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2016



## Kutsuplus – Final Report



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# Kutsuplus – Final Report

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## Abstract

Scheduled for 2012 - 2015, the intelligent demand-responsive transport pilot - Kutsuplus - was a success, both technologically and from the perspective of customer satisfaction. Apparently the world's first fully automated, real-time demand-responsive public transport service, Kutsuplus was developed by Helsinki Regional Transport Authority (HSL) and Split Finland Ltd. (earlier Ajelo Ltd.). The work resulted in a number of rewards. The system worked well, the efficiency in combining trips grew as expected, and the subsidizing level of transport decreased as the vehicular capacity was gradually increased due to the increasing popularity of the service. Customer satisfaction was exceptionally high despite the small service area and the low number of 15 vehicles.

Already before the launch of the service, it was known that operating with only 15 vehicles would need heavy subsidies. Getting the subsidies for the Kutsuplus service to a level comparable with other public transport calls for expansion to a larger scale. Further development of the control and service system would also contribute to the profitability of the service.

If the scale, costs, and obligations of two comparable transport services are equalized, it is evident that a service that is capable of taking one passenger at a time when necessary, and that can at other times effectively combine trips desired by the individual customers, will be better off than a service that is only a one-trick pony and neglects the varying individual needs of the customers at hand.

The HSL Executive Board decided that Kutsuplus in its current form would cease at the end of 2015. HSL will use the results of the experiment in its own work and will look at the possibility to implement a market-driven Kutsuplus service in the future.

This final report discusses the development and presents the key statistics and observations of the service trial. In addition, potential further development opportunities will be identified for interested parties.

## Keywords

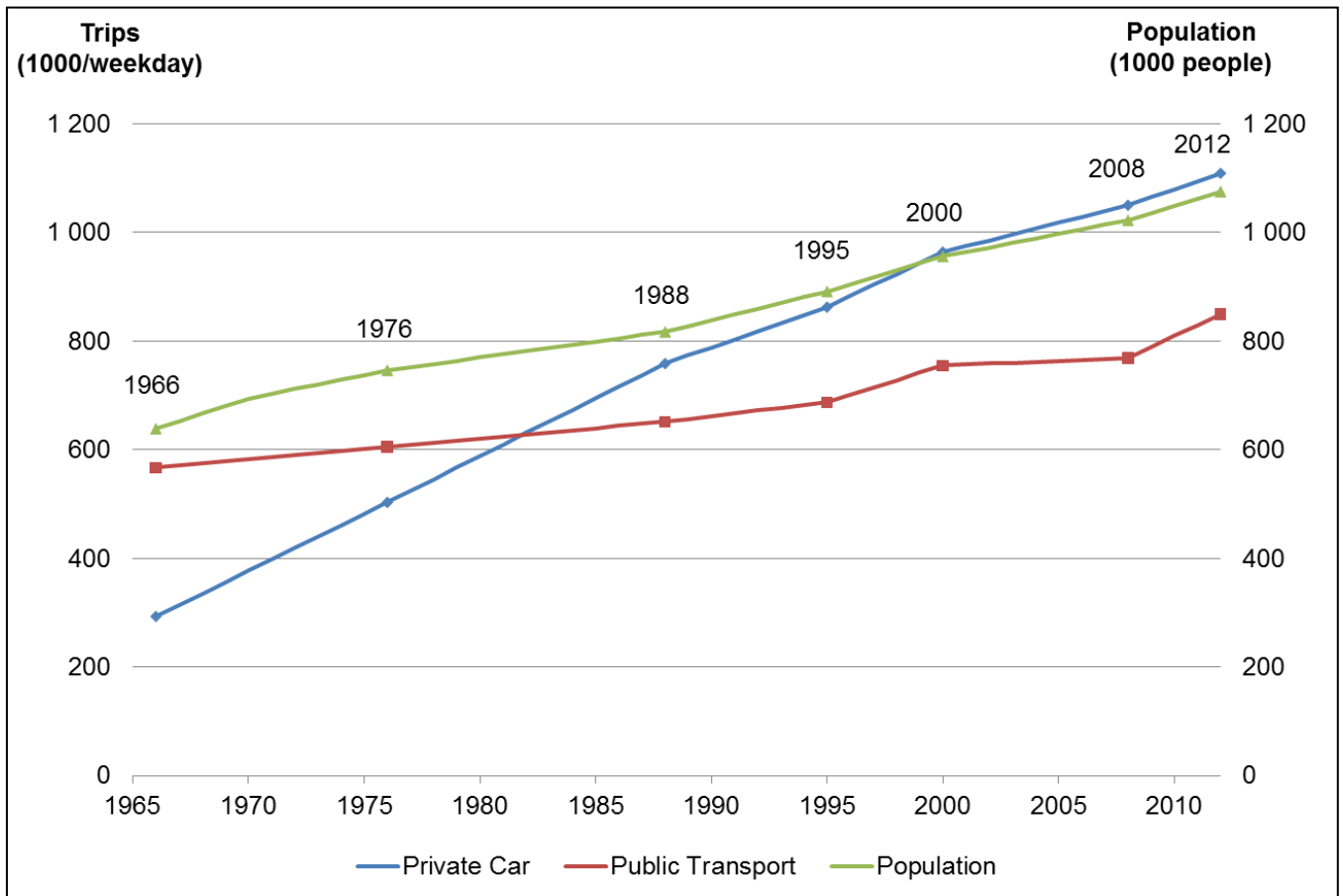
Kutsuplus, HSL, Split Finland Ltd., Ajelo Ltd., demand responsive, demand-responsive, DRT, automatic, real time, scalable, public, transport

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# 1 Background

Travel behavior surveys have been conducted in the Helsinki metropolitan area at least since 1966. At that time, the share of public transport for public transport and private car trips was 66% (Fig. 1).



**Fig. 1 - Helsinki region traffic survey 2012 (HLJ2015)**

During the research period of almost 50 years, the share of public transport among trips by Helsinki metropolitan area residents had been decreasing, although the absolute number of journeys had increased. According to the 2012 travel behavior survey, it seems that the trend had ceased: for the first time during the survey’s history, the share of public transport had increased from 42% in 2008 to 43% in 2012. However, in absolute terms, the number of private cars trips in the Helsinki metropolitan area is still increasing as before. In 2012, almost two million trips were made per weekday, of which 1.1 million were with private cars. Orbital traffic is related to this development. In orbital traffic, traditional public transport has not been at its best, as the origin and destination points of journeys tend to be scattered over a large area and it is therefore rather difficult to provide a good level of service with a traditional fixed route and fixed schedule service.

The basic idea of the Kutsuplus transport service is based on a very simple premise: In the rush hour, some 3,000 trips were made per minute and some 50 per second in the Helsinki metropolitan area. Although the area is large, the huge potential for combining trips in an intelligent way was realized. Thanks to the evolving technology, a positive tool with estimated external effects comparable to a congestion tax (>100 M€ / year) can be implemented to tackle congestion, parking problems, and other environmental problems caused by non-shared private car trips in the metropolitan area.

Evolving ICT, including accurate positioning technologies, enables on-the-fly optimization of shared trips in real time in larger and larger-scale services. A system with appropriate algorithms could take the var-

ying needs of many kinds of passengers into account and connect a passenger flexibly to the nearest viable vehicle. Automatic arrangement of public transport has also become possible in greater metropolitan areas. The efficiency of the existing transport system can be boosted by allocating sufficient vehicular capacity for an easy-to-use transport service that can take into account individual travel needs in real time. The more the functions are automated, the more cost-effective the service. A competitive alternative to the increasing number of privately owned cars can be offered by expanding such a service. By utilizing robot vehicles in the future, the costs could drop even to less than half of the costs of conventional systems.

Since 2007, Aalto University undertook a research project to study the possibility to develop a new, high-quality, and cost-effective mode of public transport service that could provide a competitive alternative to private car trips. The project was funded by the Finnish Funding Agency for Innovation (TEKES), Helsinki City Transport Innovation Fund, Helsinki City Transport (HKL), and the Ministry of Transport and Communications. Later, the Finnish Transport Agency was also involved in the project, and when the Helsinki Regional Transport Authority was established, it inherited the role of HKL in the project. The results of the research were promising. With 5,000 – 8,000 vehicles in the Helsinki metropolitan area, each serving 6 trips per hour and 100 trips per weekday, a total of 500,000 – 800,000 trips per weekday could be reached. Given that by 2027, 2.3 million trips will be made per weekday, the share of the new mode of transport would be 20% - 35%. With this volume, a huge positive impact could be made on the regional transport system.

In 2010, a MoU for strengthening the competitiveness of the Helsinki metropolitan area was signed by the metropolitan area cities, the Ministry of Transport and Communications, and the Ministry of Employment and the Economy. In the memorandum, the strengthening of the highest-level education and competence was mentioned, and the cities were to improve public transport between campuses by launching a particular demand-responsive transport pilot for inter-campus traffic, together with the state of Finland.

For these reasons, it was decided that a program to create a novel transport service offering shared rides individually, on the basis of an automated control and service system would be launched. This had been considered realistic by the preceding research project by Aalto University, given that adequate vehicular capacity would be provided.

The experiment was started with low vehicular capacity with the purpose to develop and test the service. On this basis, the service could later be expanded to increasingly substitute private car trips. The consortium agreement was signed on June 1<sup>st</sup>, 2011, and this was followed by field trials with test passengers from October 1<sup>st</sup>, 2012, and public service from April 3<sup>rd</sup>, 2013.

Later, focus-group studies and interviews were also conducted to verify that demand exists for a public service providing a more rational choice for motorists in the Helsinki metropolitan area. Additional mock-up experiments were made to support the concepting of the novel service. During these experiments, it was noticed, for example, that the ability of passengers to find the place of pick-up is rather limited, and it was realized that paying attention to this particular issue in the system development phase was mandatory. The image conveyed to the test passengers was that the service would be reliable, easy to use, and personal: “a convenient route for you, always”.

