Making Squares

A Study of Urban Form and Co-presence

KAILUN SUN

Master Thesis in Architecture

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A Study of Urban Form and Co-presence

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Examiner: Dag Tvilde

Supervisor: Meta Berghauser Pont

Gothenburg, Sweden 2016

CHALMERS
UNIVERSITY OF TECHNOLOGY

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To my parents

Abstract

Increasing residential segregation in cities gives public spaces a more important role in solidarity processes, bringing people together, supporting movement, co-presence and co-awareness (Hanson 2000, Legeby 2013). Thus public squares have great significance providing an arena for social interplay as people become co-present.

As the way we build the city organizes and forms the public space further forms the shape of society (Legeby, 2010), we need better understand how design interventions influence co-presence in public space, specifically, at squares. The earlier studies (Legeby et al. 2015; Legeby 2013) shows that high spatial integration and the relation between local and global integration plays an important role for the mix of locals and non-locals beside aspects relating to land use. The study in Gothenburg was so far limited to squares in neighbourhoods developed following modernistic planning ideals and the urban form variables studied were limited to the centrality measures. Therefore this thesis will contribute to the earlier findings in two ways: firstly, by adding more squares representing a broader spectrum of neighbourhood types and secondly, by adding more urban form variables.

The empirical data is collected through observation including snapshots and interviews. The spatial analysis includes besides integration and betweenness, an analysis of densities and land uses accessible from the squares within various radii. Also, geometric characteristics such as size and enclosure of the squares are included. The correlation study will finally help us to better understand which variables are related to co-presence. Aiming for bridging the gap between research and practice, a design manual containing four modules and three tables is formulated and tested in real cases.

The study shows a clear different pattern of co-presence in the studied squares. Betweenness is a more sensitive variable than integration, for the nuance of co-presence in the non-CBD squares. Working population density has great influence on diversity of people co-present at both CBD and non-CBD squares. Geometric characteristics of squares cannot have impact on the diversity nor the amount of people co-present. The design manual is a helpful tool in both decision making and designing.

Keyword: Co-presence, public squares, urban form, space syntax, social exclusion

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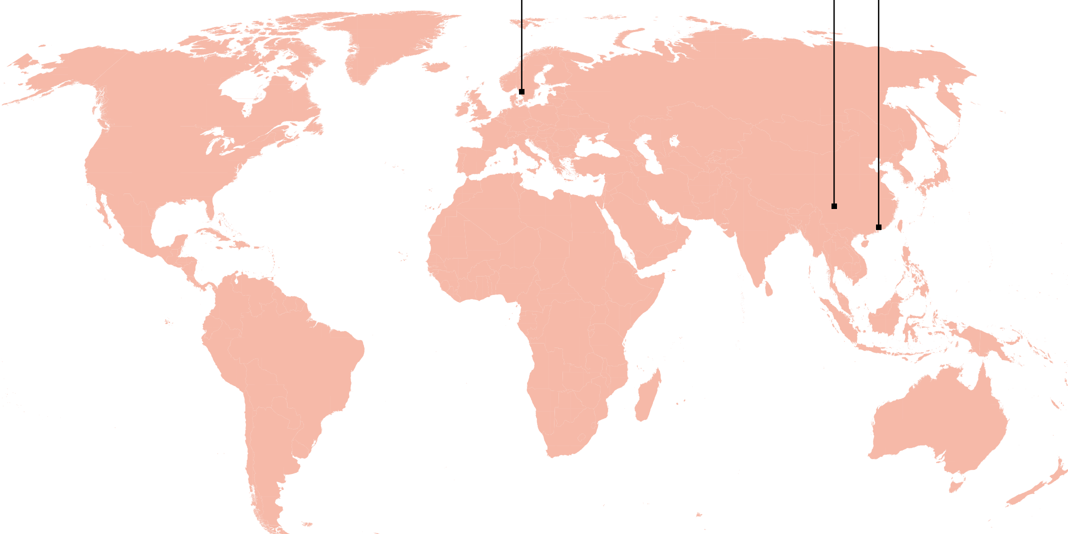

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Kailun Sun
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Terminology

Betweenness

A measure of centrality in space syntax. It analyses how many shortest paths between every point to all other points in the system pass through each segment within certain radius. In other words, it describes how often a segment is part of the shortest route between all segments in the city within a certain radius.

Integration

Integration is a measure of centrality in space syntax (Hillier and Hanson, 1984). It captures how accessible one place is to all other place in the system. In the analysis, it is how many steps are needed from one point to another point within certain radius. The more steps it takes from say location A to reach all other points, the 'deeper' A is in the system and the fewer, the 'shallower', which in space syntax terms is called the 'depth' of the system.

Configuration

In the thesis it means spatial configuration. More precise, it is 'how things are put together', which is how the built environment is understood in space syntax. It is more important than the thing in itself or to us Bill Hillier's (2007, p. 1) words, it is about 'relations taking into account other relations'.

Axial map

An axial map is a model in space syntax analysis. Space is represented as axial lines, "fewest and longest straight lines covering all convex spaces". Our perception of continuity in space is added into the model when building it. Axial maps are good at capturing the 'natural' and is often used in urban space analysis. Integration analysis in the thesis is conducted on axial map.

Segment map

A segment map is an often used model in space syntax analysis. The space element 'segment' is the axial line broken down into parts at every crossing or intersection. Similar with axial maps, one segment represents a space and each turn means a choice when moving through the space. In this model, angular analysis can be operated and it is a more suitable model for some of the analysis used in space syntax, such as betweenness or choice.

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1. Introduction

Figure 1. Public space in the city. Author's own copyright.

Public Spaces and City

We live in the city and use public spaces every day. Many everyday activities are carried out in public space: we meet people on our way to work; we encounter strangers at a corner of a square; we jog in a park and take a walk with friends along the river. In public space, we meet other people, we observe what others do and how they act, interact with them and share the space together. Consciously and unconsciously, we influence others and are influenced by others through being co-present in public space.

Public space, as argued, plays a vital role in our daily life as a venue being co-present and providing a need or a sense of 'being in the city', more precisely, 'being in society' (Zukin, 1995; Legeby, 2013). To some extent, city as the built environment forms the shape of society through 'a distinguishable influence on people's everyday lives' and the way we build the city organizes and forms the public space (Legeby, 2010). This brings a matter of concern to architects and urban planners that our design actually can create and reproduce certain social problems and how we design may enforce, neutralize or decrease them, for instance, residential segregation in the city (ibid.).

In Gothenburg, segregation is a problematic issue impeding its development and leading to social exclusion. Many initiatives for a more integrated city have been discussed and implemented in practice, such as building new housing in these areas, inviting cultural events and other activities, renovating the façade of buildings etc. It is good to make efforts on these issues in different aspects. However, not many initiatives stress on an essential part: the relations between space and society. Public space, an important component of cities and urban life, is for instance already segregated in most areas no matter whether the neighbourhoods are segregated or not (Legeby, 2010). We argue that bringing people together is one direction to overcoming social segregation and creating an inclusive city. Public space hereby is an important arena for people to meet. It is therefore its urban form needs to be studied further – how public space is shaped, and which position it has in the city and how this interacts with public life?

Co-presence

What is co-presence

Co-presence is a sociological concept brought up by sociologist Emile Durkheim in his theory about different forms of social solidarity (Durkheim, 1984), which, according to Hillier and Hanson, is one of few sociological theories with truly spatial foundations and implications (Marcus, 2015). Randall Collins is the sociologist who in recent decades most distinctly has continued the Durkheimian's micro-sociological tradition (ibid.). In this thesis, I use Collins' definition, of physical co-presence, that is: "Two or more people are physically assembled in the same place, so that they affect each other by their bodily presence, whether it is in the foreground of their conscious attention or not" (Collins, 2004, p. 48).

Co-presence and Social Segregation

The inner connection between social segregation and co-presence has been demonstrated in Ann Legeby's PhD thesis:' Patterns of Co-presence: Spatial configuration and social segregation' (2013). She has studied the relations between co-presence (amount and diversity of people present in public space) and spatial segregation.

In her work, it is argued that co-presence matters for society and is fundamental for social processes. Co-presence is seen as a vital prerequisite for the development of different social solidarities (Giddens, 1984; Collins, 2004) and also has potential to create so called weak or strong ties among people and different types of societal processes of bridging and bonding. Promisingly, the socio-spatial aspect of urban segregation could be studied through co-presence.

Further, urban form matters for co-presence. Through studying different urban models and their conceptions, it is not difficult to see the discrepancy between what the ideas and models aimed for and how they turn out to be in reality. Following Lars Marcus' (2000, 2012) argument, it is important to know how urban design/urban form performs in a larger context and that it both has a representative and a performative dimension.

To disclose the social performance of urban space, Legeby (2013) chose the spatial analysis method 'space syntax' as a tool combined with observation to do the research. From the empirical results of the Stockholm study, it is shown that 'urban form has a critical

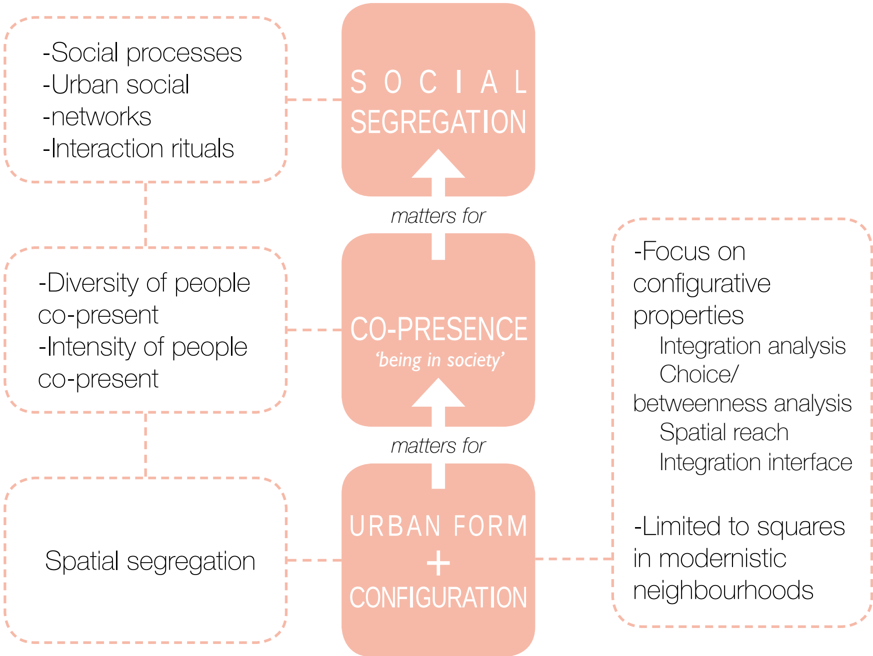


Figure 2. Outlines of Patterns of Co-presence: Spatial Configuration and Social Segregation. Author's own copyright.

impact not only on the creation of co-presence but also on creating variations in its intensity and constitution'. The segregation of public space reproduces residential segregation patterns and the distribution of space influences the distribution of resources and urban services.

Legeby's work focuses much on the analysis of the network and how this contributes to the distribution of both people and urban services. Density and diversity are two other central variables when discussing urban form that is less studied in this work. Further, the work is academic influencing the public debate. How to implement the results in practice, however, is still a challenge. A recent study in Gothenburg where the results of Legeby's work were tested in Gothenburg (Legeby, Berghauser Pont and Marcus, 2015) is a first step in this direction on which this Master thesis will build further on.

In the Gothenburg project seven neighbourhoods are analyzed and it is proved that several of the neighbourhoods are in unfavourable situation as a result of their spatial configuration. The focuses in this study are areas with multifamily housing built in the period between 1960 and 1970. More research in a variety of neighbourhoods in Gothenburg is needed to study the impact of other urban form variables (density and land use diversity) on co-presence. Further, the gap between theoretical knowledge and practical operation, which is meaningful to social sustainability, needs to be filled by testing different design alternatives and evaluate the impact on co-presence using the results from the analysis in Gothenburg.

How does urban form, network configurative properties, density and land use diversity, influence co-presence, the number and diversity of people, in public space?

RESEARCH QUESTIONS

The purpose of this Master thesis is to contribute to previous research such as the work of Ann Legeby and research conducted by the Spatial Morphology Group SMoG and more specifically to the international Spatial Morphology Lab (SMoL) comparing three European and two Swedish cities. Practically, the thesis aims at a design approach, which can be used in practice to **better understand how design interventions influence co-presence in public space, and more specific on squares**. In a larger perspective, I hope this will also bring some useful inputs, from architectural perspective, to the discourse of social sustainability by creating a more integrated city.

The main question of the thesis is:

How does urban form (network configurative properties, density and land use diversity) influence co-presence (the number and diversity of people) in public space?

Following the main question, I also explore:

How to bridge the gap between research and practice? In other words, how to implement knowledge we get from the research in urban design?

The first question regards the research and the second regards the translation in a design manual. The first question will be answered by doing observations, spatial and statistical analysis to find the relations between on the one hand the observed amount and diversity of people and on the other hand urban form characteristics. The second question is dealt with through synthesizing the statistical analysis' results, translating this in what I call a design manual and a design test in a real case.

APPROACH TO THE THESIS

The thesis contains two parts: research and implementation, and is divided into four phases. The first three phases describe the research part, the last the implementation part.

In the first phase, through literature study, I chose the suitable and feasible methods for setting up the research including deciding on the relevant spatial variables to analyse and doing the observations. Meanwhile, all squares were mapped and with a set of selection criteria, squares for empirical studies were selected. In the second phase, the materials for the observations were prepared and the observations were conducted on good weather weekdays. In parallel I run spatial analysis using GIS software programme. The results from the observations and analysis were used in the third phase, the statistical analysis. In this step, I looked for correlations between the observations and spatial analysis results and synthesized the findings. Through the research, a better understanding of the relationship between urban form and its performance were reached. With a better understanding of the relation between urban form variables and co-presence, I moved to the implementation part, the last phase, to formulate a design manual according to the conclusions from the research part. In this phase I also conducted a showcase to test the manual and show how to use it.

Figure 3. Approach. Author's own copyright.

Delimitation

Public spaces include public squares, shopping malls, libraries etc. To narrow down the scope of the thesis, the focus will be on public squares as important nodes in public space. People are co-present in public space everyday and it is a part of our everyday life. To approach the research, I used location-based analysis, a better method to perceive everyday life phenomena, instead of only area-based analysis. The latter is limited to descriptions of the space itself, not regarding its position in a bigger context. In other words, the squares are studied not only in a local scale, but also in the context of the city as a whole. As for urban form, the focus is on what physical, more structural, conditions matter for co-presence. In other words, the influence of materiality, architectural style, amenities and attractions in the squares etc. is not included in the research. As for co-presence, it is the intensity (amount of people) and diversity of people co-present in public squares that are studied. This means that the results of the thesis can only be used to influence these two aspects of co-presence when designing a new or redesigning an existing square.

When it comes to the second research question regarding urban design, I focus on the design of the configuration of the square and not the design of the square itself, that is, its materiality. It is the urban form variables that are included in the research, as mentioned earlier, that will also be used in the design manual. Furthermore, the implementation part has an explorative character bridging research and practice. Thus as a point of departure in architectural practice, the result is a test case rather than a concrete design proposal.

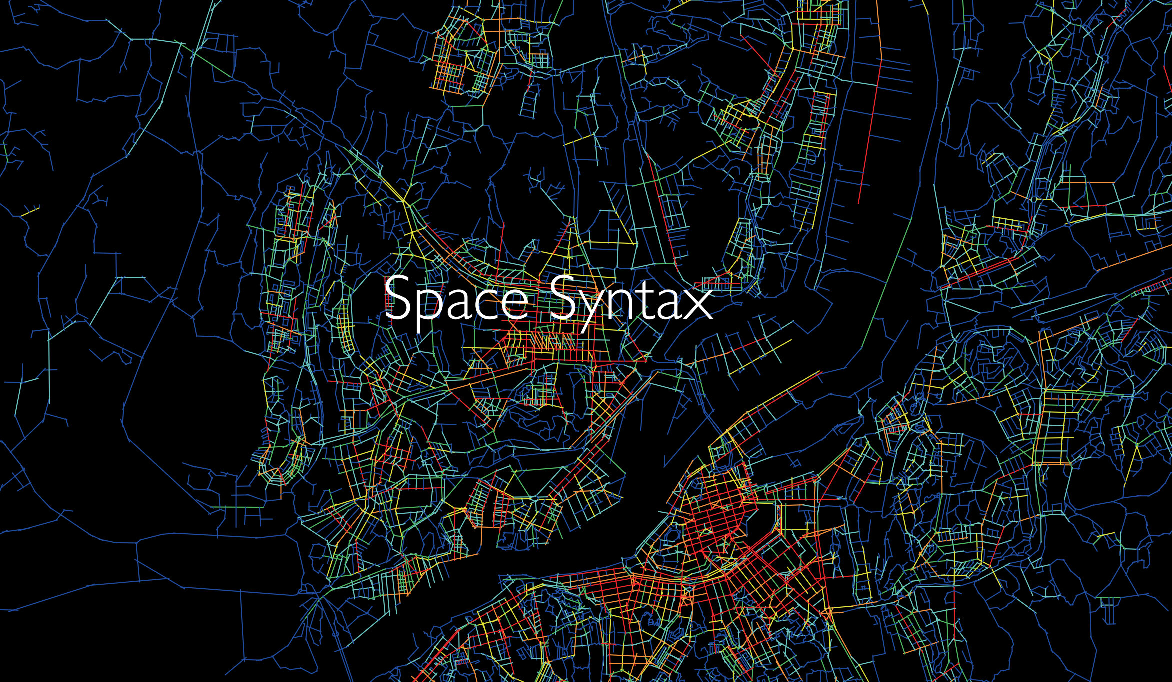
The segment map and axial map I used in the analysis are pedestrian models. Due to the limitation of the models, the research limits itself to pedestrian flows and all analysis is based on walking distance. Thus cycling and automobile movements are not included in the study. Also, the data used in this thesis is similar to that used in the research project Dela[d]stad (Legeby, Berghauser Pont and Marcus, 2015, p. 31) and is not updated to the latest datasets available. Most data dates from 2013 except for population (2010-2011) and the axial and segment map (2014). The results can therefore be impacted by a dissonance between the date of the datasets used and the observation that are conducted in 2016.

As mentioned, I hope the thesis has its contribution to social sustainability by creating a more integrated city. Again, putting the research in the broad perspective, I argue that this is one way to approach the goal of creating an integrated city and it is one aspect, an important aspect, of the issue. There are of course other ways to reach the same goal and different methods should definitely work together.

"…buildings operate socially in two ways: they constitute the social organisation of everyday life as the spatial configurations of space in which we live and move, and represent social organisation as physical configurations of forms and elements that we see."

– Bill Hillier, Space is the machine.

2. Theory and Methodology



Space Syntax

What is space syntax

Space syntax, referring to a set of theories and analytic tools, was first set out by Bill Hillier and Julienne Hanson in the early 1980s, in London. Since then, the theory has been developed extensively and further, not least when it comes to social aspects. An important contribution was the development of a new tool, Place Syntax Tool[1] (PST) that enables the combination of space syntax with other geographical data and traditional urban morphology.

The theory of space syntax is about the understanding of the relation between society and the built environment. There are two fundamental theoretical links necessary to make for a robust foundation of space syntax methodology. The first concerns the link between humans and their environment, where space syntax has contributed to the development of what can be called a cognitive geometry for the analysis of spatial form. The second is the link between humans and humans, that is, the generation of social processes, where space syntax has highlighted the idea of co-presence as critical in such processes (Marcus, 2015).

To be able to relate the social and the physical, the built environment should be understood in a specific manner where the question 'how things are put together' is more important than the thing in itself or to us Bill Hillier's (2007, p. 1) words, it is about 'relations taking into account other relations'. What we design when designing neighbourhoods and cities is actually the relations or in other words, the spatial configuration. In this sense, how parts are put together as a whole is more important than any component itself (Hillier, 2007). Through space syntax analysis, the 'hidden' logic of space emerges, representing its relations. This in turn allows us to understand the 'physical and cognitive affordances'[2] (personal communication, November 16, 2016) and helps us to understand what the spatial design is about and how it functions.

Figure 4. Space syntax map of Gothenburg, Integration R2. Author's own copyright.

1 A plugin analysis tool in GIS software MapInfo.
2 *Theory of Space Syntax - Representations, Cognition and Co-presence,* PhD lecture from Lars Marcus

Models in space syntax

In space syntax theory, there are three conceptions of space, convex space, axial space and isovists. Based on this, three kinds of models are used in space syntax analysis: node graphs, axial line maps and 'visual field' models (Manum, 2006).[1]

In a node graph, there are two elements, nodes and connections. A node represents a convex space and a line (link) connecting nodes represents relations between nodes. In a convex space, every point in the space is visible from every other point (figure 5). The line between two random points in the space is always within the perimeter. A building space can be divided into several convex spaces without any overlap. Linking all the nodes with lines, we can get a connectivity node graph (figure 6). This model is often applied in dwelling analysis.

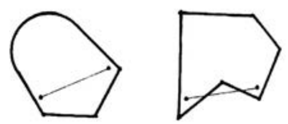


Figure 5. Convex (left) and concave (right) spaces (Klarqvist, 1991).

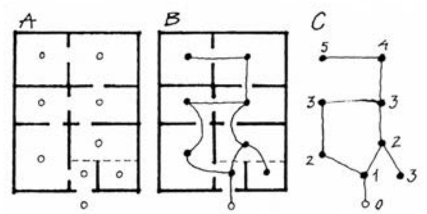
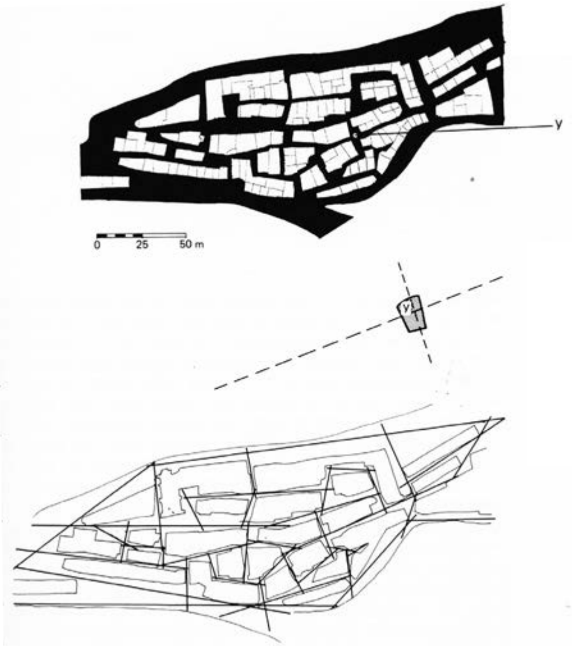


Figure 6. Floor plan to a node graph (Klarqvist, 1991).

In an axial line map, space is first represented as lines. It is modeled by "fewest and longest straight lines covering all convex spaces". Next, these axial lines become nodes in a node graph model and the junction points of axial lines equals to the links in a node graph. While building the model, we already add our perception of continuity in space into the model and the way to capture the space by axial lines differs depending on the type of movement we want to analyse in the research. For instance, the axial line map built for studying pedestrian movement is not relevant for a study on how bees move around in cities (Marcus, Berghauser Pont and Gren, 2014). Since the model is better at capturing the 'natural' movement than a node graph model, it is often used in urban space analysis.

In visual field model, an isovist is the space visible from a particular point in space. Its size and shape can change with location. It is like one wanders in a space, and what he sees and what he perceives are changing all the time while he moves from one point to another point in that space. In other words, the visual field changes along with the movement. With this feature, it is a model more relevant to spaces like public buildings such as museums and shopping malls or urban parks, which are not to be known well by people who newly visit these (in contrast to dwellings) or highly ordered by the street layout. It should be noted that these three conceptions of space have clear relations to one another. The axial lines can for instance be described as a reduced representation of the visual field.

1 The following paragraphs are based on this work.



The open space structure of G.

The point *y* seen convexly and axially.

Axial map of G.

Figure 7. Axial-line modelling of streets and public spaces (Hillier and Hanson, 1984, p. 91).

