jamk.fi

Polycentric city development and Public transport planning

Case Kangas area / Seppälä

Mika Salovaara

Bachelor's thesis
March 2018
Technology, communication and transport
Degree Programme in Logistics Engineering

Jyväskylän ammattikorkeakoulu
JAMK University of Applied Sciences

jamk.fi

Description

Author(s)	Type of publication	Date
Salovaara, Mika	Bachelor's thesis	
		Language of publication: English
	Number of pages 71	Permission for web publication: x

Title of publication

Polycentric city development and Public transport planning

Case Kangas area / Seppälä

Degree programme

Logistics Engineering

Supervisor(s)

Kokkonen Toni, Paananen Juha

Assigned by

Jyväskylä city

Abstract

Planning public transport in an urban area is one of the most important details in any growing city as society is aiming to reduce its ecological footprint by trying to get people to use buses, trams, bicycles or other alternative means of transport besides personal vehicles.

The consigner, Jyväskylä City public transport division, is a municipal authority in charge of providing public transport services in Jyväskylä area. The thesis focused on first identifying factors that affect public transport planning in Finnish urban areas from municipal authority's point of view, and then applying the factors on a real developing area in Jyväskylä, with the result being some suggestion on how public transport planning could be approached in the area in question. The theoretical part consists of basics of public transport, legislation, service levels and infrastructure requirements. The base material for the thesis was mainly collected as observations from current lines and zoning plans.

The results of the thesis consist of concrete variations on how to organize public transport in Kangas area, with a preferred suggestion being identified. Results highlight the thought process in public transport planning from municipal authority's point of view. The pre-set aims of the thesis were fulfilled, and the thesis provides the consigner an option on how to provide public transport services to Kangas area.

Keywords/tags (subjects)

Public transport, Municipal authority, Zoning, Bus transport

Miscellaneous

jamk.fi

Kuvailulehti

Tekijä(t)	Julkaisun laji	Päivämäärä
Salovaara, Mika	Opinnäytetyö, AMK	
	Sivumäärä 71	Julkaisun kieli Suomi
		Verkkojulkaisulupa myönnetty: x

Työn nimi

Polycentric city development and Public transport planning

Case Kangas area / Seppälä

Tutkinto-ohjelma

Logistics Engineering

Työn ohjaaja(t)

Kokkonen Toni, Paananen Juha

Toimeksiantaja(t)

Jyväskylän kaupunki

Tiivistelmä

Julkisen liikenteen suunnittelu on yksi tärkeimmistä kehityskohteista kaikissa kasvavissa kaupungeissa, sillä yhteiskunta pyrkii pienentämään ekologista jalanjälkeään saamalla ihmiset käyttämään linja-autoja, raitiovaunuja, polkupyöriä tai muita vaihtoehtoisia liikkumismuotoja henkilöautoille.

Toimeksiantaja, Jyväskylän kaupungin joukkoliikenneosasto on Jyväskylän seudun julkisen liikenteen palveluista vastaava kunnallinen yksikkö. Opinnäytetyössä keskityttiin tunnistamaan tekijät jotka vaikuttavat julkisen liikenteen suunnitteluun suomalaisilla kaupunkialueilla kunnallisviranomaisen näkökulmasta ja soveltamaan tekijöitä kehittyvällä alueella Jyväskylässä. Työn tuloksena saatiin ehdotuksia siitä, miten julkisen liikenteen suunnittelua voisi lähestyä Kankaan alueella. Teoreettinen osa koostuu julkisen liikenteen perusteista, lainsäädännöstä, palvelutasojen määrittelystä ja joukkoliikenteen asettamista infrastruktuurillisista vaatimuksista. Opinnäytetyön perusaineisto kerättiin pääasiassa havaintoina nykyisistä linjoista ja kaavoitussuunnitelmista.

Opinnäytetyön tulokset muodostuvat konkreettisista suunnitelmista, jotka koskevat julkisen liikenteen järjestämistä Kankaan alueella, ja näistä suunnitelmista tunnistetaan toteuttamiskelpoisin. Tulokset korostavat julkisen liikenteen suunnittelun ajatusprosessia kunnallisen viranomaisen näkökulmasta. Opinnäytetyön ennalta asetetut tavoitteet täyttyivät, ja opinnäytetyö antaa toimeksiantajalleen vaihtoehdon palvelutasot täyttävälle julkisen liikenteen toteuttamiselle.

Avainsanat (asiasanat)

Joukkoliikenne, Kunnallinen viranomainen, Kaavoitus, Linja-autoliikenne

Muut tiedot

Contents

Figures

1 Introduction

1.1 Research Background

Public transport and specifically bus transport has been in turmoil for last few years in Finland. The challenges and changes in the industry can be traced to 2014 when bus transport was opened to competition, as per EU legislation that was set on 2009. These events and my part-time work in a medium sized bus company sparked my interest on public transport in Finland as whole. It was felt that during its heyday before opening for competition the industry and the operators in it stagnated and as it is catching up to current realities much advancements and discoveries on how to organize public transport can be made.

Every year 346 million bus trips are made. Share of buses in all public transport trips in Finland is almost 60 percent. Outside Helsinki area buses share of public transport journeys is more than 80 percent. The fundamental right of movement every individual has is largely dependent on bus transport. It has particular importance for those more than 2 million Finns who lack a driver's license. (Bussijärjestelmä 2017)

The idea for the thesis topic was a product of a conversation made with the consigner, in this case Jyväskylä city. The decision making behind choices on where to provide public transport was looked at and it was concluded that research should be made on what parameters decisions are based on when a municipal competent authority plans bus service within its operating envelope, and how to apply these principals to a real area under development. Every area in the authorities' responsibility has its own unique traits, but the variables that the service providers look at when determining where and how to direct public transport stay the same. The idea is that when need arises for new connections in new areas, what are the variables that the competent authority must consider before decision on how to provide transport services is made. The district in focus was chosen to be the developing Kangas area. Public transport also goes hand in hand with land use planning, and researching their relationship is vital in understanding the development of public transport as a part of a growing city and transport politics.

1.2 Objectives

The main objective in this thesis is to find information about key factors behind public transport planning in Jyväskylä, specifically what parameters matter when it comes to planning for new lines for areas where previously no public transport service exists. At the end of the research there should be an idea what factors are vital to consider when doing plans or evaluating current operations, specifically how they factor in a real-world example. The specific area chosen to be researched is the quickly developing Kangas area In Jyväskylä. The goal is to find out how public bus transport would be implemented to Kangas area.

The base data for this research is formed on public transport reports and plans made for Jyväskylä city during last few years and data on city infrastructure and population. Costs of establishing operations will be observed so they can be also factored into the research.

The research questions considered were; what are the factors that must be evaluated before municipal transport operator can decide whether public transport service will be initiated on an area, and how to implement public transport to Kangas area. The first question is on the different parameters and challenges that are found in the background work, and the latter is the product of applying those parameters to the subject area in question.

1.3 Research Limits

In this research, only the public transport policies of Jyväskylä city are considered, although results could be useful in other cities as well. The research will focus on city bus traffic only, and the research won't be extended to further regions outside main Jyväskylä area. The key factors that was considered are population density, roads and infrastructure and land usage planning from the viewpoint of competent authority offering the public transport service, so the service providers viewpoint is in this case excluded.

1.4 Jyväskylä City

Jyväskylä is the largest city of central Finland. It was first recognized as a city 22nd of March 1837, back when Finland was an autonomy under Russian rule. Its location means it has experienced traffic for hundreds of years; it sits in the crossing of three major waterways, a fact that has surprising ramifications to public transport planning in 2017. The current attractiveness of Jyväskylä as a prominent studying city and the reason it has grown into a lone major city in central Finland can be traced to 1850s and 1860s when several Finnish language schools were established in Jyväskylä. Over the last few decades several smaller neighboring counties were attached under its jurisdiction. Currently it is home to some 139 000 inhabitants, the yearly increase in population being around 1500 people, and its expenditure in 2016 was 962,9 million euros. (Perustietoa Jyväskylästä 2016)

Jyväskylä city is the biggest employer in Jyväskylä with around 7000 employees. The city is responsible for organizing services from healthcare to public transport. The public transport division, who assigned this project, operates under the arm of Traffic and green areas department.

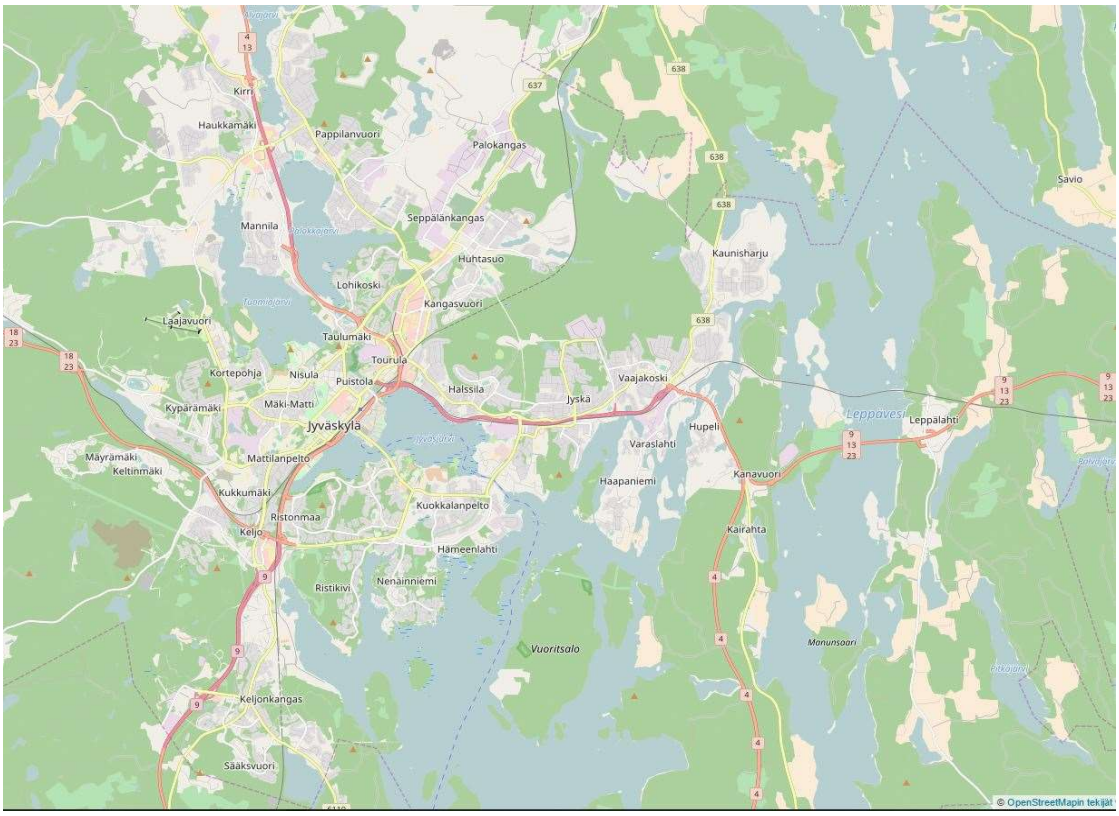

Figure 1 Major Jyväskylä area (OpenStreetMap 2017)

2 Research Methodology

2.1 Research Thought Process

Several steps and variables face public transport providers and its users. Some of them are through force of nature, others through legislation, some caused by human behavior. If the simple action of making a bus move so that it's not only effective but also legal is a component of countless variables even as an abstract thought, what does those variables look like when they are placed on a real environment? As the city stretches to various directions, and in the place of singular strong center are several smaller ones, does it have effect on the thought process as public transport plans are made?

When looking at practical example it was decided to focus in a single developing area in Jyväskylä city, specifically Kangas area, near the center of Jyväskylä. Kangas as an area is a topical and unique area, as it takes advantage of an area in a prime location that previously wasn't available for use for housing. Thus, the lack of existing infrastructure requires more than just planting some apartment houses on the side of the road and calling it a day. The requirement for comprehensive planning presents a challenge for all municipal authorities involved, and public transport providers are no exception.

2.2 Research Method

In any research it must be considered what research method and approach to apply. The base information for the research was mainly available as previously published data, and dissertations can be made by critically analyzing and applying such information. After considering the subject of public transport planning in a specific target are it was decided that desk research method is to be used. In desk research information and data relevant to the subject is sourced from various internal and external sources, such as government publications, consigning organizations material, calculations from lines and other researches touching on the subject. Sources for theoretical part consists of literature and online publications. The base thought process is supported by Jyväskylä city's long term public transport plans. (Desk Research – Methodology and Techniques 2018)

Theory and methods relevant to the development of public transport and city structure are gathered and then applied to the example district in question, Kangas area. (Desk Research – Methodology and Techniques 2018)

3 Public transport

3.1 Definition of Public Transport

Most human beings have the need and right to transport. Public transport is seen as a basic service in any city, and it should be able to be procured at an affordable price point for all customers. Even though modern societies revolve heavily around personal vehicles, not all people have a chance to acquire or use one. For example, people with disabilities, the elderly and younger people have and will always need some sort of transport, and public transport offers them the freedom of transport what which they couldn't otherwise exercise. (Ahonen & Hokkanen 2015, 8)

Public transport is a powerful driver of large numbers of people, but at the same time it is a basic service which together with the society supported passenger traffic gives people the opportunity to satisfy essential everyday mobility needs with an economically advantageous manner regardless of ownership of different transport devices and the place where they live. Charters, call traffic and school buses are examples of additional passenger services. (Julkisen liikenteen sanasto 2013, 9)

By definition, public transport consists of regularly scheduled vehicle trips, open to all paying passengers, with the capacity to carry multiple passengers whose trips may have different origins, destinations, and purposes. (Walker 2012, 13)

The definition According to Walker (2012, 13-14) can be split into following parts:

- Regularly scheduled vehicle trips: The transport is provided by a vehicle running on a regular schedule or pattern. There is room for variation in routes and schedules. Demand-responsive services, for example, may vary their routing according to customer requests, within set limits. But at its core, transit service must be predictable so that different people can plan around it without coordinating directly with one another. This feature is the crucial difference between transit and other ways of sharing a ride.

- Open to all paying passengers: The word public in public transport means ''open to entire public.'' This does not refer to the fact that it is generally organized by public entities, as private companies are equally happy to let any paying passenger use their product. Failure to comply can become a civil rights issue.
- That can carry multiple passengers: The ability to carry several passengers with a single vehicle is a given virtue of transport, and a basis for its efficiency.
- Whose trips may have different origins, destinations and purposes: In this case carpools and ridesharing are excluded, where several people with same destination share a ride and taxis, which usually carry only small amount of people to a same destination. (Walker 2012, 13-14)

Several types of multi-occupant vehicles can and are used, but the principal of carrying several individuals in a single vehicle instead of each driving alone to the betterment of environment and congestion stays the same. (Walker 2012, 13-14)

3.1.1 The Expectations for Useful Public Transport Service

Defining public transport as a concept is all well and good, but what are the expectations of the potential customer? What can be considered essential properties that public transport is evaluated by the common man? Seven broad expectations that a potential customer usually considers are:

- It takes him where he wants to go
- It takes him when he wants to go
- It is a good use of time
- It is a good use of money
- It respects the passenger in the level of safety, comfort and amenity it provides
- It can be trusted
- It gives the passenger freedom to change his plans (Walker 2012, 24)

The most essential requirements from the eyes of the customer are listed first. The crucial component, a transport service from point A to point B at a desired point in time is logically first. The more the public transport service can cater to this need the better, as accessibility and timeliness of public transport is often seen as its most important development aspect in the eyes of the potential customer. The resources (time and money) it takes from you are next, as these factors are often compared to using your own vehicle. The demand of respect for safety and comfort is a requirement regarding the actual usability and comfort level of the service, so that you feel your time isn't wasted or that you are in danger.

Should the customer start to use the service in regular intervals trust is a key factor, as the customer starts to expect that the service operates the same way every time they use it.

The demand of freedom is where public transport has its tightest challenge; whether the operation can be used on a whim to for example go shopping on a moment's notice and also come back after few hours, or can it be used to cover for a failure of another transport option. A personal vehicle's use can be spontaneous, so the transport system should be able to compete with that.