## **2 Objectives**

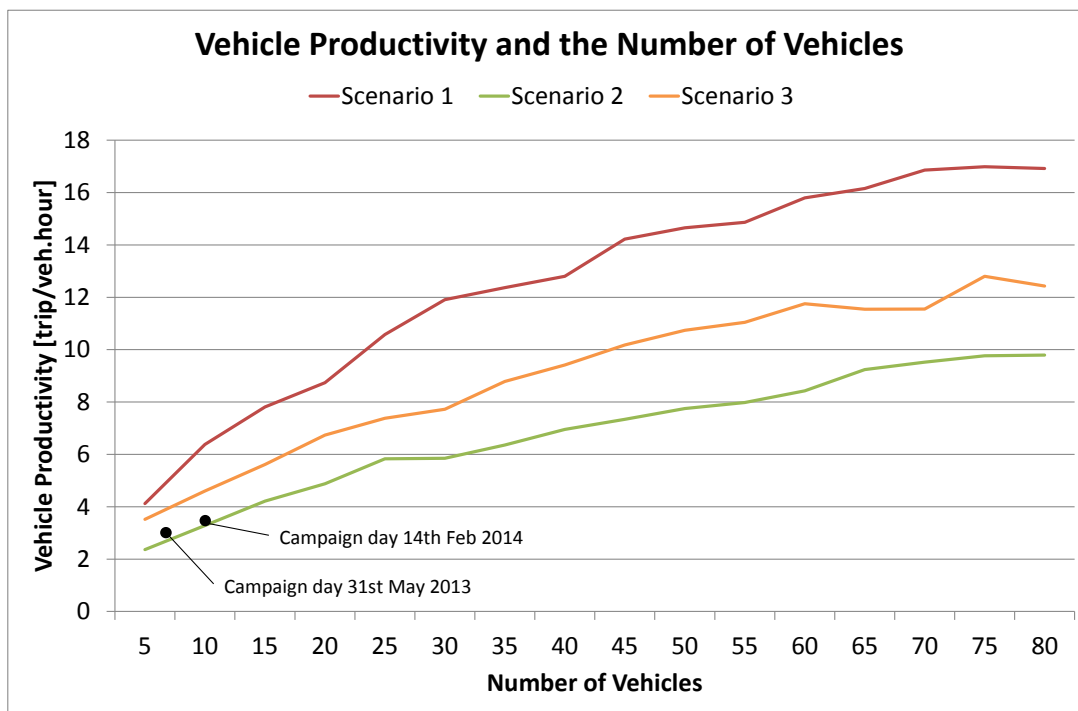
The aim of the new mode of public transport is to have an increasing number of motorists switch to public transport. This could be achieved by providing a comfortable and easy-to-use service that is flexible in time and travel route as well as in terms of service and price level.

When the objectives were outlined, customer time-efficiency was considered important in the case of motorists. The strategic outline of the service design was made on this basis. The new mode of transport was to become a powerful tool in tackling congestion. The service was also to offer good public transport service for orbiting traffic and in other new areas where regular public transport had not been competitive



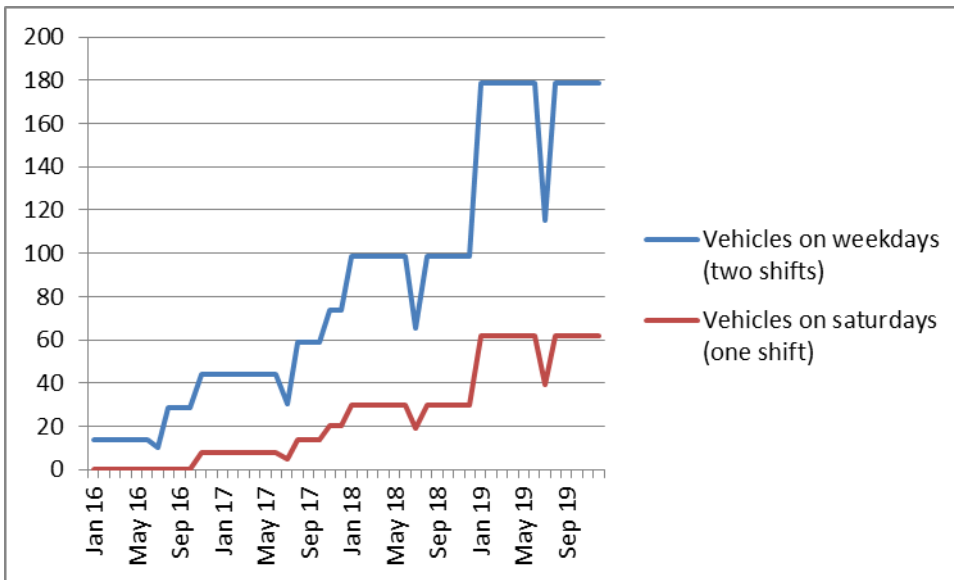
so far. The new service was to become an increasingly flexible and personal form of public transport, enabling door-to-door guided journeys, while competing with the private car in terms of time usage, ecology, and economy.

An area approximating the Kutsuplus service area was fed into the simulator, which was built earlier at Aalto University. The simulation was based on sufficient demand and a flat population distribution and road topology. When an efficient system with sufficient demand is considered, vehicular efficiency depends decisively on vehicle density, meaning the number of vehicles per square kilometer. In practice, the efficiency also depends on road topology, which, with its speed limits and other restrictions, is significantly different in a one-directional street in Helsinki downtown and on the local highways. Many practical issues, like the details of the implemented service and the effect of traditional public transport, not to mention travel behavior, were not included in the simulations.



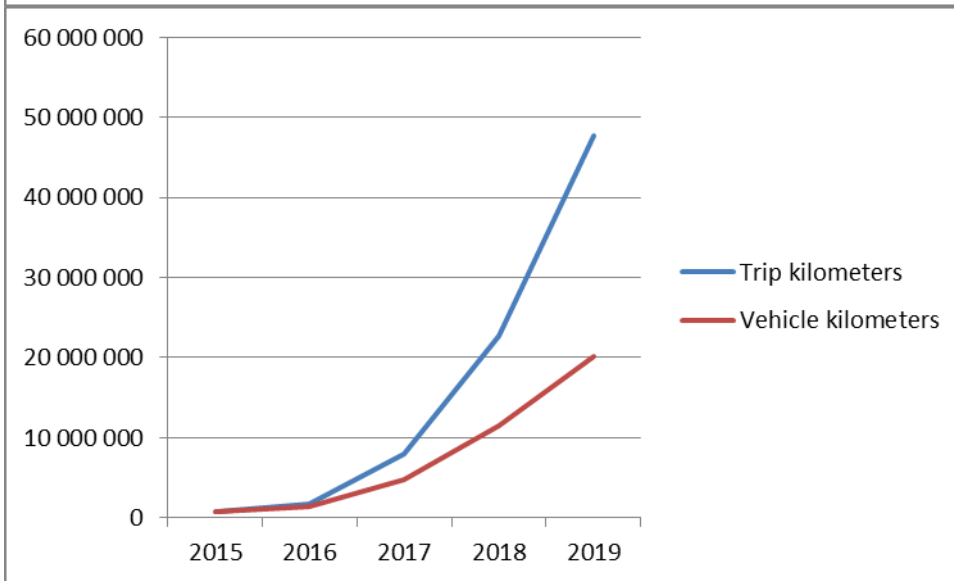
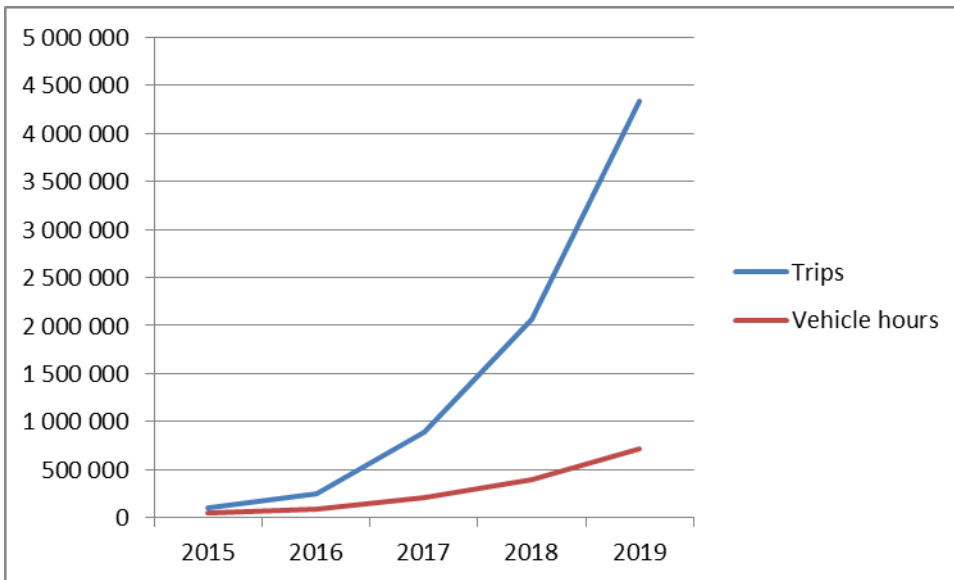
**Fig. 2 – Vehicle productivity grew as expected, when the number of vehicles simultaneously serving Kutsuplus customers was increased.**

As the service trial produced travel statistics, those were compared with the simulation results. In the early stage of the trial, demand was accelerated by arranging campaign days (Fig. 2). Hence, it was possible to measure the productivity of the system at an early stage, with the demand closer to that of a mature system. Later, these records were broken without campaigns, as the service became more popular. The comparison took into account the fact that only some of the Kutsuplus vehicles were simultaneously operating in Kutsuplus mode, paid for by HSL. If the expansion of the service area between the campaigns had been taken into account, the measured and simulated trends would have been even more precisely parallel. The simulated and measured trend showed clearly that an extension of the number of vehicles in the service area will raise the efficiency of the service. The accumulated information was used in setting the next targets for the coming years.