Besides these three models, the segment map is another often used model in space syntax analysis. The space element 'segment' is the axial line broken down into parts at every crossing or intersection. Similar with axial maps, one segment represents a space and each turn means a choice when moving through the space. In this model, angular analysis can be operated and it is a more suitable model for some of the analysis used in space syntax, such as betweenness or choice.

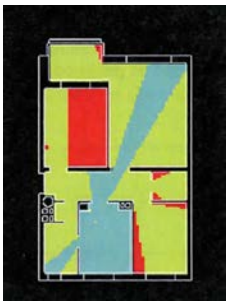


Figure 8. Visual fields (Manum, 2006, p. 76).

As mentioned, different models capture different aspects of space and therefore we should choose relevant models according to the research questions. Since the scope of my thesis is in urban study and public space, the axial map and segment map of Gothenburg are applied in spatial analysis.

Why space syntax

As mentioned above, space syntax bridges the gap between social and spatial theory. What is studied in space syntax is the relative space rather than the absolute space (Harvey, 2004). Different from a geographical approach to space where the distribution of things in space is modelled, space syntax analyses and represents the distribution of space and through space. Besides, it has another advantage to what I earlier referred to as area versus location measures and that is that it can operate on different scale levels, from local (neighbourhood) to global (city wide) and analysis on different levels can be compared within the same scheme.

9-way MATRIX	Material space	Conceptualized space	Lived space
Absolute space	tactile/sensory/ physical things we can touch/sense	representations of literal/material space	realms where our representations originate
Relative space	recognition that space is experienced/ perceived differently from different perspectives	representations of relations	imagined/felt aspects of relationships assoc. w/ this space
Relational space	view of space as created by process what we bring to the space from past/ other places	Representations of processes assoc. w/ the space	imagined/felt aspects of processes

Figure 9. Space as a Keyword (Harvey, 2006).

Measurements central to space syntax

Integration

Integration is a measure of centrality in space syntax (Hillier and Hanson, 1984). It captures how accessible one place is to all other place in the system. In the analysis, it is how many steps[1] are needed from one point to another point within certain radius. The more steps it takes from say location A to reach all other points, the 'deeper' A is in the system and the fewer, the 'shallower', which in space syntax terms is called the 'depth' of the system. A shallow space (high integration value) tends to integrate the system and a deep space (low integration value) is segregated from the system (ibid., p. 108). The depth of system is relative in a sense that adding space in the existing system will increase the depth of the whole system, and vice versa.

Betweenness

In contrast with integration, betweenness measures another aspect of centrality (Hillier and Iida, 2005). It analyses how many shortest paths between every point to all other points in the system pass through each segment within certain radius. Segments with high betweenness value are important links connecting the system and more likely to attract through movement (ibid.). Streets with high betweenness value are important to the city; taking out such a segment has a huge impact on the through movement as many routes passed through this segment. Segments with high integration not necessarily have high betweenness value and vice versa.

1 In space syntax, the distance is measured as topological distance. This is different from Euclidean distance. Stpes mean how many turns it needs moving from one axial line to the destination.

Tool and Data

For selection and spatial analysis, I used the GIS software MapInfo Pro. 15.0 and the Place Syntax Tool 2.10.7. PST is a tool that can do space syntax analysis, such as integration, betweenness and choice and also attraction analysis adding other geographical data than only network. The data, such as segment map, axial map, population data, etc., is the same as was used in the research project Dale[d]stad (Legeby, Berghauser Pont and Marcus, 2015) and data of building height is from the project Spatial Morphology Lab. As mentioned before, the segment map and axial map are pedestrian maps. Therefore the research is studied from a pedestrian's point of view and except for integration that is measured in steps, other analysis is measured in metric walking distance. All statistical analysis is done in Microsoft Excel.

SELECTION OF SQUARES

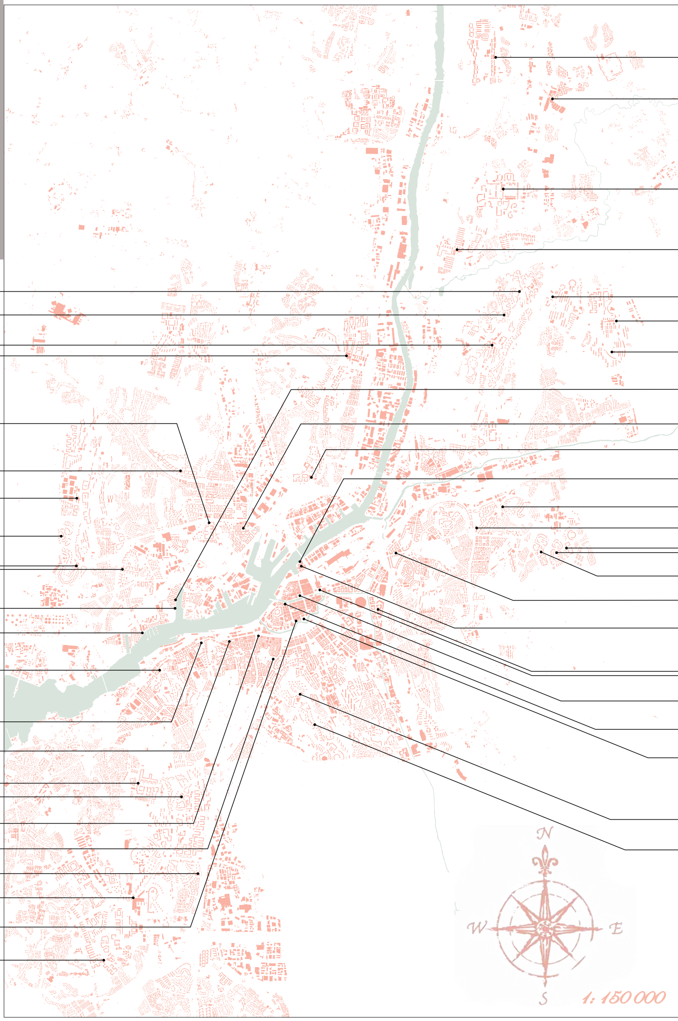


Figure 10.
All squares in Gothenburg.
Author's own copyright.

What are the squares

Before selecting the squares for the empirical study, I needed to map all the public squares in Gothenburg as a base set of squares for selection. The question is what kind of space can be defined as squares? Instead of defining squares by some kind of spatial rule, I decided to select all 'torg' on the map, based on the naming system of streets and public spaces. In this way, the subjectivity of defining squares is avoided. As a consequence 'Götaplatsen' is not defined as a square as it is not named 'torg'. While mapping all the squares that are named 'torg', I excluded squares that obviously are not a square, but merely a street (e.g. Kaserntorget, which was a square in the history but not anymore) or a shopping mall. In the end, 48 squares distributed all over Gothenburg are qualified as square.

Selection Criteria

A diverse set of squares is important for the research to get a good result. In other words, different types of squares in terms of urban form features should be included to be able to find out whether these criteria play a role for the amount and diversity of people present at the squares (see research question).

Urban form has three essential elements: density, distance and diversity (Cervero et al., 1997; Berghauser Pont and Marcus, 2014). Distance, as defined by accessibility which is related directly to the layout of the streets, both locally, but also in the context of the city as a whole. Taking accessibility into account distinguishes the research from 'place making'. Density, both including 2-dimension and vertical dimension, is a concept often used in urban study and planning. The idea is to make a diverse selection of squares by controlling for 'density' and 'distance' on different scale levels. These can be called the contextual criteria. Further, two local criteria are included that describe the local formal characteristics of the squares. Therefore, I set up 4 criteria - betweenness & population density as the contextual criteria chosen; size & enclosure as the local criteria chosen – to select the squares for the empirical study.

Betweenness

Betweenness represents the distance criterion. Betweenness is a measurement in space syntax. It describes how often a segment is part of the shortest route between all street segments in the city within a certain radius. I chose to use value of betweenness analysis in radius 2km walking distance as reference. The analysis was run in MapInfo Pro with PST, and the results were divided by natural break[1] into 3 groups – high, medium and low betweenness streets[2]. The squares were therefore divided into 3 groups by the highest betweenness-value street among those that have direct access (figure 11) to the square or pass by the square (figure 12).

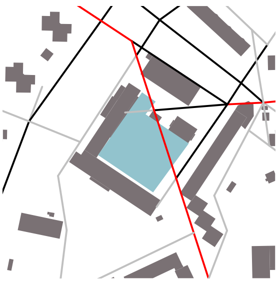


Figure 11. Axel Dahlstroms Torg - High betweenness. Author's own copyright.

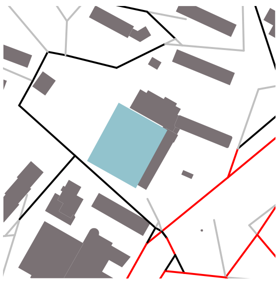


Figure 12. BjurslattsTorg - Medium betweenness. Author's own copyright.

Group	Min=<	<Max
High	66617	474640
Medium	13808	66617
Low	0	13808

Figure 13. Ranges of betweenness groups. Author's own copyright.

1 A classification method, dividing data into groups by clusters.
2 To be more specific: segments in segment map.

Population

Population is used as criterion for density. It is measured by the total number of people (including residential and work) that can be reached through the street network within 500m walking distance from each square. The results were divided into 3 groups – high, medium and low population - by natural break.

Group	Min=<	<Max
High	10090	25016
Medium	4463	10090
Low	0	4463

Figure 14. Ranges of population groups. Author's own copyright.

Size

Closed outlines were drawn as boundaries for each square in MapInfo, according to Gothenburg aerial map. The areas of squares (the polygons) were calculated and the same boundaries were used in calculating the enclosure and building heights later.

The squares were divided into 3 groups – large, medium and small squares- by natural break.

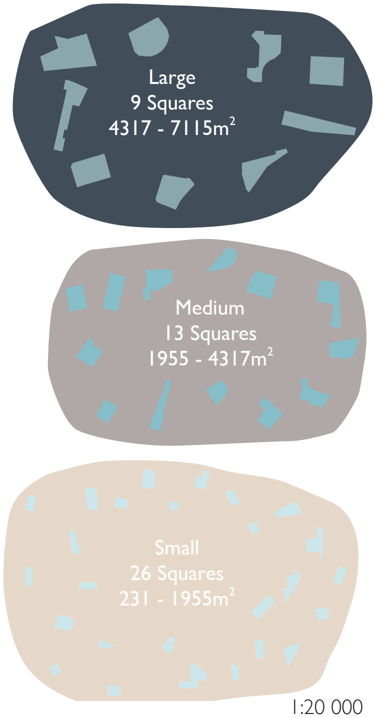


Figure 15. Ranges of size groups. Author's own copyright.

Enclosure

Enclosure describes how a square is enclosed by buildings around it. By using the same boundaries as is used for the criterion size and a figure ground map, the enclosure value is the percentage of the boundary touched by buildings that define the square space (figure 16). If the boundary is detached from buildings, I offset the boundary until it cut through main buildings. In this case, the percentage of the offset boundary cutting through buildings is counted. The offset range differs from 0m to 25m. The results were divided into 3 natural break groups - high, medium and low.

Figure 16. Calculation of enclosure, Kaggeledstorget. Author's own copyright.

Group	Min=<	<Max
High	0,56	0,81
Medium	0,37	0,56
Low	0,14	0,37

Figure 17. Ranges of enclosure groups. Author's own copyright.

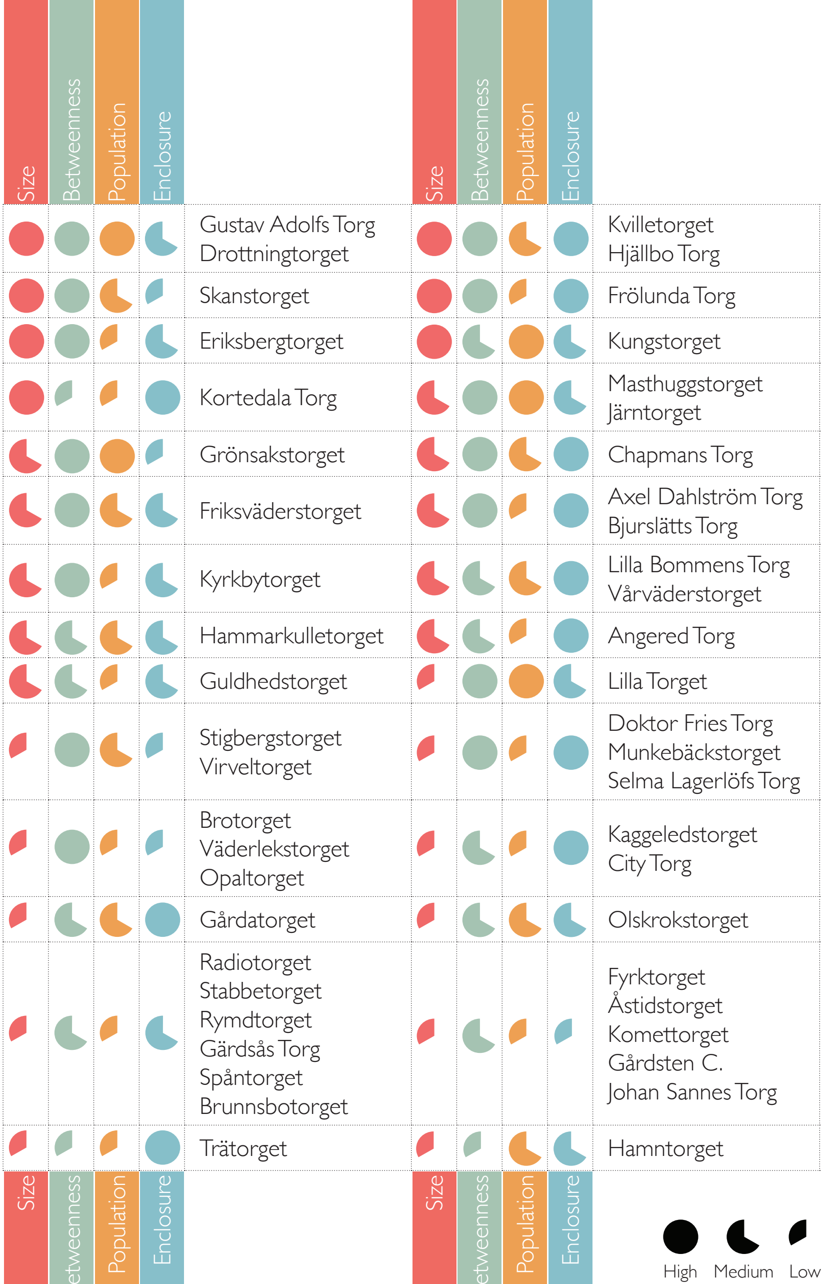


Figure 18. Square type.
Author's own copyright.

Summary

Putting the four criteria and squares into a selection matrix, each square got a combination of area, betweenness, population and enclosure as its own selecting feature. In total, there are 28 types of combinations and 11 types have more than one square in the same category.

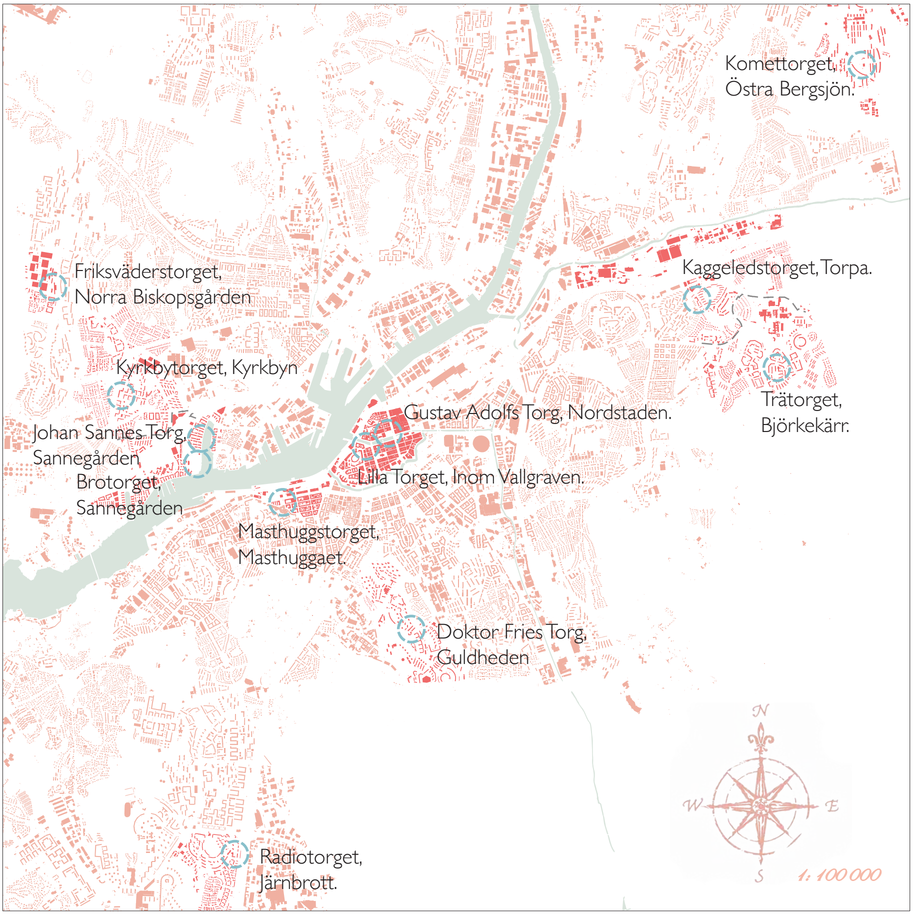


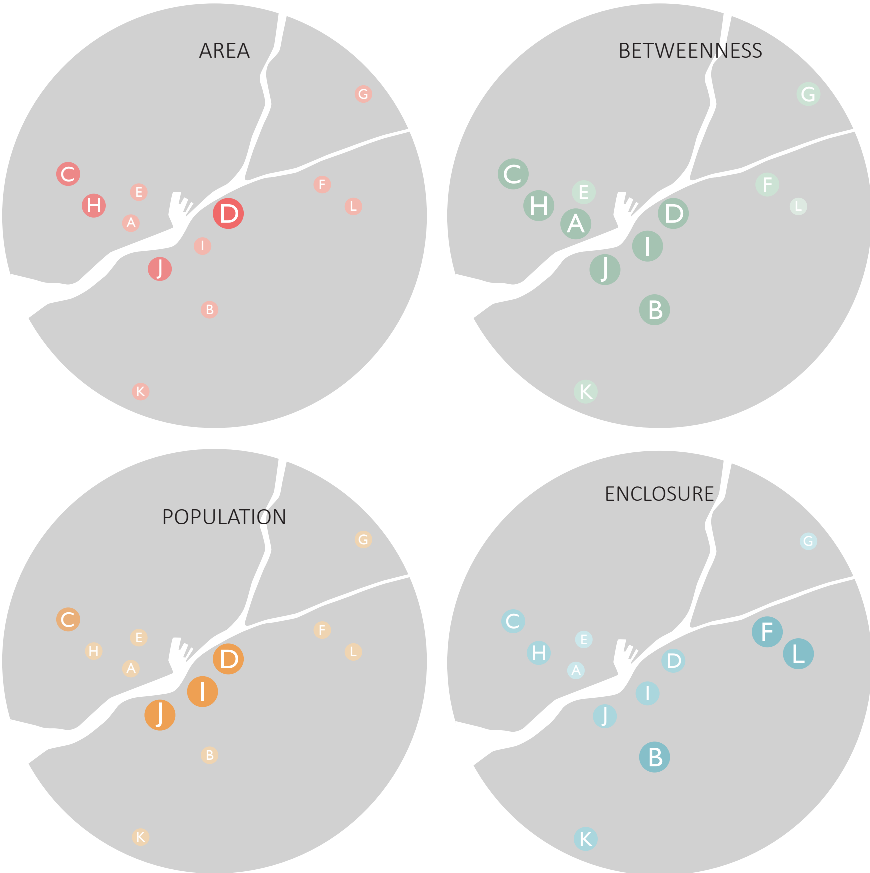
Figure 19. Selected squares. Author's own copyright.

A diverse set of squares

To get a diverse set of squares, I needed to select a set of squares whose selecting features cover 3 groups in each criterion. I kept three out of four criteria constant in the combination and comparing the fourth criteria one by one to select squares. For instance, Gustav Adolfs Torg, Masthuggstorget and Lilla Torget have the same combination of betweenness, population and enclosure but represent different values in the size of the square (figure 21). In this way, 10 squares in total were selected for further study.

To take time as an important parameter into account, I also included two squares, Brotorget and Johan Sannes Torg, locating in newly built neighbourhood in the set.

Eventually, 12 squares were selected as sites of my empirical studies.



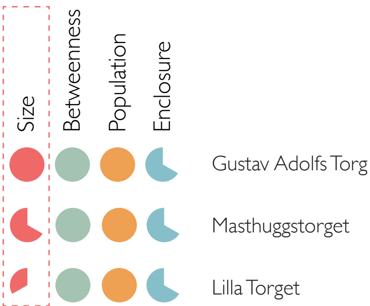


Figure 21. Author's own copyright.

Number the square:

A	Brotorget
B	Doktor Fries Torg
C	Friskväderstorget
D	Gustav Adolfs Torg
E	Johan Sannes Torg
F	Kaggeledstorget
G	Komettorget
H	Kyrkbytorget
I	Lilla Torget
J	Masthuggstorget
K	Radiotorget
L	Trätorget

Figure 20. Selection crteria of 12 selected squares. Author's own copyright.

Figure 22. Pictures of 12 selected squares.

Spatial Analysis

This section includes the method details of the different spatial analysis at three levels of scale: local, meso and global as shown in the figure 23. Here I used the same logic as for selection – including both contextual variables and local variables. The analysis to describe the context of the squares is enlarged from the selection criteria to analysis of betweenness, integration, from local to global, and densities of working and residential population, building volume, network and attraction densities within three radii – 500m, 1km and 2km. Besides the size and enclosure, the local variables, which I call below architectural characteristics, include building height as a description of the vertical dimension of a square.

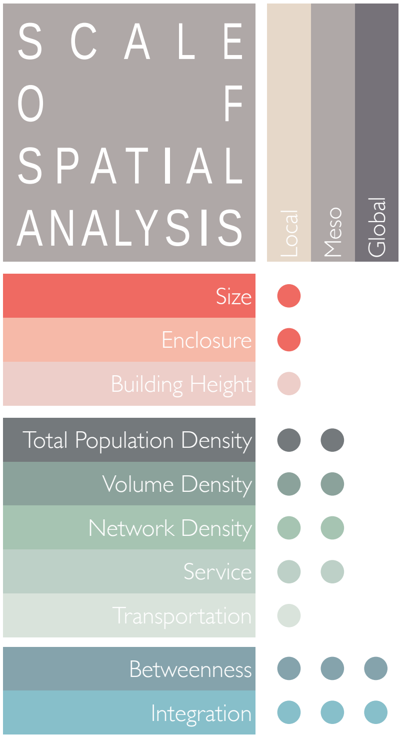


Figure 23. Spatial analysis on different scales. Author's own copyright.

Betweenness and Integration

Betweenness and integration are two measurements central to space syntax that describe different aspects of centrality in cities (Hillier and Hanson, 1984; Hillier and Iida, 2005).

The material for the betweenness analysis is the segment map of Gothenburg. It calculates the number of shortest paths, from all segments to all other segments in a certain radius, that pass through each segment. A higher betweenness means that the segment has a more important function when travelling through the city. Taking out such a segment will impact the movement patterns a lot as a segment with low betweenness has only little impact. Betweenness analysis was done in radii 500m, 1000m, 2000m, 3000m, 4000m, 5000m and 10000m, walking distance.

For integration, the axial map is used in the analysis. It calculates how many steps in total it takes from one axial line to all other lines in the whole network, again within a certain radius. A higher integration means that you can in fewer steps reach more other lines in the network. Integration analysis was done in radii 2 steps, 4 steps, 6 steps, 10 steps, 14 steps, 16 steps, 30 steps and 50 steps.

Figure 24. Betweenness in 2 km. Author's own copyright.

The streets with high betweenness values are fragemented in the neighbourhoods in the north but more connected in the south of the river, for instance streets in the inner city and Majorna show the continuity of network and the city, comparing 'islands' in the north.

