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FACULTEIT BEDRIJFSECONOMISCHE WETENSCHAPPEN
*master in de verkeerskunde: mobiliteitsmanagement*
*(Interfacultaire opleiding)*

# Masterproef
## Space-temporal decision making in transport

Promotor :
Prof. dr. Davy JANSSENS

Gertjan Dupont
*Masterproef voorgedragen tot het bekomen van de graad van master in de verkeerskunde , afstudeerrichting mobiliteitsmanagement*

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KNOWLEDGE IN ACTION

# PREFACE

This report is my master thesis to end the studies of transportation sciences at the University of Hasselt. It is written to obtain the degree of master in transportation sciences with specialization in mobility management. The document contains information of work done between October 2012 and June 2013. In these months, I tried to obtain more insight in the field of time geography. To obtain this insight I had some help from other people. I really appreciate the help these people gave me.

First, I would like to thank was my attendant PhD Sofie Reumers, from the Institute of Mobility (IMOB) linked to the UHasselt. She was responsible for the succession of this document and helped me to gain information. She also commented what I was doing and advised me how to do things, how to do things better or in another way. The second person was Prof. Dr. Davy Janssens, the promoter for the thesis. At certain times he also indicated what to do or how to do things in the research. At some times it was hard to write this thesis but at the end we dealt with several concepts in time geography and learned something from writing this document.

Except these two people from the University of Hasselt I would like to thank some other people who helped me during this study. First of all, I would like to thank my parents, who gave me the opportunity to study. I also would like to thank my classmates for the past great times at school. Of course I would also like to thank everyone else who I might be forgotten.

So, when you read this sentence I’m already happy that you have at least read one page of this document. If you are planning to continue: enjoy reading!

# SAMENVATTING

In deze masterthesis is onderzocht hoeveel alternatieve locaties een individu kan bereiken gegeven zijn of haar huidige tijd-ruimte prisma. Niet alle verplaatsingen zijn opgenomen in dit onderzoek, enkel: winkelen, ontspanning, onderwijs, diensten en werk verplaatsingen. De reden dat niet alle verplaatsingen zijn opgenomen is omdat het niet gemakkelijk was om alternatieve locaties te vinden voor de overige verplaatsingsmotieven. De methode die gebruikt is voor de analyse in dit onderzoek is gebaseerd op de methodes van Lee et al., Yoon et al. en Miller H.J..

De data die gebruikt is voor het onderzoek is afkomstig van het OVG 3 (Onderzoek verplaatsingsgedrag 3), de analyse is gebeurd met het open source programma QGIS. De analyse is gebeurd op een selectie van 100 respondenten uit het OVG 3. Na zuivering van deze selectie blijven er 80 respondenten over die beschikken over alle bruikbare informatie zoals coördinaten en dergelijke. Op deze selectie werden analyses uitgevoerd zoals de invloed van afstand op het aantal alternatieve locaties, de invloed van de vervoersmodus, invloed van de periode van de dag en of het gebied waar de respondenten wonen een invloed heeft op het aantal alternatieve locaties dat men kan bereiken. De samenstellingen van de selectie van respondenten die gemaakt zijn voor dit onderzoek komt in grote mate overeen met de selectie van respondenten in het OVG 3. Andere gegevens die gebruikt zijn tijdens dit onderzoek zijn afkomstig van Open Street Map bestanden. Deze data bevatten gegevens over verschillende functies, het wegennetwerk en verschillende zones. Om het aantal mogelijke alternatieve locaties te bepalen werden deze Open Street Map gegevens gebruikt in QGIS.

Als men kijkt naar de algemene resultaten, blijkt dat verplaatsingen die winkel gerelateerd zijn het grootste aantal  alternatieve locaties bevatten, de verplaatsingen die ontspanning gerelateerd zijn kunnen het kleinste aantal alternatieven bereiken. Als men kijkt naar de invloed van de afstand op het aantal alternatieve locaties dat een respondent kan bereiken, kan men stellen dat voor elk verplaatsingsmotief dat geanalyseerd werd, het aantal alternatieve locaties toeneemt naarmate de afstand toeneemt. Hoe verder de huidige verplaatsing, hoe meer alternatieve locaties men kan bereiken binnen dezelfde afstand. Respondenten die hun verplaatsing per wagen maken of met een ander gemotoriseerd voertuig kunnen meer alternatieve locaties bereiken, rekening houdend met de vogelvlucht afstand tot hun huidige locatie.

In een andere analyse is gekeken naar de invloed van het gebied waar de respondenten wonen op het aantal alternatieve locaties dat men kan bereiken. Over het algemeen kunnen respondenten die in stedelijke gebieden wonen meer alternatieve locaties bereiken dan respondenten die niet in stedelijke gebieden wonen. In sommige gevallen kunnen respondenten uit plattelandsgebieden echter meer alternatieve locaties bereiken. Dit kan men verklaren door de afstand tot de huidige locatie. Deze afstand is, in veel gevallen, verder voor deze respondenten dan voor respondenten uit stedelijke

gebieden. Hierdoor is de oppervlakte die men bestrijkt door het tekenen van een cirkel (met als straal vertrekpunt - bestemming) groter en heeft men dus meer alternatieven.

Tot slot zijn er ook nog een aantal analyses gedaan op basis van tijd. Een eerste analyse kijkt naar het aantal alternatieve locaties dat een respondent kan bereiken tijdens bepaalde periodes van de dag. En de andere tijdgebaseerde analyse bestudeert hoe het aantal alternatieve locaties verandert als de werkelijke reistijd verandert.

# ABSTRACT

In this thesis is the number of possible alternative locations that an individual can reach within his current space-time prism investigated. Not all the trips are taken into account, only: shopping, leisure, education, services and work activities. Because it wasn't easy to find alternatives for the other trip purposes. The method that is used to analyse this, is a method based on the methods of Lee, Yoon et al. and Miller H.J..

The data provided for this analysis are derived from the OVG 3 (Onderzoek Verplaatsingsgedrag 3) and the analysis is done with the open source program QGIS based on a sample of one hundred respondents from the OVG 3. After filtering this sample 80 respondents left, these contain all the useful information that was required, such as ordinates. On this sample we performed some analyses like the influence of the distance on the number of alternative locations, influence of transportation mode, influence of the time of the day and if the area respondents live in affects the number of alternative locations they can reach. The composition of the sample matches pretty well with the total number of respondents of the OVG 3. Other data that are used are derived from Open Street Map files. These data contain information about places of interest, the road network and different zones in an area. To determine the alternative locations Open Street Map Objects in QGIS are used.

The general results show that trips with shopping purposes have the most alternative locations and trips with leisure purposes the least. When looking at the influence of the distance on the number of alternative locations a respondent can reach, it can be said that for every analyzed trip the number of alternative locations increases as the distance increases. The further people travel for their current locations the more alternatives they can reach within the same distance. Respondents who travel by car or another motorised vehicle can reach the most alternative locations, taking into account the bird's eye view distance to their current locations.

In another analysis is looked at the influence of the area respondents live in on the number of possible alternative locations they can reach. For most of the trip purposes respondents who live in urbanized areas can reach more alternative locations than other people. But in some cases people who live in rural areas have more possibilities. An explanation for this is the distance they travel to their current locations. This distance is, in most cases, further than respondents in urbanized areas so the radius of the trip is bigger which means it covers a larger area with alternative locations.

Finally some analyses are based on time. The first analyses takes the periods of the day into account, based on this is looked at the alternative locations a respondent can reach. The other time-based analysis examines how the number of alternative locations a respondent can reach reacts on a change in travel time.

# TABLE OF CONTENTS

# 1. INTRODUCTION

This master thesis is written to obtain the degree of master of transportation sciences at the University of Hasselt, specialization mobility management. The title of the thesis is ‘Space temporal decision making in transportation’. The research done for this thesis is situated in the area of time geography, a quiet young area in transportation sciences. This thesis is partly based on a continuation of the research done in the case study during the first master of transportation sciences. The promoter of the thesis is Prof. Dr. Davy Jansssens and the mentor is PhD Sofie Reumers.

The purpose of this master thesis is to obtain insight in the number of alternative locations a respondent can reach taking his current space-time prism into account. In the literature study is an explanation of some concepts, definitions and methods. This literature study should make us more familiar with the field of time geography. After the literature review, we will explain how we did our analyses. We will explain the method that is used to determine the number of alternative locations.

After explaining the used method, we will proceed to the analysis and results of the research. To determine the number of alternative locations we took the bird’s eye view distance into account. In the analyses we will look for several things. We will determine the influence of the distance, transportation mode, departure area and time of the day on the number of alternative locations that a respondent can reach. We also take a look how the number of alternative locations reacts when the real travel time of a trip increases.

Finally the results are explained, a conclusion is formulated and there is some space for discussion about the research done in this master thesis. This discussion will contain limitations experienced during the analyses and some recommendations or options for future research.

# 2. PROBLEM STATEMENT

One of the reasons why this master thesis is written is the fact that little information about space-temporal decision making in transportation is available nowadays. The research in the time geography of transportation sciences is not as extensive as other topics or areas that are related to traffic. So the 'lack' of information is part of the problem statement for writing this thesis.

Another motivation for this research is the knowledge of people about the environment. How well do people know the environment they live and move in? Maybe people don't know the number of alternatives they have within their habitat. It can be that they travel much further than necessary to participate in an activity because they don't know the existence of the possible alternative locations.

Also habitual behaviour can be a reason to do this kind of research. When an individual knows where he can find a certain activity it is more likely that he or she will return to this place every time without taken some alternative places into account where he or she can participate in a specific type of activity.

The purpose of the research is to gain more insight of how, when, why,... people want to move from one place to the other. With the information of why, how, when,... it is possible to create activity-based models to analyze a person's mobility and reason for this mobility. It will also be possible to predict a respondent's destination choice or selection by using models, based on the research done in this study.

# 3. OBJECTIVE

The objective of this research is, as in the case study of last year, to understand the travel behaviour of individuals. The goal is to know how many locations, with respect to the sort of activity, an individual can reach within a certain amount of time and in a certain space as an alternative for the present chosen location. Not every person will be able to reach the same number of locations within his PPA.

With the establishment of this thesis the following objectives are pursued:

- The student is able to recognize a traffic related problem, describe this problem and to find a traffic related solution for the problem. The problem is situated within the specialization of the student, mobility management in this case.
- The student is able to find, use and report the required information that is useful for the subject.
- The student has to choose a scientific method that he or she will use and explain why he or she chooses this method.
- The student is able to report about his or her findings, both positive and negative results.
- At the end the student has to give a presentation about the thesis where the student, briefly, explains the results of the thesis and discusses these results with other people.

The master thesis must be original and it is not a duplicate of an existing research. The thesis doesn't necessarily leads to positive conclusions. Negative results can be useful as well. (UHasselt, 2012-2013)

# 4. RESEARCH QUESTIONS

The main research question of this thesis reads as follows:

**How many alternative locations, can an individual reach in space and time, taking his Potential Path Area into account?**

The purpose of this research question is, as in the case study of last year, understanding the travel behaviour of individuals. The goal is to know how many alternative locations an individual can reach within a certain amount of time and in a certain space taking the same characteristics as the present activity and location into account. Another objective is to know which factors influence a person's PPA (and how much they do). Not every person will be able to reach the same number of locations within his PPA. This will depend on the area where he or she lives. Persons in urban areas are more likely to have more possibilities, considering the locations that they can reach within a time period than people who live in more rural areas. The number of alternatives may also be depending on the type of activity in which the respondent participates.

Possible sub research question for this thesis can be formulated as follows:

- Are there existing methods in the time geography to determine the alternative locations of a respondent?
- Which data is necessary to do research in the time geography or to determine the alternative locations of a respondent?
- Which are frequent concepts in time geography?
- Is there a difference in the number of alternative locations a person can reach during time of the day?
- Is there a difference in the number of alternative locations a person can reach depending on the place they live?
- Is there a difference in the number of alternative locations a person can reach depending on the modus that is used to make a trip?

These research questions are partly derived from the chapter " toekomstig onderzoek" (or future research) of the case study from the first master in transportation science. These questions were then defined as possible subjects for the thesis in the second master year. The first three research questions will be answered in the literature study, the other ones in the research.

# 5. LITERATURE STUDY

In this literature study some research is done about the topic of this thesis. First of all it will explain different definitions or terms that are useful for this research and also to define some concepts in this field of transportation sciences. After these definitions and concepts is an overview of the data that are used in other similar researches and the methodology that was used in these researches is studied.

## 5.1. Definitions and concepts

In this first part of the literature study is looked at the definitions and concepts that are useful for the research in this thesis. The following definitions and concepts are explained: space-time prism, the difference between PPT en PPA, fixed and flexible activities and constraints in this research. First of all what is a space-time prism?

Due to Hägerstrand a space-time prism can be defined as follows: "a set of possible paths through space and time that an individual can follow within a time budget" (Farber S., Neutens T., Miller H.J., 2012). These space-time prisms are used to measure people's accessibility to particular opportunities, activities or facilities. The geometric footprint of a typical network space-time prism takes the form of a potential path tree (PPT), which defines all accessible locations on the network during the specified time interval. The potential path tree is directly analogous to the geo-ellipse or potential path area (PPA) from classical time geography. This time geography is the quintessential approach for analyzing the movements and interactions of humans and other mobile agents (Downs J.A., Horner M.W., 2012). The geo-ellipse constrains the prism locations to account for any stationary activity time during the time interval. (Miller H.J., 2004)

Another definition for the space-time prism is delivered by Miller H.J., he says that: the space-time prism measures the spatiotemporal limits of reachability or physical accessibility of an individual given one or more space-time anchors, the maximum velocity of physical movement, and the minimum time required for some activity. Space-time anchors represent fixed activities, such as home and work: activities that are relatively difficult to reschedule or relocate, see further on. (Miller H.J., 2004)

FIGURE 1 shows a visual representation of a space-time prism and the potential path area. On the figure the x-y plane is representing geographic space and the vertical axis is denoting time. The bold solid line traces the movement of an individual in time-space, where a vertical segment parallel to the time-axis indicates no movement in space during that time interval (e.g., t0-t1, t2-t3). A diagonal segment (e.g., t1-t2) represents travel through geographic space over time; the slope (i.e., change in time over change in space) expresses the inverse of the velocity. The time-space prism itself, shown in bold dashed lines as the volume contained by the two oblique elliptical cones with a common base, does not trace observed movements through time-space. Rather, it defines the region of space possible for an individual to be in at specified times. The time-space prism is determined by the time budget of an individual, the extent and the level of service (i.e. travel velocities) of the transportation network, and temporal-spatial constraints such as the need to be at particular locations at particular times. The projection of the three-dimensional TSP onto the two-dimensional geographic space delimits solely the spatial extent within which one can travel and is called the Potential Path Area. (Lee B.H.Y., Waddell P., Wang L., Pendyala R.M., 2008)

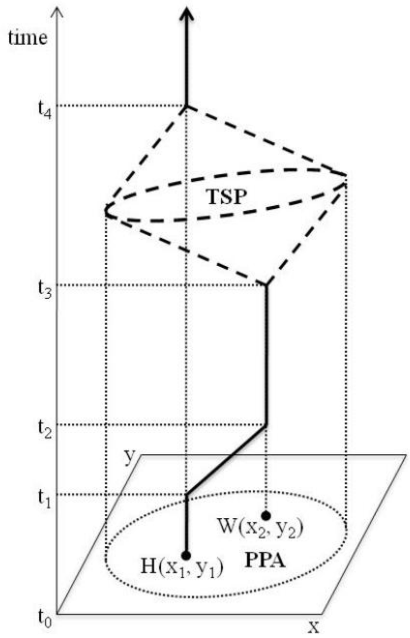


**FIGURE 1 Time-space prism (TSP) and potential path area (PPA).**

(Lee B.H.Y., Waddell P., Wang L., Pendyala R.M., 2008)

The potential path area or PPA is the area where a person can potentially pursue activities within the time budget while they are travelling from one skeletal (or fixed) activity location to the next skeletal activity location. (Yoon S.Y., Goulias K.G., 2012)

Another definition, but very similar to the definition of Lee et al. (2008), for this potential path area is given by Miller H.J.: “the potential path space (or area) is determined by an individual's time budget or the time available for travel and activity participation, the potential travel velocities in the environment, any stop time (time that must be spent at an unspecified location to participate in an activity), and spatial constraints such as the need to be at a certain location at the beginning of the available period (the travel origin) or at the end of the period (the travel destination)”. (Miller H.J., 2007)

In the literature the following definitions are given to fixed and flexible activities. Fixed activities are activities that are spatially and/or temporally fixed. First of all, home activities are considered to be fixed due to the nature of the activities occurring at home. Some of these activities are: sleeping, eating, being with family or household chores. These activities usually take place at fixed times and very strictly at home. Other fixed activities are work or school activities, medical appointments, community meetings, political or civic events, public hearing, voting and religious activities because these activities are spatially and temporally fixed because the location for these activities and the time they take place are usually not decided by the individuals but by an external entity. Also travelling by airplane or intercity bus is considered to be fixed activities (Yoon S.Y., Goulias K.G., 2012). Although there are some fixed activities that an individual can schedule on his own, like a medical appointment. But when the appointment is made an individual cannot skip this appointment.

Flexible activities, on the other hand, are activities that are not limited by time and/or location. An individual can choose, to a large extent, on his own when and where these activities will take place. At the end of the literature review is a remark on these definitions and the one that are used in the continuation of the document.

Furthermore the literature mentioned some constraints that need to be considered in this field of transportation science. In the literature they are speaking about capability, authority and coupling constraints. Individuals are restricted in space and time not only by their physiological capabilities such as the need to eat, drink and sleep (called capability constraints), but also by norms, rules and laws (the authority constraints) and commitments to join other people tools, or material artefacts that bind them to particular locations at specific times across the diurnal cycle[1] (coupling constraints) (Farber S., Neutens T., Miller H.J., 2012). Hägerstrand defines these constraints as follows (Susilo Y.O., Avineri E., 2012):

- Capability constraints: an individual's activity choice set will be limited by his/her ability to do activities. Not only a geographical boundary, but also space-time walls limit an individual's possibility to visit and participate in activities. These "walls" change from day to day and depends on individual daily constraints. So capability constraints are physical constraints that a person experiences. People must eat, are limited in their own travel speed, need to sleep,...;
- Authority constraints: these constraints relates to the time-space aspects of authority. In this time-space entity things and events are under the control of a given individual or a given group. Some places aren't accessible for some people, shops are having opening hours,...;
- Coupling constraints: the freedom of individuals activities will be bounded by where, when and for how long, the individual has to join other individuals, tools or materials . For example, people don't work alone (in most cases), people interact with each other to participate in activities.

[1] Diurnal cycle: diurnal cycle refers to patterns within about a 24-hour period that typically reoccur each day. (World of Earth Science, 2003) The diurnal cycle indicates the daily course of a day.

These constraints define the boundaries of an individual's space-time prism.

## 5.2. Methodologies and data

This section summarizes some methodologies that were found in the literature on time geography. The purpose of this part is to find a method that is useful to implement in the continuation of this thesis. A first method, that is likely to be used, is presented by Lee et al (Lee B.H.Y., Waddell P., Wang L., Pendyala R.M., 2008).

The method is described in the paper of Lee et al.: Operationalizing time-space prism accessibility in a building-level residential choice model. The operational procedure used in this residential choice model application is based on the Feasible Opportunity Set (FOS) approach. This approach focuses on identifying potential opportunities constrained by the time-space prism. First, the daily activity schedule of an individual, observed or simulated, is assessed to identify mandatory activities (like work). These are commitments at predefined locations during predefined times. These committed time intervals are called blocked periods and their complement is a set of open periods, when discretionary activities may take place. Second, given an open period and a travel mode, determine for each TAZ[2] (Transportation Analysis Zone) whether it can be visited with sufficient time remaining in order to participate in an activity. This determination is repeated for all zones to identify the set of feasible TAZs for visit, providing a maximum spatial extent akin to the PPA. Finally, the cumulative opportunities approach is applied to the set of feasible TAZs to quantify the amount of opportunities that are available to an individual in an open period given the temporal and spatial constraints. By using the TSP framework, the impact of land-use and transportation system changes on activity-travel patterns would be evident in this accessibility measure. If the transportation network performance or the density of opportunities decreases, then the set of feasible TAZs or the measure itself, respectively, decreases. Similarly, if travel is better or more opportunities exist, then increases are expected. (Lee B.H.Y., Waddell P., Wang L., Pendyala R.M., 2008)

[2] TAZ: Transportation Analysis Zone is a unit used in transportation planning models. (Martinez L.M. et al., 2009) The size of a TAZ is depending from model to model. Some zones only contain one block of buildings, other contain whole parts of a city. These TAZ's contain socio-economic data, that's why they are used in transportation modelling.

Another method is presented by Yoon et al. This method is based on an algorithm, to find the potential path area or PPA, that is programmable and readily applicable for a travel time matrix, and that can use data from existing regional models suitably modified to increase spatial detail. This research also identified implementation issues and estimated the computational requirements to describe an area within a large region, it shows the time of day changes in availability of opportunities and finds choice sets using space-time prisms for a large-scale destination choice model based on data from a household survey. In this survey they used household travel results of the Southern California Association of Governments (SCAG), they also used the US Census blocks[3] as spatial units. One of the purposes of this study is to identify the activity opportunities that a person can reach within a given amount of available time. The amount of opportunities an individual can reach depends on the time window, the space one can reach within that time window and the density of opportunities, living in an urbanized area can lead to more opportunities than living in a rural area.. The density of opportunities depends on spatial organisation and opening and closing hours of businesses (authority constraints). So, to know what these opportunities are, a variety of different data is used, e.g. Household travel survey data, data about the roadway network, employment data, geographical information, data about the business establishments in the region and finally a land parcel database (Yoon S.Y., Deutsch K., Chen Y., Goulias K.G., 2012).

Yoon et al. uses four time periods in their research, these time periods are also used to derive the travel speed. The four time periods they use are the AM peak, PM peak, off-peak and the night time. They also take time-dependent availability of opportunities (closing and opening hours of shops and other facilities) into account. This is done by considering the fixed and flexible activities. (Yoon S.Y., Deutsch K., Chen Y., Goulias K.G., 2012)

In this research, a potential path area was computed for each time window (derived from the skeletal/fixed activities), based on the origin and destination skeletal activities and the time budget between them to find the choice set for each time window. This gives the authors an idea about the amount of computation (time) needed to implement the time-space prism concept.

[3] US Census blocks: Census blocks, the smallest geographic area for which the Bureau of the Census collects and tabulates decennial census data, are formed by streets, roads, railroads, streams and other bodies of water, other visible physical and cultural features, and the legal boundaries shown on Census Bureau maps. (United States Census Bureau)

A third method, described by Miller H.J., is a generic procedure for building network based potential path areas. This method is a basic network based PPA that does not consider stationary times at an activity location. The data that is necessary for this method is listed in TABLE 1, each node in the network in uniquely identified by a non-zero number. It is also assumed that the arcs are completely traversed by individuals when travelling. The procedure for this method results in the identification of the set of arcs that comprise the PPA given the specified travel origins and destinations and the time budget for travel. (Miller H.J., 2007)

**TABLE 1 Data Requirements for PPAs Based on Geographical Information Systems**

| | Data characteristics | |
|---|---|---|
| Data requirements | Punctiform version | Network version |
| Travel origin/end locations | Point objects in planar space | Nearest nodes in a defined transportation network structure to the actual locations |
| Activity locations | Point objects in planar space | Nearest nodes in a defined transportation network structure to the actual locations |
| Travel environment | Direct paths between travel origin/end locations and activity locations | Arcs and nodes corresponding to linkages (streets, intersections) in the urban transportation network |
| | Each path characterized by a representative travel distance and a set of temporally dependent travel velocities | Each arc characterized by the length of the linkage and a set of temporally dependent velocities |
| | | Each node characterized by a set of temporally dependent turn times |

(Miller H.J., 2007)

But in the research that will be done in the continuation of this thesis an own ‘method’ is developed based the previous three described methods. The method that is used will be described under the title ‘Calculating Potential Path Area’.

For the continuation of the research a caveat must be mentioned, the definition of fixed and flexible activities will slightly differ from what is mentioned above. Normally a fixed activity is an activity a person has to participate in at a certain time and space. Like going to work or school every day. A flexible activity is an activity that a person doesn’t do every day, can reschedule or skip. In this thesis a fixed activity is considered to be fixed in space and time. By fixed in space is meant that the activity, for example a leisure activity, can take place at any location that is suitable for leisure activities. By fixed in time the times, given by the respondents, are considered to be invariably. The flexible activities are activities that can take place anywhere or anytime. For example visiting someone can take place at any moment of the day or at any place in space. The same for taking a walk or bringing someone. This last one depends on a third person, so it is not possible to determine this.

After this literature review it is already possible to answer some of the research questions that are set earlier in this document. These research questions can be considered as preliminary question to gain insight in the field of time geographic research.

- Which are frequent concepts in time geography?

The literature research started with the explanation of frequent concepts in the time geographic field of transportation research. In this chapter explained what a space-time prism is, what the definition is of a potential path area or PPA and how it is used. Then the difference between fixed and flexible activities is explained. Fixed activities are activities that are spatially and/or temporally fixed while flexible activities are activities that are not limited by time and/or location. In the literature research is also mentioned the possible constraints in this field of transportation research: capability, coupling and authority constraints.

- Which data are necessary to determine the alternative locations of a respondent?

To do research in the time geographic field of transportation science several different data sources are required for meaningful analysis/research. This is explained in  Methodologies and data. In this part, the data that is useful is described together with the possible methods. The different methods will be explained in the next research question. To do time geographic research data about the road network, travel behaviour of people (OVG 3), a land parcel database, geographical information, all possible information about locations in the studied area (presence of activities, opening hours, employment...) is necessary.

For this research this means that the next data must be used: data of the OVG 3 (Onderzoek Verplaatsingsgedrag Vlaanderen 3) (Janssens D. et al, 2009), data about the roadway network, geographical information provided by overlays from Open Street Map objects (OSM objects and POI layer) for Quantum GIS (Quantum GIS 1.4.7), information about business establishments in Flanders (including locations, opening and closing hours) and also a land parcel database.

- Are there existing methods to determine the alternative locations of a respondent?

In the literature research, three methods that are used in the time geography are explained. The methods of Lee et al., Yoon et al. and Miller H.J. are mentioned. These are three different methods used to analyse time geography issues. For the research in this thesis an own ‘method’ is created based on these three methods. How this methods works is described further on. In the method that is developed the time budget of a respondent is not taken into account, as well as the real travel distance. The analysis are based on the distance in bird's eye view.

# 6. RESEARCH

The first part of the research is a description of the data that is used to perform the research. This chapter contains a description and summary of the OVG 3 data and of the different layers used in Quantum GIS. The method that is used for the research is also explained.

## 6.1. Data description

### 6.1.1. OVG 3

The purpose of the OVG is to gain insight in a few characteristics of households and individuals with regard to mobility. For the households this contains characteristics of transportation modes that are available in/for the household. On the individual side the research focuses on the trips persons make. Besides this, some additional features (i.e. socio-demographic characteristics) are surveyed to assure a meaningful social analysis.

In Flanders the first research towards travel behaviour was performed from April 1994 till April 1995. A second research took place from January 2000 till January 2001. Both researches were carried out on the Flemish level, this means that the surveyed households lived scattered throughout the whole region of Flanders. The same procedure is used in the preparation of the OVG 3.

The research was done by a survey, filled in by 7.265 persons from six years and older, selected on the basis of a sample from the national register. The selected persons had to answer a face-to-face survey (on computer). They were asked about the household characteristics (through the household questionnaire), and a couple of questions about their travel behaviour and their personal characteristics (through the person questionnaire). Besides this, every respondent received a travel diary to mark up the trips they did on a randomly selected day. Afterwards, these data were included in the computer by a face-to-face contact between the interviewer and the respondent. (Janssens D. et al, 2009)

The research in this thesis is performed on a sample of 100 randomly selected respondents from the respondents in the OVG 3. In this selection of respondents occurs an error in 20 percent of the cases. An error means that one or more coordinates are missing from an origin or destination, origin and destination have the same coordinates or that an address/postal code is wrong or unfindable. The other 80% contains all the coordinates for the trips. The 80 respondents (1,1% of the whole OVG 3) represent 416 individual trips (representing 1,5% of the total trips in the OVG 3). The selection of 100 respondents was made to have an exact number of respondents that has to be analyzed. At the beginning was agreed to determine as much respondents as possible but in order to make this number concrete, it was said to analyze 100 respondents. Why the sample of 80 respondents is not filled up to 100 respondents again, is explained further on in this document.

The selected respondents are shown in the appendix. The number of males in this selection (without errors) is 55% or 44 males and percentage of females is 45% or 36 females. The mean birth year of the selected respondents is 1967. Considering the capability to drive a vehicle, 75% (81.67%) of them is in possession of a driving license; 16,25% (18.33%) isn't and for 8,75% of the respondents this data is unknown. The value in parentheses shows the percentage of each attribute in the whole 'Onderzoek Verplaatsingsgedrag Vlaanderen 3' (Janssens D. et al, 2009).