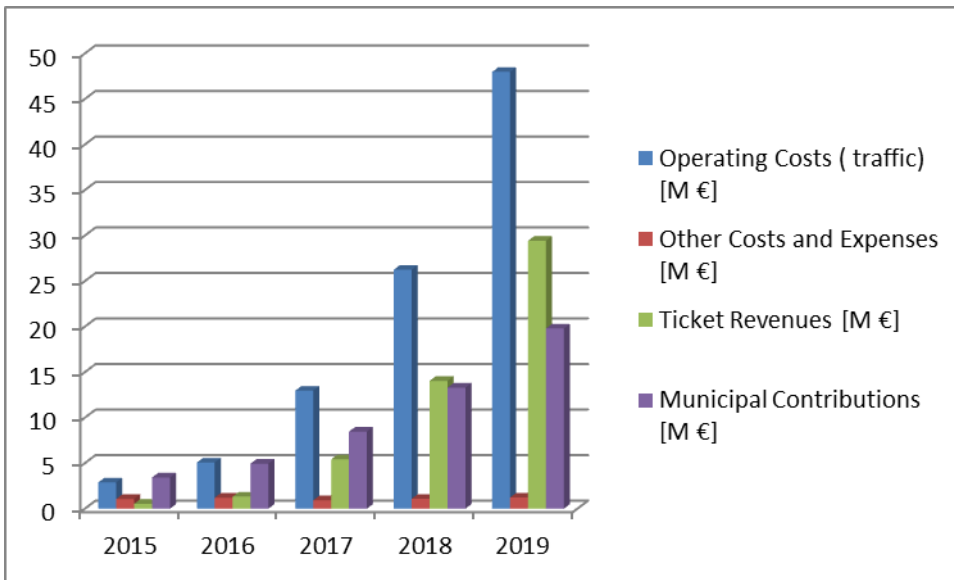
**Fig. 3 – The preliminary financial and operational plan of HSL for 2016-2018 was based on expanding the vehicular capacity to 100 vehicles driving on weekdays by 2018.**

The idea behind the whole service trial was the large-scale service. HSL's goal was to begin the expansion by increasing the number of vehicles to 45 by May 2014. This target was not met, due to the challenging financial situation of the municipalities. Therefore, this target was postponed until fall 2016 (Fig. 3). On this basis, the development of essential efficiency figures was estimated for the proposed fleet size. These figures formed the basis of the preliminary financial and operational plan of HSL for 2016-2018.



**Figs. 4a and 4b – Target figures for the developing Kutsuplus service, spring 2015**

The target was to achieve five trips per vehicle hour and two trip kilometers with one vehicle kilometer by 2018. The target setting was ambitious, but it was considered achievable, as long as the system development continued with determination under guidance from HSL.



**Fig. 5 – As an automated Kutsuplus type of service is brought into large-scale use, ticket revenue and operating (transport) costs become decisive, and the role of general costs will diminish.**

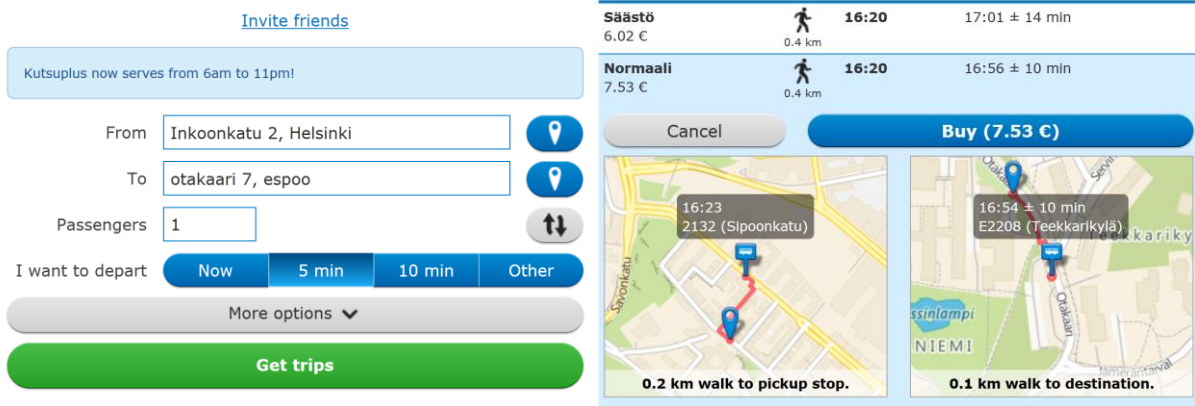
The increasing targets for ticket revenue were based on the growing efficiency. On top of these, no targets were set for raising the pricing basis. A more significant increase in the tariff-setting would have required service re-positioning closer to a taxi-like service, away from traditional public transport.

Other costs and expenses play some role in the early stages of service ramp-up, due to small-scale transport operation accompanied by intense service development and high marketing costs per vehicle. Along with the expansion of an automated Kutsuplus type of service, the ticket revenue and cost of transport will become dominant (Fig. 5). By following the development of transport subsidy levels, along with the available vehicular capacity, the importance of adequate vehicular capacity in creating an efficient service may be understood.

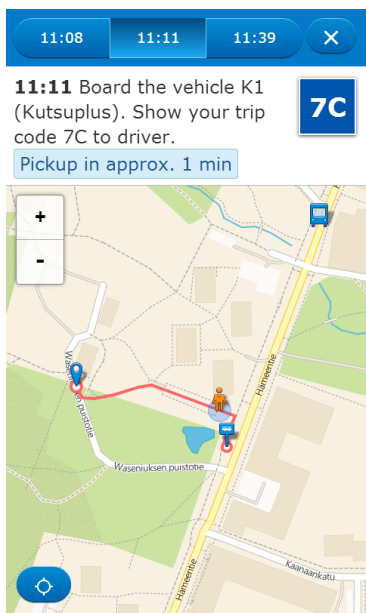
### 3 Solution

In an efficient demand-responsive transport system, the routes of the vehicles are optimized on the basis of trip orders from customers, in such a way that customers heading approximately in the same direction are directed to the same vehicle. The system was to estimate driving times reliably in the ongoing traffic situation. Unpredictable distractions in traffic may cause congestion. As the estimate is never accurate due to the nature of traffic, it is beneficial if the system can react fast to changes and perform re-optimization in a short time, during which the traffic situation is not likely to change significantly. The ability of a system to react fast is also beneficial because it is then less likely that the vehicles will pass decision-making points of the automated route optimization – like intersections and customers ordering a trip at the very last moment - during a short calculation time.

The emerging solution was a new kind of real-time intelligent transport system in which a server receives trip orders from customers for centralized optimization of the routes over all viable vehicles and trips in real time. The passengers themselves can choose the desired level of service, and the fare they pay is determined on the basis of their selections (Figs. 6a and 6b), and real-time information, including guidance to and from the nearest bus stops, will be provided (Fig. 6c). Passengers going in roughly the same direction will be picked up in the same vehicle, as the control and service system optimizes the routing of each vehicle within the time windows of the passengers.



**Fig. 6a and 6b – Order and select Trip in Kutsuplus.fi, © HSL and Split Finland Ltd.**



**Fig. 6c – Real-time travel information on a GPS-enabled smart phone, © HSL and Split Finland Ltd.**

Reliable estimation of driving time is a critical success factor in a service based on automatically combined trips. Reliability and punctuality are prerequisites for efficient operation and for smooth journeys with co-passengers. Therefore, the control and service system should be aware of the traffic situation at hand. The fluent punctuality was to be backed up by not picking up customers from all possible locations. Instead, the bus stop network was to be supplemented by carefully chosen pick-up and end-point locations, which were called virtual stops. These were defined in safe and easily reachable places for fluent travel with co-passengers.

Trip order, payment, driver's instructions and navigation information all have to happen in real time to enable efficient and optimized real-time routing of moving vehicles. These are also pre-requisites for service scalability in terms of service area and fleet size. Given that

- a) the above-mentioned are implemented properly,
- b) the high-quality service marketing is sufficient,
- c) the service is priced reasonably for sufficient demand,

causality according to which an increase in vehicular density would dramatically increase vehicular efficiency [1, 2] would exist. Therefore, it is possible to create a profitable service by significantly expanding the scale of the service, if sufficient attention is paid to the following points: Firstly, this calls for an easy-to-use, high-quality service. Secondly, the correct positioning of the service classes between taxi-like services and traditional public transport is mandatory. Thirdly, attention has to be paid on cost efficiency and especially on the dominant cost items, such as transport costs.

The streamlining of the cost structure could, in the future, even mean that the traditional public transport-like operating concept of Kutsuplus could be replaced by a more dynamic concept. For example, the vehicular efficiency of the taxi fleet could be increased by providing alternative levels of service for different types of customers with the nearest suitable vehicle (and suitable driver, if specific skills are needed, as in social transport). For example, a step in this direction could be to add address-based shared rides to the current service offering of taxi. Dynamic pricing would also contribute to the service profitability: Vehicular efficiency could be further boosted with an automated auction over an open interface between the automated subscription centers that the taxi services provide and the passenger application (with time management personal valuation, €/min). This would also reduce congestion in peak hours.

The reward for target-oriented service development and expansion toward profitability may be the big bang of the transport revolution: as the service becomes profitable, expansion of the service is easy, as the monetary municipal contributions become void. On a large scale, the additional positive effects of the service have been estimated to be at least hundreds of millions of euros [3].

## 4 Implementation

HSL was responsible for the service ecosystem, service design, the defining of the requirement specifications for the partners and subcontractors of HSL, ranging from transport operators to mobile telecommunication system vendors, and software and hardware vendors. Numerous parallel developments and preparation efforts took place in HSL, ranging from arranging quotations for the expanding Kutsuplus-transport service to gradually increase the vehicular capacity to equipping the vehicles, and from the design of the service details to the visual image and service name selection. HSL held overall responsibility for program coordination and leadership.

The transport operators Rappiditaxi, Taksikuljetus, and Andersson provided and assembled the vehicles and infrastructure for the information system, hired the drivers, and provided the actual physical transport.

The responsibilities of Ajelo Ltd. included the development and maintenance of the core control and service system. Implemented functions included receiving trip orders and providing and allocating shared rides for vehicles in real time. In addition, Ajelo programmed the driver and passenger information system, and implemented and maintained the database setup for event-logs and, for example, for customers' trip wallets. Ajelo was also responsible for the vector-based map database and map database modifications, and for providing passenger statistics.

In summer 2012, the core software by Ajelo was able to accept ride bookings and combine individual trips on the basis of optimized real-time routing within the passengers' time budgets, and could direct the movement of vehicles via Android tablets, which were selected as a flexible and future-proof platform for driver information services, including navigation, passenger registration, break requests, and feedback.

Independent real-time traffic data sources for the travel-time forecast system were established and offered, to ensure reliable and smooth service. A payment function was integrated with trip ordering, and payment in advance was chosen to eliminate fraud. Hundreds of virtual bus stops were defined in the thickening HSL bus stop database. The virtual bus stops consist of photographs with fill-in graphics on the pick-up- locations for driver and passenger guidance, related geographical coordinates, and direction information. Also the whole HSL bus stop database was complemented with direction information for determining reliably on which side of the road the bus stop is. This was provided for automated route optimization.

