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Improving Financial Result of Charter Bus Service With Data Based Shift Planning

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This thesis was carried out for Kovanen, one of the largest and most versatile people logistics companies in Finland. The thesis focused on shift planning and supply and demand equilibrium of Kovanen's minibus services.

As Kovanen is not utilizing detailed data in shift and capacity planning in their minibus charter service, Kovanen's minibuses may be moving in slow demand times and not moving on busy times. The objective of this thesis was to propose a new shift planning frame which matches demand with supply better than in the current situation.

In terms of research method, this thesis used a quantitative approach to research. A large-scale analysis was carried out to identify how shift planning was currently being done, what kind of demand Kovanen minibuses have and does the supply meet demand. After identifying key problem areas, existing literature as researched for finding tools and knowledge for solving the identified problems.

A new shift planning frame was built after the demand was modelled and equations for calculating required fleet at any given time were built. The required changes to the current shift planning frame and operating model were identified, and required changes proposed. A pilot test for the new shift planning frame was carried out, and the results of the pilot were analysed in terms of success, both operationally and financially. Suggestions for next steps were given to Kovanen for immediate and long-term improvement.

Keywords	Shift planning, Manpower planning, Capacity planning, Fleet utilization, Taxi services, Charter bus services, Demand and supply equilibrium, Demand modelling.

Contents

1 INTRODUCTION

1.1 Context background

This Thesis will be done for Kovanen Yhtiöt Oy, one of the largest and most versatile people logistics companies in Finland. Kovanen is a family-owned company founded at 1978 that focuses on Taxi traffic and charter minibus services in Helsinki Capital area. In 2015 Kovanen had a turnover of 14 million euros. Buses created turnover of 5 million, and Taxi's 9 million euros. Total amount of employee's is around 350 people.

Kovanen people logistics fleet is currently 35 Mercedes E 1+4 seat taxicabs, 10 Mercedes Vito 1+8 seat taxicabs, 18 Mercedes Sprinter 1+10 seat minibuses, 12 Mercedes Sprinter 1+16 seat minibuses and 8 Mercedes buses with 34 – 57 seats. Fleet size is 84 cars overall, and it has been divided in two for administrational purposes. Number of vehicles in Kovanen's fleet is subject to change in any given time. In this context Kovanen's vehicles are divided in two segments, and called "Taxis" and "Buses". "Taxi's" contain 1+4 seat 1+8 seat cars, which are also allowed in normal taxi traffic. "Buses" will contain 1+10 seat, 1+16 seat minibuses. Even though 34-57 seat buses are a part of the same internal department as 10 and 16 seaters, they are not calculated as a part of buses in this context. This thesis will focus only on Kovanen's minibus charter service, so called "buses".

By Finnish law cars are not allowed to offer customers taxi services without a taxi permit. Taxi permit can be given only to a car with 4 - 8 customer seats, and the amount of taxi permits are regulated by Finnish authorities. By Finnish law a bus can drive charter services when it has more than 8 passenger seats, and has an operating license. Basic requirement of charter services is that a booking must be made beforehand. This is also the case here, since without ordering this service beforehand, the service would be totally similar to taxi, and therefore it would be illegal.

For the most part Kovanen uses 12 hours shifts in vehicle operating, regardless of the car size. Only big busses fall under collective bargaining, and their driving times are based on pre-made orders. Kovanen's vehicles usually drive in two shifts: The morning shift is from 06:00 to 18:00, and the night shift is from 18:00 to 06:00. There are some drivers that drive some other type of shifts, but the amount of such shifts is extremely low.

Salary of a driver is based on percentage of the money he is able to produce during his shift (known in the industry with term “takings”). This is quite normal in taxi industry, and also Kovanen’s minibuses follow this system. It is only natural that such salary system causes drivers to work harder, since their salary is based on their own performance level. Financial result of the company is also dependent on the takings of the drivers. The expenses of the company are based from driver salary, vehicle, vehicle technical services, fuel, other vehicle related costs, administration call center and sales. Fixed expenses include all others but driver and fuel. Service agreement with manufacturer makes car service and maintenance costs more or less fixed. This means that the non-fixed costs for a company are only fuel (used to create takings) and driver (fixed percentage of takings). It is clear that the cars should be moving and producing as much as possible, regardless of the driven extra kilometers it may cause. This creates a lot of pressure for shift planning, as the financial result of a company is based on maximum utilization rate of the cars. As the peak demand times vary a lot during the week and the time of day, and the industry has a chronical shortage of drivers, creating a maximum profit is very demanding and difficult.

The impact of shift planning to financial result of the company is obvious. At the moment Kovanen is gathering a large amount of data related to demand and supply, but they are not utilized in any way. Shift planning is based mostly on gut feeling and driver’s demands and wishes. It is quite possible that Kovanen is losing money because of the reasons mentioned above.

Kovanen bases their success on high customer service levels. Such service level is demanding for a driver, who is the ambassador of Kovanen brand. A driver must wear a suite at all times, and the car must always be clean and in perfect condition. Kovanen gives probably the highest amount of training in the industry for their drivers. All drivers must go through a set of trainings to make sure their skill level is good enough to represent Kovanen’s brand, and Kovanen will also keep training their drivers during one’s career at Kovanen.

Taxis have many ways of getting their profit. They can get a customer though Kovanen’s Call Center, though the areal taxi center or from a taxi stand. For regulatory reasons, as mentioned before, all 10 and 16 seat minibus orders are made true Kovanen's Call Center which will make a booking based on customer request. There are different types of bookings, which are based on different service levels. On the highest (and most expensive) level the car (and a driver) will be assigned to a booking more than a day advance, and it will be at customer's disposal some time before the actual travelling begins. Also, many other services, such as beverages can be added to this booking. On lowest level of service is the immediate booking, for which the car is requested during a call. This service has many similarities to normal taxi service. Pricing models are based on time and/or meter, depending on booking made.

1.2 Business challenge, objective and expected outcome

As Kovanen is not utilizing detailed data in shift and capacity planning of their minibus charter service, their minibuses may be moving in slow times and not moving on busy times. It is very likely that Kovanen's minibus charter service is losing money because of lack of detailed analysis on demand and supply equilibrium.

The objective of this thesis is to propose a new shift planning frame that matches demand with supply better than in the current situation, and to create a better financial result through improvement in supply and demand equilibrium and operational model.

As a result of this thesis Kovanen expects to have an improved shift planning frame which is based on detailed supply and demand analysis. If building of such shift planning frame is successful, it will be put in pilot testing and financial results will be measured with expectation of positive effect.

2 PROJECT PLAN

2.1 Flowchart illustration of key project steps

Kovanen has realized that they are not utilizing the data they have at their disposal, and therefore we can assume that they lose money in the lack of data based planning. To create a data based frame for shift planning, an empirical research has to be made.

Figure 1 represents the overall flowchart for this project.

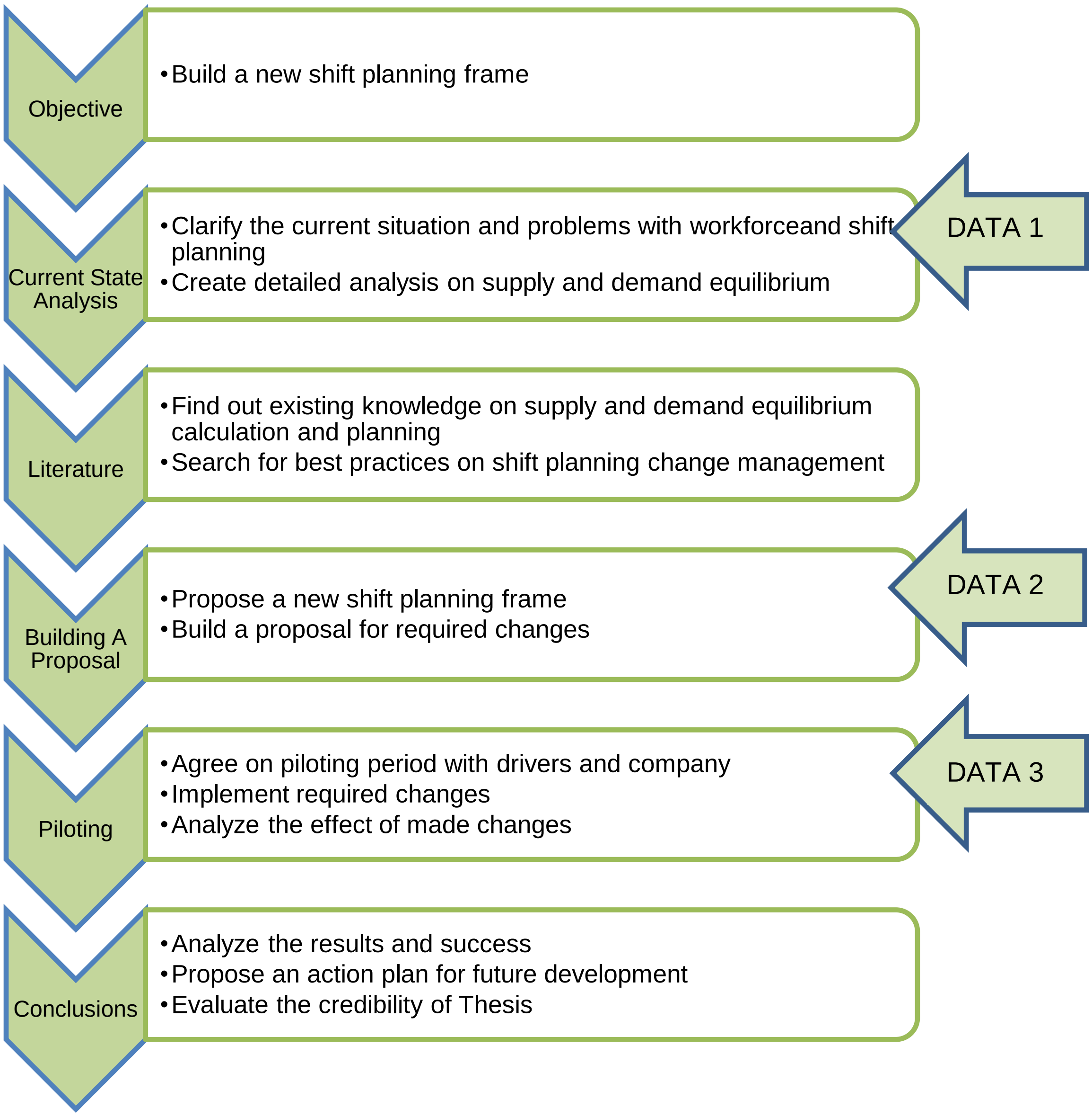

Figure 1. Flowchart of the project.

This thesis started with an introduction section to explain the business context and project outcome. Both of these have been represented in section 1. Moving forward, the next step after project plan will be Current State Analysis.

Research method for this Thesis will be quantitative. Reason for this is obvious: Kovanen is already planning shifts based on people's assumptions, therefore data based analysis is required. This thesis will take a longitudinal approach to data, where a significant period from past will be studied, and then later on compared to pilot test time period.

In many ways, this Thesis will take an action research type of approach, especially in the later stages. Since the outcome will be something new tested in a pilot period, and afterwards conclusions will be made, it is obvious that an action research type of circle will start from piloting period. It is assumed that this type of approach would be a necessity for Kovanen in constantly changing demand and supply environment. Philosophical approach will be very close to realism in this data based research.

Once the current state is properly analyzed and the key problems are identified existing literature will be reviewed. Main areas of interest from literature will be in supply and demand analysis, shift planning best practices and workforce flexibility strategies. Depending on the problems identified in the current state analysis, the areas of literature may be subject to change.

Once there is a detailed analysis of the current state, identified key problems areas and a profound search of best practices from literature have been done, building a proposal will be started. In section 5, a shift planning frame that would match the current demand as well as possible is created. After a new frame has been created, it will be compared to current one to identify the required change. With this analysis, it is possible identify the changes needed to move towards with new shift frame. After this, a proposal for implementation will be made, and required internal discussion made.

In the beginning of piloting stage, it is required to make sure that both company and drivers agree to the upcoming changes. Implementation will be made slowly during a one-year development and change project. If the changes work as they are assumed, larger scale changes will be proposed in conclusions section. Action research type of process will be proposed to make sure that the need for continuous change understood also after this Thesis is completed.

In the last section conclusion of the completed Thesis will be made to analyze the success and credibility of completed work. Action plan for future needs and for continuous improvement implementation will be made, and proposed to Kovanen.

2.2 Data collection plan

Data collection in this Thesis will be done in three different stages. The Data1 collection point will be in the Current State Analysis stage(figure 2). To be able to extract data required for this thesis, Kovanen has agreed to build a statistics program that will collect and analyze data from many different and complex Kovanen's IT systems. Author is grateful for Kovanen that such program will be built, as this thesis would likely be impossible to do without it. All data required and used in this thesis will be provided by Kovanen's new statics program. Figure 2 show which data is required in each data point, where does it come from and what is the expected outcome.