These demands aren't a literal definition of service level, especially from a public transport provider's standpoint, because they don't set any key values to aim for, rather they are the qualities that the potential customer cares about and properties which must be taken care of in order for the system to be called useful. (Walker 2012, 24)

The reason this listing isn't quite perfect is that it doesn't consider two more abstract demands; feedback of function and side effects of operations. Feedback of function has to do with the issues of fair treatment of employees, media relations, discrimination and so forth. Side effect of operations has to do with the effects that in this case public transport has in the form of emissions, vibrations, noise and visual detriment. (Walker 2012, 25)

3.1.2 Bus Transport in Finland

First buses arrived in Finland in 1905, but regular connections started only few years later. The oldest still existing bus companies in Finland were founded in the 1920's. Nowadays there is more than 35000 daily bus connections across Finland. (Ahonen & Hokkanen 2015, 19)

First buses were used to transport both people and goods, passengers sitting in wooden seats and goods on a flatbed. After 2nd world war factory production of bus chassis was started in Finland. As the vehicles were made to order one could get many variations of body types, the number of passengers being carried was between 10 and 30. In the 1950s buses started to look like their current counterparts. The size of the vehicles rose as did the passenger amounts. 1970s saw the introduction of creature comforts like toilets and coolers to the equipment of buses. Currently the development of powertrain technology is the field where biggest advances are made, motivated by the need to reduce emissions. The bus in figure 2 has 49 passenger places, all the creature comforts one expects from a modern car plus a coffee machine and a cooler, while it also meets current emission standards. (Ahonen & Hokkanen 2015, 19)

Diesel has been the prevalent fuel for heavy vehicles for decades, but especially in a city environment alternative fuels are already used. With the long-term goal of moving away from using fossil fuels due to energy security and environmental reasons, heavy vehicles must also be increasingly ecological to operate. City buses are rare specimens compared to other heavy vehicles in that electricity has been a viable option as a fuel for a century. Trolley buses where overhead electrical wires provide power to the bus through poles on the roof of the bus have been in widespread use for decades, and continue to be if the networks are maintained. Battery powered electric buses are also implemented but in a much smaller scale, as the charging networks and battery technology evolves. Other options include biofuels, which is easy to adapt to current diesel-powered vehicles, but several variations of fuels exist, and all need unique modifications, liquid and compressed natural gases, but these vehicles have had teething problems in use, mainly related to exorbitantly high running costs. (Smart choices for cities: Alternative Fuel Buses, 2016, 6,22-31)

Figure 2 A modern long-distance bus

3.1.3 Finnish Transport Policy and its Goals

Transport policy is all the actions between different factions that aim to produce and procure nationwide transport services and any influencing decisions within. Transport policy is decided between the state, municipalities, private sector and citizens. (Ahonen & Hokkanen 2015, 9)

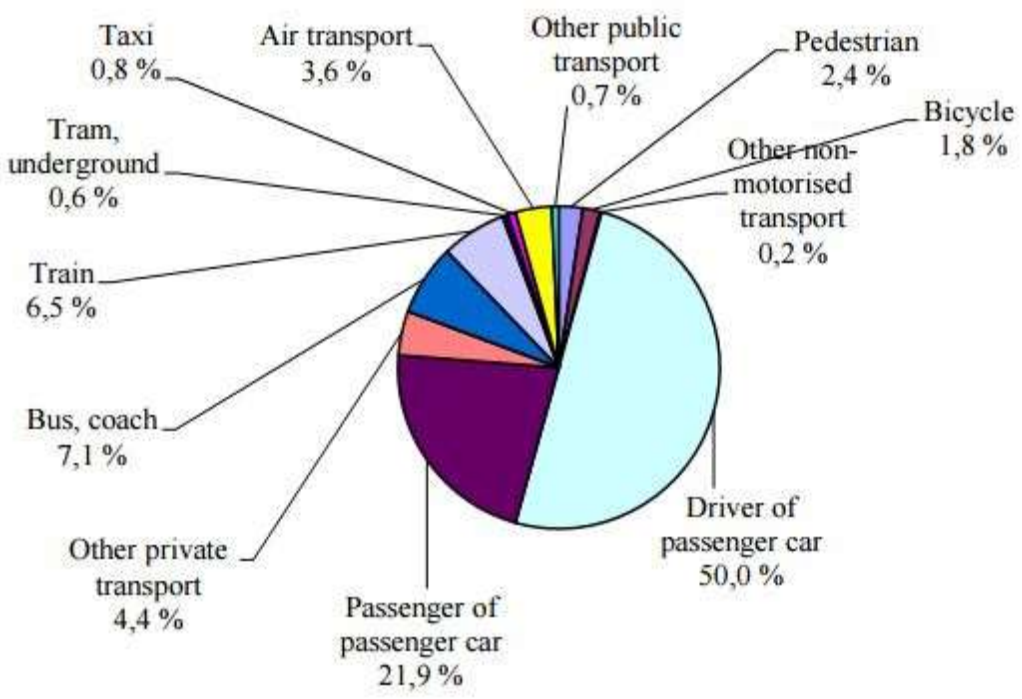

Figure 3 Average distribution of journeys as daily travelled kilometers according to the 2010-2011 National Travel Survey

The main goal of Finnish transport policy is to secure everyday commutes, uphold the competitiveness of business and reduce emissions to slow down global warming. Public transport that is effective and well taken care of is in the best interest of Finnish transport policy.

For small and average sized cities Finnish transport policy's goals are that commuting and service traffic are handled efficiently, ecologically and at an affordable price point. In large cities passenger amounts are easier to increase, as the usage of public transport is naturally at a higher level there. Of all public transport journeys 75% are made within larger cities. (Ahonen & Hokkanen 2015, 9-10)

To further attract customers and gain users particularly from car users service level should be improved. Things like dedicated lanes for buses can be used to increase the effectiveness and thus attractiveness of public transport.

In small towns and scarcely populated areas in the countryside a basic level of public transport services should be secured.

As public transport companies cannot profitably run adequate connections in these scarcely populated areas, the basic service level should be secured by procuring those routes that are still important as connections between residential centers. Ideally bus transport should act as a network connecting conurbations with each other. In long distance traffic focus is put on improving the trip chain. This covers aspects like competitiveness of pricing, service quality, passenger information and compatibility of different ticket systems. Fringe benefit tickets should also be developed to better suit bus transport. (Ahonen & Hokkanen 2015, 9-10)

The biggest challenge bus transport faces are the loss of profitability due to decrease of passenger amounts. The different operators in the public transport field have set a goal to increase the number of journeys done with public transport by 200 million from the current 530 million trips. The collaboration is between Finnish transport agency, ministry of transport and communications, large cities, the national railway company VR, Association of Finnish Local and Regional Authorities, Finnish bus transport association, regional traffic association and TVV ticket and payment system organization. To make evaluating the effects of transport policies as a whole equal the Finnish transport agency has provided tools to determine adequate public transport service level thorough the country. This also makes directing funding just. As Finnish transport agency is responsible for directing national public transport development projects and making decisions on large cities' state subsidies to public transport ensuring that all municipalities evaluate their public transport service levels on same standards is of their best interest. (Liikenneviraston rooli valtakunnallisessa joukkoliikenteessä, 2017)

3.1.4 Public Transport Legislation

Bus transport operation conditions are provided by national public transport law (869/2009), as well as the EU's public service contract (1370/2007). The transport of persons professionally for a payment always requires a valid public transport permit in accordance with the law.

Public transport act and the EU's public service contract came into effect at the end of 2009. Public transport act is run in with a ten-year transitional period during which the new public transport organizing methods will be introduced gradually in accordance with the new law. Intercity passenger transport permits made under the old law were transformed to transition period transport permits and they are gradually expiring between 2014 and 2019. EU public service contract specifies how the government can ensure the quantity and quality of public transport services by intervening in the market.

The competent authorities are responsible for organizing public transport in accordance with the public transport act. The competent authorities are the nine centers for economic development, transport and the environment (ELY Centers), as well as 26 municipal authorities. The competent authorities define the service level of their area, and they determine how transport services are organized. They can be arranged either as a market-based transport or in accordance with EU public service contract with competitive tendering. (Liikenneviraston rooli valtakunnallisessa joukkoliikenteessä 2017)

Traffic must be arranged by competitive tendering in accordance with the procurement legislation and public law, provided there is no market-based transport providing an adequate level of service and transport services are funded with public support. The competent authorities make independent decisions on what ticketing and payment system is used in the area, as well as decide ticket pricing.

A market-based transport requires a valid public transport license or a license for route traffic granted by the competent authorities. In market-based transport, a carrier independently determines the pricing of tickets. (Liikenneviraston rooli valtakunnallisessa joukkoliikenteessä 2017)

Public transport license is a license required to practicing public transport with a bus in accordance with EU's public service contract. It authorizes the operator to exercise public transport according to the public service contract on an agreement made with a competent authority and charters in whole country except Åland. A public transport license is valid for five years. (Julkisen liikenteen sanasto 2013, 20)

License for route traffic gives the right in combination with the public transport license to exercise line operations. This license is issued to an applicant that has a public transport license and commits to practicing traffic in accordance to the operators' quality assurance for at least two years, the maximum duration of the license being ten years. (Julkisen liikenteen sanasto 2013, 22)

3.2 Organizing Public Bus Transport in Finland

Before the year 2014 public transport by bus in Finland had been based primarily on a company-led system, where the transport activities were based on self-sustainability, and the companies weren't supported with funds given by the society. Majority of Finnish bus traffic has been self-sufficient to the tone of 80 percent of all bus traffic, and this way society hadn't been required to offer public transport services to locations where it couldn't be profitable. Through special legislation municipalities had the responsibility to procure transport services for schooling and social- and medical services purposes. To make traffic services at a level which the society sees adequate, some parts of the services have had to be funded with public funds. The traffic and communication agency LVM has secured traffic connections it sees vital, both in rails and roads, whether it is supporting regional traffic in Helsinki area or funding long distance bus lines. Municipalities have procured bus lines which function as a part of school transport or as a commuting connection. Local regional self-supporting transport services have been supplemented with additional transport services and connections. (Ahonen & Hokkanen 2015, 11)

As there is great variance between sizes of cities and the requirements for public transport systems across municipalities, the transport services have been arranged uniquely through Finland. The transport system in capital area has been planned by a federation of municipalities dubbed Helsingin seudun liikenne (HSL). HSL has planned and procured the services it requires from private contractors. The operators have been chosen based on competitive bidding, and the contractor is paid for the acquired services for the duration of the contract, which is usually few years. The contractor *settles* profits gained from selling tickets to HSL. (Ahonen & Hokkanen 2015, 11)

In average sized cities, public transport services were mainly produced by self-sufficient companies. The cities procured any services they deem necessary to add to that self-supporting transport. These cities could have received state subsidies to maintain public transport services they need. (Ahonen & Hokkanen 2015, 12)

Post 2014 public transport management of road and in parts rail traffic is governed in particular by European Parliament and Council decree of rail and road public passenger transport services public service contract (PSA) (1370/2007) and Finnish public transport act (869/2009). Public service contract states guaranteeing safe, efficient and high-quality passenger transport services through regulated competition as the main goal of European transport policy, which at the same time guarantees the transparency of public passenger transport services and adequate performance and considers social, environmental and regional development factors. The public service contract also notes that many passenger transport services necessary for common good cannot be operated on a commercial basis, thus the competent authorities must be able to carry out necessary actions in order to ensure supply. The public service contract regulates precisely the way in which public authorities can intervene with the market regarding its actions within public passenger transport. (Julkisen liikenteen sanasto 2013, 9-10)

Practicing public transport is subject to authorization. Transport licenses are regulated by the law on public transport. The law on public transport also decrees the competent authorities' responsibility to plan and ensure adequate public transport services within their operating envelope. (Julkisen liikenteen sanasto 2013, 9-10)

As per the EU public service contract organizing public transport has moved more and more to be the responsibility of the society. Two major changes happened in 2014 when long distance route traffic licenses were started to give out more freely and organizing of public transport in average sized cities was changed. The competent authority, for example a municipality, determines the service level in its area, and decides how the public transport is planned to meet that service level. When the competent authority decides that market-based transport doesn't cut it and more expansive, better quality, more reliable or cheaper service is required, EU's public service contract is followed when it comes to procuring public transport. The only way the competent authority can receive state subsidies for transport is to follow the public service contract. In Figure 4 is visualized the amount of state subsidies applied and granted for public transport for the last few years. (REGULATION (EC) No 1370/2007 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL 2007, 1-2)

When following the public service contract, the operator is chosen through competitive tendering, and this ties to European Councils goal of free markets in transport business. (REGULATION (EC) No 1370/2007 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL 2007, 1-2)

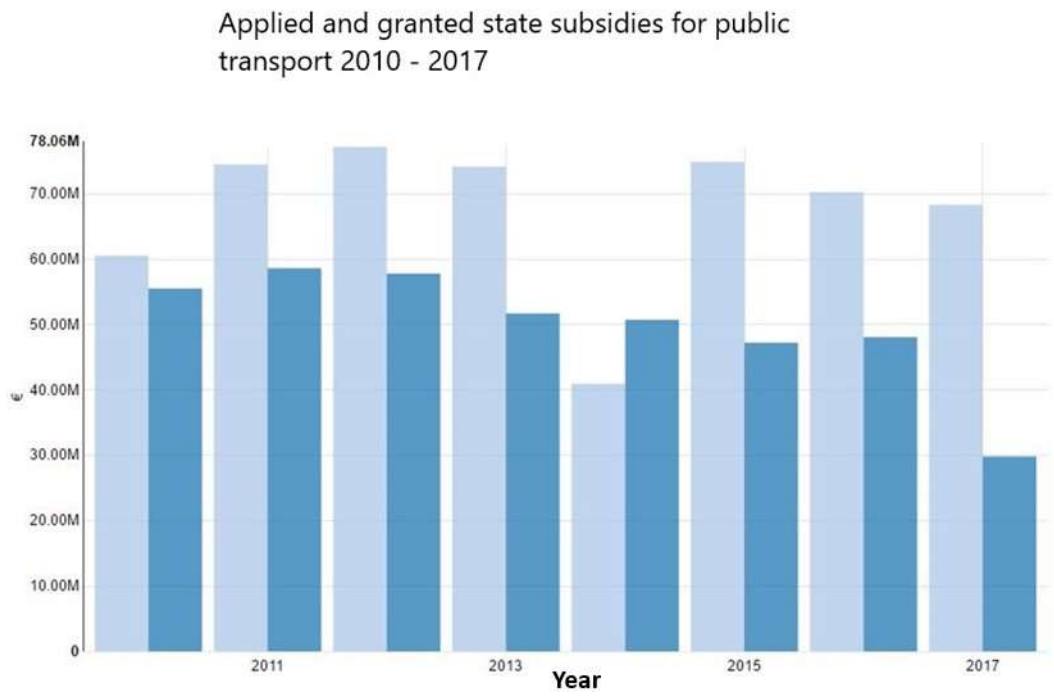

Figure 4 Applied and granted state subsidies for public transport 2010-2017. Granted amounts in darker blue.

Researches and experiences gained from areas where there have been years of competition in the field of public transport show that a controlled competitive environment increases innovativeness and cost effectiveness without proving to be a hindrance for public transport operators and their field. (REGULATION (EC) No 1370/2007 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL 2007, 1-2)

3.3 Bus Transport in Jyväskylä City Area

The responsibility of organizing public transport in Jyväskylä area is held by Jyväskylä city. In the city's organization, the task is the job of the public transport division. The ticket prices, schedules, routes and competitive tendering of public transport services are decided in the regional public transport section, where representatives are not only from Jyväskylä city, but from nearby regions of Muurame and Laukaa as well. (Ohjeita ja tietoja, 2017)

As the competent authority Jyväskylä city had to decide with which way it should organize public transport. During the planning phase for current public transport plan for Jyväskylä city it was decided that in Jyväskylä public transport should be organized with gross model. Same model is in use for example in Helsinki and Turku as well. As opposed to a model like service concession, where the transport operator has exclusive rights to traffic in a given area or route and gains profit from tickets, in gross model the transport operator is paid based on the amount of line kilometers, while the competent authority takes the risk of the service being profitable or not. It provides the authorities' lot of control over the transport services, as the competent authority can control different aspects affecting the attractiveness of transport services, most importantly ticket prices and routes. For the transport operator it's a simpler model, as they don't need previous experience from the profitability of the transport in an area, making the competitive tendering playing field more even for transport operators. However, as the transport operator has no risk in the case that the number of passengers is unsatisfactory, it also cannot gain direct financial advantage should the passenger amounts increase. (Jyväskylän kaupungin joukkoliikennesuunnitelma 2012, 46)

The gross model was chosen so that the competent authority has the best ability to not only reach the planned public transport service level but also to be able to further its goals in transport policy. With the gross model the routes, service scope and ticket prices are in the competent authority's control, thus public transport can more easily be integrated to land usage and transport system planning. Previous experiences from other cities using the gross model have also been good. (Jyväskylän kaupungin joukkoliikennesuunnitelma 2012, 47-48)

The local bus traffic in Jyväskylä is mostly run by a subsidiary of Koiviston Auto, Jyväskylän Liikenne Oy. Jyväskylä city has 12 transition period transport permits, the last one expiring in May of 2018. Currently Jyväskylä city offers two services for public transport in Jyväskylä area; regular line traffic that is operated with large (45 passenger and larger) buses, and six demand responsive transport vehicles that are small (around 14 passenger) buses operated by Mennään Bussilla Oy. Demand responsive transport is a combination of regular line transport and a taxi service, where

it has set stops but can also be hailed using your phone even into your home address. (Jyväskylän kaupungin joukkoliikennesuunnitelma 2012, 12)

In 2012 about 6,5 million journeys were done in Jyväskylä's public transport. This number includes all ticket products. During the last 20 years the number of yearly journeys has shifted between 5,8 and 7,1 million journeys, the average being 6,4 million journeys. From figure 5 it can be seen that the decreasing of journey amounts has been halted by increasing the amount of ticket subsidy. In 2008 a long-term average was reached as far as number of journeys goes, as Laukaa region public transport was integrated to local public transport. Roughly 30 years ago the number of passengers suffered a catastrophic drop, as in 1984 8,4 million journeys were done in Jyväskylä local public transport. The reaction was to lower the price of the most convenient and popular tickets with ticket subsidy. (Jyväskylän kaupungin joukkoliikennesuunnitelma 2012, 12)

To increase the attractiveness of public transport Jyväskylä City public transport executes several campaigns on certain times and gives discounts to certain groups of people. For example, a person with a pram can travel for free between 9:00 and 14:00. Students and retirees are eligible to buy tickets and travel cards with discounted prices, and veterans travel for free. (Jyväskylän seudun joukkoliikenne, Ohjeita ja tietoja, 2017)