66617 to 474640
(4009)

13808 to 66617
(13562)

0 to 13808
(47059)

Density

The density analysis includes population density distinguishing work and residential population, volume density, network density and attraction density including the amount of public transport stop and lines and public and food service. Except for public transportation which was examined only in radius 500m, other analysis were done in radii 500m, 1km and 2km walking distance.

To calculate densities, I needed to know the quantity of the variables and its relevant area. All the density calculations are based on the catchment area of each square from a network perspective. In other words, I used the area of convex hull[1] of reached lines in segment map as base area for density. Reached lines are all segments that people can walk within a certain distance from the square. This means that for different squares, the base area for density in the same scale is not necessarily the same(figure 25). Data of population, building volumes and service points within the base area was calculated using the 'Attraction Distance' tool in PST. It calculates the number of attractions (e.g. population, food stores, etc.) that can be reached, through the network (here the segment map is sued), within a certain radius (here 500m, 1km and 2km are used). The number of public transportation stops and lines within the area of convex hull in radius 500m were counted manually. The length of the streets was calculated using the 'Reach' tool in PST. The input for the Reach analysis is the segment map itself. It calculates the length of reached lines, line by line. In other words, the result is the total length of street lines that people can walk in all direction from the squares. If the network density is high, this means that there are many different ways to reach the square and the blocks surrounding the square are relatively small. This is according to Jane Jacobs an important factor as it gives people different routes to choose from.

As input data, for population, I calculated total population and also distinguished residential and working population. For volume, first I used GIS data of buildings footprint to calculate the area of all buildings, and then this is multiplied by building height to get the volume of buildings. As for service, I separated food service, including groceries, café and restaurants, and public service, such as libraries, activity houses, citizen service[2], etc.

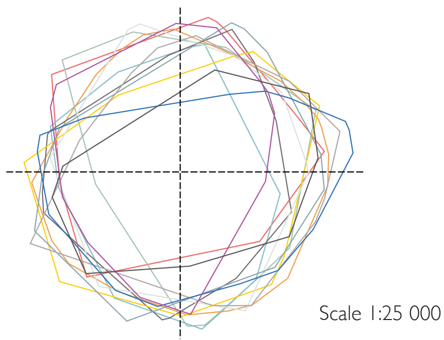


Figure 25. Catchment boundaries (in 500m radius) of 12 squares. Author's own copyright.

1 A convax hull is shaped by the end points of the furthest segments that the square can reach.
2 Aktivitetshus och medborgarservice.

Architectural Characteristic

In this category, variables are in a very local scale, looking into the square itself. Except for the area of square and enclosure, building height is included. For the first two variables, I re-used the values in selection criteria. For building height, in order to describe the dominant height of buildings that enclose a square, I chose to use mean value (heights) weighed by the length of the interface between the building and squares or the cut length of the offset boundaries used in enclosure.

Observation

Different observation methods

Through studying four works[1], I found five relevant observation methods: personal observation, snapshot, interview, time-lapse and Hägerstrand map. I will illustrate them one by one.

Personal Observation

Among these four works, personal observation has only been used in one of them. The main purpose of personal observation is to get information about how people act in public space and it is also a good way to get a general understanding and experience of the site and its context. The author went to the site for several times, did regular visits and recorded any relevant details and also conversations with local people. It is a useful tool to when the study focuses on human behaviour or the author is not familiar with the site. And also, through personal visits and observation, problems and issues that have not been expected or acknowledged by authors could be possibly discovered.

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1 Aragone, A. (2015). *Migrated Space Contrasts: Spaces for possible social interaction in Matonge, Bruxelles* (Master thesis, TU Delft, Department of Urbanism).

Kritsioudi, M. (2015). *Living wiht the others. Spatial Transformations towards liveability: the case of the Schilderswijk* (Master thesis, TU Delft, Department of Urbanism).

Legeby, A. (2013). *Patterns of co-presence: Spatial configuration and social segregation* (PhD thesis, Royal Institute of Technology, Department of Architecture and the Built Environment).

Rodionova, A. (2014). *Safety in Public Spaces: The Case of Osdorp-Oost* (Master thesis, TU Delft, Department of Urbanism).

Snapshot

Snapshot is used in three studies. In Anna Rodionova's study, she visited the site within three time intervals on a day, both in weekdays and weekends. During the visits, the activities taking place and people in different categories were observed and recorded. Through this method, the information she got helped her to understand how public facilities were being used by inhabitants.

Maria Kritsioudi also used snapshot analysis in her Master thesis to figure out 'which areas are the most attractive for people, which routes are mainly used for moving within the neighbourhood and where groups of interests are mainly concentrated'. To avoid generalization and to get a strong image of public life, she conducted the analysis in three time periods which covered the whole day. Activities (walking, standing or sitting, cycling) were mapped with distinguishing the gender and age of people. Different from Anna Rodionova, the snapshot analysis in Maria's thesis was only on Saturdays.

Momentary intensity and pedestrian flow were both observed in Ann Legeby's snapshot analysis. People at present in the public space were counted within 4 minutes and several times during the day. Where people come and go were written down 3 times at each 'gate' of the space. The research got both the amount of people co-present and the direction of pedestrian flow as inputs from snapshot analysis.

Interviews

Interviews and questionnaires are often used in many kinds of projects to get more accurate and detailed information as supplements that we cannot get from visual observation. Since authors can make conversations with people and get first-hand information from different stakeholders through, the method is interactive and relevant to social issues. There are informal and formal interviews. In Ann's research, informal interviews were conducted to people co-present in the public spaces during two visit in a day. The questionnaires included basic information and some specific questions relating to the research questions.

Time-lapse analysis and Hägerstrand map

These two methods used in Andrea Aragone's Master thesis take time as a dimension into the analysis. Time-lapse mapping can be understood as a whole of several same continuous snapshots with fixed intervals, like the relation between scenarios and movies. People in 21 chosen spots were counted for 10 minutes in six moments during a day and were mapped down. The time-lapse mapping helped the author to understand how people behaved during these six time slots. Hägerstrand map is called time-space map because it shows people's movement in the space during time[1]. The author followed pedestrians for 10 minutes four times of the day.

1 This is referred to Giddens A. (1984) by Andrea Aragone in his originally report.

Observation methods used in this thesis

The purpose of observation is to help me understand how public squares function in a sense of co-presence. In other words, I need to know how many people use public squares and how diverse this group of people is. Therefore, the data of the intensity and diversity of people co-present in public squares and other detail information of visits are essential to the research.

Further, it needs to be possible to quantify the results of the observation to be able to correlate them with the results of the spatial analysis. So personal observation is not an efficient method in this sense. Time-lapse map and Hägerstrand map are very interesting to the research because time is taken into consideration in the analysis. However, because of time limitations I did not choose these two methods. In the end, snapshot and short interviews were used in the thesis.

Snapshot for intensity of co-presence

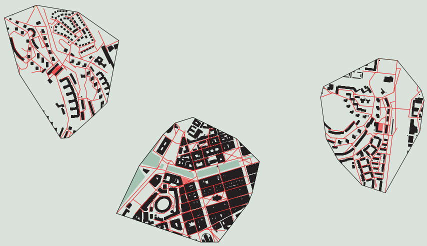
People present in squares were counted for four minutes every half hour during a weekday, from 8.00 to 18.00. The thesis is about everyday life, therefore Monday, Friday and summer time from mid-summer till late August was excluded when conducting the observation, to avoid the influence of weekends and vacations. The counting included people passing through the square and people staying, but people on the streets at the side of the squares were not included. Two exceptions were Brotorget and Lilla Torget. When I went to these two squares, I found that the squares were integrated with the streets rather well, which blurs the boundary between them. For these two squares, I did the counting separately in the squares and on the streets and dealt with both data in the correlation. Other relevant behaviour and weather condition were also recorded.

Interviews for diversity of co-presence and other information

Interviews were operated in-between each snapshot counting. The questionnaire, designed both in English and Swedish, started with a short introduction of the survey and followed with general questions, like the transportation means, purpose and frequency of visit and how visitors perceive the space. It ended with basic information: age, gender and home address. The conducting time of one questionnaire was about three minutes. Except for the time, weather, weekday, I also counted how many people refused to answer the questionnaire due to time, languages and other personal reasons.

With help from my colleagues and friends, nine squares were observed. The observation of the other three squares were used from an earlier study in Gothenbrug, Dela[d]Stad project.

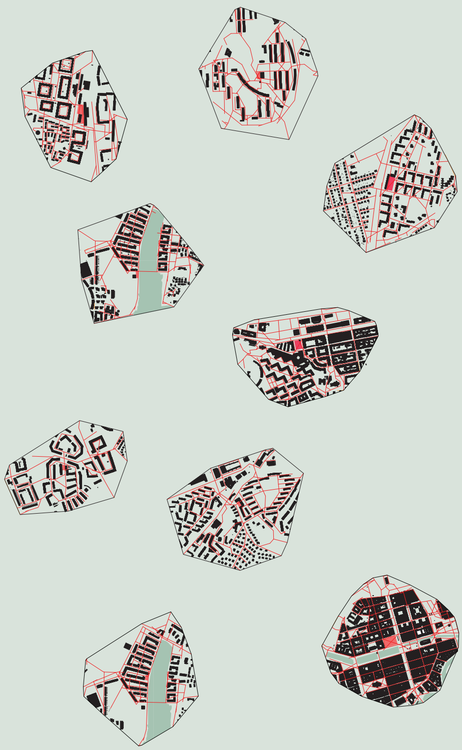
3. Findings, Conclusions and Discussion



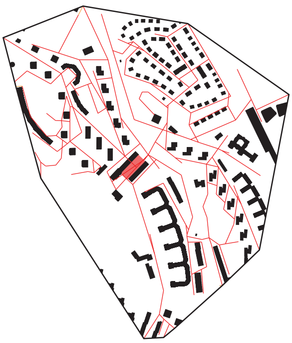
Spatial Analysis

Here I mainly show the results of density analysis in 500m. The full table of spatial analysis results are included in the appendix.

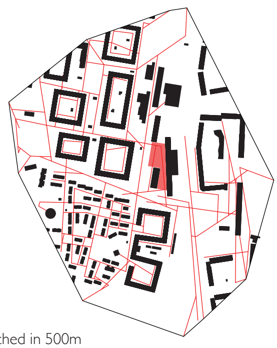
From the figure ground maps of each square, it is clear that the shape and area of catchments in same radius are rather different among squares. This is a big difference between location-based analysis and area-based analysis.



A - Brotorget						
Size	972 m^2	Enclosure	0,16	Building Height	18,65 m
	500m		1km		2km
Catchment Area	404862,07 m^2		1636891,13 m^2		5791637,75 m^2
Population Density	74,67 per ha.		61,02 per ha.		55,90 per ha.
Volume Density	4,41 m^3/m^2		5,65 m^3/m^2		5,03 m^3/m^2
Network Density	0,0228 m/m^2		0,0207 m/m^2		0,0190 m/m^2
Public Service	4		30		77
Food Service	5		39		91
Number of Stops	2		NA		NA
Transportation Lines	5		NA		NA



B - Doktor Fries Torg					
Size	1529 m^2	Enclosure	0,72	Building Height	10,74
	500m		1km		2km
Catchment Area	439328,20 m^2		1888799,65 m^2		7630255,58 m^2
Population Density	71,34 per ha.		75,44 per ha.		101,88 per ha.
Volume Density	8,56 m^3/m^2		7,72 m^3/m^2		6,83 m^3/m^2
Network Density	0,0237 m/m^2		0,0204 m/m^2		0,0188 m/m^2
Public Service	19		43		176
Food Service	8		29		283
Number of Stops	2		NA		NA
Transportation Lines	1		NA		NA



Square

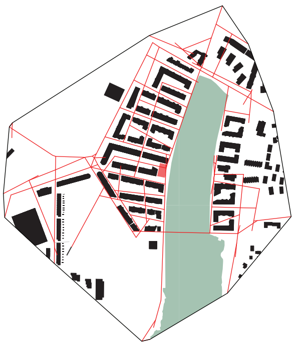
Area reached in 500m

Reached streets in 500m

Scale 1:20 000

C - Friskväderstorget					
Size	3413 m^2	Enclosure	0,51	Building Height	20,97 m
	500m		1km		2km
Catchment Area	444700,56 m^2		1859791,41 m^2		7436458,00 m^2
Population Density	100,36 per ha.		74,19 per ha.		41,61 per ha.
Volume Density	12,01 m^3/m^2		6,85 m^3/m^2		5,94 m^3/m^2
Network Density	0,0271 m/m^2		0,0198 m/m^2		0,0161 m/m^2
Public Service	15		34		115
Food Service	8		14		33
Number of Stops	2		NA		NA
Transportation Lines	5		NA		NA

D - Gustav Adolfs Torg						
Size	5992 m^2	Enclosure	0,46	Building Height		12,77 m
		500m		1km		2km
Catchment Area		564251,64 m^2		1968385,69 m^2		8779722,00 m^2
Population Density		443,35 per ha.		260,93 per ha.		149,52 per ha.
Volume Density		51,27 m^3/m^2		21,91 m^3/m^2		12,18 m^3/m^2
Network Density		0,0315 m/m^2		0,0277 m/m^2		0,0187 m/m^2
Public Service		94		152		401
Food Service		162		327		782
Number of Stops		6		NA		NA
Transportation Lines		40		NA		NA



E - Johan Sannes Torg						
Size	868 m^2	Enclosure	0,32	Building Height		13,12 m
		500m		1km		2km
Catchment Area		452778,37 m^2		1692349,85 m^2		6007420,13 m^2
Population Density		56,72 per ha.		57,25 per ha.		55,97 per ha.
Volume Density		3,59 m^3/m^2		4,54 m^3/m^2		4,91 m^3/m^2
Network Density		0,0209 m/m^2		0,0196 m/m^2		0,0196 m/m^2
Public Service		3		19		82
Food Service		5		28		95
Number of Stops		1		NA		NA
Transportation Lines		4		NA		NA

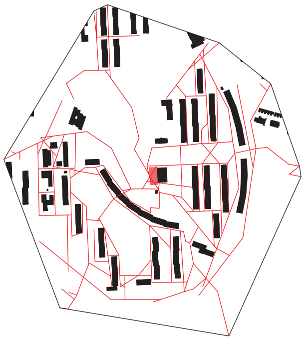
Square

Area reached in 500m

Reached streets in 500m

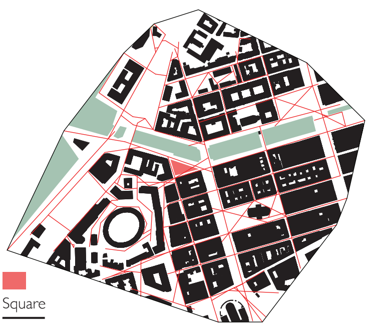
Scale 1:20 000

F - Kaggeledstorget						
Size	803 m^2	Enclosure	0,68	Building Height		9,64 m
		500m		1km		2km
Catchment Area		550524,33 m^2		1587226,13 m^2		6694492,25 m^2
Population Density		57,10 per ha.		46,83 per ha.		48,02 per ha.
Volume Density		4,03 m^3/m^2		3,26 m^3/m^2		2,92 m^3/m^2
Network Density		0,0213 m/m^2		0,0196 m/m^2		0,0150 m/m^2
Public Service		22		38		132
Food Service		8		20		49
Number of Stops		1		NA		NA
Transportation Lines		2		NA		NA



G - Komettorget						
Size	1038 m^2	Enclosure	0,28	Building Height	1,15 m	
	500m		1km		2km	
Catchment Area	472824,24 m^2		1401514,31 m^2		4594404,50 m^2	
Population Density	65,82 per ha.		55,06 per ha.		32,93 per ha.	
Volume Density	5,27 m^3/m^2		2,82 m^3/m^2		2,12 m^3/m^2	
Network Density	0,0250 m/m^2		0,0221 m/m^2		0,0155 m/m^2	
Public Service	18		45		77	
Food Service	3		7		13	
Number of Stops	2		NA		NA	
Transportation Lines	5		NA		NA	

H - Kyrkbytorget						
Size	3904 m^2	Enclosure	0,43	Building Height	10,34 m	
	500m		1km		2km	
Catchment Area	490953,44 m^2		2100499,63 m^2		8881023,50 m^2	
Population Density	43,55 per ha.		38,81 per ha.		46,88per ha.	
Volume Density	3,81 m^3/m^2		2,56 m^3/m^2		2,72 m^3/m^2	
Network Density	0,0238 m/m^2		0,0209 m/m^2		0,0188 m/m^2	
Public Service	11		28		131	
Food Service	7		17		91	
Number of Stops	1		NA		NA	
Transportation Lines	4		NA		NA	



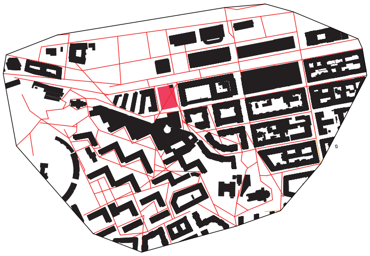
Square

Area reached in 500m

Reached streets in 500m

Scale 1:20 000

I - Lilla Torget						
Size	879 m^2	Enclosure	0,46	Building Height	18,25 m	
	500m		1km		2km	
Catchment Area	541507,34 m^2		1776513,67 m^2		8321435,17 m^2	
Population Density	299,09 per ha.		258,23 per ha.		159,07 per ha.	
Volume Density	21,90 m^3/m^2		24,15 m^3/m^2		13,84 m^3/m^2	
Network Density	0,0279 m/m^2		0,0300 m/m^2		0,0201 m/m^2	
Public Service	97		165		399	
Food Service	105		339		813	
Number of Stops	4		NA		NA	
Transportation Lines	31		NA		NA	



J - Masthuggstorget

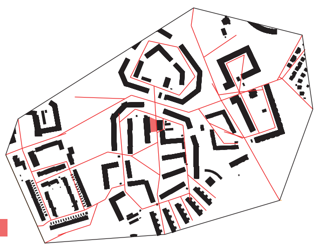
Size	3151 m^2	Enclosure	0,50	Building Height	16,08 m

	500m	1km	2km
Catchment Area	453036,23 m^2	1823597,31 m^2	6862329,63 m^2
Population Density	222,72 per ha.	179,50 per ha.	150,48 per ha.
Volume Density	23,55 m^3/m^2	19,41 m^3/m^2	14,82m^3/m^2
Network Density	0,0292 m/m^2	0,0247 m/m^2	0,0224m/m^2
Public Service	35	112	378
Food Service	58	193	608
Number of Stops	2	NA	NA
Transportation Lines	5	NA	NA

K - Radiotorget

Size	1403 m^2	Enclosure	0,50	Building Height	5,39 m

	500m	1km	2km
Catchment Area	434165,69 m^2	1829035,49 m^2	7171213,50 m^2
Population Density	43,19 per ha.	49,00 per ha.	47,38 per ha.
Volume Density	2,17 m^3/m^2	4,06 m^3/m^2	4,92 m^3/m^2
Network Density	0,0206 m/m^2	0,0180 m/m^2	0,0151 m/m^2
Public Service	10	35	55
Food Service	4	8	15
Number of Stops	2	NA	NA
Transportation Lines	4	NA	NA



L - Trätorget

Size	603 m^2	Enclosure	0,68	Building Height	8,78 m

	500m	1km	2km
Catchment Area	352150,82 m^2	1540225,00 m^2	6076562,50 m^2
Population Density	71,45 per ha.	42,62 per ha.	33,99 per ha.
Volume Density	9,85 m^3/m^2	4,86 m^3/m^2	1,81 m^3/m^2
Network Density	0,0183 m/m^2	0,0133 m/m^2	0,0112 m/m^2
Public Service	9	21	55
Food Service	4	8	15
Number of Stops	3	NA	NA
Transportation Lines	1	NA	NA

Square

Area reached in 500m

Reached streets in 500m

Scale 1:20 000

Observation

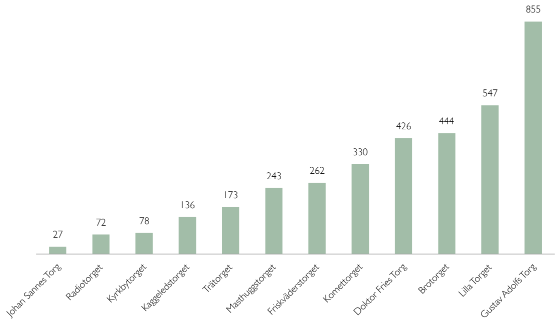


Figure 26. Hourly amount of people co-present.
Author's own copyright.

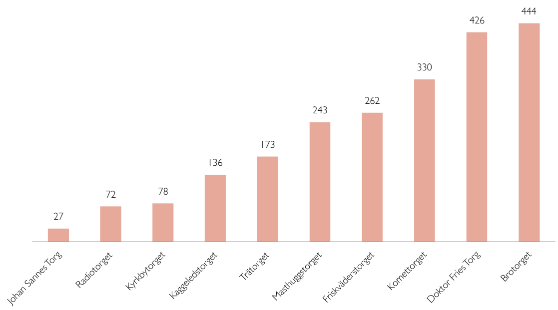


Figure 27. Hourly amount of people co-present, non-CBD squares.
Author's own copyright.

Snapshot

I used the hourly average amount of people co-present in squares as an indicator of intensity of co-presence. The result is shown in the chart and table. Gustav Adolfs Torg had the most visitors among all squares and Johan Sannes Torg got the least.

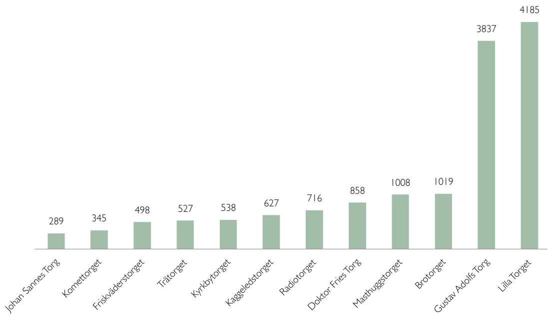


Figure 28. Median distance of home address.
Author's own copyright.