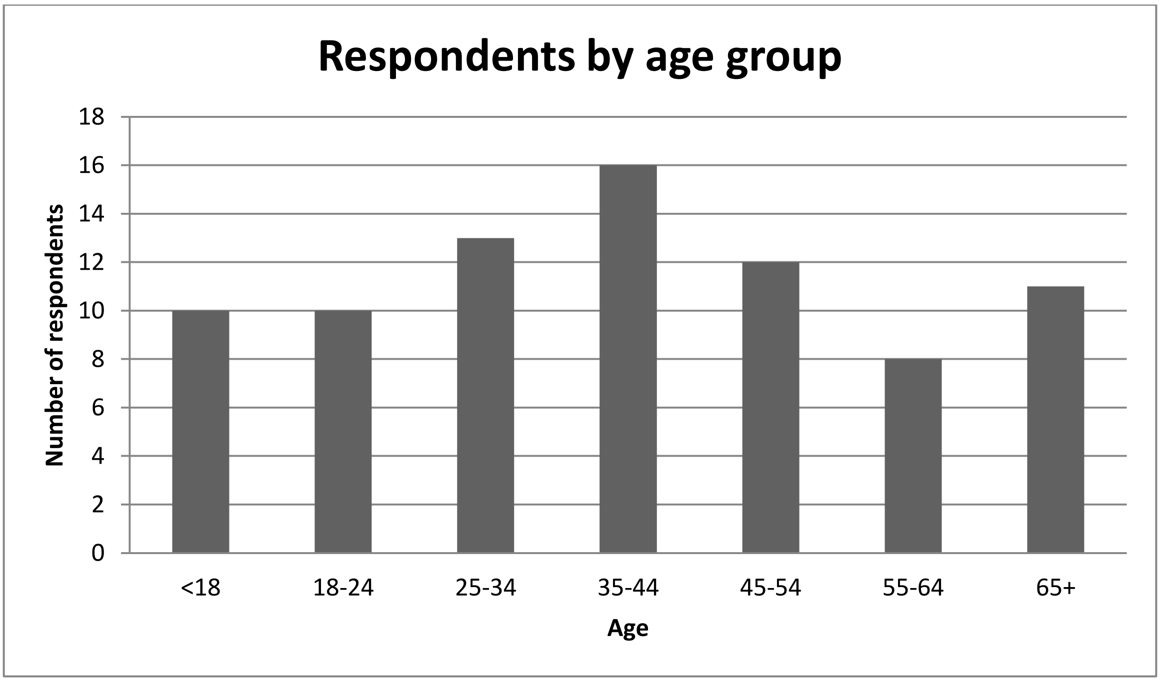


**FIGURE 2 Respondents by age group.**

Taking the level of education into account for the remaining respondents, means that in 2,5% of the cases the respondent doesn't have a diploma, 20% has only a diploma of primary school, 7,5% didn't finish his or her high school, 37,5% has finished high school and 31.25% has a diploma of higher education. The education level of one respondent is unknown.

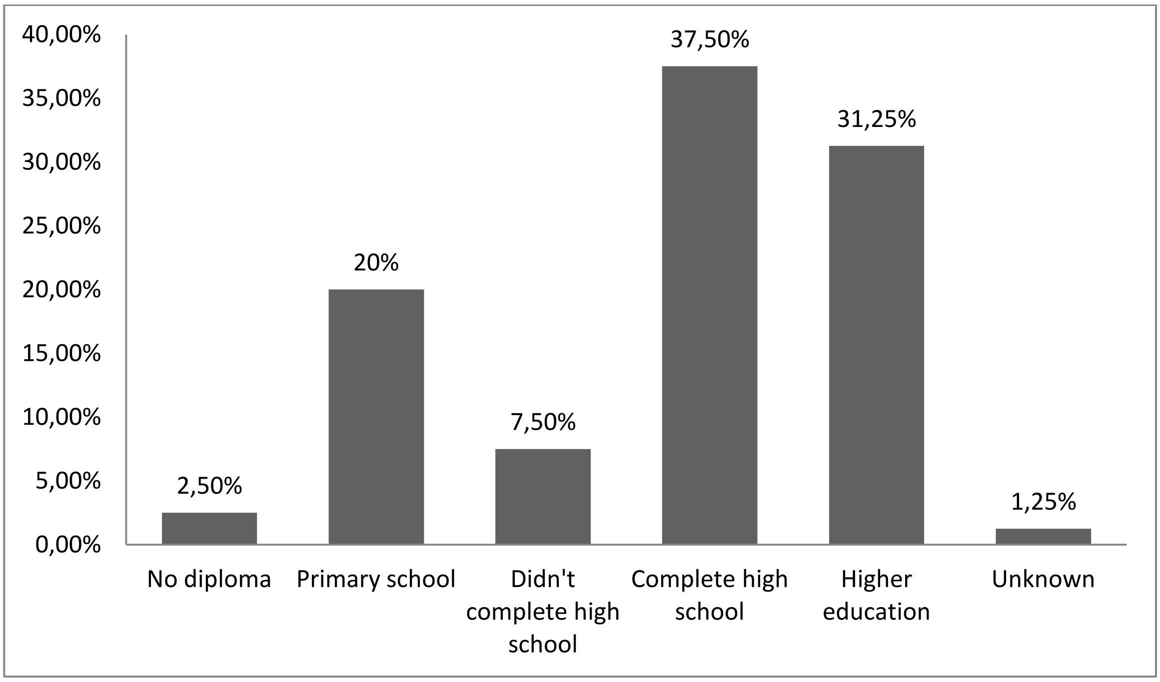


**FIGURE 3 Level of education.**

TABLE 2 shows the number of trips per transportation mode and per purpose. Most of the trips that are analyzed in this research are shopping trips. This table makes clear that the majority (53,6%) of the trips is made by a car, as driver. Followed by cyclists (16,3%) and trips made as a car passenger (15,9%). Trips made by public transport represent only 3,6% of the total amount of trips, of the selection.

**TABLE 2 Number of Trips per Purpose by Transport Mode**

| Transportation mode | Trip purpose | | | | | | | | | | Total trips | Percentage (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Business trip | Work | Shopping | Visit | Education | Walk | Dropping someone off | Leisure | Services | Something else | | |
| Pedestrian | 2 | 2 | 13 | 2 | 2 | 2 | 6 | 6 | 4 | 0 | 39 | 9,4 |
| Cyclist | 0 | 6 | 20 | 9 | 6 | 1 | 5 | 9 | 11 | 1 | 68 | 16,3 |
| Moped | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Motorcyclist | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0,5 |
| Car driver | 31 | 54 | 39 | 17 | 2 | 1 | 51 | 15 | 4 | 9 | 223 | 53,6 |
| Car passenger | 0 | 0 | 15 | 13 | 4 | 2 | 7 | 18 | 6 | 1 | 66 | 15,9 |
| Bus | 0 | 1 | 1 | 0 | 2 | 0 | 0 | 1 | 0 | 1 | 6 | 1,4 |
| Tram | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Train | 0 | 0 | 2 | 0 | 5 | 0 | 0 | 1 | 0 | 1 | 9 | 2,2 |
| Autocar | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0,7 |
| Total trips | 37 | 64 | 90 | 41 | 21 | 6 | 69 | 50 | 25 | 13 | 416 | |
| Percentage (%) | 9 | 15 | 22 | 10 | 5 | 117 | 12 | 6 | 3 | 0 | | 100 |

### 6.1.2. QGIS layers

The basic layer in Quantum GIS, is a layer that contains the contours of Belgium and divides Belgium in zones. The origin and destinations of the trips are displayed by the coordinates that came from the OVG 3 research. This layer and the OVG 3 data are provided by the IMOB, Institute for Mobility. Due to the tool 'Basisstatistieken' (Vector => analyse gereedschap => Basisstatistieken) in QGIS, the following information of the (whole) data is known. The mean number of trips in the OVG 3 is 3,14 trips per person a day (Moons E., 2009), with a minimum of one trip and a maximum of 19 trips. In the selection of 80 respondents, the average number of trips is 3,5 ranging from one to ten trips. FIGURE 4 shows how much respondents have a particular number of trips. Most respondents make four trips a day, followed by six trips a day. FIGURE 4 shows the percentage of respondents in the sample for this research and the OVG 3 corresponding to the number of trips they have made. The selection don't contain respondents who made more than ten trips, in the OVG 3 this is 0,07% of the respondents.

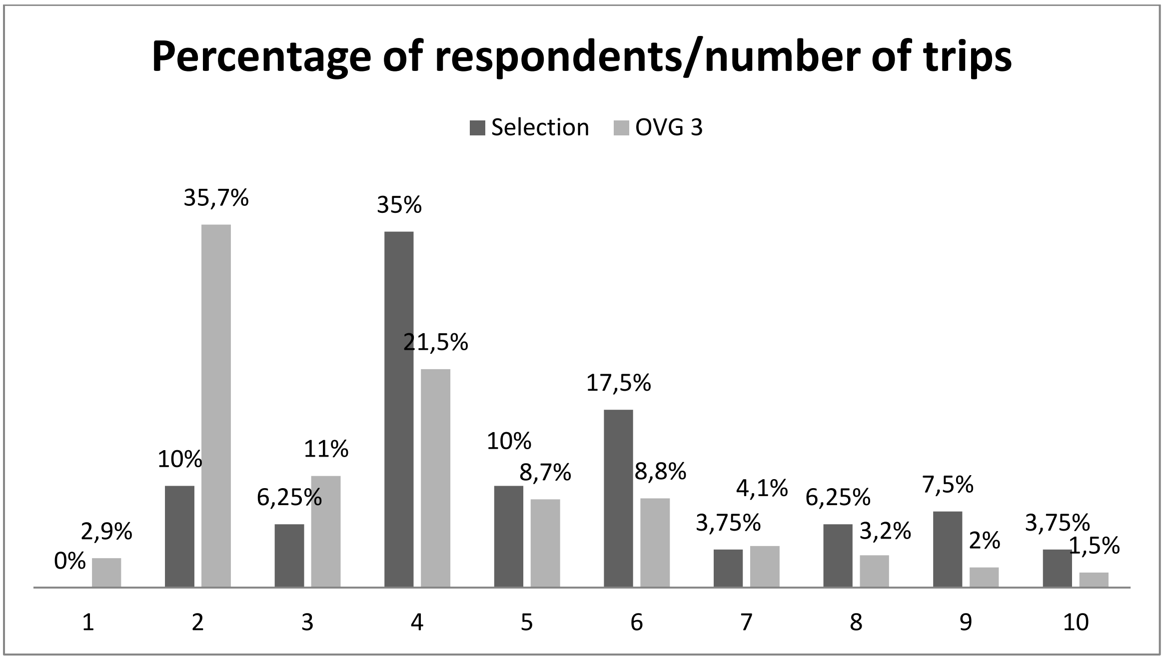


**FIGURE 4 Respondents/number of trips.**

For each selected respondent, two layers are uploaded in QGIS. One layer contains the coordinates of the last departures (*respondent xxxxxxx (vorige vertrekplaats)*) while another layer displays the arrival places (*respondent xxxxxxx (aankomstplaats)*). In the majority of the cases these two layers coincide. In FIGURE 5, a printout of QGIS shows the map of Belgium with the layers of the road network, places of interest (small black spots) and the arrival and departure places of one respondent (big grey spots).

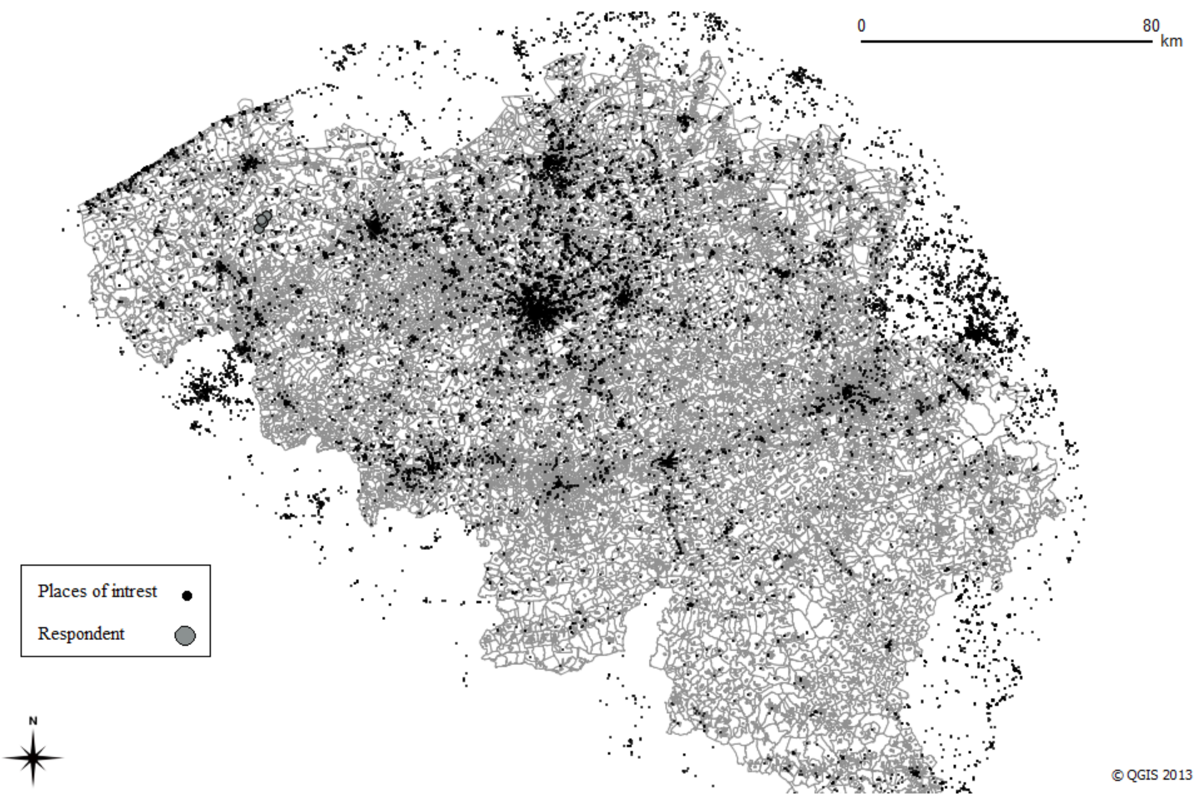


**FIGURE 5 Print-out of QGIS.**

In the layer belgium_poi (places of interest), downloaded from OpenStreetMap (Cloudmade, 2008-2013), are some things that are not relevant for the research. These objects are deleted from the layer. A list of the objects that are deleted is attached in the appendix. This layer contains information about places of interest that are interesting for the research done in this thesis, such as the location of restaurants, schools, sport facilities, leisure attractions, banks,.... The layer is renamed as ''Places of interest' and contains 21.710 objects, the original layer contained over 120.000 objects. The points that are deleted represent things/places like bus stops, power towers, stop signs, traffic lights...

Because the layer 'points of interest' does not contain all the information that is necessary for the research, several other layers were downloaded from OpenStreetMap. This are layers that display severally areas, they contain information about the road network, education, shops, land use,... Problem with these layers is that a download may not contain more than 50.000 nodes, otherwise the section is too big to download. So in urban areas the downloadable area is smaller than in rural areas. There are two different ways of collecting these layers. The first one is via the site of OpenStreetMap.org, by selecting an area. From this site the data of the selected area can be exported to your computer and upload it in QGIS, as an OSM file, with the aid of the OpenStreetMap plug-in. The other way is that one has to select an area in QGIS and then you can download this area with the OpenStreetMap plug-in. The second way is faster than the first one.

Finally one can also download bigger files (zipped up to 1,5 GB) from OSM planet. These files contain data for whole countries or bigger areas, but to process these data a lot of space on your computer and a powerful device is needed.

The OSM objects that are downloaded contain three layers: points, polygons and lines. To have an idea of what is displayed by an object the points and the polygons are labelled. In this research, the lines were disregarded because for the research, it only matters which functions are available within a respondent’s potential path area and the lines display streets, highways, canals,.... But by extension of this research it can be very useful information. The points are labelled by name, so this gives an idea of what they are, what their function is. With the aid of this, it is possible to locate alternatives for each trip of a respondent like schools, shops, leisure activities and so on. The polygons display areas, which are labelled by land use. Due to this label, it is possible to locate industrial sites, forests, residential areas and so on. If a respondent, for example, indicates that the purpose of a trip is work related, there is searched for other industrial sites or buildings within his or her potential path area and were displayed as an alternative for his or her current work location.

FIGURE 6 shows the map of Belgium with the OSM objects downloaded with the OpenStreetMap plug-in and from the website of OpenStreetMap. We did not download layers for whole Belgium, the downloaded objects are limited to OSM objects that cover the trips in the selection. The big purple dots on the map are the trips of the selection and the small red dots show us the places of interest from the OSM objects.

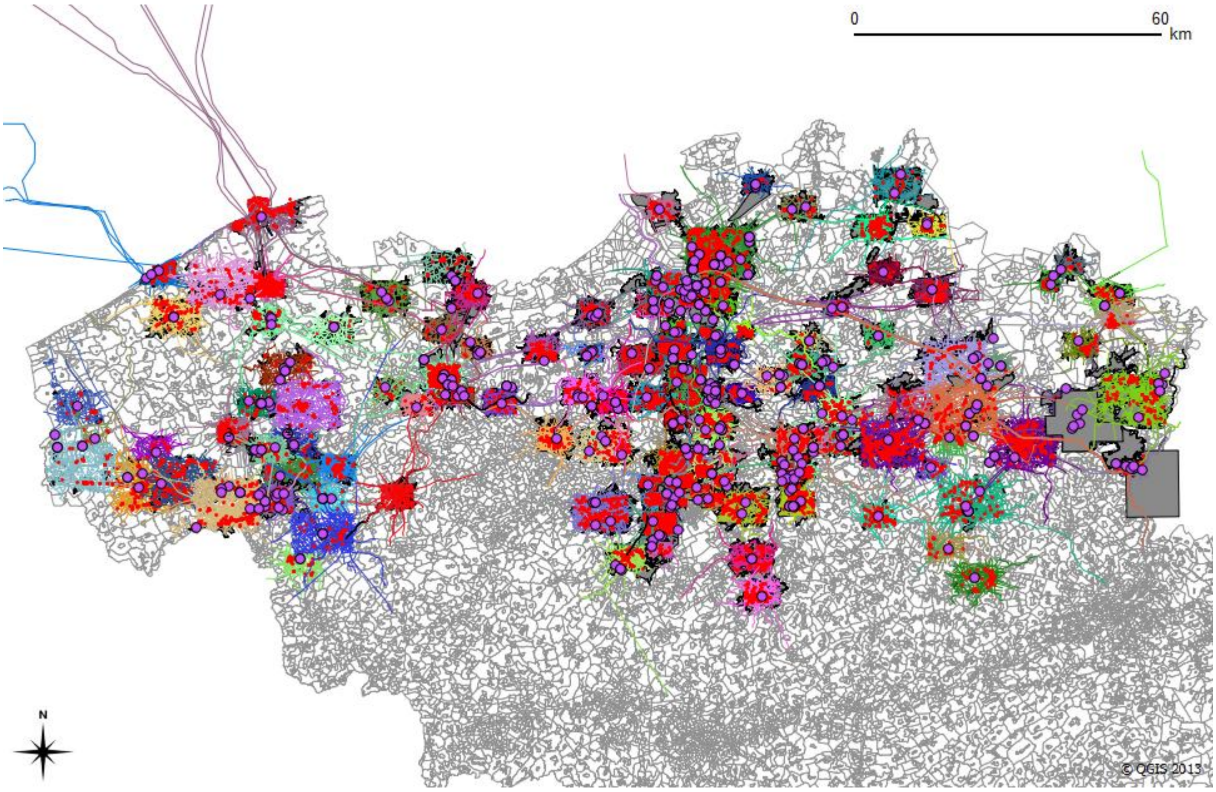


**FIGURE 6 Map of Belgium with OSM objects and selected trips.**

### 6.1.3. Quality of OSM and POI data

To determine the quality of the data provided by OSM objects and the Places Of Interest Layer, the data of these two is compared to the Gouden Gids (Gouden Gids, 2013). To do this, is looked at the city centre of Hasselt (within the large ring road, R71). We searched for several functions in the Gouden Gids, and these results are compared to the results of the OSM objects and POI layer. The next table shows how these data correspond. Because Open Street Map users were not located in the province of Limburg, we looked also at a city in a province with several Open Street Map users, namely Leuven in the province of Vlaams-Brabant. In Leuven is also looked for locations within the ring road, R23. This province, Vlaams-Brabant counts 22 Open Street Map users. (Openstreetmap.org, 2012)

**TABLE 3 Comparing Datasets**

| Functions | Hasselt | | | Leuven | | |
|---|---|---|---|---|---|---|
| | Gouden Gids | OSM Objects | POI layer | Gouden Gids | OSM Objects | POI layer |
| **Pharmacy** | 15 | 3 | 4 | 29 | 6 | 10 |
| **Bank** | 36 | 8 | 8 | 26 | 5 | 8 |
| **School** | 10 | 8 | 8 | 20 | 6 | 9 |
| **Pub** | 28 | 9 | 14 | 71 | 46 | 71 |
| **Restaurant** | 82 | 10 | 10 | 135 | 56 | 85 |
| **Police station** | 1 | 2 | 2 | 1 | 1 | 1 |
| **Shop** | 192 | 29 | / | 266 | 176 | / |

To compare the data is looked for some different functions like pharmacies, banks, schools, pubs, restaurants, police stations and shops. Most of these functions are included in this study. The data of OSM objects and POI layer are more or less corresponding to each other it most of the cases. But the difference with data from the Gouden Gids is quiet large. So the data of the OSM objects and the POI layer don't match with the data from the Gouden Gids. The last update in the maps that contain the data of POI layer dates back to 13 December 2011 (CloudMade, 2013). Maybe this explains a part of the difference but not all. The data of OSM objects is, normally, up to date. But these data are provided by individual users who implement the data in Open Street Map, because the program is an open source program. Due to the site of Open Street Map Belgium counts 161 Open Street Map users (Openstreetmap.org, 2012). These users aren't disseminated over the whole territory of Belgium. In some provinces are no registered users. Also, it is not sure that all these users are still 'active' updating the maps. So this could e an explanation for the amount of data in the OSM Objects.

So the results of the research that is done in this study, will be dependent of the quality of the used data. In reality the number of alternatives a respondent can reach will, probably, be higher because TABLE 3 shows that the quality of the OSM objects and POI layer data is not perfect. But because these are the available data, it is done this way.

## 6.2. Calculating travel distance in reality and in bird's eye view

### 6.2.1. Reality

First, the distances between arrival and departure that are given by the respondents are calculated. This indicates how much kilometres a respondent has to travel from departure to arrival in real distances. With these results it's possible to look if the respondent can reach other options, with the same characteristics, within his or her space or time budget. For example: if a person has to travel 10 kilometres to a supermarket, it would be possible to look in his environment if he can reach other supermarkets as well within this distance of 10 kilometres or the time that is necessary to reach the original supermarket. In the research, the real travel time is used to analyze how the number of alternative locations reacts when the travel time increases. The real distances are available in the excel-files but are not used in this research, they can be useful for further research in the field of time geography. Originally it was intended to do all the analyses based on bird's eye view distance and real distance but in the end only the bird's eye view distance is used.

The real distance and time for a trip is calculated with the aid of the TomTom route planner (TomTom, 2013). In this route planner it is possible to choose a specific day. Based on the choice that is made, the average traffic conditions on this day are taken into account. Because Tuesday is considered to be an average weekday, the trip distance and time is calculated on this day. The departure time of the trip is the same as given by the respondent. In some cases, the respondent's answer for the trip destination is not specific enough. For example when the respondent indicates that the arrival spot was a provincial domain, with no address. The address was determined on the postal code and/or city. One respondent, 1061313, marked some trips as private. So for this respondent it wasn't possible to calculate the distance and time of the trips, also because the coordinates of these destinations where just the same as the home location.

The distance and time that are calculated by the route planner are in most cases different from the distances and times (given by the respondents) that are available in the OVG 3. Some trips have a huge deviation in space or time, but in other cases the values are more or less the same. A possible explanation is overestimation as well as underestimation by the respondents or by using the wrong data for a trip. Using wrong data implies that when no house number is available TomTom chooses the middle of a street, so this can declare some small deviations. Another explanation is that in the OVG 3, in most cases, no house numbers are available. So the position taken by the route planner can differ from the position indicated by the respondent. The TomTom route planner is a route planner for cars, so all the distances and times are compared for cars. When a respondent takes a trip by another (none motorised) vehicle, this can also be an explanation for the differences. TomTom route planner was used because they take traffic delays on specific days into account. A disadvantage of this is that TomTom doesn't distinguish the different transportation modes.

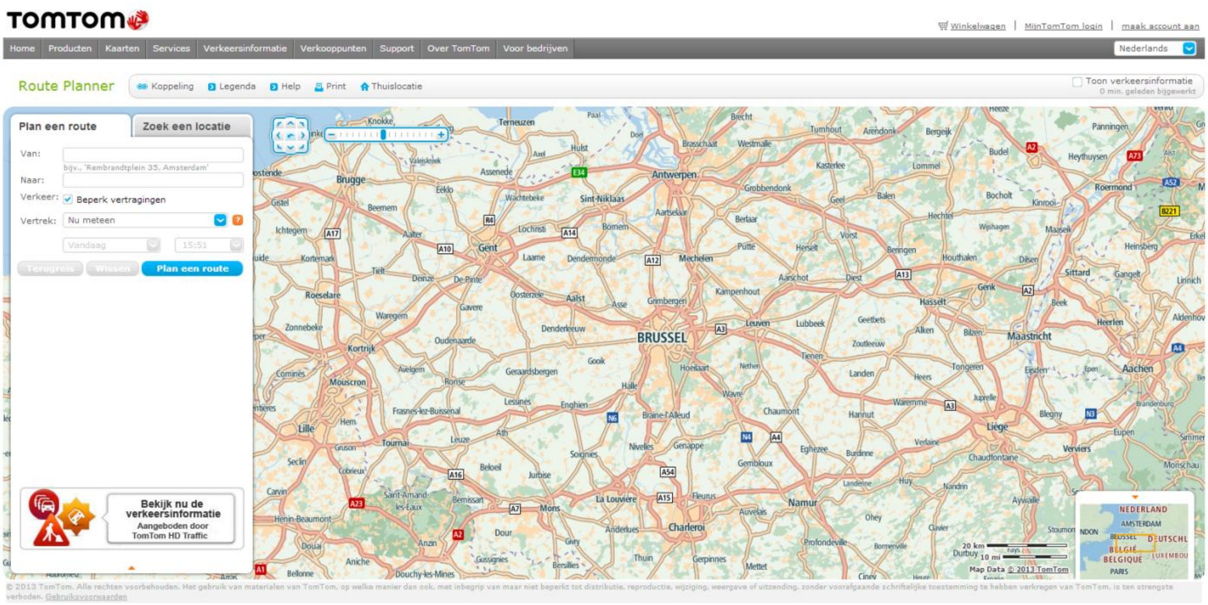


**FIGURE 7 TomTom route planner (TomTom, 2013).**

When comparing the distance given in the OVG 3 with the calculated distance by TomTom, the minimal deviation is 0 kilometres and the maximal deviation is 94,5 kilometres. With an average deviation of 3,7 kilometres. In 81,5% of the trips the deviation is equal or smaller than the mean deviation of 3,7 kilometres. Although this does not imply that the values in the OVG 3 are wrong. Respondents don't take necessarily the shortest path to a destination.

**TABLE 4 Comparing OVG 3 Distances With Real TomTom Distances**

| | Minimum (km) | Maximum (km) | Mean (km) |
|---|---|---|---|
| **Deviation between OVG 3 distances and real TomTom distances** | 0 | 94,5 | 3,7 |

### 6.2.2. Bird' eye view

The distance in bird's eye view is measured in QGIS. With the function 'lijn opmeten' or measure line it is possible to calculate the distance between two or more points. De distance measured (in bird's eye view) is in some cases bigger than the distance that was calculated by the TomTom route planner. An explanation for this is that, in TomTom, a point in the street is used (chosen by TomTom) as reference point when no house numbers are available. In QGIS the distance between the coordinates given in the OVG 3 was measured. FIGURE 8 shows how to measure the (bird's eye view) distance between two points in QGIS.