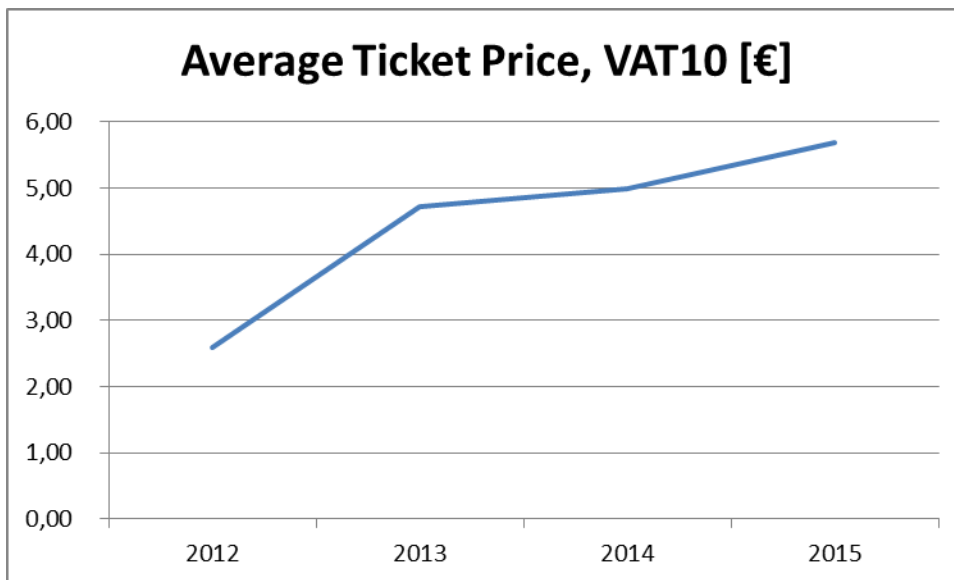
The latest pick-up time stated by the control and service system was varied in the trial. In an Internet-based trip order, it was always possible to request trips for the current time. The last pick-up time was varied between 30 minutes and 2 hours. In the early service, 60 minutes was typically used, and as the popularity increased, this was shortened to 45 minutes. During campaign days with exceptional demand, a latest pick-up time of 30 minutes was chosen in advance. In a simplified SMS-based trip order, a narrower time range was used. The selection of the last possible pick-up time was a compromise between the customer's preference for a possibility to order a ride for any time in the future, and the vehicular efficiency provided by the control and service system, routing the small 15-vehicle fleet in partially unpredictable traffic.

Pre-order, for example, several hours or days in advance accompanied by possible immediate or later confirmation, is an important passenger function. However, neither a pre-order to the more distant future, nor a recursive order with confirmation, was implemented, partially due to the small number of vehicles in the service area. From the system design perspective, assigning a specific vehicle to a specific customer during confirmation a long time before the pick-up could have reduced the efficiency of the limited-size fleet at the very beginning, due to the partial unpredictability of traffic. HSL saw pre-order as an important function in the development of a large-scale service, but the function was not yet tested in the small-scale service trial.

## **5 From field tests to public service**

The field testing of the Kutsuplus service with real passengers started on schedule on October 1<sup>st</sup>, 2012, with three vehicles. With a few exceptions, the ordered trips were taken care of reliably from the very beginning. During the next few weeks, the fleet was expanded to 10 vehicles. Each of the 10 vehicles operated 8 hours a day on weekdays. In November 2013, the number of vehicles was increased by five, with each new vehicle operating 17 hours a day on weekdays. The service time was also increased from 7.30am–6.30pm to 6am–11pm using the 15 vehicles. In August 2014, seven of the ten original vehicles doubled the operating hours per vehicle from 8 to 16 per weekday, and the service time was extended by one hour until midnight.

The initial service area was mainly located inside Ring Road I. At that time, the area included the campuses of Aalto University and Helsinki University, from which test passengers were invited to book rides from any existing bus stop to any other bus stop within the area. Lauttasaari was added to the service area in early 2013; Herttoniemi and Mustikkamaa in summer 2013; and Itäkeskus, Myllypuro, and Tapiola at the beginning of 2014. In October 2015, the service area was expanded in Tapiola, Vallikallio, Pukinmäki, Malmi, Roihuvuori, Herttoniemi, Herttoniemenranta, and Kalasatama.

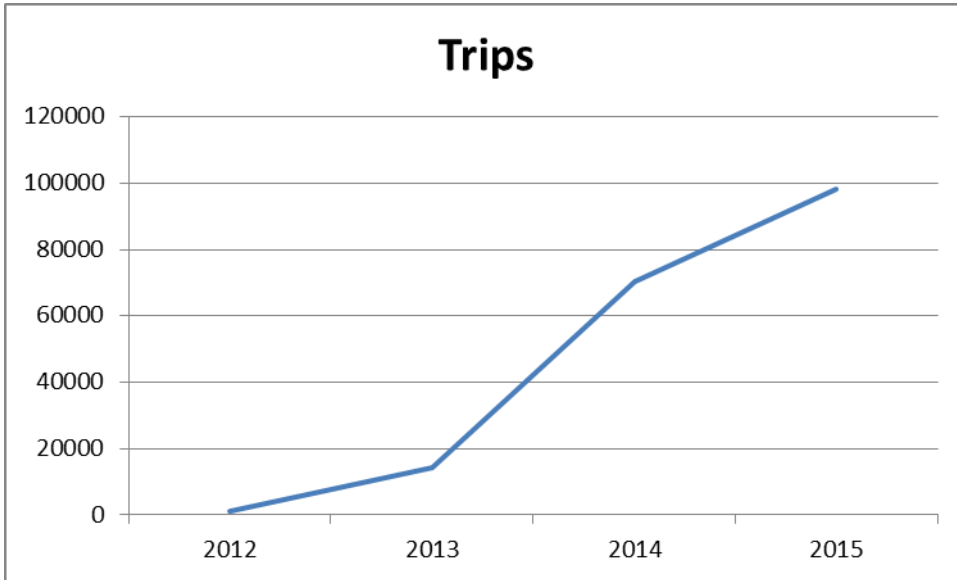


**Fig. 7 – Average ticket price**

In the testing phase, aggressive pricing of €1.5 + €0.15/km was used (Fig. 7). The basis for trip pricing was more than doubled to €3.5 + €0.45/km at the time of the public launch of the Kutsuplus service on April 3<sup>rd</sup>, 2013. After this change, the price of one ticket covered the differential costs of the trip, and additionally an increasing share of the fixed costs of the service, due to the increasing efficiency of the expanding service. The basis for trip pricing was further increased by approximately 17% in January 2015 as the 20% cheaper and slower economy class was replaced by the 20% cheaper happy hour pricing for trips ordered between 10am and 2pm, to flatten the morning and evening rush-hour peaks and improve the availability of the service. This measure took place, as HSL was not allowed to increase the size of the small fleet of 15 vehicles although the service demand had been increasing substantially.

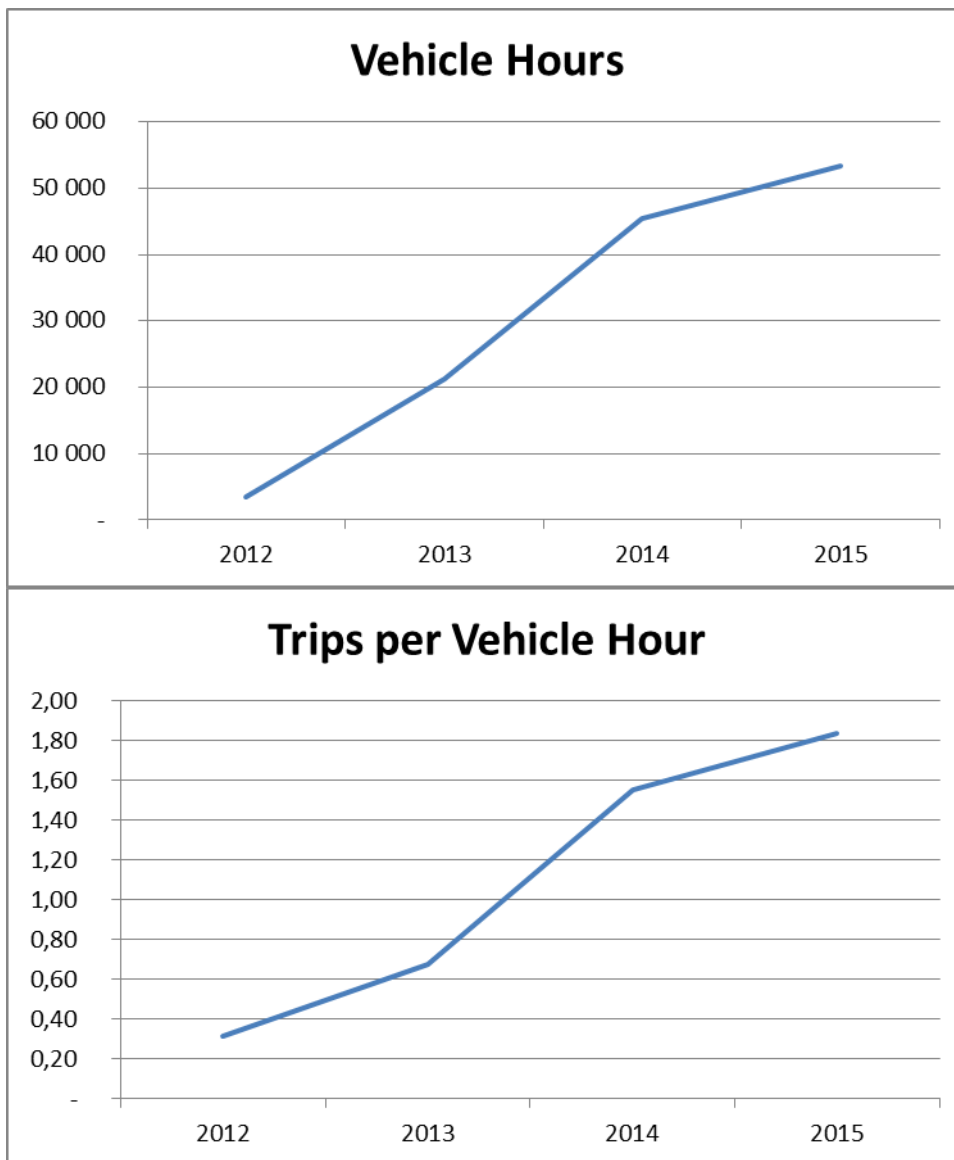
The service has been load-tested several times with real passengers in heavy demand conditions: Valentine's Day free-ride campaigns in 2013 and 2014; the public launch of the Kutsuplus service on April 3<sup>rd</sup>, 2013, on two TV channels, and in newspapers and other media; and the free-ride campaign on May 31<sup>st</sup>, 2013. The central system also worked reliably in heavy-demand conditions where real-time trip-combining was more intense. Later, the load tests turned out to be necessary in the sense that the service became increasingly popular. All the campaign-day records were later broken as the vehicles served several trips per hour on busy days.