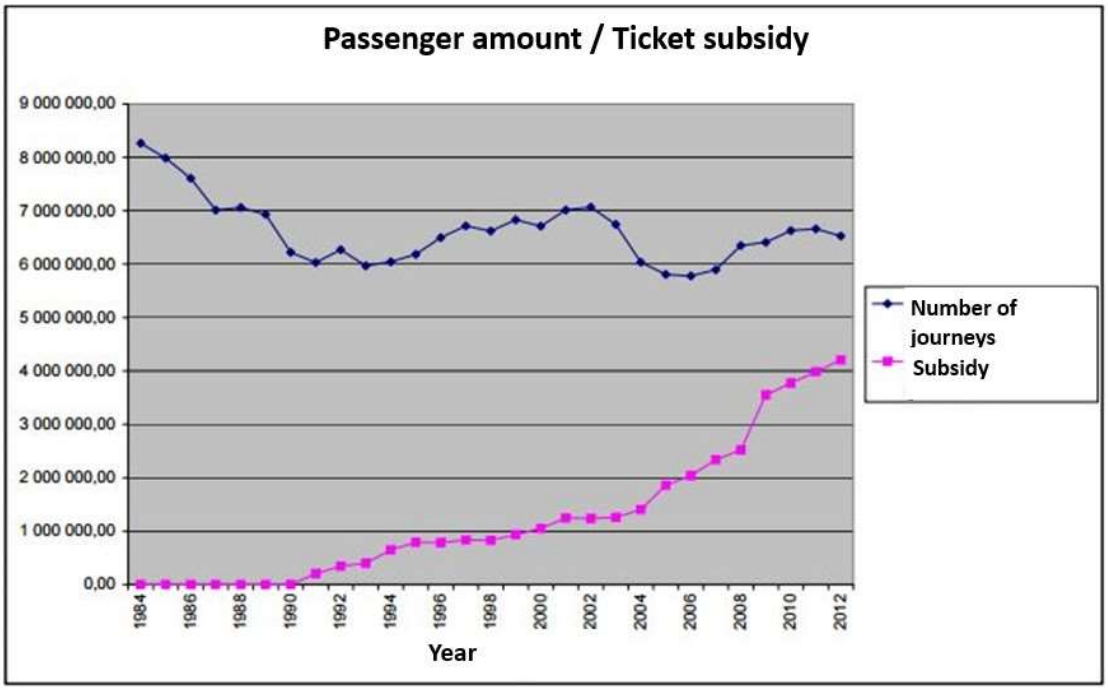

Figure 5 Passenger amounts and ticket subsidies 1984-2012 in Jyväskylä.

3.4 Public Transport Service Level

The Finnish public transport act obliges competent authorities to define the service level of the public transport in their area. This is done to tell what kind of public transport services are planned to offer and to what degree the competent authority aims to develop public transport in its region. However, it doesn't force the competent authority to actually offer public transport in a service level it defines, thus setting a service level doesn't create any subjective right to get public transport services. (Joukkoliikenteen palvelutason määrittely 2015, 10)

The defined service level creates a service level goal, which directs the planning and organizing of public transport. Hence public transport service level is preferable to be set to a level that all parties involved can commit to it. Cities acting as competent authorities should also look to get acceptance for the service level in a political level to enhance the availability of funding in the long-term. (Joukkoliikenteen palvelutason määrittely 2015, 11)

The purpose of defining public transport service level is to describe, what level of public transport is designed to be available in an area. This way the planned service level directs the planning of public transport. (Joukkoliikenteen palvelutason määrittely 2015, 12)

In conurbations service level is defined together with the competent authority of the central city. In traffic that crosses jurisdictional borders the vision from different competent authorities should be united. (Joukkoliikenteen palvelutason määrittely 2015, 12)

Defining public transport service level is closely tide to regional and municipal land usage planning, traffic systems, public transport plans and other mobility plans in a region. Additionally the service level process must be tied to aforementioned plans from development perspective. If can also function as a part of goal setting for transport system planning. Infrastructural development plans should respectively be in line with the development requirements of public transport service level. This makes the collaboration between parties involved with the development of infrastructure and public transport vital. (Joukkoliikenteen palvelutason määrittely 2015, 12)

3.4.1 Public Transport Service Level Process

Public transport service level is expressed as classes from one to seven, one being the most comprehensive service level. Service level classes one to four are applied in sufficient size city environment, while classes four to seven are applicable mostly in rural areas. As an example, class two service level is defined as making everyday life without a personal vehicle possible and in this class public transport should be real and attractive option for using a car. Service level class two is commonly used in densely populated areas of large and medium-large cities and connections between population centers within cities. A drop of one class to class three sees service frequency decreasing from minimum of four buses per hour in a given connection to between four to two buses per hour when looking at busiest times of day. Also, connections during weekends are lessened to an amount that requires more though when planning journeys. (Joukkoliikenteen palvelutason määrittely 2015, 25-27)

The service level class itself is defined by service level class criterions that are used to divide the traffic under inspection into service level classes. Every determinative criterion must be fulfilled to achieve given service level class. Determinative criterions are total traffic time, service frequency in rush hours from Monday to Friday in winter, service frequency in day hours from Monday to Friday in winter and service frequency in day hours from Monday to Friday in summer. Fulfillment of other criterions for a given service level class isn't necessary to achieve the service level class. If determinative criterions required for example class one service level are covered and the service frequency for Sundays is inadequate for class one, the service level class is still one. (Joukkoliikenteen palvelutason määrittely 2015, 23-24)

Defining service level is usually done for a period of 3 to 8 years, or if necessary renewed during the period if something in the operating envelope changes drastically. These drastic changes can, for example, be changes in land usage, lack of resources to commit to current service level or sudden influx of population caused by changes in school network in the area. The level of service is also inspected when doing competitive tendering of transport services. (Joukkoliikenteen palvelutason määrittely 2015, 19)

The service level process consists of five phases: analyzing current state, identifying and setting goals, defining service level, service level cost evaluation by focusing planning, and fulfillment and monitoring of defined service level. (Joukkoliikenteen palvelutason määrittely 2015, 14)

When analyzing current state of transport for service level process the current supply of public transport and service level and the nature of land use in the area, ie jobs, educational institutions and other services and their location are sorted out. When doing the analysis, it is also necessary to clarify population development projections and known or planned changes in land use. Different forecasts help to better anticipate the magnitude of passenger flows and future orientation of traffic. For example, in the analytical stage earlier plans for public transport and traffic systems can be utilized. (Joukkoliikenteen palvelutason määrittely 2015, 14)

In the goal setting phase relevant traffic-, environmental- and energy political goals are identified. The goals can be both national and regional. In this phase the needs of citizens and businesses and budgeting possibilities are considered and on the basis of this information goals are set for the public transport service level. (Joukkoliikenteen palvelutason määrittely 2015, 14)

Defining service level itself is based on results and goals produced in the previous phases. Current state analysis and goal setting make it possible to define what level of service is required in given regions or connections, and on the other hand what level of service is the competent authority able to provide. In this phase fiscal consequences and effects on traffic are evaluated. (Joukkoliikenteen palvelutason määrittely 2015, 15)

In the execution phase public transport services are set to be organized in accordance to the decided level of service. If public transport is organized in accordance to the public service agreement, the competent authority or authorities are responsible from planning of the service, dividing expenses, allocation of funding and organizing the transport services. The Finnish transport agency is mostly responsible for the allotment of state funding. (Joukkoliikenteen palvelutason määrittely 2015, 15)

The relationship between zoning and public transport is handled by municipalities in the region. The transport operators produce the public transport services. Lastly the fulfillment and execution of defined service level is monitored, as it is a key part in the entity that is the service level process. Regular monitoring of service level also helps in the future as decisions are made on organizing of public transport further down the line. (Joukkoliikenteen palvelutason määrittely 2015, 15)

3.4.2 Public Transport Service Level in Jyväskylä

Public transport service level was last defined in Jyväskylä 25.10.2012 for a period of three years, starting from 1.1.2013 and ending 31.12.2016, which means that technically the service level definition is in need of looking into, or it should at least be continued as is. (Jyväskylän kaupungin joukkoliikennesuunnitelma 2012, 5)

When the service level was last defined, an older Finnish transportation agency model on service level classes was in use. It had five classes instead of seven, but the principal thought stays the same; service level classes are divided on what goal does a given service level have for the effect of public transport. (Ohje joukkoliikenteen palvelutason määrittelyyn 2010, 13)

In figure 6 is depicted the designated level of service in public transport for different areas in Jyväskylä, according to the plan made in 2012. (Jyväskylän kaupungin joukkoliikennesuunnitelma 2012, 23).

Red lines represent areas where the goal is to provide public transport services on a competitive level. That means that in most of the tightly populated areas in Jyväskylä and the connections between them should be covered with traffic that is a true alternative for a car and thus increases the share of traffic that public transport has. This service level class is comparable to the first service level class used currently. (Ohje joukkoliikenteen palvelutason määrittelyyn 2010, 13)

Yellow lines represent the attractive level of service. Attractive level of service should be compelling enough that it can be considered as an effective alternative to other transport modes and has the ability to bring more customers for public transport. (Ohje joukkoliikenteen palvelutason määrittelyyn 2010, 13)

In order to effectively achieve attractive and competitive levels of service not only does this require great effort from the service provider and competent authorities, but they should also have effective relationship with other deciding elements within the municipal decision making circle. The obvious connection is to the development of city infrastructure to allow not only the operating of attractive public transport services, but to make developing said services feasible to increase the share of public transport. (Ohje joukkoliikenteen palvelutason määrittelyyn 2010, 15)

Green lines depict areas and connections where the goal is to achieve average service level. Here the goal is to offer everyday connections to people with no car. These connections are scheduled to offer possibility to travel to work, school institution or for other everyday transactions. In these areas some compromises are made for holiday periods and weekends when it comes to service frequency. (Ohje joukkoliikenteen palvelutason määrittelyyn 2010, 13)

Connections and areas highlighted in dark grey fall under basic service level. Basic service level sets out to cover the equality of mobility; within municipalities the goal is to provide people with no car the ability to run errands more or less frequently and offer an alternative for school or work connections, giving the chance to use public transport. Finally there are light grey areas visualizing minimum service level. In these areas the aim is just to cover the legally obligated connections the municipality has, meaning in the context of a city like Jyväskylä mainly school transports. (Jyväskylän kaupungin joukkoliikennesuunnitelma 2012, 18)

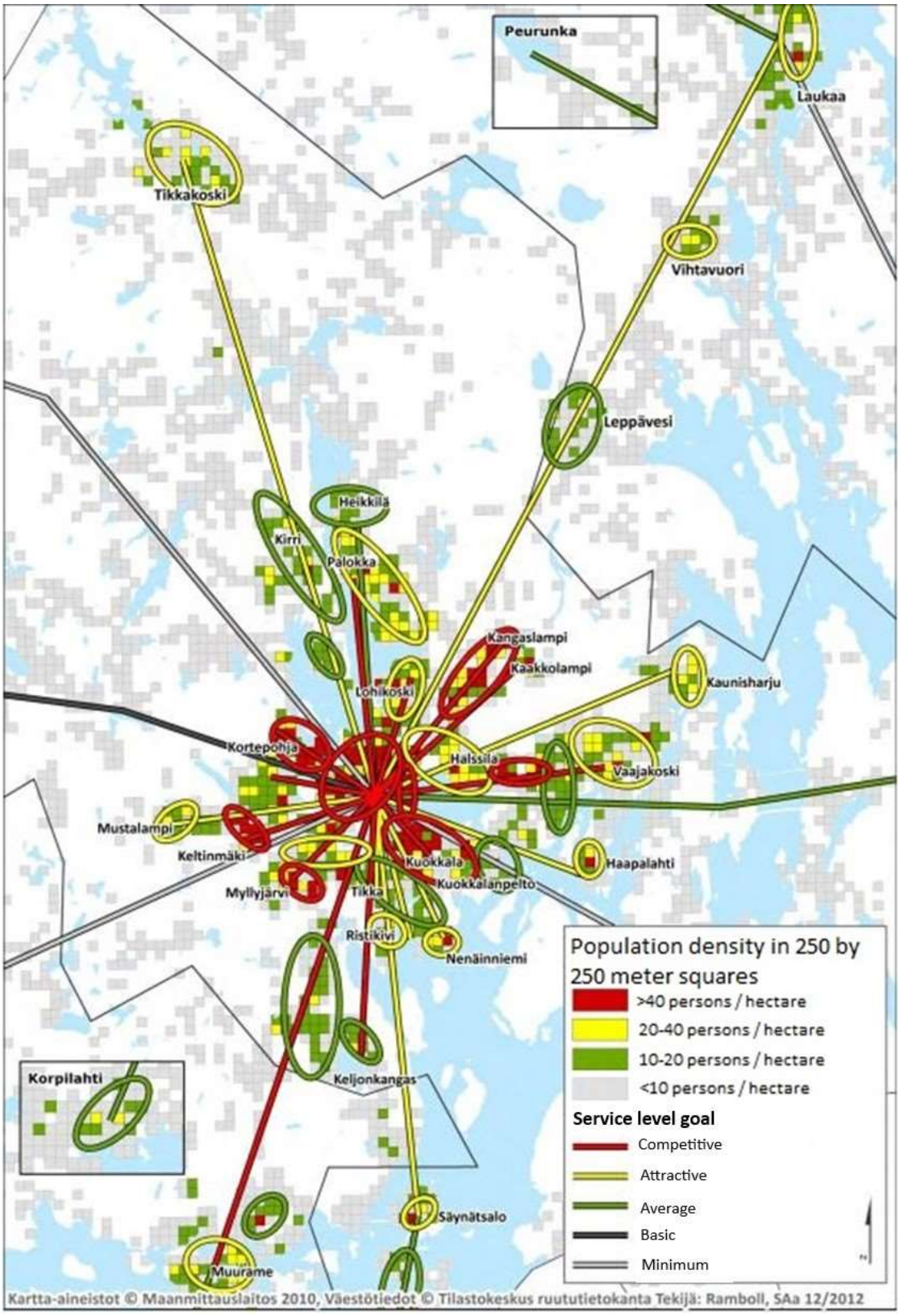

Figure 6 Population density and target level of service in public transport in different areas in Jyväskylä (Ramboll 2012)

4 Public Transport Planning and Zoning

4.1 Public Transport and Zoning

4.1.1 Challenges in Public Transport in Medium-sized Cities

Public transport passenger numbers have declined in several Finnish medium-sized urban areas over the past decade. However there hasn't been a significant change in public transport service levels or pricing of tickets. The reduction in public transport passenger numbers is explained more by motorization and spreading of urban areas. The development of public transport has failed to respond to residents' changing and diversifying mobility needs. Major challenge for the development of public transport, however, is the scarcity of funding and the lack of political support. The strategic importance of public transport is still not recognized on decision-making level. (Joukkoliikenne kaupunkiseutujen kaavoituksessa 2008, 5)

In the future aging of the population and its focus of scarcely populated regions will highlight the issues that the weakening of public transport will cause. Municipalities and cities will see an increase in expenditure as more discrete transport is needed. (Joukkoliikenne kaupunkiseutujen kaavoituksessa 2008, 5)

Rising energy prices and climate change pose a challenge for urban transport systems. Rising cost of motoring and measures to mitigate climate change on the other hand improve the status of public transport. Land usage planning can influence the issue decisively. Public transport operating preconditions can be improved by slowing down the growth of motorized cities and promote building that favors land usage friendly to public transport. Similarly, land usage solutions that hamper the operating conditions of public transport have a long-term effect, as the built environment, and in particular the basic infrastructure renews very slowly. Target years that are used in the climate debate are for example 2030 or 2050, while the lifetime of a building is generally designed to be a hundred years. (Joukkoliikenne kaupunkiseutujen kaavoituksessa 2008, 5)

Designing regional land-use patterns has become more common in recent years. City regions are drawn up as different regional master plans, development models and structure models. The role of public transport in these plans is still unclear. In urban land use plans public transport is handled with very different levels of care. All regions have made public transport plans, but their connection to land-use planning is thin. Creation of common land-use planning and land use policy with its power-sharing aspects is difficult and public transport can be discarded with a bland statement. (Joukkoliikenne kaupunkiseutujen kaavoituksessa 2008, 12)

The challenge of interacting the planning of urban land use and public transport is considered to be the great difference in attitude towards the importance of public transport between the center of the city and neighboring municipalities. In the centers of urban areas, the operating conditions that public transport requires have been started to take increasingly into account during recent years, but in neighboring municipalities those conditions can get overlooked. In addition, the fragmented nature of urban centers and polycentric scattering of services make planning of sustainable public transport routes challenging. (Joukkoliikenne kaupunkiseutujen kaavoituksessa 2008, 12)

When the trips are directed not only to the central area of the city, but they are divided upon service centers spread all over the region even great planning doesn't always help. This polycentric construction requires abnormal public transport solutions. (Joukkoliikenne kaupunkiseutujen kaavoituksessa 2008, 12)

4.1.2 Public Transport Line Types

Public transport lines drive along a given route according to their schedule. When planning public transport lines different types of lines are used, depending on the land usage type in the city. Public transport routes are designed around the city structure and natural obstacles like waterways and old infrastructure. Line types can be divided into six groups based on their position in relation to the city center and their pattern. In figure 7 are depicted the six types; ring line (1.), radial line (2.), pendulum line (3.), octagonal line (4.), transverse line (5.) and inter-city line (6.).