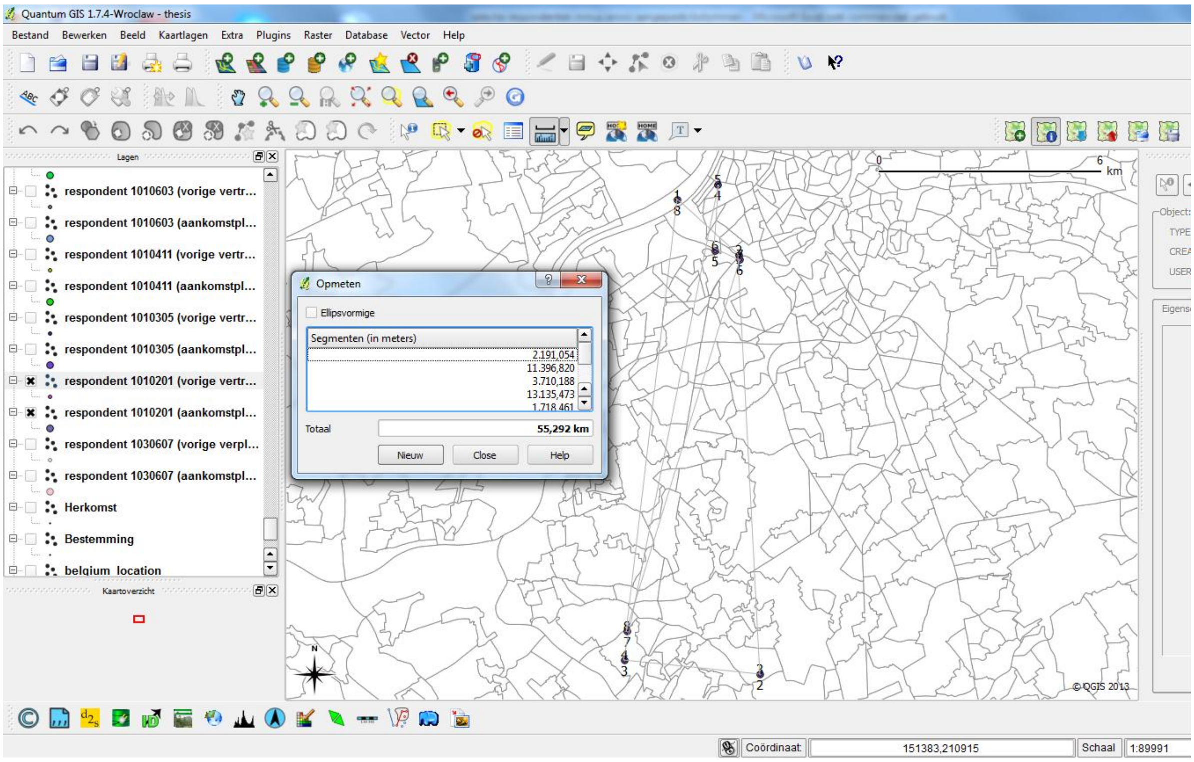


**FIGURE 8 Measuring distances in bird's eye view.**

## 6.3. Calculating Potential Path Area

This part explains the steps how to determine a respondent's potential path area. It contains a detailed explanation of how and what to do in QGIS. To make it clear, this explanation is based on the trips of one respondent. To calculate the potential path area, the bird's eye view distance is used. This distance is used because it is easy to determine the number of alternative locations. An advantage of this method is that one can easily drawn a circle to determine the number of alternative locations. Some disadvantages are that the real travel distance and time aren't taken into account as well as a respondent's time budget. A circle will be drawn, with the departure point of a trip as midpoint and the radius will be equal to the distance to the arrival point that is given by the respondent. It is chosen to use the bird's eye view because when using the real distance, as radius, the surface a respondent can reach will be larger than he or she can reach in reality. The real distance will always be larger than the bird's eye view distance because it is, in most cases, not possible to travel straight to a destination. When using the bird's eye view it is certain that a respondent can reach all the alternative locations it the drawn circle, because these locations will be more or less within the same real travel distance as the current trip.

In this method only travel distance is used, there is no account of the time budget of respondents. This is because every single trip is analyzed and not the whole chain, as in some of the methods in the literature study. Thereafter is looked which location are inside this circle and similar to the current activity type. For example: if a respondent indicates that it was a shopping trip, the number of shops within the drawn circle will indicate the number of alternative locations.

When opening QGIS the first thing to do is uploading a layer of Belgium. This layer contains the zones of Belgium. The layer must be uploaded as a vector layer, make sure the 'Ruimtelijk Referentie Systeem' or spatial reference system is *Belge 1972* and the scale is in kilometres (project settings). Now QGIS shows a map of Belgium divided in zones.

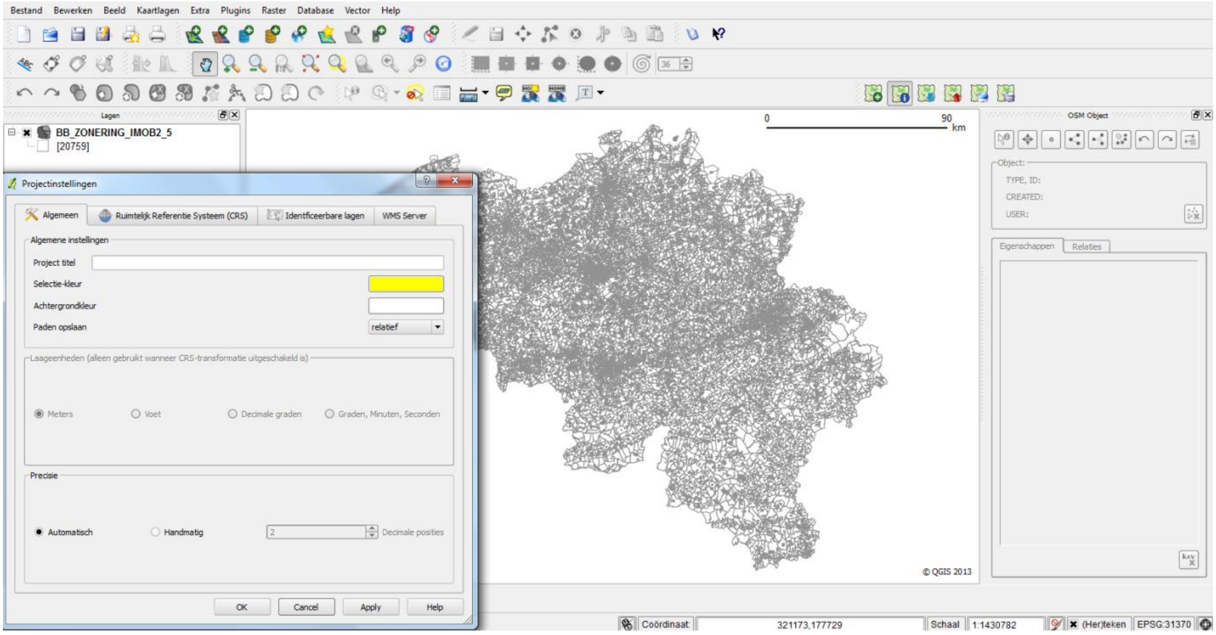


**FIGURE 9 Uploading map of Belgium.**

The next thing is uploading an individual respondent by adding a CSV-file (excel-file saved as .csv). This file contains all the information of a respondent given in the OVG 3. To display the information, determine the X en Y coordinates so QGIS can display the coordinates on the map. This procedure must be run twice, for the coordinates of the last departures and the coordinates of the arrival point. Also note that the 'Ruimtelijk Referentie Systeem' that is used is *Belge 1972*. It is possible to label the coordinates with the number of the trips, so the departure and arrival coordinates of a trip can be linked to each other.

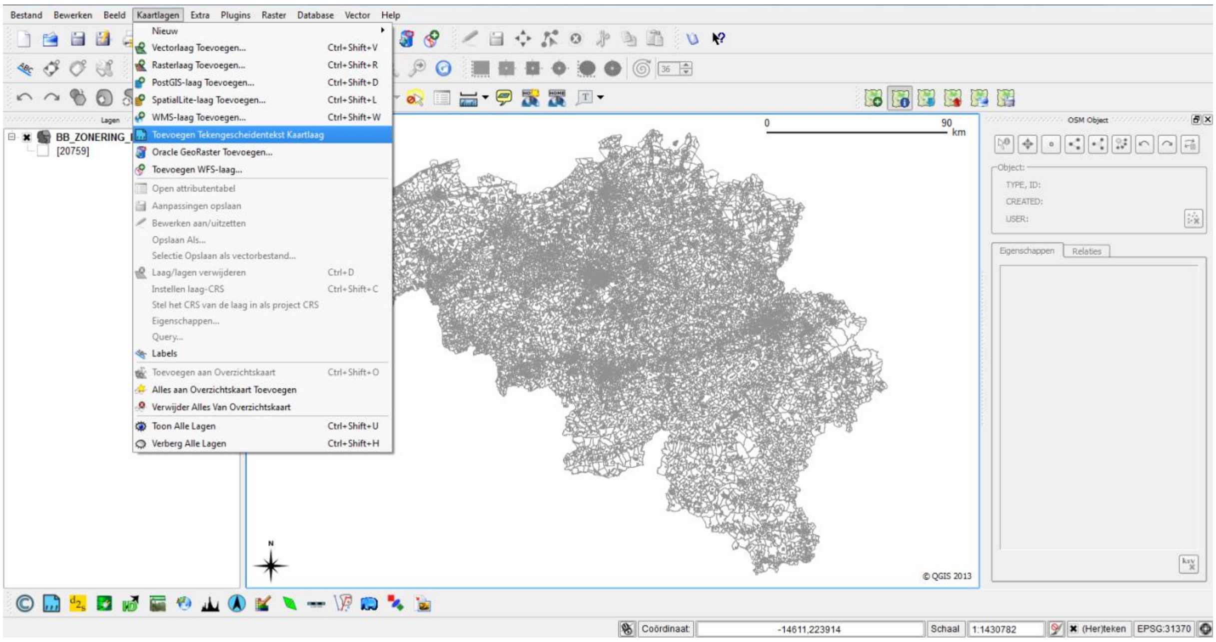


**FIGURE 10 Uploading respondents coordinates.**

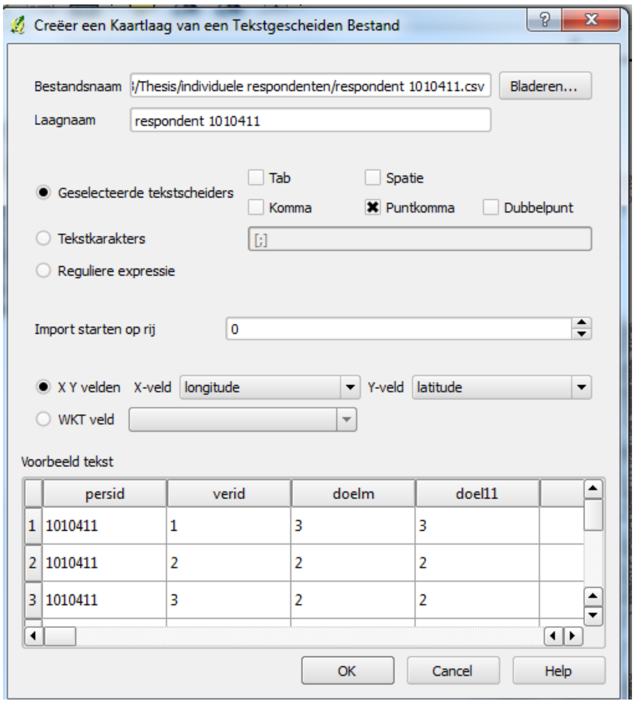


**FIGURE 11 Uploading respondents coordinates.**

After uploading the respondent coordinates the next thing to do is to upload the layers that contain all of the information for the environment, the OSM objects. This is possible with the OSM data downloader, available in QGIS. To download the information for a specific area, zoom in on this area. Make sure the area is not too big because it is only possible to download a limited amount of data at once.

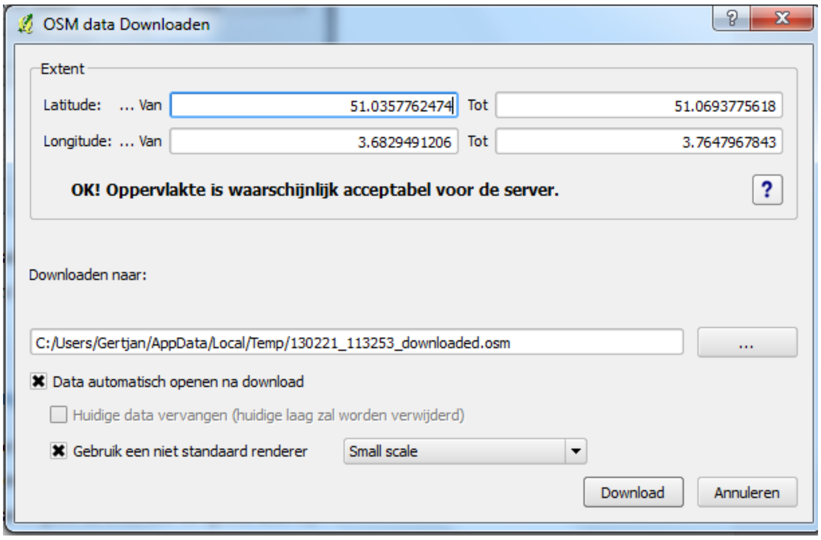


**FIGURE 12 Downloading OSM objects.**

After uploading these OSM objects the map will contain information about the streets, points of interest, areas... The map will look like the FIGURE 13.

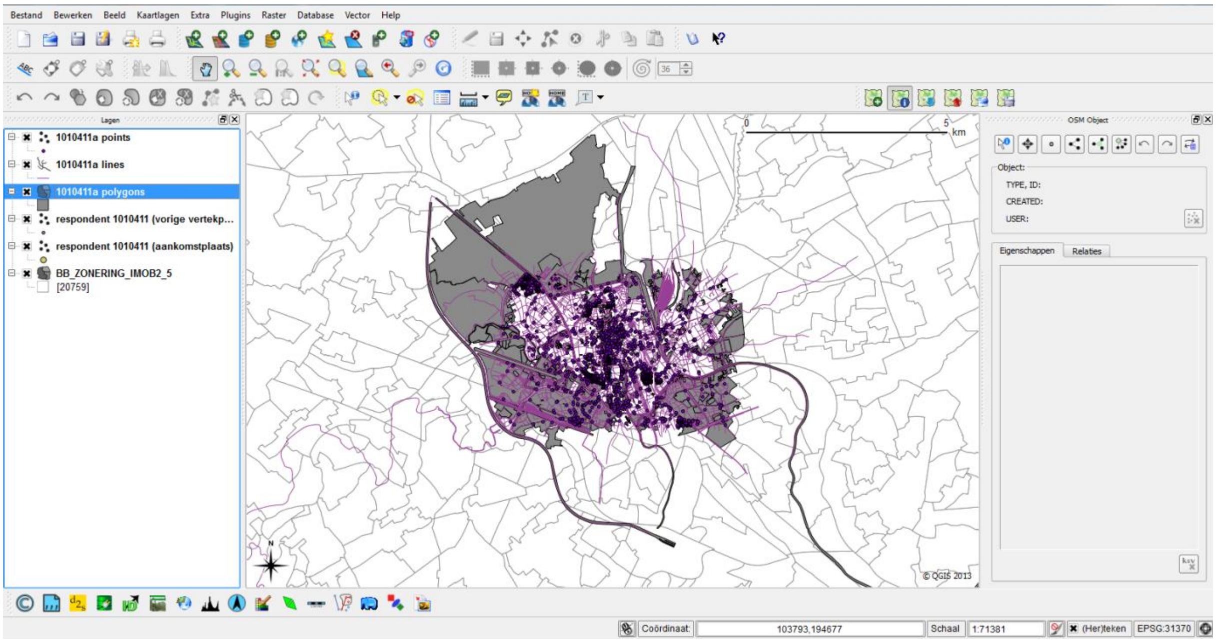


**FIGURE 13 Map of Belgium with OSM objects.**

Now one can drawn a circle to determine which points are within the same distance as the current destination. The midpoint of the circle exists of the coordinates of the previous location; the radius is the distance (in bird's eye view) from departure to destination. QGIS will highlight all the points of interest in this circle. These places are shown in the attribute table. In this attribute table it is possible to select all the points that can be an alternative for the current destination of the trip.

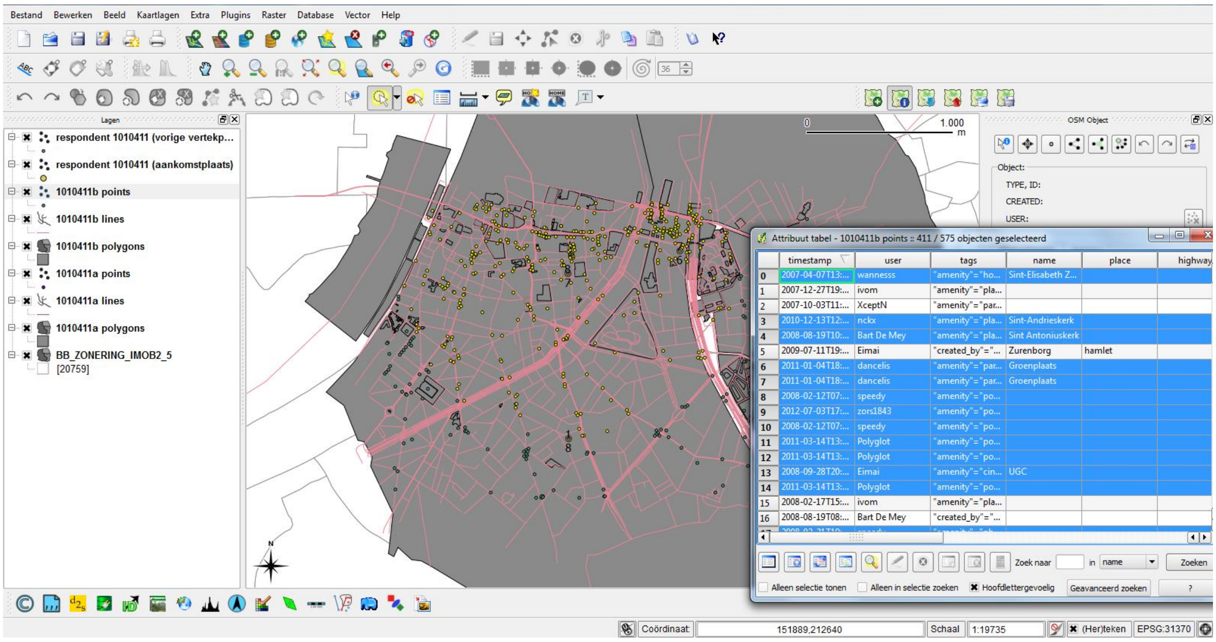


**FIGURE 14 Selection of alternative locations within PPA.**

This procedure must be run for each respondent and for each individual trip in the selection that was made earlier. For this research it isn't necessary to do this for all the trips because the focus is on a couple of trip purposes. Nevertheless it is done for all the trips in the sample. The data are available in the excel-file 'final selection'. The selection of specific trip purposes is explained further on in the document.

For every trip purpose a table is made with the average number of alternative locations a respondent can reach depending on the variables like distance, transportation mode, municipality type and time. These tables contain the average number of alternatives of the selection, the minimum number of alternatives in the selection, the maximum number of alternatives in the selection and the confidence interval of the selection. Each analysis is provided with a table/column with the average surface of each factor, this to give an indication of what the average surface is that a trip covers. To give an idea of the surface ,TABLE 5 shows some values of surfaces to compare with. The average surface is calculated based on the average radius of all the trips with the specific characteristic (for example all cyclist trips). With this average radius (r) is used to calculate the surface of a circle ($\pi * r^2$).

**TABLE 5 Values to Compare Trip Surfaces**

| | Surface |
|---|---|
| **Belgium** | 30 527 km² |
| **Flanders** | 13 522 km² |
| **Province of Limburg** | 2 422 km² |
| **Hasselt** | 102 km ² |

(FOD, 2013)

The confidence intervals are calculated based on the excel-files, the calculations are available in each specific excel-file. The formula that is used to calculate the confidence interval is: =BETROUWBAARHEID(alfa;standard deviation;size of the selection) (Microsoft, 2013). With alfa equal to 0,05 (to calculate a confidence interval of 95%), the standard deviation is calculated with the function =STDEV() and the size of the selection indicates how much trips the selection with a specific attribute (municipality type, transportation mode,...) counts. The confidence interval indicates between which values the actual value is likely to be situated. When only one value for alternative locations is available, it is not possible to calculate a confidence interval. In case the data are not complete, so one can not calculate a confidence interval because some data is missing to calculate the confidence interval. In these cases the confidence interval will give a distorted picture. The minimal and maximal number of alternative locations of the selection is located outside the confidence interval in most of the cases. (Anderson et al., 2006)

In some cases the minimal value for the confidence interval was negative, which is not possible in this study. In this research this will imply that the real number of alternative locations a respondent can reach will be situated between a value lower than zero and the maximal value. When a confidence interval had a negative minimal border this is changed in zero, so the lower boundary of the confidence interval is considered to be zero.

The confidence interval is also calculated for the average surface (based on bird’s eye view distance). The same remarks are valid in this case. When a value of the confidence interval is negative this is considered to be zero, because a surface cannot be negative. The confidence intervals for the surface are also 95% confidence intervals. The calculations are based on the same method as mentioned above and are also available in the specific excel-files of each trip purpose.

# 7. RESULTS

This chapter contains the results of the analysis described in the previous chapter. For the continuation of the research, the sample of 80 remaining respondents is analyzed, which respondents can be found in the appendix. These 80 respondents remain (corresponding to 1,1% of the whole OVG 3 respondents) after deleting errors from the random selection of 100 respondents (FIGURE 15). The selection of one hundred was made to have an exact number of respondents to analyze, initially the idea was to analyze as much respondents as possible. But to make this number concrete one has taken 100 respondents. Some trips can't be analyzed because it isn't possible to determine alternative locations. This is the case for trip purposes like visiting, business trip, walking and dropping someone off. These activities can take place at anytime and especially anywhere. With the data that are used (points of interest) it is not possible to determine (specific) alternative locations for these purposes. For the other remaining trips (work, leisure, shopping, education and services) the analysis is done as described earlier.

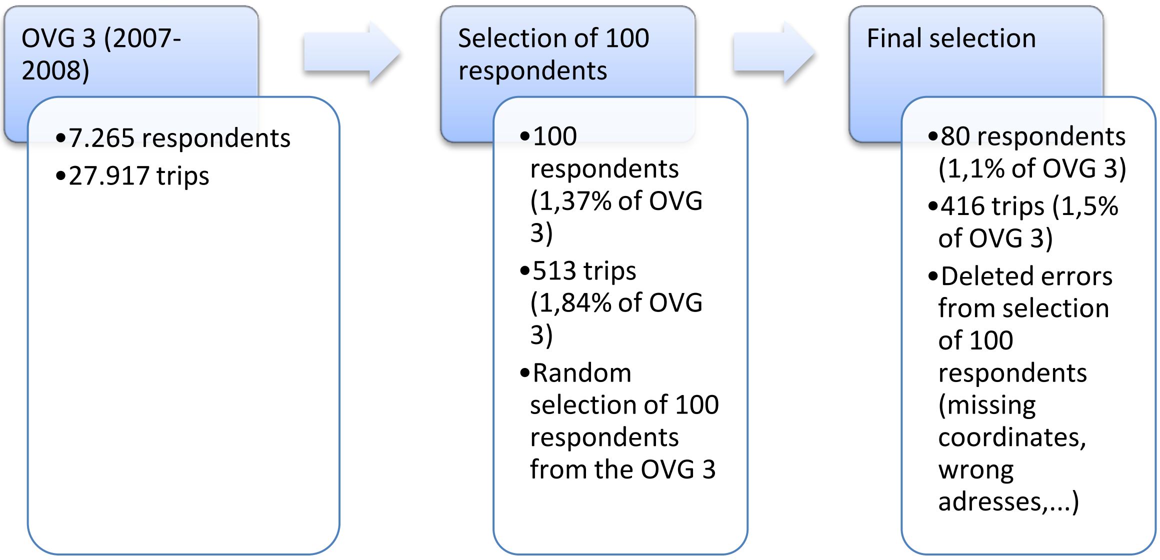


**FIGURE 15 Schematic overview of data selection.**

The selection counts a huge number of trips, 158 trips representing 38% of the total number of trips, where the respondents indicate that it was a home-based trip. Home cannot be on more than one location because it is a specific location in space. To deal with this 'problem' the trip purpose of these trips was adjusted to the trip purpose of the previous trip, as in the OVG 3. The following percentages of trips represent the original trip purposes plus the adjusted home-based trips. Respondents also indicated that some trips had another purpose then the possible answers. For these trips it is also impossible to find alternative locations because it is unknown what the purpose was, these trips represent 3% of the total number.

So for the analysis the focus is on shopping (22%), leisure (12%), work (15%), services (6%) and education (5%) based trips. In case of shopping trips, one has looked at the number of alternative shops within a respondent current space-time interval. For the work-based trips is looked at industrial areas or buildings. Looking at the leisure trips, we searched for alternative leisure locations, independent of the exact type of leisure activity the respondent is taking part in. And for the service locations is looked at alternative services like police stations, banks, post office, pharmacy,....

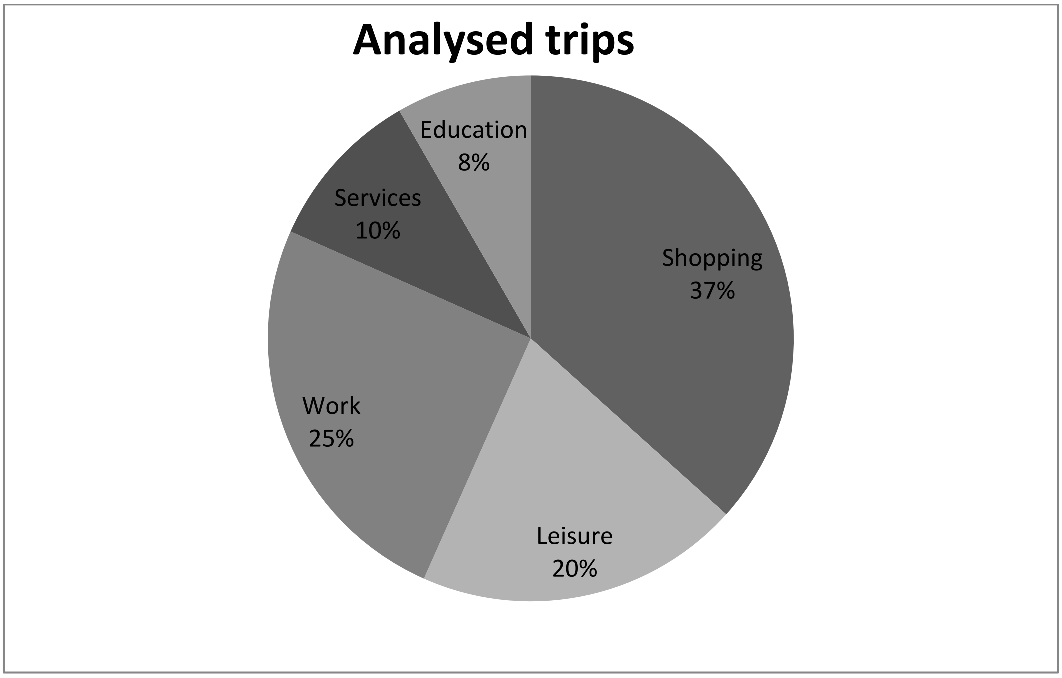


**FIGURE 16 Analyzed trips.**

## 7.1. General results

The total number of analyzed trips (work, shopping, education, leisure and services) in this research represents 60% of the total number of selected trips. Comparing the percentages of our selection to the OVG 3, displays the image of TABLE 6. This table shows a reasonably large conformity between the percentages of trips in the OVG 3 and the selection for this research. Some outliers are the trips with the purpose to drop someone else off and the business trips. But the difference between the OVG 3 and the selection for this research is negligible.

**TABLE 6 Comparing OVG 3 and Own Research**

| Trip purpose | OVG 3 (%) | Selection for research (%) |
|---|---|---|
| **Business trip** | 5,7 | 9 |
| **Work** | 14,76 | 15 |
| **Shopping** | 21,42 | 22 |
| **Visit** | 12,34 | 10 |
| **Education** | 6,60 | 5 |
| **Walk** | 3,74 | 1 |
| **Dropping someone off** | 11,50 | 17 |
| **Leisure** | 13,15 | 12 |
| **Services** | 5,34 | 6 |
| **Something else** | 4,63 | 3 |
| **No answer** | 0,82 | 0 |

After this general overlook of the results, the different trip purposes of the trips are elaborated, beginning with the shopping trips. Followed by the leisure and education-based trips and finally the work-based and service trips.

For each of the single trip purposes the same things are analyzed. The next things are determined: the influence of travel distance in bird’s eye view is on the number of alternative locations a respondent can reach. As well as the influence of transport mode, municipality type, real travel time and time of the day. So the analysis of each trip purpose is based on these aspects. The number of alternative locations is calculated once, based on the distance in bird’s eye view and then is looked at the influence of the previously mentioned factors.