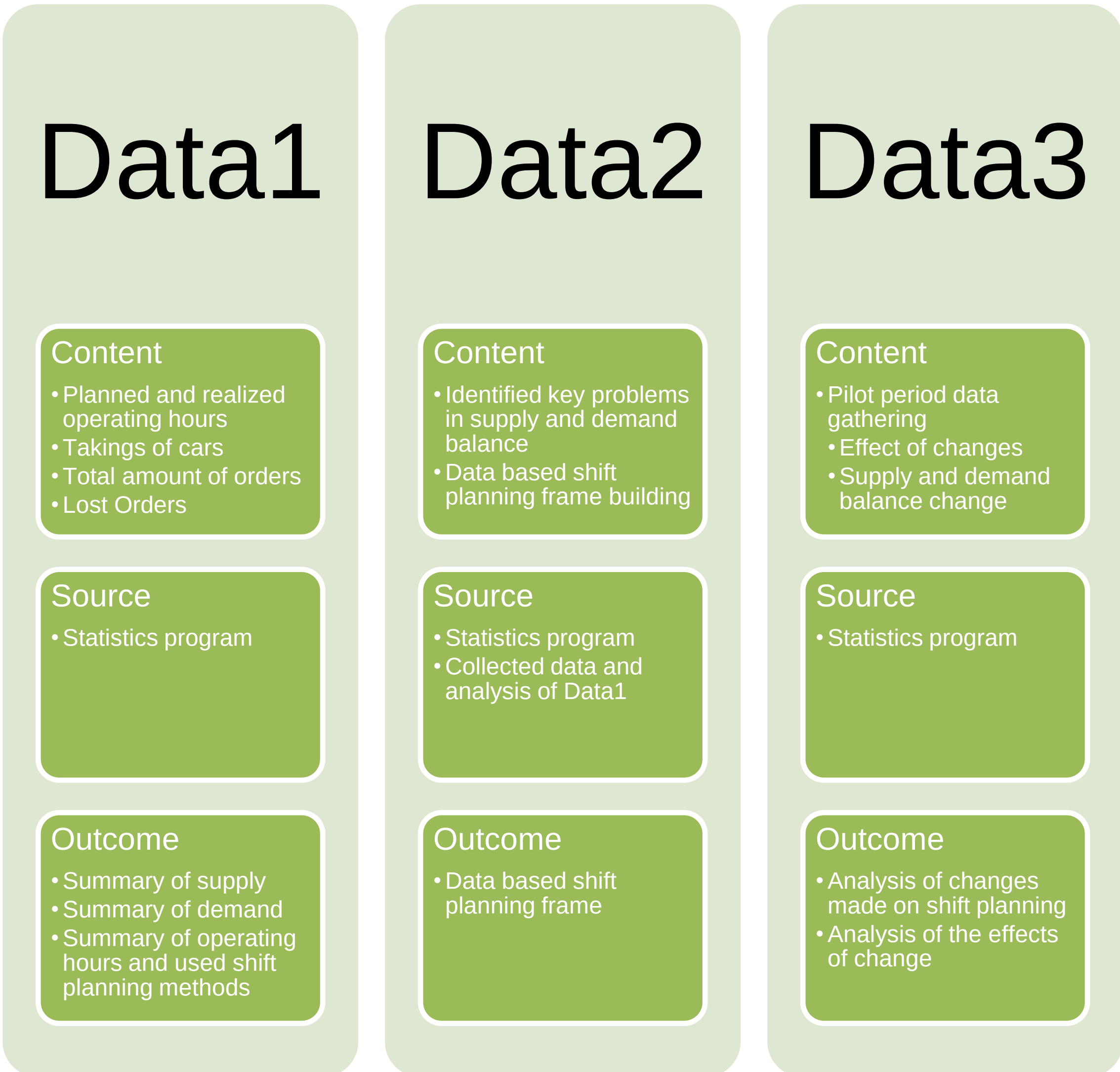

Figure 2. Data collection points and their contents.

2.3 Timeframe of the analysis

Timeframe was chosen in way that the results of this Thesis can be used in the future. Use of a long time period is needed to make sure all seasonal and on the other hand weekly fluctuations do not cause any disturbances in the data. It is required to use maximum data gathering time period of the system, which is 26 weeks at the moment. As a result of a system changes in the past, it is possible to obtain data starting from June 2015.

Time period of 8.6.2015 – 13.12.2015 was chosen. Length of the period is 26 weeks, half a year. This time period should include slow demand and busy demand times to balance the seasonality and any other fluctuations that could cause problems in the data. The expected outcome of this thesis and statistic program building is that in the future this analysis can be duplicated at any time to see what the results of any implemented changes are.

Timeframe used in piloting will be a full year since the time the actual improvements will start to be implemented. Pilot implementation is expected to start in March 2016.

3 CURRENT STATE ANALYSIS

3.1 Intro to Current State Analysis

Before moving into detailed analysis, it is important to understand that in some situations Kovanen's buses are actually not operating at the times Kovanen would like them to due to due to lack of workforce. Kovanen has a brand that is based in high level of customer service. To have high level of customer service Kovanen needs very high-quality professionals to work as drivers. Kovanen is currently struggling to find high quality drivers. This problem will be more deeply analyzed when building the new shift planning frame, in section 5.3.

The effect of this problem is that in some situations Kovanen is not able dispatch buses even though they are aware that they would be needed. In current situation Kovanen has to make a lot of compromises with their drivers, as to when they want to be working compared to when Kovanen wants their buses to operate.

Buses will not be listed in any way as they may change at any given time. Percentage calculations are used instead, so that the results are comparable to any car amount Kovanen may have at any given time. 10 and 16 seaters will be differentiated in analysis due to their different nature in terms of demand and operating times.

3.2 Current shift plan building

For better understanding of how shift plan is currently built, a simplified model of current shift planning process was created.

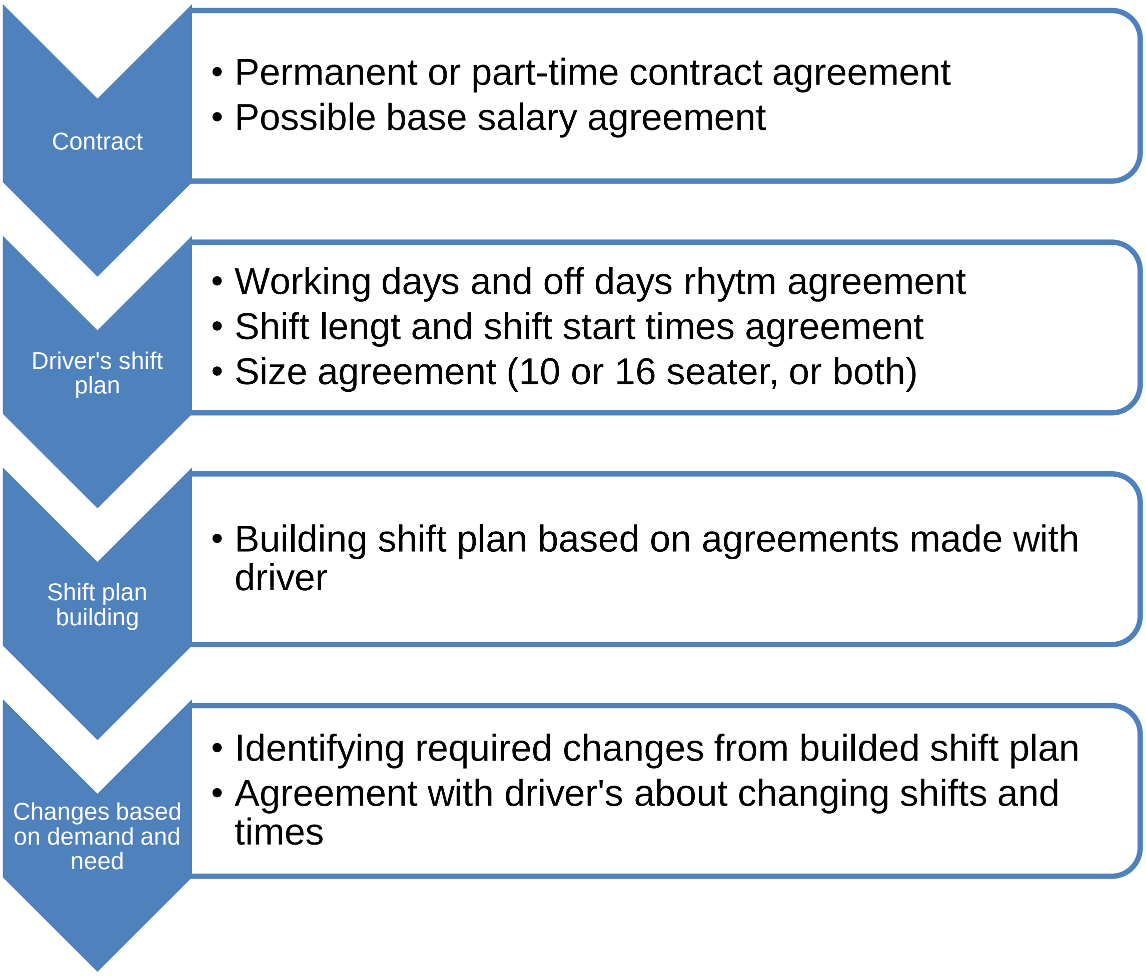

Figure 3. Current shift planning process

As figure 3 shows, currently shift planning is greatly affected by drivers’ own personal acceptable. Currently the shifts are built based on made agreements with drivers, and altered to meet demand and need of the shift planned afterwards. It is likely that this model is not optimal for Kovanen.

3.3 Analysis of supply and demand equilibrium

3.3.1 Planned operating hours and the current shift planning frame

For a long time Kovanen has relied in 12 hour shifts in shift planning. This operational model traces back to the taxi industry where Kovanen has operated since the beginning and still is a very large player in terms of fleet size. Still today Kovanen operates most of their taxis in 12 hours shifts that are from 06:00 to 18:00 and 18:00 to 06:00. As the minibus service was created it was natural that the same type of shift planning was used. At the moment, almost all of the minibus shifts are operated in this same context. Some changes have been made to this though, such as early starters at 03:00 to 05:00 and shifts that start at 11:00 and end at 23:00, but the amounts are marginal. When analyzing the operating times of minibus, investigation of how well this operating model works has to be made.

Analysis will start from the planned operating hours of minibuses.

	Ma	Ti	Ke	To	Pe	La	Su
0:00	27	18	32	38	40	48	45
1:00	27	18	32	37	40	48	45
2:00	27	17	32	37	39	48	45
3:00	27	21	36	42	39	47	44
4:00	27	22	36	42	39	47	44
5:00	33	31	45	50	47	51	49
6:00	41	56	64	67	64	35	34
7:00	41	57	64	68	64	35	34
8:00	41	57	65	68	65	38	37
9:00	41	57	65	68	65	40	37
10:00	42	59	68	71	66	44	40
11:00	42	59	69	71	66	45	40
12:00	43	61	73	75	72	53	43
13:00	43	61	74	75	71	53	43
14:00	42	57	69	70	71	53	43
15:00	35	49	63	64	66	49	38
16:00	35	49	62	64	65	50	38
17:00	34	47	60	62	63	50	39
18:00	19	36	46	47	54	58	35
19:00	19	36	46	46	54	55	32
20:00	19	36	45	46	54	55	32
21:00	19	35	45	46	54	56	33
22:00	19	33	42	43	54	54	30
23:00	18	32	39	41	52	50	28

Table 1. 10 seater planned hours in percentages.

As shown in table, the highest number of buses is being dispatched during the day time in weekdays and Friday and Saturday nights. The highest number of buses planned to be operating is 75%, Thursday from 12:00 to 14:00.

	Ma	Ti	Ke	To	Pe	La	Su
0:00	30	22	19	34	40	43	42
1:00	30	22	18	33	39	42	42
2:00	30	22	18	33	39	42	42
3:00	30	22	18	33	39	41	41
4:00	29	22	18	32	39	41	41
5:00	28	24	21	31	39	40	40
6:00	36	52	62	58	61	30	26
7:00	36	52	62	58	61	30	26
8:00	36	52	63	58	61	30	26
9:00	36	54	63	58	61	30	26
10:00	36	57	65	59	62	32	29
11:00	36	57	65	61	62	32	29
12:00	38	60	67	68	72	46	41
13:00	38	60	68	69	72	47	41
14:00	38	60	68	69	72	46	41
15:00	38	60	69	69	73	47	41
16:00	38	59	68	68	73	46	42
17:00	37	57	69	68	74	48	44
18:00	23	25	35	49	52	57	46
19:00	23	24	35	48	52	57	46
20:00	23	24	35	48	52	57	46
21:00	23	22	35	48	52	57	45
22:00	22	21	34	47	52	57	42
23:00	22	19	34	43	49	52	39

Table 2. 16 seater planned hours in percentages.

There are plenty of similarities between 10-seater and 16-seater operating times. 16-seaters are planned to move more 6-18 shifts than 10 seaters. There is massive rise in 16-seaters planned to operate at 6:00 and a drop at 18:00.

Tables 1 and 2 indicate that current shift planning is based on increasing amount of buses from Monday to Friday, in both nightshift and dayshift. Weekend nights have high number of operating buses but during day time there are less than during the week. Current dispatching pattern seems to be that Kovanen dispatches maximum amount of buses during Wednesday to Friday daytime, and Friday and Saturday nights. Other times have less planned buses, which indicates that there are less buses needed.

At the moment, there is no shift planning frame that would indicate the success of shift planning. As there is no current frame, an assumption that this presented data above (table 1 and table 2) is the current shift planning frame. Because of the lack of drivers, Kovanen does not reach the full capacity usage at any given time. Therefore, for comparing purposes, tables are altered so that they have a 100% value, to see what are the current "goals" of shift planning.

	Ma	Ti	Ke	To	Pe	La	Su
0:00	36	24	42	50	52	64	59
1:00	36	24	42	50	52	64	59
2:00	36	23	42	50	52	63	59
3:00	35	28	47	55	52	62	58
4:00	36	29	47	55	52	62	58
5:00	44	41	59	67	63	68	65
6:00	54	74	84	89	85	46	44
7:00	55	75	85	90	85	46	44
8:00	55	75	86	90	86	51	48
9:00	55	76	87	91	86	53	48
10:00	56	78	90	94	87	58	53
11:00	56	79	91	94	88	59	53
12:00	57	81	97	100	95	70	57
13:00	56	81	97	100	95	70	57
14:00	56	75	92	93	95	70	57
15:00	46	65	83	85	87	65	50
16:00	46	65	83	85	86	66	51
17:00	44	63	80	82	84	66	51
18:00	25	48	60	62	72	77	46
19:00	25	48	60	61	72	73	42
20:00	25	48	60	61	71	73	43
21:00	25	46	60	60	72	74	43
22:00	25	44	56	58	71	71	40
23:00	24	43	52	55	69	67	38

Table 3. 10 seater planned hours in percentages with fixed amount of buses.

Table 3 will be called as the current shift planning frame for 10-seaters. With percentages, comparing without being restricted by the number of drivers or cars is possible.

