Quarter* corresponds to the municipal goals aiming at the extension of the publicly funded *Art Gallery*.

However the Gallery today still appears like a single object rather than a *Museum Quarter*. There further investment is required. To benefit from the near-by City-Tunnel station *Market Square,* the *Art Gallery* needs to be associated with the station and the direct access from there to the area. Although the design of station facilities under ground has been assigned by competitions, the layout of the City-Tunnel stations in relation to the public realm remains mainly undecided (cp. fig. 7). Anyhow the simulations of 2015 (cp. fig. 31,33) clearly highlight places within the northern development area that benefit most from an improved external and internal access. Movement rates around there are likely to increase. Therefore the extended external ring road access at *Hallisches Tor* and the link from station *Market Square (North)* to the new construction site of the *Brühl* are predestinated places for municipal investment into public space. In addition, the above ground elements of the station require adequate design and spatial integration to bring underground investment into the public realm.

The comparative simulation of *Through-Movement (Choice)* (cp. fig. 32,33) proves that interventions into urban space at certain places do impact on other places further away. For example, a better permeability at principal access points like *Hallisches Tor* reduces trough-movement at other places like the eastern ring road. In this way the barrier effect along the ring can be reduced through a reduction of through-movements there. This is a simple example for what is considered the complexity of urban configuration and emergence respectively. Today the lock out of movements at important access points like *Wagnerplatz* and *Hallisches Tor* keeps trough-movements on the ring road. As a result the ring obtains a higher potential for trough-movement.

The isolation of the central entrances increases the use of the ring road and therefore contributes indirectly to its barrier effect. The simulation model 2000 indicates the isolation of the northern development area from any significant through-movement (cp. fig. 32). The reduction of the barrier effect increases the relevance of through-movements. The simulation 2015 shows two significant North – South connections with high through-movement potentials. The position of the *Art Gallery* and the future *Museum Quarter* will then be situated at one of the most important routes for through-movement. The simulation shows that the opening of two northern accesses to the centre reduces the barrier effect of the ring road. At the same time the isolation of the existing *Art Gallery* and future developments can be tackled. The above findings are based on axial models that function universally in terms of different kinds of movement. Therefore the trough-movement potentials have to be created in a "multi-modal" way. This includes non-stop cycling and pedestrian connections at ground level, parking spaces and public transport links. Gate A11 at *Augustusplatz* (cp. chapter 3.2) is a good example for a successful change-over from all modes to walking and cycling.

The structural interventions that have been simulated so far looked at the impact of city wide movement and long journeys respectively. The model can cope with long routes because of its relatively large size (r=6km). Long routes are examined by the use of Rn (radius infinity) and are commonly associated with car uses and particularly in Leipzig also with the use of public transport (cp. chapter 3.2). The large radius reflects the importance of the historic centre and analyses what kind of routes people use to get to *(Integration)* or pass by *(Trough-movement)* the centre. Now the following examination aims at simulating local routes people collectively choose. Local routes are examined by the use of small radia like R3 (topological) or radius 400, 800 (metric). These relatively short routes are commonly associated with local or pedestrian movements. The current examination is about *Through-Movement (Choice)* with a radius of 800m. Examination 7 aims at defining areas for prioritised public investments. In this regard an own proposal for the modification of public space is tested exemplary by the insertion of a new route between *Central Station* and the *Museum Quarter*.

Today many visitors miss the area of the Art Gallery because coming from *Central Station* they walk straight on and turn right not until they have moved deeper in to the historic centre. Although this route may be fairly longer to Market Square for example the decision visitors take is comprehensible. After the principle of *energy efficiency*[7] (cp. chapter 1.4) the straight route seems to be direct and initially passes by historic buildings. However coming from *Central Station* many local people turn right earlier. They know that the apparently direct street visitors take, offers little in terms of shopping and leisure facilities. Hence after turning right locals pass the Art Gallery in the development area and arrive earlier at *Market Square* and the shopping streets behind it. What can be done to divert visitors coming from Central Station towards the *Museum Quarter* ?

The answer can be found in the destinction of routes of vistors and locals. The task is to create a direct path that guides visitors from the station into the area of the *Museum Quarter* and further on to Market Square. It is proposed to make the right turn already on the station square before entering the historic centre. From there the entrance of *Hallesches Tor* is already visible. The space between the station square and *Hallesches Tor* is subject for modernisation after the City-Tunnel