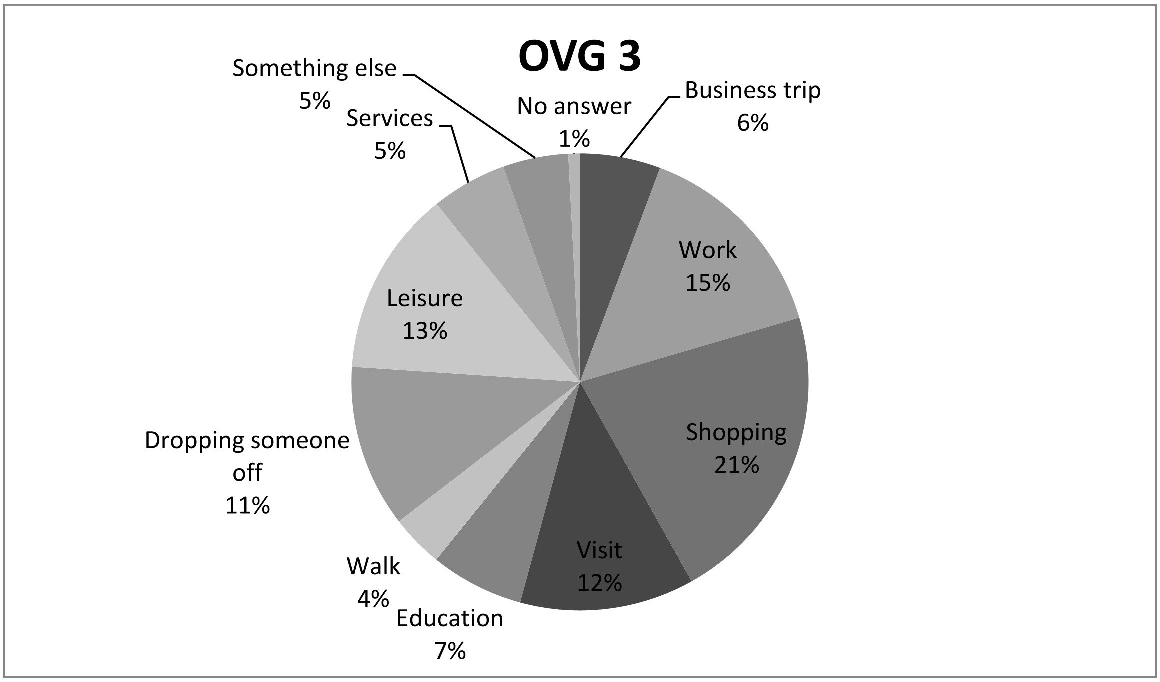


**FIGURE 17 Distribution OVG 3 trips.**

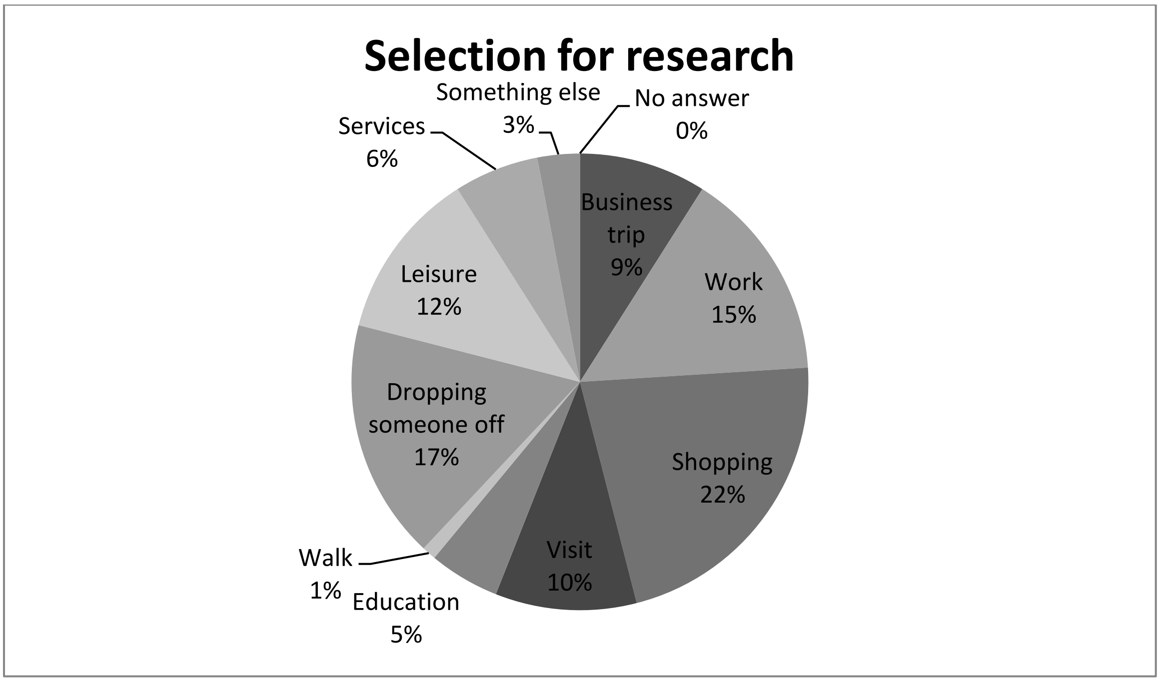


**FIGURE 18 Distribution selection for research trips.**

When analyzing the average number of alternative locations a respondent can reach, it seems that trips with a shopping purpose can reach more alternative locations than other trip purposes. Work related trips are also able to select multiple other work locations. Although for work based trips it is difficult to say that respondents can switch locations. Because it is not possible to say that one day a respondent will work on place x and the other day on place y. So the meaning of this analysis is to indicate how much other work locations a respondent can reach when he or she wants to switch jobs or look for another, comparable, employer within the range of his or her current distance. Further it is seen that respondents, who take part in leisure activities have the least alternative locations within their current bird's eye view distance. The values for shopping and work in the POI column are missing because this layer doesn't contain information for these trip purposes, as will explained further on. The values in the OSM objects and the POI layer are more or less equal to each other. Except the value for education based trips, the POI layer indicates more alternative locations than the OSM objects. The results in TABLE 7 are based on the complete results for each trip purpose. This means that the trips with a distance larger than 20 kilometres are filtered out of this analysis.

**TABLE 7 Average Number of Alternative Locations for each Trip Purpose**

| | OSM objects | POI layer |
|---|---|---|
| **Shopping** | 77,8 | / |
| **Leisure** | 14,1 | 10,8 |
| **Education** | 18,6 | 28,5 |
| **Work** | 63,1 | / |
| **Services** | 23,2 | 21,6 |

## 7.2. Shopping

The total number of shopping trips in our selection is 50 trips out of 416, this represents 12% of the total number of trips. The layer 'places of interest' doesn't contain information about the presence of shopping facilities, so only the OSM objects can be used. These layers contain information about the presence of shops. By analyzing this particular type of trip isn't made any distinction between the types of shop. In the attribute table is looked under the column 'tags' and searched for shops. In general an individual has 77,8 alternative locations where he or she can find an alternative shop for his or her current location. This ranges from zero alternatives up till 1242 alternative locations.

The first analysis that is made, is based on the distance to the locations. This shows how much alternatives a respondent can reach within a specific distance. The assumption is that the number of alternative locations will increase with the distance. TABLE 8 shows the number of shopping locations within specific distances. In a distance of one kilometre, a respondent will find almost 3 locations where he or she can participate in a shopping activity. Logically, when the distance increases the number of locations for shopping activities will grow. In the selection that is made, a respondent can arrive at more than 500 locations when the distance is larger than ten kilometres. The table shows a comparison between the number of alternatives when taking 90 shopping trips into account and when looking at 88 trips. This distinction is made because the area of two trips was too big to analyse. So these 88 trips don't contain the two trips that were beyond (approximate) 20 kilometres because the processing time for these trips was too long and labour-intensive. This will occur again by other trip purpose. So in this case the results of the OSM objects (88) are complete, in the case of OSM objects (90) two trips are missing so the average number of alternative locations isn't complete (*) for distances above ten kilometres.

It is not possible to calculate the confidence interval for trips larger than ten kilometres because these data are not complete. For other distances it is possible to calculate a confidence interval. The value of the number of alternatives is, for every distance class, inside the confidence interval. The real value of the number of alternatives is located between the minimal and maximal value of this confidence interval.

**TABLE 8 Alternative Shopping Locations Based on Travel Distance**

| Distance | Alternative locations | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | OSM Objects (90) | | | | OSM objects (88) | | | |
| | Alternatives | Min. | Max. | C.I. | Alternatives | Min. | Max. | C.I. |
| **< 1 km** | 2,87 | 0 | 13 | (1,68;4,05) | 2,87 | 0 | 13 | (1,68;4,05) |
| **1-5 km** | 37,08 | 0 | 349 | (10,73;63,43) | 37,08 | 0 | 349 | (10,73;63,43) |
| **5-10 km** | 121,75 | 12 | 318 | (68,14;175,36) | 121,75 | 12 | 318 | (68,14;175,36) |
| **> 10 km** | 404,6* | 126 | 1242 | / | 505,75 | 126 | 1242 | (273,25;738,25) |

**TABLE 9 Average Surface Shopping Trips (Distance)**

| Distance | Average surface ($km^2$) | CI |
|---|---|---|
| **< 1 km** | 1,27 | (1,04;1,53) |
| **1-5 km** | 19,59 | (13,61;26,67) |
| **5-10 km** | 176,71 | (132,38;227,44) |
| **> 10 km** | 1440,07 | (281,71;3494,25) |

**TABLE 10 Alternative Shopping Locations Based on Municipality Type**

| **Municipality type** | **Alternative locations** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **OSM Objects (90)** | | | | **OSM objects (88)** | | | |
| | Alternatives | Min. | Max. | C.I. | Alternatives | Min. | Max. | C.I. |
| **Rural areas** | 58,66* | 0 | 402* | / | 61,27 | 0 | 402 | (26,26;96,28) |
| **Metropolitan areas** | 146,9 | 1 | 544 | (0;297,20) | 146,9 | 1 | 544 | (0;297,20) |
| **Urban areas** | 32,64 | 1 | 178 | (14,25;51,03) | 32,64 | 1 | 178 | (14,25;51,03) |
| **Urban area around Brussels** | 300,71 | 4 | 1242 | (0;642,87) | 300,71 | 4 | 1242 | (0;642,87) |

**TABLE 11 Average Surface Shopping Trips (Municipality Type)**

| **Municipality type** | **Average surface (km²)** | CI |
|---|---|---|
| **Rural areas** | 83,7 | (10,74;225,63) |
| **Metropolitan areas** | 61,44 | (1,51;208,75) |
| **Urban areas** | 32,69 | (13,51;60,22) |
| **Urban area around Brussels** | 151,44 | (18,89;410,71) |

In a second analysis is looked at how much locations respondents can reach depending on the area they live in. The assumption in this case is that respondents who live in urban areas have more options than the ones who are living in rural areas. Due to the results, respondents in metropolitan areas have three times more options than people who live in rural areas. So the assumption meets reality. Also in this case the distinction is made between 90 trips and 88 trips. The difference between these two is situated in the alternative locations a person can reach in rural areas (*). People who live in rural areas can reach more alternative locations than people in urban areas. In one way or another this is a strange result. Because it is expected that people in urban areas have more options than the ones who live in rural areas. An explanation for this result can be that the distance people must travel in rural areas is bigger than the distance for people who live in urban areas. So the ones who live in rural areas must travel further to an activity, so they have a larger radius where they can participate in alternative activity locations. People in urban areas will probably have more alternatives in a shorter distance than people in rural areas. When taking the time budget of a respondent into account, activity duration or other time elements this conclusion can be different. This conclusion depends on the method that is used in the research.

Respondents who live or participate in an activity in the environment of Brussels are able to reach much more alternative locations within their current distance to an activity. This can be explained by the fact that the ‘Brussels Hoofdstedelijk Gewest’ is the most urbanized area in Belgium (svh, 2007). Also the respondents who participate in an activity in metropolitan areas have a lot more alternative shopping locations than other respondents. This isn’t unusual, because a city centre counts more shops than a rural area.

In the next part the influence of transportation mode on the number of alternative locations is investigated. TABLE 12 shows that people who travel by car or another motorised vehicle can reach more locations than people travelling by foot or bike. The shopping trips made by train were beyond 20 kilometres so, as explained earlier, it wasn’t possible to analyse these trips with the developed method.

Remarkable in the table with transportation mode is that respondents who travel by foot can reach more locations than respondents who do their shopping by bike. A possible explanation for this is that when respondents do their groceries by foot they live in a city or an area with a high(er) density of shops. FIGURE 19 is a visualisation of the results from TABLE 12.

Some trips in the selection are made by train, but these trips are further then 20 kilometres, so they cannot be analyzed, using the developed method. It was not possible to calculate a confidence interval for bus trips because there was only one bus trip in the selection and it is not possible to determine a confidence interval for one value. The other values, for alternative locations, are all between the minimum and maximum value of the confidence interval.

**TABLE 12 Alternative Shopping Locations Based on Transportation Mode**

| Transportation mode | Alternative locations | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | OSM Objects (90) | | | | OSM objects (88) | | | |
| | Alternatives | Min. | Max. | C.I. | Alternatives | Min. | Max. | C.I. |
| **Pedestrian** | 18 | 0 | 171 | (0;43,42) | 18 | 0 | 171 | (0;43,42) |
| **Cyclist** | 6,15 | 0 | 46 | (1,06;11,24) | 6,15 | 0 | 46 | (1,06;11,24) |
| **Car driver** | 122,49 | 0 | 1242 | (44,61;200,37) | 122,49 | 0 | 1242 | (44,61;200,37) |
| **Car passenger** | 114,33 | 1 | 349 | (48,13;180,53) | 114,33 | 1 | 349 | (48,13;180,53) |
| **By bus** | 153 | 153 | 153 | / | 153 | 153 | 153 | / |
| **By train** | /* | / | / | / | /* | / | / | / |

**TABLE 13 Average Surface Shopping Trips (Transportation Mode)**

| Transportation mode | Average surface (km²) | CI |
|---|---|---|
| **Pedestrian** | 3,24 | (1,75;5,17) |
| **Cyclist** | 7,55 | (2,07;16,46) |
| **Car driver** | 67,67 | (32,61;115,36) |
| **Car passenger** | 80,01 | (36,53;140,33) |
| **By bus** | 8,04 | / (only 1 value) |
| **By train** | 10 495,56 | / (only 2 values) |

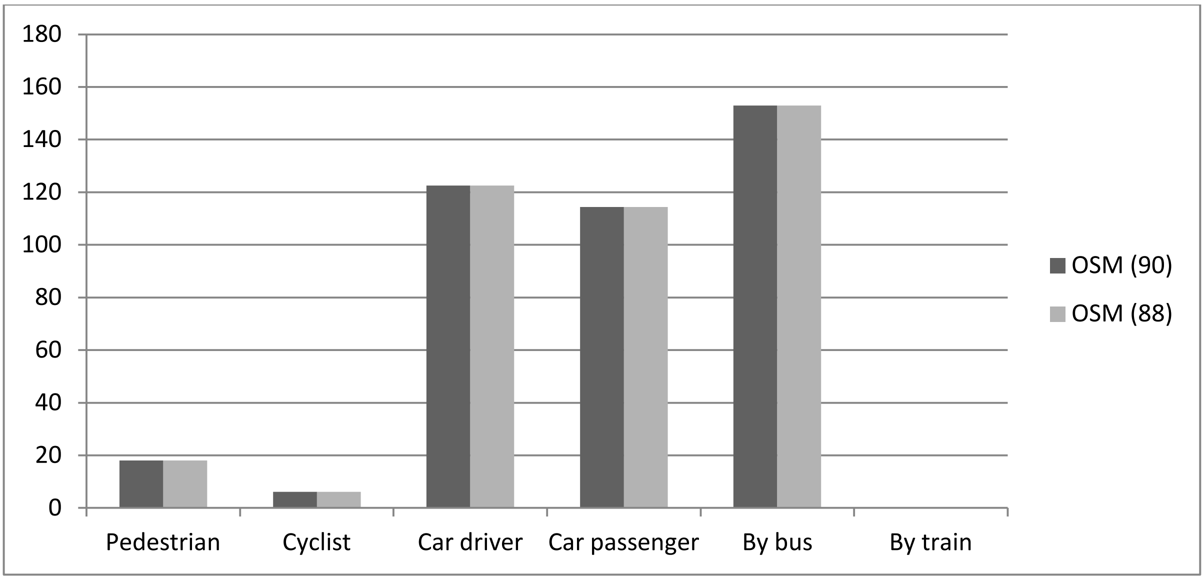


**FIGURE 19 Alternative shopping locations based on transportation mode.**

The final two analyses are based on time. In the first one is looked how the number of alternative locations react when the travel time changes. The two ‘missing’ trips are located at a travel time above 30 minutes (*). The table shows that the number of alternative locations increases as travel time increases, which is logical. When a respondent has to travel between five and ten minutes the number of alternative locations is almost five times more than when he or she travel less than five minutes. The number of alternative locations a person can reach when travelling between 11 and 20 minutes is more than four times bigger than when he or she travels five to ten minutes.

When the travel time is longer than 30 minutes it is not possible to say how much locations a respondent can reach because the distance is too big to determine the alternative locations using the current method. In case of two trips the travel time is larger than 30 minutes.

A final analysis is based on the periods of the day. To do this, the day is divided into four parts. The first part contains the morning peak (6:30 – 09:30), the second part consists of the time during the day between the morning and evening peak. A third part contains the evening peak (16:00 – 19:00) and the final part is the night. TABLE 16 shows that a person can reach more location in an off peak period. Because the research was done based on distances in bird’s eye view this analysis isn’t that meaningful. It would be better if real distances and travel times were taken into account as well as the time budget of a respondent and other time related issues from the travel diaries. This is a suggestion for further research. Expectations are that people can reach less alternative locations (in the peak periods) because traffic delays are taken into account. Also the duration time of an activity will influence the travel time to the activity location. For example: when people have a time budget of one hour to do the weekly shopping, they will not single travel 25 minutes to a supermarket to have ten minutes to do the shopping and travel 25 minutes back.  Another expectation is that: because of not including the opening hours (authority constraint) of shops in the research, it is more likely that the number of alternative locations between 19h and 6h30 and between 6h30 and 9h30 will decreases. This because of the fact that most shops close at 6 pm and re-open at 9 am or 10 am, with the exception of night shops and big supermarkets (open till 8pm). One of the not-analyzed trips is situated between 6h30 and 9h30 and the other between 9h30 and 16h (*). FIGURE 20 shows the results of OSM objects (88) with regard to the periods of the day in a graphic. This figure clearly shows that a respondent can reach more alternative locations during the off peak periods.

**TABLE 14 Alternative Shopping Locations Based on Travel Time**

| **Travel time (min.)** | **Alternative locations** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **OSM Objects (90)** | | | | **OSM objects (88)** | | | |
| | Alternatives | Min. | Max. | C.I. | Alternatives | Min. | Max. | C.I. |
| **< 5** | 11 | 0 | 349 | (0;26,10) | 11 | 0 | 349 | (0;26,10) |
| **5-10** | 50,4 | 0 | 319 | (16,06;84,76) | 50,4 | 0 | 319 | (16,06;84,76) |
| **11-20** | 216,7 | 16 | 579 | (110,87;322,47) | 216,7 | 16 | 579 | (110,87;322,47) |
| **21-30** | 357,2 | 103 | 1242 | (0;761,48) | 357,2 | 103 | 1242 | (0;761,48) |
| **> 30** | * | / | / | / | * | / | / | / |

**TABLE 15 Average Surface Shopping Trips (Travel Time)**

| **Travel time (min.)** | **Average surface (km²)** | CI |
|---|---|---|
| **< 5** | 4,15 | (2,55;6,14) |
| **5-10** | 24,1 | (13,77;37,29) |
| **11-20** | 251,84 | (169,25;350,78) |
| **21-30** | 350,33 | (198;545,84) |
| **> 30** | 10 495,56 | / (only 2 values) |

**TABLE 16 Alternative Shopping Locations During Periods of the Day**

| Periods of the day | Alternative locations | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | OSM Objects (90) | | | | OSM objects (88) | | | |
| | Alternatives | Min. | Max. | C.I. | Alternatives | Min. | Max. | C.I. |
| **6:30 – 9:30** | 32,25* | 0 | 318 | / | 34,4 | 0 | 318 | (0;80,29) |
| **9:30 – 16:00** | 105,5* | 0 | 1242 | / | 107,8 | 0 | 1242 | (42,75;172,79) |
| **16:00 – 19:00** | 44,9 | 1 | 319 | (9,13;80,59) | 44,9 | 1 | 319 | (9,13;80,59) |
| **19:00 – 6:30** | 108,5 | 2 | 402 | (0;300,35) | 108,5 | 2 | 402 | (0;300,35) |

**TABLE 17 Average Surface Shopping Trips (Periods of the Day)**

| Periods of the day | Average surface (km²) | CI |
|---|---|---|
| **6:30 – 9:30** | 104,77 | (4,22;507,41) |
| **9:30 – 16:00** | 91,04 | (26,6;193,93) |
| **16:00 – 19:00** | 13,91 | (2,64;34,04) |
| **19:00 – 6:30** | 86,59 | (5,28;266,12) |

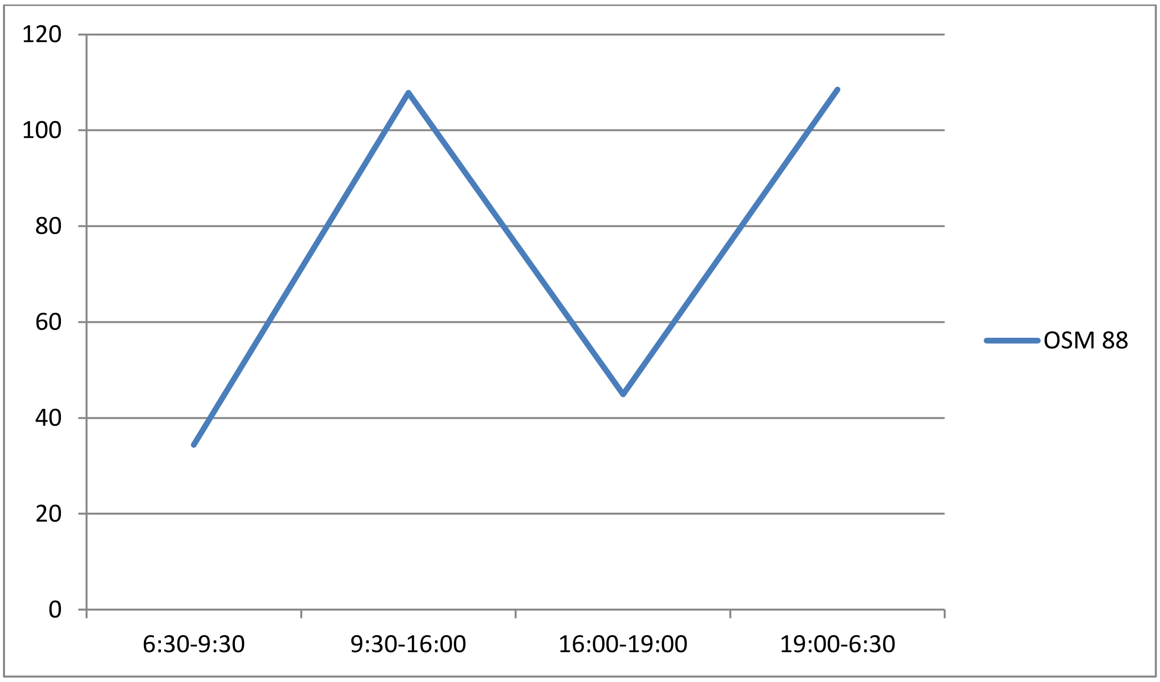


**FIGURE 20 Alternative shopping locations during periods of the day.**

In the first time based analysis it is not possible to calculate the number of alternative locations, so it is also not possible to determine the confidence interval. In the second analysis it is not possible to calculate a confidence interval for the periods between 6:30 am till 9:30 am and for 9:30 am till 4:30 pm. This is because some values are missing due to the used method. In both analyses the value of alternative locations is situated inside the confidence interval. The real value will be situated between the maximal and minimal value of this interval.

## 7.3. Leisure

For this type of activities it is possible to compare the OSM objects with the points of interest layer, because both contain information about leisure activities. The leisure-based trips represent 12% of the total number of selected trips. When searching for alternative locations within the points of interest layer, the average number of alternative locations a respondent can reach was 47,6 locations. This number ranges from 0 to 741 locations. To determine the alternative leisure locations is searched for leisure activities as well as sport and tourism locations. There isn't made a distinction between the types of leisure activities. This because the respondents didn't had to indicate what type of leisure activity they took part in, in their travel diary. We looked for all possible leisure activities. Disadvantage of this method is that when a respondent is going to the movie, also all sport facilities are displayed as alternative leisure locations. An advantage of doing it like this is that people have multiple options for leisure activity. So when they don't know what to do they can choose between all the activities within their range. For the layer with OSM objects, the general average contains 11,6 alternative locations ranging from 0 to 86. The low average number can be explained by the amount of analyzed respondents. Because the method with the OSM objects is highly time consuming and intensive, trips where the distance in bird's eye view was larger than 20 kilometres were not analyzed. This because of the fact that the program was running slow when adding more layers and the analysis took a long time, using the chosen method. Again, a distinction is made between the number of trips, 50 or 42. The results for the 42 trips are complete, these of the 50 trips contain trips that cannot be analyzed. So the number of alternative locations can be lower or higher than when this was happened (*).

The first thing that is analyzed is how many locations a respondent can reach within limited distances. As in the case of shopping locations, TABLE 18 shows that a respondent can reach more locations when the distance increases. The amount of leisure activities close to home (< 1km) is not that much. By comparing these results with the results for shopping trips it is clear that there are less locations for leisure activities than in case of shopping activities.

The fact that the number of alternative locations for 5-10 km is higher than for >10 km in the column OSM objects (42) can be explained because of the fact that the results of trips >10 km only consist out of two trips and the results for 5-10 km out of more trips.

When taking the area of departure of a trip into account (for 42 trips) and the leisure locations they are able to reach, it can be said that the people who live in metropolitan areas and the urban area around Brussels, are able to reach more alternative leisure locations than people who live in rural areas or urban areas. As mentioned before, it was difficult to analyse trips with a distance larger than 20 kilometres. Out of this table (for 42 trips) seems that people living in rural areas have more alternative locations than people in urban areas. Respondents who live in the metropolitan area and the urban area round Brussels are having the most possibilities and these values are more or less equal to each other.

It is not possible to calculate a confidence interval for the longest distance class (OSM (50)), this due to the already mentioned ‘problems’ of the method that is used. In all the other cases the average number of alternative locations is located inside the confidence interval of 95%. The same applies to trips which origin is located in rural areas, urban areas and the urban area around Brussels. In these cases a value is missing, due to the method, so it is not possible to set up a confidence interval. For all the other values it is possible to determine the confidence interval.

**TABLE 18 Alternative Leisure Locations Based on Travel Distance**

| Distance | Alternative locations | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OSM Objects (50) | | | | OSM Objects (42) | | | | POI layer (50) | | | | POI layer (42) | | | |
| | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. |
| **< 1 km** | 1,55 | 0 | 8 | (0.09;3) | 1,55 | 0 | 8 | (0.09;3) | 0,45 | 0 | 3 | (0;1,06) | 0,45 | 0 | 3 | (0;1,06) |
| **1-5 km** | 7,6 | 0 | 71 | (0,60;14,60) | 7,6 | 0 | 71 | (0,60;14,60) | 5,75 | 0 | 30 | (2,06;9,44) | 5,75 | 0 | 30 | (2,06;9,44) |
| **5-10 km** | 39,44 | 20 | 86 | (26,16;52,72) | 39,44 | 20 | 86 | (26,16;52,72) | 24,33 | 4 | 40 | (16,64;32,02) | 24,33 | 4 | 40 | (16,64;32,02) |
| **> 10 km** | 7* | 33 | 37 | / | 35 | 33 | 37 | (31,08;38,92) | 208,9 | 15 | 741 | (77,15;340,65) | 56,5 | 15 | 98 | (0;137,84) |

**TABLE 19 Average Surface of Leisure Trips (distance)**

| Distance | Average surface (km²) | CI |
|---|---|---|
| **< 1 km** | 1,31 | (0,7;2,1) |
| **1-5 km** | 21,48 | (13,52;31,28) |
| **5-10 km** | 200,5 | (165,43;238,94) |
| **> 10 km** | 1 690,93 | (528,81;3510,1) |

**TABLE 20 Alternative Leisure Locations Based on Municipality Type**

| Municipality type | Alternative locations | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OSM Objects (50) | | | | OSM Objects (42) | | | | POI layer (50) | | | | POI layer (42) | | | |
| | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. |
| **Rural area** | 14,92* | 0 | 86 | / | 17,05 | 0 | 86 | (7,64;26,46) | 61,42* | 0 | 741 | (0;126,65 | 9,61 | 0 | 40 | (4,30;14,94) |
| **Metropolitan area** | 22,17 | 0 | 71 | (0;45,05) | 22,17 | 0 | 71 | (0;45,05) | 25,5 | 0 | 98 | (0;55,92) | 25,5 | 0 | 98 | (0;55,92) |
| **Urban area** | 1,5* | 0 | 7 | / | 2 | 0 | 7 | (0,82;3,18) | 26,5 | 0 | 132 | (3,11;49,89) | 2,42 | 0 | 11 | (0,24;4,60) |
| **Urban area round Brussels** | 19,75* | 8 | 49 | / | 26,33 | 8 | 49 | (2,75;49,91) | 94,25 | 11 | 309 | (0;234,95) | 22,67 | 11 | 37 | (7,73;37,61) |

**TABLE 21 Average Surface of Leisure Trips (Municipality type)**

| Municipality type | Average surface (km²) | CI |
|---|---|---|
| **Rural area** | 263,26 | (35,93;699;96) |
| **Metropolitan area** | 53,67 | (1,38;250,49) |
| **Urban area** | 67,56 | (16,37;153,59) |
| **Urban area round Brussels** | 390,57 | (3,46;1418,65) |

Taking a look at the table with the results of alternative leisure locations according to the transportation mode (TABLE 22), it seems that people have more alternatives if they travel with motorised vehicles, which isn't illogical. This is the same result as for the shopping activities. They can travel further in the same amount of time when using a non motorised vehicle. The asterix (*) means that the selection counts trips where the distance was too large to analyse (at least for the OSM objects, for the POI this wasn't a problem), so these numbers are a bit distorted. So when looking at the columns with complete results, these with 42 trips, it is possible to conclude some things. Respondents who travel by bus have the most opportunities. But a remark for these values is that only one trip is made by bus so this number isn't very representable. For respondents who made their trip by foot the numbers for the OSM objects and the POI layer are approximately the same.