	Ma	Ti	Ke	To	Pe	La	Su
0:00	41	30	25	46	54	58	57
1:00	41	30	25	44	53	57	57
2:00	41	30	25	44	53	57	57
3:00	41	30	25	44	53	56	56
4:00	40	30	25	43	53	56	56
5:00	39	33	28	42	53	54	54
6:00	49	70	85	78	82	41	35
7:00	49	71	85	79	83	41	35
8:00	49	71	85	79	83	41	35
9:00	49	73	85	79	83	41	36
10:00	49	77	88	80	84	43	39
11:00	49	78	88	82	85	43	39
12:00	51	81	91	92	97	62	56
13:00	51	82	93	94	98	63	56
14:00	51	82	93	94	98	63	56
15:00	51	81	93	93	99	64	56
16:00	51	81	92	93	99	63	57
17:00	50	78	93	93	100	65	60
18:00	31	33	48	66	71	77	62
19:00	32	33	47	65	71	78	62
20:00	31	33	47	65	71	78	62
21:00	31	31	47	65	71	78	61
22:00	31	29	46	64	71	77	57
23:00	30	26	46	59	67	71	53

Table 4. 16 seater planned hours in percentages with fixed amount of buses.

Equal to 10-seater, this table will now be called as the shift planning frame of the 16-seaters.

3.3.2 Planned operating hours versus realized operating hours

Due to the lack of data utilization, Kovanen is not aware if drivers actually operate their shift from beginning to the end. Kovanen also does not have data about the speed of driver shift change, and its success.

Data is gathered in 15-minute timeslots.

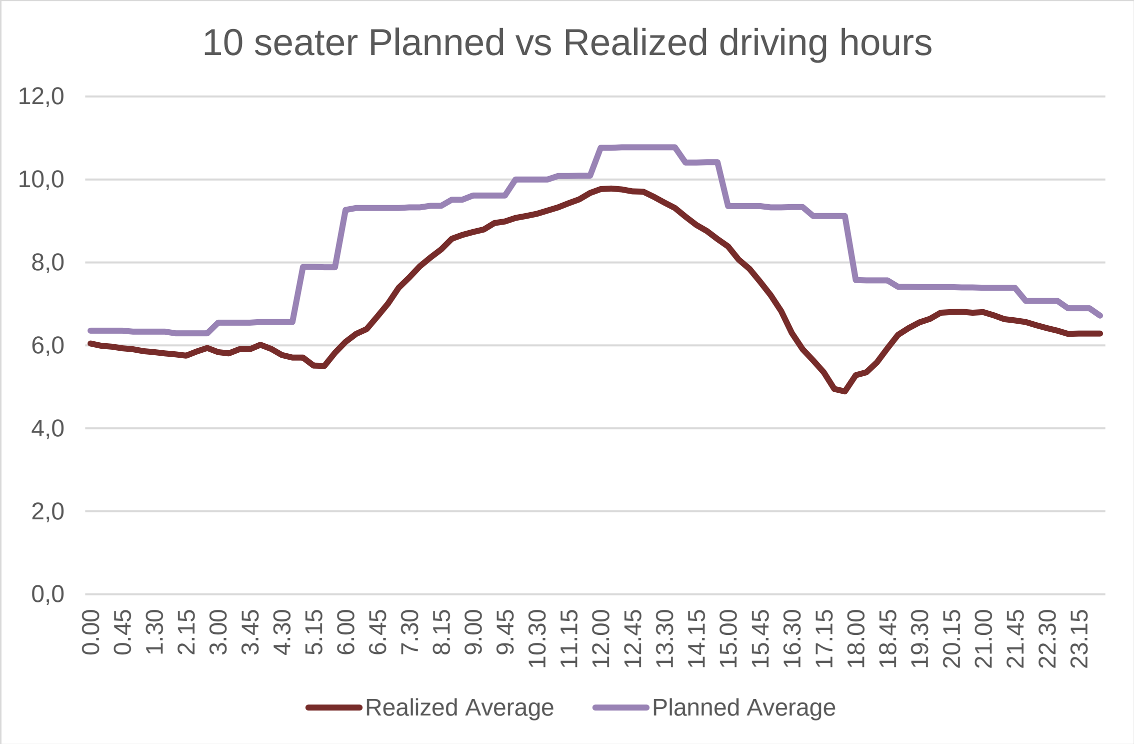

Table 5. 10-seater planned versus realized operating hours.

In table 5, as well as in future tables about the subject, weekly averages from all days will be used. A table with all days separated is almost impossible to read because of the massive amount of data. Showing tables on daily basis is not required, since in closer analyses it was noticed that the problem is the same on daily and average basis.

From table 5 it is possible to identify that there is a large difference between planned and realized hours. There is always a difference between planned and realized hours. The difference increases rapidly the closer we get to driver shift change time, which is usually close to 06 or 18 o´clock. The difference is much smaller in the middle or the “normal shift”, which indicates that there is a problem in shift change.

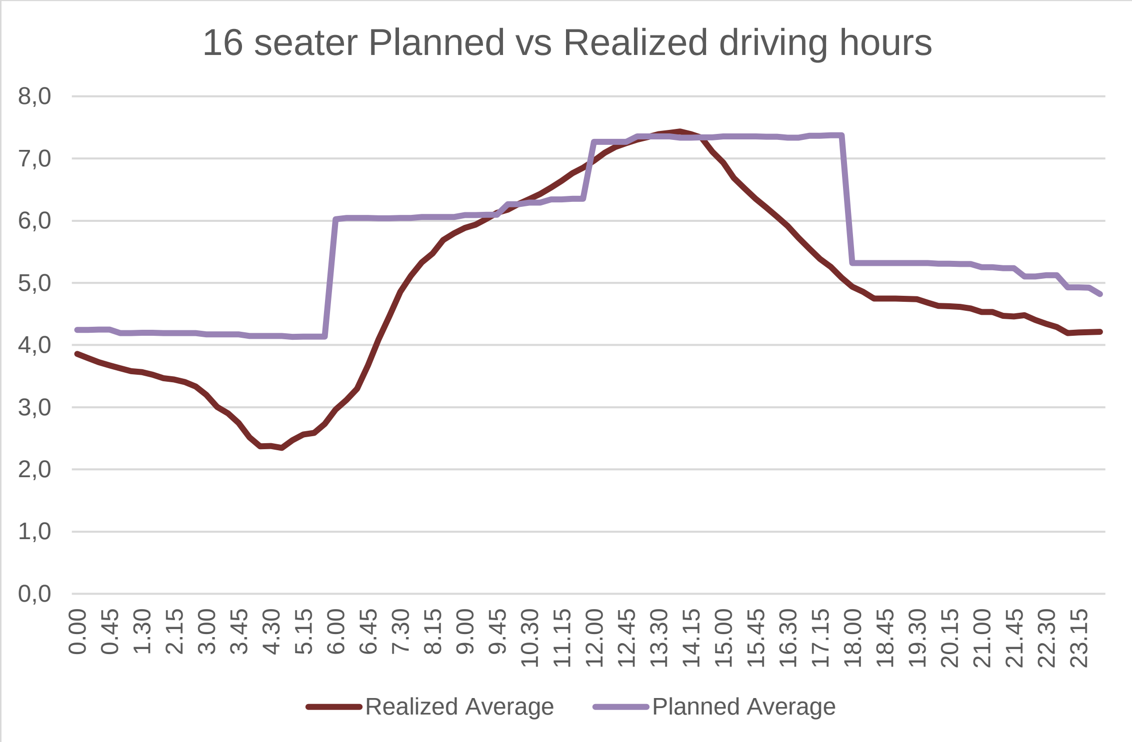

Table 6. 16-seater planned versus realized operating hours.

Table 6 shows realized average versus planned average for 16-seaters. The difference during the midday is significantly smaller and there are moments where there are more cars moving than planned. However, the problem is equal to 10-seaters. Almost in every hour of the day there is a difference between planned and realized hours, and the difference is larger closest to the driver shift changing times.

Tables 5 and 6 represent one key issue in current shift planning. Tables 5 and 6 also show how Kovanen’s buses are planned to operate in a different form compared to section 3.3.1. However, there is a difference between weekend and weekdays both in amount as well as in emphasis, which does not show in this average based table.

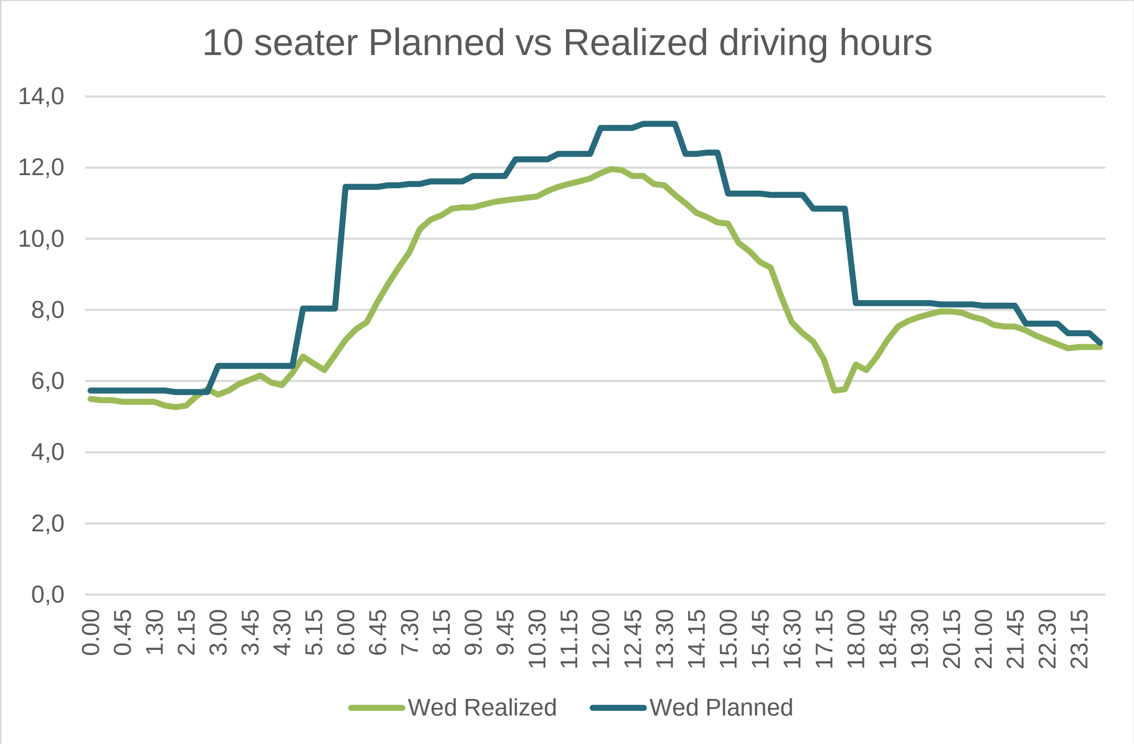

Table 7. 10-seater planned versus realized operating hours Wednesday

Table 7 shows how 10 seater shifts are planned during weekdays, and the gap between realized and planned operating hours. Differences between planned and realized hours are massive at times. At 17:00 almost 50% of planned operating buses are not operating.

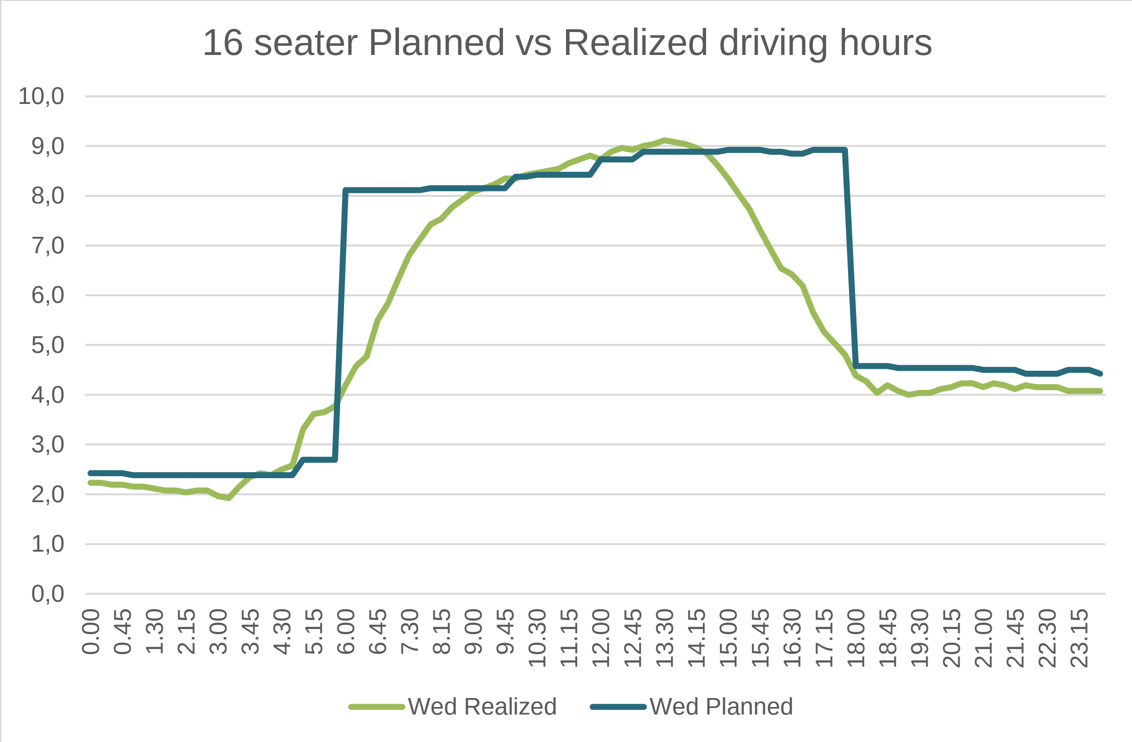

Table 8. 16-seater planned versus realized operating hours Wednesday

Table 8 shows how 16-seater shifts are planned during weekdays, and the gap between realized and planned operating hours. Similarities to 10 seaters are obvious in terms of gap size and the times of the largest gaps. From 9:00 to 13:00 there actually more operating busses than planned.