Ring lines form a closed circle, which is traversed either way. Radial lines go from conurbation zone to city center. Pendulum lines traverse through the city from conurbation zones. Octagonal lines have two rings crossing in the center while making an octagonal pattern. Transverse lines are routes that travel across conurbation zones. Intercity lines are shorter lines within city center. (Joukkoliikenne kaupunkiseutujen kaavoituksessa 2008, 7-9)

Ring – and octagonal lines aim to cover larger population base and reduce the amount of transfers. However, they can be unclear and slow from the customer point of view. Transverse lines are mainly used in larger cities where there are clear larger sub-centers. (Joukkoliikenne kaupunkiseutujen kaavoituksessa 2008, 9)

Radial – and pendulum lines are most common. This way lines become clear and easy to traverse. These lines can however have difficulties to attract as many customers. (Joukkoliikenne kaupunkiseutujen kaavoituksessa 2008, 8)

Inter-city lines are rare in Finnish cities, but it can accomplish dense schedules. However, these lines can have trouble accessing adequate passenger potential. (Joukkoliikenne kaupunkiseutujen kaavoituksessa 2008, 9)

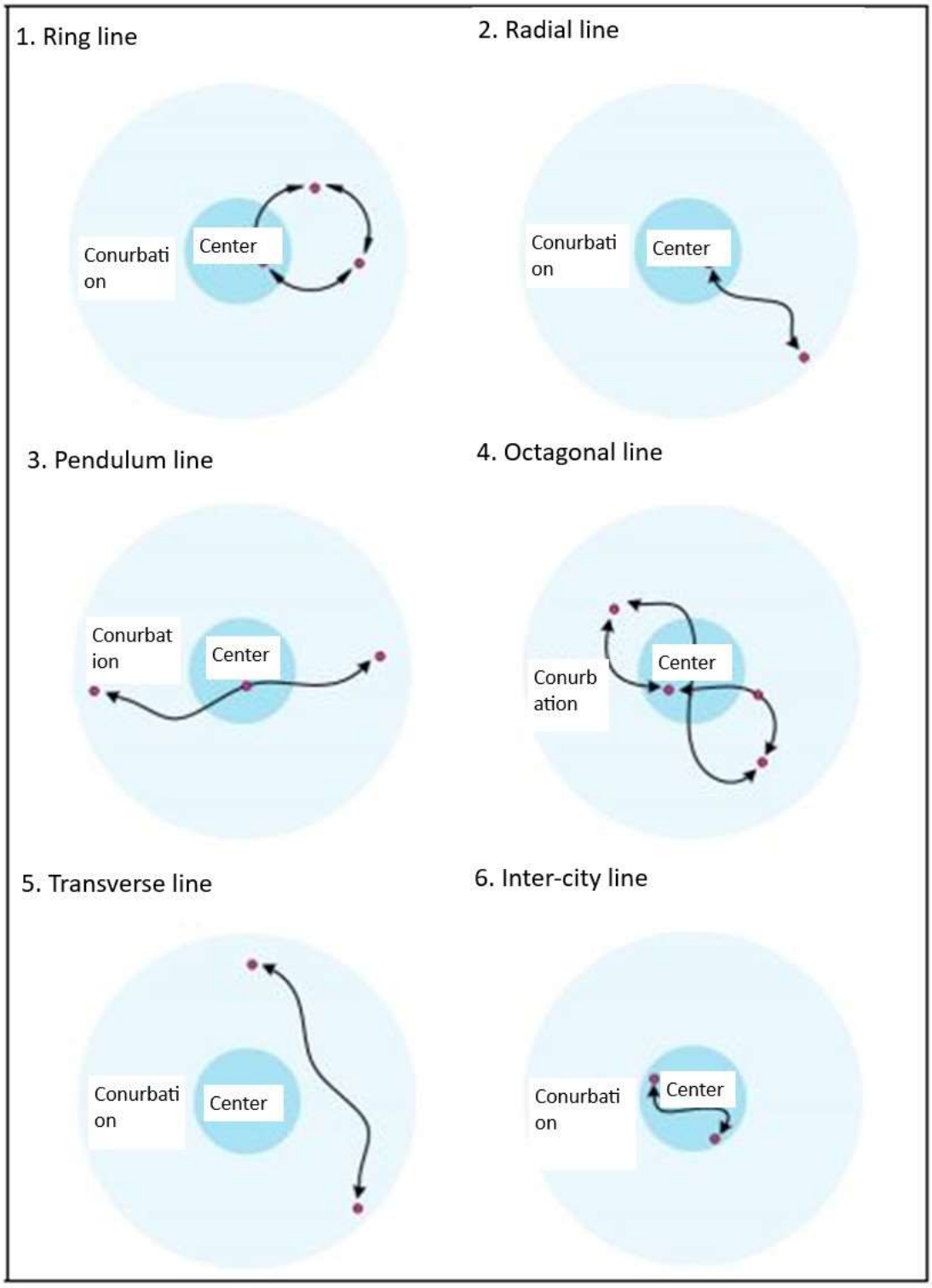

Figure 7 Public transport line types

4.2 Basics of Bus Stop Positioning

There are nearly 66 000 marked bus stops on the roads of Finland. Additionally, there exists tens of thousands of bus stops overseen by municipalities. Bus stops function as a part of every bus passengers' travel chains from start to finish. The stops represent decades of varying planning, quality and equipment. The significance of bus stops has changed from mere stopping places of buses to a part of the appeal and travel comfort factor of the overall journey. The stops also act as an image factor and a ''face'' of public transport for everyone, not only for those using public transport. (Linja-autopysäkkien luokittelu 2013, 10)

The positioning of bus stops is mostly directed by land usage and the demand for public transport created by land usage. Generally, bus stops are positioned so that:

- The walking distances to the bus stops are not unreasonably long
- The stop is safe to use for both the passengers and vehicles using it
- The stop doesn't increase danger to other road users
- Accessing the stop is smooth and easy for the vehicles
- The stop doesn't cause excessive harm to its environment in the form of noise, vibrations, littering or disorderly conduct
- Minimal vandalism
- Too short gap between stops doesn't slow down the buses in an excessive manner
- If necessary organizing connecting – and escort traffic is possible

In conurbations, technical criterion for the stops makes way to accessibility, minimizing detriments for environment, preventing vandalism and the functionality of connections. (Linja-autopysäkit 2003, 14)

In scarcely populated areas, the walking distances to bus stops become naturally longer, thus when positioning stops technical criterion should be more prevalent. (Linja-autopysäkit 2003, 14)

Central bus stops in large cities serve different types and volumes of vehicles and passengers, then stops in the countryside which serve only long-range traffic. The parties involved, such as passengers, operators and road authorities, also have different expectations for the stops. The role of the bus stop as a part of the public transport system, infrastructure and land usage planning varies greatly depending on the location of the stop. (Linja-autopysäkkien luokittelu 2013, 14)

4.3 Road Requirements of Public Transport

As vehicles on the larger side city buses need certain things to be considered when planning road infrastructure. Buses have regulatory maximum dimensions which helps the planning though: buses with two axles can be up to 13,5 meters long, with three axles 15 meters, and jointed buses can be up to 18,75 meters. The maximum width is always 2,55 meters and height 3,8 meters for single decker and 4,2 meters for double decker buses. The space required for turning depends on things like axle positioning and amount but at the largest with a three-axle bus with solid rear axles it can be up to 14,5 meters. For measuring purposes, a three-axle bus should always be used. (Mitoitusajoneuvot ja ajouramallit 2008)

In traffic there always is unique situations, but the space availability on bus routes should be checked for example when deciding lane widths, bus stops, roundabouts turn points, underpasses and speed bumps.

5 Kangas Area Urban Development and Transportation

5.1 Kangas Area Background and Design Philosophy

Kangas area resides between Jyväskylä's center and Seppälä area, bordered on one side by highway 4 and Tourujoki on the other. The area has long and illustrious history as it was the location for one of Finland's oldest paper mills, dating back to 1872. The paper factory was in action up until 2010, when the last operator of the factory, Sappi Oy, closed the factory due to structural changes in the forest industry. When Sappi Oy sold the properties to M-Real Oyj, Jyväskylä city used its legal right to first refusal and bought the area. The zoning planning for Kangas area started in late 2010. With the areas location near the center and also its vicinity to the quickly developing Seppälä area, Kangas area is the most important urban development project for Jyväskylä in years. (Jyväskylän Kangas: Historia 2017)

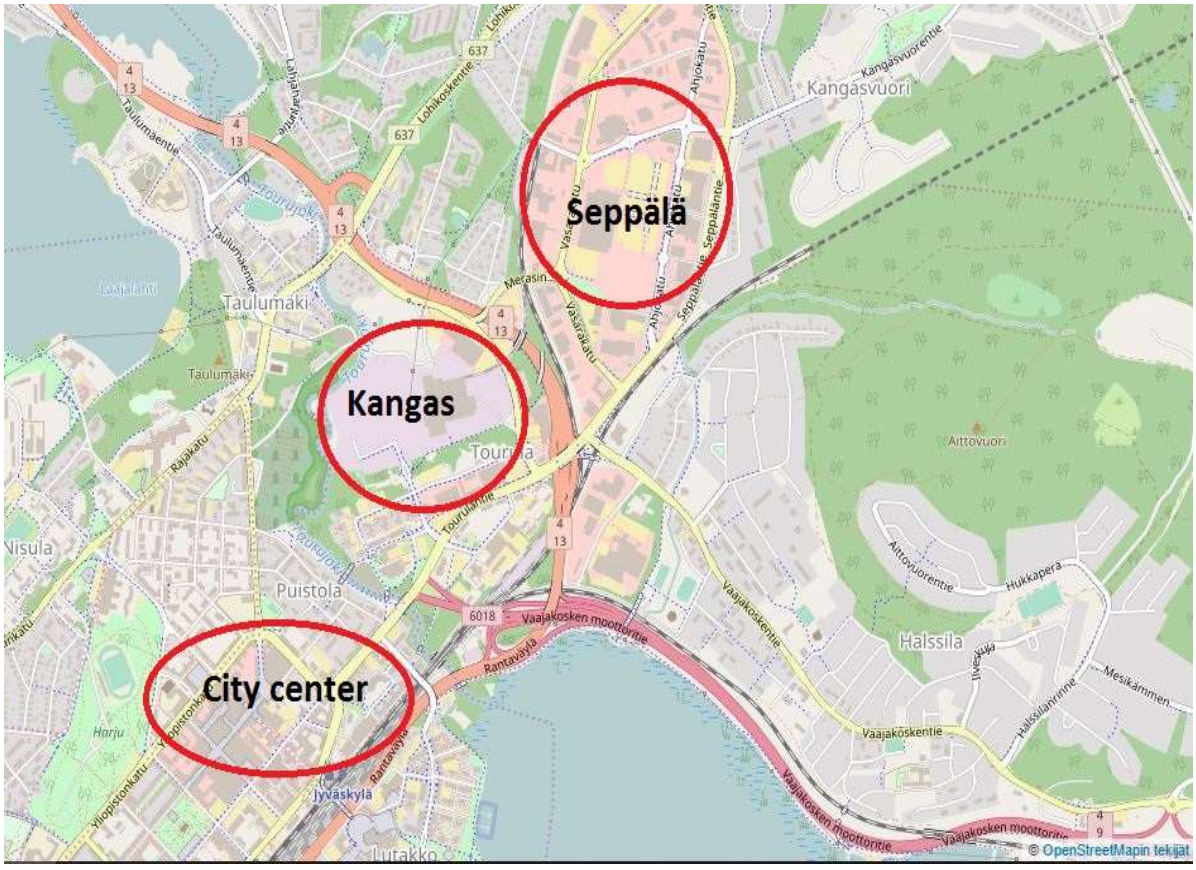

Figure 8 Kangas area in relation to the center (OpenStreetMap 2017)

Citizen involvement was combined into the planning in early stages of the area development project. Anyone could leave suggestions and ideas for the area in a dedicated internet portal, and the results were gathered and taken into consideration in the planning stage. The general zoning plan was decided with a competition. The goals set for Kangas area were that it should have a completely new look and blend in with the Tourujoki - river area and the oldest factory buildings which have historical value and cannot be taken down. In the long run Kangas area should develop into a versatile center with services, activities and working opportunities, all the while bridging the gap between city center and Seppälä area. It should be noted that unlike Seppälä, Kangas is intended to be used for living and working, and it shouldn't support the building of massive daily goods stores and car markets. (Jyväskylän Kankaan ideakilpailu: Arvostelupöytäkirja 2011, 10-11)

As from accessibility and transport point of view, the area should not be dependent on personal vehicle access, instead offering connections for contemporary transport modes. (Jyväskylän Kankaan ideakilpailu: Arvostelupöytäkirja 2011, 10-11)

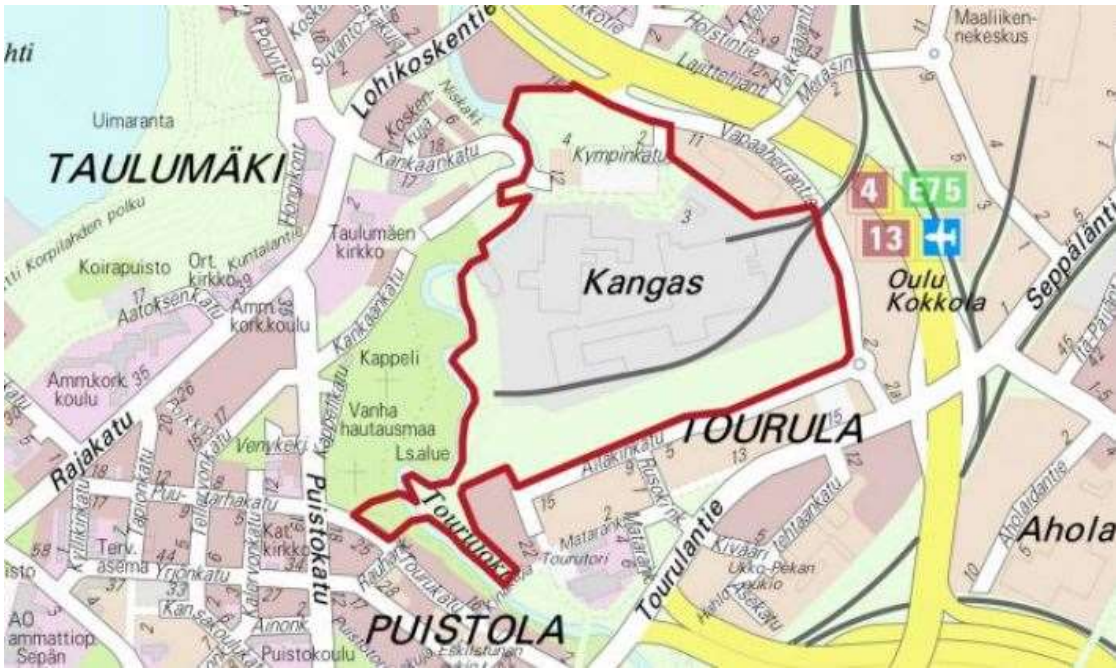

Figure 9 Kangas planning zone

5.2 Potential of Scale and Service Level

What initially generates interest for public transport provider in any operation is the scale and potential passenger amounts that can be served. Any commitment beyond what the law obliges for the competent authority has to make financially some sort of sense and in public transport that is measured in passenger amounts. What sort of potential does Kangas area have in this regard?

When the area is fully developed the only thing separating Kangas from the city center is Tourujoki. This makes it a part of the core city area, where in 2015 lived 27 332 inhabitants, which translates to roughly a quarter of the main city areas population. (Tietoja Jyväskylästä suuralueittain 2016). Furthermore, Kangas is within 1,5 kilometers from Seppälä area, which is a rapidly developing business district in Jyväskylä. Like Kangas, Seppälä was also once home to manufacturing plants, but now it sees use as a location for stores and businesses of great variety. (Jyväskylän liiketilamarkkinat murroksessa 30.1.2017)

Kangas area itself is of course built gradually as time goes on, as only few buildings have to this date been completed. The first inhabitants moved in Kangas in January 2017. The long-term goal is that in 2040 Kangas is a home for 5000 inhabitants and a workplace for 2100 people. (Jyväskylän kangas: FAQ)

As is visible in figure 12, Kangas area falls in the best service level class possible in the public transport plan made in 2012. As the area is bordered on one side the densest population center in Jyväskylä and on the other a quickly developing business district, the area is naturally surrounded by several connections already. The areas importance as a part of Jyväskylä's development as a city and the volume of potential customers justifies providing level of service in accordance with the public transport plan and ensuring good service frequency. The multitude of connections that already pass around the area gives the planner options whether to redirect existing lines, creating new ones, or as is most likely, some sort of combination approach.