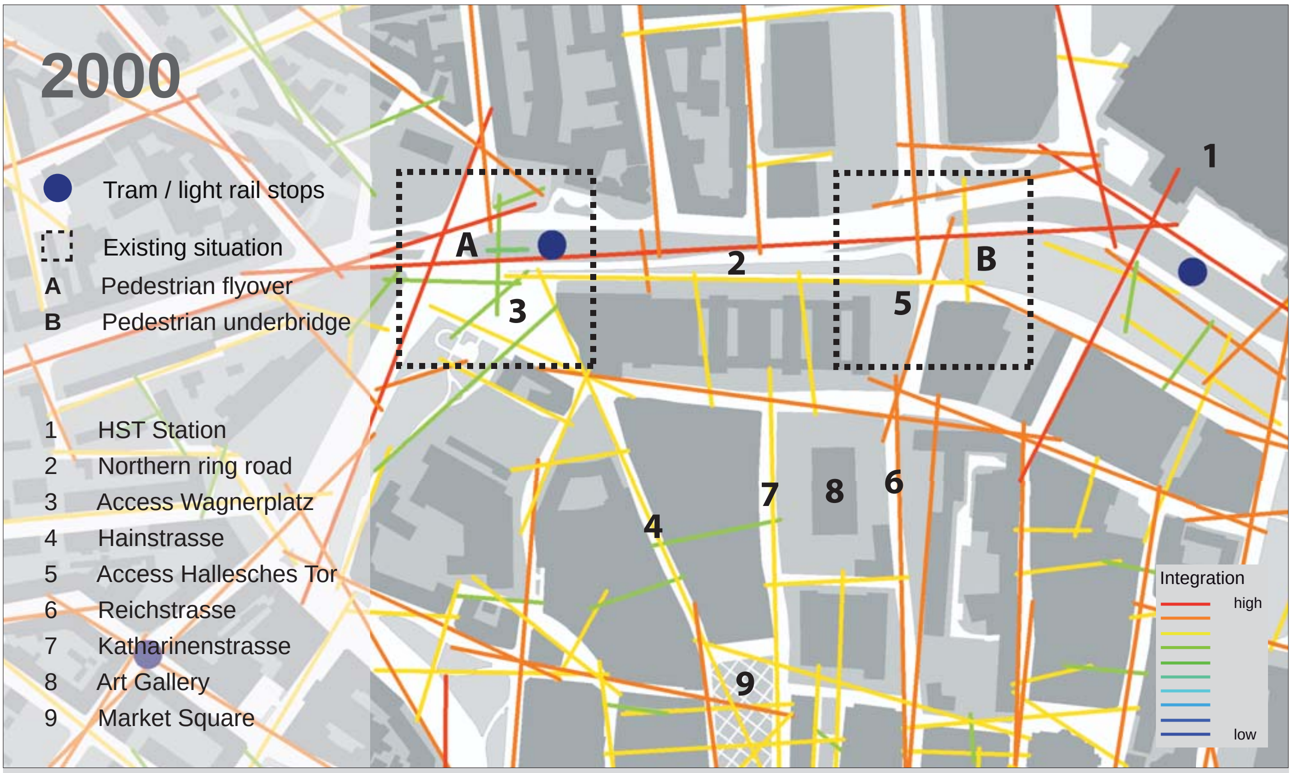


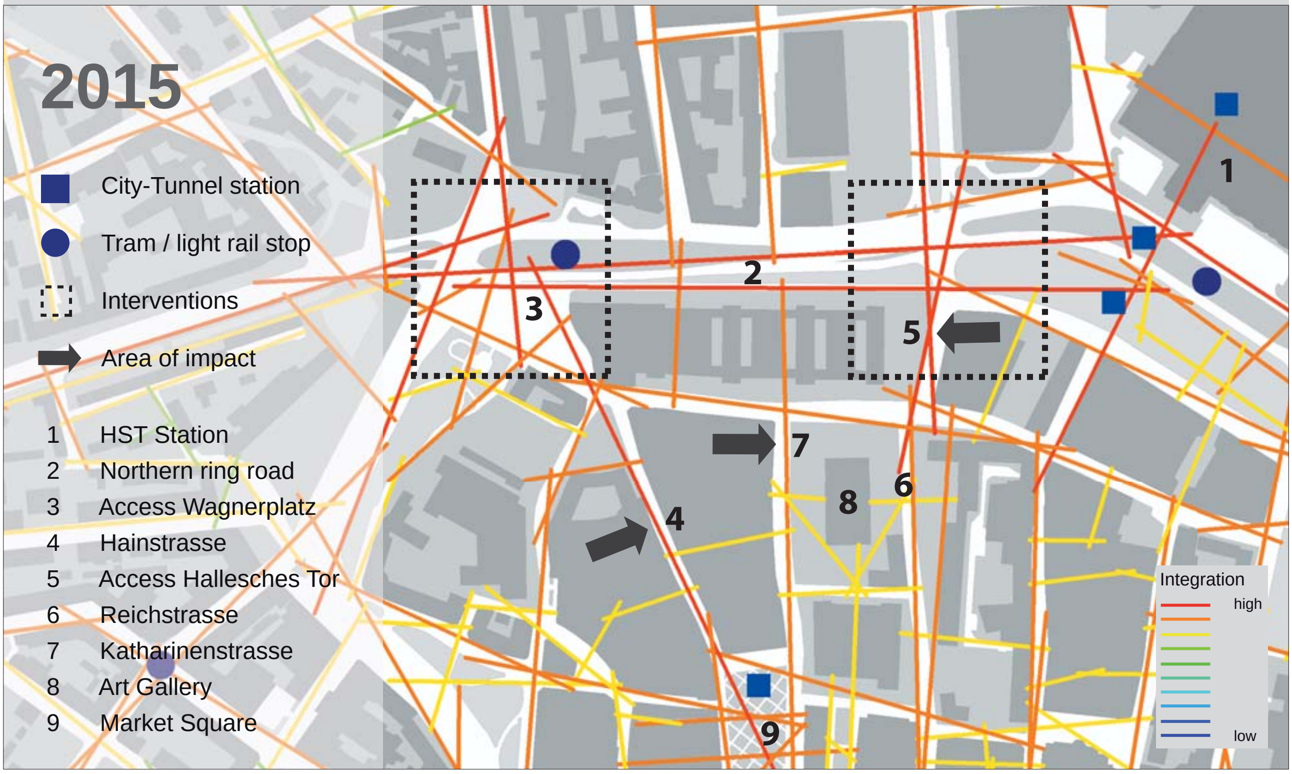
Fig. 37 a

Fig. 37 Comparative Simulation: Accessibility of the northern City Centre 2000 / 2015 (Thematic maps C. Schaber)

a In 2000 the access to the northern City centre is still obstructed. The frames mark the area at Wagnerplatz (A) and Hallesches Tor (B). The axial model shows a high accessibility only outside and around the ring road.

b After the planned interventions at ring road crossings the accessibility of inner-city areas will be improved substancially. Interestingly these interventions also lead to a much higher accessibility in the wider surrounding of the entrance gates as the arrows in fig. 37b demonstrate.