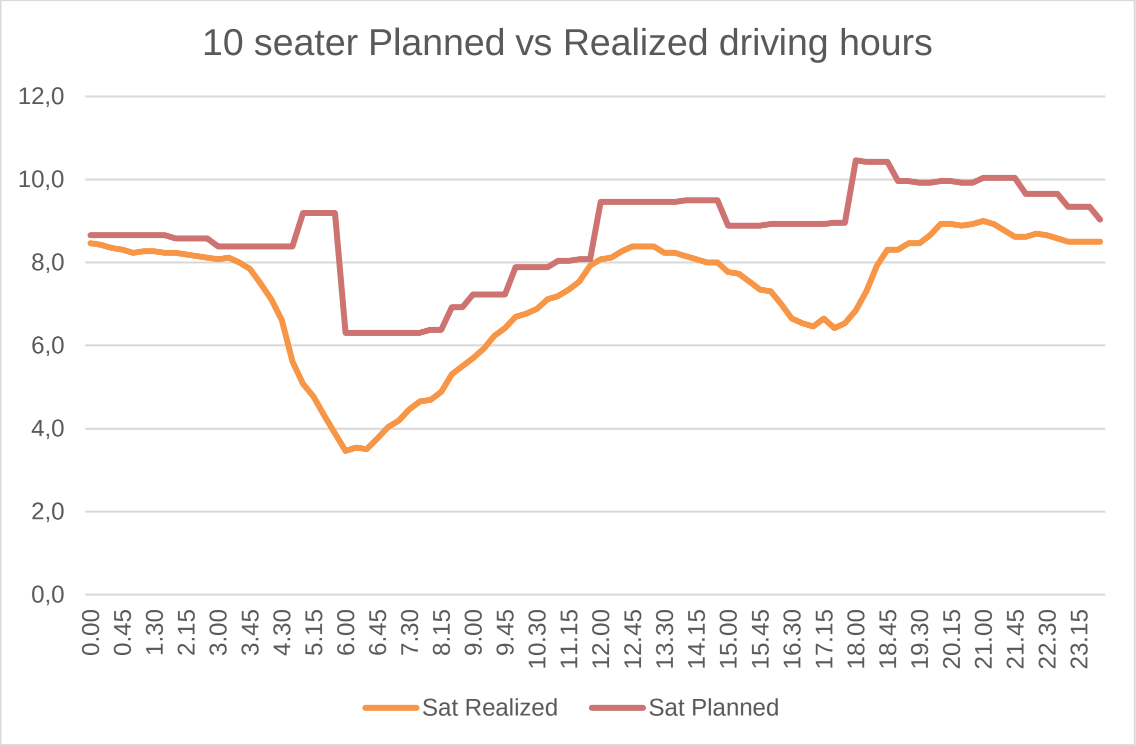

Table 9. 10-seater planned versus realized operating hours Saturday

Table 9 shows the planned and realized hours of 10-seaters on Saturday. Compared to table 7 the difference in planning is quite large, but problems remain the same.

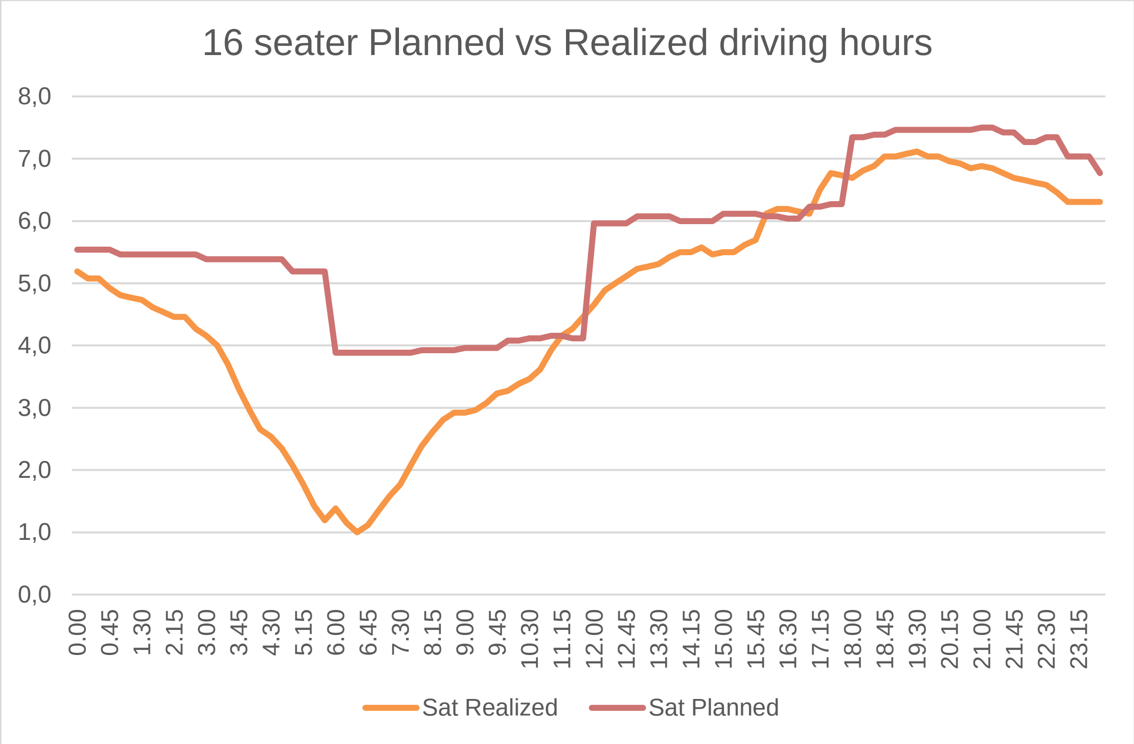

Table 10. 16-seater planned versus realized operating hours Saturday

Table 10 presents planned and realized hours of 16-seaters on Saturday. Gap between realized and planned hours is at its largest of all of tables in table 10 at 05:30 where only 1,2 out of planned 5,2 buses were operating.

In tables 5 to 10 it can be identified that even though the emphasis is very different during the week than on weekend, the problems remain very much the same. As a result of these tables identifying that there are real issues related to driver driving hours is not very difficult. As the problems are clearly biggest close to the driver changing time, it seems that the drivers cut their shifts short from both ends of the shift. There are also some differences in planned and realized driving hours everywhere with both 10 and 16 seaters, which means that there are also some other problems related to this. It is possible that sometimes a driver simply does not come to work for whatever reason. There are also sick leaves and sometimes the buses brake down. Though such reason may have an effect in the results, the shift planner should also react to these issues and make changes to shift planning. Therefore, it is likely that a process change is required so that these changes are always updated to shift planning. For example, sick leaves should not affect these results as they are known usually in advance and should be updated to shift planning.

3.3.3 Hourly distribution of shift income

In this section, the income of an operating bus will be investigated. The tables will be divided in two sizes. Income per hour is calculated based on the full amount of money earned by minibuses in given time and divided by number of buses actually operating during the given time. Calculation is automated and numbers printed out from Kovanen statistics program.

	Ma	Ti	Ke	To	Pe	La	Su
0:00	31,3	36,1	34,1	32,3	33,0	44,2	50,1
1:00	27,0	34,8	23,4	21,8	24,7	38,1	46,9
2:00	21,6	16,7	14,2	17,7	26,0	32,2	38,6
3:00	28,5	25,3	23,6	27,0	27,8	40,0	39,4
4:00	32,8	27,8	36,3	37,5	38,0	47,4	49,5
5:00	38,8	34,3	39,6	41,6	46,1	61,2	53,9
6:00	40,8	36,0	39,7	44,3	38,6	49,1	50,6
7:00	27,1	28,4	30,0	31,9	30,0	37,7	37,0
8:00	31,9	38,1	34,8	35,2	32,6	26,0	27,7
9:00	28,4	30,5	28,3	31,5	30,1	28,8	32,7
10:00	29,6	23,2	22,3	24,5	28,2	30,5	30,1
11:00	28,0	24,8	23,3	26,1	29,8	30,3	33,6
12:00	31,1	25,5	25,1	28,0	28,1	30,1	34,1
13:00	31,4	28,3	27,7	28,1	31,5	36,0	33,3
14:00	41,4	34,8	35,6	35,9	38,0	36,8	38,7
15:00	40,7	38,3	39,7	41,5	38,6	39,7	45,0
16:00	42,4	38,9	37,8	38,0	41,3	37,2	37,4
17:00	43,0	41,3	41,9	40,5	40,5	32,9	39,3
18:00	40,2	30,0	28,6	29,4	26,1	29,1	27,6
19:00	26,9	25,7	25,7	23,2	26,2	30,2	19,8
20:00	21,3	21,3	26,4	24,3	24,7	29,4	19,5
21:00	27,0	26,6	30,6	27,8	26,0	30,8	14,0
22:00	29,9	32,8	32,4	31,8	35,6	37,9	18,5
23:00	30,7	28,3	34,0	33,2	38,7	50,1	35,5

Table 11. 10-seater earnings per hour per operating bus

Table 11 indicates that there are a lot of peak times and slow times during the day and week. It can be identified from the table that there is a peak from 4:00 until 9:00 from Monday to Sunday. This time is commonly known in the company, as there is a massive demand for vehicles to take customers to the airport. There is also a peak from 14:00 to 18:00 or 19:00 during the weekdays. This time is known as afternoon rush hour. Between 22:00 and 01:00 there is also a small peak in demand as there are plenty of people returning their homes from the airport, and leaving home from the center area of Helsinki. It is also very important to notice times that are very quiet: from 01:00 to 04:00, 9:00 to 14:0 and 18:00 to 22:00. In the weekends, it is quite clear that Friday and Saturday night shifts are very busy. Still there is a slow time for the night shifters starting at 18:00, as 18:00 to 22:00 is semi-quiet. Sunday night seems to be the quietest night of the week. Weekend afternoons are busy from 11:00 until 18:00.

	Ma	Ti	Ke	To	Pe	La	Su
0:00	40,9	36,2	31,4	45,9	38,3	53,5	66,1
1:00	31,7	34,2	31,5	24,5	26,4	53,5	56,1
2:00	20,9	18,5	17,0	20,7	17,4	37,0	50,9
3:00	42,6	31,7	31,4	39,7	37,5	50,2	52,8
4:00	45,0	41,1	40,6	45,8	56,6	67,6	67,9
5:00	50,9	40,4	36,9	39,6	48,1	63,7	73,6
6:00	37,3	32,1	34,8	33,5	37,6	53,8	52,1
7:00	25,7	27,2	28,0	30,5	26,6	29,7	30,3
8:00	36,8	38,3	36,3	42,0	34,7	29,0	41,6
9:00	35,6	34,7	27,6	36,9	30,3	34,9	23,1
10:00	29,3	25,1	25,0	32,6	27,2	33,4	30,6
11:00	30,8	27,6	27,3	28,7	28,4	30,8	34,7
12:00	32,9	27,0	27,2	32,5	30,1	38,8	33,9
13:00	34,4	27,6	29,3	33,3	32,8	39,5	38,2
14:00	36,8	37,0	36,1	38,4	42,2	41,8	41,4
15:00	46,4	44,3	48,2	45,3	42,3	51,2	39,9
16:00	47,1	48,8	49,2	45,4	42,2	41,5	43,4
17:00	49,3	51,7	43,9	47,6	47,1	44,2	42,2
18:00	42,9	49,0	51,0	39,3	53,5	47,9	37,8
19:00	36,7	42,1	44,4	36,9	39,1	45,3	36,6
20:00	36,3	32,2	30,3	31,0	34,0	39,7	24,2
21:00	41,8	37,1	29,5	28,9	32,6	41,8	22,6
22:00	36,4	38,2	39,3	39,2	45,1	49,3	26,1
23:00	41,0	37,5	40,3	42,8	54,4	65,8	36,6

Table 12. 16-seater earnings per hour per operating bus

Table 12 indicates that there are many similarities between 10- and 16-seaters, but there are also some differences. What should be noticed that the quiet time during the day is actually a little bit longer for 16 seaters than 10 seaters, and that between 06:00 and 14:00 there is actually only one really busy hour for 16 seaters, from 8:00 to 09:00. Afternoons and evenings are different as well. 10 seater has a quiet time from 18:00 to 22:00 but the 16-seater is busy until 20:00 before the two-hour quiet time begins. Friday evening is similar to 10 seaters but Saturday is a different story. 10-seater have a slower time 18:00 to 22:00 but 16-seaters are busy starting from Saturday 12:00 all the way until 7:00 at Sunday morning. At Sunday, there is one peak for 16 seaters from 13:00 to 19:00. Friday and Saturday nights are very busy for 16 seaters, and by far the highest hourly earnings are made with 16-seaters, up to 73,6 euros per hour, on average. 10-seater reaches 61,2 euros per hour at its highest.

3.3.4 Lost opportunities due to capacity shortages

In this section, amount of lost opportunities is analyzed. By Finnish law there is a difference between 10- and 16-seaters. 10-seater is allowed to drive anything from 0 to 10 people, zero being goods transportation, but 16-seaters from 5 to 16 people as well as goods transports. Lost opportunities are shown as order units. In section 5.1, where demand is being modelled, estimated value of lost opportunities will be created.

	Ma	Ti	Ke	To	Pe	La	Su
0:00	1	1	1	1	1	3	15
1:00	2	1	1	1	1	3	4
2:00	1	0	0	1	0	1	2
3:00	1	1	0	1	1	4	10
4:00	1	1	1	1	3	5	19
5:00	2	0	1	3	3	3	5
6:00	3	1	1	2	3	2	1
7:00	1	1	2	2	1	1	0
8:00	3	7	5	8	3	0	0
9:00	2	4	3	5	3	1	0
10:00	1	2	2	2	3	1	1
11:00	1	2	1	1	2	1	1
12:00	1	1	2	1	2	1	2
13:00	1	2	1	2	2	1	1
14:00	3	2	2	5	5	2	3
15:00	2	3	4	8	5	3	1
16:00	3	4	2	7	3	1	1
17:00	2	7	4	6	1	3	1
18:00	3	8	2	2	4	3	1
19:00	2	2	2	1	3	2	1
20:00	1	1	1	2	2	2	1
21:00	1	2	1	1	1	2	1
22:00	1	2	2	1	2	5	1
23:00	1	1	1	1	3	21	1

Table 13. 10-seater lost opportunities

Table 13 indicates that Kovanen is losing opportunities mostly at the high peaks identified already in section 3.3.3. There are also some lost opportunities during the quiet times of the day and week. It is likely that even though Kovanen has vehicles available, they may be too far away from the customer, or there can be some other unidentified reason for why customer decided not to use the service.