**Fig. 8 – The number of trips annually**

Passenger numbers were rising at a pace of several hundred per cent annually, until the limited availability of the small 15-vehicle fleet started to saturate growth (Fig. 8). 2015 was a record year despite speculation about ending the service organized by HSL.

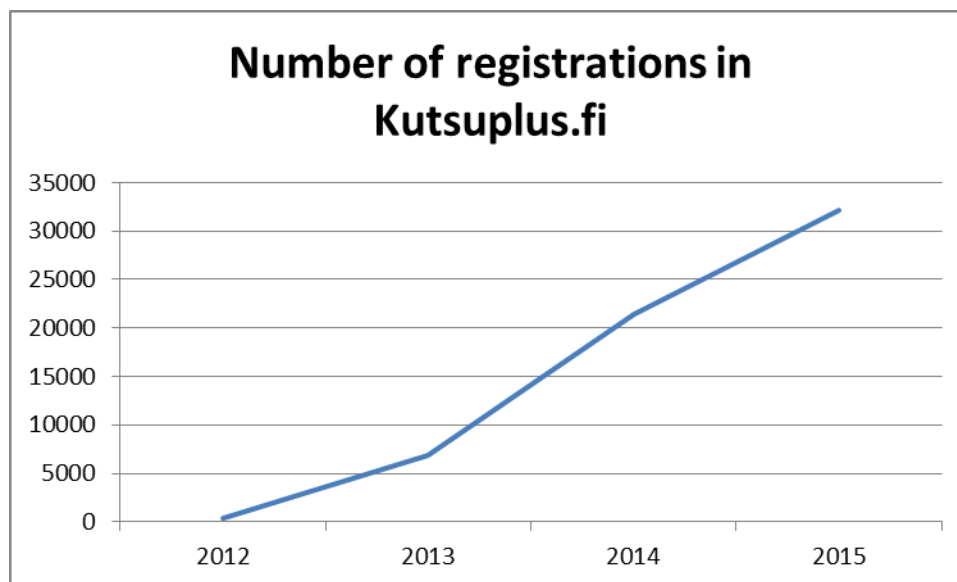


**Fig. 9a – Vehicular capacity was increased gradually. Fig. 9b – Vehicular efficiency correlated strongly with the vehicular capacity in the service area - as was expected due to earlier studies made at Aalto University.**

The vehicular efficiency of Kutsuplus showed an upward trend. Despite the limited vehicular capacity, the efficiency rose already during the trial to a level between the efficiency of a typical traditional bus service and that of a typical taxi service. The increase in vehicular capacity correlated strongly with vehicular efficiency (Figs. 9a and 9b). This could be expected on the basis of earlier studies and simulations done at Aalto University [1, 2]. Whenever the capacity of the service with increasing demand was increased, the vehicle arrived in less time, and the combining of trips called for fewer zigzag route patterns. As the quality of service increased, it was possible to increase the price of the trips (Figs. 7 and 8).

Kutsuplus picks up timely customers from bus stops and virtual bus stops, whereas the address-based taxi service waits for late customers. Therefore, a direct comparison of the two is not justified. However, it can be noted that already with only 15 vehicles, each serving 8 - 17 hours (service open 18 hours on weekdays), more trips were made per vehicle hour in Kutsuplus than are made in a typical taxi service. Furthermore, simulations run using the simulator of Aalto University have indicated that with a large number of vehicles, many times more trips per vehicle hour could be achieved with a real-time system when compared to the corresponding system on small scale (Fig.2).

If the scale, costs, and obligations of two comparable transport services are equalized, it is evident that a service that is capable of taking even only one passenger at a time when necessary, and that can also at other times effectively combine trips in real time within the price and time-limits desired by less busy individuals, will be better off when compared to one-trick ponies that partially miss the differing individual preferences of the customers at hand.



**Fig. 10 – Kutsuplus.fi registrations**

By December 31<sup>st</sup>, 2015, a total of 32,193 registrations had taken place at Kutsuplus.fi (Fig. 10). The demand for the service grew strongly despite the limited service area and vehicular capacity. Customers requested service expansion geographically and temporally on a daily basis.

## 6 Service development

Numerous service improvements and new functions have been implemented since October 2012. These include:

- enhanced Digiroad map database and method for concealing the shortcomings in the map database, such as in the area of Kalasatama, which is under construction
- bus stop database with increased accuracy and complementary direction information
- alternative service classes for customer-based tailoring of service quality
- group discounts, friend invitation, business and family pack
- four alternative languages for using the service
- price simulator ([kutsuplus.fi/pricing](http://kutsuplus.fi/pricing))

Alternative means of payment were also developed to complement the original trip wallet loading from the bank account. These included payment with the phone bill of a trip ordered by SMS, trip wallet loading with a credit card, and a voucher function. The use of money loaded onto an HSL travel card was planned.

Subsidized by the member municipalities, the Kutsuplus service, in its infancy, was exposed to strong criticism, as only Internet users could order a ride. This was noted, and a lightened online order ([kutsuplus.fi/m](http://kutsuplus.fi/m)) was offered to customers using cellphone models with lesser Internet browsing capability. Registration-free premium SMS ordering with automatic trip charging on the phone bill was also added. It was then possible to reliably order a ride using any model of cellphone. Later, it turned out that

only 3% of trips were ordered using SMS, but public criticism was gradually replaced by increasing confidence in the service.

Already in 2011, HSL saw the importance of a native smartphone application that is easy for mobile use. Later, according to an HSL customer survey, this turned out to be the most important item to be included in the service. A well-designed application would enable trip orders to a customer's most popular destinations from the sensed location with just one click (plus optional confirmation). By enabling payment on the phone bill, via credit card, or with other popular relevant payment methods, there would be no need for mandatory registration. Unfortunately, the mobile application was never offered to Kutsuplus customers, although the prototype was tested with the help of HSL in spring 2014 to improve usability.

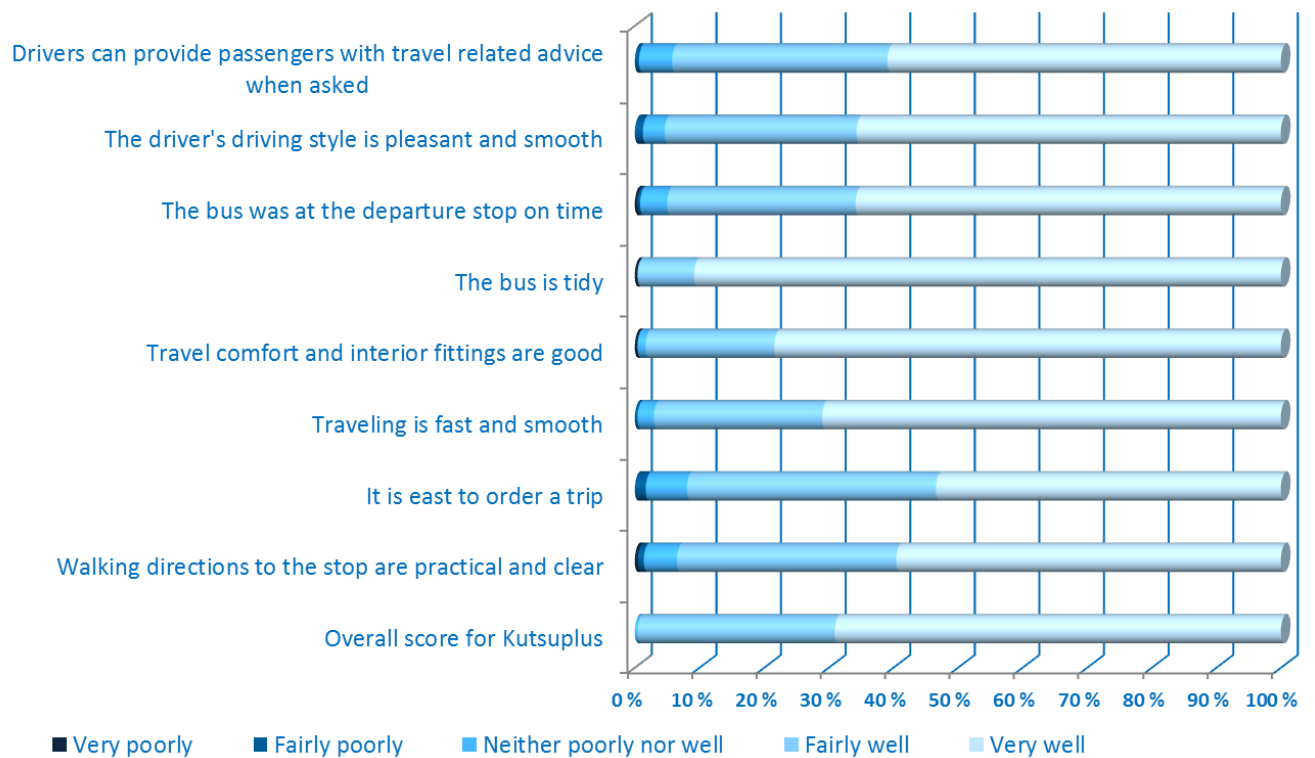
Since December 2013, in compliance with the strategic outline of the Kutsuplus service design, a free high-quality wireless Internet connection (Wi-Fi, WLAN) was offered to Kutsuplus passengers. Kutsuplus passengers then had the option (that private car users – some 75% of which are drivers - were lacking) to take more out of their travelling time. Several communication technology solutions were tested in the vehicles, and the high subjective quality and cost-effectiveness were gradually fine-tuned to be better and better.

Hundreds of Kutsuplus virtual bus stops were photographed and defined in the Helsinki metropolitan area. The first ones were introduced in 2013 in order to make the bus stop network denser on the basis of customer needs and suggestions. In principle, any safe and feasible location within the road network can be defined as a virtual bus stop. In spring 2015, the total number of virtual stops within the service area was increased to some tens.

The overall usability, reliability, and timeliness also improved in the developing service. Dynamic pricing was introduced in January 2015 to flatten the demand from peak-hours to midday, hence improving service reliability further. The “temporal reliability” of the trip-combining service depends decisively on the current state of the partially unpredictable traffic. The fact that 35% of pick-ups were within a +/-30-second range of the given pick-up time illustrates well the accurate nature of the automated real-time Kutsuplus service.