Normally it is plausible that car drivers and car passengers have the same amount of possible alternative locations that they can reach. In this research it seems that this isn't true. In case of shopping trips this number was more or less equal but in the case of leisure trips is a remarkable difference between these two transportation modes. This also applies for education, work and service trips where the difference is more visible.

In this table it is not possible to determine the confidence interval for several values. When the minimal and maximal value of alternative locations is the same it means that only one respondent in the selection matches with these characteristics. As mentioned already it is not possible to determine a confidence interval when only one value is available. In case of train trips in the OSM objects, these trips are too large to analyse with the chosen method, this is why a value is missing and no confidence interval is calculated. In case of car trips, driver as well as passenger, some values are missing because of the method so it is not possible to determine a confidence interval in the case of OSM objects (50).

**TABLE 22 Alternative Leisure Locations Based on Transportation Mode**

| Transportation mode | Alternative locations | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OSM Objects (50) | | | | OSM Objects (42) | | | | POI layer (50) | | | | POI layer (42) | | | |
| | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. |
| **Pedestrian** | 5,67 | 0 | 22 | (0;12,78) | 5,67 | 0 | 22 | (0;12,78) | 4,67 | 0 | 20 | (0;11,20) | 4,67 | 0 | 20 | (0;11,20) |
| **Cyclist** | 16,78 | 3 | 43 | (6,82;26,74) | 16,78 | 3 | 43 | (6,82;26,74) | 11,89 | 0 | 40 | (3,58;20,20) | 11,89 | 0 | 40 | (3,58;20,20) |
| **Car driver** | 20,47* | 0 | 86 | / | 25,58 | 0 | 86 | (8,23;42,93) | 45,13 | 0 | 309 | (3,90;86,36) | 13 | 0 | 37 | (6,01;19,99) |
| **Car passenger** | 3,5* | 0 | 37 | / | 4,5 | 0 | 37 | (0;9,56) | 75,28 | 0 | 741 | (0;161,33) | 8,33 | 0 | 98 | (0;21,82) |
| **By bus** | 39 | 39 | 39 | / | 39 | 39 | 39 | / | 36 | 36 | 36 | / | 36 | 36 | 36 | / |
| **By train** | /* | / | / | / | /* | / | / | / | 207 | 207 | 207 | / | 207 | 207 | 207 | / |

**TABLE 23 Average Surface of Leisure Trips (Transportation mode)**

| Transportation mode | Pedestrian | Cyclist | Car driver | Car passenger | By bus | By train |
|---|---|---|---|---|---|---|
| **Average surface (km²)** | 15,9 | 65,52 | 137,68 | 304,81 | 283,53 | 1 604,6 |
| **CI** | (0,26;55,78) | (13,11;157,95) | (31,96;317,34) | (16,24;954,1) | / (only 1 value) | / (only 1 value) |

FIGURE 21 shows the results of the number of alternative locations a person can reach depending on his or her transportation mode.

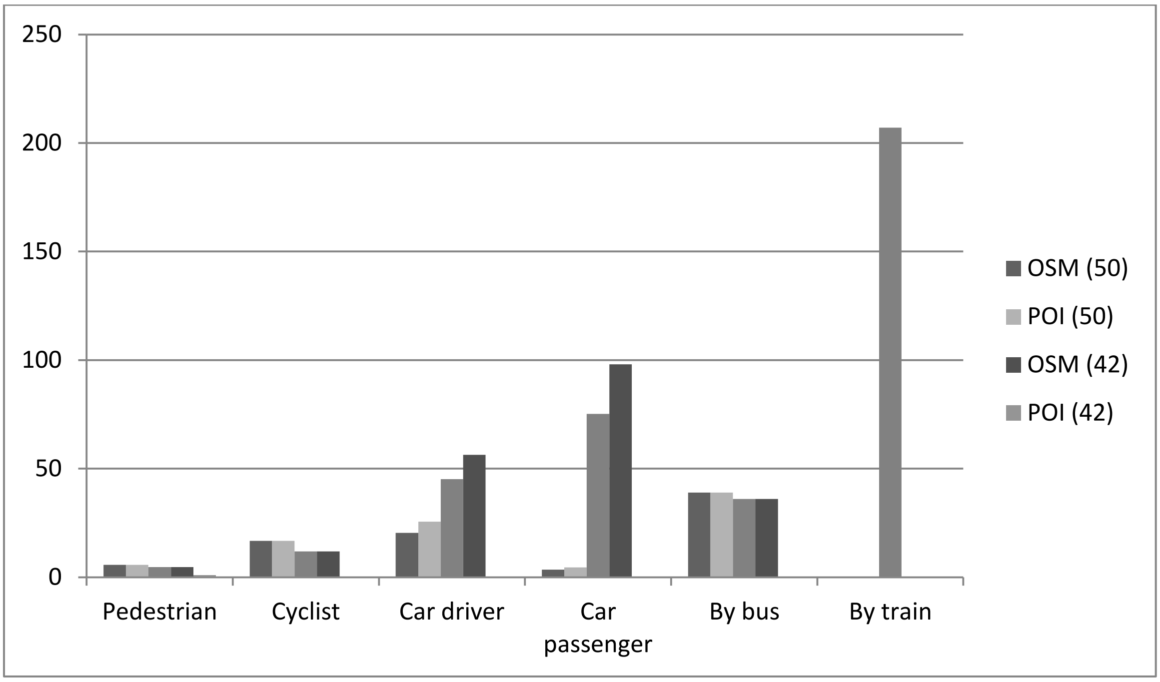


**FIGURE 21 Alternative leisure locations based on transportation mode.**

In the end, two time-based analyses are made. The first one takes the travel time, calculated with TomTom into account, and the final one takes the periods of the day into account. TABLE 24 shows the results of the influence of travel time on the number of alternative locations. Looking at the columns with complete results (42 trips), it is clear that the number of alternatives increases as the travel time increases. There is a difference between the number of alternatives a respondent can reach in OSM objects and POI layer. When a respondent travels between five and 10 minutes this difference isn't so large. But for the values between 11-20 minutes the POI layer has fewer options than the OSM objects, almost 8,4 alternatives.

Finally the alternative locations according to the periods of the day are analyzed based on the distance in bird's eye view. As mentioned earlier, it would be better if this is done with real distances and travel time. But this can't be achieved using the current method. Looking at the results in TABLE 26, it seems that respondents, in general, can reach more leisure locations during off peak periods. An explanation for this is that most people participate in leisure activities outside the working or school hours. In this case the trips that were too long to analyse are situated in every period of the day (*).

**TABLE 24 Alternative Leisure Locations Based on Travel Time**

| **Travel time (min)** | **Alternative locations** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **OSM Objects (50)** | | | | **OSM Objects (42)** | | | | **POI layer (50)** | | | | **POI layer (42)** | | | |
| | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. |
| **< 5** | 1,3 | 0 | 8 | (0,31;2,27) | 1,3 | 0 | 8 | (0,31;2,27) | 0,5 | 0 | 3 | (0,02;0,92) | 0,5 | 0 | 3 | (0,02;0,92) |
| **5-10** | 3,9 | 0 | 10 | (1,64;6,14) | 3,9 | 0 | 10 | (1,64;6,14) | 4,6 | 0 | 11 | (1,69;7,43) | 4,6 | 0 | 11 | (1,69;7,43) |
| **11-20** | 33,6 | 3 | 86 | (22,60;44,52) | 33,6 | 3 | 86 | (22,60;44,52) | 25,2 | 2 | 98 | (14,03;36,35) | 25,2 | 2 | 98 | (14,03;36,35) |
| **21-30** | * | / | / | / | / | / | / | / | 98,75 | 79 | 132 | (74,25;123,25) | / | / | / | / |
| **31-40** | * | / | / | / | / | / | / | / | 258 | 207 | 309 | (158,04;357,96) | / | / | / | / |
| **>40** | * | / | / | / | / | / | / | / | 532,5 | 324 | 741 | (123,85;941,15) | / | / | / | / |

**TABLE 25 Surface of Leisure Trips (Travel time)**

| **Travel time (min)** | **< 5** | **5-10** | **11-20** | **21-30** | **31-40** | **>40** |
|---|---|---|---|---|---|---|
| **Average surface (km²)** | 3,84 | 15,21 | 174,95 | 494,81 | 1 893,45 | 8 824,73 |
| **CI** | (1,46;7,36) | (8,05;24,62) | (112,82;250,66) | (421,87;573,56) | (1349,79;2528,88) | / |

**TABLE 26 Alternative Leisure Locations Based on the Periods of the Day**

| Periods of the day | Alternative locations | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OSM Objects (50) | | | | OSM Objects (42) | | | | POI layer (50) | | | | POI layer (42) | | | |
| | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. |
| **6:30 – 9:30** | /* | / | / | / | / | / | / | / | 207 | 207 | 207 | / | / | / | / | / |
| **9:30 – 16:00** | 13,06* | 0 | 86 | / | 16,3 | 0 | 86 | (1,57;31,09) | 37,93 | 0 | 309 | (0;79,03) | 6,42 | 0 | 23 | (1,37;11,47) |
| **16:00 – 19:00** | 3,83* | 0 | 22 | / | 4,6 | 0 | 22 | (33,60;42,26) | 71,67 | 0 | 741 | (0;191,62) | 3,9 | 0 | 20 | (0;7,87) |
| **19:00 – 6:30** | 16* | 0 | 71 | / | 17,6 | 0 | 71 | (0;15,58) | 36 | 0 | 324 | (5,72;66,28) | 16,8 | 0 | 98 | (6,38;27,22) |

*: values are missing owing to the chosen method, therefore it is not possible to calculate a confidence interval in these cases or indicate an exact number of alternative locations.

**TABLE 27 Average Surface of Leisure Trips (Periods of the Day)**

| Periods of the day | Average surface (km²) | CI |
|---|---|---|
| **6:30 – 9:30** | 1 604,6 | / (only 1 value) |
| **9:30 – 16:00** | 139,79 | (28,09;318,97) |
| **16:00 – 19:00** | 207,05 | (2,61;777,11) |
| **19:00 – 6:30** | 135,67 | (16,72;428,21) |

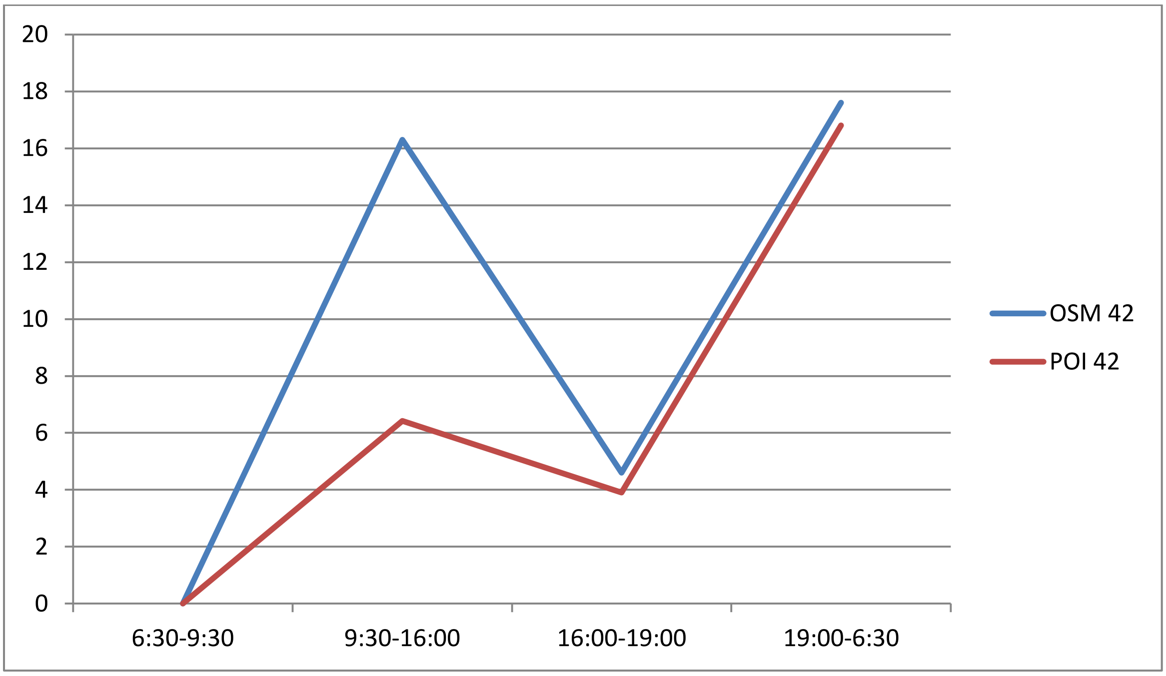


**FIGURE 22 Alternative leisure locations based on periods of the day.**

FIGURE 22 shows the number of alternative leisure locations a respondent can reach based on the periods of the day. Only the results for 42 trips are displayed because these results are complete. The values for POI and OSM between 4-7 pm and 7 pm-6.30 am are almost the same. The number of alternative leisure locations between 9.30 am and 4 pm is very different for OSM objects and the POI layer.

## 7.4. Education

For the education-based trips, which are 6,6% of the total number of trips, it was possible to look in both layers. Because both of them contain information about school locations. In the points of interest layer the average number of alternative locations was 118. This number ranges from 0 to 1602 alternative school locations. In case of the OSM objects the average number of possible alternative education locations was 16,85 locations. The number of alternative locations, based on the OSM objects, is ranging from 0 up till 104. The average is much lower than the average of the POI layer because some trips had a distance which is larger than 20 kilometres. To determine the set of alternative locations, the data about schools and universities in OSM objects and POI layer are used. In case of education no distinction is made between types of schools, so the number of alternative locations contains nursery school, primary schools, high schools, universities.... In case of primary schools and nursery schools this is maybe a little short-sighted because when looking at the age of a respondent, it would be possible to determine the type of school. But when respondents go to high school or university there is no information about the course a respondent follows, so it wasn't possible to look for different high schools or universities. Although it was possible to make a distinction between these two school types, it was decided to look at the school types in general, because it wasn't possible for all school types.

The first analysis is based on the travel distance in bird's eye view. Out of TABLE 28, seems that a student already has several options in a short distance (< 5km). When a respondent's school location is situated further than five kilometres of the departure location, the amount of alternative schools increases quickly. The number of alternative locations in both layers (POI and OSM) is more or less the same, looking at the results for 18 trips (which are complete). When travelling more than five kilometres to a school location, the amount of alternatives is almost ten times more than when a respondent has to travel between one and five kilometres. Only in case of trips >5 km (OSM objects) it is not possible to calculate a confidence interval because some are values missing due to the method.

When looking at the characters of the location of departure (18 trips) in TABLE 30, it shows that people who live in urban areas have more options than other people. Again some trips had a distance that was too long to analyse, so this is why the results for rural area are marked with an asterix (*) in some cases. When looking at the POI layer of 18 trips, the numbers are almost equal to those in the OSM object of 18 trips. So both layers contain more or less the same information about education locations. The number of options for respondents in metropolitan areas is remarkable low. This is because only two respondents in the selection starts their trip in a metropolitan area.

**TABLE 28 Alternative Education Locations Based on Travel Distance**

| Distance | Alternative locations | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OSM Objects (21) | | | | OSM Objects (18) | | | | POI layer (21) | | | | POI layer (18) | | | |
| | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. |
| **< 1 km** | 1,6 | 0 | 5 | (0;3,41) | 1,6 | 0 | 5 | (0;5,37) | 0,6 | 0 | 2 | (0;1,38) | 0,6 | 0 | 2 | (0;9,95) |
| **1-5 km** | 5,13 | 0 | 10 | (2,11;8,14) | 5,13 | 0 | 10 | (2,11;8,14) | 6,5 | 0 | 18 | (1,73;11,27) | 6,5 | 0 | 18 | (1,73;11,27) |
| **> 5 km** | 38,13* | 25 | 104 | / | 50,83 | 25 | 104 | (24,79;76,87) | 303 | 29 | 1602 | (0;673,53) | 59 | 29 | 100 | (35,16;82,84) |

**TABLE 29 Average Surface of Education Trips (Distance)**

| Distance | Average surface ($km^2$) | CI |
|---|---|---|
| **< 1 km** | 1,37 | (0,48;2,7) |
| **1-5 km** | 16,08 | (8,72;25,67) |
| **> 5 km** | 1 346,14 | (847,56;1959,55) |

**TABLE 30 Alternative Education Locations Based on Municipality Type**

| Municipality type | Alternative locations | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OSM Objects (21) | | | | OSM Objects (18) | | | | POI layer (21) | | | | POI layer (18) | | | |
| | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. |
| **Rural area** | 2* | 0 | 10 | / | 2,44 | 0 | 10 | (0;5,21) | 196,91 | 0 | 1602 | (0;479,68) | 4,63 | 0 | 18 | (0;9,65) |
| **Metropolitan area** | 3,5 | 2 | 5 | (0,56;6,44) | 3,5 | 2 | 5 | (0,56;6,44) | 1 | 0 | 2 | (0;2,96) | 1 | 0 | 2 | (0;2,96) |
| **Urban area** | 40,6 | 3 | 104 | (15,65;65,60) | 40,6 | 3 | 104 | (15,66;65,60) | 38,9 | 5 | 100 | (14,93;62,82) | 38,9 | 5 | 100 | (14,93;62,82) |

**TABLE 31 Average Surface of Education Trips (Municipality Type)**

| Municipality type | Average surface (km²) | CI |
|---|---|---|
| **Rural area** | 230,39 | (6,34;775,07) |
| **Metropolitan area** | 1,77 | (0,34;10,5) |
| **Urban area** | 409,18 | (112,07;892,22) |

Respondents who are still going to school, are in most cases not allowed to travel by car as a driver. This is clearly visible in TABLE 32. The respondents who go to school by car as a driver have not so much alternative locations because they aren't that much represented. When taking the school type into account it can be that this group will have even less options than now, because these respondents would probably go to high schools, universities or evening classes. Respondents travelling as a car passenger are more represented and have more alternatives locations. The amount of alternative locations a respondent can reach by walking or cycling to school is relatively low. But the smaller the distance, the fewer alternatives a respondent has in this case. Students travelling by train have more options because the distance is longer. This transportation mode contains trips that were too long to analyse (*). FIGURE 23 shows the results from TABLE 32 in graphics.

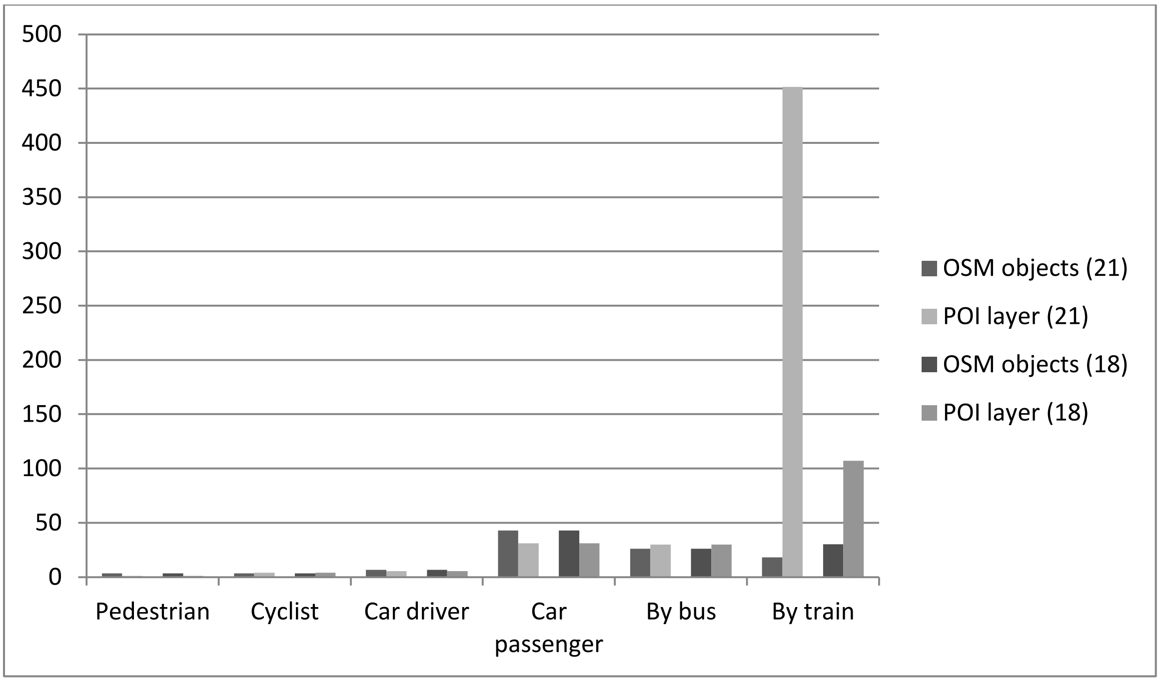


**FIGURE 23 Alternative education locations based on transportation mode.**

Finally two analyses based on time are made. The first one is based on the travel time and the final analysis is based on the periods of the day. So when taking the travel time into account and look for the number of alternative locations a respondent can reach, this is shown in TABLE 34. Comparing the complete number of alternative locations in the columns with 18 trips, the results are almost the same for OSM and POI. So the data of education locations in both layers will be more or less equal. Again the number of alternative locations a respondent can reach increases when he or she travels longer. Respondents who travel 21-30 minutes will double their options than when they travel ten minutes less. When travelling less than five minutes, a respondent will not have many alternatives, almost one. When travelling between five and ten minutes, they will have almost seven alternative locations that they are able to reach.

**TABLE 32 Alternative Education Locations Based on Transportation Mode**

| Transportation mode | Alternative locations | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OSM Objects (21) | | | | OSM Objects (18) | | | | POI layer (21) | | | | POI layer (18) | | | |
| | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. |
| **Pedestrian** | 3,5 | 2 | 5 | (0,56;6,44) | 3,5 | 2 | 5 | (0,56;6,44) | 1 | 0 | 2 | (0;2,96) | 1 | 0 | 2 | (0;2,96) |
| **Cyclist** | 3,33 | 0 | 10 | (0;6,67) | 3,33 | 0 | 10 | (0;6,67) | 4 | 0 | 16 | (0;8,93) | 4 | 0 | 16 | (0;8,93) |
| **Car driver** | 6,5 | 3 | 10 | (0;13,36) | 6,5 | 3 | 10 | (0;13,36) | 5,5 | 5 | 6 | (4,52;6,48) | 5,5 | 5 | 6 | (4,52;6,48) |
| **Car passenger** | 42,75 | 0 | 104 | (0;93,34) | 42,75 | 0 | 104 | (0;93,34) | 31 | 0 | 68 | (0;66,41) | 31 | 0 | 68 | (0;66,41) |
| **By bus** | 26 | 9 | 43 | (0;59,32) | 26 | 9 | 43 | (0;59,32) | 30 | 18 | 42 | (6,48;53,52) | 30 | 18 | 42 | (6,48;53,52) |
| **By train** | 18,2* | 25 | 66 | / | 45,5 | 25 | 66 | (5,32;85,68) | 451,6 | 29 | 1602 | (0;1024,12) | 64,5 | 29 | 100 | (0;134,08) |

**TABLE 33 Average Surface of Education Trips (Transportation Mode)**

| Transportation mode | Pedestrian | Cyclist | Car driver | Car passenger | By bus | By train |
|---|---|---|---|---|---|---|
| **Average surface ($km^2$)** | 1,77 | 10,95 | 26,42 | 217,73 | 158,37 | 1 839,84 |
| **CI** | (0,34;10,5) | (3,18;23,35) | / | (0,41;909,07) | (42,54;1004,33) | (1246,64;2548,13) |

**TABLE 34 Alternative Education Locations Based on Travel Time**

| Travel time (min) | Alternative locations | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OSM Objects (21) | | | | OSM Objects (18) | | | | POI layer (21) | | | | POI layer (18) | | | |
| | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. |
| **< 5** | 0,71 | 0 | 2 | (0;1,42) | 0,71 | 0 | 2 | (0;1,42) | 0,71 | 0 | 2 | (0;1,42) | 0,71 | 0 | 2 | (0;1,42) |
| **5-10** | 6,8 | 3 | 10 | (4,29;9,31) | 6,8 | 3 | 10 | (4,29;9,31) | 6,8 | 0 | 18 | (0,94;12,66) | 6,8 | 0 | 18 | (0,94;12,66) |
| **11-20** | 26,5 | 10 | 43 | (0;58,84) | 26,5 | 10 | 43 | (0;58,84) | 29 | 16 | 42 | (3,52;54,48) | 29 | 16 | 42 | (3,52;54,48) |
| **21-30** | 52,4* | 25 | * | / | 65,5 | 25 | 104 | (33,87;97,13) | 89 | 29 | 192 | (33,81;144,19) | 63,25 | 29 | 100 | (34,41;92,93) |
| **>30** | * | / | / | / | / | / | / | / | 968,5 | 335 | 1602 | (0;2210,14) | / | / | / | / |

**TABLE 35 Surface of Education Trips (Travel Time)**

| Travel time (min) | < 5 | 5-10 | 11-20 | 21-30 | >30 |
|---|---|---|---|---|---|
| **Average surface (km²)** | 4,96 | 9,95 | 208,67 | 1 115,09 | 2 715,47 |
| **CI** | (0,42;3,74) | (0,24;4,57) | (52,65;1384,62) | (0,04;1437,52) | (5796,93;5956,71) |

**TABLE 36 Alternative Education Locations Based on Periods of the Day**

| Periods of the day | Alternative locations | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OSM Objects (21) | | | | OSM Objects (18) | | | | POI layer (21) | | | | POI layer (18) | | | |
| | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. |
| **6:30 – 9:30** | 19,9 | 0 | 67 | (2,28;37,52) | 22,1 | 0 | 67 | (3,53;40,69) | 181,2 | 0 | 1602 | (0;491,31) | 23,33 | 0 | 100 | (0,16;46,50) |
| **9:30 – 16:00** | 17 | 0 | 104 | (0;40,04) | 19,13 | 0 | 104 | (0;43,57) | 36,67 | 0 | 192 | (0;77,23) | 17,25 | 0 | 68 | (1,33;33,17) |
| **16:00 – 19:00** | 1* | 2 | 2 | / | 2 | 2 | 2 | / | 168,5 | 2 | 335 | (0;494,83) | 2 | 2 | 2 | / |
| **19:30-6:30** | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |

**TABLE 37 Surface of Education Trips (Periods of the Day)**

| Periods of the day | Average surface (km²) | CI |
|---|---|---|
| **6:30 – 9:30** | 232,89 | (15,97;703,59) |
| **9:30 – 16:00** | 191,13 | (11,93;585,5) |
| **16:00 – 19:00** | 740,23 | (466,64;5778,45) |
| **19:30-6:30** | / | / |

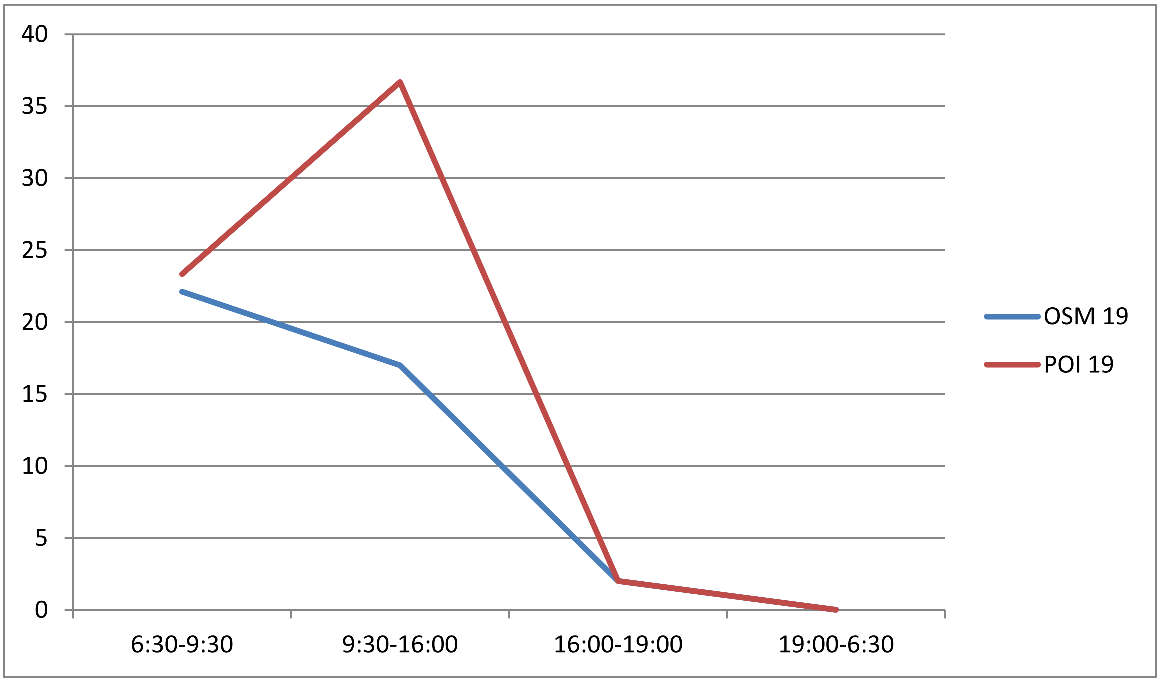


**FIGURE 24 Alternative education locations based on periods of the day.**

Finally the period of the day is taken into account. Out of this analysis it seems that no respondent moves to school in the evening and night, between 7 pm and 6.30 am. So no respondent is taking evening classes. Most of the respondents (10) travel to school during the morning peak, this is visible in the number of alternative location they can reach. University students or high school students will travel depending on their schedule. This explains the fact that the selection conatins school trips (9 trips) during the off peak period between 9.30 am and 4 pm. Only two school trips are made between 4 pm and 7 pm.