Fig. 37 b

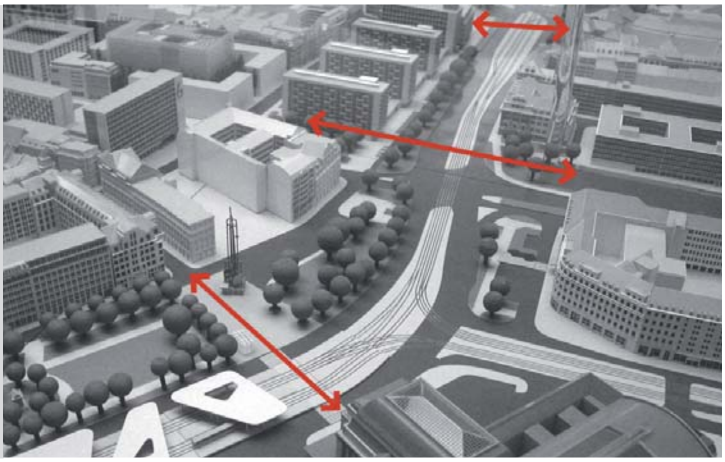


EXAMINATION 6 - Fig.38

Simulation ring road crossings

Syntactic measures:
Integration Rn / Choice Rn
Tools: Axial maps 2000 / 2015

Impact of improved accessibility on northern development area
(Illustration: C. Schaber)



works are finalised. It could be implemented as part of the successive renewal of the western station square. As a result the proposed new link (number 3a, indicated with an arrow) offers a high potential as a new direct pedestrian connection. The new route from *Central Station* into the *Art Gallery* is easy to detect for visitors because a change of direction is required only once. The proposal also helps visitors to find a direct link into the centre of the city.

3.6 Summary flow of people

The deprivation of the northern city centre comes along with low movement rates. As regards urban space, the isolation of the area is caused through an inadequate accessibility and the partly imperfect quality of the public ream (cp. chapter 3.4). An important aspect to change these poor conditions is to improve the accessibility of the city centre on different levels and in different ways. Externally the access to the centre will be improved on the national, regional, urban and local level. In this regard the city opted for a tourism-orientated strategy to bring more people into Leipzig. This is believed to contribute to the economic well-being of the entire city centre. Furthermore the external measures have also implications on the internal circulation. For the first time a busy[8] public transport station is located in the very centre of Leipzig.

The restructuring of the S-Bahn and regional train network enhances the access to the centre on the regional scale. The characteristics of the new scheme are shorter and more direct connections to and from the centre on the basis of an attractive public transport network. Thus the city enlarged its catchment area and a has now a wider number of potential visitors and clients in the conurbation. The implementation of the City-Tunnel project is expected to have strong impacts also on the urban level. In the city the scheme functions like an underground system connecting the most important destinations in the *Oberzentrum*[9] Leipzig. The new stations will be also well interrelated with the urban street network. There will be direct access for all modes of transport at different stations. Syntactic analysis proved that the northern ring road has a key function for the external access to the northern development area. Interventions at strategic points have been