	Ma	Ti	Ke	To	Pe	La	Su
0:00	0	0	0	0	0	4	15
1:00	0	0	0	0	0	2	3
2:00	0	0	0	0	0	0	0
3:00	0	0	0	0	0	2	6
4:00	0	0	0	1	0	2	15
5:00	0	0	0	0	0	0	2
6:00	0	0	0	0	0	0	0
7:00	0	0	0	0	0	0	0
8:00	0	1	1	2	0	0	0
9:00	0	1	1	1	0	0	0
10:00	0	0	0	0	0	0	0
11:00	0	0	0	0	0	0	0
12:00	0	0	0	0	0	0	0
13:00	0	0	0	0	0	0	0
14:00	0	0	0	1	0	1	1
15:00	0	1	0	2	1	0	0
16:00	0	1	0	3	1	0	0
17:00	0	2	1	1	0	1	0
18:00	1	2	0	1	0	1	0
19:00	0	0	0	0	0	1	0
20:00	0	0	0	0	0	0	0
21:00	0	0	0	0	0	1	0
22:00	0	0	0	0	1	5	0
23:00	0	0	0	0	2	21	0

Table 14. 16 seater lost opportunities

From table 14 it is possible to identify that the number of lost opportunities for 16-seaters is much lower than for 10-seaters. As with 10-seaters, the lost opportunities are mostly in the peak times. Most of the lost opportunities for 16-seaters are at afternoons between 14:00 and 18:00, and during Friday and Saturday nights.

Unfortunately, these tables 13 and 14 do not tell the full story of lost opportunities. Business Class orders are premade and the car booked in advance for the customer. If Kovanen runs out of buses, which happens often in peak times with 16-seaters, these orders are not put into the systems and are not shown here. This is because they are processed differently outside the current system as sales requests. There is no way of knowing the magnitude of this problem, but what we know for sure is that these lost opportunities are all in the peak times, or Kovanen would have a bus to sell for such customer. Therefore, it is safe assume that the lost opportunities at peak times are even higher than the tables 13 and 14 indicate.

There are also prebooked orders that Kovanen is selling to their customers. Prebooked means that a Comfort Class customer pre-orders his pickup and pays an extra fee for the service. There is also an intranet ordering system that is given to Kovanen's big partners, for example hotel front desks. In prebooked orders there are time based limits for how many prebooked orders Kovanen can take in given time window. When such limit is reached, the system will be closed and Kovanen is not able to take any more prebooked orders. These orders that Kovanen is not able take will also not show in the tables 13 and 14. Kovanen is aware that typical moments of prebooking closures are from 04:00 until 9:00 and from 14:00 to 17:00. Therefore, as with BC orders, these "shut-downs" are timed into the highest peaks.

Last but not least, there are also some situations in these peak times where the sales service is not able to answer all the customer calls coming in. Naturally this usually happens during the highest peaks as well. Customer tries to call us to make an order, but gets tired of waiting and drops out of phonelines. These are still lost opportunities, but once again we are not able to calculate the amount or value of these lost opportunities of business.

3.4 "All in one" Analysis

In this section, a deeper analysis of supply and demand equilibrium will be done by collecting all information into one table. From this one table, it is possible to identify the key problems. As this is the most important area of CSA analysis, we will show tables in both sizes as well as in all weekdays separated.

Analysis will start with 10-seaters. In "All in one" tables missed opportunities, realized operating hours and earnings per operating bus per hour are shown. The idea of these tables is to show and analyze the key "peak times" that Kovanen's busses have, and weather if they are able to exploit these peaks as well as possible. In terms of shift planning, buses should be operating with maximum possible numbers in peak times, and with lower numbers in more quiet times.

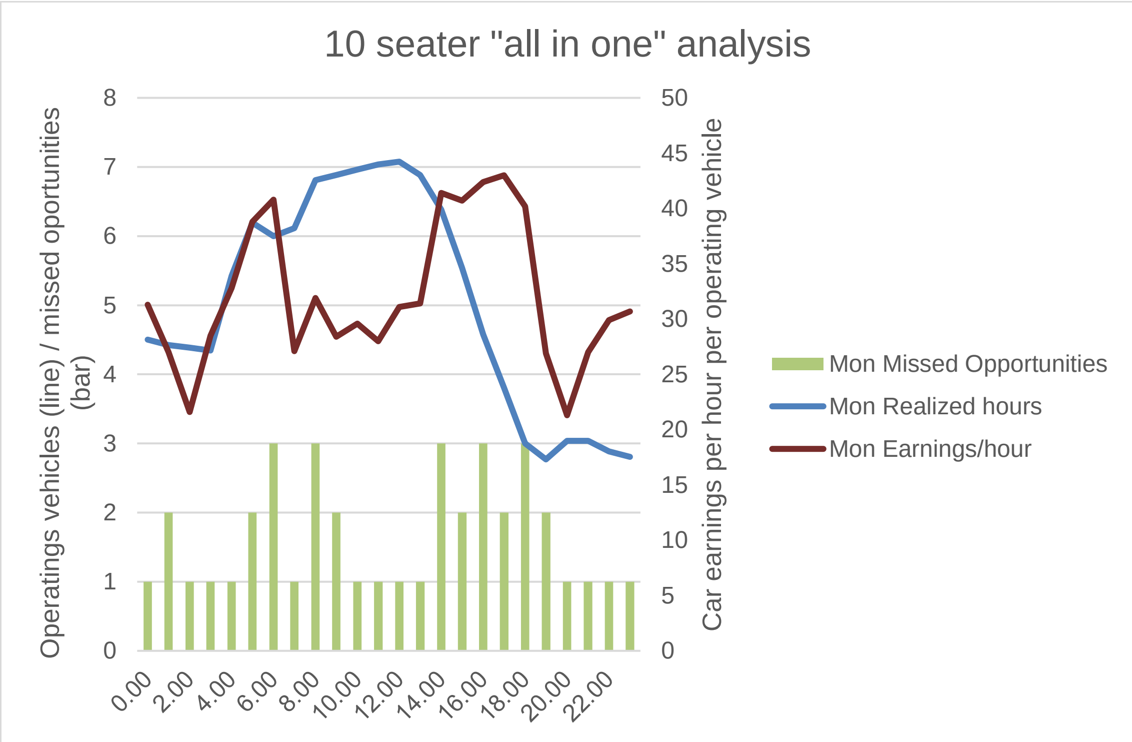

Table 15. 10-seater “all in one” table for Monday

From 5:00 to 8:00 the number of operating buses should be higher as the earnings per operating bus are high and there are still missed opportunities. From 8:00 to 14:00 earnings are lower, but the operating amount of buses is at its highest. After 14:00 amount of operating buses drops significantly, though hourly income is high and there are missed opportunities. From 22:00 to 0:00 there are higher earnings but declining amount of operating buses.

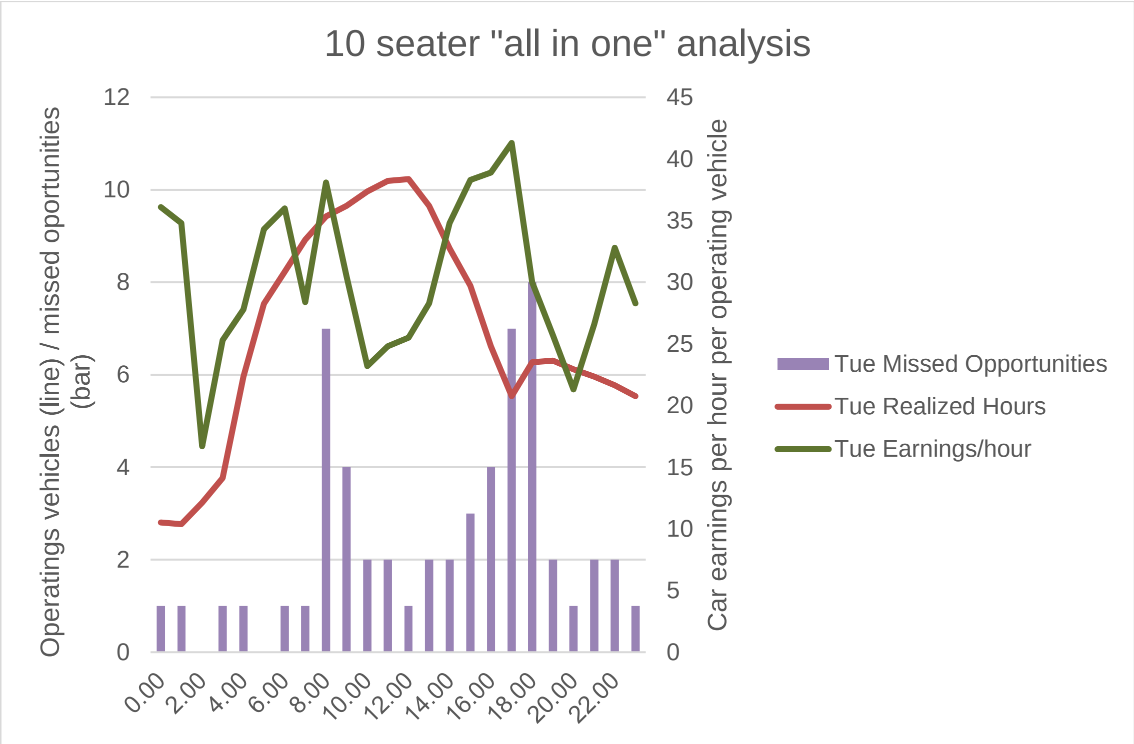

Table 16. 10-seater “all in one” table for Tuesday.

Similar to Monday, Tuesday has some problematic hours. From 8:00 until 10:00 hourly earnings are high, and there are plenty of missed opportunities. 8:00 o’clock time seems to be very problematic, as the amount of buses operating is already high. From 10:00 to 13:00 there is a quiet time in terms of earnings, but again the amount of buses operating is at its highest. From 14:00 to 19:00 earnings are high and there are a lot of missed opportunities. From 22:00 to 0:00 there are higher earnings but declining amount of operating buses.

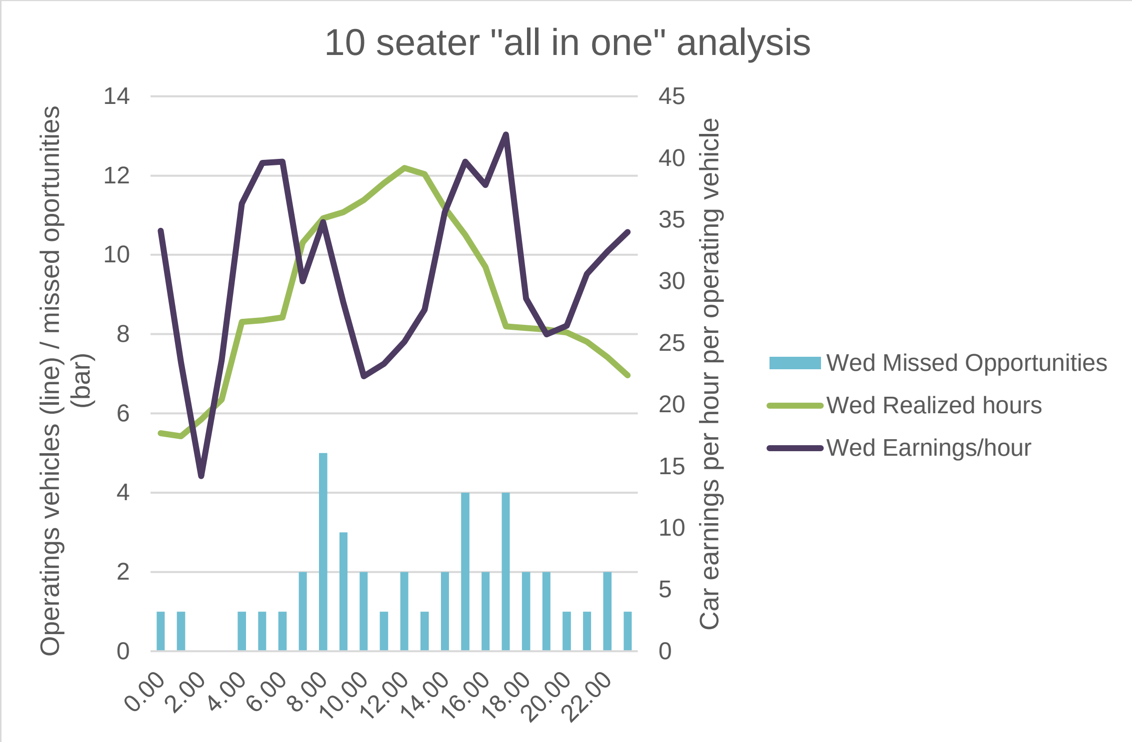

Table 17. 10-seater “all in one” table for Wednesday.

Different from Monday and Tuesday, Wednesday has very high earnings starting from 04:00 to 7:00, and also some lost opportunities. From 8:00 to 10:00 there is once again high earnings and lost opportunities. Around midday the same formula of high number of operating buses and low earnings repeats itself. From 14:00 to 18:00 the formula is also similar to previous days: high earnings and lost opportunities, but declining amount of operating buses. From 22:00 to 0:00 there are higher earnings but declining amount of operating buses.