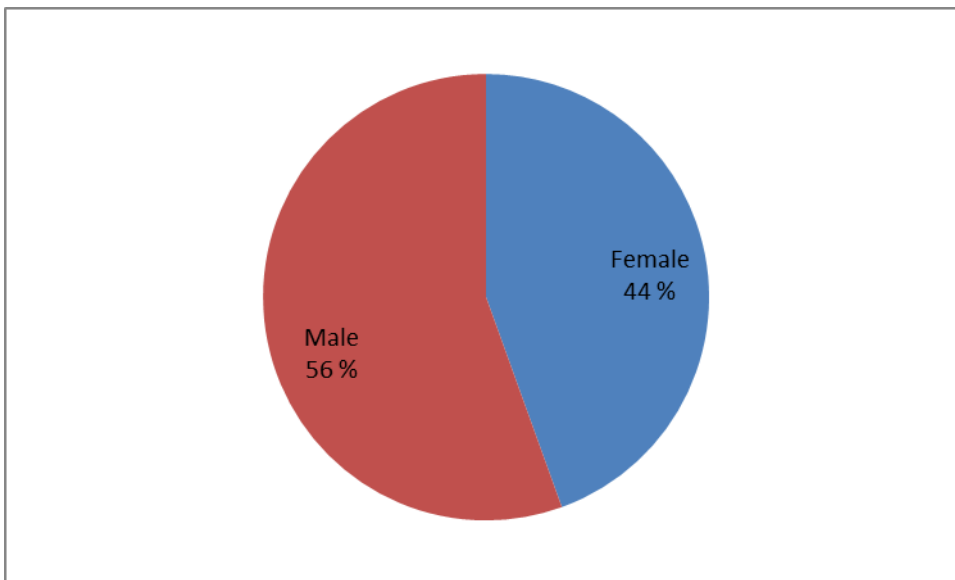
## **7 Customer base and feedback**

Feedback from the clientele, Kutsuplus bus drivers, and other interest groups was important. Passenger studies showed very encouraging results (Fig. 11). Customer satisfaction developed positively after the establishment of the Kutsuplus service. An overall rating of 4.7 on a scale of 1 to 5 was reached despite the small service area and the small fleet of 15 vehicles severely limiting service availability. The grade is exceptionally high, even when compared to other high-quality traditional HSL public transport, which involves 1,500 vehicles and which, at the same time, is ranked typically roughly at 4.1–4.2 and operates in a service area significantly greater than that of Kutsuplus. The achievement is even more remarkable when the price difference is taken into account: On traditional public transport, such as in the area of Helsinki, which is greater than the Kutsuplus service area, typically 80 trips are made on a travel card for €52.40 a month. In this case, the price of one traditional public transport trip is only €0.66, which is only slightly over 10% of the price of a typical Kutsuplus ride, priced at €5.70.

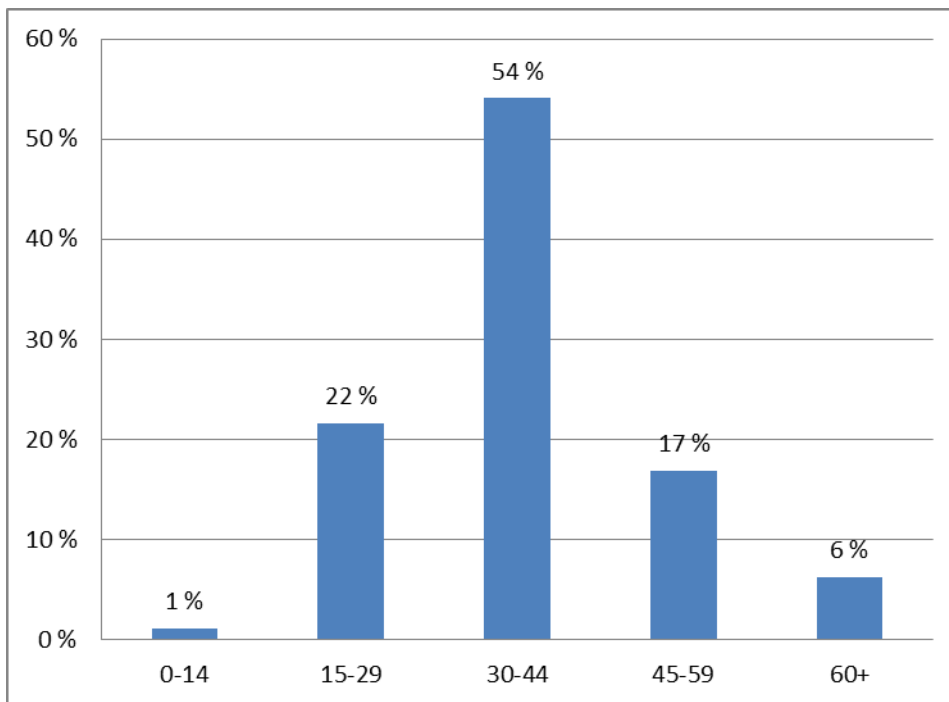


**Fig. 11 – According to customer survey 5/2015 (n=242), customers were very satisfied with the Kutsuplus service.**

Passenger surveys showed excellent results. Other studies for registered passengers gave very similar gradually improving results, in which the punctuality of the service developed most during the service trial.



**Fig. 12a – Passenger gender distribution in 2014 (n=535).**



**Fig. 12b – Passenger age distribution in 2014 (n=527).**

The majority of Kutsuplus customers were male, whereas the clear majority of traditional public transport service users in the Helsinki metropolitan area are female. The majority of Kutsuplus users were 30-44 years old (Figs. 12a and 12b). According to a study made in October 2013 (n=442), 56% of registered users had one or more private cars in their household. According to a study done in spring-fall 2014 (n=244), 100% of the users had a driving license. Kutsuplus was found useful (n=355) for personal matters and shopping (79%), business trips (65%), trips to hobbies (50%), trips to school/work (48%), and also various other kinds of trips (12%).

The possibility to place an order 30-60 minutes before departure was rated as very important in 66% of the answers (n=353), and right before the departure (55%), 1-8 hours before (54%), 1 day before (34%), 1-7 days before (12%), and over a week before departure (0.6%), correspondingly. However, 12% found a repeated automatic weekly order very important (n=441).

People who sometimes did not accept the offered Kutsuplus trip claimed that (n=246) they were making trip searches out of curiosity, for example to find out the price level (63%). As this was discovered, the pricing simulator [Kutsuplus.fi/pricing](http://Kutsuplus.fi/pricing) previously under testing was published to decrease the calculation load of the control and service system. The second most important reason for not accepting the offered Kutsuplus trip was that the pick-up time of the offer was too late (24%). After this observation, the cost function of the routing system was adjusted to give more weight to rapid pick-up, the adjustment of which immediately increased passenger numbers. Other reasons were that the price was too high (22%), the travel time was too long (22%), the arrival was too late (21%), a more suitable arrival time had to be found as it was not possible to search for trips on arrival time basis (21%), and the walk was too long (16%), indicating that, if more of the virtual stops photographed and defined by HSL could have been included into the service, passenger numbers would have increased even more rapidly. Some mentioned that the reason for not accepting an offered trip was that money had been loaded into the trip wallet (14%). Another reason was given in 21% of the answers.

A wider service area was found to be very important in 46% of the answers (n=442). A service time extension to range from 6.30pm to 11pm was found very important in 43% of the answers, with operation on weekends (41%), a denser bus stop network (25%), and door-to-door operation even with a higher price (24%) were found very important, whereas only 17% found a service time extension from 7.30am to 6am very important, and only 13% found a service time extension from 11pm to 4am very important.

According to a study in February 2013, trips were mostly ordered using smartphones (33%), followed by laptops (30%), desktops (26%), and tablets (9%). The role of smartphones was assumed to be increasingly significant, and this was confirmed in a study in February 2014, according to which 42% of orders were already being made with easily portable smartphones.

A more detailed study was carried out in October 2013, to ensure that the Kutsuplus service developers would take customer needs sufficiently into account. In October 2013, the only method for placing a trip order was via the kutsuplus.fi web site, where an account accompanied by an e-wallet had to be created, into which money had to be loaded. As anticipated by HSL already in 2011, a mobile application for placing an order was, as expected, found to be very important in 60% of the answers (n=442)! SMS orders were based on bus stop numbers (26% found it very important correspondingly) and this was later included in the service. A phone call with a reasonable additional fee included was found very important only in 14% of the answers and this was not included in the service. One must, however, bear in mind that the survey questionnaire was directed at registered customers. They do not represent the whole population. For example, customer feedback from live customer occasions implies that there could also be a significant demand for telephone conversation-based trip orders, where the ticket price could be added, for example, to the telephone bill.

Regarding potential future payment methods (n=441), paying in advance with an HSL travel card, which is intended for 'traditional' public transport in the Helsinki metropolitan area, was found to be very important in 47% of the answers. HSL also found this trip payment option to be very important, but as the ticketing and information system for HSL's traditional services was to be renewed, an independent payment, ticketing, and information system was developed for Kutsuplus to ensure service continuity, instead of investing in something that would later become obsolete. The possibility to later integrate the Kutsuplus system with that for HSL's traditional services was ensured separately. The architecture was designed in HSL to replace the Kutsuplus payment system with the new HSL payment system, as this will be implemented. Direct credit card payment without the trip wallet (42%) was found to be very important, whereas paying afterwards with a monthly invoice was found to be very important only in 18% of answers. A loyalty program with discounts for regular customers was found to be very important in 38% of answers.