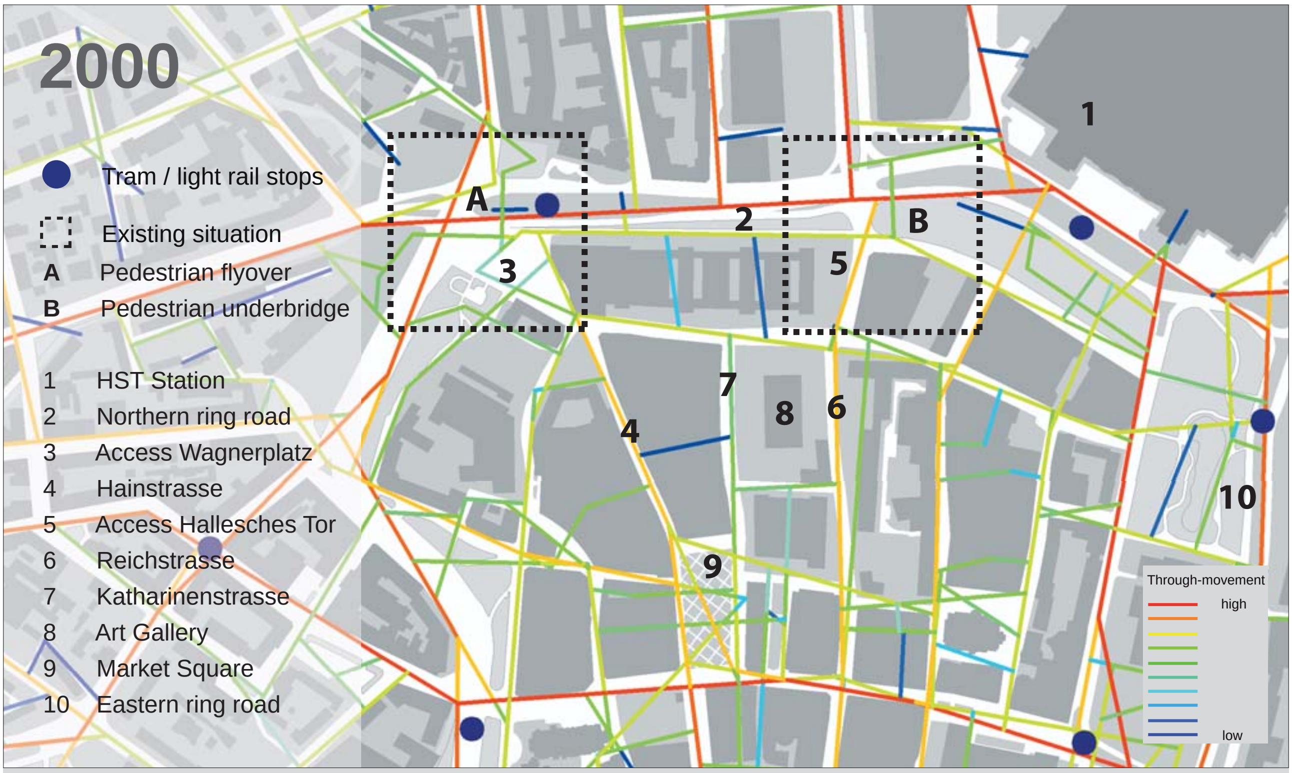


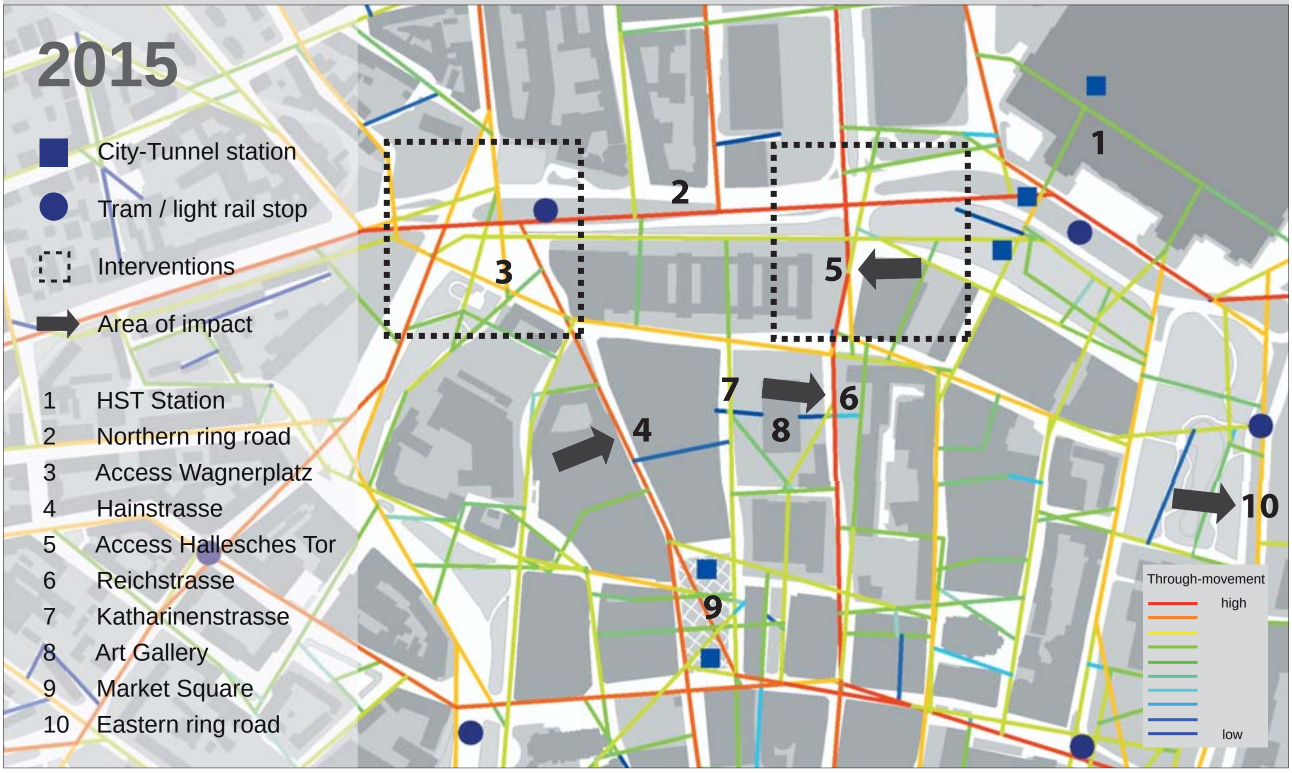
Fig. 39 a

Fig. 39 Comparative Simulation: Through-movement capacities of the northern City Centre 2000 / 2015
(Thematic maps C. Schaber)

a The marked squares again show the northern entrances Wagnerstrasse (A) and Hallesches Tor (B). The axial model detects the through-movement capacity of the northern ring road at this segment. However the northern centre remains uneffected of this emergence.

b The planned interventions at ring road crossings increase through-movement capacities of the area Wagner-Platz (3) / Hainstrasse (4) and Hallesches Tor (5) / Reichstrasse (6). In addition the opening up of the northern centre can lead to the reduction of through-movements around the ring roag (10).

Fig. 39 b

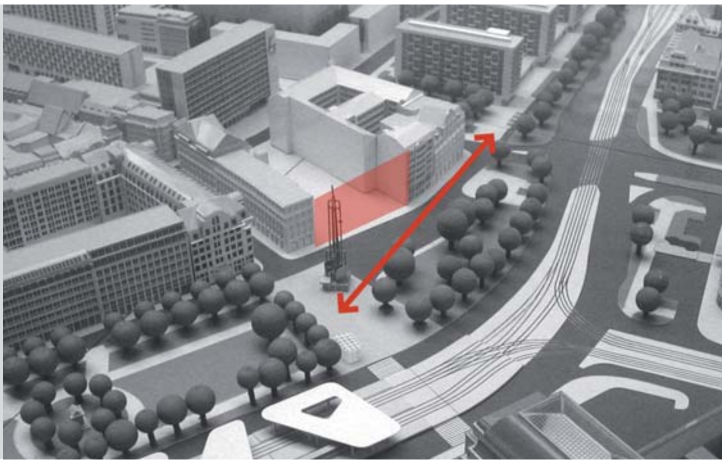


EXAMINATION 7 - Fig.40

New route proposal
Central Station to Museum Quarter

Syntactic measures: *Choice R 800*
Tools: Axial maps 2000 / 2015

Recommendation visitor-friendly public realm
(Illustration C. Schaber)



analysed. *Hallisches Tor* is the most important external link to the development area. However there are no public transport stops at this point because of its relative proximity to Central Station and other stops nearby. The simulation showed that unlocking of entrances is not enough. It is therefore equally important to create an attractive change-over from car use outside to walking and cycling inside the centre particularly at *Hallisches Tor*. According to studies like TranSEcon development areas like the northern centre are likely to benefit from the improved public transport accessibility. The study reported remarkable structural changes and a qualitative enhancement of new constructions in comparable cases.