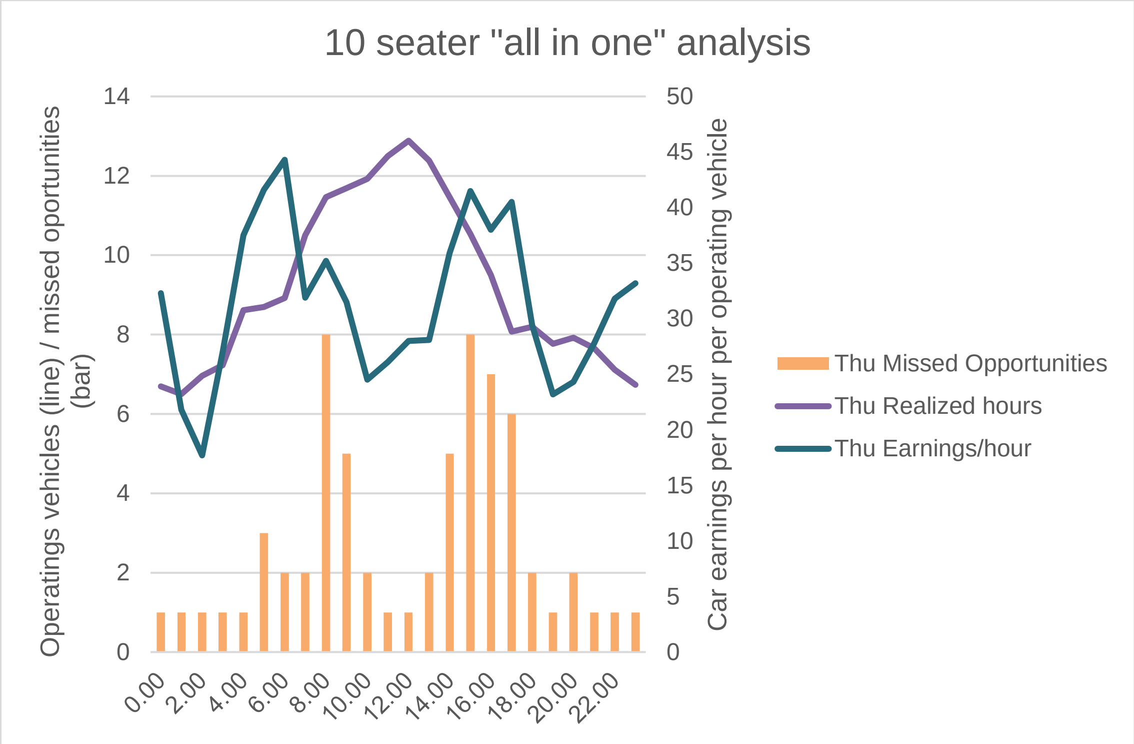

Table 18. 10-seater “all in one” table for Thursday.

Similar to Wednesday, Thursday morning from 04:00 to 7:00 the earnings are very high and there are some lost opportunities. From 7:00 to 9:00 earnings are still high but there is a very high amount of lost opportunities. Midday has the same problem as before, as does the 14:00 to 19:00 time period. Thursday and Wednesday also have a short peak around 23:00 to 01:00 in earnings, though the amount of missed opportunities is low.

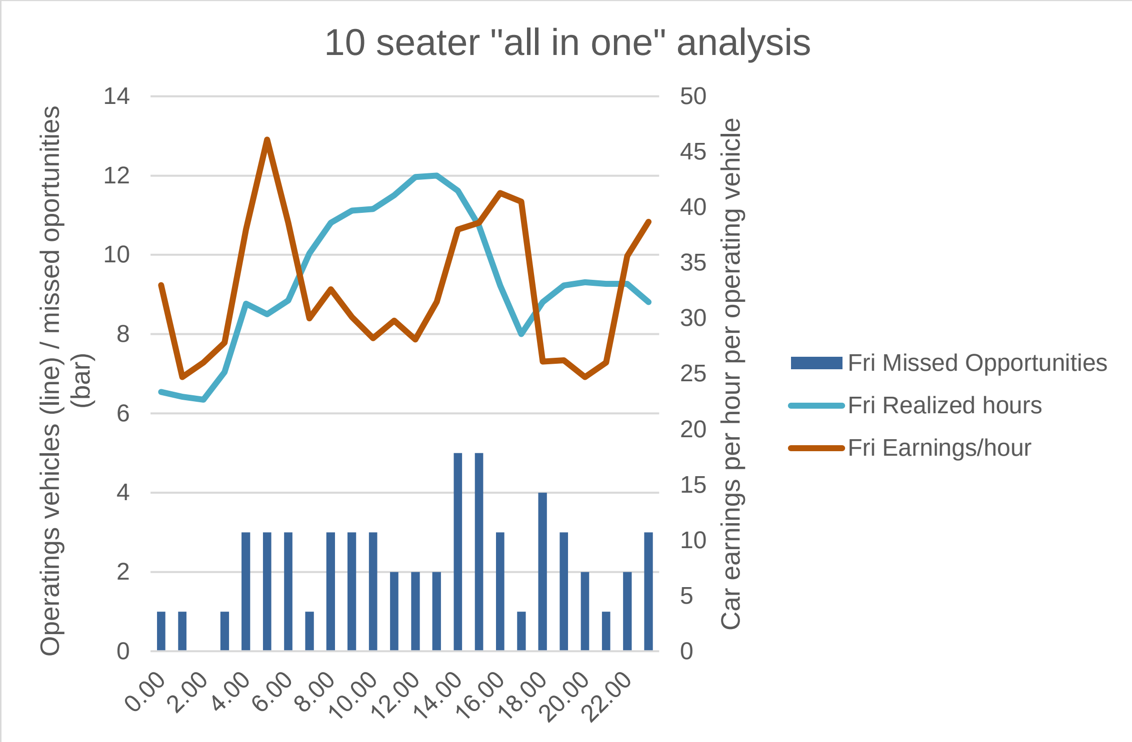

Table 19. 10-seater “all in one” table for Friday.

From 4:00 to 6:00 the earnings are high, and some opportunities are lost. Differently from other days, midday has more lost opportunities, though earnings are not very high. From 13:00 to 18:00 there are lost opportunities and high earnings, and the amount of operating buses is declining once again. From 22:00 forwards the effect of weekend nights starts to show, as there are high earnings and lost opportunities, though the number of operating cars is higher than on other weeknights.

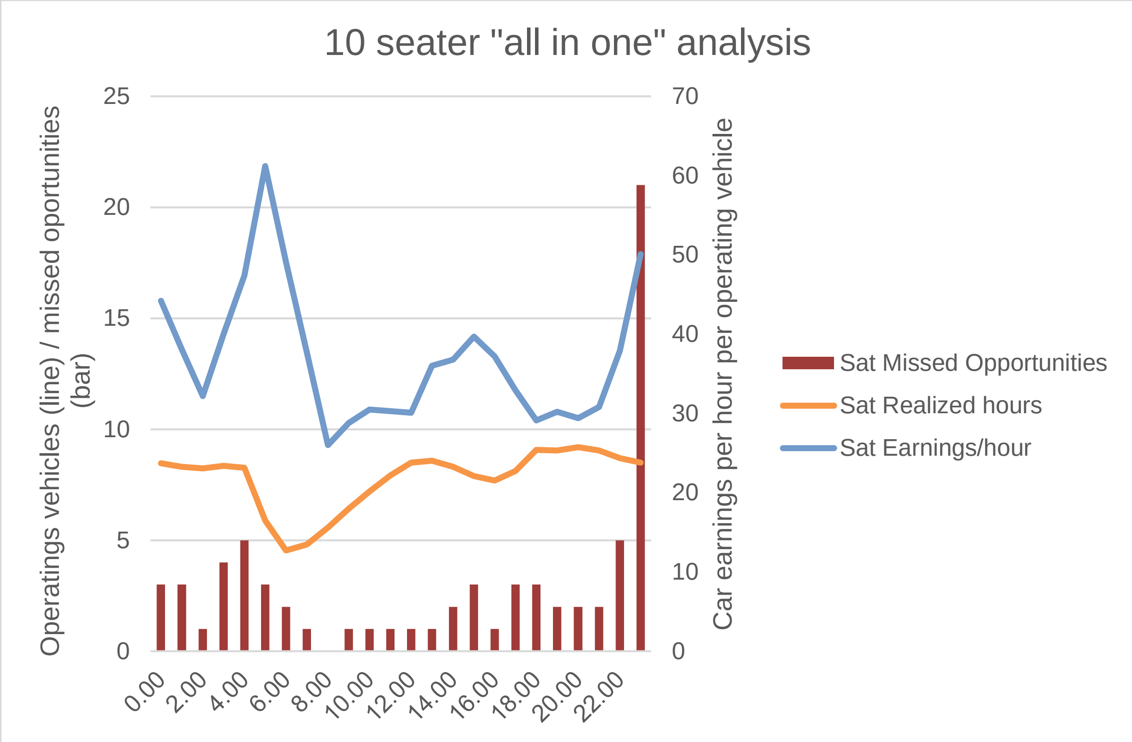

Table 20. 10-seater “all in one” table for Saturday.

Weekend night -effect is showing itself from 0:00 to 7:00. Earnings are high and there are a lot of lost opportunities. Around 5:00 there is a massive peak in earnings, which can be explained by high demand and declining number of operating busses. Earnings are high until 8:00. From 8:00 to 12:00 is a stable demand time with correct number of operating buses. From 12:00 to 18:0 there are higher earnings and lost opportunities. From 18:00 to 22:00 earnings are stable but lower. After 22:00 the demand rises very high but the number of operating cars shows zero growth. From 23:00 forwards the earnings per bus are extremely high and the number of lost opportunities is massive.

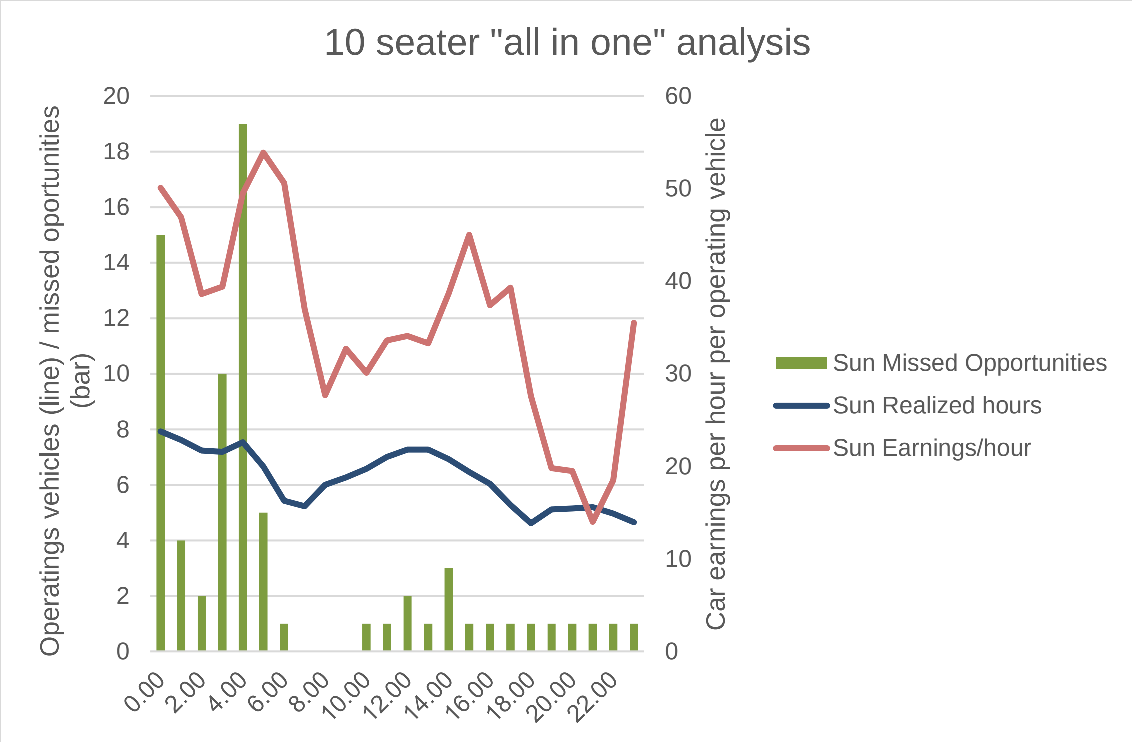

Table 21. 10-seater “all in one” table for Sunday.

Peak that started from Saturday at 22:00 goes on until 7:00. The earnings are very high as well as the amount of lost opportunities. Amount of operating bus is slowly declining during this time. From 7:00 to 13:00 there is a more stable time where earnings are ok and the amount of lost opportunities is under control. From 13:00 to 18:00 there is another peak of higher earnings, but low amount of lost opportunities. From 18:00 to 22:00 there is one of the quietest moments of the week. From 23:00 forwards there is a small peak in earnings, but low amount of lost opportunities.

16-seaters are analyzed next. It is important to differentiate these two sizes from one another as 16-seaters are not able to drive all the same orders as 10-seaters are. As mentioned earlier in 3.3.4 the 16-seater is not able to take orders with less than 5 people by Finnish law. Missed opportunities, realized operating hours and earning per operating bus per hour are shown similarly to 10-seaters. Idea of the tables is to show and analyze the key “peak times” that Kovanen’s busses have, and weather if they are able to exploit these peaks as well as possible.

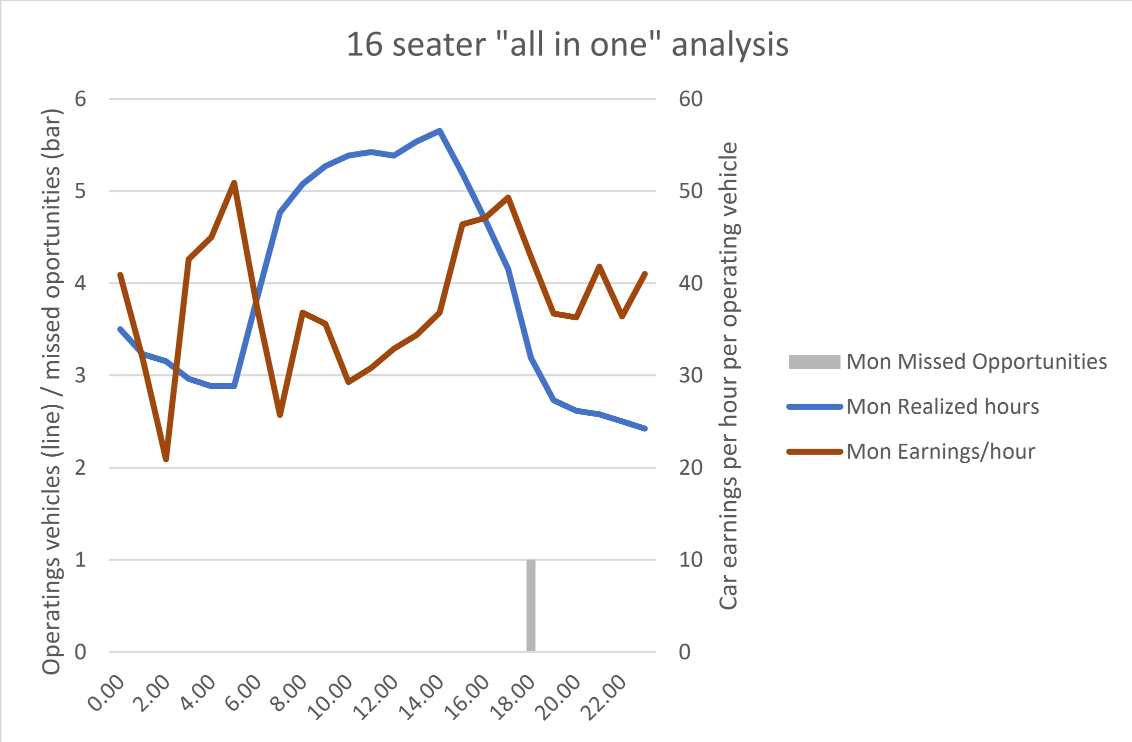

Table 22. 16-seater “all in one” table for Monday.