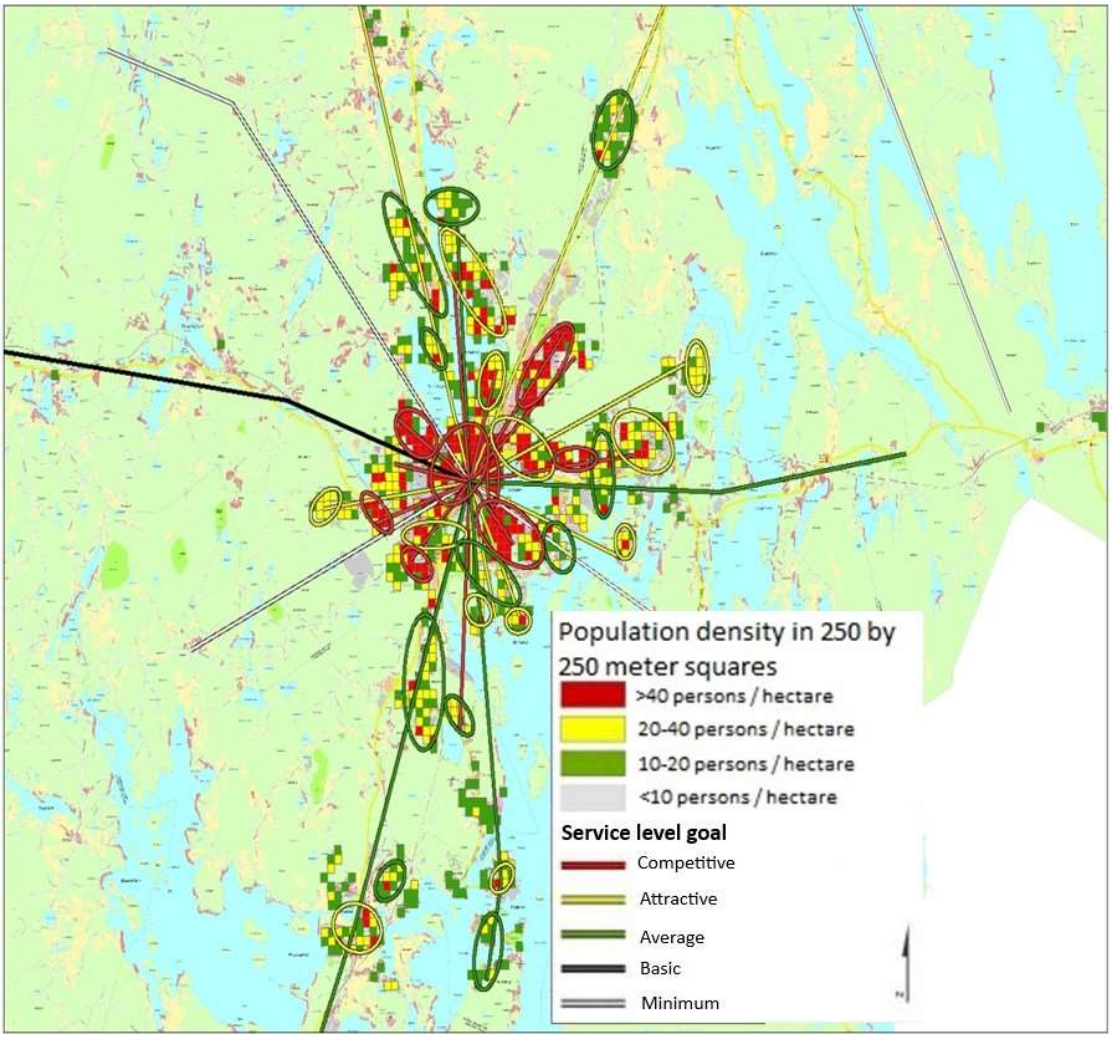

Figure 10 Population density and target level of service in public transport in different areas in Jyväskylä (Jyväskylä city public transport division 2017)

5.3 Infrastructure and Accessibility

Because the development of the Kangas area is such a large and long-term project, it's difficult even to imagine what the area should look like in a completed state. To make matters more complicated, the growth of the area and road development might not go hand in hand, and some temporary solutions might be needed as far as public transport goes as the need for connections grows before the infrastructure develops into a desired state in the area. The area has naturally quite good access from highway 4 from the north and Tourulantie in the south, but as the plans state public transport access as one of the key developmental disciplines, buses should have access to the central area itself so that walking distances to the stops don't come too large.

Figure 11 Kangas area in 2025

The car parking solutions are meant to be centralized to parking halls and under the ground, with above-ground parking being reserved to escort traffic, visitors and parking spots for the disabled. This decreases the need for excessive roadside parking and the traffic that comes with it which in turn makes the roads more accessible for alternative transport modes. (Kankaan osayleiskaavaselostus 2013)

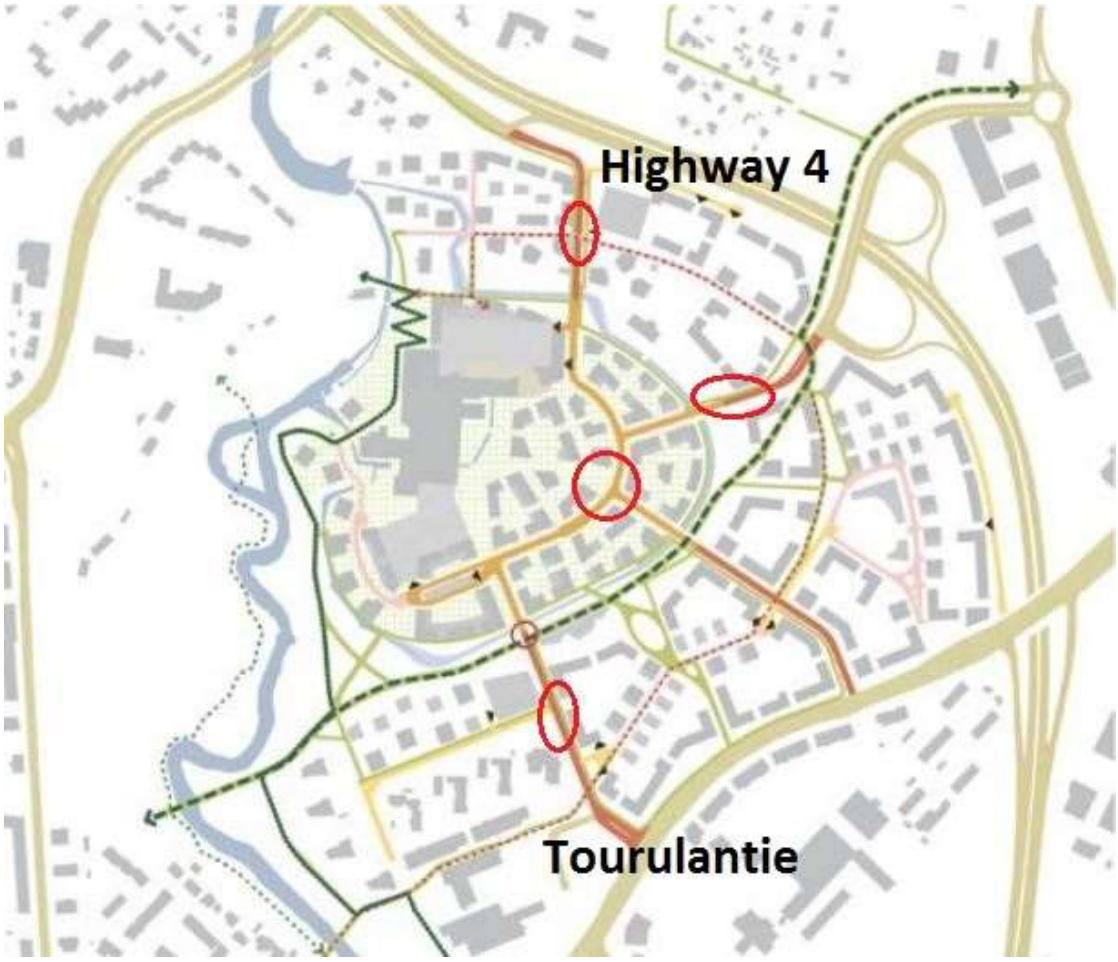

Figure 12 Traffic graph draft for Kangas

Kangas represents a unique opportunity to design connections within an urban area completely from scratch. Therefore, traffic systems can be designed to align with current philosophies of sustainability and environmentally friendly solutions. Key part of this is ensuring that public transport options are attractive for inhabitants of Kangas or people commuting there to work. In figure 13 is a map on how traffic is planned to be organized in Kangas and how it is connected to existing main roads. The colored roads represent different classes of road; red and yellow roads are collector roads, through which vehicle traffic passes through. Yellow roads end in yards of businesses or apartment blocks. Light green routes are main routes intended for cyclists and pedestrians. The dashed green route is a rapid cycling route, so that cyclist can quickly pass through between Center and Seppälä in a road reserved exclusively for that purpose. The solid green line represents a track used to traverse along the Tourujoki-river. Black triangles depict parking hall entrances. (Kankaan osayleiskaavaselostus 2013, 46)

Centralizing parking to halls and underground is an important detail in the grand scheme of traffic planning: Instead of cars being left on the side of the road, moving them to select locations that are used only for parking makes the roads more accessible for pedestrians, cyclists and public transport. Subjectively speaking it also makes the area seem tidier and smarter as well. It is also important to note that traffic that otherwise would be roaming the streets looking for and traversing to their parking spots is lessened or directed to parking hall entrances. Naturally for businesses, visitors and disabled people parking some roadside spots are reserved, but by focusing the parking traffic near the entrances and exits of parking halls, the roads that cross the area are left to be used more effectively as they are supposed to; escort traffic, passing traffic and public transport. The entry- and exit way to highway 4 is still subject to change, but should it be done as in the current concept, the ramps and bridge from Seppälä straight to Kangas can achieve two clear improvements; Instead of having to congest the already heavily stressed Tourulantie to access highway 4, it can be reached with ramps next to the proposed bridge from either Seppälä or Kangas. Secondly, traffic coming either from north or south by highway 4 can use the ramps to get to center or Seppälä, two major business districts, making again more room to Tourulantie for traffic from center to Seppälä direction.

Competitive / class one service level that is in use in the area dictates that the walking distance to bus stops within that service levels area should be no more than 400 meters. Highlighted in red are the authors suggestions for possible stop locations, that should everything fall into place as in this plan this criterion is comfortably fulfilled. The speed limit in the area is 40 km/h, which enables effective traffic flow but also makes bus stops safer for both the buses and passengers. To further help safety and traffic flow the stops should be built into recesses.

So far only single decker two- and three axle buses are used in public transport in Jyväskylä city, so lane dimensioning isn’t any more of a headache than it is elsewhere in the city. The zoning plan doesn’t have any roundabouts on potential bus routes, but should those emerge it is important to note that a fitting radius for a roundabout used by buses is at least 15 meters. (Mitoitusajoneuvot ja ajouramallit)

6 Line Planning for Kangas

6.1 Cost Factors

Before possible changes or new line plans are presented, the costs that these actions can cause must be outlined. As Jyväskylä city acts as a competent authority and merely purchases the operation from the service provider, in this case Koiviston Auto Oy, the cost that are directed towards the city are the ones that have been outlined in the procurement agreement made between the service provider and Jyväskylä city. The costs to consider are the change in amount of line kilometers, working hours and daily fixed cost for a bus if new line is to be started. The prices are displayed in the winning bid for Jyväskylä city public transport tender of 2013. The contract was initially made with Onnibus Oy, but they sold all Jyväskylä city operations to Koiviston Auto Oy. (Onnibus myi Jyväskylän ja Tampereen paikallisliikenteet 2014)

Jyväskylä city bus traffic currently consists of five sets where the lines are divided to. The tender of 2013 was split into these five sets so bus operators could send offers for individual sets or for all of them.

	Set 1	Set 2	Set 3	Set 4	Set 5	AVERAGE
€/km	0,672	0,651	0,69	1,017	0,68	**0,742**
€/working hour	32,346	32,381	30,082	21,992	31	**29,5602**
€/vehicle day	158,344	148,574	155,448	165,048	155	156,483

Figure 13 Line set costs and average cost

Changes to lines are calculated with the prices of appropriate sets, so for example ten kilometer daily increase to a line in set 3 costs the city 6,9 euros per day. In the proposition for new line we use average values of all sets as the actual values would be agreed on a case by case - basis with the bus operator should there be a new line.

6.2 Changing Existing Lines

So far it is established that the Kangas area is justifiably within the parameters of top service level and therefore must be provided with a frequent connection as a part of the bus line network in Jyväskylä city. The decision then becomes how to approach the line planning, where is a couple of different options; either to create a new line or modify existing network. Several lines pass the kangas area, so there exists options for modifying lines.

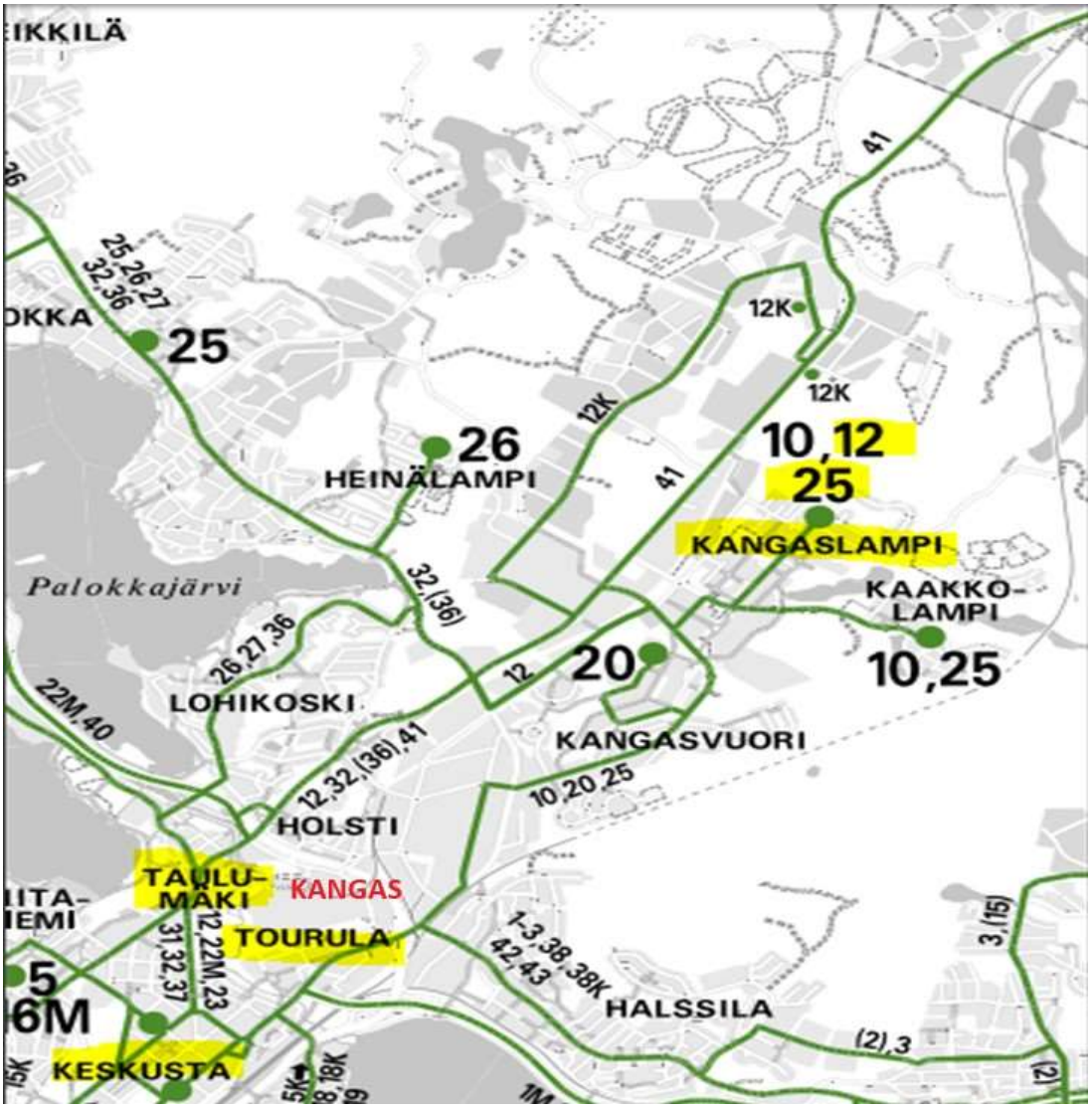

Figure 14 Jyväskylä city bus line chart 2017

Line chart in figure 14 clearly shows that no connections exist that can easily be re-routed to cover the Kangas area. Thus, significant changes must be made to lines to serve the area. In earlier chapters it was established that to fulfill the level of service

requirements to Kangas the new connection cannot just pass the area from either east or south side, but it must converge in the road going through Kangas.

Two lines which already go past Kangas with regular intervals thorough the day were taken under inspection: Line 12 from Kangaslampi to city center via Taulumäki (North of Kangas), and Line 25 also from Kangaslampi to city center but this time via Tourula (South of Kangas). The line routes are in figures 15 and 16, with Kangas area encircled to distinguish it from the map.