On the local level the new crossings on ground level help to create a closer link between both sides of the ring. Further benefits can be expected from municipal investments into frequented public spaces. In examination six and seven potential locations with an expected increase in movement rates were examined. These are for example, the new link between the station square and *Hallisches Tor* and at *Hallisches Tor* itself. The route from Market Square (North) to the *Art Gallery* and further to the *Brühl* (cp. fig. 35) will be highly integrated. However the potential of this route is rather internal than external. The street closely links the City-Tunnel station *Market Square (North)* with the two most important future developments. These are the new construction at *Brühl* and the extension of the *Art Gallery* to a *Museum Quarter.* The above examples suggested prioritised investments as a result of the simulations carried out in this chapter. The examinations reported major improvements of accessibility in these places through the intended measures. The recommendation is related to the conception of new street segments and to the creation of public spaces that are able to meet the current needs.

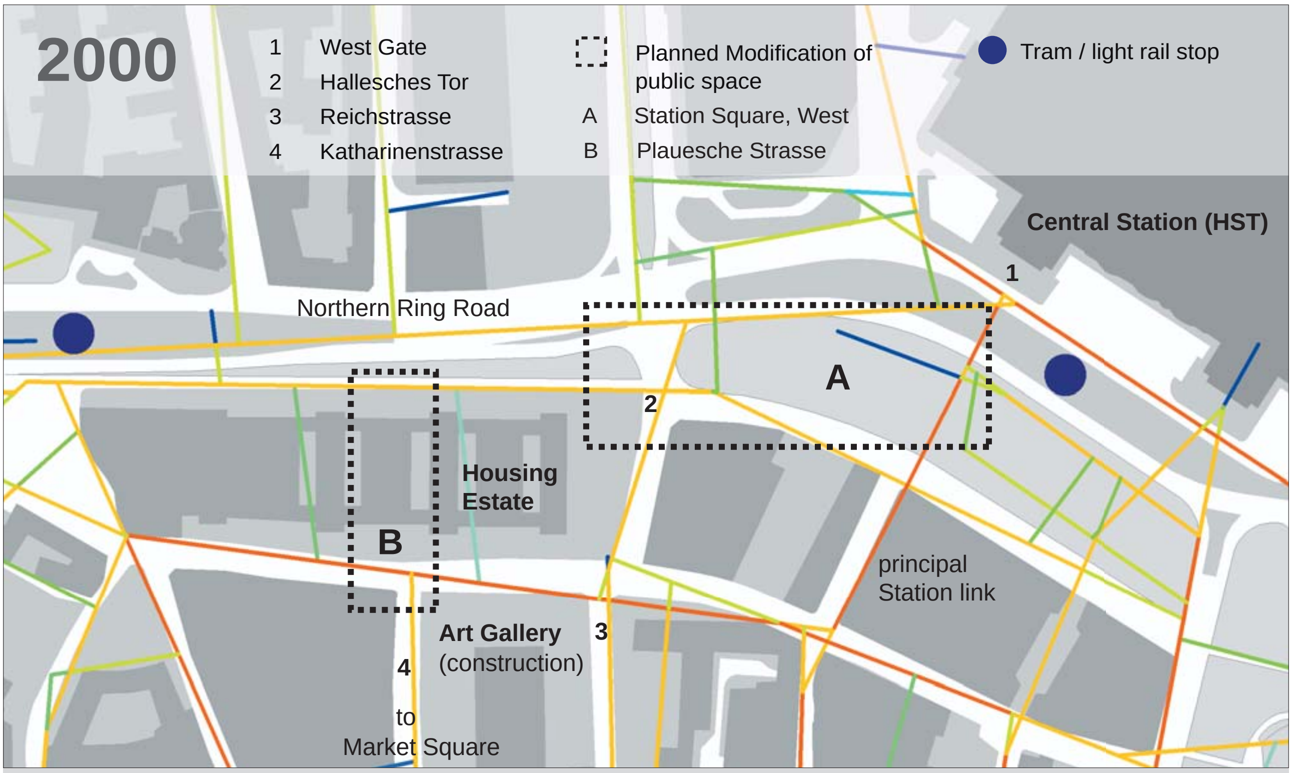


Fig.41 a

Fig. 41 Comparative Simulation: Alternative link from Central Station to Museum Quarter (Thematic maps C. Schaber)

a Station Square, West (A) and Plauestrasse (B) are two areas in the northern centre where new layouts of public space are planned. Both measures come along with major projects like the City-Tunnel construction and the replacement of an existing (2007) housing estate.

b The simulation shows that the layout of a new park (A) can be utilised as an alternative Station - Museum Quarter connection. The layout of a new street segment (B) increases the through-movement capacity of the new mixed-use development that is likely to have a strong focus on retail.