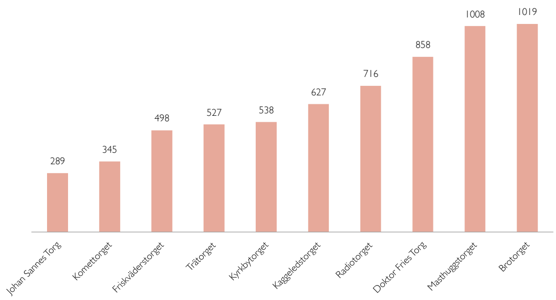


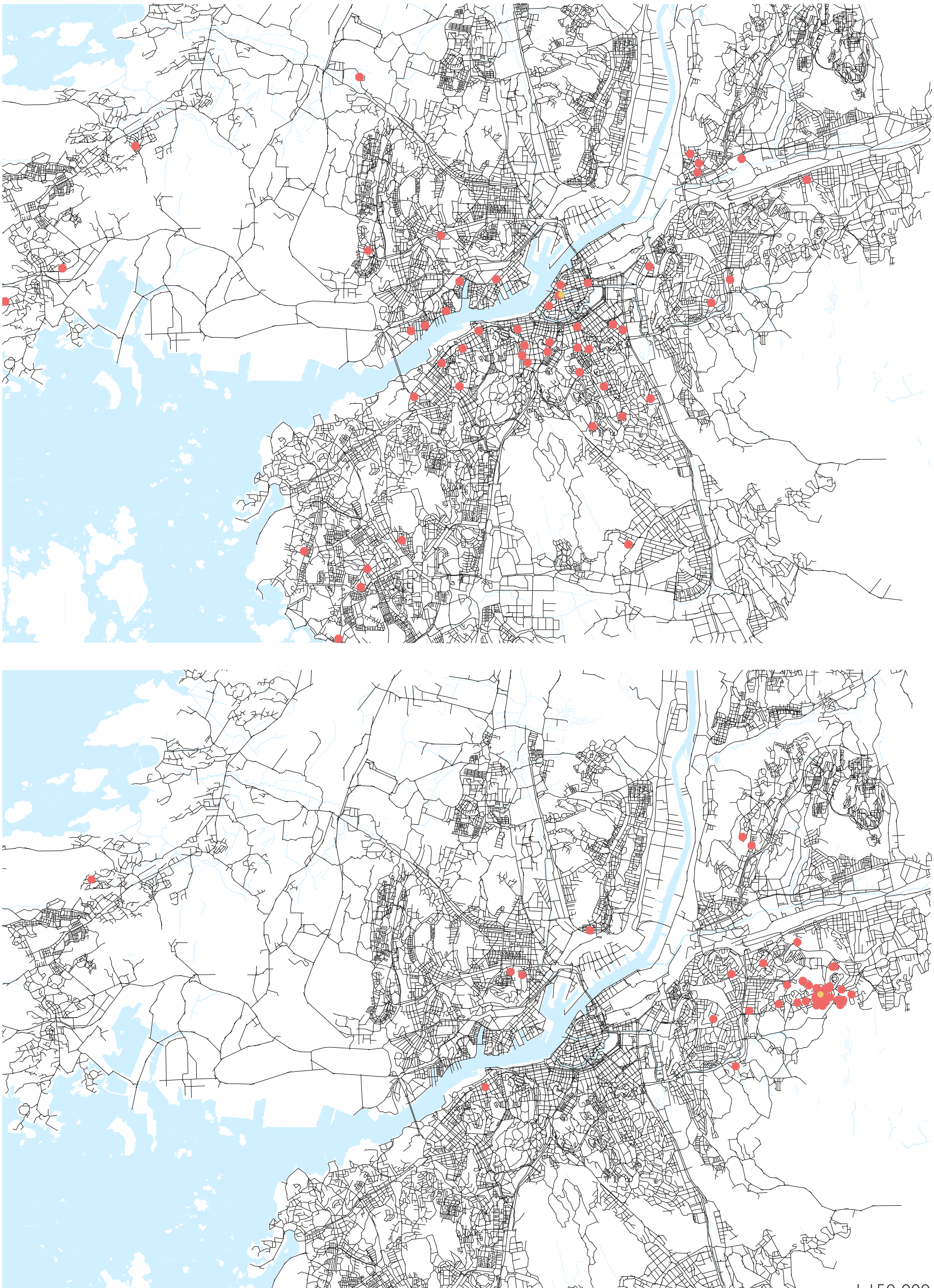
Figure 29. Median distance of home address of non-CBD squares.
Author's own copyright.

Interview

In Dela[d]Stad project, the distances from visitors' home to the square were used to measure if people co-present in the square are local, non-local or mixed both, which we see as a parameter of the diversity of people co-present. To keep consistent, I used information of home address as inputs too. Due to time limitation, the information from other five general questions and basic information I got from interviews are not used in this thesis and saved for future studies. In average 60 people for one square answered the questionnaires.

The home address points were pointed out on the map with red dots. As we can see, for some squares, e.g. Gustav Adolfs Torg, the red dots are rather spread out however squares like Kaggeledstorget mostly got visitors from its own and adjacent neighbourhoods. In other words, these squares are mainly used by locals and the average distance from home to square is short. Squares like Gustav Adolfs Torg are visited by different people from all over Gothenburg and even other cities, which generates a long average travelling distance from home to square.

Therefore the distance from home to square can be used to describe the diversity of people co-present in squares. Instead of average distance, I used median distance in correlation in case some extremely values skew the data. The calculations were done using the 'Attraction Distance' tool in PST.



1:150 000

Figure 30. Address map of Lilla Torget (up) and Trätorget (down). Author's own copyright.

Statistical Analysis

Intro

In this section, I looked for linear relations between different spatial variables and the diversity and intensity of people co-present on the squares. I correlated spatial analysis data with observation results one by one in Microsoft Excel and compared the results by regression[1]. Within social science, regressions above 0,3, meaning that 30% of the phenomenon can be explained by the variable, are regarded as high or at least relevant.

In Chapter II, I mentioned for people co-present in Brotorget and Lilla Torget were counted in the squares and on the streets respectively. Correlations for intensity were tested both with and without people on the streets. Taking out the street counts reduces the correlations in general but the trends are still the same. The findings below are therefore based on observation data with all counts.

Gustav Adolfs Torg and Lilla Torget (from now on referred to as CBD-squares) often stand out from all squares in many aspects, e.g. integration R6 with amount of people (figure 31). They have in comparison to other squares a high diversity and intensity of co-presence. These so-called outliers can be the reason for the high regressions found. One can almost say that they may represent another group different from the other ten squares (from now on referred to as non-CBD squares) and should be studied separately from non-CBD squares in case some details of what happens in non-central area are hidden because of the dominance of the CBD squares. We therefore also tested whether the same correlations were found in the set of squares excluding these two very central squares.[2]

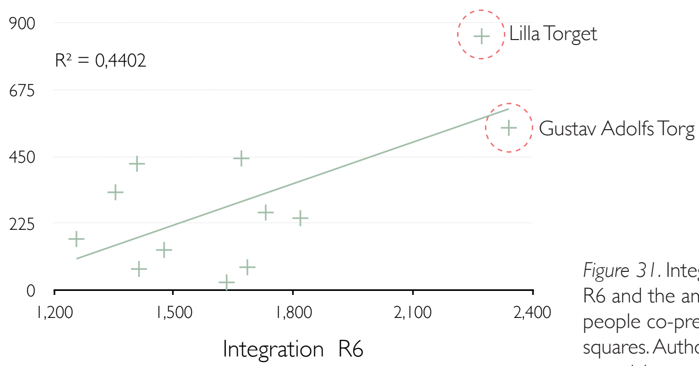


Figure 31. Integration R6 and the amount of people co-present, 12 squares. Author's own copyright.

1 Regression, the square of correlation, is often used when showing the results.
2 Taking out CBD-squares reduces correlations in general.

Integration

Diversity of people co-present

Strong regressions with all squares throughout all scales are found between integration and median distance value. By taking out the two CBD-squares, the regressions reduce in general and disappear on local scales. However, the integration in larger radii accounts for the diversity of people more than that in small radii, especially for squares not in the city centre. But also, at radius 10, a correlation of 0,24 is found. This means the integration at the meso scale is also important for the diversity of people co-present in the non-CBD squares. In other words, the global centrality of these squares is important, but also the integration at the meso sale, or the in between neighbourhoods scale. For urban design, this means that one should focus on both integrating neighbouring neighbourhoods but also take into account the position of the square in the city as a whole. In other words, without the support of global integration, only having high local integration value does not provide conditions to attract both local residents and people from other places in the city. Both the link to other neighbourhoods nearby and the city as a whole is important.

Integration	12 Sqaures	10 Squares
R2	0,3891	0,0384
R4	0,6133	0,0385
R6	0,7774	0,0870
R10	0,7884	0,2442
R14	0,5768	0,2092
R16	0,5448	0,2269
R30	0,5202	0,2893
R50	0,5441	0,4306
R80	0,5023	0,3677

Figure 32. Regression of integration with diversity. Author's own copyright.

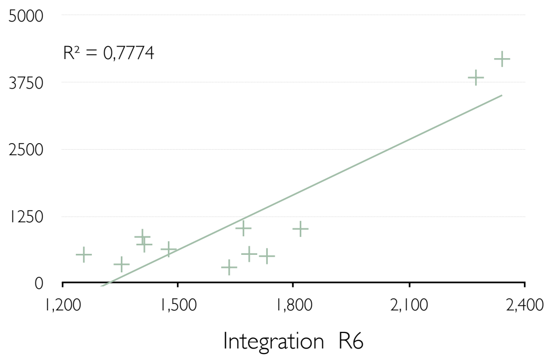


Figure 33. Integration R6 and diversity of people co-present, 12 squares. Author's own copyright.

Intensity of people co-present

Regressions at meso scales are found with all squares and are less strong on local and global scales. By taking out the CBD-squares the regressions disappear. This means that integration is not important for the amount of people present in non-CBD squares.

Integration is mostly an indicator for the centrality of the squares and explains the difference between the centre and suburbs. From the results above, it shows that integration is an important variable for the diversity of people co-present in the squares but not for the amount of people. It may be so that integration needs to get over a certain threshold to get the 'urban buzz'. However we cannot know this for sure as we have too little samples in the central area.

Integration	12 Squares	10 Squares
R2	0,2537	0,0011
R4	0,3779	0,0006
R6	0,4402	0,0004
R10	0,4082	0,0069
R14	0,2719	0,0031
R16	0,2439	0,0029
R30	0,2636	0,0003
R50	0,2226	0,0115
R80	0,2291	0,0035

Figure 34. Regression of integration with intensity. Author's own copyright.

Betweenness

Diversity of people co-present

For betweenness the regressions are rather low. However, by taking out the two squares in the inner city, it shows that betweenness, especially in radius 2km with regression 0,53, is an important variable in non-central areas. In other words, the connections among adjacent neighbourhoods is important in the design of squares if the goal is to have a more diverse public present in these squares. That this doesn't seem important for the two inner-city squares can be explained by the fact that the high integration of these two squares dominates the outcome. If more squares in the inner-city were included in the study, we might had found that also within that group of squares more diversity would have been found in squares with a higher betweenness value.

Betweenness	12 Squares	10 Squares
500m	0,0294	0,0884
1000m	0,0874	0,3590
2000m	0,1929	0,5332
3000m	0,0490	0,3778
4000m	0,0212	0,3295
5000m	0,0249	0,3080
10 000m	0,0842	0,2749

Figure 35. Regression of betweenness with diversity. Author's own copyright.

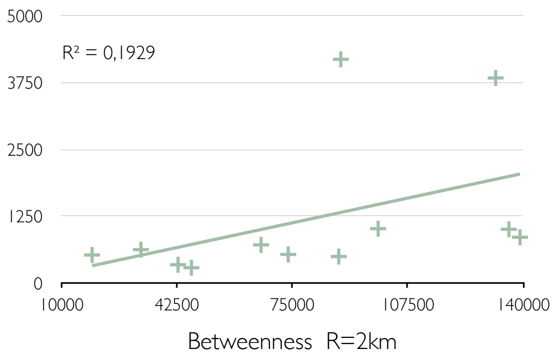


Figure 36. Betweenness in 2km and diversity of people co-present, 12 squares. Author's own copyright.

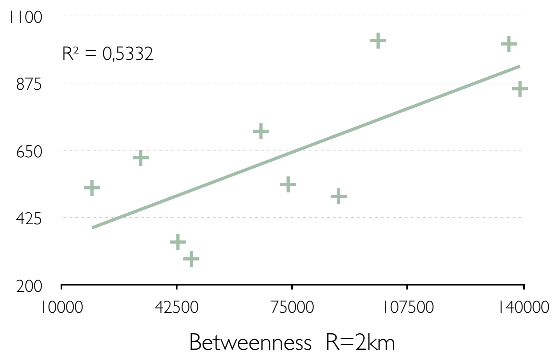


Figure 37. Betweenness in 2km and diversity of people co-present, 10 squares. Author's own copyright.

Intensity of people co-present

Regressions (0,43 in radius 1km and 0,37 in 2km) are found with all squares and when CBD-squares are excluded, the regressions become stronger. In radius 500m, the regression doubles, from 0,15 to 0,31 and the regression in 1000m is still the highest value with 0,65. Therefore we can say that betweenness on relevant scales is a variable that explains the amount of people both in the non-central area and inner city. Although betweenness on global scale is not as effective in creating vitality in public squares, we can say that it explain the amount of people co-present in the squares better than integration, especially in non-central area.

Betweenness	12 Squares	10 Squares
500m	0,1545	0,3058
1000m	0,4301	0,6548
2000m	0,3709	0,3011
3000m	0,0415	0,0241
4000m	0,0143	0,0079
5000m	0,0193	0,0070
10 000m	0,0776	0,0021

Figure 38. Regression of betweenness with intensity. Author's own copyright.

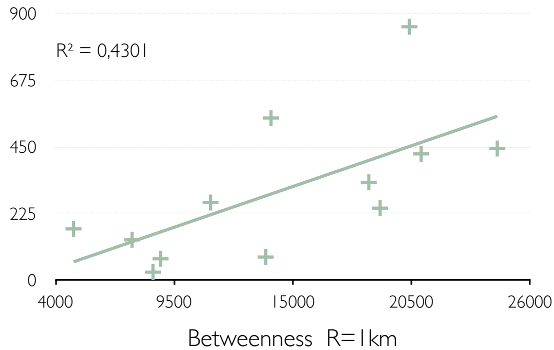


Figure 39. Betweenness in 1km and the amount of people co-present, 12 squares. Author's own copyright.

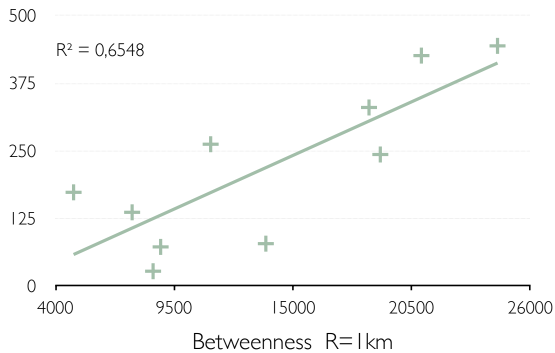


Figure 40. Betweenness in 1km and the amount of people co-present, 10 squares. Author's own copyright.

Population Density

Diversity of people co-present

Population density shows very high regressions with all squares and keeps the strong trend also without CBD-squares. In the results of 10 non-CBD squares, the regression increases from 0,25 to 0,30 to 0,44 when the radius changes from 500m to 1km to 2km. We can simply say that it is an important variable for diversity in the inner city and becomes more influential in the suburbs with the increasing of scales. But if we instead of looking into the total population density, distinguish between residential and working population density, it is noticeable that working population is the factor that plays the most important role (except for radius 2 km where residential population shows a regression of 0,35 with 10 squares). From this, it is clear that job opportunities/ offices (or mixed-used area) is important to create the diversity of co-presence especially for non-central areas. When we also exclude Masthuggstorget which has a relative high working population in comparison to the other squares, the trend is still clear. The working population still shows strong regressions of 0,60, 0,33 and 0,33 in radii 500m, 1000m and 2000m respectively, however, the regressions with residential and total population do not exist anymore. We can thus conclude that working population is an important factor for the diversity of people co-present on squares. In the areas where the working population density is relatively low we still find a strong correlation (see chart below), especially on the most local scale (500 m).

All in all, no matter in the central area or suburbs, for population, working population density plays a dominant role in creating diversity of people co-present in public squares. Residential population density is not as important for diversity in most of the cases.

Population Density	500m	1km	2km
Total	0,8066	0,8500	0,6450
Working	0,8851	0,9741	0,8317
Residential	0,2505	0,0634	0,1926

Population Density	500m	1km	2km
Total	0,2487	0,2973	0,4446
Working	0,3147	0,4423	0,4724
Residential	0,1081	0,1820	0,3531

Population Density	500m	1km	2km
Total	0,0061	0,0635	0,2757
Working	0,5972	0,3256	0,3282
Residential	0,0036	0,0077	0,1393

Figure 41. Regression of population density with diversity, 12 squares(up), 10 squares (middle), 9 squares(down). Author's own copyright.

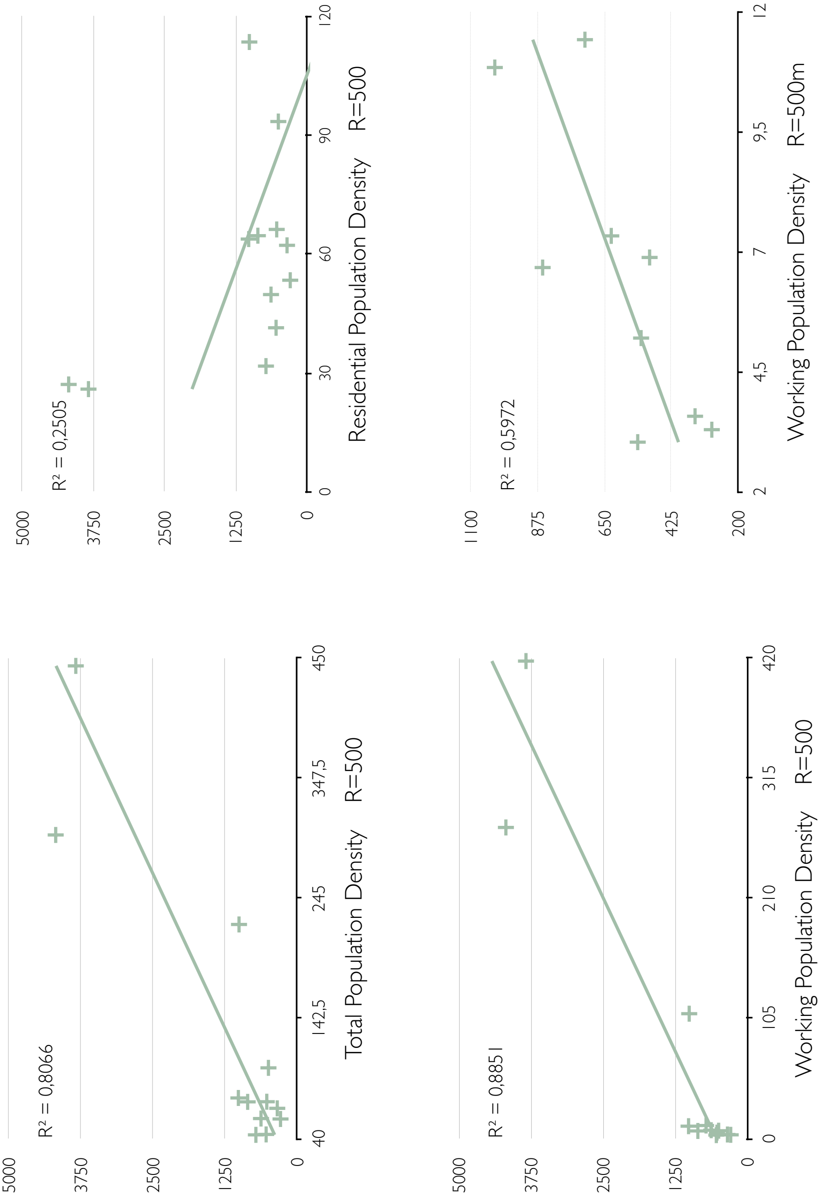


Figure 42. Population densities and diversity of people co-present. Author's own copyright.

Intensity of people co-present

With all squares, working population has a strong regression with the amount of visitors hourly. We see the three squares, Gustav Adolfs Torg, Lilla Torget and Masthuggstorget, with a lot of working population clearly in the chart. By taking them out, the result shows the opposite. Noticeably, it is the residential population that has regressions, especially a regression of 0,30 in radius 500m, rather than working population. In other words, when areas with high working population are excluded, higher residential population densities are important.

Population Density	500m	1km	2km
Total	0,6702	0,5845	0,4402
Working	0,6663	0,6307	0,5397
Residential	0,0603	0,0165	0,1568

Population Density	500m	1km	2km
Total	0,3627	0,4142	0,1652
Working	0,0775	0,0989	0,1937
Residential	0,3024	0,2634	0,0630

Figure 43. Regression of population density with intensity, 12 squares(up), 9 squares(down). Author's own copyright.

Volume Density

Diversity of people co-present

Volume density highly correlates with total population density, which makes sense, as it is the buildings that accommodate the residential and working population. It also correlates with the diversity of people co-present in the squares. However, by taking out CBD-squares, the regressions decrease from 0,62 to 0,17 on the local scale (500 m). On the higher scale of 2 km, however, the regression continues to be relatively strong even in the non-central area (a regression of 0,32).

In combination with the findings of population densities, we can conclude that the working population is the most important factor. On the very local scale (radius 500 m), it is work population that is key and volume density or total population density is not significant for the diversity of people co-present.

Volume Density	500m	1km	2km
12 Squares	0,6203	0,7725	0,5610
10 Squares	0,1661	0,3624	0,4371
9 Squares	0,0048	0,1931	0,3219

Figure 44. Regression of volume density with diversity. Author's own copyright.

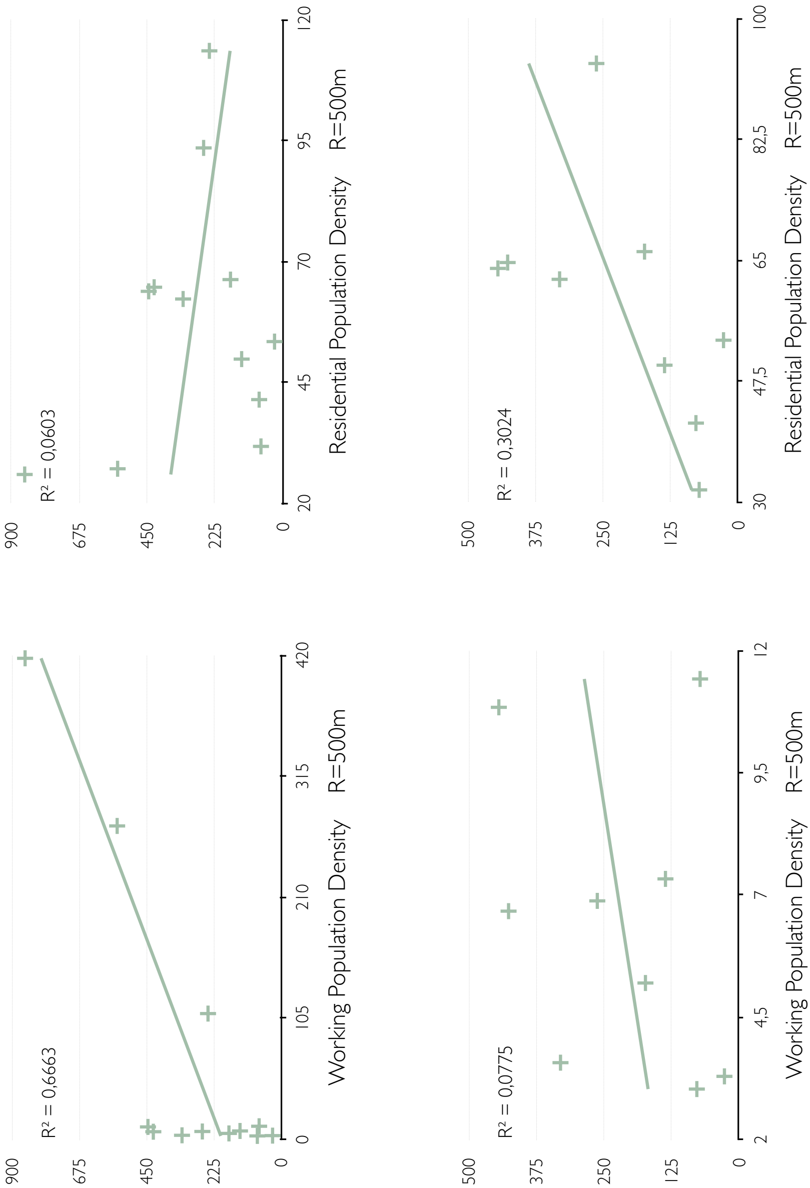


Figure 45. Population densities and the amout of people co-present.
Author's own copyright.

In other words, a general high volume or total population density in the larger context is beneficial for co-presence, but on local scale directly surrounding the square, we need to focus on work opportunities/offices and thus a mix of functions.

Intensity of people co-present

Regressions with all squares are high, especially on local scale. Taking out of CBD-squares and Masthuggstorget, suddenly the regression at 1 km stands out in this group but disappears in other two radii. Since volume density is highly correlated with total population density, we expect a similar regression result here. However the regression (0,15) in 500m with 9 squares is less than half of the regression of total population density (0,36). The big difference in the results is possibly because the distribution of data, in other words, how data is organized in GIS, is different in two data sets. The volume data is organized in buildings and population data is assembled in 500m*500m squares due to the privacy issue. The volume data thus is more accurate than the population data. Therefore we see the volume density in 1km is a more accurate variable than total population density to explain the phenomenon, as long as no accurate population data is used in the analysis.

Volume Density	500m	1km	2km
12 Squares	0,6410	0,5169	0,3331
9 Squares	0,1464	0,3143	0,0870

Figure 46. Regression of volume density with intensity. Author's own copyright.

Network Density

Diversity of people co-present

From the regression results, the conclusion can be drawn that network density on the local scale plays a role for the diversity of the squares in the inner city[1] (footnote, which area is inner city in Gothenburg), but is not relevant for squares in the non-central area.