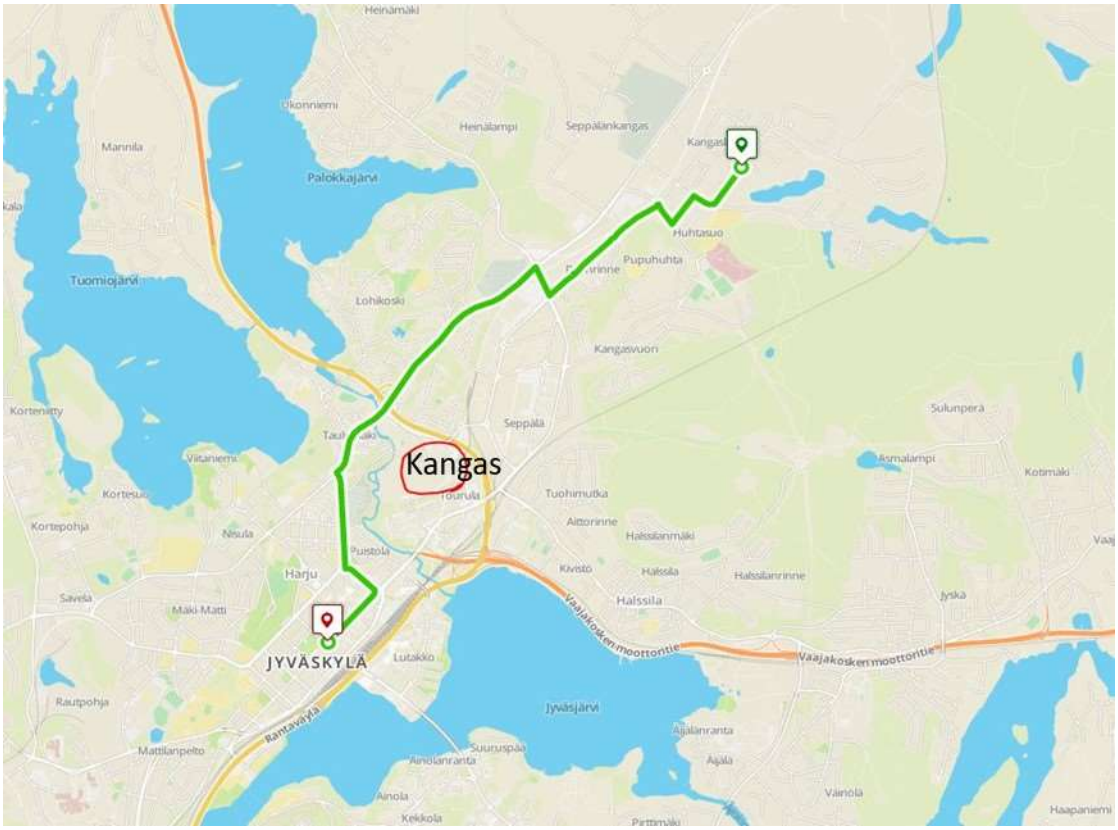

Figure 15 Line 12 from Kangaslampi to City center (Reittiopas, Jyväskylän seudun joukkoliikenne 2017)

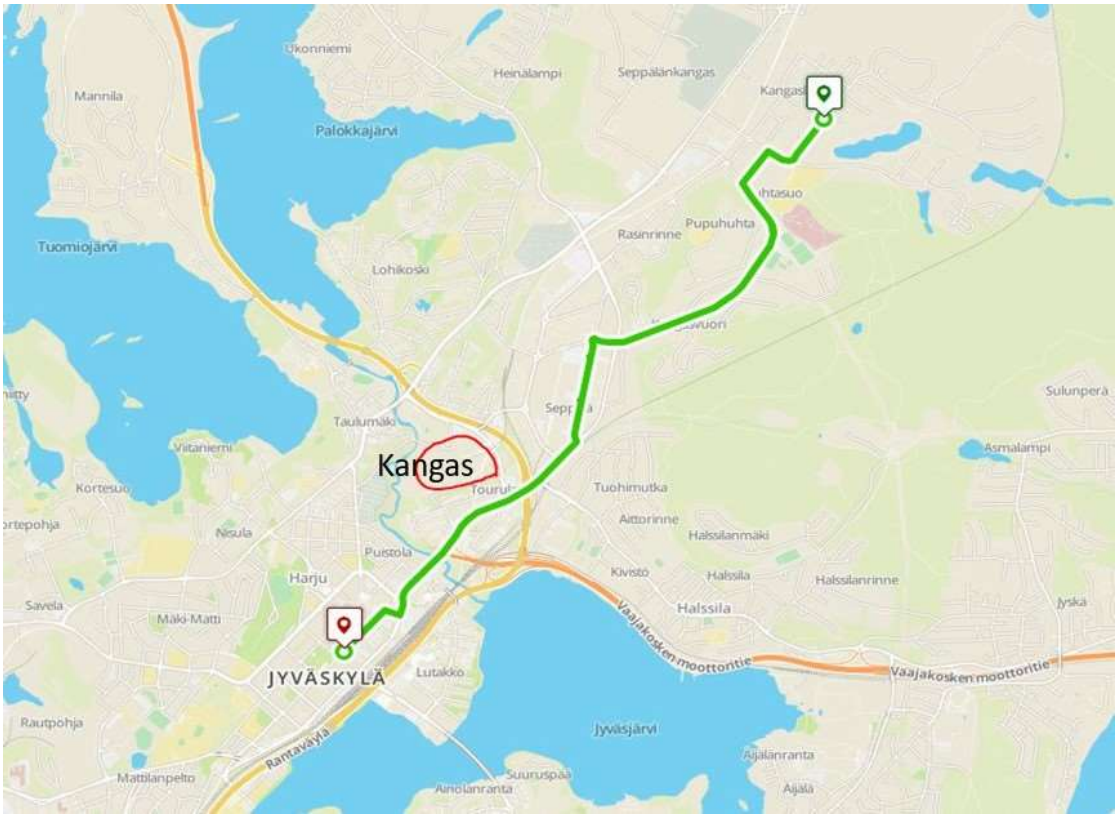

Figure 16 Line 25 From Kangaslampi to City center (Reittiopas, Jyväskylän seudun joukkoliikenne 2017)

6.2.1 Line 12

Line 12 connects Kangaslampi to City center via Taulumäki, going north of Seppälä and Kangas. Between 6:00 and 18:00 line 12 goes 15 minutes, 40 minutes and 55 minutes past each hour every weekday. This interval of three departures per hour is quite common in Jyväskylä bus lines, with only a few more popular lines such as 18 having four to five departures during peak hours. During weekends the departure interval for line 12 decreases to two buses per hour with half hour intervals. The line section from Kangaslampi to city center is 6.4 kilometers long. Line 12 continues after city center to Keltinmäki. Line 12 is a part of set 2, so changes to line length affect the cost by 0,651 euros per kilometer, and working hours change the cost 32,381 euros per hour.

12 **KANGASLAMPI–KESKUSTA**

Reitti: **Kangaslammentie**–Suluntie–Nevakatu–Kangasvuorentie–Palanderinkatu–Seppäläntie–Lohikoskentie–Puistokatu–Kalevankatu–Vapaudenkatu (pysäkki 7).

	M–P				L		S	
t	minuutit							
	12	12	12	12	12	12	12	12
5								
6		15	40	55				
7	10Y1	15	40	55				
8		15	40	55	10	40		
9		15	40	55	10	40		
10		15	40	55	10	40		40
11		15	40	55	10	40	10	40
12		15	40	55	10	40	10	40
13		15	40	55	10	40	10	40
14		15	40	55	10	40	10	40
15		15	40	55	10	40	10	40
16		15	40	55	10	40	10	40
17		15	40	55	10	40	10	40
18		15	40		10	40	10	40
19		10	40		10	40	10	40
20		10	40		10	40	10	40
21		10	40		10	40	10	40

Y1 = poikkeusreitti: vuoro ajaa kauppatorin ja Voionmaankadun kautta keskussairaalaan.

Linjat 10 ja 25 liikennöivät myös Kangaslammelta. Katso tarkemmat aikataulut ja reitit linjakohtaisista aikatauluista tai yhdistelmäaikatauluista.

AJOAIKA:

Kangaslampi	Keskusta	KeljonMarketit	Myllyjärvi	Keltinmäki
	15 - 20 min	n. 25 min	n. 30 min	35 - 40 min

42

Figure 17 Line 12 schedule (M-P = weekdays, L = Saturday, S = Sunday)

6.2.2 Line 25

Line 25 Starts similarly as line 12, but instead of going to Lohikoskentie and going via Taulumäki to city center, line 25 goes through Seppälä and Tourula to center, just south of Kangas. On busier morning hours it has four to five departures, but most of the day between two and three. The line section from Kangaslampi to center is 6 kilometers, and travel time around 20 minutes. Line 25 is a part of set 1, so changes in line kilometers are 0,672 euros per kilometer, and changes in working hours are 32,346 euros per kilometer.

25 **KAAKKOLAMPI–KANGASLAMPI–KESKUSTA**

Reitti: **Suluntie**–Kangaslammentie–Kulottajantie–Nevakatu–Kangasvuorentie–Ahjokatu–Seppäläntie–Tourulantie–Vapaudenkatu (pysäkki 6).

	M–P					L		S	
t	minuutit								
linja	25	10	25kp	25	25	25	25	25	25
5				20	40				
6	00	15		20	40	15		15	
7	00	15	25Y1	20	40	15	45	15	
8	00	25		20	40	15	45	15	
9	00			20	40	15	45	15	
10	00			20	40	15	45	15	
11	00			20	40	15	45	15	45
12	00			20	40	15	45	15	45
13	00			20	40	15	45	15	45
14	00			20	40	15	45	15	45
15	00			20	40	15	45	15	45
16	00			20	40	15	45	15	45
17	00			15	45	15	45	15	45
18				15	45	15	45	15	45
19				15	45	15	45	15	45
20				15	45	15	45	15	45
21				15	45	15	45	15	45
22				15		15		15	
23				00		00		00	
24				00		00		00	

Y1 = poikkeusreitti: vuoro ajetaan kauppatorin kautta Viitaniemeen, ei keskustaan.
kp = vuoro ajetaan koulupäivisin.

AJOAIKA:
Kaakkolampi — Keskusta
20-25 min

75

Figure 18 Line 25 Schedule

6.2.3 Line 12 variation

The changes needed for line 12 to comply with Kangas area requirements require re-routing the line to continue straight from Palanderinkatu to Vasarakatu, instead of going to Lohikoskentie. This effectively negates the possibility for line 12 to go through Taulumäki, creating some service vacuum north of Kangas. On the other hand, currently no lines use Vasarakatu, and due to several shops along that street and in the general Seppälä area this new service could spark some interest. What effectively would be lost in this case is few connections that go along Puistokatu, as otherwise there is few stops with significant customer interest along the old route.

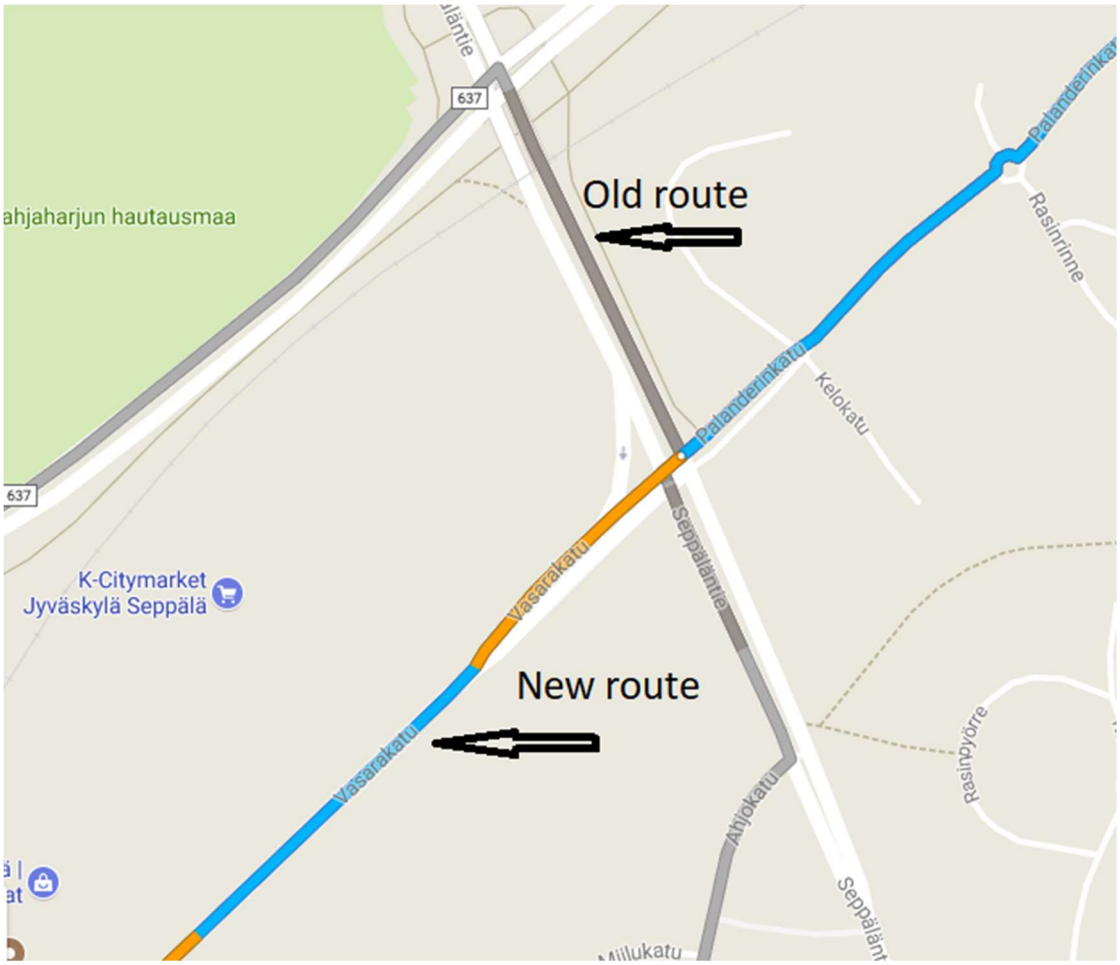

Figure 19 Line 12 rerouting (Google Maps, 2017)

From Vasarakatu the new line would divert from the new junction to be built that connects Kangas to Seppälä (Figure 21, Planned route for public transport through Kangas). That route would be chosen over the northern connection from the direction of Taulumäki as Vasarakatu has more customer potential due to the vicinity of a large shopping center adjacent to Vasarakatu, whereas the northern route would pass by a graveyard. The line would then drive through the Kangas area and depart to Tourulantie, after which the end of the line would follow the same route as Line 25 does currently.

The length of this section would be roughly 6.1 kilometers, or around 300 meters shorter than the current line. Time expenditure is the same as even though the route is shorter, as the speed limits are lower. During normal week with 5 weekdays, one Saturday and one Sunday, over 542 departures the kilometer saving would be 162,2 kilometers during schoolyear.

The average price for one line kilometer in a line in set 2 for Jyväskylä city is 0,651 € per kilometer, thus the per week saving in this case would be 105,85 euros, or 4234,1 euros over a 40 week schoolyear.

LINE 12 CHANGES

Previous lenght	Lenght	Weekly Departures	Total weekly line kilometer difference
6,4	6,1	542	-162,6 =(Lenght - Previous lenght) x Weekly Departures

	Set 2 costs	Cost difference per week	Cost difference over school year (40 weeks) in euros
€/kilometer	0,651	-105,8526	-4234,104
€/working hour	32,381		

Figure 20 Cost calculation for line 12 changes

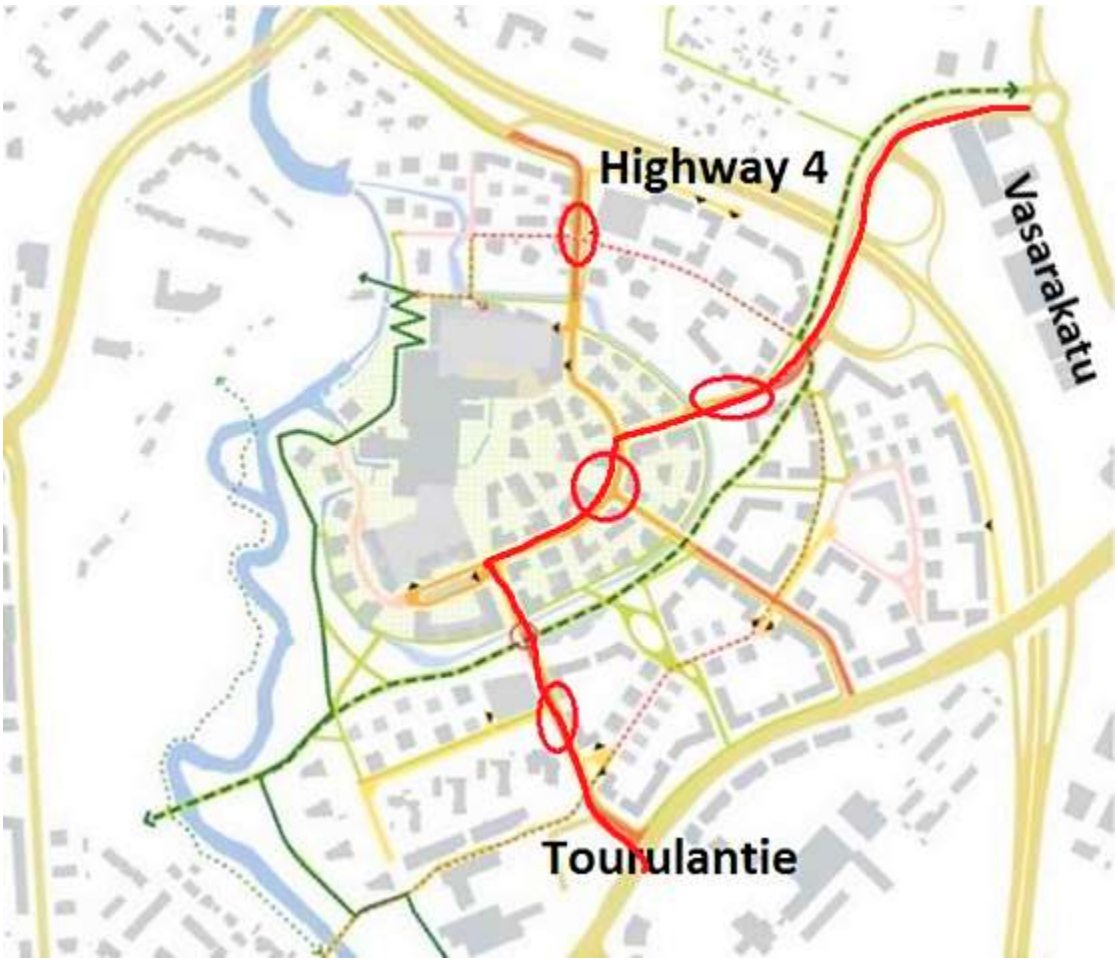

Figure 21 Planned route for public transport through Kangas

6.2.4 Line 25 Variation

Figure 22 Line 25 route change

The changes in line 25 start after it reaches Seppälä, specifically the first roundabout after the line crosses Seppäläntie from Kangasvuori direction. Instead of going along Ahjokatu the new line would continue straight on Alasinkatu and join Vasarakatu at the next roundabout. From Vasarakatu the route would again use the new intersection to Kangas and follow the same route to city center as the changed line 12.