Fig.41 b

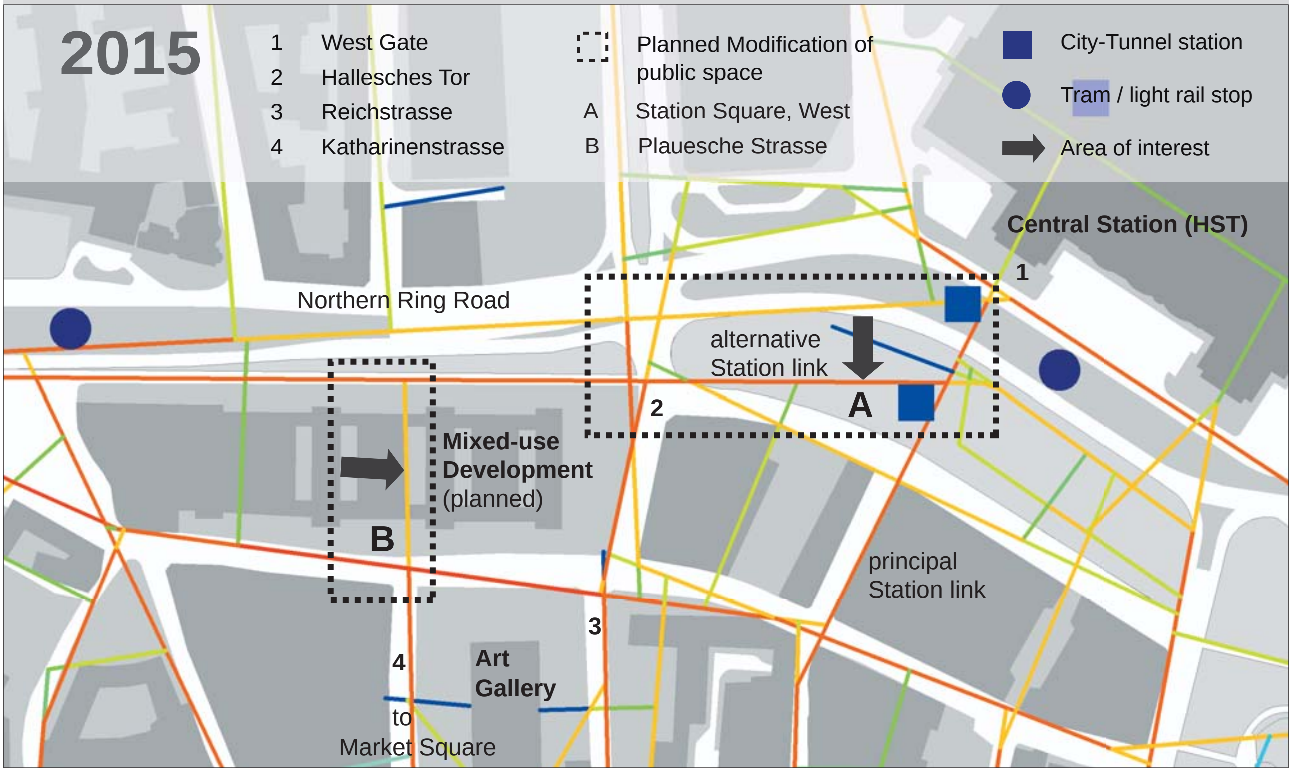



Fig. 42a

Fig. 42b

Chapter 4
Summary and recommendations

4.1 Summary

The intention of this report is to use the flow of people as an indicator for the appraisal of investments into HST related issues and strategies. Therefore the relation of urban space and public rail transport has been studied. In doing so the scientific context of mobility research was analysed. Thereafter the spatial approach of the Space Syntax method was selected. Anyway the insights of other user-based approaches like those of *Molnar* and *Schenk* respectively (cp. chapter 1.4) have been an important endorsement to the use of Space Syntax. In both cases the examinations require "another language". The understanding and use of such a language has been an integral part of this work.

The utilised Space Syntax method aims at examining the use of public space scientifically. Thereby the collection of data about the human spatial behaviour is an essential element that underlines the scientific comprehension of Space Syntax and enables the combination of spatial and user based analysis. The empirical part focuses on counts of persons and forms an important basis for the understanding of movement in station surroundings. Practically the method is useful in the process of opinion formation or as a policy advice because of its objective characteristics. However, a difficulty of Space Syntax is that the method resembles a kind of unknown language. This notion complicates the understanding and the distribution of the method among professionals in the field of planning. However the utilisation was facilitated in recent years. A better handling and the use of a widespread computer system is provided today. Space Syntax also aims at distributing its use more internationally. The AGORA, cities for people research project is a good example for that intention. For it the method was simultaneously used in four European cities.

The case study project in Leipzig exemplifies the characteristics of a future regional train network and its impact on urban development. Thereby the regional train network functions as a feeder for *Central Station*, an important public transport hub and HST station. In addition its role as a catalyst for urban regeneration in the nearby city centre is of equal importance. It is expected that the new scheme increases movement rates within the inner-city significantly. Space Syntax was used to carry out a set of examinations at different scales. Public transport stops and stations were considered as an interface between different rail carriers and urban space. For example, the local


Fig. 43a

Fig. 43b

or pedestrian accessibility of the most important stations was analysed. Interestingly the regional train stations and *Central Station* are poorly accessible for pedestrians on the local level today (cp. chapter 2.4). Further analysis by means of several syntactic measures resulted in a generally poor integration of regional train stations into urban space. This finding led to the ideal type distinction of *independent* and *integrated* public transport rail networks. Carriers that run independently from public space like S-Bahn (suburban rail) and regional train lines use their own routes. In contrast, integrated carriers like the tram runs in urban space and their stations are on this account well integrated into the public realm. Current regional train schemes like the City-Tunnel project in Leipzig intend to combine the positive aspects of both *integrated* and *independent* networks. In doing so, the *independent* regional train network will be conducted by means of a tunnel to the most frequented places in the city. Several regions and smaller cities without S-Bahn networks use special light rail trains to run on both the *integrated* local tram network as well as the *independent* railway lines. The analysis about the role of stations as an interface between public transport and urban space could be further elaborated through the use of passenger numbers boarding and getting off at each station. However the availability of such data was limited in the case of Leipzig.

The use of direct routes is a commonly accepted cognition that has been proved empirically for pedestrians and equally applies for cyclists and car users (cp. chapter 1.4). For this work the same principles were assumed for public transport. For example, the regional light rail scheme (Zweisystem Stadtbahn) in Karlsruhe recorded a high increase of passenger rates after the implementation of the scheme in 1992.The attractiveness of such systems lies within the provision to offer so called "*unbroken*" journeys. These derive from direct and thus fast train connections without any need for change-over. In this regard the connection of local and regional train networks gains importance. As a result a kind of hybrid rail system emerge that similarly run in cities and the surrounding regions. The case study also shows that there is no panacea for the conception of such a network. The "*Karlsruher Model*" was tested also for Leipzig but failed for local circumstances.

A common measure to legitimise large investments into rail transport infrastructure is to appraise the impact of such projects. Practice has shown that there are difficulties in evidencing the precise impact of rail-bound transport infrastructure on investments regardless other factors. At least it

Fig. 42a, 43a (Source: http://www.hstimpactstudy.net/)   **Fig. 42b, 43b, 44a, 44b** (Pic.: C. Schaber) is hardly possible to implicate direct causal relations between investments into rail-bound transport infrastructure and accompanying investments into urban development. In addition it takes often 10-15 years from the planning to the operational phase of rail-bound infrastructure projects. Therefore findings of earlier studies like TranSEcon 2003 that worked on comparable investments cases have been used for the appraisal of the City-Tunnel project. The study reports a positive influence of such projects on centrality. In Leipzig, these effects are even stronger through the integration of the HST station and the airport. Also the availability of land in the station surroundings is seen as a useful indicator. In the compact centre of Leipzig consolidated and future development areas are located in proximity to each other (cp. chapter 3.3).