Monday starts with a small peak that has started from Sunday evening, but it ends quickly by 1:00. As the number of buses operating drops there is a peak in earnings between 03:00 to 05:00. From 05:00 to 07:00 earnings drop, but they rise again at 08:00 and stay in high level until 10:00. During the midday from 10:00 to 14:00 the number of buses is high but earnings per operating bus are low. From 14:00 to 19:00 there is high peak. This is also the only time where there are lost opportunities for 16-seaters. From 19:00 to 0:00 the earnings are semi stable as is the number of cars operating.

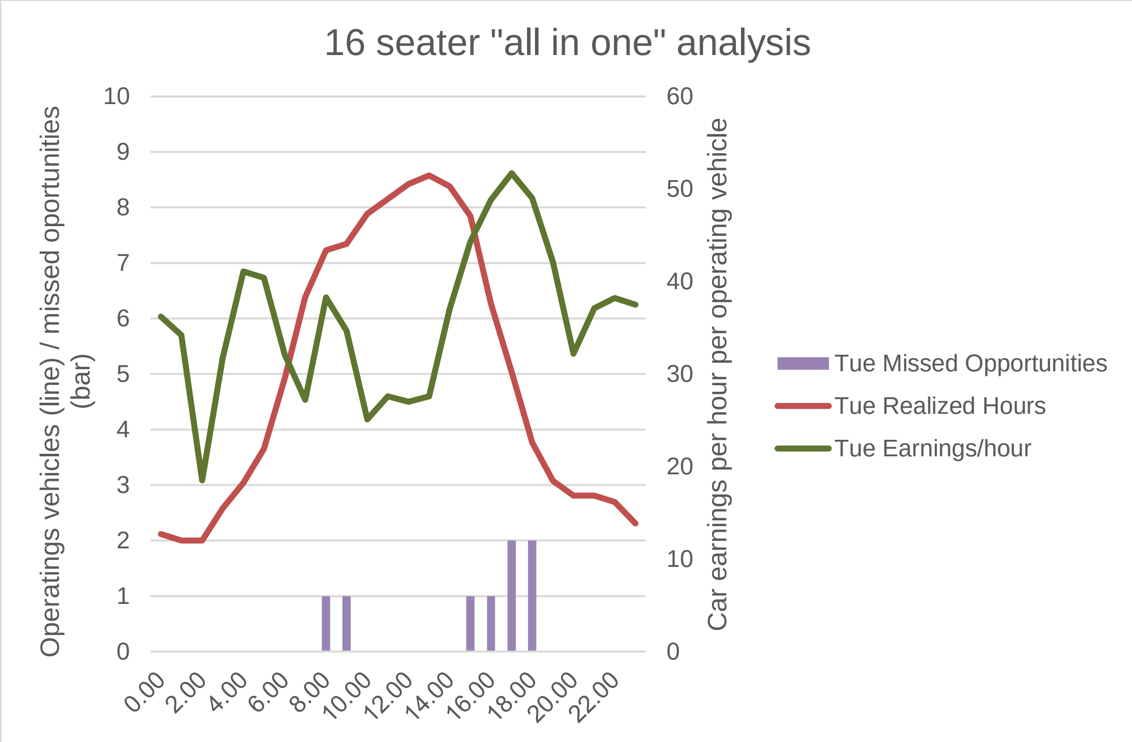

Table 23. 16-seater “all in one” table for Tuesday.

Tuesday begins with a small peak between 0:00 and 02:00. After this there is another peak from 05:00 to 7:00 and again from 08:00 to 09:00. There are also some lost opportunities between 08:00 and 09:00. Between 11:00 and 15:00 there are a lot of buses operating with low earnings. As the number of buses operating starts to drop at 15:00 also the next peak starts. The earnings are high and there are also lost opportunities between 15:00 and 19:00. From 19:00 forwards the number of buses and earnings are steady.

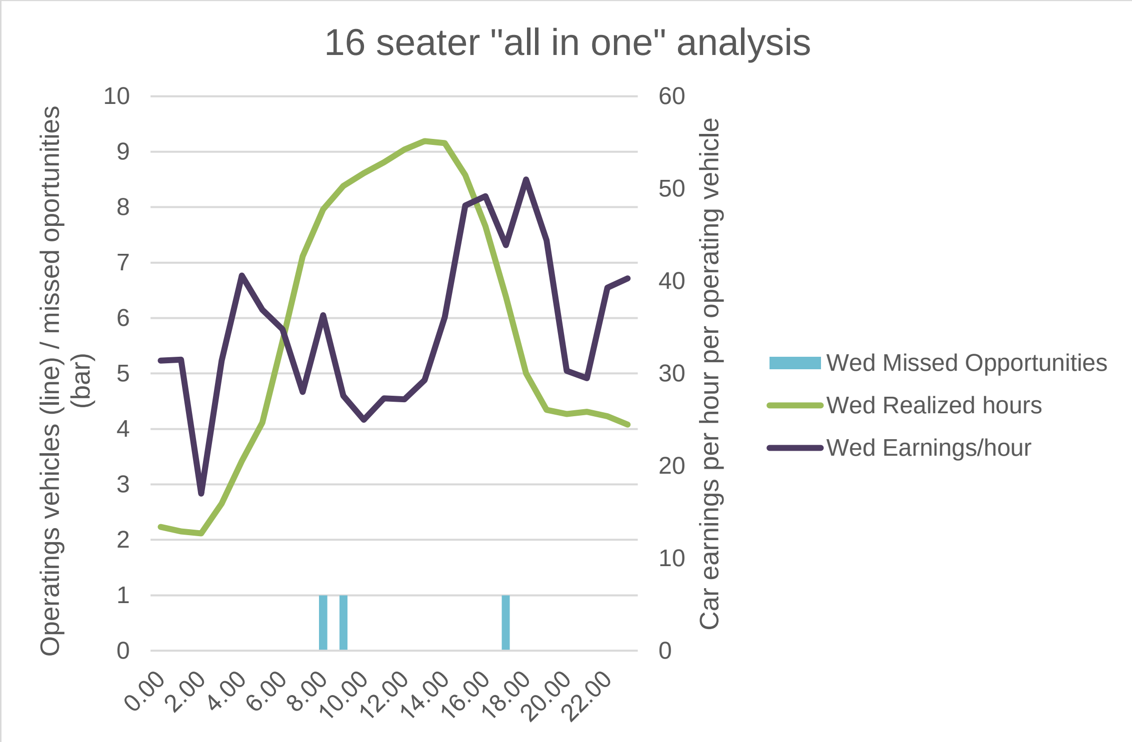

Table 24. 16-seater “all in one” table for Wednesday.

Wednesday morning the earnings are low until 04:00 where a small peak starts. As the number of buses operating is increasing the earnings drop but stay stable until 14:00. There are a couple of lost opportunities between 08:00 and 10:00. From 15:00 the number of buses operating starts to drop but the earnings increase. There is a high peak between 16:00 and 20:00 and some lost opportunities around 17:00. From 23:00 to 0:00 there is also a small peak.

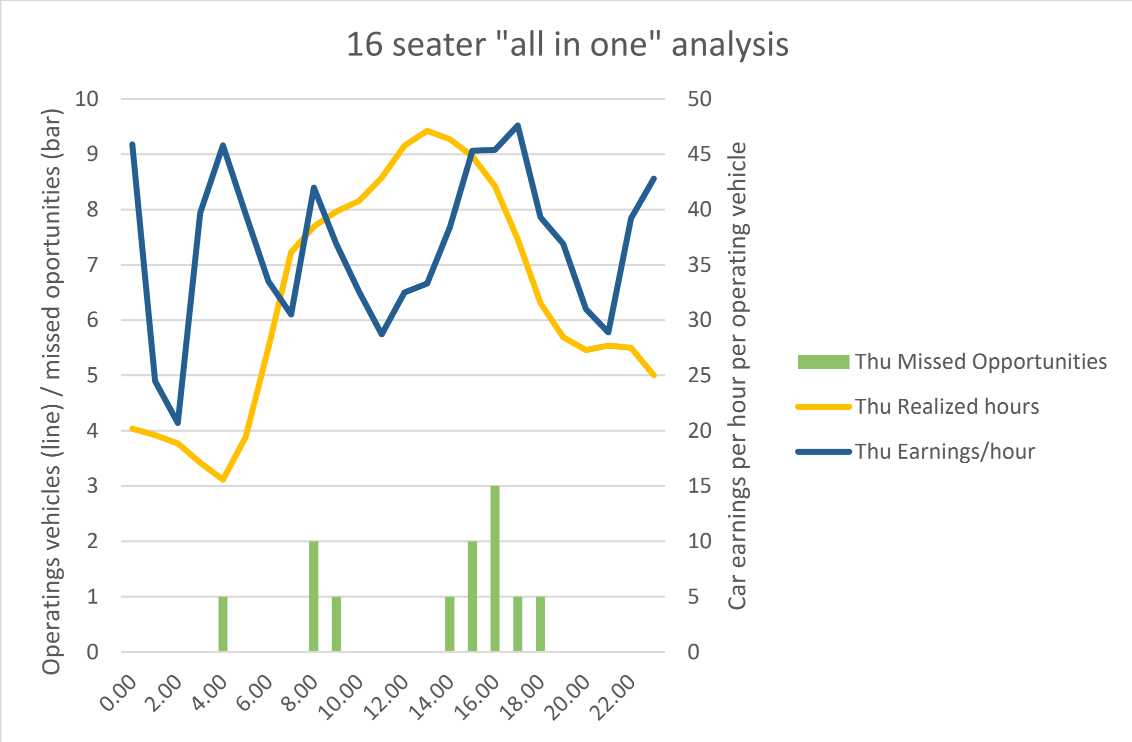

Table 25. 16-seater “all in one” table for Thursday.

Thursday begins with a high peak that started late Wednesday evening. This peak is however very short, lasting only until 01:00. The earnings rise again from 04:00 to 06:00. Though the number of buses operating rises the earnings stay pretty high until 07:00. From 07:00 to 08:00 there is a slower time, but from 08:00 to 10:00 another high peak. There are lost opportunities around 04:00 and from 08:00 to 10:00. From 10:00 to 15:00 there is a quieter period, but the number of buses operating peaks at 13:00. From 15:00 to 19:00 earnings are high and there are a lot of missed opportunities. From 22:00 to 0:00 there is also a small peak in earnings.

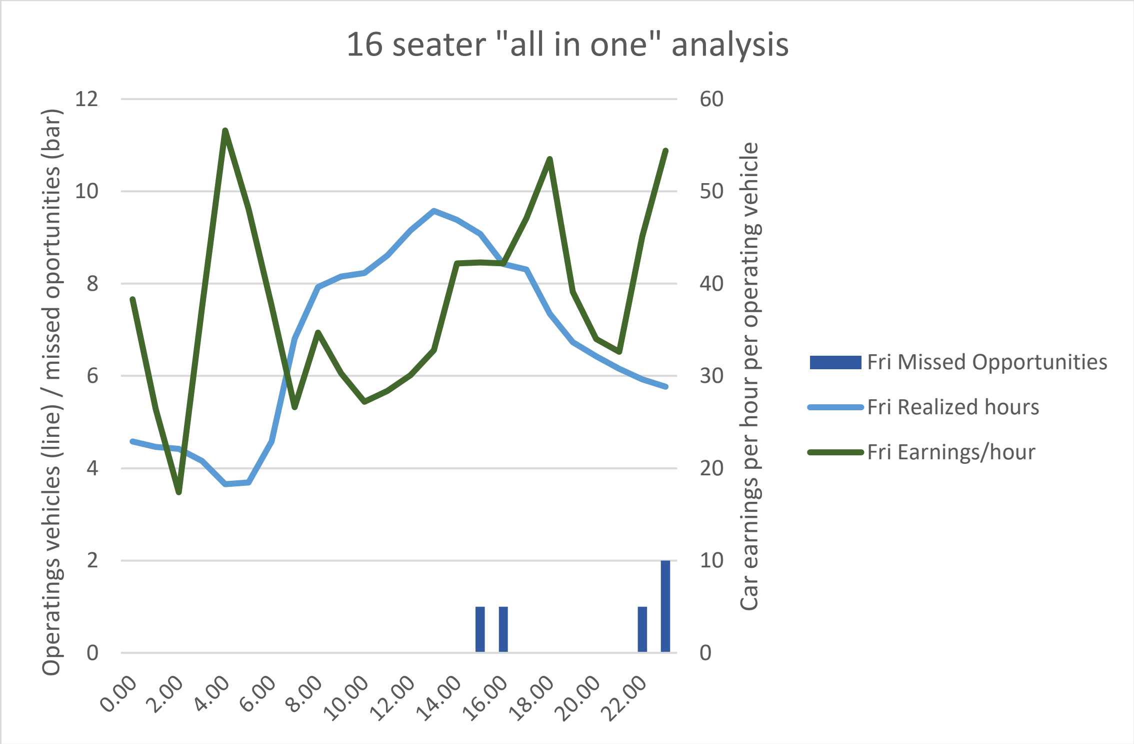

Table 26. 16-seater “all in one” table for Friday.