With the changes the length of this section would go to 6,3 kilometers, up 300 meters from the old line. During normal week with 5 weekdays, one Saturday and one Sunday, over 637 departures the kilometer increase would be 191,1 kilometers during schoolyear. With line kilometer price for a line in set 1 being 0,672€ per kilometer, the cost of this change for Jyväskylä city would be 128,42€ every week, or 5136,8 euros over a 40-week schoolyear.

	LINE 25 CHANGES								
Previous lenght	Lenght	Weekly Departures		Total weekly line kilometer difference					
6	6,3	637		191,1	=(Lenght - Previous lenght) x Weekly Departures				
	Set 1 costs	Cost difference per week		Cost difference over school year (40 weeks) in euros					
€/kilometer	0,672	128,4192		5136,768					
€/working hour	32,346								

Figure 23 Cost calculation for line 25 changes

6.3 New Line Option

So far two realistic line variations have been identified. If the loss of coverage on parts of the aforementioned sections feels too significant, or should there be increasing customer feedback, a completely new line option should be prepared. For this case the new line is planned to not only answer the needs of Kangas area, but also to connect the developing Seppälä to an area that lacks that connection.

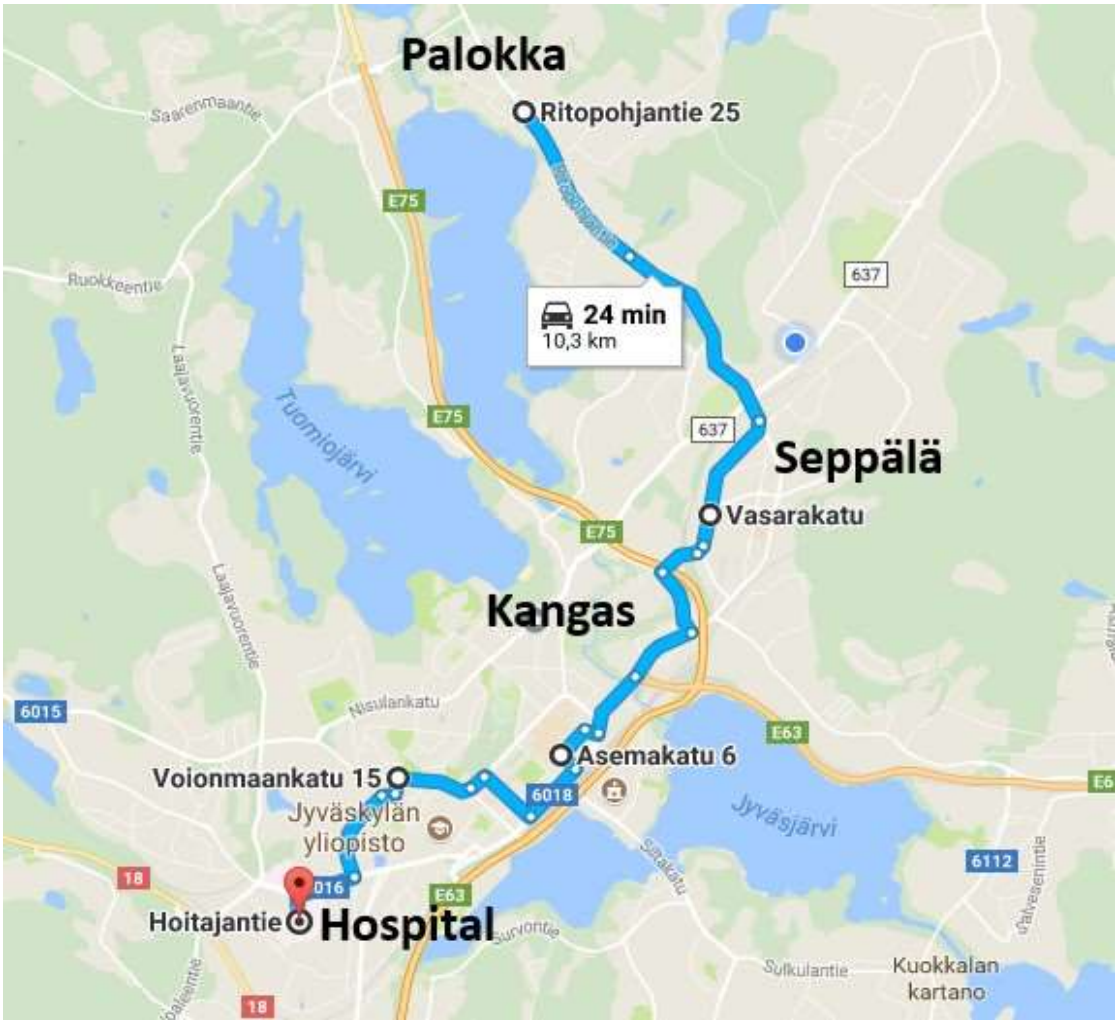

Figure 24 New line ''28'' from Palokka to Hospital

As Seppälä as an area has garnered interested from businesses and consumers, the new massive Seppä shopping center being opened there late October of 2017, few customers from Palokka have asked to extend the line network to connect the region to Seppälä.

With this line it's possible to answer those requests and cover the demands of Kangas region. This new line is dubbed 28 as that number happens to be free. Line 28 is classified as a radial line, as it passes from conurbation area to city center and back.

The one-way length for this line is around 10,4 kilometers, once it is considered that current maps don't yet show Kangas area at its future state. The length of transfer from Jyväskylän Liikenne's garage in Kuormaajantie 1 to starting point in Ritopohjantie 25 (Palokka health center) is 4,2 kilometers.

The driving time for the line is around 22-24 minutes, but time must be accounted for stops along the way, hence 30 minutes one way driving time is expected. In this case only one bus is scheduled, as the cost of additional vehicles can be added at per-vehicle basis when the cost and schedule of one is known. The costs will be calculated with the averages from all sets.

	Set 1	Set 2	Set 3	Set 4	Set 5	AVERAGE
€/km	0,672	0,651	0,69	1,017	0,68	**0,742**
€/working hour	32,346	32,381	30,082	21,992	31	**29,5602**
€/vehicle day	158,344	148,574	155,448	165,048	155	156,483

Figure 25 Costs for line sets and average cost

	Departure		Departure		Arrival		
Pal	6:25	**Kes**	6:45	**Kes.S**	6:55		
Kes.S	6:55	**Kes**	7:05	**Pal**	7:25		
Pal	7:25	**Kes**	7:45	**Kes.S**	7:55		
Kes.S	7:55	**Kes**	8:05	**Pal**	8:25		
Pal	8:25	**Kes**	8:45	**Kes.S**	8:55		
Kes.S	8:55	**Kes**	9:05	**Pal**	9:25		
Pal	9:25	**Kes**	9:45	**Kes.S**	9:55	**Pal**	Palokka
Kes.S	9:55	**Kes**	10:05	**Pal**	10:25	**Kes**	City center
Pal	10:25	**Kes**	10:45	**Kes.S**	10:55	**Kes.S**	Hospital
Kes.S	10:55	**Kes**	11:05	**Pal**	11:25		
Pal	11:25	**Kes**	11:45	**Kes.S**	11:55		
Kes.S	11:55	**Kes**	18:20	**Pal**	12:25		
Pal	12:25	**Kes**	12:45	**Kes.S**	12:55		
Kes.S	12:55	**Kes**	19:20	**Pal**	13:25		
Pal	13:25	**Kes**	13:45	**Kes.S**	13:55		
Kes.S	13:55	**Kes**	20:20	**Pal**	14:25		
Pal	14:25	**Kes**	14:45	**Kes.S**	14:55		
Kes.S	14:55	**Kes**	15:05	**Pal**	15:25		
Pal	15:25	**Kes**	15:45	**Kes.S**	15:55		
Kes.S	15:55	**Kes**	15:55	**Pal**	16:25		
Pal	16:25	**Kes**	16:45	**Kes.S**	16:55		
Kes.S	16:55	**Kes**	16:55	**Pal**	17:25		
Pal	17:25	**Kes**	17:45	**Kes.S**	17:55		
Kes.S	17:55	**Kes**	17:55	**Pal**	18:25		
Pal	18:25	**Kes**	18:45	**Kes.S**	18:55		
Kes.S	18:55	**Kes**	18:55	**Pal**	19:25		
Pal	19:25	**Kes**	19:45	**Kes.S**	19:55		
Kes.S	19:55	**Kes**	19:55	**Pal**	20:25		
Pal	20:25	**Kes**	20:45	**Kes.S**	20:55		
Kes.S	20:55	**Kes**	20:55	**Pal**	21:25		
Pal	21:25	**Kes**	21:45	**Kes.S**	21:55		

Figure 26 Line 28 bus 1 schedule

The schedule is applicable during school year traffic, and extends well over normal business hours on both ends. This way each vehicle has 31 departures every day, as per competitive service lever requirements the service must cover Kangas area needs up to late at night. The total weekly kilometers for one bus comes in at 2315,6 kilometers, and with the cost of kilometer being 0,742 euros, the weekly cost of kilometers is 1718,18 euros. The work cost is for 15 hours and 30 minutes of effective working hours per day, as the client, in this case Jyväskylä city, only pays for driving time to the operator, who has to take additional working costs into account when preparing an offer. The cost of one hour is 29,56€, so one weeks' work costs are 3207,28 euros.

The daily starting cost for one vehicle is 156,48€, so this brings the cost of one week to 6020,84 euros for one bus, including weekends. For a 40 week school year total costs to operate one bus come in at 240 833,516 euros. To reach an acceptable service level in Kangas at least three vehicles is needed for the departure interval to be within 20 minutes every day, so that brings it to 722 500,548 euros.

LINE 28 (All values for one bus unless otherwise mentioned)

Daily departures	Lenght	Transfer kilometers per day	Weekly Departures	Weekly line kilometers
31	10,4	8,4	217	2315,6
				=Lenght * weekly departures + (transfer kilometers x days)

Working hours/day		AVG Costs	Cost per week	Total weekly cost	6020,84
	€/kilometer	0,742	1718,1752		
15,5	€/working hour	29,5602	3207,2817		
	€/vehicle day	156,483	1095,381		

Cost over a school year (40 weeks)
240833,516
722500,548 for three buses

As for weekends, even though the collective bargaining agreement states that drivers should be paid double for Sunday working hours, the hourly cost for the city is always the same that is stated for any given set according to the agreement between Jyväskylä City and Koiviston Auto.

The total cost for a completely new line with this configuration for 40-week schoolyear is 722 500,548 euros. The framework built here gives us the possibility to expand or substract services as seen fit. For example, adding one extra bus to further add service to busiest hours for 10 departures every day would add costs 108 551,744 euros over one school year.

Daily departures	Lenght	Transfer kilometers per day	Weekly Departures	Weekly line kilometers
10	10,4	8,4	70	786,8
				=Lenght * weekly departures + (transfer kilometers x days)

Working hours/day		AVG Costs	Cost per week	Total weekly cost	2713,79
	€/kilometer	0,742	583,8056		
5	€/working hour	29,5602	1034,607		
	€/vehicle day	156,483	1095,381		

Cost over a school year (40 weeks)
108551,744

7 Results

COST COMPARISON			
	LINE 12 CHANGES	LINE 25 CHANGES	NEW LINE 28
Yearly costs (-) / Savings (+)	4234,104	-5136,77	-722501 euros

It is established that the avenue of progress has two major lanes; either a new line is made at great expense, or existing lines are altered to fit a need. To recap, the costs to change line 25 are 5136,77 euros for schoolyear, the savings to change line 12 are 4234,104 euros per school year and the cost of creating a completely new line 28 is 722 501 euros. However, the comparison cannot only be judged by absolute cost or savings.

So far it is established that both Seppälä and Kangas areas have some interest from denizens of Palokka, but how much is needed for the line to make sense? All public transport operators receive countless feedback from possible customers but many times the feedback doesn't realize to real customers should you cater to everyone's whims.

TICKET PROFITS FOR SCHOOL YEAR 2015 - 2016

	August	September	October	November	December	January	February	March	April	May	June	July	TOTAL
Operational costs	1 213 969	1 321 098	1 350 481	1 345 920	1 277 354	1 269 194	1 310 276	1 326 144	1 348 806	1 351 910	841 997	842 776	14 799 925
Ticket profit	790 655	762 660	872 614	969 637	854 279	1 122 907	1 040 759	983 732	883 368	750 130	480 020	388 052	9 898 813
Amount of journeys	384090	502107	547884	634177	561594	662721	702953	651186	603973	487095	317499	245329	6300608
													AVERAGE
Ticket profit per journey	2,059	1,519	1,593	1,529	1,521	1,694	1,481	1,511	1,463	1,540	1,512	1,582	1,584

Figure 27 Ticket profits over school year 2015- 2016

The changes to line 25 causes it to lose any customers coming from Ahjokatu, but on the other hand line 25 could easily gain comparable amount from going through Vasarakatu as both Vasarakatu and Ahjokatu can serve the new shopping center in Seppälä, so it is estimated that the net negative effect of moving connections from Ahjokatu to Vasarakatu might be negligible, especially as lines 10 and 20 already go

through Ahjokatu. The cost here would be actual cost of lengthening the line, which in the scope of Jyväskylä City's annual expenditure on public transport (14 799 925 euros in 2015 - 2016) is not all too significant, but a cost is a cost.

Line 12 has more dramatic changes which result in the shortening of the line, but first it should be looked at where the reductions in service are. (Figure 30 Line 12 service reductions)

The losses in passenger amounts from Lohikoskentie crossing up to Puistokatu and Rajakatu crossing are insignificant, as there are few stops and few users. The main loss here would be towards the end of the Line at Puistokatu. However, five other lines pass along Puistokatu, to and from city center. Changing line 12 would mean that line 25 could continue serving along Ahjokatu where there is less service. Furthermore line 12 would also go along Vasarakatu where no service currently exists, and that combined to the customers from the new habitation and business district in Kangas tips the scales in favor of changing line 12.

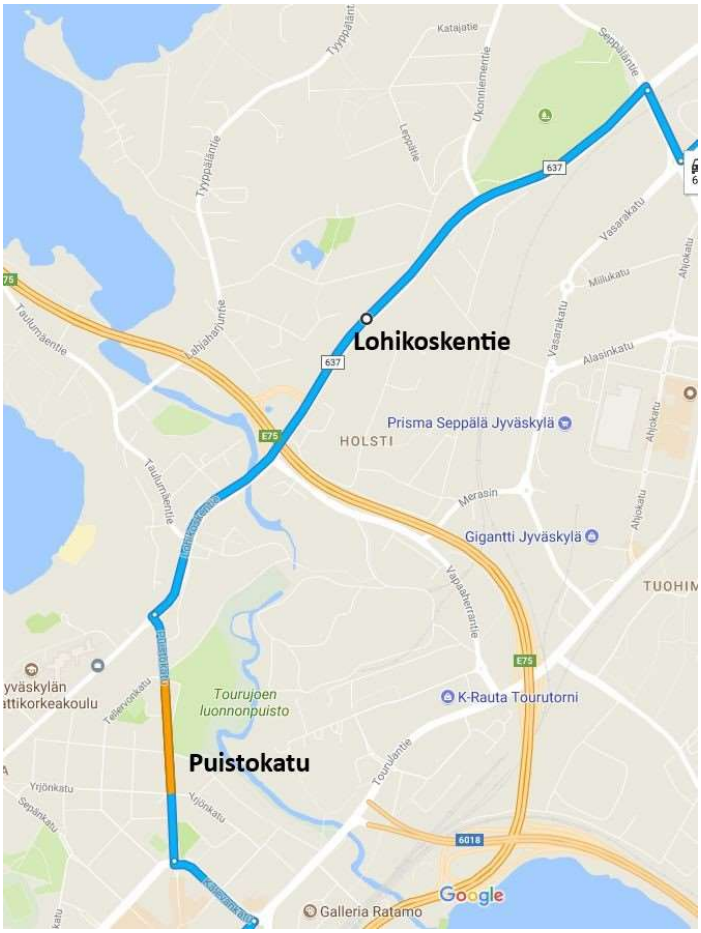

Figure 28 Line 12 service reductions

By changing line 12 the least amount of damage is being caused to current connections. Some savings, both fiscal and ecological, are created as the route is shorter, and should the need to arise further vehicles can be added to this concept with ease. As only one line is changed instead of creating a new one, the resources needed to educate both drivers and customers are manageable. When an existing framework is changed instead of creating a new one, the changes are quicker to implement in the case that new service is needed in the Kangas area before it is even finished, as most likely will be the case. Based on these factors it is recommended that line 12 is changed according to these plans should the Kangas region project progress as is currently planned, as it is the most flexible solution to the problem with the least amount of fiscal commitment. It provides further value as it can be changed even before the area is fully completed.