Referring to the findings in integration and betweenness, the location of the square and how the network is designed and connected is more important than the number or length of streets.

Network Density	500m	1km	2km
12 Squares	0,4265	0,6679	0,1314
10 Squares	0,0878	0,1027	0,1867

Network Density	500m	1km	2km
12 Squares	0,5059	0,4756	0,0839
10 Squares	0,1463	0,0897	0,0282

Figure 47. Regression of network density with diversity (up) and intensity (down). Author's own copyright.

Intensity of people co-present

Same regressions found here also. With all squares, regressions between amount of people and network density can be found 0,51 in radius 500m and 0,48 in radius 1km. However both of them disappear when CBD-squares are taken out. Network thus is not a good variable that can explain the variation among squares in non-central areas. The high regressions found with all squares, which disappear with 10 squares, is similar with the regression in integration and amount of people. It may because the integration that counts for the results.

Service	500m	1km	2km
Public Service	0,9336	0,8406	0,6790
Food Service	0,8555	0,8882	0,7875

Service	500m	1km	2km
Public Service	0,1348	0,2958	0,3500
Food Service	0,2799	0,3451	0,4024

Service	500m	1km	2km
Public Service	0,0005	0,0586	0,1383
Food Service	0,1031	0,3484	0,2388

Figure 48. Regression of the amount of service with diversity, 12 squares(up), 10 squares(middle), 9 squares(down). Author's own copyright.

Proximity to Service

Diversity of people co-present

For public service, we see similar result as with volume density: by taking out CBD-squares, the strong regression that is shown with 12 squares decreases on all scales, especially on local scale (500m) from 0,94 to 0,13. It does not seem to be an important variable for non-central squares on local scale and cannot explain the diversity of people co-present there. With 9 squares, at 1 km the regressions are 0,06 for public service and 0,35 for food service. This does not say that public service is

1 The inner city includes Nordstaden and Inom Vallgraven.

not important for people living in these areas, but not so much for the diversity of people co-present on the squares. Regression with food service is stronger for all squares and moderate without the two central squares and even without Masthuggstorget, which has a relative high number of public and food service. Compared to public service, food service is a more important factor for the diversity of people co-present in squares in non-central area. In combination with the findings of population density, we can see on one hand, the co-variance between working population and food service: more people working give more market for food service; on the other hand, it confirms the importance of working population for the diversity of people co-present in squares.

Service	500m	1km	2km
Public Service	0,6072	0,5421	0,3857
Food Service	0,6418	0,5475	0,5142

Service	500m	1km	2km
Public Service	0,0381	0,0493	0,0018
Food Service	0,0038	0,0154	0,0450

Figure 49. Regression of the amount of service with intensity, 12 squares(up), 10 squares(down). Author's own copyright.

Intensity of people co-present

Regressions with both public and food service are strong with all squares. Without CBD-squares, regressions disappear in both. However, we cannot easily draw the conclusion that the public and food service can explain the intensity of people co-present in CBD-squares because after all population is one important and essential driver behind service.

Transportation	Diversity	Intensity
Stops	0,7288	0,7388
Lines	0,9154	0,6616

Transportation	Diversity	Intensity
Stops	0,0606	0,1946
Lines	0,0001	0,0016

Figure 50. Regression of transportation with diversity and intensity, 12 squares(up), 10 squares(down). Author's own copyright.

Public Transportation

Public transportation is only tested on local scale, in radius of 500m. From the result we can see that both the number of stops and lines are not a good variable to explain neither diversity nor intensity of people co-present in non-central squares.

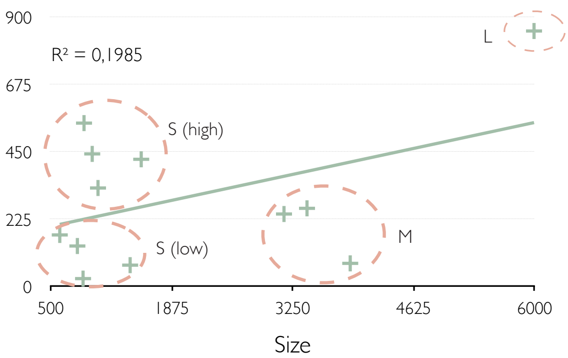
Architectural Characteristic

No correlations are found in this group, which means size, enclosure and building height of a square have little to do with the diversity and intensity of people co-present in squares.

However, through the charts of size with intensity and diversity, we see almost three groups of squares in the intensity chart (figure 52) and two in the other (figure 53).

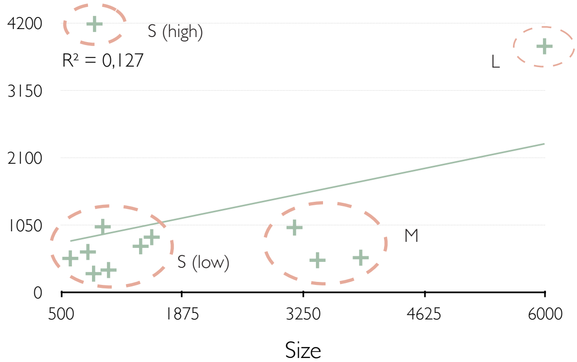
	Diversity	Intensity
Size	0,1270	0,1985
Enclosure	0,0008	0,0119
Building Height	0,1159	0,0969

Figure 51. Regression of architectural characteristic with diversity and intensity. Author's own copyright.



Group	Squares
L	Gustav Adolfs Torg
M	Masthuggstorget
	Friskväderstorget
	Kyrkbytorget
S (low intensity)	Trätorget
	Kaggeledstorget
	Johan Sannes Torg
	Radiotorget
S (high intensity)	Lilla Torget
	Brotorget
	Komettorget
	Doktor Fries Torg

Figure 52. Size and diversity. Author's own copyright.



Group	Squares
L	Gustav Adolfs Torg
M	Masthuggstorget
	Friskväderstorget
	Kyrkbytorget
S (high intensity)	Lilla Torget
S (low intensity)	Kaggeledstorget
	Johan Sannes Torg
	Radiotorget
	Trätorget
	Brotorget
	Komettorget
	Doktor Fries Torg

Figure 53. Size and intensity, chart (left) and table (right). Author's own copyright.

Other findings

Besides findings above, it is interesting to notice that Brotorget stands out among non-central squares. Maybe something is going on there. This can be good weather during the observation day, close to the river with a nice view, or close and well connected to ferry stop. The ferries are so far not included in the segment map for pedestrian. Adding the ferry lines can change the centrality of the square and therefore, it may change the analysis results.

Johan Sannes Torg is found to be under functional in many aspects. It with Brotorget is a square locating in a newly built neighbourhood and closed to Brotorget. One reason can be the bridge between Brotorget and the ferry stop gives Brotorget a better location and pushes Johan Sannes Torg into a deeper location in the network. Moreover, the counting on two squares was done by two observers on different days, and the subtle differences of how they conducted the counting may be another factor.

Conclusion and Discussion

For the diversity of people co-present in squares, integration on global and meso scales is important, which for urban design means that architects need to take care of both integrating neighbouring neighbourboods and the location of squares in the city as a whole. Betweenness is a good variable for non-CBD squares. Connecting neigbourhoods in this sense is still important because it makes sure that people pass by the square when they are moving from one neighbourhood to the other. Working population plays an important role, especially on local scale, in both CBD and areas where the working population density is relative low. Therefore we need also focus on a mix of functions in design. Food service is more important than public service, as more working population means more demands on food service. Volume density or total population is beneficial in larger context and network density is not a relevant variable, neither is the number of transportation stops nor the number of bus/tram lines.

For the intensity of people co-present in squares, betweenness is an important variable on relevant scales (within 2km). However integration is not important for the intensity of co-presence. Residential population desnity, especially within 1km walking distance, shows its importance in areas with low working population density. The volume density in 1km is a more accurate variable than total population density in non-central area. Food and public service cannot explain the intensity in non-central area and the high regressions found with all squares is possibly driven by high population density in downtown.

Network and transportation has no relevance to it.

Integration and betweenness are two different measurements for centrality. From the results, integration is an important variable for the diversity but not for the intensity of people co-present. This may be the result of the fact that I did not have enough squares in CBD. And thus some other variations within that 'group' cannot be seen clearly through this study. Also, due to the multiplier effect (Hillier, 2007, ch. 4), in the inner city it is hard to say that public service correlating with both aspects is because of the population density or not. What is the chicken and what is the egg?

The reason for taking out Gustav Adolfs Torg and Lilla Torget is because they are in a rather different built environments and locations compared to the other squares. Sometimes in the analysis, I took out Masthuggstorget as well. This is because Masthuggstorget is the only square, besides the two CBD squares, whose catchment area (in radius 2km) covers the inner city.

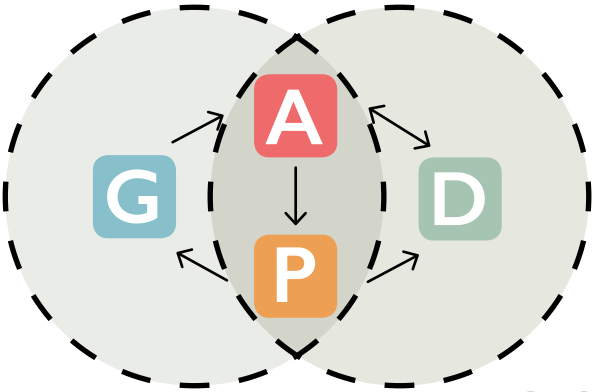
In the statistical analysis, I only did single correlations. Apparently, the variables I tested can be argued that some of them co-vary with each other, to some extend. It is therefore also interesting to do a multiple regression analysis where one can include more than one explanatory variable. This is something that could be added later in a follow-up study or by another master student.

4. Design Manual

Design Manual. Beta

Diagram of Four Modules

Loop 1:
Analysis Loop



Loop 2:
Design Loop

Figure 54. Design Manual.
Author's own copyright.

G Goal

Set up a goal and interpret it in terms of co-presence, that is the diversity and intensity of people co-present in public space.

A Analyse

Choose relevant variables from Table I and analyse the context (loop 1) or the effect of design (loop 2).

P Predict

Use the regression in Table II to estimate co-presence.

D Design

Design and redesign with information in Table III.

Description

The design manual is subdivided in four modules that cover the four steps of the analysis loop and design loop, and three inquiries that support it. Two diagrams that show high, medium and low values of the intensity and diversity of co-presence, based on empirical observation data, are added in the end as references for users to compare.

There are two loops in the diagram. Loop 1 is an analysis loop that helps us to understand the context and form a realistic goal. In this loop, we conduct the most relevant analysis (A), according to Table I, and estimate the diversity and intensity of co-presence with the analysis results in module P (predict), using Table II. For city planners, if the goal (G) is to use the square to integrate people, they can examine the current situation and get to know, through the analysis loop, what can be improved and what are the limitations to increase the diversity and intensity of co-presence. Other actors, such as politicians, developers etc. can, with help from professionals, also use the analysis loop as a tool for decision making. Once a clear goal is set, we can move to the design loop.

Loop 2, the design loop, can contribute to design work and it addresses architects and city planners. Using this loop one can test if the design proposal would function well in terms of co-presence in public squares. For instance, when an architect designs a square, (s)he can choose the relevant analysis (A) and estimate results (P). From the result, it will become clear what the weak points of the proposal are and what should get more attention when adjusting the design. But even without going through the whole loop, the designer can find some general recommendations about the most important variables for co-presence and how to work with it in Table III. The procedure from design to analysis and re-design, sometimes can run back and forth many times to arrive at a satisfying proposal.

Therefore, Loop 1 starts at Goal to Analysis to Predict to Design, and is more related to decision making. An architect with a commission to design a square at the appointed location is more related to Loop 2: Goal to Analysis to Predict to Design to Analysis to Predict, etc.

The design manual is an explorative move from academia to architectural practice. It is still a beta version and needs to be developed further before and tested by others.

Inquiry Table

TABLE 1			
Diversity of co-presence			
Squares	Variable	Radius	Importance Level*
In CBD	Integration	R6	+++
	Working Population Density	500m	+++
		1km	+++
	Volume Density	1km	+++
	Network Density	1km	++
Out of CBD	Integration	R50	+
	Betweenness	2km	++
	Working Population Density	500m	+ (++**)
	Proximity to Food Service	1km	+
	Volume Density	2km	+
Intensity of co-presence			
In CBD	Integration	R6	+
	Betweenness	1km	+
	Working Population Density	500m	++
		1km	++
	Volume Density	500m	++
Out of CBD	Betweenness	1km	++
	Residential Population Density	500m	+
	Total Population Density	1km	+
	Volume Density	1km	+

* Importance level and respective regression:
- +++ 0,30 - 0,50
- ++ 0,50 - 0,70
- \+ 0,70 - 1,00

** Only apply when the working population density is low.

Figure 55. Table 1 for analysis. Author's own copyright.

TABLE II

Squares	Variable	Radius	Regression	Equation	p**
Diversity of co-presence					
In CBD	Integration	R6	0,78	y=3440,7x-4547,2	
	Working Population Density	500m	0,89	y=9,3184x+538,57	
		1km	0,97	y=15,613x+403,17	
	Volume Density	1km	0,77	y=144,52x-105,24	
	Network Density	1km	0,67	y=247678x-4096,4	
Out of CBD	Integration	R50	0,43	y=5223,7x-1201,6	
	Betweenness	2km	0,53	y=0,0045x+308,7	
	Working Population Density	500m	0,31	y=9,3184x+538,37	
			0,60*	y=58,459x+223,56	
	Proximity to Food Service	1km	0,35	y=12,849x+353,38	
	Volume Density	2km	0,32	y=78,892x+302	
Intensity of co-presence					
In CBD	Integration	R6	0,44	y=464,67x-477,28	
	Betweenness	1km	0,43	y=0,025x-59,392	
	Working Population Density	500m	0,67	y=1,451x+195,82	
		1km	0,63	y=2,2547x+183,78	
	Volume Density	500m	0,64	y=13,574x+129,57	
Out of CBD	Betweenness	1km	0,65	y=0,018x-29,559	
	Residential Population Density	500m	0,30	y=4,8835x-69,454	
	Total Population Density	1km	0,41	y=7,7553x-214,59	
	Volume Density	1km	0,31	y=49,38x-15,256	

* Apply when the working population density is lover than 12 per ha.

** p is probability, which can be added in further studies.

*** x: analysis result; y: estimation result.

Figure 56. Table II for estimating. Autho own copyright.

TABLE III			
	Scale	Variables that counts	How
Diversity	Global	Integration	Integrating neighbourhoods and see the square in the city as a whole
	Meso	Integration, betwenness, working population density, volume density	Connecting adjacent neighbourhoods on meso scale
	Local	Working population density, volume density, Proximity to food service	Mixed function; offices and job opportunities; Café, restaurant and grocery in 1km
Intensity	Meso	Integration	Integrating adjacent neighbourhoods
	Local	Betweenness, population density, volume density	Using different strategies when dealing with squares locating in CBD area and non-CBD area to increase intensity

Figure 57. Table III for design. Author's own copyright.

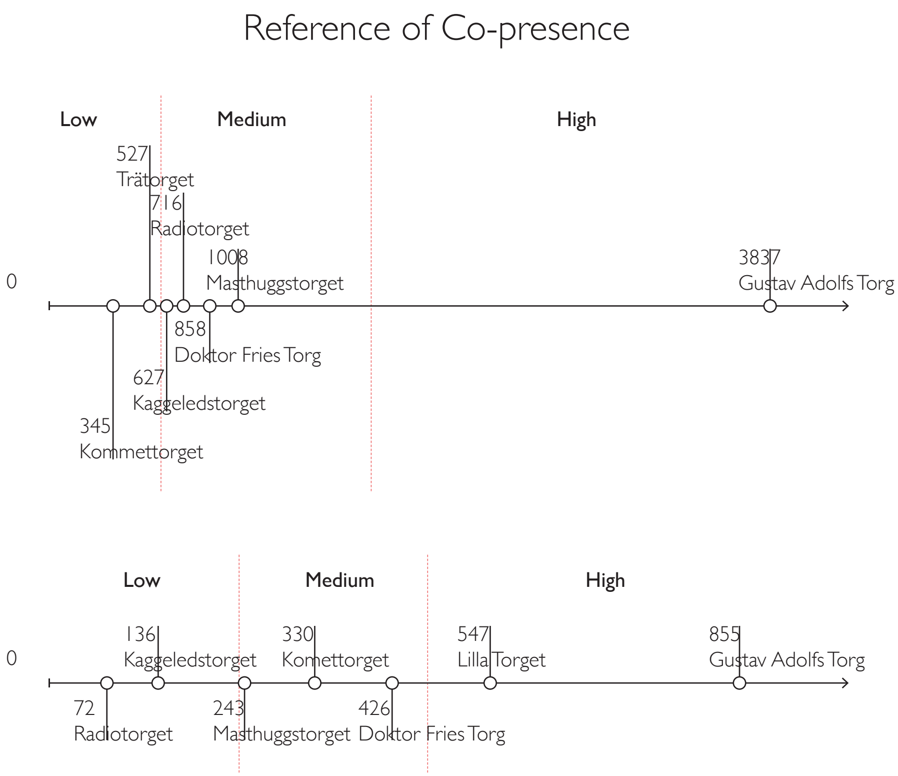


Figure 58. Reference for the diversity (up) and intensity (down) of co-presence. Author's own copyright.

Showcase

In this section, I will use Kvilletorget and Lilla Bommens Torg as two examples to show how to use the design manual to improve two aspects of co-presence in real cases. One square locates in the inner-city and the other in what I referred to as non-CBD area. Both of them are within 1km, straight line distance, from the planning project of Frihamnen. The project is important for the future of Gothenburg and carries the hope of integrating two sides of the river. Hereby, we see the Frihamnen project as a big intervention that will impact also these two squares. By using the design manual, we will test the impact of one proposal of the Frihamnen project on the two squares. In other words, we want to know if the project contributes to a higher intensity and diversity of co-presence on these two squares. If not, other intervention will be introduced to reach our goals by following the design loop described earlier.


Kvilletorget
Kvilletorget locates in Brämaregården, an adjacent neighbourhood of Frihamnen. The square is surrounded by buildings from
R = 1km

The Planning Project of Frihamnen

A very important project for the future of Gothenburg. The challenges the planning project Frihamnen faces (Spacescape, 2016):

- **how to tackle social segregation?**
- how to reduce car traffic?
- How to make professions where the main point is lifelong learning and the exchange between people more interesting at the labour market.

Lilla Bommens Torg

Located in office area, Lilla Bommens Torg is close to the river on one side and enclosed by buildings on the other side, next to the famous 'lipstick' - a high rising building as a landmark of Gothenburg. It embraces a nice view of Frihamnen on the other side of the river, and Opera House in the southwest.

Figure 59. Map of Frihamnen and surroundings. Author's own copyright.

G

Since Brämaregården, where Kvilletorget locates, is in a raletive segregated situation. Therefore the goal is to tackle the social segregation issue through integrating the public square, Kvilletorget.

On the other side of the river, Lilla Bommens Torg has a nice location: close to the water, nice view of the Opera House and Frihamnen, and in central Gothenburg. It has potential to be one node of waterfront design along the river. Therefore we want to transform the square into a popular place and we hope more people can enjoy it.

G A

In this step, we analyse the current situation of two squares.

1. Choose relevant analysis for both squares respectively in Table 1.

2. Conduct the relevant analysis.

3. Write down the analysis results.

Co-presence	Kvilletorget			Lilla Bommens Torg		
	Variable	Importance	Analysis Rslt	Variable	Importance	Analysis Rslt
Diversity	Integration R50	+	0,371	Integration R6	+++	1,531
	Betweenness 2km	++	69082	Work Pop. D. 500m	+++	148,44
	Work Pop. D. 500m	+	25,43	Volume D. 1km	+++	17,34
	Food Service 1km	+	72	Network D. 1km	++	0,0185
	Volume D. 2km	+	4,13			
Intensity	Betweenness 1km	++	11493	Integration R6	+	1,531
	Res. Pop. D. 500m	+	80,96	Betweenness 1km	+	3860
	Total Pop. D. 1km	+	58,93	Work Pop. D. 500m	++	148,44
	Volume D. 1km	+	5,35	Volume D. 500m	++	5,66

Figure 60. Analysis results of current situation. Author's own copyright.

Estimate the two aspects of co-presence on two squares according to the equations in Table II. Through the reference diagram, we can find the positions of estimation results for two squares.

Co-presence	Kvilletorget			Lilla Bommens Torg		
	Variable	Regression	Estimation	Variable	Regression	Estimation
Diversity	Integration R50	0,43	736	Integration R6	0,78	721
	Betweenness 2km	0,53	620	Work Pop. D. 500m	0,89	1922
	Work Pop. D. 500m	0,31	775	Volume D. 1km	0,77	2401
	Food Service 1km	0,40	960	Network D. 1km	0,67	475
	Volume D. 2km	0,32	628			
Intensity	Betweenness 1km	0,65	177	Integration R6	0,44	234
	Res. Pop. D. 500m	0,30	326	Betweenness 1km	0,43	37
	Total Pop. D. 1km	0,41	242	Work Pop. D. 500m	0,67	411
	Volume D. 1km	0,31	249	Volume D. 500m	0,64	269

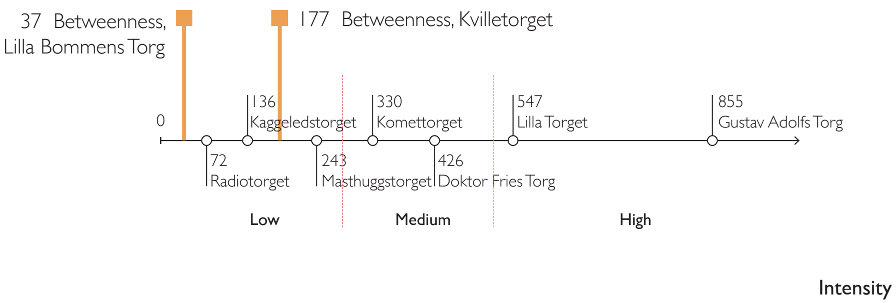


Figure 61. Estimation of current situation. Author's own copyright.

GAPG

In this step, we build our goals on the results from the prediction. In other words, we translate the result in terms of diversity and intensity of co-presence on squares through the analysis loop.

As we can see from the prediction results, the most important variables for intensity and diversity of people co-present on Kvilletorget, betweenness 1km and 2km, result in low values. Therefore, the goal is translated to increase both diversity and intensity of co-presence on the square. To achieve the goal, we need focus on betweenness 1km and 2km. To make Lilla Bommens Torg more popular, we want more people to visit here. The estimation of diversity seems good but we need increase the intensity.

To make Lilla Bommens Torg popular, we indeed need increase the amount of people co-present since now we get a low estimation of the intensity. The diversity estimation is alright. Therefore, we address on increasing the intensity of co-presence and keep the diversity level.

GAPGD

Here we use one proposal of the project Frihamnen to start the design loop. There are two reasons:

1. The planning project Frihamnen tries to tackel social segregation issue;
2. The project is close to both squares and it tries to build connection with both side.

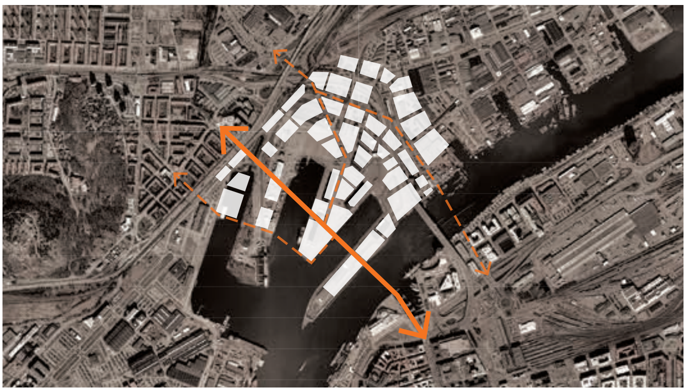


Figure 62. Proposal 1 of the planning project Frihamnen (Spacescape, 2016).