The collection of data also leads to a better understanding of the principles of human locomotion like the use of direct paths. It has been found that visitors and locals or businessmen and shoppers not only move with different paces but also use different routes. For example, visitors prefer direct routes with few turns whereas locals rather use short routes even if these require several turns. By means of comparative simulations two visitor-friendly modifications of public space have been proposed. That way movement rates for these new elements and their impact can be estimated
The interventions aim at an improved pedestrian accessibility. Instead modified links from future City-Tunnel stops and the HST station to new or planned developments were suggested (cp. chapter 3.5). The use of such simulations is seen as a meaningful tool for municipalities to identify locations where the investment of public money makes sense. Leipzig, for example aims at investing into highly frequented places. The investments intend to divert flows of people into the rather segregated development areas, like the northern city centre.

Another aspect is the modification of the urban layout by the design of pavements, lighting, guidance etc. This applies particularly to existing urban configurations and aims at making the best use of syntactic potentials. For example, in Leipzig the integration values at *Hallisches Tor,* a strategic gate to the inner-city, conflict with low movement rates. A possible solution was found in the provision of at-grade crossings to improve the accessibility of the northern city centre. Generally the accessibility of stops and stations is crucial for attractive public transport schemes. Yet the examinations in Leipzig showed that the "last kilometre" of the travel chain proved to be very unattractive for the users if stations are not well integrated into urban space. In this regard the future City-Tunnel stations make up a presentable showcase for station accessibility of all modes, in particular the non-motorised transport modes.

The simulation of the flow of people in relation to urban space was found to be an important issue for the appraisal of investments. That way the case study enabled the analysis of several challenges HST partners face (cp. fig. 4). The examination demonstrated that the indicator flow of people delivers useful information to appraise HST related issues and strategies. In this way the method can contribute to create an "added value".

Fig. 44a

Fig. 44b

4.2 General recommendations for HST related issues II

"Although the use of cars is still dominant, the current challenge is to combine many different modes of transport. In this regard city centres and train stations are very complex issues because all kind of transport modes have to be integrated into rather limited spaces" (Schaber 2006).

Revitalisation of the City Centre

The following insights derive from the examination of the City Tunnel Project. Since the project is an opportune case study for rail-bound public transport infrastructure it is useful to generalise the most important notions. These refer to the accessibility of HST and regional train stations and their impact on urban regeneration.

What is the general movement behaviour of people within pedestrianised city centres ?
The Leipzig case exemplified that the busiest streets were those that had a multi-modal accessibility in combination with high *Integration* values and corresponding land uses. That is where the change-over from car use and public transport to walking and cycling is organised in a direct and convenient way. This involves the provision of accessible car parking facilities and nearby public transport stops. In contrast, the areas without direct car and public transport access were those with lower movement rates (cp. fig 16). In Leipzig the former areas were generally shopping streets whereas the later refer to underdeveloped areas. The barrier effects caused through large railway grounds and busy roads are a commonly known challenge for the promotion of non-motorised transport in inner-city locations (cp. fig. 4). Thus station areas are isolated from their urban surrounding, particularly from the inner-city and districts at the other side of the tracks. The barrier effect can be minimised trough the tunnelling of railway lines below urban space. This solution has often become the norm for new railway projects and was implemented in several cities throughout Europe, for example in Barcelona, Valencia and Berlin. The new HST stations of Stratford and Ebbsfleet will also be of this kind. However, the implementation is related to new constructions and proves costly for inner-city locations, like in Leipzig or Den Haag. Anyhow, in Leipzig the scheme applies for the restructuring of the S-Bahn (suburban rail) and regional train network (cp. chapter 2.2). Stations in inner-city locations often do not permit comprehensive interventions because these would require unjustified expenditures. In such places, where the new layout of railway grounds proves not feasible, other measures have to found to overcome the segregation between station area and adjacent inner-city locations. The analysis demonstrated that barrier

effects along busy roads can be tackled through crossings at-grade (cp. chapter 3.5). That way the circulation of non-motorised transport modes is prompted offering lanes for both pedestrians and bicycles. The later require further installations like parking places and shelters in the station surrounding. By this means the link from the station to the city centre can be improved substantially. The provision of easy and short change over between trains or different carriers is rather a technical than urban development issue to improve the attractiveness of public rail transport for walking. This also implies coordinated train timetables that help to reduce waiting times. However it is reported that a reduction of waiting time also reduces the number of potential customers in the shopping facilities within the station.

The accessibility of stations

HST stations and the stations of the secondary regional train scheme both contribute to an attractive public transport network (Kramar). However the characteristic of human movements in relation to both kinds of stations differs from one another. As regards urban space the HST station commonly evokes journeys trough-out the entire city. In contrast the catchment area of regional train stations is smaller because of their denser network of stations. The latter also permits the split of functions within the network.

What is the role of Central Station for the revitalisation of the city centre ?

The modernisation of the railway changes the role of stations technically but also in relation to urban space. As a consequence new developments with varied functions are built in the station surroundings. In Leipzig, for example the spacious character of the Central Station resulted in developments inside the station. That way the station has also become a shopping centre with 18,000 m^2 of floor space. There after it is difficult to determine classical passenger numbers. The Deutsche Bahn talks about 150,000 visitors instead of passengers each day (DB 2006).The access to HST stations is usually of city wide or even regional significance. As a result these stations generate movements throughout the entire urban street network. It is no surprise that the length of most journeys to the HST station exceed walkable distances. For example, the Central Station (Leipzig) is located at the most important through-roads and belongs to the set of urban spaces with the highest accessibility city wide. Central locations together with disposable grounds offer high potentials for new developments. The insertion of new developments on former railway grounds is a chance to reintegrate these areas back into urban space. That way the extension of public space offers potentials for both a better local and pedestrian accessibility around stations. The development of different kinds of attractors also helps creating new public spaces inclusive walking links and therefore is an indirect measure to increase the quantitative flow of people in the HST station area. Disposable space of this kind is often available in cities and towns because the operation of modern railways is space-saving.