8 Scattering city development, Seppälä and Kangas

As is visible from figure 10, Kangas lies between two major business districts in Jyväskylä; Seppälä and the City center. Seppälä in particular has experienced major investments from businesses in recent years, expanding the service offerings available in the Seppälä area and also reinforcing Seppälä as a real competitor to the city center. (Jyväskylän liiketilamarkkinat murroksessa 30.1.2017) The philosophy for Kangas area then naturally has to be that it connects Seppälä and the city center. This, however, exaggerates the dilemma that the city center faces as far as escaping businesses from the center.

Jyväskylä's location in the crossing of various waterways was a wonderful advantage when most of the transport happened on waterways, but as the city has grown and the transport systems are mainly land based, the growth of the city has been sporadic, and planning road infrastructure and transport services problematic. The bus line amount for a city this size, 41 in total, and them being mostly pendulum lines shows that in order to offer adequate service level thorough the city, is of direct consequence of the city area being bordered by lakes and hills in all directions. (Jyväskylän kaupunkiseudun joukkoliikennesuunnitelma 2012, 49)

During last few years the traffic organization in Jyväskylä city center has been renewed with a heavy hand. Several streets closest to the center have been transformed to yard streets, where cyclist and pedestrians can roam more freely, encouraging people to make their trips with alternative transport modes to cars, be it cycling, walking, public transport or a combination of sorts. The goal is to limit personal vehicle traffic to the city center and promoting other modes of transport, and to return the centers image as an area of specialized businesses and a place to spend time in. (Jyväskylän keskustan kehityshanke 2015)

The goal indeed is noble and the effort valiant. However, Finland is very much a land of the personal vehicle, and as businesses have at the same time not received the return on investment they desire with the added premium they pay for the more expensive rents in city center, consumers living outside city center with access to a vehicle now have options: they can either drive to heavily congested city center and pay significant amounts of money on parking, or drive on quicker roads to large stores with free parking. This phenomenon contradicts heavily with the principles of reducing emissions. Jyväskylä city has advanced intermodal public transport terminal combining bus- and a railway station under one roof, and a dedicated local bus terminal in the city center only accessible for buses and taxis, but the prevalence of personal vehicles and blocking center of cars has had an interesting effect. Even as traffic is quite congested at rush hours in Seppälä very similarly as it is in city center, Seppälä still attracts customers.

Much like Kangas, Seppälä is an area originally used for manufacturing facilities. However, loose zoning and limited manufacturing options saw the area develop more into a pit of car markets and smaller businesses. Presumably because of this development in Kangas zoning plan the possibility to make excessively large car markets to the area is denied. Nevertheless, as Seppälä has grown into such a formidable business district the authorities have had to take it into account as a comparable to the city center, ensuring that not only the residents of Kangas can reach the services of the center, but Seppälä as well, and herein lies the problem that polycentric city development causes for growing municipalities. If one can predict how these areas develop around the cities and control the development with zoning and intelligent road infrastructure planning, municipalities can easily procure public transport services to those areas.

9 Comments

The starting point for the project was that Jyväskylän Kangas is a developing urban area only realized on ink and pixels rather than concrete and steel, and the goal was to seek variables affecting planning and execution of public transport and their application in the context of Kangas area, and additionally Seppälä. Others were dissected maybe more than others, but overall coherence in the structure was hopefully kept as new ideas and problems unveiled themselves. The objectives for the thesis were to first find out about variables affecting public transport planning in an urban area, and then use that knowledge to research an area where no public transport or infrastructure currently exists, and to try to come up with possible solutions to the case. In the end both goals were fulfilled.

Reliability of the thesis is bound on many factors, such as the coherence of the author and the credibility of the sources. While sources might for some seem as being too many from too few entities and authors, the theories and themes discussed justify the use of those sources, who are independent in relation to the beneficiary of the thesis. Subjects that were possible to be researched with international sources were generally examined so. As the subject revolved around the concept of public transport in Finland, however, many sources were Finnish, as many of the key ideas are supported by research done by local Transport agency. One could also see that as a challenge within the work, as much of the sources had to be translated.

At the core of the work are plenty of calculations and data points within a broad spectrum of subjects, so some human error can be and likely is present. Calculations itself were checked several times to ensure their reliability, but difference of few hundred euros in either direction when it comes to cost calculations are possible. The distance calculations can only be accurate to the nearest 100 meters, as the area still under construction.

The other dilemma considered the phenomenon known as polycentric city development, what it is and how it manifests itself. This area was tied to the overall project quite well even as its discovery for me personally came as a bit of a surprise, but there is much more to research and found it personally quite interesting. Maybe that avenue should be covered in a further research.

In the end the changes to line 12 was chosen to be the apt way to solve the problem of providing public transport to Kangas area, and provide further service to Seppälä region. This of course doesn't disclose the possibility to use the other plans discussed in varying capacity as need arises, as it is possible that the demand could be bigger than expected, or that some changes are made to for example the zoning plans. Nevertheless, this work provides insight on how real decisions are made on real public transport services in Finnish urban environments.

References

Aavajoki, S. Vuoriainen, T. Jyväskylän keskustan kehityshanke. [*Jyväskylä city center development project*] 2015 https://koulutus.fcg.fi/Portals/2/Users/163/63/163/7_Timo_Vuoriainen_Saara_Aavajoki.pdf

Definition of polycentrism in English. Oxford dictionaries https://en.oxforddictionaries.com/definition/polycentrism

Hirsjärvi, S., Remes, P., & Sajavaara, P. 2009. *Tutki ja kirjoita*. 15th ed. Helsinki: Tammi.

Joensuu, T. 2011. Joukkoliikenteen ja maankäytön suunnittelun integrointi kaupunkiseuduilla. [*Public transport and land usage integration in urban areas*] Liikenneviraston selvitys 27/2011 http://www2.liikennevirasto.fi/julkaisut/pdf3/lts_2011-27_joukkoliikenteen_ja_web.pdf

Joukkoliikenteen palvelutason määrittely. [*Defining public transport service levels*] 2015. Liikennevirasto http://www2.liikennevirasto.fi/julkaisut/pdf8/lo_2015-31_joukkoliikenteen_palvelutason_web.pdf

Joukkoliikenne kaupunkiseutujen kaavoituksessa. [*Public transport as a part of urban area zoning*]2008. Insinööritoimisto Liidea http://www.bussikaupunki.info/Esiselvitys.pdf

Jourquin, B., Rietveld, P., & Westin, K. 2006. Towards Better Performing Transport Networks

Julkisen liikenteen sanasto 2013, [*Glossary of public transport terms*] Liikennevirasto http://www2.liikennevirasto.fi/julkaisut/pdf3/lop_2013-04_julkisen_liikenteen_web.pdf

Jyväskylän kangas: FAQ. 2017. Jyväskylän kaupunki http://www3.jkl.fi/blogit/kangasjyvaskyla/?page_id=2862

Jyväskylän Kangas: Historia. [*Jyväskylä Kangas region: History*] 2017. Jyväskylän kaupunki http://www3.jkl.fi/blogit/kangasjyvaskyla/?page_id=2

Jyväskylän Kangas: Kaavoitus. [*Jyväskylä Kangas region: Zoning*] 2017. Jyväskylän kaupunki http://www3.jkl.fi/blogit/kangasjyvaskyla/?page_id=317

Jyväskylän Kankaan ideakilpailu: Arvostelupöytäkirja 2011. [*Jyväskylä Kangas area idea competition: Evaluation transcript 2011*] Jyväskylän kaupunki http://www2.jkl.fi/kaavakartat/kangas/kangas_poytakirja_08022012.pdf

Jyväskylän kaupunkiseudun joukkoliikennesuunnitelma. [*Jyväskylä city public transport plan*] 2012. Ramboll

Jyväskylän liiketilamarkkinat murroksessa. 30.1.2017. toimitilat.fi https://www.toimitilat.fi/aluekatsaus/keski-suomi

Jyväskylän seudun liikenne 2025. [*Jyväskylä region traffic in 2025*] 2011. Keski – Suomen ELY-keskus
http://www.jyvaskyla.fi/instancedata/prime_product_julkaisu/jyvaskyla/embeds/jyvaskylawwwstructure/44315_Liikennepoliittinen_ohjelma.pdf

Jyväskylän seudun joukkoliikenne, Ohjeita ja tietoja. [*Jyväskylä region public transport, guides and information*] 2017, Jyväskylän kaupunki
http://linkki.jyvaskyla.fi/info

Jäppinen, J., & Voutilainen, H-M. 2012. Markkinapaikasta mainio kaupunki: Lyhyt johdatus Jyväskylän historiaan [*Short introduction into history of Jyväskylä*]
http://www3.jkl.fi/historia/lyhyt/index.shtml

Kankaan osayleiskaavaselostus. [*Kangas area zoning plan*] 2013. Jyväskylän kaupunkirakennepalvelut
http://www2.jkl.fi/kaavakartat/Kankaan_osayleiskaava/Kankaan_oyk_selostus_17102014_lainvoimainen.pdf

Kaupungistumisen kehitys. [*Development of urbanization*] 2016. Tilastokeskus.
http://suomifinland100.fi/kaupungistumisen-kehitys/

Kouri, P., & Mäntynen, J. 1993, Liikenteen suunnittelu

Liikenneviraston rooli valtakunnallisessa joukkoliikenteessä. [*Role of Finnish Transport Agency in national public transport*] 2017. Liikennevirasto
http://www.liikennevirasto.fi/liikennejarjestelma/henkiloliikenne/joukkoliikenne#.WOV8I_mLSUk

Linja-autopysäkit. [*Bus stops*] 2003. Tiehallinto
http://alk.tiehallinto.fi/thohje/pdf/2100015-02lautopys.pdf

Linja-autopysäkkien luokittelu. [*Bus stop classification*] 2013. Liikennevirasto
http://www2.liikennevirasto.fi/julkaisut/pdf3/lts_2013-41_linja-autopysakkien_luokittelu_web.pdf

McMillen P. 2001. Polycentric urban structure: The case of Milwaukee
https://core.ac.uk/download/pdf/6793024.pdf

Mitoitusajoneuvot ja ajouramallit. [*Measuring vehicles and roadway modeling*] 2008. Suomen paikallisliikenneliitto ry

Ohje joukkoliikenteen palvelutason määrittelyyn. [*Public transport service level definition guide*] 2010. Liikennevirasto
http://www2.liikennevirasto.fi/julkaisut/pdf3/lo_2010-07_ohje_joukkoliikenteen_web.pdf

Paikallisliikenteen matkustajamäärät. [*Local traffic passenger amounts*]2013. Jyväskylän kaupunki
http://www.jyvaskyla.fi/instancedata/prime_product_julkaisu/jyvaskyla/embeds/jyvaskylawwwstructure/61564_Yhdistelmaraportti_2012_JKL.pdf

Perustietoa Jyväskylästä. [*Basic info of Jyväskylä*] 2016. Tilastokeskus, Työ- ja elinkeinoministeriö, Opetushallitus/tilastopalvelu Vipunen
http://www.jyvaskyla.fi/info/pahkinankuoressa

Polycentric cities and sustainable development. UCL Center for Advanced Spatial Analysis.
http://www.casa.ucl.ac.uk/duncan/duncan_smith_poster.pdf

Polycentric city. Atributos Urbanos.
http://atributosurbanos.es/en/terms/polycentric-city/

Public Transport Performance Statistics. 2013. Liikennevirasto
http://www2.liikennevirasto.fi/julkaisut/pdf8/lti_2015-03_public_transport_web.pdf

Praechi, J. 2018. Desk Research – Methodology and Techniques. Management study guide
https://www.managementstudyguide.com/desk-research.htm

REGULATION (EC) No 1370/2007 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL. 2007. European union
http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32007R1370&from=EN

Seppälä, A. 2014. Onnibus myi Jyväskylän ja Tampereen paikallisliikenteet. [*Onnibus sold local traffic in Jyväskylä and Tampere]* Yle.fi, 4.3.2014.
https://yle.fi/uutiset/3-7119719

Smart choices for cities: Alternative Fuel Buses. 2016. CIVITAS Initiative.
http://civitas.eu/sites/default/files/civ_pol-08_m_web.pdf

Tietoja Jyväskylästä suuralueittain. [*Jyväskylä major regions*] 2016. Jyväskylän kaupunki
http://www.jyvaskyla.fi/info/tietoja_jyvaskylasta/suuralueet

Väestö. 2017. Tilastokeskus
http://www.tilastokeskus.fi/tup/suoluk/suoluk_vaesto.html

Valtionavustukset. [*State subsidies*] 2017. Liikennevirasto
https://juku.liikennevirasto.fi/#/tilastot/valtionavustukset

Walker, J. 2012. Human Transit: How clearer thinking about public transit can enrich our communities and our lives

Appendices

Appendix 1. Jyväskylä city public transport price comparison

JYVÄSKYLÄN KAUPUNKI

Kaupunkirakennepalvelut
Liikenne- ja viheralueet

Jyväskylän joukkoliikenne, hintavertailu

15.10.2013

Kohteiden suoritteet	Kohde 1	Kohde 2	Kohde 3	Kohde 4	Kohde 5
Linjakilometri	2074972,56	1580687,85	833502,95	985388,91	155097,5
Linjatunti	84684,1	66554,56	34377,99	33197,15	8750
Autopäivä	6979	6165	3228	2962	750

Tarjoaja

Onnibus Oy	Kohde 1	Kohde 2	Kohde 3	Kohde 4	Kohde 5
Tarjouksen hinnat					
Linjakilometri	0,672	0,651	0,69	1,017	0,702
Linjatunti	32,346	32,381	30,082	21,992	32,346
Autopäivä	158,344	148,574	155,448	165,048	172,131
Vertailuhinta					
Linjakilometri	1 394 381,56	1 029 027,79	575 117,04	1 002 140,52	108 878,45
Linjatunti	2 739 191,90	2 155 103,21	1 034 158,70	730 071,72	283 027,50
Autopäivä	1 105 062,78	915 958,71	501 786,14	488 872,18	129 096,25
Vertailuhinta yhteensä	5 238 656,23	4 100 089,71	2 111 061,87	2 221 084,42	521 004,20

Pohjolan Matka oy / Pohjolan Turistiauto Oy	Kohde 1	Kohde 2	Kohde 3	Kohde 4	Kohde 5
Tarjouksen hinnat					
Linjakilometri					0,765
Linjatunti					43,427
Autopäivä					314,67
Vertailuhinta					
Linjakilometri	0,00	0,00	0,00	0,00	118 649,59
Linjatunti	0,00	0,00	0,00	0,00	379 986,25
Autopäivä	0,00	0,00	0,00	0,00	236 002,50
Vertailuhinta yhteensä	0,00	0,00	0,00	0,00	734 638,34

Jyväskylän Liikenne	Kohde 1	Kohde 2	Kohde 3	Kohde 4	Kohde 5
Tarjouksen hinnat					
Linjakilometri	0,68	0,68	0,68	0,68	0,68
Linjatunti	33	33	33	33	31
Autopäivä	194	162	176	196	155
Vertailuhinta					
Linjakilometri	1 410 981,34	1 074 867,74	566 782,01	670 064,46	105 466,30
Linjatunti	2 794 575,30	2 196 300,48	1 134 473,67	1 095 505,95	271 250,00
Autopäivä	1 353 926,00	998 730,00	568 128,00	580 552,00	116 250,00
Vertailuhinta yhteensä	5 559 482,64	4 269 898,22	2 269 383,68	2 346 122,41	492 966,30

S&P Lehtonen	Kohde 1	Kohde 2	Kohde 3	Kohde 4	Kohde 5
Tarjouksen hinnat					
Linjakilometri					0,85
Linjatunti					44
Autopäivä					160
Vertailuhinta					
Linjakilometri	0,00	0,00	0,00	0,00	131 832,88
Linjatunti	0,00	0,00	0,00	0,00	385 000,00
Autopäivä	0,00	0,00	0,00	0,00	120 000,00
Vertailuhinta yhteensä	0,00	0,00	0,00	0,00	636 832,88

Veolia Transport West Oy	Kohde 1	Kohde 2	Kohde 3	Kohde 4	Kohde 5
Tarjouksen hinnat					
Linjakilometri	0,746	0,775			
Linjatunti	33,617	33,479			
Autopäivä	236,304	247,889			
Vertailuhinta					
Linjakilometri	1 547 929,53	1 225 033,08	0,00	0,00	0,00
Linjatunti	2 846 825,39	2 228 180,11	0,00	0,00	0,00
Autopäivä	1 649 165,82	1 528 235,89	0,00	0,00	0,00
Vertailuhinta yhteensä	6 043 920,54	4 981 448,88	0,00	0,00	0,00

Halvin tarjous	5 238 656,23	4 100 089,71	2 111 061,87	2 221 084,42	492 966,30
Tarjoaja	Onnibus	Onnibus	Onnibus	Onnibus	Jyväskylän Liikenne