GAPGDA

Build new model for the proposal and redo the analysis. Here we only do the analysis that is important and results in a low value in the predicting step. I test integration R6, R50, betweenness 1km, 2km and network density in 1km in this case. Volume density and population density are also concerned and could be tested too. However, due to lacking of data, we will not test it here.

From the analysis results, we can see that proposal 1 improves these variables in general but not integration and betweenness on local scale.

Co-presence	Kvilletorget			Lilla Bommens Torg		
	Variable	Current	Proposal 1	Variable	Current	Proposal 1
Diversity	Integration R50	0,371	0,425	Integration R6	1,531	1,441
	Betweenness 2km	69082	69645	Network D. 1km	0,0185	0,0201
Intensity	Betweenness 1km	11493	16323	Integration R6	1,531	1,441
				Betweenness 1km	3860	1812

Figure 63. Analysis results of proposal 1. Author's own copyright.

GAPGDAP

Here are the results from the estimating calculations. We still need to improve the betweenness 2km for Kvilletorget. For Lilla Bommens Torg, proposal 1 decreases the diversity a lot, which is not what we want. Also it does not help with increasing the amount of people visiting Lila Bommens Torg. We need re-design to increase the betweenness for both squares and integration for Lilla Bommens Torg.

Co-presence	Kvilletorget			Lilla Bommens Torg		
	Variable	Current	Proposal 1	Variable	Current	Proposal 1
Diversity	Integration R50	736	1018	Integration R6	721	411
	Betweenness 2km	620	622	Network. D. 1km	475	878
Intensity	Betweenness 1km	177	264	Integration R6	234	192
				Betweenness 1km	37	0

Figure 64. Estimation results of proposal 1. Author's own copyright.

In this step, we will use the information in Table III to guide the design. Here I will invite interventions to two squares respectively.

For Kvilletorget

In Table III, we know the importance of connecting adjacent neighbourhoods to increase betweenness. Frihamnen has been connected in proposal 1. The green area on the west limits the possibility towards that direction. We thus address on the connections to Kvillebäcken and Hjalmar. Besides building connections, we will also add the planning project Hjalmar as an important intervention, since the project Frihamnen has little influence on betweenness 2km for the square.

Figure 65. Adjacent neighbourhoods of Kvilletorget. Author's own copyright.

Figure 66. New interventions for Kvilletorget. Author's own copyright.

For Lilla Bommens Torg

Although Lilla Bommens Torg is close to central area, it is on the periphery of the inner city and the infrastructure that carries heavy traffic becomes a strong barrier to separate Lilla Bommen from the central part. Therefore, we break the barrier and need strengthen the connections in three directions as shown in figure 65.

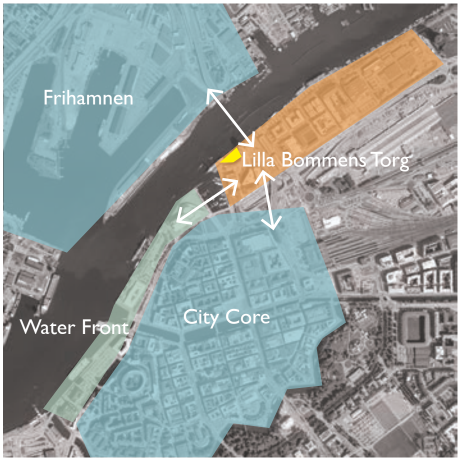


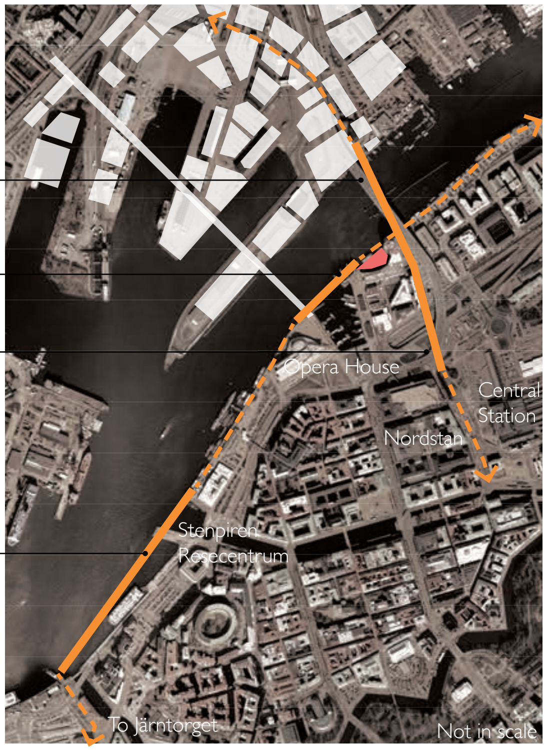
Figure 67. Author's own copyright.

A bridge or frequent ferries to connect Frihamnen and Lilla Bommen.

Direct connection to Opera House.

Link Nordstan and central station to break the traffic barrier.

Extending the path to Järntorget to create a nice waterfront walking trail.



Lilla Bommens Torg
New Connection
Connected street

Figure 68. New interventions for Lilla Bommens Torg. Author's own copyright.

GAPGDAPDA

Redo the betweenness and integration analysis for the new proposals and compare the results. We can see from the table that betweenness 2km for Kvilletorget increase a lot and so does integration R6 for Lilla Bommens Torg. This may give a better result in next step (P). If the analysis results only change a bit comparing to the previous proposal, the following step, Module P, can be skipped from to Module D, if one is familiar with the design manual.

Co-presence	Kvilletorget			Lilla Bommens Torg		
	Variable	Proposal 1	Proposal 2	Variable	Proposal 1	Proposal 2
Diversity	Integration R50	0,425	0,431	Integration R6	1,441	2,019
	Betweenness 2km	69645	86279	Network D. 1km	0,0201	0,0208
Intensity	Betweenness 1km	16323	17141	Integration R6	1,441	2,019
				Betweenness 1km	1812	5733

Figure 69. Analysis results. Author's own copyright.

GAPGDAPDAP

Estimate the new proposal. In the table below, we can see the diversity and intensity of co-presence on Kvilletorget and Lilla Bommens Torg are increased in different degrees. Through bringing other interventions, we can say that the new design proposal would better achieve our goals. In other words, the planning project Frihamnen need work with other interventions around and even other planning project around Frihamnen to tackle the social segregation issue for these two squares.

Co-presence	Kvilletorget				Lilla Bommens Torg			
	Variable	Current	Prpsl 1	Prpsl 2	Variable	Current	Prpsl 1	Prpsl 2
Diversity	Integration R50	736	1018	1050	Integration R6	721	411	2400
	Betweenness 2km	620	622	697	Network. D. 1km	475	878	1046
Intensity	Betweenness 1km	177	264	279	Integration R6	234	192	461
					Betweenness 1km	37	-14	84

Figure 70. Final estimation results. Author's own copyright.

Summary

Through two cases of Kvilletorget and Lilla Bommens Torg, I show how to use the design manual to examine the current situation of public squares and achieve our goal with our design proposal. The two loops, analysis loop and design loop, can be used flexible in the design process. Moreover, in reality, it can go back and forth several times in-between designing and analysing to find a proposal that works. I would recommend to use the design manual in a early stage of design process. Later on, we can continue the deisgn and add other layers into the proposal that is shown effective in this method.

5. Reflections

On the Thesis

Earlier studies in Gothenburg and in Stockholm showed that high spatial integration, and especially the relation between local and global integration, play an important role for the mix of locals and non-locals. By adding more squares representing a broader spectrum of neighbourhood types and adding more urban form variables, the thesis confirms the importance of integration and arrives at a better understanding of how different urban form variables influence the diversity and intensity of co-presence in public squares. Interestingly, different patterns show up in CBD areas and non-CBD areas. For the mix of locals and non-locals in non-CBD squares (diversity of co-presence), betweenness is a more important variable than integration as in CBD areas, it is still integration that counts. Moreover, working population density plays a vital role for the diversity of people co-present in public squares. For the intensity of co-presence, betweenness has its influence on squares in both CBD and non-CBD areas; working population density is important for CBD squares, residential population density seems more important for non-CBD squares. Integration is only related to CBD squares.

The different patterns shown in the thesis help us to better understand the relation between urban form and co-presence, especially non-CBD squares. It is clear that they need different strategies and solutions to overcome social segregation. In other words, if we want to use public squares to integrate people, simply copying what we do in the centre, for instance, social events, is not a long-term and sustainable solution for suburbs. Also, one reason that the built environment results in social segregation is that, let's say, we as architects cannot be certain about what we are doing. What we design and what kind of impact this will have for social life is unclear in the generative design process. Understanding how different design variables influence which aspect of co-presence in different areas is very useful to conduct urban design when it comes to practice. Using knowledge from real cases, as I did in the research part of my thesis, and translate this in a design manual as I proposed is one way to bridge the gap between research and practice.

In the design manual, the prediction equations and regressions are based on the empirical studies and the results from statistical analysis. It is good to keep in mind that no prediction will be exactly accurate and since I only tested 12 squares in the research, without deviation detection, it is not enough to get a robust result. But it gives a good estimation, or direction of the proposal. The design manual can and should be developed further in the future studies, by adding more squares in other cities in Sweden and other countries, and adding multiple-regression and probability analysis.

Moreover, the spatial analysis in the thesis was run on the pedestrian map. Due to the limitation of the model (this map), the thesis in this sense has limited itself. People move around in the city not only by walking but also by cycling, public transportation and personal vehicles that increases our mobility. How the transportation means may affect the co-presence in squares need further studies with suitable models. The attraction accessibility analysis was done in metrics radii with segment map. It is also interesting to see the results of analysis in amount of axial steps instead as this has proven to be of importance especially in suburban settings.

Also, I only used the information about home address from the interviews. The data of transportation means, frequency and purpose of visiting and basic information of visitors, which has already been collected for 9 squares in this thesis, can be added and contribute to other relevant research. Relevant observations that have not been done due to the time limitation is the direction of people flow and timelapse analysis, which can be added in further studies. In this thesis, I conducted the observation on weekdays only. How are public squares used on weekends?

In the thesis, the idea that the city is a system has been central throughout the whole thesis, meaning that the parts are always influenced by the whole and the vice versa. I included architectural characteristic of the square as well, but these have shown not to effect co-presence. By saying the architectural characteristic cannot explain the diversity and intensity of people co-present in squares, does not mean that the aesthetic aspects are not important, but it has its own meaning. However, only working on the architectural design is far from enough and may not work well without the support of the built environment, or the structural (systemic) design. In other words, the built environment defines the conditions for the functioning of public space and it is hard to make up the poor conditions with just attractions on the square.

On Personal Experience

From the beginning to the end, I learned a lot about what is a research, how to do research and what professional quality a researcher should have. I wanted to do something about integrating the city and building connections between city core and suburbs at first, and gradually narrowed down the research questions throughout the researching process. In a research, we sometimes need to de-construct the reality to many factors and study one factor at a time to be able to focus. That means we sometimes have to be 'unrealistic' when researching. In contrast to research, practice requires us to consider many different aspects and whether the proposal is feasible in reality or not counts very much. This leads to a gap between academia and practice. To bridge the gap, both sides need to understand each other better.

Another important thing I learned from the thesis is honesty. Researchers need to be open about every small decision, the process including empirical data, analysis etc., and what we get in the end. It can be frustrating when a small mistake skewed the work that has already been done. But it is worth and necessary to redo all the work to get an honest result, to others and to myself.

Every research stands 'on the shoulders of giants' and contributes a little bit to the world. I hope my work could become a tiny part of the shoulders of giants.

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Figure 22 Harvey, D. (2004). *Space as a Keyword.*

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J: Fluff. (2010). *Masthuggstorget i Göteborg, Sverige* [Online Image]. Retrieved from https://upload.wikimedia.org/wikipedia/commons/1/1a/Masthuggstorget%2C_G%C3%B6teborg-100425.jpg

K: Author's own copyright.

L: Åström, P. (2000). *Trätorget* [Online Image].Retrieved from http://www.bebyggelseregistret.raa.se/bbr2/anlaggning/visaSelectedAnlaggningFoto.raa;jsessionid=54538588D65E87F680E54FB93C2E7FF8?fotoId=21500000006577

Figure 62 Spacescape. (2016). *FÖR ETT NÄRMARE GÖTEBORG - Stadsstrukturanalys av planalternativ för Frihamnen och Hjalmar Brantingsstråket: Planalternativ 2.*

Appendix I

a lot elderly people. 毛毛雨-雾气.

Snapshot - ~~30~~ 07 ~~June~~ Sept 2016, Wednesday

Time	Number	Weather	Commends	No Answer
8.00	3 (0)	Cloudy, Grey		‖ (2)
8.30	6 (0)	~~humid~~	1 mom with a kid & a babe in stroller; 1 bike (interviewed). counted as 2 ppl	‖ (2)
9.00	5 (0)	humid. 毛毛雨.		|||||||||||| (12)
9.30	9 (1)	—"—	1 making phone call for long;	|||||||| (8) last no
10.00	12 (4)	cloudy.	; 2 sitting outside (on the stairs) having breakfast; 1 one wanders	| (1)
10.30	7 (2)	cloudy.	; 1 begger	|||||| (6)
11.00	10 (1)	cloudy. 毛毛雨.	; 1 biking	||| (3)
11.30	11 (1)	Cloudy.		||||||||| (9) no English / no time
12.00	11 (1)	cloudy.		||| (3)
12.30	10 (4)	cloudy.	; 2 sitting outside of cafe, having lunch; 1 sitting and phoning (working in pizzeria)	
13.00	13 (1)	cloudy.	; 1 biking.	
13.30	13 (1)	cloudy.	.	|||| (4) lunch
14.00	10 (4)	cloudy	; 3 sitting out side of café and pizzeria	[illegible]
14.30	18 (5)	cloudy	; ~~many~~ some kids & moms ; 4 sitting outsid café or restaurant.	||||| (5)
15.00	17 (2)	cloudy.	; an old lady sitting.	‖ (2)
15.30	10 (2)	cloudy.	;	
16.00	15 (3)	cloudy.	; 1 mom wandering with babe stroller and her son was sitting. they waiting for daughter who [illegible] kid shop [illegible]	|||| (4)
16.30	20 (4)	cloudy	; 3 cafe;	||| (3)
17.00	16 (4)	—"—	; 2 cafe; 1 sitting	||| (3)
17.30	22 (2)	Sunny.	; 2 biking; 1 sitting	‖ (2)
18.00	8 (2)	Sunny.	; another sitting	
Square	Trätorget			
Name	Kailun			

CHALMERS

This survey is part of a Master thesis project. The purpose of this survey is to see how the squares are used by citizens. By collecting how many people come to this public square and how diverse it is that people is co-present in public squares, it helps us to understand functioning of these squares and to link social problems. The research is conducted by a master student who is doing her Master thesis in Chalmers University of Technology and it is voluntary to be involved in this survey. All the information will be confidential and it will only take you less than 5 mins.

I. General Questions

1. How did you get to this square?

☐ walk ☐ by bus ☐ by tram ☐ by car ☐ other ________

2. Are you passing by or doing anything here?

☐ passing by ☐ visiting, purpose: __________________________

3. How often do you come and pass by the square?

☐ seldom ☐ 1/month ☐ 1-2/week ☐ 3-4/week ☐ everyday

☐ other ________

4. Do you like this place?

☐ 5 (like) ☐ 4 ☐ 3 ☐ 2 ☐ 1 (dislike)

5. How do you perceive this area/ square?

II. Basic Information

6. Gender ☐ female ☐ male ☐ no gender

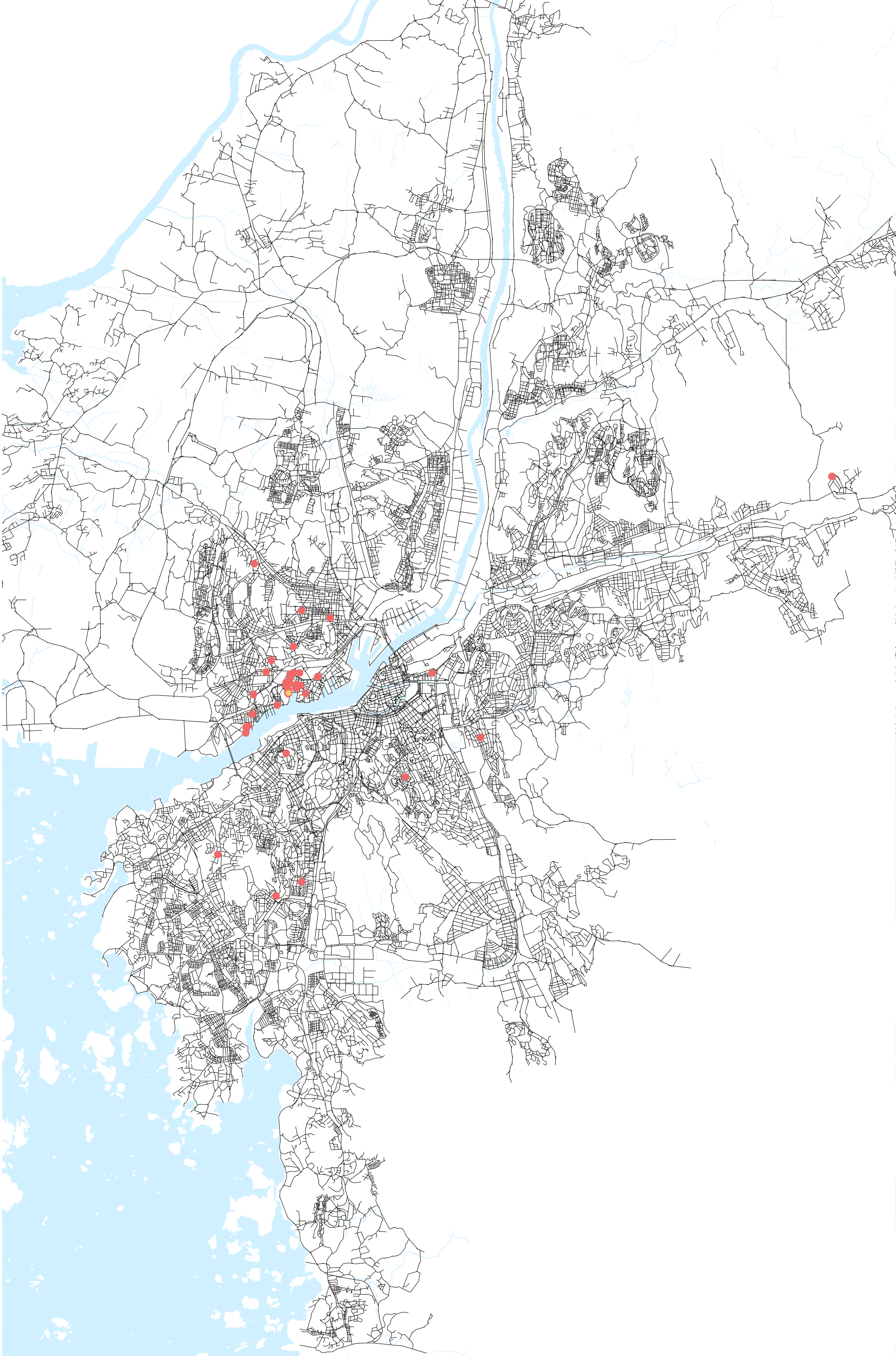
7. Age ☐ ≤15 ☐ 16-25 ☐ 26-44 ☐ 45-64 ☐ ≥65

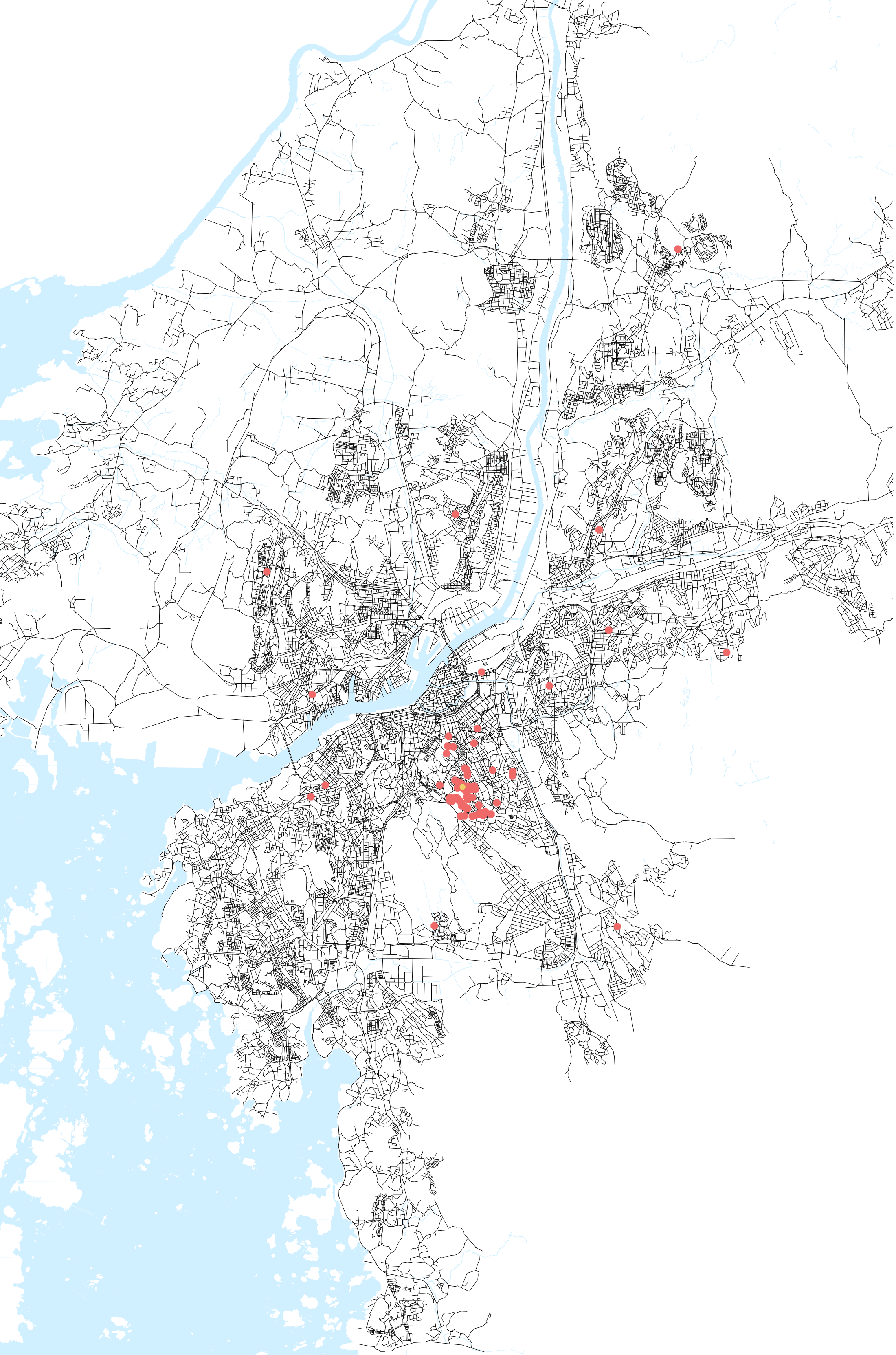
8. Home Address

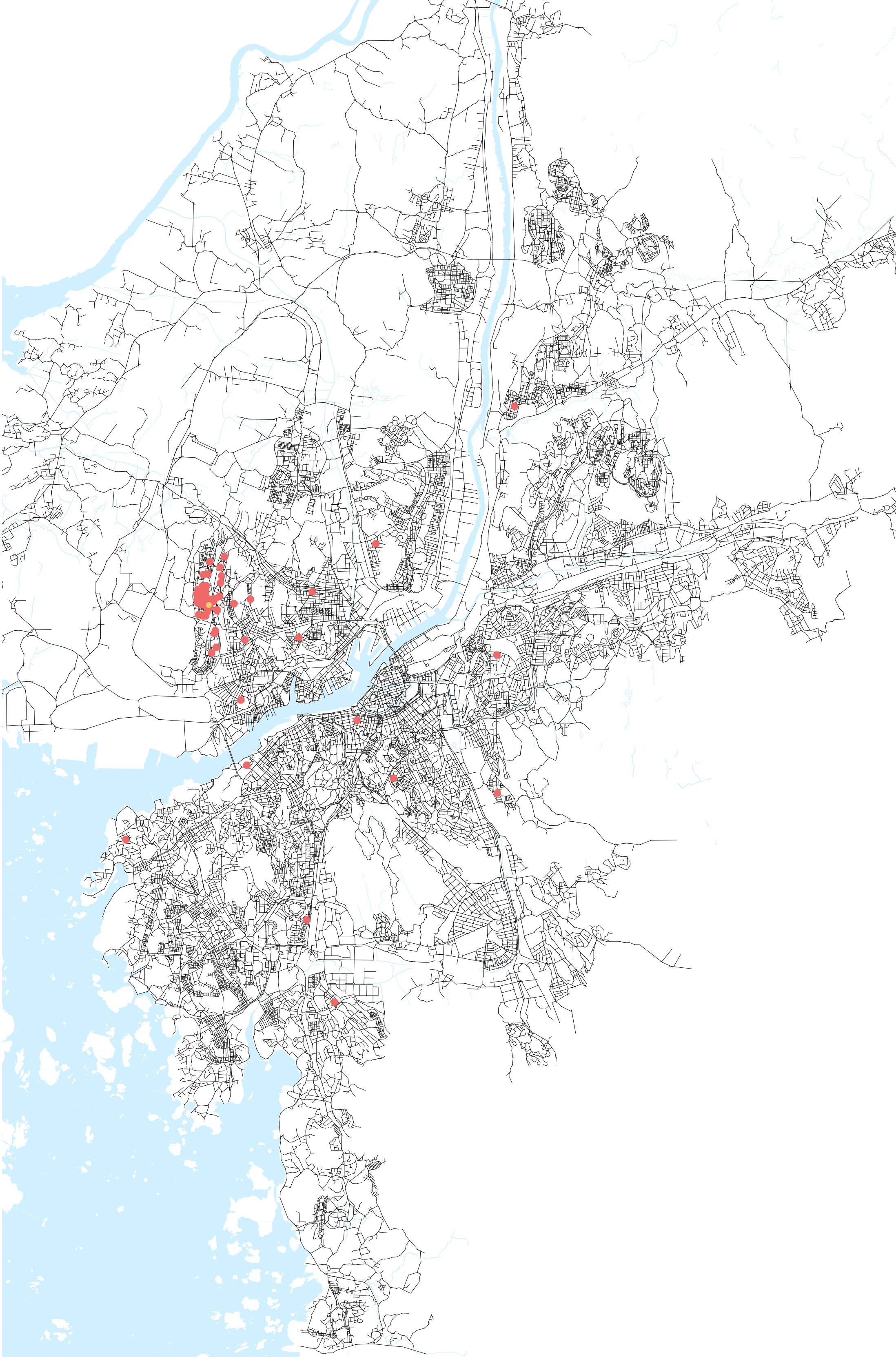
Street ______________________________ Number ____