## 7.5. Work

The amount of work related trips was 15% of the total selected number. In this case, the point of interest layer doesn't contain useful information about workplaces for this research, so only the OSM objects are used. In these OSM objects is searched for 'industrial' in the column 'tags'. So actually we searched for areas where the land use was indicated as industrial and also for buildings that are indicated as industrial buildings. This search method is chosen because it has to be a clear what the definition of work locations is. In principle, the layers contain more work locations, a police station, fire station, shop, leisure location and so one can all be work locations, but the choice for industrial locations sets a clear boundary. When an individual makes a work related trip, he or she can reach 54,25 alternative work locations in average within the distance of the current trip, ranging from zero alternatives to 238 alternative locations. In this case some trips also had a distance that was too large to analyse with the current method. These trips can be analyzed with a more powerful device that can read and download the templates with information for whole Belgium. It was only possible to determine the alternative locations for trips under 20 kilometres (bird's eye view).

The further a respondent has to travel from his or her origin, the more alternative work locations the respondent can reach. This is the same as for all the previous trip purposes that were analyzed.

**TABLE 38 Alternative Work Locations Based on Travel Distance**

| Distance | Alternative locations | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | OSM Objects (64) | | | | OSM objects (55) | | | |
| | Alternatives | Min. | Max. | C.I. | Alternatives | Min. | Max. | C.I. |
| **< 1 km** | 3,25 | 0 | 13 | (0;9,62) | 3,25 | 0 | 13 | (0;9,62) |
| **1-5 km** | 21,9 | 0 | 70 | (14,84;28,96) | 21,9 | 0 | 70 | (14,84;28,96) |
| **5-10 km** | 50,2 | 12 | 99 | (32,48;67,92) | 50,2 | 12 | 99 | (32,48;67,92) |
| **10-20 km** | 133,41 | 21 | 309 | (105,79;177,71) | 141,75 | 21 | 309 | (104,68;178,82) |
| **> 20 km** | /* | / | / | / | /* | / | / | / |

*: the area was too big to determine the number of alternative work locations with the method of OSM objects. The area that was needed, was too much to download with the result that the program QGIS was running too slow. These trips were over the province boundaries and some of them covered the entire territory of Flanders. Therefore it is also not possible to calculate a confidence interval.

**TABLE 39 Average Surface Work Locations (Distance)**

| Distance | Average surface (km²) | CI |
|---|---|---|
| **< 1 km** | 0,56 | (0,03;1,72) |
| **1-5 km** | 22,99 | (17,16;29,66) |
| **5-10 km** | 162,26 | (124,76;204,68) |
| **10-20 km** | 562,62 | (463,43;671,42) |
| **> 20 km** | 3 755,56 | (2518,17;5239,42) |

The next analyses that are made for the trips with a work purpose, are based on the location of departure of the trip. Again it is clear that people in rural areas can reach more alternative work locations than other respondents, due to the radius of their current trip. When looking at the complete results for OSM objects of 55 trips, this is confirmed. Respondents in rural areas can reach the most alternative work locations (91,41 locations in average), followed by respondents living in the urban area around Brussels (66,5 locations) and people living in metropolitan areas (53,77 locations in average). Finally respondents who live in urban areas are having the least number of possible alternative work locations, namely an average of 34,94 alternative work locations.

After the analysis about the departure location of a trip is looked at the transportation mode that was used to travel. The possible number of alternative locations a respondent can reach using a certain transportation mode is analyzed. When a respondent travels to his or her work by foot, they cannot reach any alternative location. These results are highly dependent on the used method. They can reach the most alternative locations when they travel as a motorcyclist. This is a biased result because only one respondent is travelling to his work by motorcycle. Respondents who go to their work by bus can reach the most alternative locations (94 locations in average), followed by respondents who travel by car as a driver (55,96 locations in average). Again, these results are highly dependent on the used method. When travelling to work by bike, a respondent can meanly reach almost 20 alternative work locations, based on the current distance in bird’s eye view.

**TABLE 40 Alternative Work Locations Based on Municipality Type**

| Municipality type | Alternative locations | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | OSM Objects (64) | | | | OSM objects (55) | | | |
| | Alternatives | Min. | Max. | C.I. | Alternatives | Min. | Max. | C.I. |
| **Rural area** | 91,41 | 0 | 309 | (56,77;126,04) | 91,41 | 0 | 309 | (56,77;126,04) |
| **Metropolitan area** | 41,12* | 0 | 238 | / | 53,77 | 0 | 238 | (10,57;96,97) |
| **Urban area** | 27,35* | 2 | 161 | / | 34,94 | 2 | 161 | (15,43;54,46) |
| **Urban area around Brussels** | 66,5 | 39 | 94 | (12,60;120,40) | 66,5 | 39 | 94 | (12,60;120,40) |

**TABLE 41 Average Surface of Work Trips (Municipality Type)**

| Municipality type | Average surface ($km^2$) | CI |
|---|---|---|
| **Rural area** | 263 | (151,13;405,65) |
| **Metropolitan area** | 513,77 | (63,94;1394,03) |
| **Urban area** | 341,88 | (132,42;591,06) |
| **Urban area around Brussels** | 132,73 | / |

**TABLE 42 Alternative Work Locations Based on Transportation Mode**

| Transportation mode | Alternative locations | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | OSM Objects (64) | | | | OSM objects (55) | | | |
| | Alternatives | Min. | Max. | C.I. | Alternatives | Min. | Max. | C.I. |
| **Pedestrian** | 0 | 0 | 0 | / | 0 | 0 | 0 | / |
| **Cyclist** | 19,67 | 3 | 30 | (10,41;28,92) | 19,67 | 3 | 30 | (10,41;28,92) |
| **Motorcyclist** | 238 | 238 | 238 | / | 238 | 238 | 238 | / |
| **Car driver** | 55,96* | 0 | 309 | / | 67,16 | 0 | 309 | (47,18;87,13) |
| **By bus** | 94 | 94 | 94 | / | 94 | 94 | 94 | |

**TABLE 43 Average Surface of Work Trips (Municipality Type)**

| Transportation mode | Average surface ($km^2$) | CI |
|---|---|---|
| **Pedestrian** | 0,07 | (0;0,2) |
| **Cyclist** | 11,54 | (9,42;13,88) |
| **Motorcyclist** | 415,48 | / (only 1 value) |
| **Car driver** | 434,15 | (242,67;680,92) |
| **By bus** | 289,53 | / (only 1 value) |

FIGURE 25 shows the alternative work locations according to transportation mode, which were displayed in TABLE 42. It is clear that the ‘missing’ trips (*) are located by car drivers.

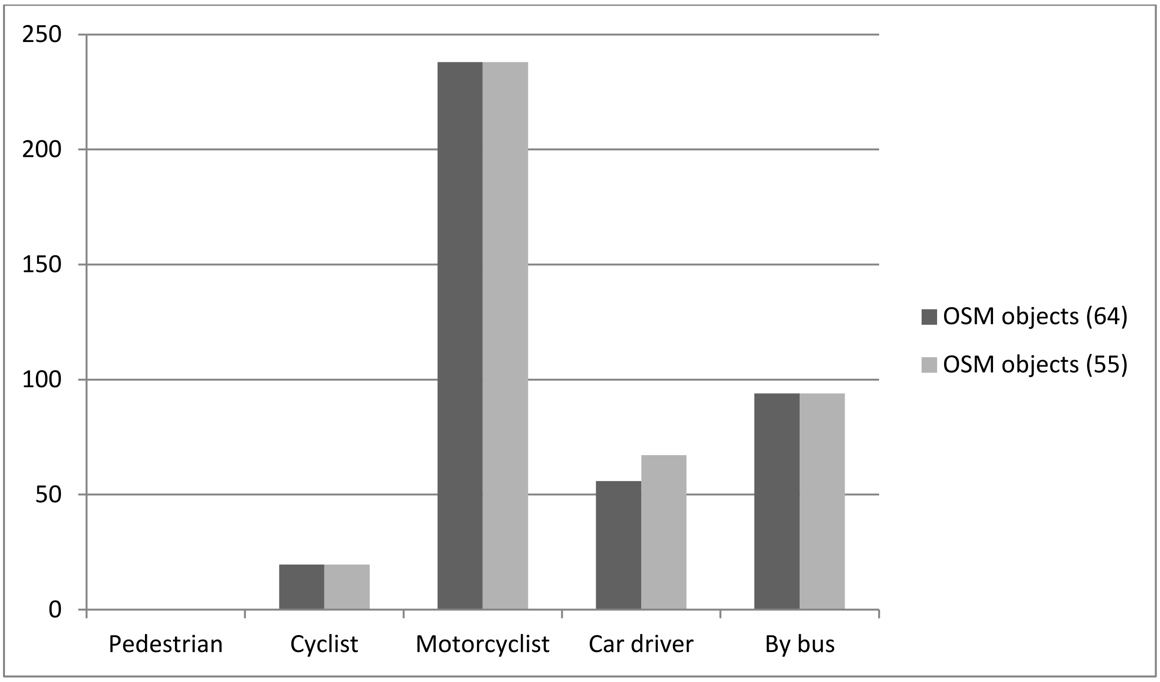


**FIGURE 25 alternative work locations based on transportation mode.**

As done for the other trip purposes, also for work trips is looked how many alternative work locations a respondent can reach taking the time of the day and the travel time into account. Again the following remark that the results of the analysis of the time of the day doesn’t say much must be made, but when this is done with real distances and travel times they will become more meaningful. This analysis is done to have an idea of how it will look like, it will indicate the number of alternative locations a respondent can reach during the day.  But first is looked at the influence of the travel time on the number of alternative locations a respondent can reach. Respondents who travel less than five minutes to their work cannot reach any other alternative work location based on the industrial sites that were looked up for this analysis. When travelling between five and ten minutes, they can reach almost 30 alternative work locations. When the travel time doubled to 11-20 minutes, the number of alternatives also doubles (57,7 alternative locations in average). When they have to travel between 21-30 minutes this number multiplies with more than two. In that case they can reach meanly 132 alternative locations, looking at the results in column OSM objects (55), which are complete results.

**TABLE 44 Alternative Work Locations Based on Travel Time**

| Travel time (min.) | Alternative locations | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | OSM Objects (64) | | | | OSM objects (55) | | | |
| | Alternatives | Min. | Max. | C.I. | Alternatives | Min. | Max. | C.I. |
| **< 5** | 0 | 0 | 0 | / | 0 | 0 | 0 | / |
| **5-10** | 28,45 | 2 | 99 | (17,04;39,86) | 28,45 | 2 | 99 | (17,04;39,86) |
| **11-20** | 57,7 | 3 | 197 | (31,12;84,15) | 57,7 | 3 | 197 | (31,12;84,15) |
| **21-30** | 116,5* | 21 | 309 | / | 132 | 21 | 309 | (91,60;172,40) |
| **> 30** | * | * | * | * | * | * | * | * |

**TABLE 45 Average Surface of Work Trips (Travel Time)**

| Travel time (min.) | Average surface ($km^2$) | CI |
|---|---|---|
| **< 5** | 1,32 | (0;5,49) |
| **5-10** | 31,07 | (20,33;44,09) |
| **11-20** | 157,53 | (98,19;230,84) |
| **21-30** | 610,07 | (454,63;788,34) |
| **> 30** | 4 071,5 | (2738,93;5667,36) |

The following analysis is based on the periods of the day. When looking at the results of this analysis, it can be said that a respondent can reach the most alternative locations during the night time, from 7pm till 6:30am. Followed by the period during the evening peak were they can reach meanly 53,64 alternative work locations within the bird's eye view distance of their current trip. The difference between the number of alternative locations a respondent can reach during the day or the morning peak and the other periods of the day, isn't that big. They can almost reach the same amount of alternative work locations during these periods. This is an effect of the used method. In case that the real travel times and distance are taken into account, it is expected that respondents have to travel longer (in time) during the peak hours because of traffic during these peaks. As a result of the increasing travel time, it is more likely that they can reach less alternative locations during the peak periods than during off peak periods. 'Missing' trips (*) are situated in every period of the day. FIGURE 26 shows the results of TABLE 46 in graphical form.

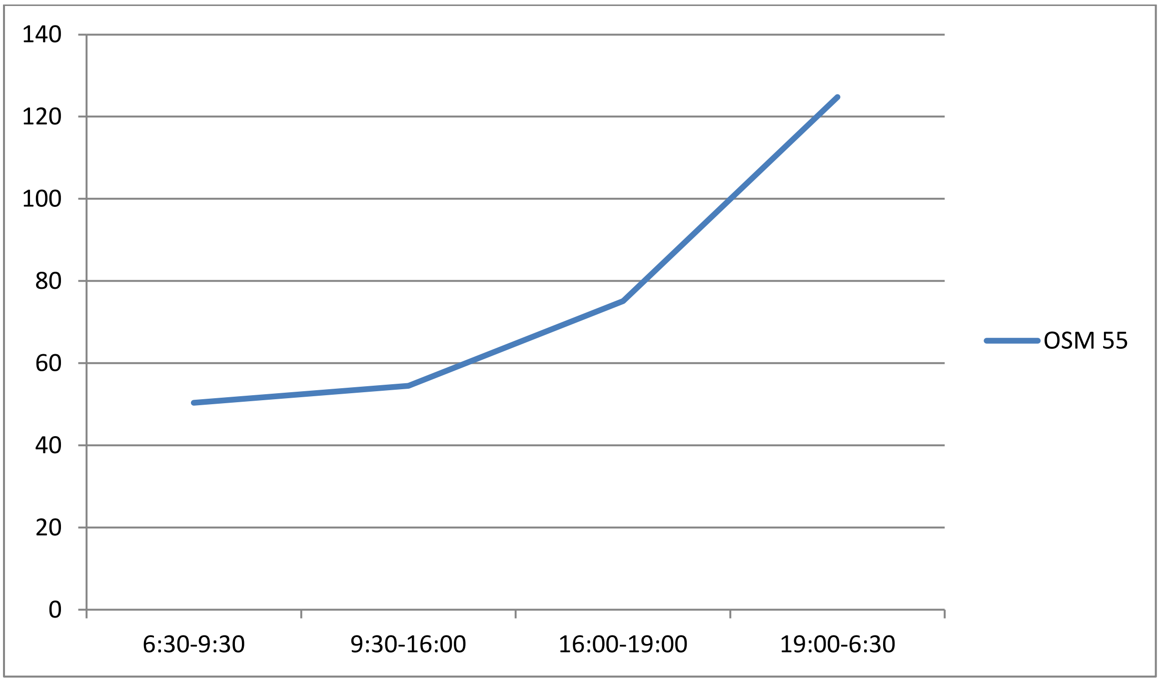


**FIGURE 26 Alternative work locations based on periods of the day.**

**TABLE 46 Alternative Work Locations Based on Periods of the Day**

| **Periods of the day** | **Alternative locations** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **OSM Objects (64)** | | | | **OSM objects (55)** | | | |
| | Alternatives | Min. | Max. | C.I. | Alternatives | Min. | Max. | C.I. |
| **6:30 – 9:30** | 47,95* | 0 | 238 | / | 50,35 | 0 | 238 | (22,3;78,4) |
| **9:30 – 16:00** | 49,55* | 0 | 181 | / | 54,5 | 0 | 181 | (28,08;80,92) |
| **16:00 – 19:00** | 53,64* | 21 | 201 | / | 75,1 | 21 | 201 | (36,07;114,13) |
| **19:00 – 6:30** | 89,14* | 0 | 309 | / | 124,8 | 0 | 309 | (26,9;222,7) |

**TABLE 47 Average Surface of Work Trips (Periods of the Day)**

| **Periods of the day** | **Average surface (km²)** | **CI** |
|---|---|---|
| **6:30 – 9:30** | 176,94 | (64,96;343,87) |
| **9:30 – 16:00** | 220,95 | (65,91;467 |
| **16:00 – 19:00** | 723,04 | (185,65;1612,31) |
| **19:00 – 6:30** | 821,57 | (112,96;2180,72) |

## 7.6. Services

The final kinds of trips that are analyzed are trips with a service purpose. These are 6% of the total amount of trips. Here it is possible to analyse both the OSM objects and the points of interest layer. First a distinction is made of what activities can be categorised as services. Therefore the following locations are marked as locations of services: bank, atm, pharmacy, police station, doctor, library, post boxes and post offices, town hall, hospital, veterinary, fire station, court house, social service and the Red Cross. When searching for alternative locations (for 25 trips) within the points of interest layer, a respondent meanly have 108,52 alternative locations for the current destination of the trip. This number ranges from zero to 2195 alternative locations. When analyzing the OSM objects, this number was meanly 22,24 alternative service locations. This number ranges from zero till 108 alternatives. The explanation for the huge difference between the OSM objects and the points of interest is that one trip is not analyzed (2012611) with 2195 alternative locations because this area was too big to deal with, regarding to the method that is used. When this trips is 'deleted', the average number of alternative locations in the OSM objects is meanly 23,17 alternatives and 21,58 alternatives for the points of interest layer. Both numbers are comparable.

When analyzing the number of alternative locations by distance, without respondent 2012611, note that the further the distance of a trip, the more alternative locations a respondent can reach within his current (bird's eye view) trip distance. The number of alternative service locations a respondent can reach, taking the OSM objects into account, almost equals the number of alternative locations they can reach when analysing the POI layer. The conclusion, as already mentioned, is the same for all the previous trip purposes. The further a respondent travels for the current location in bird's eye view, the more alternative locations the respondent can reach. The 'missing' trip (*) is situated in the distances above five kilometres. When travelling between one and five kilometres the number of alternatives is more than doubled in comparison with respondent who travel less than one kilometre for a service location. For distances above five kilometres (> 60 alternative locations) this number is more than three times higher than when looking at the number of alternatives between one and five kilometre (circa 20 alternative locations).

**TABLE 48 Alternative Service Locations Based on Travel Distance**

| Distance | Alternative locations | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OSM Objects (25) | | | | OSM Objects (24) | | | | POI layer (25) | | | | POI layer (24) | | | |
| | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. |
| **< 1 km** | 7 | 0 | 20 | (0,95;13,05) | 7 | 0 | 20 | (0,95;13,05) | 7,14 | 0 | 23 | (0,72;13,56) | 7,14 | 0 | 23 | (0,72;13,56) |
| **1-5 km** | 18,08 | 0 | 90 | (3,51;32,65) | 18,08 | 0 | 90 | (3,51;32,65) | 17,31 | 0 | 96 | (2,77;31,85) | 17,31 | 0 | 96 | (2,77;31,85) |
| **> 5 km** | 54,4* | 31 | 108 | / | 68 | 31 | 108 | (32,68;103,32) | 487,6 | 34 | 2195 | (0;1324,47) | 60,75 | 34 | 88 | (33,62;87,88) |

**TABLE 49 Average Surface of Service Trips (Distance)**

| Distance | Average surface ($km^2$) | CI |
|---|---|---|
| **< 1 km** | 1,67 | (0,98;2,53) |
| **1-5 km** | 14,26 | (7,89;22,51) |
| **> 5 km** | 1 593,26 | (23,51;7170,64) |

**TABLE 50 Alternative Service Locations Based on Municipality Type**

| Municipality type | Alternative locations | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OSM Objects (25) | | | | OSM Objects (24) | | | | POI layer (25) | | | | POI layer (24) | | | |
| | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. |
| **Rural area** | 17,06* | 0 | 90 | / | 16,06 | 0 | 90 | (2,60;31,52) | 145 | 0 | 2195 | (0;267,54) | 16,88 | 0 | 96 | (2,51;31,25) |
| **Metropolitan area** | 30,33 | 17 | 54 | (7,08;53,58) | 30,33 | 17 | 54 | (7,08;53,58) | 26 | 15 | 40 | (11,55;40,45) | 26 | 15 | 40 | (11,55;40,45) |
| **Urban area** | 38,4 | 3 | 108 | (0,93;75,87) | 38,4 | 3 | 108 | (0,93;75,87) | 34 | 3 | 88 | (3,78;64,22) | 34 | 3 | 88 | (3,78;64,22) |

**TABLE 51 Average Surface of Service Trips (Municipality Type)**

| Municipality type | Average surface ($km^2$) | CI |
|---|---|---|
| **Rural area** | 120,08 | (14,19;659,6) |
| **Metropolitan area** | 7,07 | (0,33;22,5) |
| **Urban area** | 161,06 | (14,7;464,32) |

After the distance of the trips, is looked for the municipality area where respondents starts a trip. The service trips that are analyzed, have departure locations in three different areas: rural areas, metropolitan areas and urban areas. A respondent can reach the most alternative locations when a service trip has his origin in an urban area (circa 38 alternatives), followed by the metropolitan area (circa 30 alternatives) and the rural area (16 alternatives in average). This in case that the complete trips are taken into account, OSM (24) and POI (24) . This result is reasonably logical because respondents will find more service locations like banks, post offices, atm's, pharmacies, ... in cities than in the countryside. The difference (*) between 25 and 24 respondents is situated in the trips that has a departure location in rural area.

When looking at the number of alternative service locations a respondent can reach based on the transportation mode, these results are shown in TABLE 52. The difference between 25 and 24 trips (*) is, in this case, situated in the number of alternative locations a car driver can reach taking the current bird's eye view of the trip into account. When looking at the complete results (24 trips) it can be said that when a respondent travels by car as a passenger he or she can reach the most alternative service locations taking the current bird's eye view trip distance into account. The number of alternative locations the respondent can reach as a car passenger, is far more than the number of alternative locations he or she can reach using any other transportation mode. On the second place is the option that a respondent travels by car as a driver or that he or she travels as a cyclist. The difference between the numbers of alternative locations the respondent can reach using these transportations modes are not so large. When travelling by foot, a respondent can only reach two alternative service locations taking the bird's eye view distance of the current trip .into account.

FIGURE 27 shows the results mentioned in TABLE 52. Here, it is clear that a car passenger can reach the most alternative service locations, looking at the complete results of 24 trips.

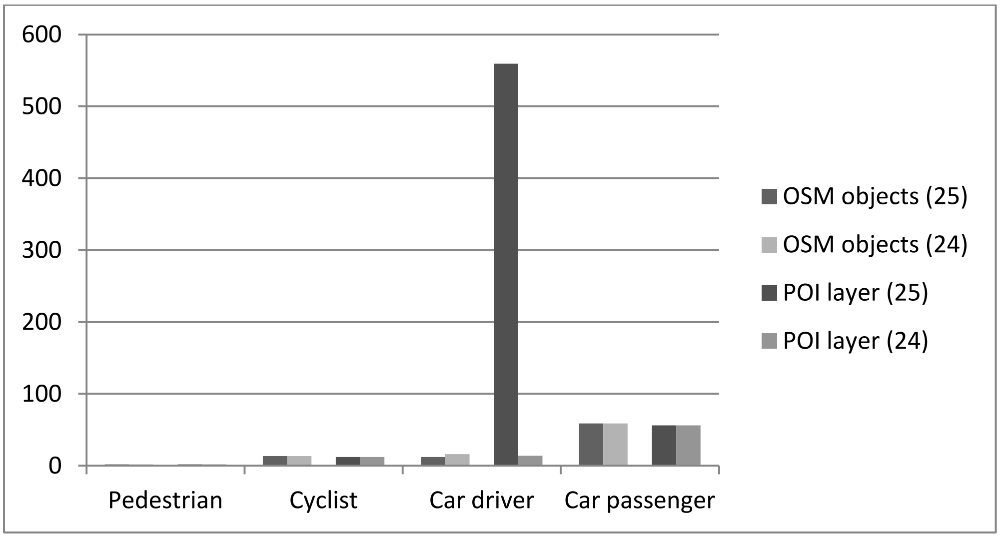


**FIGURE 27 Alternative service locations based on transportation mode.**

**TABLE 52 Alternative Service Locations Based on Transportation Mode**

| Transportation mode | Alternative locations | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OSM Objects (25) | | | | OSM Objects (24) | | | | POI layer (25) | | | | POI layer (24) | | | |
| | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. |
| **Pedestrian** | 2 | 0 | 5 | (0;4,40) | 2 | 0 | 5 | (0;4,40) | 2 | 0 | 5 | (0;4,40) | 2 | 0 | 5 | (0;4,40) |
| **Cyclist** | 13,27 | 0 | 54 | (1,94;21,88) | 13,27 | 0 | 54 | (3,30;23,24) | 11,91 | 0 | 40 | (4,17;19,65) | 11,91 | 0 | 40 | (4,17;19,65) |
| **Car driver** | 12* | 1 | 45* | / | 16 | 1 | 45 | (0;40,43) | 559,25* | 1 | 2195 | (0;1628,07) | 14 | 1 | 40 | (0;39,48) |
| **Car passenger** | 59 | 17 | 108 | (26,45;91,55) | 59 | 17 | 108 | (26,45;91,55) | 56,17 | 15 | 96 | (27,31;85,03) | 56,17 | 15 | 96 | (27,31;85,03) |

**TABLE 53 Average Surface of Service Trips (Transportation Mode)**

| Transportation mode | Average surface (km²) | CI |
|---|---|---|
| **Pedestrian** | 1,65 | (0,36;3,88) |
| **Cyclist** | 8,76 | (4,77;15,26) |
| **Car driver** | 1 523,99 | (450,36;9860,14) |
| **Car passenger** | 109,98 | (10,83;312,71) |

**TABLE 54 Alternative Service Locations Based on Travel Time**

| Travel time (min) | Alternative locations | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OSM Objects (25) | | | | OSM Objects (24) | | | | POI layer (25) | | | | POI layer (24) | | | |
| | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. |
| **< 5** | 6,14 | 0 | 20 | (2,85;9,43) | 6,14 | 0 | 20 | (2,85;9,43) | 6,29 | 0 | 23 | (2,81;9,77) | 6,29 | 0 | 23 | (2,81;9,77) |
| **5-10** | 40,86 | 0 | 90 | (12,76;68,96) | 40,86 | 0 | 90 | (12,76;68,96) | 38,3 | 0 | 96 | (10,48;66,10) | 38,3 | 0 | 96 | (10,48;66,10) |
| **11-20** | 76,5 | 45 | 108 | (14,76;138,24) | 76,5 | 45 | 108 | (14,76;138,24) | 64 | 40 | 88 | (16,96;111,04) | 64 | 40 | 88 | (16,96;111,04) |
| **21-30** | 31 | 31 | 31 | / | 31 | 31 | 31 | / | 34 | 34 | 34 | / | 34 | 34 | 34 | / |
| **>30** | * | * | * | / | / | / | / | / | * | * | * | / | 2195 | 2195 | 2195 | / |

**TABLE 55 Surface of Service Trips (Travel Time)**

| Travel time (min) | Average surface (km²) | CI |
|---|---|---|
| **< 5** | 5,85 | (3,47;8,84) |
| **5-10** | 22,66 | (5,59;51,2) |
| **11-20** | 404,71 | (206,94;668,19) |
| **>20** | 5 647,83 | (1151,24;33942,14) |

As done for all the previous trip purposes, also in the case of a service trip is looked at the travel time and the time of the day. Starting with the result of the real travel time, in TABLE 54. The 'missing' trip (*) is situated at the travel times above 30 minutes. When a respondent travels less than five minutes he or she can reach circa six alternative service locations, looking at the complete results of 24 trips. When this travel time increases up to five to ten minutes, the number of alternative locations (meanly circa 40 alternative locations), a respondent can reach, is more than six times higher than the previous number. When looking at the next travel time category (11-20 minutes), the number of alternatives almost doubles again, till 76,5 alternative locations in case of the OSM objects and 64 alternatives in case of the POI layer. The results for the travel time category between 21 and 30 minutes are biased because, only one respondent's travel time is in this category. When expanding the number of respondents in this category, it is more likely that the number of alternative locations will be higher than the previous categories.