## 8 Finances

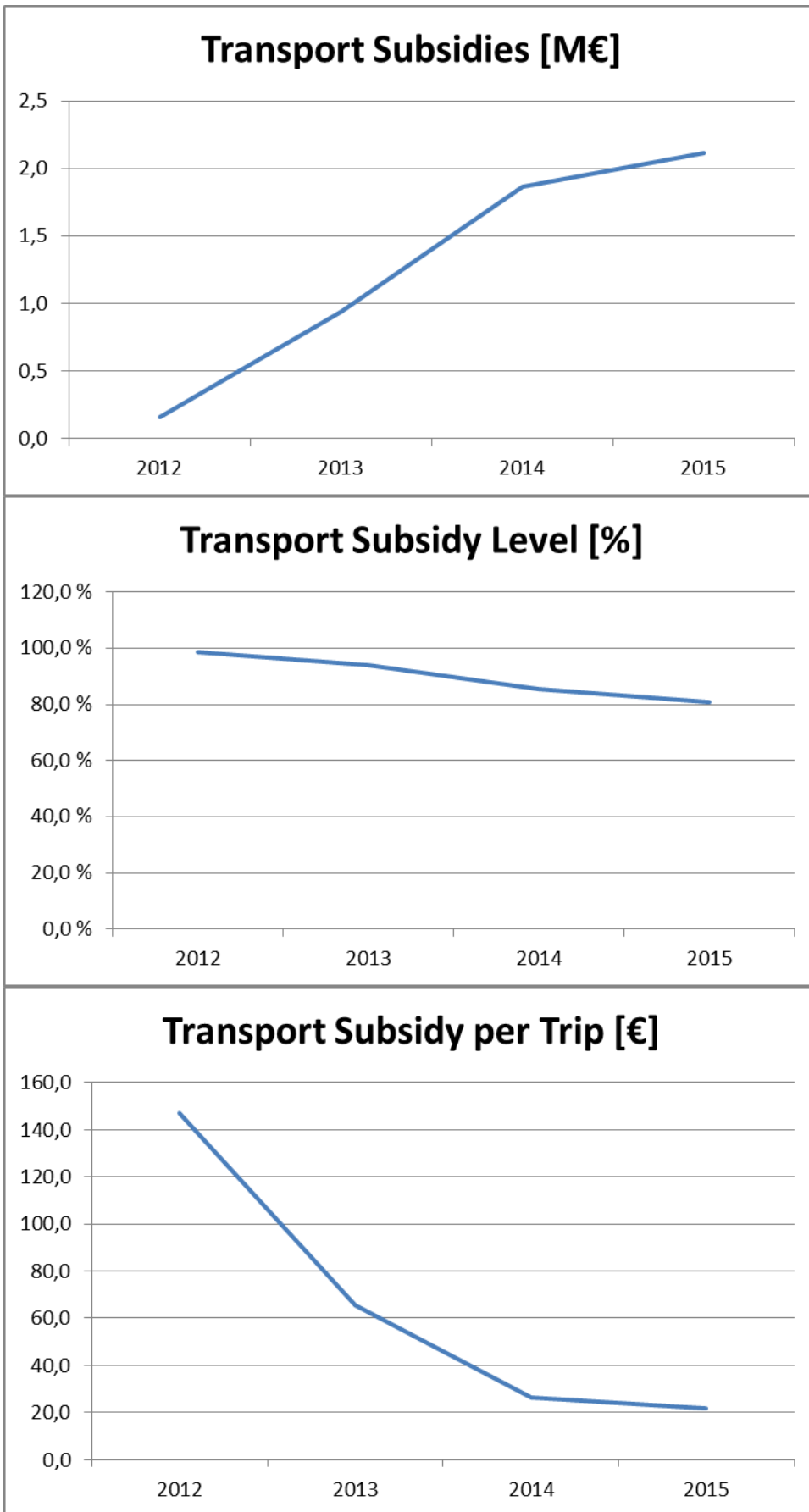
The net cost for the member municipalities (municipal contributions) for 2015 was €3 million and a total of €7.9 million for 2012-2015 (Table 1). In addition, an advance booking of €800,000 was made for 2016 due to the expected costs for ramping down the service, including the cost of terminating those operating contracts that were still in force in 2016. It is likely that the terminating costs will be much less than the €800,000 anticipated.

<b>Kutsuplus</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2012 - 2015</b>
<b>Operating revenues</b>	<b>3 000</b>	<b>62 700</b>	<b>321 800</b>	<b>507 900</b>	<b>895 400</b>
Ticket revenues	2 600	61 700	319 200	507 700	891 200
Other operating revenues	400	1 000	2 700	200	4 300
<b>Purchases of services</b>	<b>-316 800</b>	<b>-1 521 400</b>	<b>-2 750 200</b>	<b>-3 233 000</b>	<b>-7 821 400</b>
Operating costs	-164 200	-1 004 000	-2 186 400	-2 626 600	-5 981 200
Other purchases of services	-152 600	-517 400	-563 800	-606 400	-1 840 200
<b>Personnel expenses</b>	<b>-119 600</b>	<b>-276 100</b>	<b>-256 100</b>	<b>-256 000</b>	<b>-907 800</b>
<b>Other expenses</b>	<b>-15 500</b>	<b>-12 700</b>	<b>-10 600</b>	<b>-1 500</b>	<b>-40 300</b>
<b>Depreciations</b>	<b>-1 600</b>	<b>-11 100</b>	<b>-13 200</b>	<b>-13 200</b>	<b>-39 100</b>
<b>Net income</b>	<b>-450 500</b>	<b>-1 758 600</b>	<b>-2 708 300</b>	<b>-2 995 800</b>	<b>-7 913 200</b>

**Table 1 – P/L statement**

The operating costs consist of the payments for the transport contractors. These include compensation for supplying vehicles and drivers, as well as compensation based on passenger count and driven vehicle kilometers. Other purchases of services include ICT costs, expert consultations, subcontracting, service development, and marketing of the novel service. Ticket revenues (VAT0) consist of the trip payments (VAT10) by the customers, minus a value-added tax burden of 10% for the government.





**Figs. 13a, 13b, and 13c – The amount of transport subsidies in euros increased due to minor expansions of the small-scale service, but the level of transport subsidy and the transport subsidy per trip started to decrease, as expected.**

Transport subsidies are calculated by subtracting the ticket income (VAT0) from the operating costs. The transport subsidy level is the ratio of transport subsidies to operating costs. The more the service was expanded, the more the transport subsidy level decreased (Fig. 13 b).

## 9 Environmental impact

A shared ride can be provided with fewer vehicle kilometers per passenger than a non-shared ride. When compared with a non-shared ride, a shared ride reduces emissions, traffic accidents, congestion, wasted time for citizens, investments in and maintenance of the road network, use of land for parking space and multi-lane boulevards, and the subsidy level of public transport.

The positive impact on the environment depends decisively on the number of vehicles: the more vehicles in the service area, the more travel kilometers per vehicle kilometer, and the more trips per vehicle hour. HSL's objective in the Helsinki region roughly by 2027 has been to expand the service capacity to 5,000 – 8,000 Kutsuplus vehicles, with an integral role in the novel, co-optimized transport system. A large-scale real-time demand-responsive system could then also provide connections to external areas, hence offering a real and widely available alternative to the strongly growing number of private car users in the expanding Helsinki metropolitan area, where 1.1 million daily private car trips were made already in 2012. If the co-optimized transport system could make the most of the transport possibilities provided by the vehicles, with a differing transport capacity and a variety of optional equipment, such a system could take a role within a large set of transport needs in the future.

HSL had a calculation about the environmental benefits of the Kutsuplus service made (Figs. 14 and 15). The calculation was uploaded onto HSL's website for downloading by interested parties [3]. In the calculation, the assumed input values for the pessimistic, realistic, and optimistic scenarios, with an estimate of the reliability per input value, is presented. The comments included in the spreadsheet also list other positive environmental factors excluded from the calculation for practical reasons. The calculation takes into account neither the additional benefits offered by further development of the service for improved efficiency, nor the positive effect of the co-optimized transport system, which would increase the use of the rail network by strengthening the real-time synchronized feeder services from less-populated areas with scattered starting points and destinations.

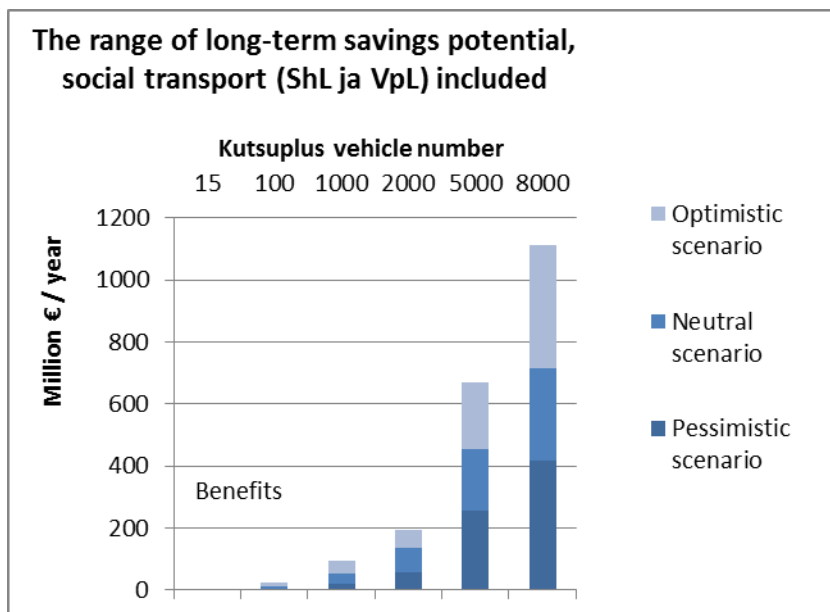
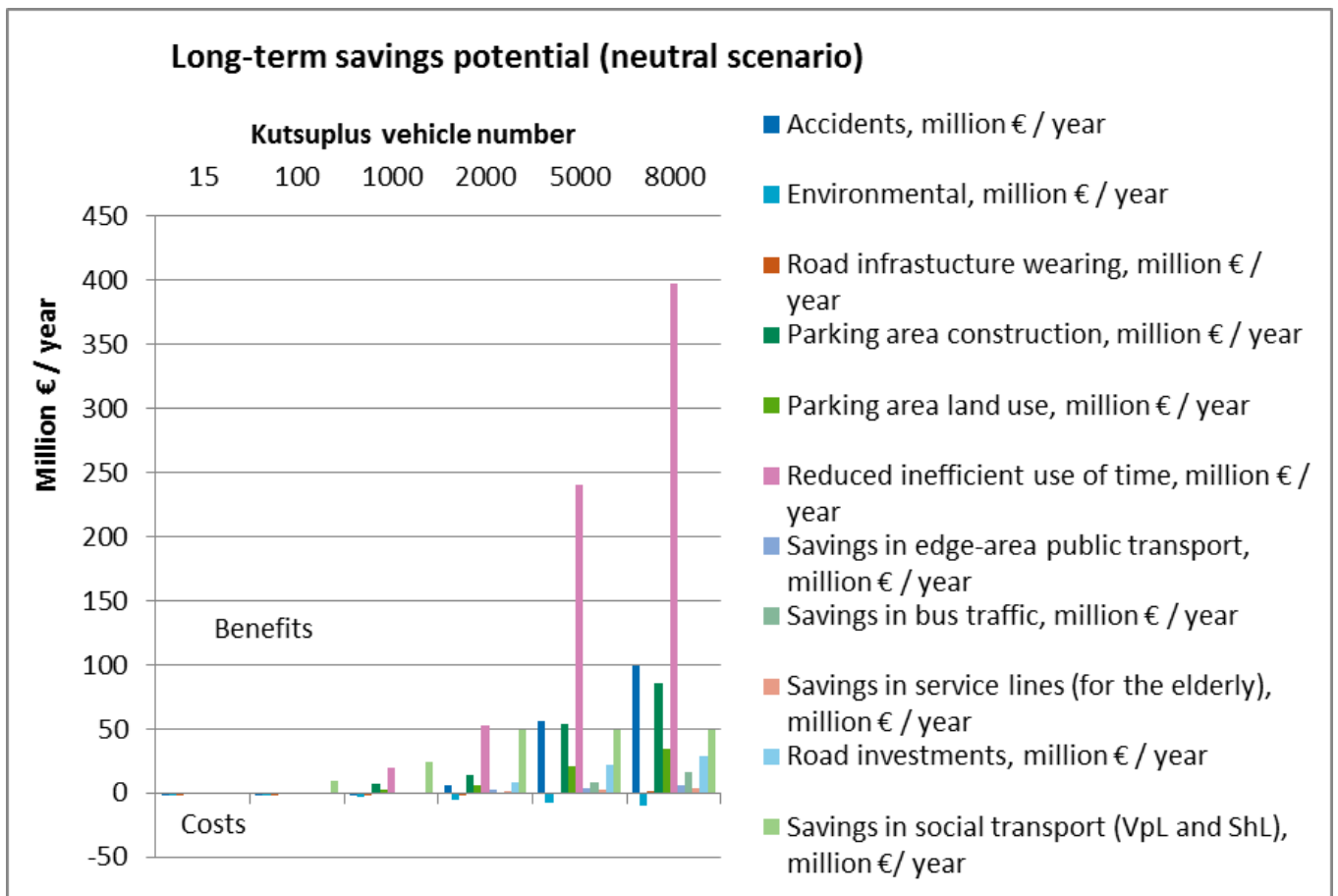