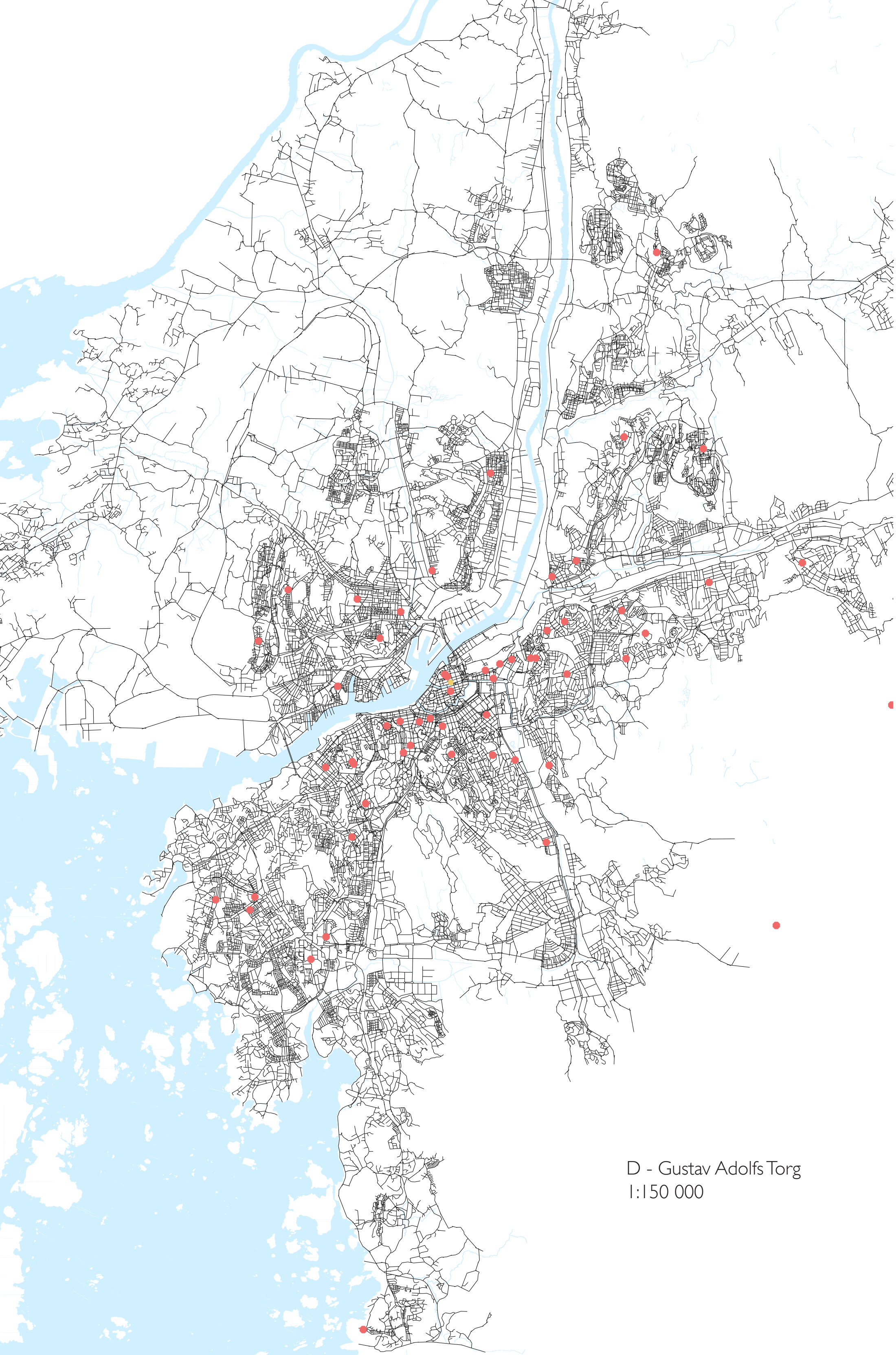
Square Weather

Time Date Weekday Name

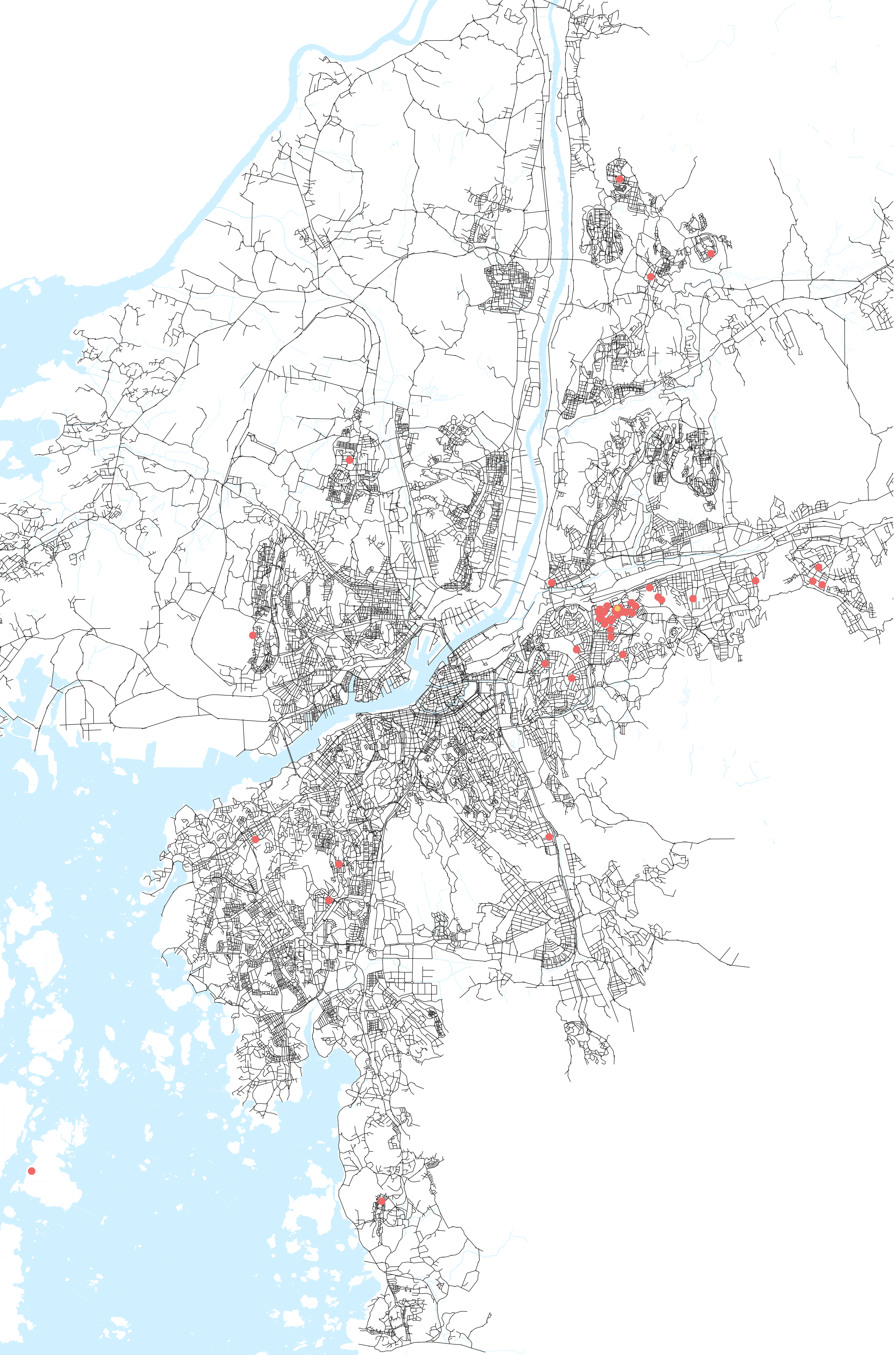


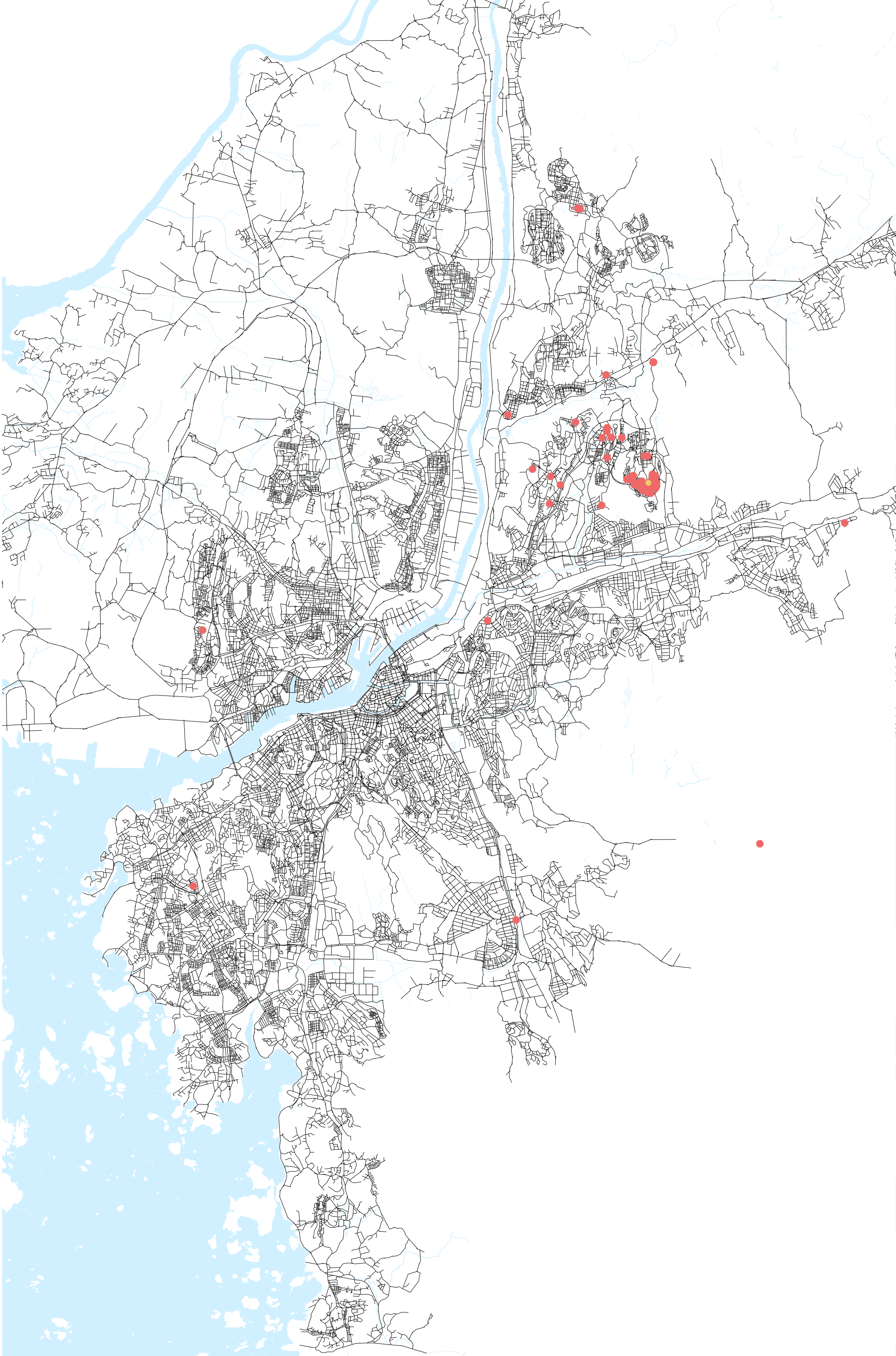


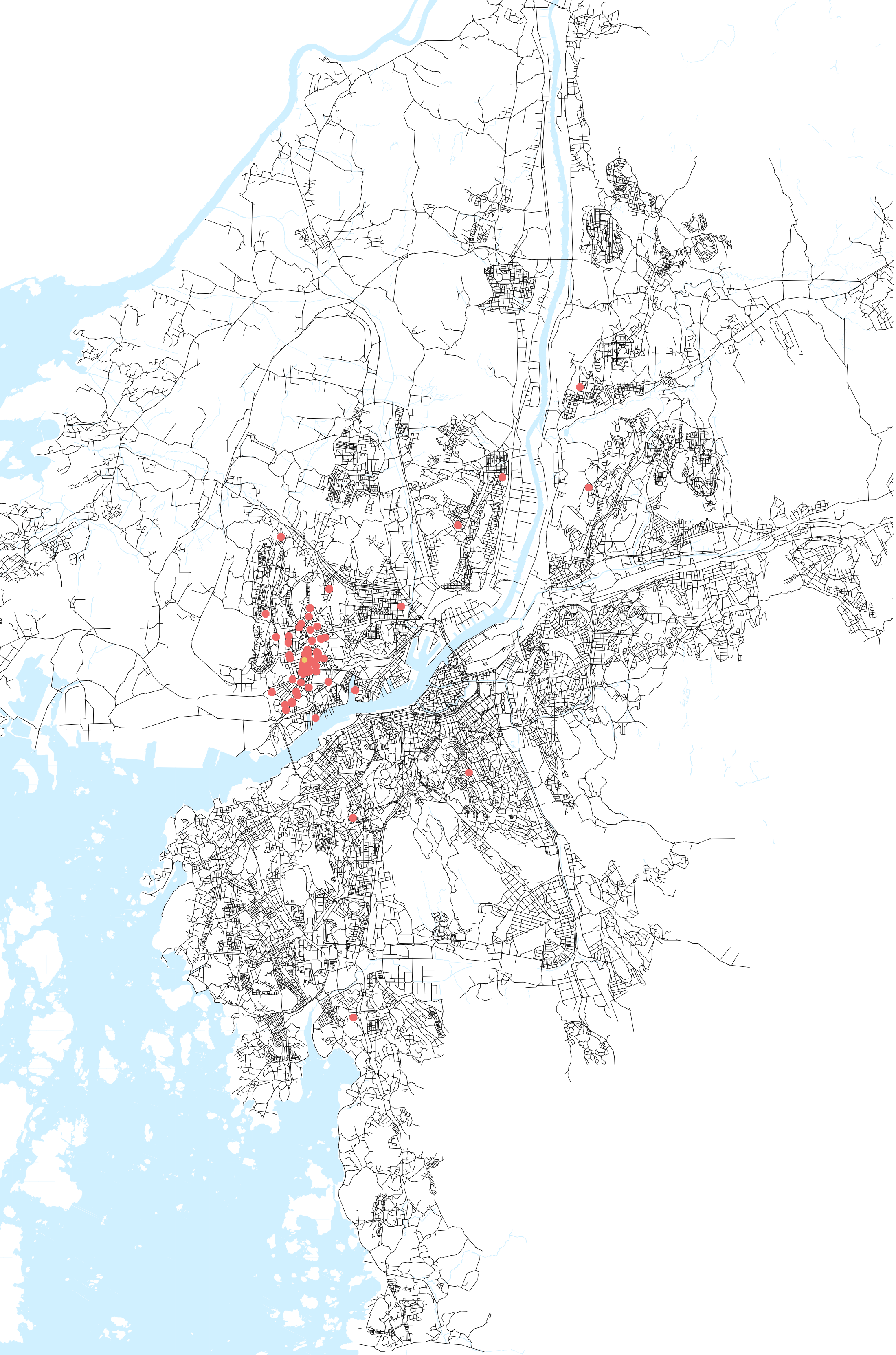


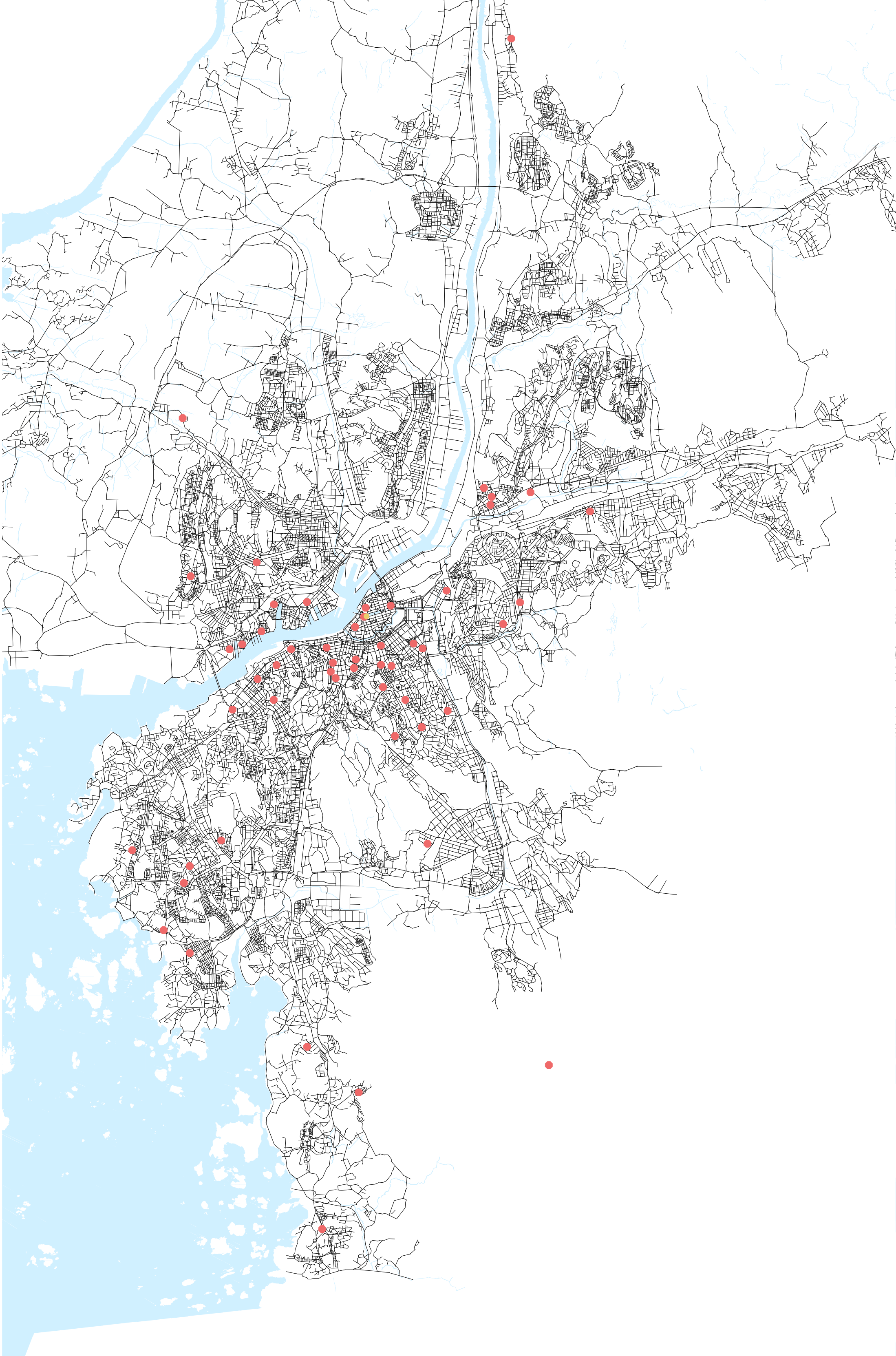


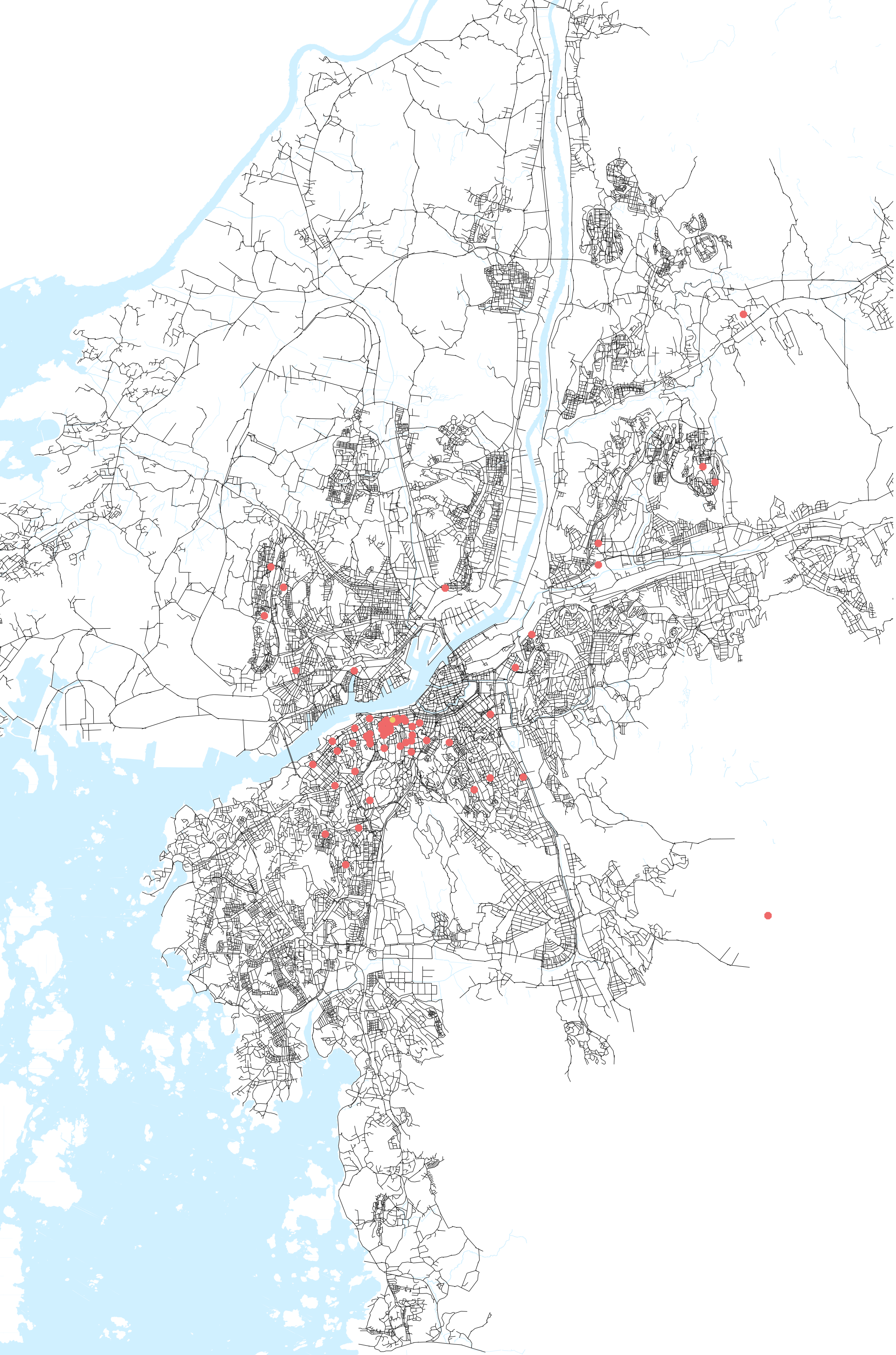
D - Gustav Adolfs Torg
1:150 000

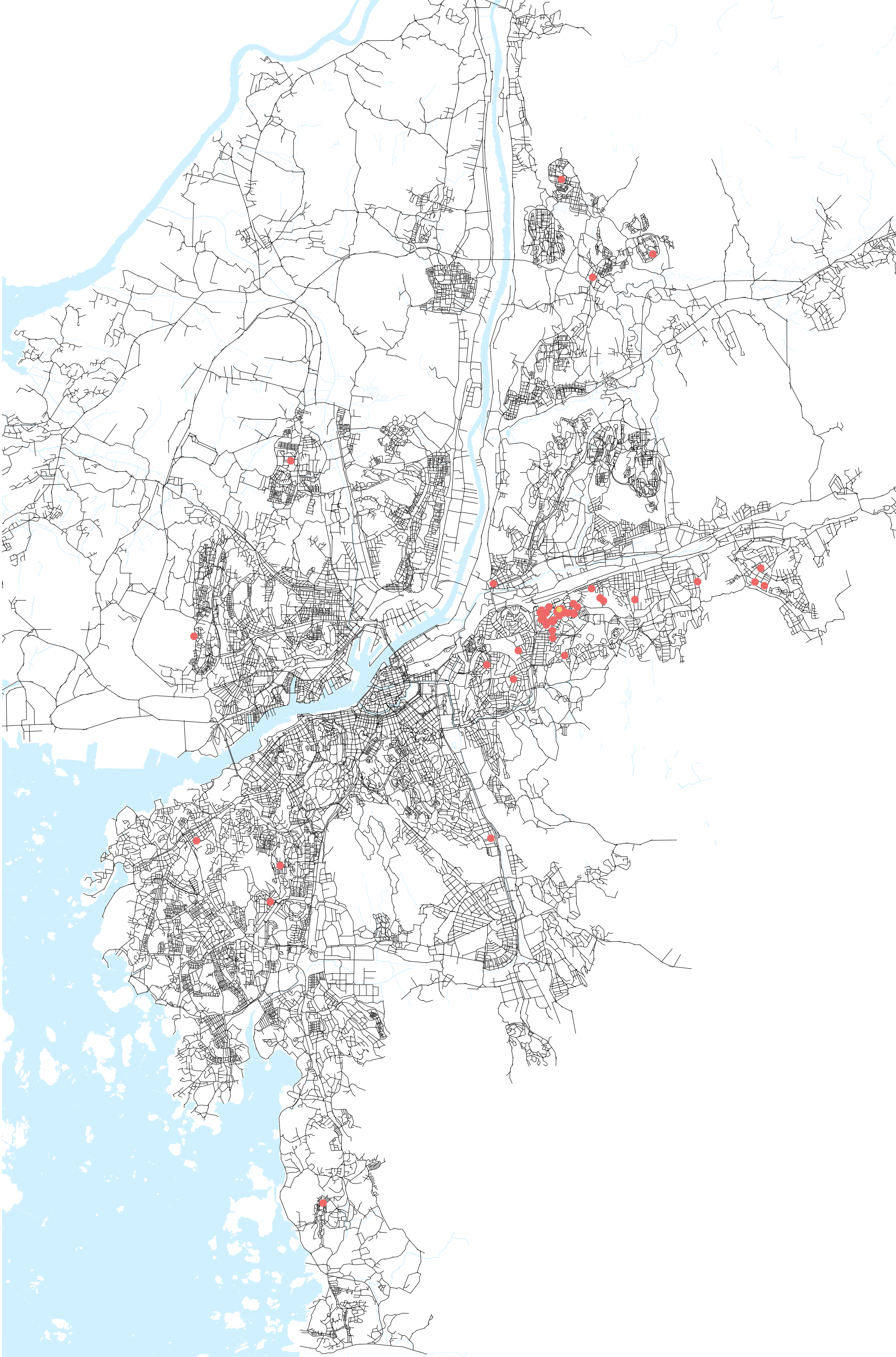












Spatial Data of Selected Squares

Appendix II

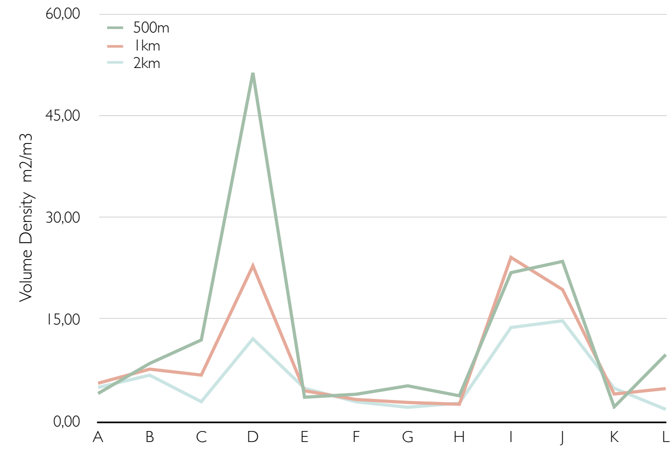
No.	Square Name	Betweenness						
		500m	1km	2km	3km	4km	5km	10km
A	Brotorget	2 531	24 484	99 146	205 338	390 016	717 322	7 060 496
B	Doktor Fries Torg	1 816	20 958	139 081	327 558	635 205	948 398	3 319 693
C	Friskväderstorget	1 293	11 196	88 053	181 396	266 970	532 473	2 919 850
D	Gustav Adolfs Torg	1 946	20 413	132 227	334 409	820 984	1 804 979	25 811 712
E	Johan Sannes Torg	1 626	8 530	46 590	142 261	274 879	517 880	5 390 028
F	Kaggeledstorget	965	7 559	32 363	61 152	101 717	127 773	611 310
G	Komettorget	2 898	18 531	42 822	51 324	65 744	82 810	179 032
H	Kyrkbytorget	1 794	13 752	73 834	321 118	780 492	1 270 309	10 495 914
I	Lilla Torget	2 037	13 998	88 634	255 161	475 134	827 787	6 702 697
J	Masthuggstorget	2 922	19 055	135 949	816 033	2 679 993	5 724 079	48 769 192
K	Radiotorget	856	8 879	66 188	133 994	237 578	304 327	740 619
L	Trätorget	996	4 847	18 636	45 998	64 640	96 576	371 627

No.	Integration								
	R2	R4	R6	R10	R14	R16	R30	R50	R80
A	3,832	2,280	1,670	1,116	0,871	0,805	0,494	0,368	0,299
B	3,214	1,821	1,408	1,032	0,825	0,782	0,531	0,359	0,281
C	4,343	2,351	1,731	1,118	0,897	0,805	0,538	0,324	0,256
D	5,618	2,984	2,273	1,532	1,111	1,000	0,598	0,418	0,338
E	5,000	2,243	1,633	1,088	0,845	0,788	0,497	0,368	0,298
F	2,979	1,850	1,476	1,071	0,841	0,757	0,496	0,342	0,269
G	4,314	1,962	1,354	0,990	0,816	0,733	0,433	0,305	0,216
H	4,343	2,349	1,685	1,187	0,972	0,914	0,534	0,353	0,286
I	5,612	2,990	2,341	1,561	1,147	1,045	0,609	0,420	0,336
J	4,614	2,519	1,818	1,375	1,134	1,032	0,603	0,414	0,329
K	2,844	1,855	1,413	1,072	0,856	0,782	0,490	0,378	0,271
L	2,238	1,496	1,256	0,969	0,761	0,693	0,461	0,319	0,237

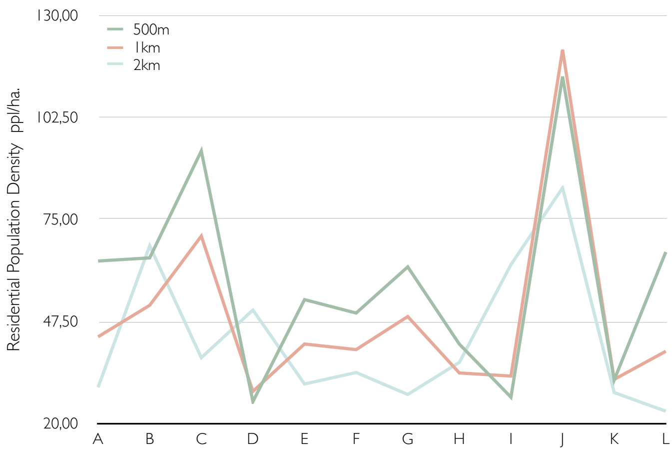
No.	Population density (/ha.)								
	Residential 500m	Residential 1km	Residential 2km	Work 500m	Work 1km	Work2km	Total 500m	Total 1km	Total 2km
A	63,82	43,41	29,78	10,84	17,61	26,12	74,67	61,02	55,90
B	64,67	51,89	67,94	6,67	23,55	33,94	71,34	75,44	101,88
C	93,48	70,54	37,76	6,88	3,65	3,85	100,36	74,19	41,61
D	25,95	28,70	50,62	417,40	232,23	98,90	443,35	260,93	149,52
E	53,43	41,46	30,69	3,29	15,79	25,29	56,72	57,25	55,97
F	49,81	39,96	33,78	7,29	6,87	14,24	57,10	46,83	48,02
G	62,24	48,86	27,87	3,57	6,20	5,06	65,82	55,06	32,93
H	41,43	33,66	36,51	3,03	5,16	10,37	43,55	38,81	46,88
I	27,13	32,83	62,85	271,96	225,40	96,23	299,09	258,23	159,07
J	113,55	120,75	83,55	109,17	58,75	66,93	222,72	179,50	150,48
K	31,76	31,92	28,38	11,42	17,09	19,00	43,19	49,00	47,38
L	66,25	39,50	23,36	5,20	3,12	10,63	71,45	42,62	33,99

No.	Area of reach (m2)			Volume density (m^3/m^2)			Network density (m/m^2)		
	500m	1km	2km	500m	1km	2km	500m	1km	2km
A	404862	1636891	5791638	4,14	5,65	5,03	0,02	0,02	0,02
B	439328	1888800	7630256	8,56	7,72	6,83	0,02	0,02	0,02
C	444701	1859791	7436458	12,01	6,85	2,94	0,03	0,02	0,02