The second time-based analysis is based on the periods of the day. The results of this analysis are shown in TABLE 56. When looking at this table it seems that, in the selection made for this research, no service trips are made in the evening peak between 4pm and 7pm. During the morning peak, a respondent can reach the most alternative service locations taking his or her current distance in bird's eye view into account. Again this analysis can be more meaningful when using real distances and times. The difference between the numbers of alternative service locations a respondent can reach, does not differ much across the different time periods. At least when talking about the complete results when using 24 trips. FIGURE 28 shows the results of TABLE 56 graphical.

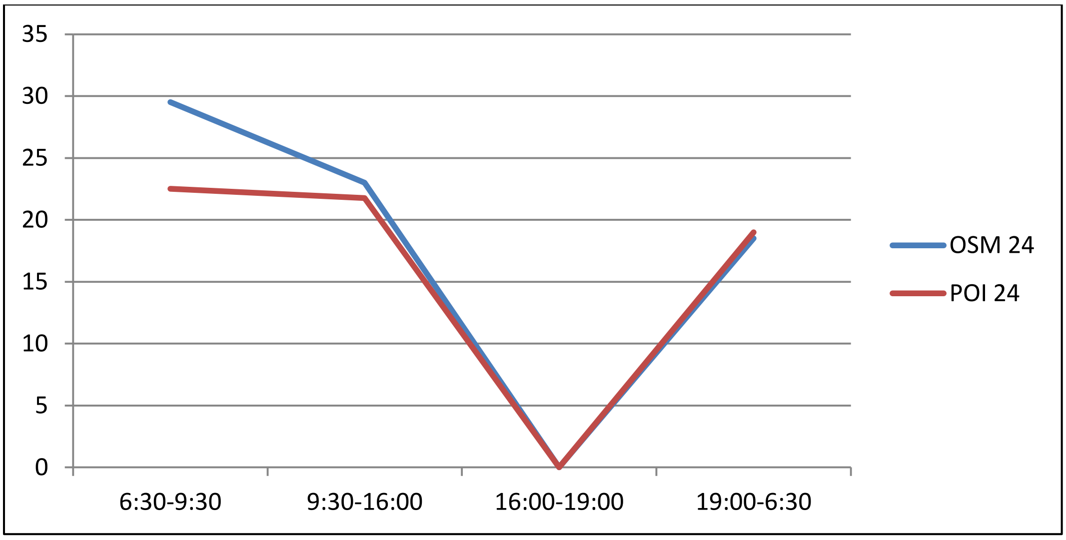


**FIGURE 28 Alternative service locations based on periods of the day.**

**TABLE 56 Alternative Service Locations Based on Periods of the Day**

| Periods of the day | Alternative locations | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OSM Objects (25) | | | | OSM Objects (24) | | | | POI layer (25) | | | | POI layer (24) | | | |
| | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. | Alt. | Min | Max | C.I. |
| **6:30 – 9:30** | 29,5 | 5 | 54 | (0;77,52) | 29,5 | 5 | 54 | (0;77,52) | 22,5 | 5 | 40 | (0;56,80) | 22,5 | 5 | 40 | (0;56,80) |
| **9:30 – 16:00** | 21,9* | 0 | 108 | / | 23 | 0 | 108 | (8,16;37,84) | 125,34 | 0 | 2195 | (8,07;35,43) | 21,75 | 0 | 96 | (0;328,49) |
| **16:00 – 19:00** | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| **19:00 – 6:30** | 18,5 | 17 | 20 | (15,56;21,44) | 18,5 | 17 | 20 | (15,56;21,44) | 19 | 15 | 23 | (11,16;26,84) | 19 | 15 | 23 | (11,16;26,84) |

**TABLE 57 Average Surface of Service Trips (Transportation Mode)**

| Periods of the day | Average surface ($km^2$) | CI |
|---|---|---|
| **6:30 – 9:30** | 10,18 | (0;39,9) |
| **9:30 – 16:00** | 139,63 | (0,02;565,92) |
| **16:00 – 19:00** | / | / |
| **19:00 – 6:30** | 2,54 | / |

# 8. METHOD OF YOON

Because the developed method only takes space into account and the definition of fixed and flexible activities differs from the literature, it is tried to apply the method of Yoon on the same data as on which the developed method will be used, in the continuation of this thesis. First the method of Yoon is described and afterwards the method of Yoon is applied on a respondent of the selection.

This part explains how to use the method of Yoon properly on the data that is used for the research in this document. This chapter will look at how the method of Yoon is intended to be used. There is looked at what influence this will have on the number of alternatives a respondent can reach and how this will react in space and time. Yoon takes both space and time into account there where the method in this thesis especially looks at space.

In the method of Yoon the objective is to identify the activity opportunities that a person can reach within a given amount of available time. The amount of opportunities one can reach depends on the amount of time available (time window), the space one can reach within that time available (which depends on speed of travel), and the density of opportunities (which depends on spatial organization and opening and closing hours of businesses). The data which are needed to do this research are a household travel survey (the OVG 3 in this case). These data are used to determine profiles of workers presence at job sites by industry type, the available time during which activities can be engaged in based on different activity types and the coordinates of origin and departure locations. Other data which are necessary to do this research are a roadway network (OSM objects) including time dependent travel speed/travel time, employment data of many industry types, geographic information of the census blocks, opening/closing hours of businesses and a land parcel database (OSM objects and POI layer). (Yoon S.Y. et al., 2012)

The travel speed of respondents is derived from a regional travel model and assumptions about the predominant speed on local roadways. This model uses four time periods (6am-9am; 9am-3pm; 3pm-7pm; 7pm-6am) in a day, almost the same as done in the research for this thesis. The method of Yoon makes further a distinction between the number of employees in 15 different industry types (agriculture, construction, manufacturing, education,...) this to know the time-dependent availability of opportunities. This enumeration must capture the spatial distribution of different opportunities in the region. To do this research the time of day profiles of workers that are present for each industry at their job sites are necessary. To do this, probably the data of SDG 2007 will be used. (Yoon S.Y. et al., 2012)

Yoon created a list with fixed and flexible activities (definition used in literature study), based on this list, time windows are found when individuals can have access to activity opportunities. The next table shows how Yoon classified the activity types of the OVG 3. The table shows that some of the activities that are 'fixed' in this thesis are flexible in the method of Yoon (services, shopping and leisure), so due to Yoon only work and education based trips are fixed in space and time. When computing the PPA of a respondent, work and education activities are fixed in space and time, they cannot take place at another moment or at another time of the day. (Yoon S.Y. et al., 2012)

**TABLE 58 Fixed and Flexible Activities**

| **Fixed** | **Flexible** |
|---|---|
| Work | Drop someone off |
| Education | ATM, buy gas, banking, post office (services) |
| Childcare, daycare, after school care (services?) | Shopping |
| Home activities | Fitness activity, recreational, entertainment (Leisure) |
| | Visit friends |

(Yoon S.Y. et al., 2012)

The next figure show how the PPA is calculated using a travel time matrices. Figure A shows how to compute the PPA between home and work with a given amount of time budget. The objective is to find all the blocks that can be reached on the way from work to home within the time budget. To do that, the travel time from block *j* to block *i* through each block *k* needs to be computed. In figure B, each row has the travel time from an origin block to all destination blocks and each column has the travel time from all the blocks to a destination block. It is obtained that the travel time from block *i* to each block k by selecting the $i^{th}$ row in the matrix and the travel time from each block *k* to block *j* by selecting the $j^{th}$ column. The $j^{th}$ column is then transposed and added to $i^{th}$ row producing travel time from block *i* to *j* through each *k* (Figure C). By selecting cells that have total travel time less than the time budget, the block IDs belonging to the PPA are obtained. To do this, data from/of census blocks is needed (Yoon S.Y. et al., 2012)

To illustrate the method of Yoon ten respondents are selected from the selection that is made for the research in the thesis. We tried to apply the method of Yoon on these ten respondents as far as possible with the available data. These ten respondents are: 1020304, 1041911, 4060912, 1130613, 2050612, 4012401, 4020804, 1020808 and 4061204. Most of the trips are fixed trips (work, school and home), only 21 trips are flexible trips. In these 21 flexible trips 11 trips are visits, taking a walk or dropping someone off. For these trips it is not possible to determine alternative locations because a respondent can visit someone or take a walk anywhere in space. Dropping someone off on the other hand depends on others, so it is difficult/not possible to determine another drop off location. Thereby only the shopping, leisure and service trips rest to analyze.

To determine which blocks/locations are reachable as an alternative for the respondent's current location the travel time must be calculated from the (fixed) origin to all the possible (flexible) location and the travel time from the next fixed destination to all the possible (flexible) location.

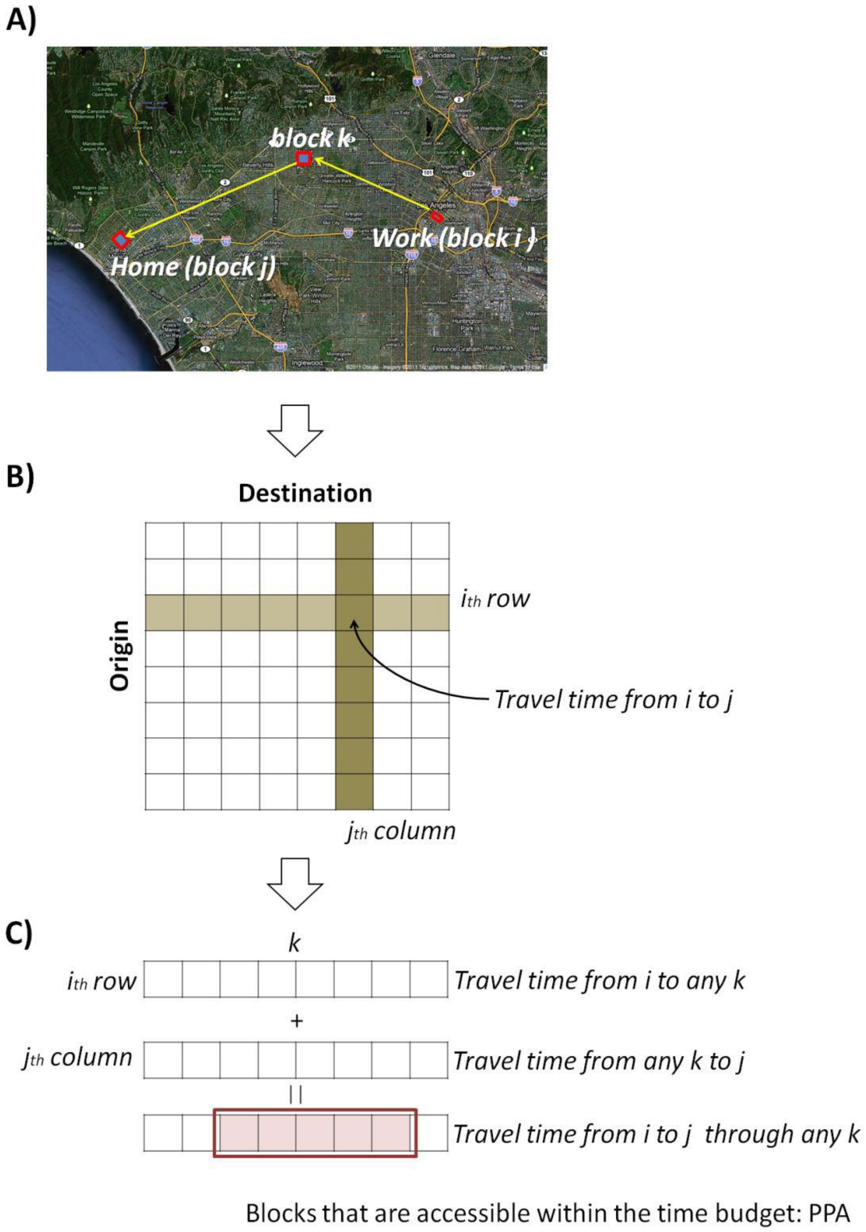


**FIGURE 29 Calculating PPA by the method of Yoon.**
(Yoon S.Y. et al., 2012)

The method of Yoon is illustrated based on a selected respondent, respondent 1020304. This respondent indicates a leisure trip (flexible), the previous and next trip are home based trips. Due to the method that is created in this thesis, the respondent has 3 (OSM objects) and 9 (POI layer) alternative locations. The location of the playgrounds is an approximation because in QGIS it is not clear where they are exact. When using the method of Yoon census blocks must be uploaded, in this case it is tried to do this with the OSM objects and POI layer.

Based on these census blocks the number of alternative locations will be determined. We will look at all possible leisure locations in the environment. The travel time from home to these locations will be displayed in a travel time matrix. When all the travel times are calculated, is looked which travel times can be achieved taking the respondent's PPA into account. The time respondent 1020304 spends on the leisure activity is 108 minutes, travel time excluded. The total time the leisure activity takes is 122 minutes. So the respondent has a single travel time of 7 minutes. The travel times to the alternative POI layer locations are calculated with the TomTom Route planner. It is also possible to determine the shortest path and travel time in QGIS by using the road graph plug-in. ( Alexander Bruy, 2011)

When enlarging the radius of possible alternative locations in QGIS some new options are available within the travel time of 7 minutes. Probably there will be more alternatives because of the lack completeness of the POI layer and the OSM objects. But based on the real travel time the respondent can reach already more leisure activities with the method of Yoon than with the method that is used in this thesis. The method in this thesis only takes the bird's eye distance to the possible alternative locations into account and does not take the travel time into account. The number of possible alternative locations can increase even more when the time spend at a location becomes shorter, so the respondent can spend more time at travelling to a location.

**TABLE 59 Origin-Destination Matrix of Respondent 1020304 Based on TomTom Travel Times**

| Destination | Origin (home) | Total travel time |
|---|---|---|
| **Joods museum** | 2 min. | 4 min. |
| **Horlogemuseum** | 4 min. | 8 min. |
| **Speelgoedmuseum** | 3 min. | 3 min. |
| **Museum Hof van Busleyden** | 2 min. | 4 min. |
| **Theater de maan** | 4 min. | 8 min. |
| **Theater Nona** | 4 min. | 8 min. |
| **Playground** | 3 min. | 6 min. |
| **Playground** | 5 min. | 10 min. |
| **Playground** | 5 min. | 10 min. |
| **Additional leisure activities:** | | |
| **Theatre 't arsenaal** | 6 min. | 12 min. |
| **'t echt Mechels theater** | 6 min. | 12 min. |
| **Museum Brusselsepoort** | 7 min. | 14 min. |

The table shows the available leisure locations in the POI layer with the same travel time (or less) as the current travel time of the respondent. Based on these travel times it is possible to drawn a respondents PPA with the alternative locations that are possible to reach within his or her current time budget. The total travel time is the travel time that is need to reach the location and move on to the next destination.

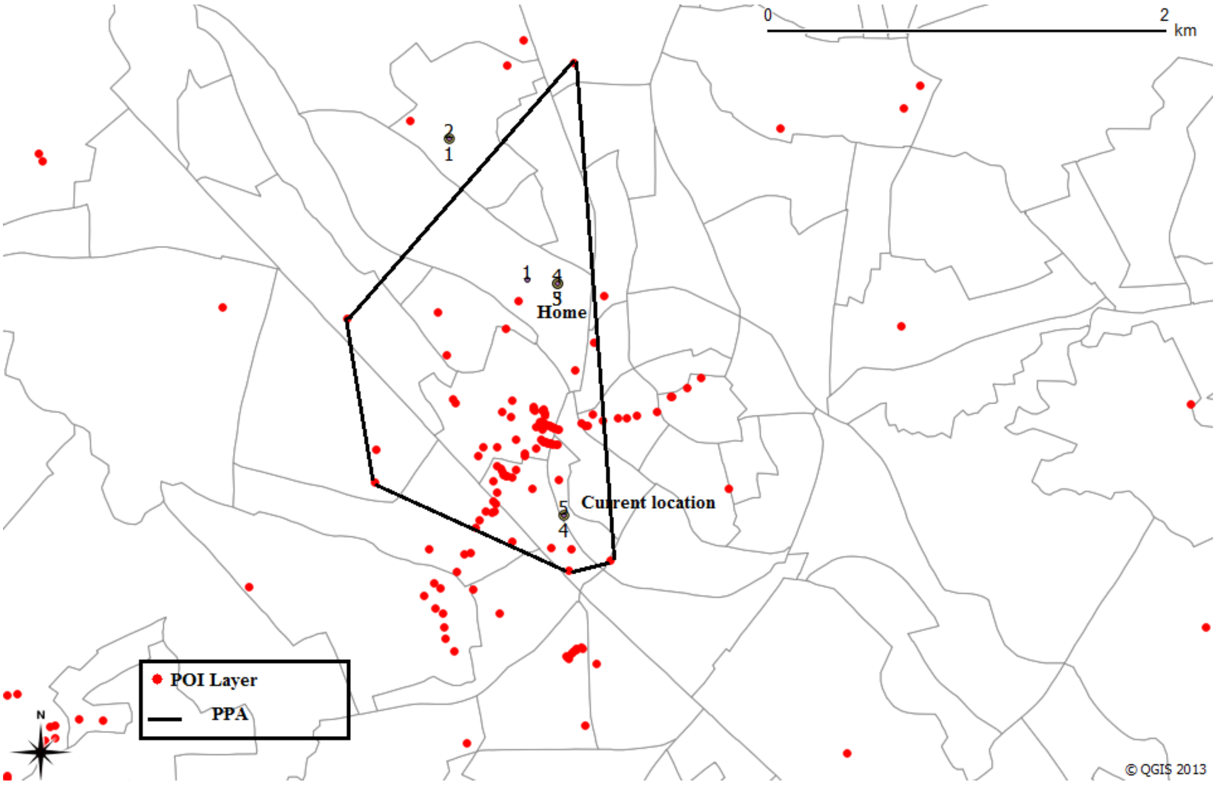


**FIGURE 30 PPA respondent 1020304.**

The potential path in FIGURE 30 is based on the travel times to the alternative locations and the alternative leisure locations that are possible in the POI layer, this layer contains more alternative locations, so that is why this layer is chosen.

The entire process of the applying of the method of Yoon on the available data and with the used programs is attached in the appendix.

# 9. CONCLUSION

In the conclusion is looked back on what is done in the research described in this thesis. First of all, the fact that not many research is done in the field of time geography of transportation sciences makes it not easy to find literature about this topic. Nevertheless some methods were found that describe how to do research in this area of transportation. These documents also described several concepts of time geography research.

In the research a sample of 80 respondents from the OVG 3 was analyzed. This sample is derived from a selection of 100 respondents that was made from the OVG 3. From this sample, some respondents had to be deleted because of errors in the data. The sample that was made, matches quite well with the whole OVG 3 selection. The selection does not contains over- or underrepresented trips purposes, age groups, transportation modes, number of trips,.... The respondents were dispersed over Flanders, which makes the research representable for the entire territory of Flanders. Nevertheless, more respondents lived in the environment of the bigger cities like Antwerp, which isn't inconsequent. Because it is more likely that the survey contains more respondents in Antwerp because this is the biggest city in Flanders.

When analyzing the sample, some problems occured, these will be discussed in the next chapter. But in the research is tried to solve these problems or limit them to a minimum.

For the analysis is focussed on trips where it was easy to find alternative locations namely: shopping, leisure, education, work and service based trips. The choice for these trips is based on the fact that, for these trips, it is easy and clear to determine alternative locations because they take place at a specific location. For trips like visits and suchlike, it was more difficult to find alternative locations because these trips can take place at different locations. A respondent can make an appointment with someone anywhere in space or time. When searching for alternative locations, depending on the distance respondents had to travel to their current location, several factors were analyzed and taken into account. Like the transportation mode they used, time of the day the trip is made, travel time and the area they lived in. These analysis are based on the bird's eye view distance between the current origin and destination location the respondent mentioned in the OVG 3.

Some of the results of the analysis were very logical. All theses analyses are based on the distance in bird's eye view. By analyzing the number of alternative locations a respondent can reach, the number of locations increases when the distance of the trip increases. Respondents travelling by motorised vehicles can reach more alternative locations. By using the proposed method, it is normal that when a respondent uses a motorised vehicle the distance he or she can travel is longer, so the respondent will have more possible alternatives. The area respondents live in also affects the number of possible alternative locations they can reach. People living in urbanised areas can, for most of the trip purposes, reach the most alternative locations for their current trip purpose and distance. In some cases the number of alternative locations that respondents in rural areas can reach, was also remarkable high. This can be explained by the fact that they have to travel further for some purposes, so the radius of their trip is large and they can cover more surface.

When looking at the travel time of a trip, the number of alternative locations a respondent can reach increases as the travel time increases. This also is a logical determination. When a respondent travels longer, the travel distance will increase, so his or her radius will increase also, which means that a respondent can cover more surface and reach more alternative locations. In another part of the research is also looked at the period of the day the trips are made. This analysis indicates how much alternative locations a respondent can reach depending on the period of the day. The results of this analysis are an indication of the number of alternatives. An indication because the travel times were not taken into account, so delays were not included in the study. A respondent can reach, in general, more alternative locations in off peak periods than in peak periods. One can assume that this image will be confirmed when using the real travel times and delays of a trip.

The conclusions of this research are all methodological consequences. Based on the method that is used, we only looked at the distance in bird's eye view and the data that is used is open source. So the data to determine the alternative locations is not one hundred percent reliable. The research, done in this these, is more a statistical approximation of the subject. There is no model built, but looked at how much alternative locations a respondent can reach taken several factors into account. The relationship between these factors has therefore not been studied. By using general places of interest (all kinds of shop, leisure activities, school,...) it is not clear how much alternative locations a respondent can reach exactly. It is only possible to say that a respondent has an average number of locations he or she can reach depending on a specific factor.

# 10. DISCUSSION

In this chapter is room for discussion about this master thesis. The limitations of the research will be illustrated and initiative for future research in time geography of transportation science is indicated.

In the data description, some limitations or difficulties of this research mentioned are already mentioned. The research experienced problems with the data as well as with the processing of this data. The 'incompleteness' of data in the OVG 3 makes that, from the original selection of one hundred respondents, only 80 respondents rest. This as a consequence of missing coordinates, incomplete or incorrect data of some respondents. Some of these errors were already visible when looking at the data selection in the excel-file, other problems displayed when uploading these data into QGIS. It is chosen to retain the selection of 80 respondents. Because in case that there will be searched 20 other respondents without errors, this would imply that the OVG 3 data is one hundred percent correct and complete. A remark, retaining the selection of 80 respondents, is an overestimation of the errors, but because of the random selection of the errors, it indicates that there are several respondents with missing or incorrect data. The choice of analyzing one hundred respondents was made at the beginning of this research. It was suggested to analyze as much respondents as possible, but to set a target this was set at a 100 respondents. When analyzing the entire OVG 3 dataset, it can be that the results differ from this research. Nevertheless, the selection for this research was made randomly and the composition of the sample came out pretty well with the entire dataset of OVG 3, so there is some truth in the research done for this master thesis.

By using QGIS for the analysis, some new problems were discovered. The Open Street Map objects (OSM objects) are uploaded by individual users of QGIS because the program is open source. So the data is not complete, it is likely that locations or information is missing. These data are checked, as seen previously in the document, and it is noted that several points of interest are missing. Another problem with these OSM objects is the amount of data that can be downloaded at once. These areas weren't very large. So when the distance of a trip increases, a lot of single areas had to be downloaded to complete the whole surface covered by the circle between departure and arrival. The amount of OSM objects also limited the processing time, this is why it is decided to make a separate file for each respondent. There are larger files available, but to analyze these, one will need a more powerful device to upload and run this data. In that case more processing time is required. Advantage of using these data is that it is available for free and easy to download. On the other hand, problems with the reliability of the data is experienced. The data are not reliable for one hundred percent because it is open source. It would be better if, for example, data is available from the telephone book (Gouden Gids) that can be uploaded in QGIS.

As already mentioned above, the distance between origin and destination of some trips makes it difficult to determine alternative locations. Trips with a distance larger than 20 kilometres cannot be analyzed using the method that was used in this research, at least not in an efficient way. Because in some cases, OSM objects must be downloaded for almost the entire territory of Flanders to determine the number of possible alternatives. So to do the analysis in one file, there is a powerful computer with a large memory to process the data needed. In case of this research, a simple laptop is used but this is enough if the files are kept small. A disadvantage of this is that a single file for each respondent is created and every time the base layer of Belgium must be uploaded as well as all the information for the respondent.

In future research, it is possible to look at the specific kind of activity because now the research only viewed at the general motivation of trips. When a respondent indicates that it was a shopping trip one looked for all possible shops within his or her potential path area. In the future you can look, for example, for other supermarkets when the respondent indicates that the trip was towards a supermarket. The same thing is possible with education based trips. In this research is not made a distinction between nursery school, primary school, high school, university,.... Same remark is valid for all the other trip purposes. Maybe some additional research has to be done in case the respondents did not indicate which type of shop, work, leisure... they did. But this can, eventually, be derived from the addresses they filled in or when the location of the coordinates matches with a point of interest. When taking the specific type of leisure, shopping, work, school or service location into account, it will be easy to determine the specific needs of a respondent. Now, no information about the specific type of activity is available, only that it is a shopping, leisure, work, education or service trip. When the specific type of activity is known, it will be easy to satisfy the need of the respondent. In case of the research, done in this thesis, it is not possible to determine the exact needs of the respondents. So now there is only a general overlook of the locations, which can be useful to determine other interesting locations within the current space-time prism where a respondent can take part in other leisure activities for example.

Another possibility for future research is to take the time spent at an activity location into account. When taking the minimal residence times into account, it is possible to determine a respondent's chain of trips. When the respondent can reach a similar location for his or her current trip closer to the previous trip destination, it can be possible that the respondent will have more time to travel to the next locations. In this case the next destination can be further in space and time and maybe more interesting. So using the minimal residence times and all the trips of a respondent can be interesting to determine the full chain of trips.

As already mentioned in the results of each trip purpose, the part where the number of possible alternative locations during the time of the day is analysed, isn't that useful when it is done with bird's eye view distances. It is better to use real travel distances and times in this case, and take the time budget of a respondent into account, as well as opening hours of facilities. Because it is more likely that a trip will take more time in peak periods and the real distance is longer than the distance in bird's eye view. By using the bird's eye view, there is an indication of how the number of alternative locations a respondent can reach will evolve during the day, but this is not an exact image of this evolution. So this can be investigated in future research. As well as all the other things that were analyzed, but in future research they will be based on real distances.

In future research, one can look at how much several factors influence the number of alternative locations. This is mentioned in the research questions but not dealt with in the document. It can be interesting to look how much each variable (travel distance, transportation mode, time of the day, travel time,...) influences the number of alternatives a respondent can reach. This can be analyzed based on a model. By quantification of the relations, it is possible to find links between the factors, included in the model and research. Analyzing a model is done with a statistic program like SPSS or SAS. In these programs it is possible to build a model an quantify the research relationships.

Despite the limitations that were encountered, it was tried to do some research in the field of time geography with the material and data which were available. From the possible topics for future research, that are mentioned above, some interesting, instructive, useful,... studies and results can occur.

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# 12. LIST OF FIGURES

# 13. LIST OF TABLES

# 14. APPENDIX

## 14.1. How the data is used

### 14.1.1. OVG 3 data

The data of the OVG 3 (Onderzoek Verplaatsingsgedrag 3) were delivered by the IMOB. This data contain information about individual respondents that took part in the survey. For our research not all the data which were available from OVG 3, are used. Some columns were adjusted or other ones were added.

First of all the coordinates had to be adjusted. So four new columns were added. Two columns for the longitude and latitude of the departure and two for the arrival point of the trip. These columns are called: longitude, latitude, longitude_vv and latitude_vv. These data were actually already adjusted last year in the case study of the first master. To become the right coordinates, the given numbers from the OVG 3 had to be divided by one million.