Fig. 14 – It has been estimated that a large-scale service will provide a considerable positive impact for the environment in the Helsinki metropolitan area.



**Fig. 15 – For practical reasons, only a subset of all the positive environmental issues were included in the calculation [3].**

The environmental benefits have been estimated at more than 700 million euros annually with a fleet of 8,000 Kutsuplus vehicles. In zones with sufficient courage, financial resources, and understanding to make the initial investment in ramping up the novel customer-driven mode of public transport, to achieve break-even, the expansion of the service is accompanied by increasing profitability and growing environmental benefits without additional cost.

A Kutsuplus type of service is more environmentally friendly if more private car users in the metropolitan area switch to the service, and via the service to co-optimized public transport. If things are done the right way, such as by developing the pre-order function to enable a large number of people - including motorists who do not yet find public transport tempting enough - to aim for the same vehicle, there is no fundamental barrier to a demand-based service – where the vehicle schedules and routes are not guessed beforehand - filling even the high-capacity vehicles designed for massive transport operations. The question is more about the role given to the novel services and travel chains in future transport. The relative shifts of passenger flows between available modes of transport can be tuned to maximize the positive environmental impact and the competitiveness of the area. Tools such as differentiating the pricing mode-wise and support offered by the transport infrastructure, for example in terms of dedicated bus lanes, prioritized traffic lights, land use for parking, and parking costs, should be included in the toolbox.

## **10 Termination of the Kutsuplus service by HSL**

The strong growth in demand, as well as the daily customer requests to extend the service time and geographical coverage, indicated that the capacity should have been substantially increased to meet the growing demand. HSL foresaw this as an important factor in ensuring the continuation of the trend to-

ward a self-sufficient, subsidy-free economy. Therefore, HSL proposed to the member municipalities that, by May 2014, when the number of trips still continued to grow by several hundred per cent annually, vehicular capacity would have been tripled to 45 vehicles to improve the availability, quality and economy of the service. However, the municipalities did not grant the funding for the proposed capacity increase in the challenging economic situation. This decision severely hurt the service development in terms of efficiency, economics, and quality development.

Despite the challenges in the operating environment, the positive development of the Kutsuplus service continued. The developing service drew wide attention (Fig. 16) and services resembling Kutsuplus started to emerge outside Finland. The service was found to be very good and the pilot interesting, including at the political level, until August 2015.



**Fig. 16 – Kutsuplus drew wide interest**

HSL prepared a preliminary financial and operational plan for 2016–2018, in which the transport subsidy level of Kutsuplus was already, by 2018, lower than that for other HSL transport services. However, in the early years of the proposed expansion, the absolute amount of subsidies still increased, largely due to the bus-type transport cost structure.

The statements by the member municipalities were made under tight economic conditions and were discouraging. On the basis of this, the HSL Executive Board decided on November 17<sup>th</sup>, 2015, that Kutsuplus in its current form would cease on December 31<sup>st</sup>, 2015. The Board also decided at the same time that during 2016, the study would continue for a trial based on a taxi-like transport concept for 2017–2018. The aim is to implement a fully market driven transport service based on a Kutsuplus type of trip combination.

Kutsuplus customers were informed in advance about the HSL service termination, and about the customer account balance return system, on the Kutsuplus.fi site, operational in January 2016. The Kutsuplus service was closed on 31<sup>st</sup> December 2015, and the Kutsuplus team at HSL was terminated. HSL started the service infrastructure ramp-down, including negotiations on terminating those operating contracts that were still in force after the closure. The balances of “responsive customers” were returned by the promised deadline of March 15<sup>th</sup>, 2016.

## 11 Conclusions

Kutsuplus-trial has shown that automated real-time scalable demand-responsive transport services that can optimize routes and add value to vehicular efficiency will have a bright future. According to the Kutsuplus survey of October 2013, the majority of customers were already, at that time, convinced that they would continue using the service in the future. Only 1.4% stated that they would stick with other means of transportation. This result is very encouraging.

The novel mode of public transport turned out to be a competitive alternative to the private car and the leased car. The system was able to offer more passenger kilometers per vehicle kilometer. Kutsuplus was a time-saver for many: no hunting for parking space, clearing the car of ice and snow, replacing tires twice a year due to seasonal changes in the weather, annual inspections, services and repairs, refueling, and so on. The passengers also had the option to start the workday near their own front door instead of focusing on driving - thanks to the Kutsuplus service, where each vehicle was equipped with a fast, free wi-fi connection, and the passenger had the option to just relax and consume media.

The service was warmly welcomed in orbiting traffic, where private cars are the dominant mode of transport due to the scattered starting points and destinations. The service was also used in conjunction with other public transport, although in this trial, the payment system and schedules were not yet synchronized to enable fluent real-time synchronized travel chains, due to the lack of funding. A database including more than ten thousand bus stops and hundreds of complementary virtual bus stops - including those near the metro, railway stations, and airports - was tailored for the automated system, to enable the fast expansion of synchronized service in the future.

The novel transport mode can be further developed to increasingly complement traditional public transport. Transfers from Kutsuplus to train and vice versa, for example, could be guided with augmented reality-enabled smartphones. When coupled with real-time information, such as about the estimated arrival time of a delayed train in a snowstorm, the demand-responsive services could adapt and provide fluent transfers with shorter waiting times.

Despite the small vehicular capacity, Kutsuplus passenger numbers were increasing. Little by little, the research outcome, according to which, with sufficient demand, vehicular efficiency can be increased by adding vehicular capacity, was proven in practice. An increasing number of passengers was observed in each vehicle as the number of simultaneously serving vehicles in the area was increased.

Kutsuplus seemed already to be on its way toward being an economically feasible service. It became apparent that these positive trends would continue, provided that sufficient marketing, accompanied by sufficient vehicular capacity and service area, was offered to customers. Naturally, the development also depends decisively on the pace of introducing prioritized key functions, as well as on the continuous improvement (Kai Zen) of the existing service, taking customer feedback, needs, and behavior into account.

As in a large-scale operation, an estimated two-thirds of the costs are based on drivers' wages, and autonomous vehicles will create an interesting opportunity for the fastest. Transport is the second most expensive cost item in households (with accommodation first). The average revenue per user (ARPU) is tenfold in transport when compared to the ARPU of telecommunications services.

The Kutsuplus service was designed to be scalable to thousands of vehicles in the Helsinki metropolitan area. Once the capacity is brought up to a large scale, service reach will be improved, and according to the simulations, vehicular efficiency will be multiplied. Expanding the service will improve service quality, which will increase customer satisfaction, which in turn also supports the trend for better economy. On a large scale, the environmental impacts of the system can also be significant due to reduced congestion, traffic accidents, wasted time, land usage for roads and parking places and related maintenance, and emissions [3].

HSL's aim has been to expand the Kutsuplus fleet to 5,000 – 8,000 vehicles roughly by 2027. By then, the share of the new mode of transport of motorized trips would be 20% - 35%, correspondingly. This target is based on the assumption that the service will become an integral part of the dynamic smartphone-assisted real-time synchronized precision travel chains, enabling fluent smartphone-guided travel between cities and beyond. A better choice, exceeding the geographical limits of any single public transport service would then be available for the majority of private car trips.

Despite the positive development, the small-scale operation required, as expected, substantial subsidies. With the bus service-like cost-structure, the absolute amount of subsidies would still have increased in the next couple of years. Due to the statements that HSL received from the member municipalities in the challenging economic situation, HSL's proposal to expand Kutsuplus was overruled. The service in its current form had to cease at the end of 2015.

The need for research, development, and piloting, targeted at cost-effective shared rides and real-time synchronized travel chains, will continue to grow in our changing environment. The fluency and ease of ordering, payment, and consumption of a shared trip and travel chain increase demand. Regarding service packetizing, the wider the set of services, the greater the potential benefit. Hence, there is no need to limit the service concept to mobility or travel chains. For example, modern public transport can be boosted further by defining a starting point and including transport in a holiday or event package.

## **12 Acknowledgement**

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Special thanks go to the traveling public, whose feedback on emerging services was extremely valuable.

Finally, thanks in advance also go to all those who are inspired to continue the development of services toward the scale they deserve, in favor of our common environment.

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