D	564252	1968386	8779722	51,27	22,91	12,18	0,03	0,03	0,02
E	452778	1692350	6007420	3,59	4,54	4,91	0,02	0,02	0,02
F	500524	1587226	6694492	4,03	3,26	2,92	0,02	0,02	0,01
G	472824	1401514	4594405	5,27	2,82	2,12	0,03	0,02	0,02
H	490953	2100500	8881024	3,81	2,56	2,72	0,02	0,02	0,02
I	541507	1776514	8321435	21,90	24,15	13,84	0,03	0,03	0,02
J	453036	1823597	6862330	23,55	19,41	14,82	0,03	0,02	0,02
K	434166	1829035	7171214	2,17	4,06	4,92	0,02	0,02	0,02
L	352151	1540225	6076563	9,85	4,86	1,81	0,02	0,01	0,01

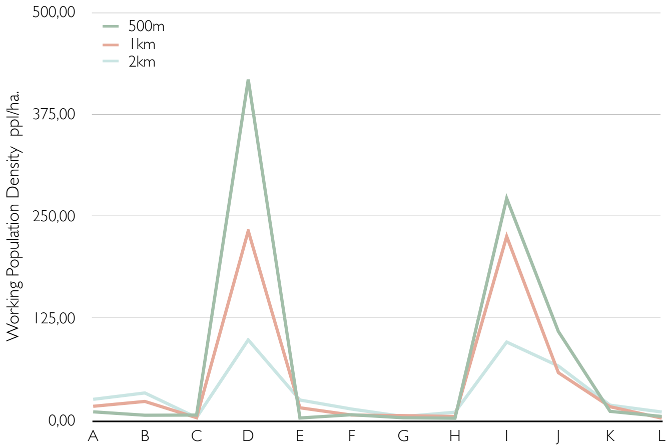
No.	Local urban form			Public transportation		Food service			Public service		
	Size of square(m^2)	Enclosure	Building Height (m)	Stops 500m	Lines 500m	500m	1km	2km	500m	1km	2km
A	972,09	0,16	18,65	2	5	5	39	91	4	30	77
B	1528,80	0,72	10,74	2	1	8	29	283	19	43	176
C	3412,67	0,51	20,97	2	5	6	14	33	15	34	115
D	5992,26	0,46	12,77	6	40	162	327	782	94	152	401
E	868,02	0,32	13,12	1	4	5	28	95	3	19	82
F	803,39	0,68	9,64	1	2	8	20	49	22	38	132
G	1037,88	0,28	4,09	2	5	3	7	13	18	45	77
H	3903,71	0,43	10,34	1	4	7	17	91	11	28	131
I	878,99	0,46	18,25	4	31	105	339	813	97	165	399
J	3151,21	0,50	16,08	2	5	58	193	608	35	112	378
K	1402,97	0,50	5,39	2	4	4	12	60	10	35	158
L	603,42	0,68	8,78	3	1	4	8	15	9	21	55

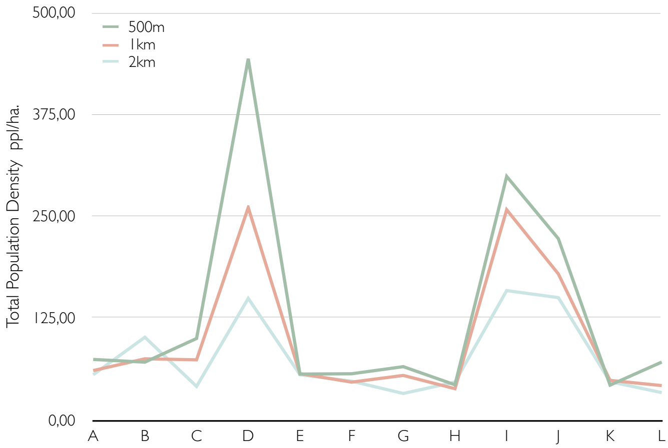


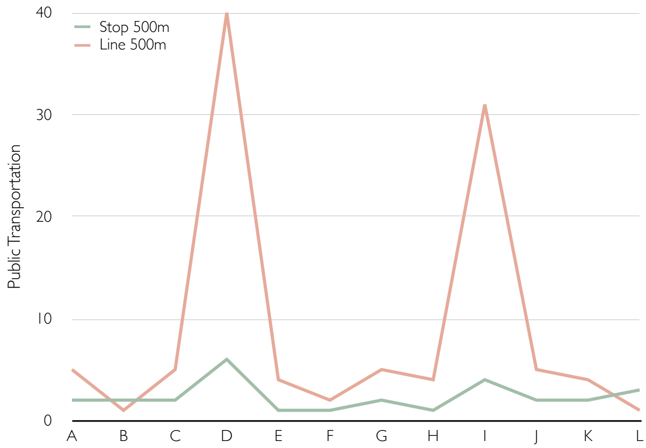
60,00
45,00
30,00
15,00
0,00
500m
1km
2km
Volume Density m2/m3
A
B
C
D
E
F
G
H
I
J
K
L



130,00
102,50
75,00
47,50
20,00
500m
1km
2km
Residential Population Density ppl/ha.
A
B
C
D
E
F
G
H
I
J
K
L

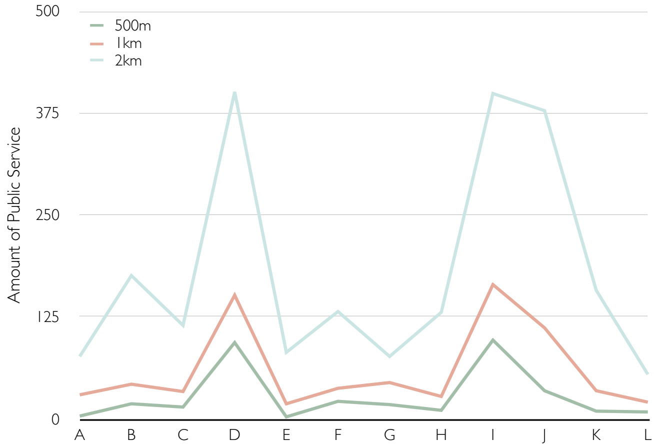

500,00
375,00
250,00
125,00
0,00
500m
1km
2km
Working Population Density ppl/ha.
A
B
C
D
E
F
G
H
I
J
K
L


500,00
375,00
250,00
125,00
0,00
500m
1km
2km
Total Population Density ppl/ha.
A
B
C
D
E
F
G
H
I
J
K
L

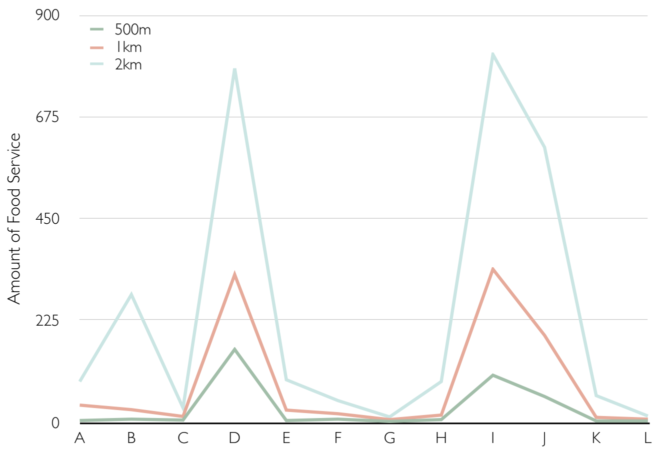


40
30
20
10
0
Stop 500m
Line 500m
Public Transportation
A
B
C
D
E
F
G
H
I
J
K
L

0,0400
0,0325
0,0250
0,0175
0,0100
500m
1km
2km
Network Density m/m2
A
B
C
D
E
F
G
H
I
J
K
L



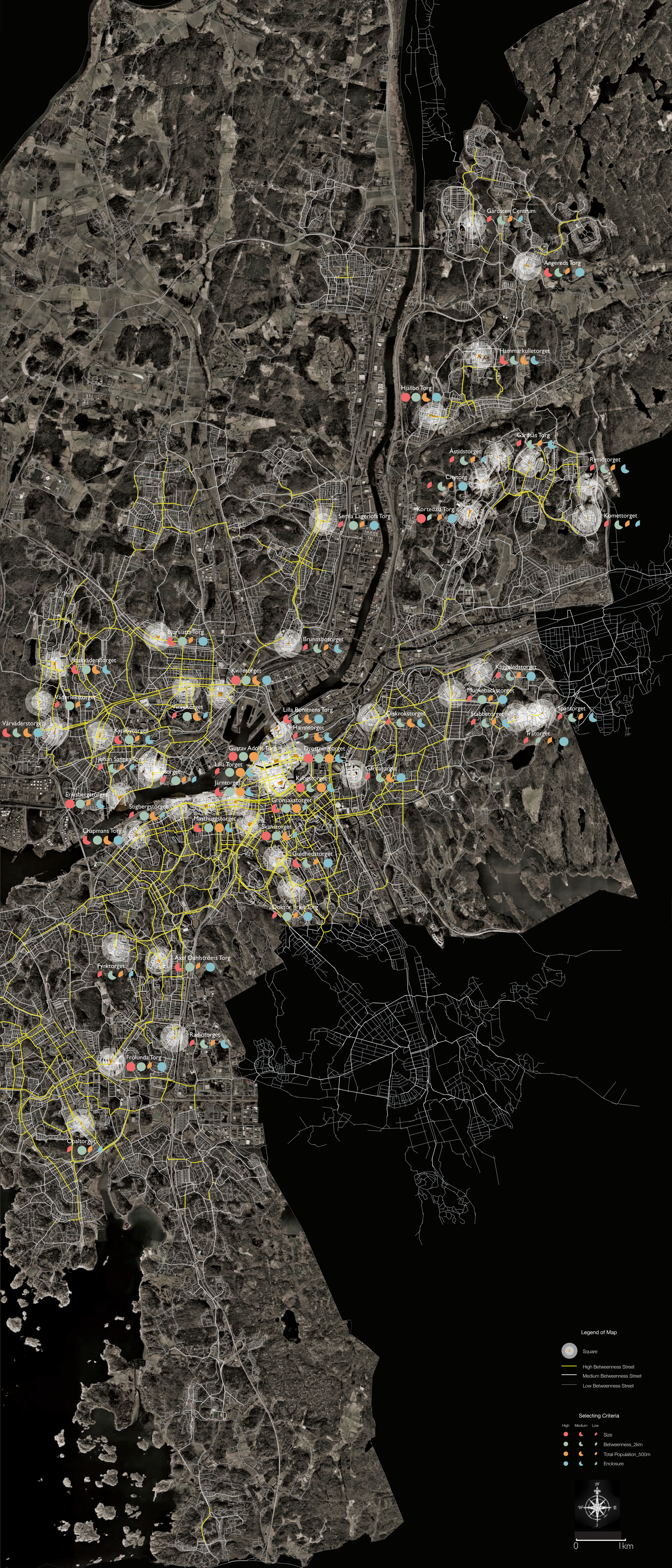
500
375
250
125
0
500m
1km
2km
Amount of Public Service
A
B
C
D
E
F
G
H
I
J
K
L



900
675
450
225
0
500m
1km
2km
Amount of Food Service
A
B
C
D
E
F
G
H
I
J
K
L

Map of Squares in Gothenburg

Appendix III


Gårdsten Centrum
Angereds Torg
Hammarkulletorget
Hjällbo Torg
Gärdsås Torg
Åstidstorget
Rymdtorget
Citytorg
Kortedala Torg
Komettorget
Selma Lagerlöfs Torg
Bjurslätts Torg
Brunnsbotorget
Friskväderstorget
Kvilletorget
Väderlekstorget
Virveltorget
Vårväderstorget
Kyrkbytorget
Lilla Bommens Torg
Hamntorget
Gustav Adolfs Torg
Drottningtorget
Johan Sannes Torg
Lilla Torget
Brotorget
Järntorget
Kungstorget
Eriksbergstorget
Grönsakstorget
Stigbergstorget
Masthuggstorget
Skanstorget
Chapmans Torg
Guldhedstorget
Doktor Fries Torg
Kaggeledstorget
Munkebäckstorget
Olskrokstorget
Stabbetorget
Spåntorget
Trätorget
Gårdatorget
Fyrktorget
Axel Dahlströms Torg
Radiotorget
Frölunda Torg
Opaltorget
Legend of Map
Square
High Betweenness Street
Medium Betweenness Street
Low Betweenness Street
Selecting Criteria
High
Medium
Low
Size
Betweenness_2km
Total Population_500m
Enclosure
0
1km

CHALMERS
UNIVERSITY OF TECHNOLOGY

Master Thesis at Chalmers Architecture
Gothenburg, Sweden
20 December 2016