Public transport hubs like the *Central Station* in Leipzig are large generators of movement that dominate the flow of people in a particular way. At first, it could be demonstrated that the flow of people in the wider station area was influenced by public transport users. The use of public transport in Leipzig is more related to certain peak hours than car use (cp. fig. 22-24). As a result the difference between lowest and highest movement rates is larger than in other places. This fact has implications for the layout of urban space. There after the streets have to cope with high absolute numbers of people during peak hours. It is assumed that the large variance in the flow of people reduces the quality of public space for different kinds of interaction. Moreover the station – city link does not represent the most important shopping street. The focal point of movements is still elsewhere at *Market Square (Markt)*, the traditional centre of trade where the two busiest shopping streets meet. There the variance of the number of people is lower. Due to its functions and to the syntactic analysis, Central Station proved to be a generator of city-wide movements. For example, whenever the station – city link accounted for high movement rates the collective journeys within the city centre were of long distances. The highest total numbers there were recorded during the weekend on Saturdays. Then the spatial determination of movements within the study area in the city centre was reduced remarkably (cp. chapter 3.2). In contrast stations of this kind often show a limited local accessibility because of the large railway grounds that obstruct pedestrian and local movements. It is the author´s supposition that safety problems in station surroundings are due to a poor local accessibility of specific areas. Besides, several partner cities reported safety problems and image problems in the immediate station surroundings.

What is the role of the future City-Tunnel stations for urban development ?

Practical experiences prove[10] that the provision of additional stops and stations result in higher passenger numbers. This is also the forecast for Leipzig where the layout of new stations comes along with an enlarged catchment area through reduced travel times. In this regard, the integration of stations within the urban space matters because that way the last kilometre of the travel chain is attractive. This notion is well reflected in Leipzig, where the new City-Tunnel stations are located along important through roads. Except Central Station they also proved to have a high local and pedestrian accessibility respectively.

The case of Leipzig is also a good example for the emergent character of the new regional train network. The scheme functions as both underground and regional train system through the bundling of several lines below the city centre and the extension of S-Bahn trains further into the region. The network character permits access and change-over to and from all kinds of transport modes and is therefore highly accessible. This involves all levels of public transport inclusive HST-platforms, car parking adjacent to all stations and also Park & Ride facilities. It is assumed that the variance of movement rates around the City-Tunnel stations is lower than at *Central Station* because of the network character the City-Tunnel offers with a dense rhythm of inner-city stations. The attractiveness of the scheme – as described above –involves access to and from several universities, hospitals, science park, trade fair, airport and HST station. In this regard land use developments in the surrounding of the future city tunnel stations have been monitored. At the time of completion around 2010, a sum of more than 500 million Euros will be spent for developments in and around the city centre and the future City Tunnel Stations (cp. fig. 10). These developments consist of both private and public investments and nearly equate the total cost of the City-Tunnel Project.

Municipal interventions

Two aspects known from previous studies have been of particular interest. These are the municipal willingness to invest into public space and the development potential of underdeveloped areas in proximity of new stations (TranSEcon 2003, p.39). The first is seen as a precondition of successful public transport investments. The later involves the opportunity of larger structural changes. In the case of Leipzig an inner-city development area exemplifies three different kinds of municipal interventions. In details these are the construction of a new attractor, the *Art Gallery* as a core element of the future *Museum Quarter*. Further it is the change of land use through the sale of a municipal housing estate to a private developer that is currently under way. Finally municipal investments into public space are planned to divert the flow of people into the today underdeveloped area. All interventions are related to the City-Tunnel Project. Two new City-Tunnel stations will frame the mentioned development area. The examination focused on interventions into public space. By this means areas for prioritised investments were quested. As a result of a comparative simulation two potential sites for municipal investments into public space were selected. In both cases new links have been created from future City-Tunnel stations towards the municipal development sites. The simulation demonstrated an improved accessibility after the modification of street links and involved different measures and radia. A better accessibility and higher through-movement potentials are associated with an increase in the number of passers-by at the selected public space segments.

Notes *Chapter 4*

1 Principle of subsidarity (german: Subsidaritätsprinzip)
Subsidarity (lat. step back, to be subordinated). Governmental decisions are realised on lower administrative levels whereas higher levels step back. The principle of subsidarity is a fundamental basis of the European Union.

2 S-Bahn: Rapid transit railway also suburban railway

3 Anticipating land use development (german: Erwartende Investitionen)
The TranSEcon study states that investments into public transport infrastructure and into urban development follow different time cycles. According to the operational phase of a public transport project, the study distinguishes between anticipating, step wise and retarded land use developments (TranSEcon 2003, p.10).

4 Athens, Bratislava, Brussels, Delft, Helsinki, Lyon, Madrid, Manchester, Stuttgart, Tyne & Wear, Valencia, Vienna, Zurich

5 S-Bahn, cp. before

6 **Source:** STEP 2004, p. 46 (english: Urban Development Plan 2004) and SKS 2006

7 Energy efficiency (Energieökonomie)
After Schenk the principle is fundamental for human locomotion. The minimised use of energy is explained as the reason for the choice of shortest and direct route connections.

8 Estimation: 20.000 passengers / day

9 Oberzentrum
The German *Oberzentren* are normally surrounded by a number of *Mittelzentren* which in their turn are bordered by *Unterzentren*. *Oberzentren* serve the adjoining municipalities with high-order commodities and services (public authorities, hospitals etc.) as well as middle- and low-order goods.

10 *Karlsruher Model* and *Railway 2000* in Switzerland

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