The document 'final selection' shows all the trips of the selection that was made from the OVG 3. Another sheet shows the individual respondents of the selection and a sheet shows each trip purpose that was analyzed (shopping, services, leisure, education and work). In the first sheet, the one with all the trips and respondents, were added some more columns:

- Werkelijke afstand (km) = real travel distance: this one gives us the distance measured with TomTom between departure and destination of the trips;
- Werkelijke tijd (min.) = real travel time: this one displays the real travel time calculated with TomTom between departure and destination of the trips;
- Verschil werkelijke afstand – afstand (ABS) = difference real distance - distance: this column shows the difference between the distance, measured with TomTom, and the distance given by the respondent in the survey. In shows the absolute value;
- Verschil werkelijke tijd - tijdsduur (ABS) = difference real time – travel time: this column tells us what the difference, in absolute value, is between the real travel time, from TomTom, and the travel time given by the respondent.

From the existing columns the following are used:

- Perid: this is the unique identification number for each respondent in the survey. This column is used to name the individual QGIS file of each respondent;
- Verid: this column shows the number of the trip when a respondent makes more trips;
- Doel11: displays the trip purpose;
- Post: postal code of the destination;

- Straat bestemming: destination street;
- Postvv: postal code of the previous departure location;
- Straat vorige vertrekplaats: street name of the previous departure location;
- Afstand = distance: distance of the trip given by the respondents;
- Tijdsduur = time: time of the trip given by the respondent;
- Uurminv: time of the day when the trip took place;
- Hfdvm: transportation mode of each trip;
- Gemeentetype= municipality type: type of municipality of the previous departure location.

For each trip purpose a separate document is made. These documents are named after the trip purposes that were analyzed. Each document has the same outlook but they contain information about a different purpose. These excel-files contain the same columns as the document called 'final selection' but some extra columns are added:

- Alternatieven OSM = alternatives OSM: this column contains information about the alternative locations for the trips based on the OSM data (Open Street Map);
- Opmerkingen = comments: comments about the data in 'alternatieven OSM';
- Alternatieven POI = alternatives POI: this column contains information about the alternative locations for the trips based on the POI data (Places Of Interest);
- Opmerkingen = comments: comments about the data in 'alternatieven POI'.

Each excel-file consists of several sub sheets. The first one is the same as in the document 'final selection'; this one contains all the information of the specific trip purpose. The other sheets are used for calculation, the name of the sheet indicates which influence in examined. The sheets are called:

- Algemeen = general: is the same as in 'final selection' and shows all trips of the chosen purpose;
- Vogelvluchtafstand = bird's eye view distance: in this sheet is the number of alternative locations based on the bird's eye view calculated;
- Gemeentetype = municipality type: shows the influence of the community type of the previous departure location on the number of alternative locations that a respondent can reach;
- Vervoersmiddel = transportation mode: this sheet shows the number of alternative locations a person can reach depending on the transportation mode;
- Leeftijd = age: this sheet contains information about the number of alternative locations each age group can reach;
- Tijdstip = time of day: in this sheet is a distinction made between the time periods during a day and looked how many alternative locations a respondent can reach given his or her current trip properties;

- Reistijd = travel time: a final analysis is based on the real travel times of the current trip. In this sheet is looked what happens when the travel times increases.

### 14.1.2. QGIS and data

Calculating the bird's eye view distance and the number of alternative locations, happened in the program QGIS. This is a free geographic information program that is available on the internet. The program is available at: http://hub.qgis.org/projects/quantum-gis/wiki/Download. Before any analysis can be done in the program, a layer is uploaded that contains the circumference of Belgium and divide Belgium in zones. This layer was provided by the IMOB and is called: BB_ZONERING_IMOB2_5. As already mentioned in the thesis make sure that the coordinate system that is used is the right one.

For each respondent the coordinates of the departure and arrival location from the excel-file are uploaded. The OSM objects can be downloaded from the website http://www.openstreetmap.org/ or they can be downloaded in QGIS, which is described in the thesis. These layers contain the information about the road network (lines), points of interest (points) and zones (polygons). In the research is a comparison between the points of interest from the OSM objects and other points of the interest layer made. This layer is called belgium_poi and is available on http://downloads.cloudmade.com/europe/western_europe/belgium#downloads_breadcrumbs in the zip file belgium.shapefiles.zip. This zip file contains several other layers like the coastline, highway, natural, water,... but this research only uses the points of interest layer, to compare this layer with the points of interest in the OSM objects.

## 14.2. Procedure method of Yoon

In this part is explained how the method of Yoon can be used with QGIS and the same data that are used to do the research in the thesis. The data that are used are the OVG 3, POI layer and OSM objects. The procedure starts the same way as the method used in the thesis. First one has to upload all the necessary files: layer of Belgium, coordinates of the respondent, the OSM objects and the POI layer. So it is possible to use the separate file of each respondent that is available from the research done with the other developed method.

To know which trips are flexible and possible to replace in time or space you have to look at the table that is given by Yoon. In case of the OVG 3 only work, education and home trips are fixed. All the other trips are flexible and though it is possible to search for alternative locations, in case of some purposes -like visits, dropping someone off, walking,...- it is not possible to determine alternative locations because they can take place anywhere and anytime. So the trips that can be analyzed using the method of Yoon are leisure, shopping and service trips.

When all the data is uploaded or the QGIS file is opened one can start with the analysis. Again it is necessary to draw a circle between origin and destination of the trip, to display the points within this circle. Now it is possible to see which points are within the bird's eye view distance of the trip. Based on the information that is available in the attribute table one can determine the address of the location, in most of the cases. With this address and the address of the next destination you can calculate the travel time with the TomTom Route planner. This is also possible in QGIS because a road network is available, with the use of the road graph plug-in. ( Alexander Bruy, 2011)

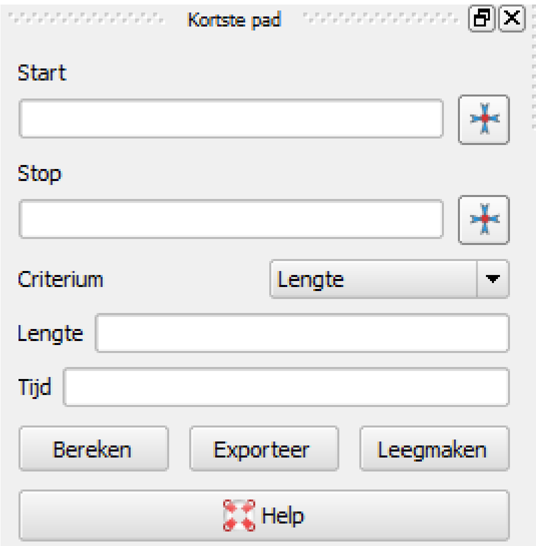


**FIGURE 31 Road graph plug-in QGIS 1.8.0**

By activating the road graph plug-in it is possible to calculate the shortest path and travel time between two places of coordinates. So one is able to select the origin of the trip and the destination as well as alternative locations to select the travel times and distances. But the version of road graph that is available in QGIS 1.7.4. (the one that is used most time of the time during this research) has another layout than the description in the manuals. By downloading the newest version of QGIS 1.8.0 (on 29 may 2013) the layout is the same as the manuals and it should be possible to calculate the shortest path of a trip. However, when doing trying to do this the program indicates that the plug-in is not configurated.

By using the road graph plug-in it is possible to select the coordinate pairs from the points of interest that are selected with the circle that is drawn. One can determine the shortest path (in space and time) between the origin of the trip and the possible alternatives.

In FIGURE 32 the origin of the leisure trip is home as well as the next destination after the leisure activity. To determine the alternative locations the POI layer is used. When searching for alternative leisure activities, these locations will be shown in another colour. For the selected locations it is possible to calculate the travel time with TomTom Route planner as done in the example of respondent 1020304 in the thesis.

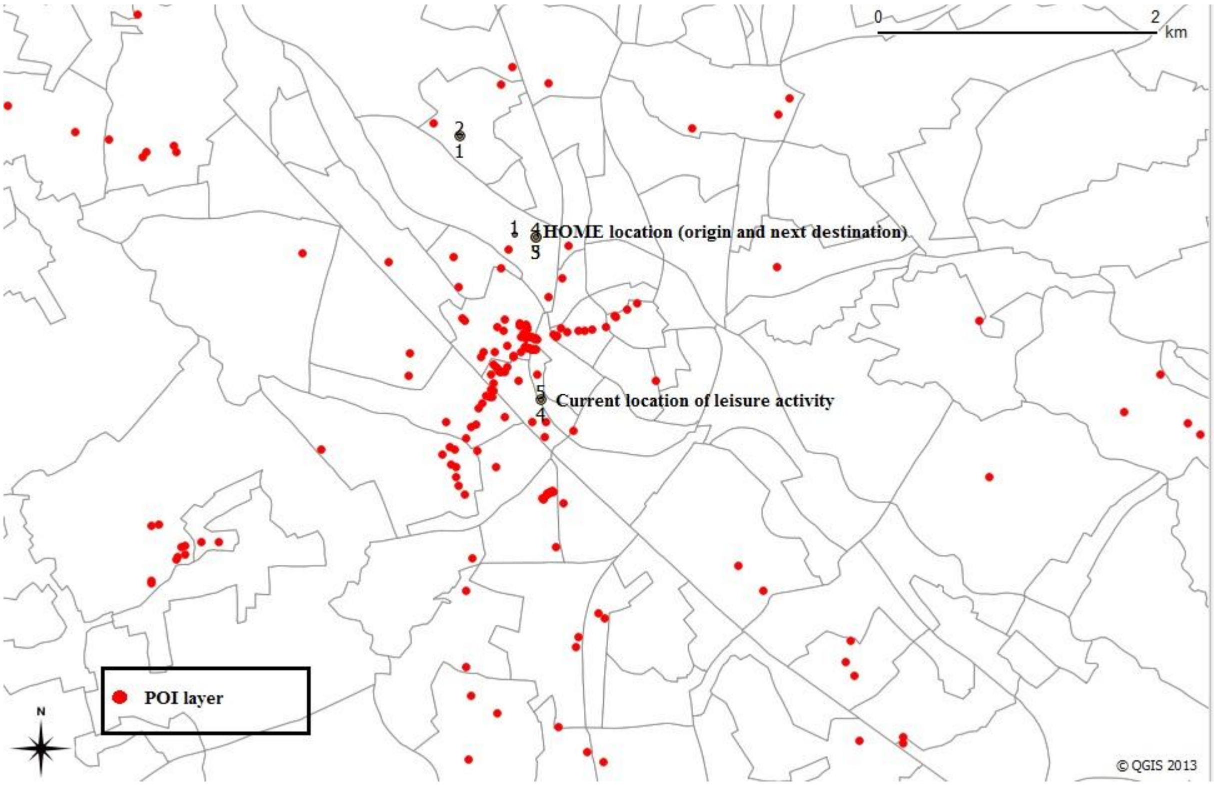


**FIGURE 32 Alternative (leisure) locations for respondent 1020304**

When the travel time of all the points of interest in the circle is calculated it is possible to enlarge the circle. When new points are available, the travel time for these points can be calculated. In the OVG 3 data the researcher can see how long the respondent travels to his or her current location. When the travel time of alternatives is longer than this travel time, the alternatives are out of reach, unless it is possible to shorten the residence time (minimal activity duration) so the travel time can be increased. When looking for average duration time of some activities the following results are found for some trip purposes: the average time people spend for (grocery) shopping is 39-42 minutes (men-women) (Goodman J., 2008) and the average time people spend for leisure activities is more or less 55 minutes. (Martin Ginis K.A. et al., 2010)

It is not always possible to know the exact address of a location, sometimes the attribute table just says that the locations, for example, is a playground with no further information. But based on QGIS it is possible to search the location in TomTom by approximation.

When all the travel times of alternative locations are calculated it is possible to determine and draw the respondents PPA, taking the travel times into account. FIGURE 33 shows how the potential path can react on different time windows or a change in activity duration. It will be possible to draw such figure with all the travel times, when this is done it will be possible to have an illustration of a person's PPA.

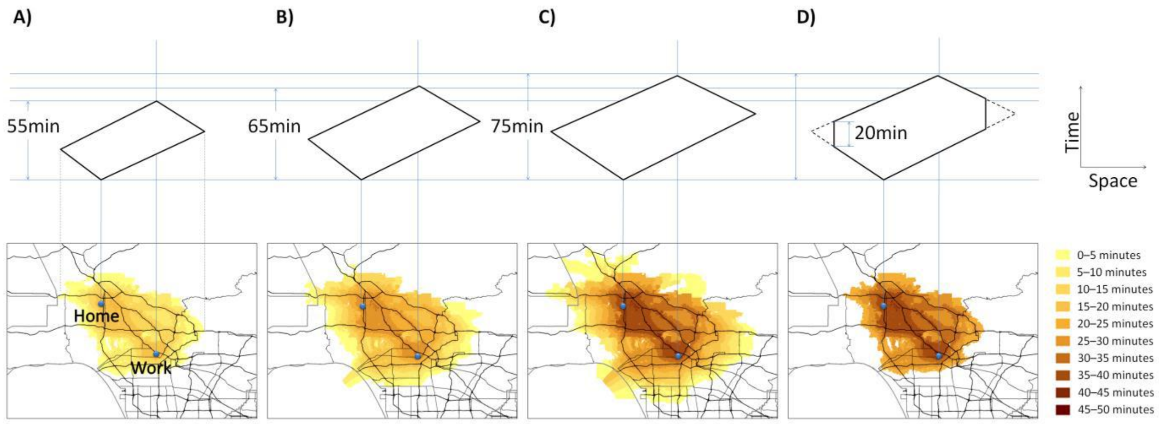


**FIGURE 33 Potential path areas for different time windows with minimum activity duration.**

(Yoon S.Y. et al., 2012)

## 14.3. Results method of Yoon

To illustrate how the method of Yoon can be applied to the available data. The previous mentioned respondents are analyzed if possible.

The addresses are approximations because it is not possible to determine the exact address in QGIS. To know the address of the destination an estimation is made about the location in TomTom route planner. With the plug-in road graph it is possible to determine the exact travel time and location because the shortest path can be calculated between two coordinate pairs. But due to problems with the plug-in this does not work.

### 14.3.1. Leisure trips

#### *14.3.1.1. Respondent 1130613*

The current travel time of this respondent to the leisure location is 4 minutes outward and 5 minutes return. The POI layer is used to determine alternative locations. The table shows the travel times to alternative locations within the bird's eye view distance of the current trip. When increasing the travel time up to 9 minutes, no additional alternatives were found.

**TABLE 60 Alternative Travel Times Respondent 1130613**

| | Home (origin) | Home (next destination) |
|---|---|---|
| **Theater de leest (St.-Jorisstraat)** | 5 min. | 5 min. |
| **Playground (Kerkestukstraat)** | 5 min. | 6 min. |

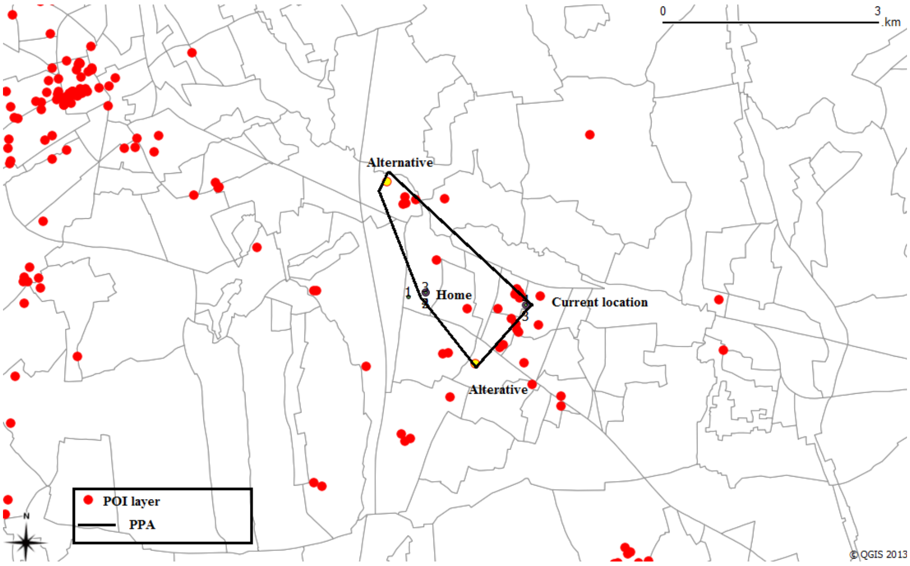


**FIGURE 34 PPA respondent 1130613.**

#### *14.3.1.2. Respondent 4061204*

The current travel time of this respondent is 1 minute outward and 2 minutes return, again the POI layer is used to search alternative locations. Within the current bird's eye view distance were no alternative locations, so the circle is enlarged. Within a travel time of 9 minutes there are two extra alternative locations.

**TABLE 61 Alternative Travel Times Respondent 4061204**

| | Home (origin) | Home (next destination) |
|---|---|---|
| **100-jarige eik (Dikke eikstraat)** | 6 min. | 6 min. |
| **Playground (Meldertsebaan)** | 9 min. | 9 min. |

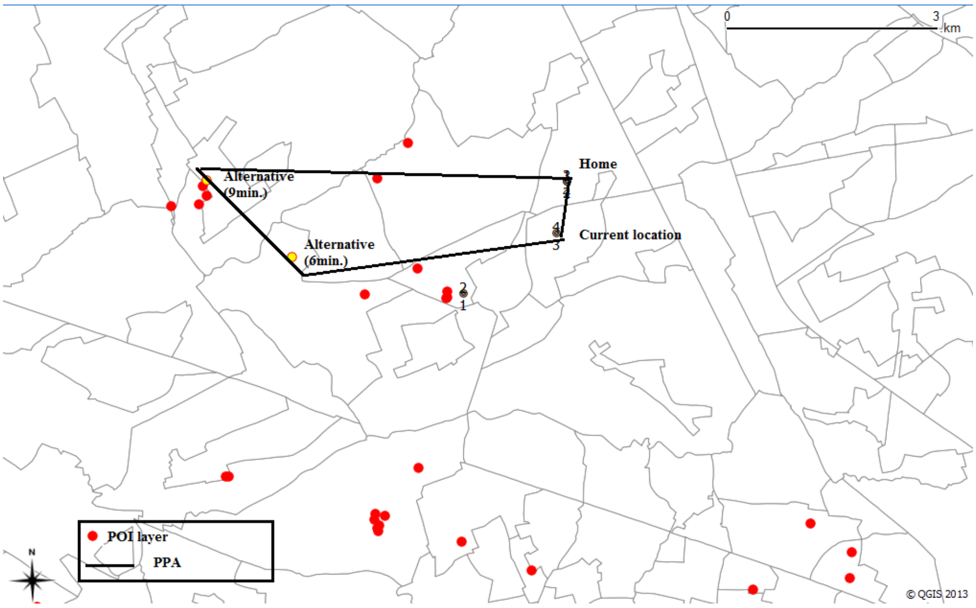


**FIGURE 35 PPA respondent 4061204.**

#### *14.3.1.3. Respondent 1041911*

The current travel time of this respondents to the current leisure location is 8 minutes outward and 5 minutes return. The purpose of the previous trip is shopping as well as the next trip. It will be difficult to know the exact time budget of this respondent because both trip purposes are flexible. In the current situation the respondent has 11 alternatives within the bird's eye view distance of the current location, due to the POI layer. When the bird's eye view distance doubled the number of alternative locations increases to 78 alternatives. The travel time is enlarged to about 25 minutes to the extreme points. Depending on the shopping activity and the duration of the leisure activity (current 37 minutes) the respondent can choose to enlarge his or her travel time.

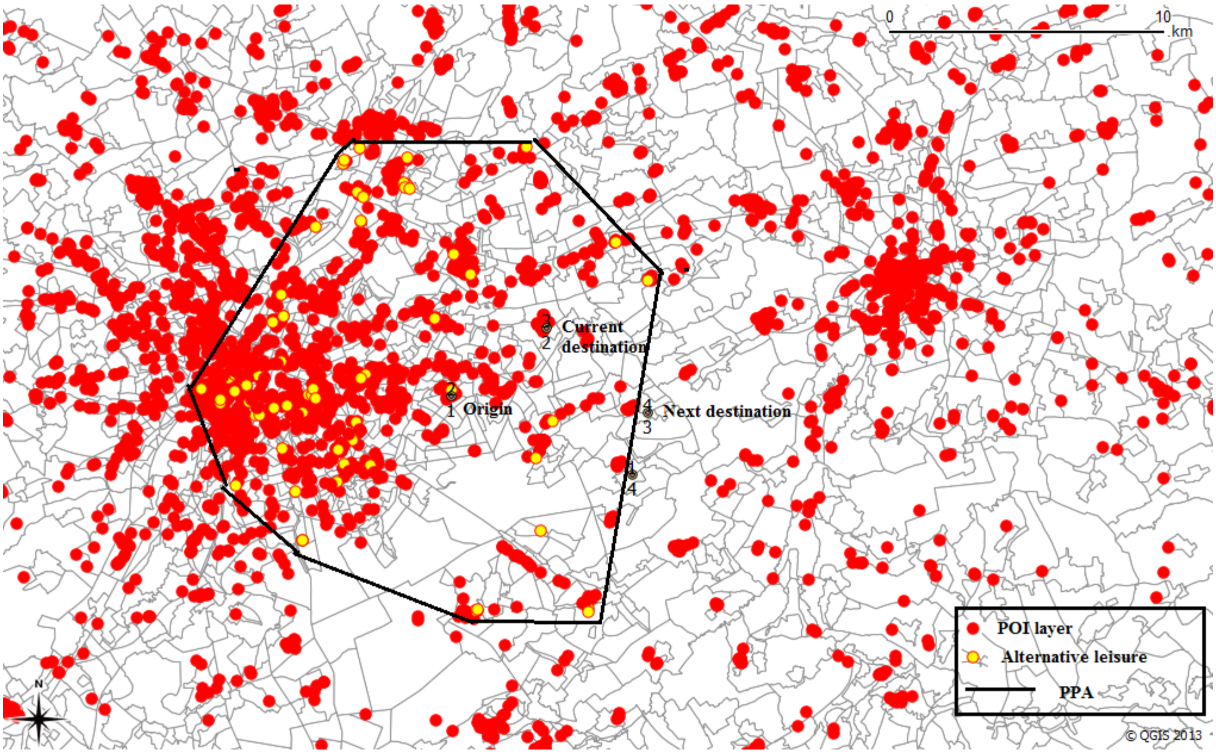

**FIGURE 36 PPA respondent 1041911**

### 14.3.2. Service trips

#### *14.3.2.1. Respondent 1020808 and 4012401*

Both respondents indicated that they have made a service based trip. When looking at the results for alternative locations (POI layer) within the bird's eye view distance the number of alternatives is quite large to analyze, using TomTom route planner. Respondent 1020808 has 96 alternative locations and respondent 4012401 has 21 alternatives. It would be easier to analyze these respondents by using the road graph plug-in, but this plug-in does not work (not configurated). We have made a PPA for these respondents based on their current bird's eye view.

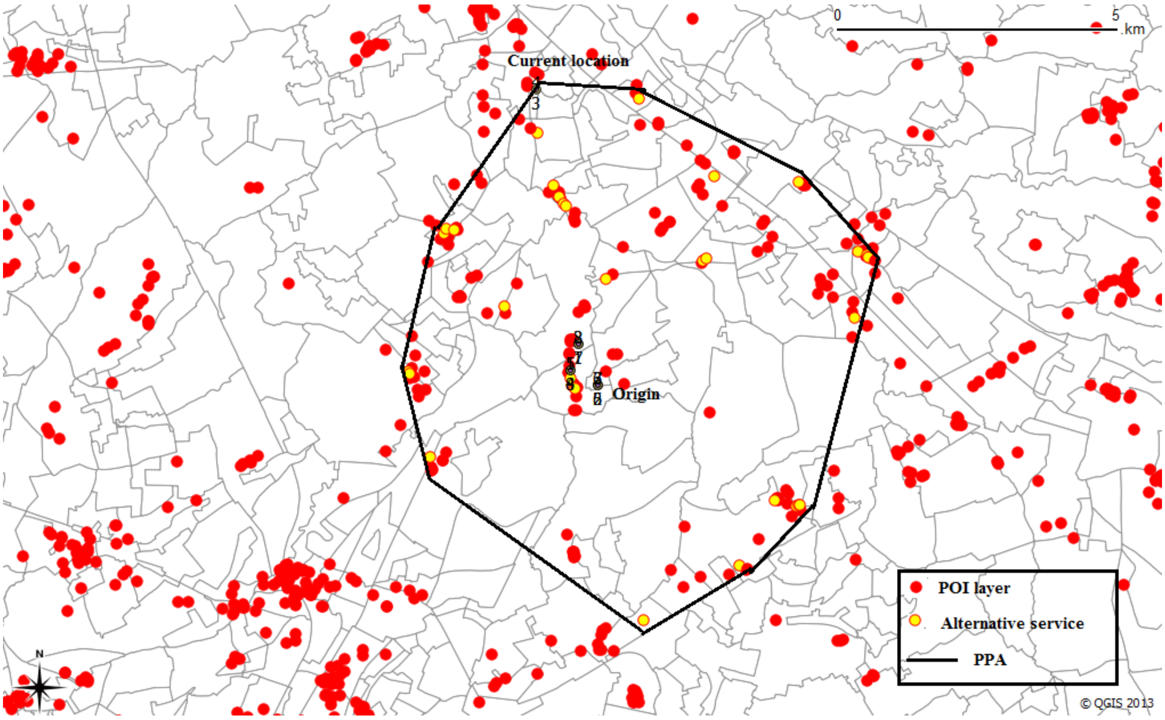


**FIGURE 37 PPA respondent 1020808.**


**FIGURE 38 PPA respondent 4012401**

### 14.3.3. Shopping trips

#### *14.3.3.1. Respondent 1130613, 1041911 and 2050612*

Same problem with these respondents as with the previous service trips. Respondent 1130613 counts 178 alternative locations due to the OSM objects, respondent 2050612 has 171 alternative shopping locations and respondent 1041911 counts 103 alternatives within the current bird's eye view. For these respondents it was not able to create a PPA as done for the previous ones. Because the file exists out of several OSM objects and it is not possible to display all the alternatives of each OSM object at once. Again this analysis can be done with the aid of the road graph plug-in, this will be a faster and better way to analyze the respondents.

## 14.4. Selected respondents

Selection of one hundred respondents out of the OVG 3. The respondents in bold are the one that are deleted from the original selection of 100 respondents.

**TABLE 62 Selected Respondents**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1010201 | 1020709 | 1062602 | 2012011 | 2051010 | 3010101 | 3060101 | 4020804 | 4090605 |
| 1010305 | 1020808 | 1070301 | 2012308 | **2060206** | 3010204 | 3060212 | **4040202** | 4100612 |
| **1010411** | 1041911 | 1071104 | 2012611 | 2060603 | 3010611 | 3121008 | 4040514 | 4110209 |
| 1010604 | 1050201 | 1080304 | **2013002** | 2061011 | **3011008** | 3130903 | 4041406 | 4120115 |
| 1013912 | 1050212 | **1081201** | 2020205 | 2080110 | 3011402 | 4011813 | 4041715 | 4120510 |
| 1020105 | **1060912** | 1081809 | **2020807** | 2080606 | 3011610 | 4012401 | 4050413 | 4120908 |
| 1020211 | **1061313** | 1081906 | **2030607** | 2081413 | 3030706 | 4012907 | 4060907 | 4130203 |
| 1020303 | **1061804** | 1130613 | 2040814 | 2090104 | 3040409 | 4013515 | 4061204 | 4130313 |
| 1020304 | 1061805 | 1131107 | 2041909 | 2120406 | 3050406 | 4020214 | 4062002 | 4130505 |
| 1020502 | 1062111 | 2011315 | 2050612 | 2120511 | 3051105 | 4020615 | 4071207 | 4131011 |
| 4131115 | **1010603** | **1020602** | **2061502** | **2062601** | **3013508** | **3050702** | **3081405** | **3100410** |
| **4040414** | | | | | | | | |

## 14.5. Deleted points of interest

The following points of interest were deleted from the layer Belgium_poi because, they weren't very useful for the trip purposes that are analyzed in this research.

**TABLE 63 Locations Deleted from Belgium_poi**

| | | | | | |
|---|---|---|---|---|---|
| Bicycle parking | Drinking water source | Information source | Picnic spot | Residential | Toilets |
| Bicycle rental | Emergency access point | Level crossing | Pipeline | Service station | Tower |
| Bunker | Ferry stop | Lighthouse | Power station | Significant tree | Traffic lights |
| Bus stop | Fountain | Mooring line | Power tower | Small power station | Tram stop |
| Car rental | Guest house | Motel | Public pieces of art | Spring | TV, radio studio |
| Cave entrance | Halt | Parking | Public telephone | Stop signs | View point |
| Chalet | Hostel | Peak | Railway crossing | Subway entrance | Water disposal |
| Currency exchange | Hotel | Pedestrian crossing | Recycling | Taxi | Water treatment |
| Watermill | Waste disposal | Bunker | | | |

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Richting: **master in de verkeerskunde-mobiliteitsmanagement**
Jaar: **2013**

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**Dupont, Gertjan**

Datum: **3/06/2013**