Friday morning is very similar to other weekdays. There are peaks from 0:00 to 01:00, from 05:00 to 07:00 and a small peak around 08:00. From 10:00 to 15:00 is more stable time in terms of earnings, and the number of buses operating peaks at 14:00. From 15:00 to 20:00 there is a bigger peak and some lost opportunities. From 20:00 to 22:00 is a little slower time. After 22:00 there is a very high peak with lost opportunities and declining amount of buses.

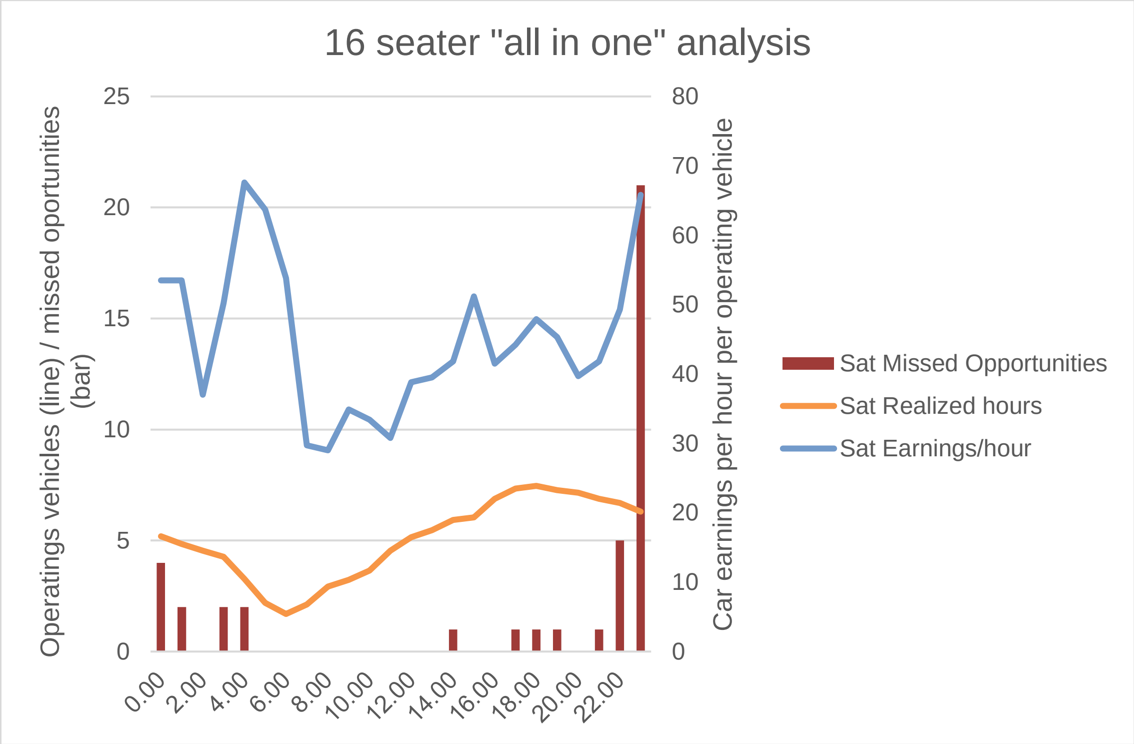

Table 27. 16-seater “all in one” table for Saturday.

Saturday is different from the weekdays. The peak that started from Friday at 22:00 keeps going in high level until 08:00. There are also lost opportunities. The number of buses operating is small and drops very low between 04:00 and 09:00. From 8:00 to 12:00 there is a little slower time in terms of earnings. From 12:00 to 22:00 the earnings stay semi-stable but semi-high, as does the number of buses operating. There are lost opportunities at 14:00 and between 17:00 and 19:00. From 22:00 the earnings and lost opportunities peak very high but the number of operating buses slowly decline.

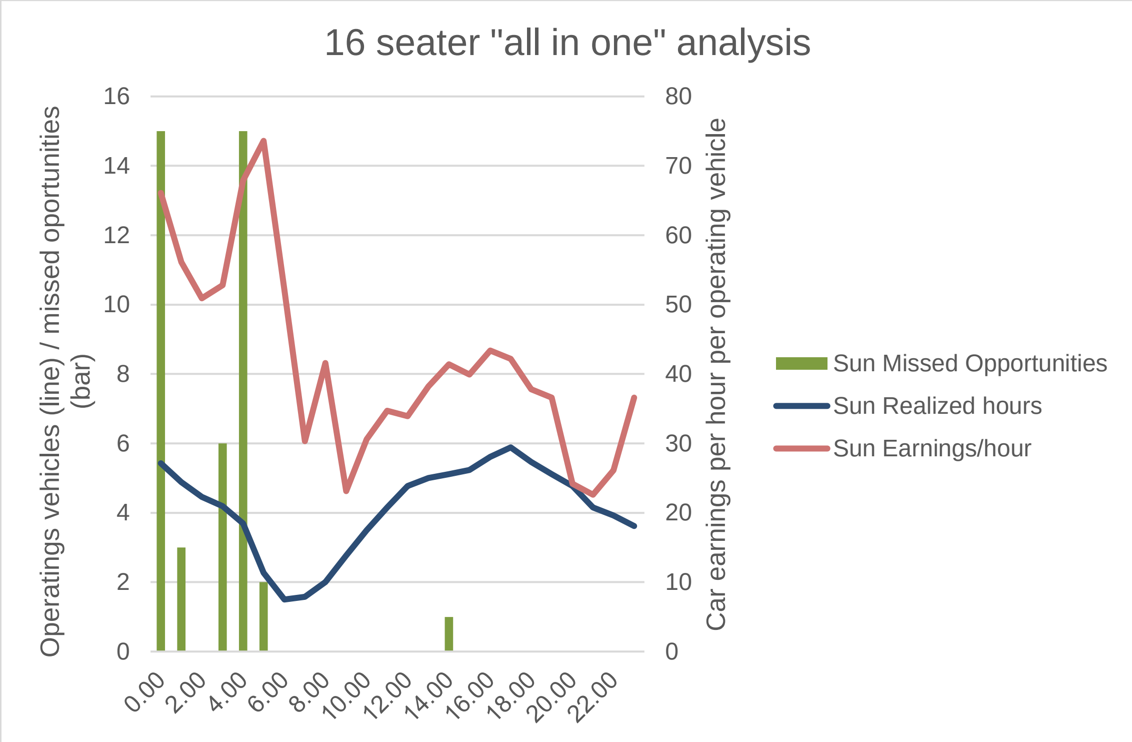

Table 28. 16-seater “all in one” table for Sunday.

From Saturday evening 22:00 forwards the peak in demand stays very high until 06:00. During this time, the amount of lost opportunities is also very high. The number of buses is low and is also dropping slow and steady from 0:00 towards 06:00. From 06:00 to 08:00 the earnings are lower, but there is a small peak around 08:00. From 09:00 to 13:00 the earnings are lower and the number of buses operating is growing steady along-side with earnings. From 13:00 to 19:00 there is a small peak in earnings, and some lost opportunities around 15:00. Earnings also make a small peak from 22:00 to 0:00.

Previously, we analytically analyzed how shift planning is currently done, how the cars actually operate versus the planned hours, how much does a car earn on hourly basis on each day and where do we lose opportunities. All information was shown in tables in two sizes, 10-seaters and 16-seaters, separately. From this analysis it possible to identify several key issues that repeat themselves. These key issues are collected and listed in section 3.6.

3.5 Quarterly demand fluctuations

In this section, differences between the quarters of the year will be analyzed. The analyze in this section will not be very deep, but there is a need to identify if there is difference between the times of the year. If required, this information can be then included into the building shift planning frame section where optimization the number of buses operating at each hour will be done.

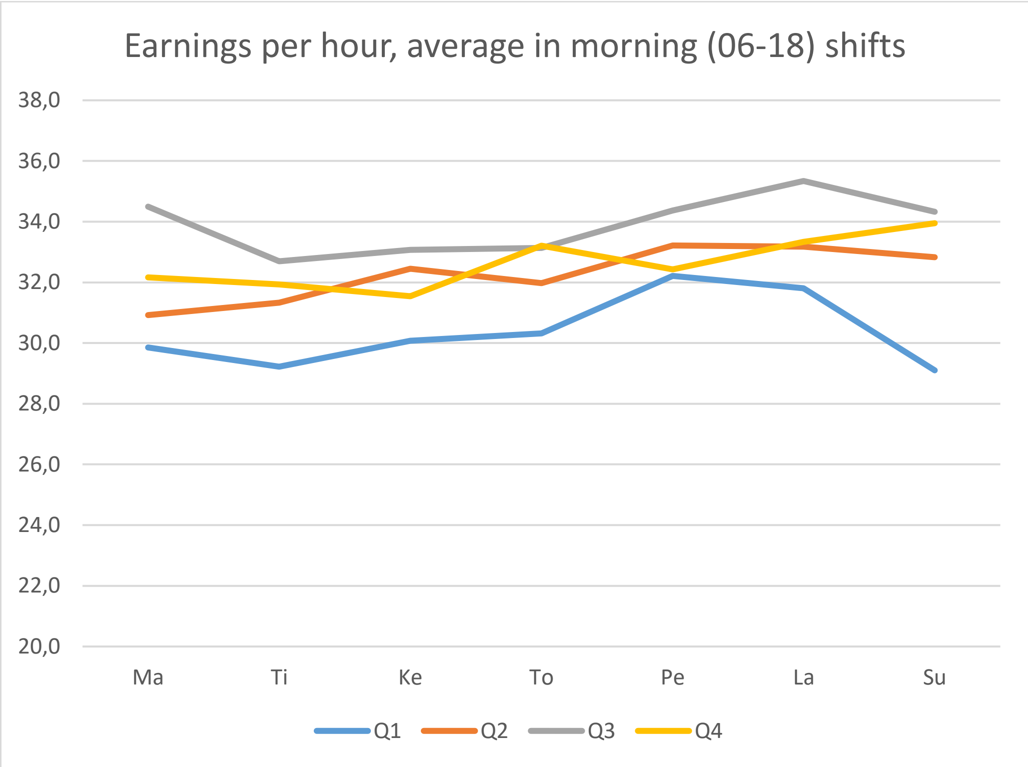

Table 29. Hourly earnings of day shift quarterly.

Table 29 shows the differences in hourly earnings per operating bus quarterly during the morning shift, from 6-18. Q1 is clearly the quietest in terms of demand. Q2 and Q4 are very similar and on yearly average in terms of demand. Q3 is the busiest time of the year based on this stat. In is likely that this is because the number of buses operating is lower during this driver holiday season.

It seems that the differences in Quarters are significant enough to make a difference in dayshift. At highest the difference is 5 euros per hour per operating bus, which would mean 60 euros in full shift (12h) earnings.

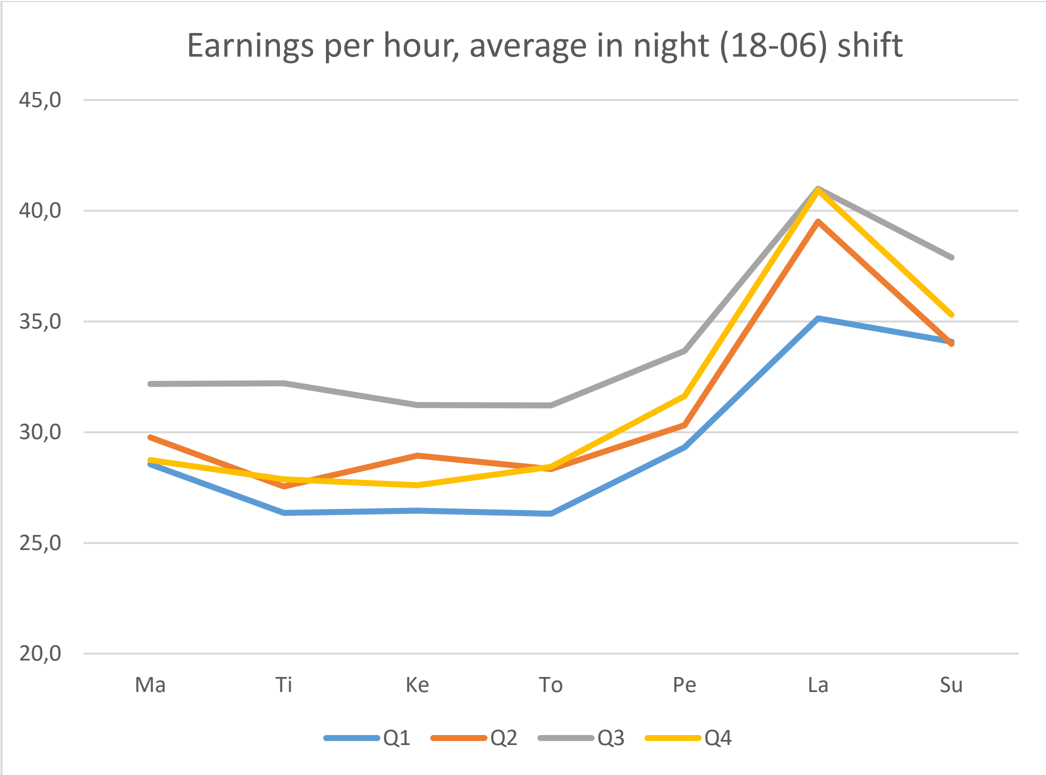

Table 30. Hourly earnings of night shift quarterly.

Night and morning shifts seem to be very similar in terms of demand by quarter. Q1 is the quietest one, Q2 and Q4 are on average and Q3 is the busiest. Surprisingly, in Q3 the demand is high during the weekdays.

Night shift averages also indicate that there is a need to include time of the year demand fluctuations to the shift planning frame. This will be done in section 5.4.

3.6 Identified key issues

Previously, we analytically analyzed how shift planning is currently done, how the buses actually operate versus the planned hours, how much does a bus earn on hourly basis on each day and where do we lose opportunities. Information was shown in tables in both sizes, 10-seaters and 16-seaters, separately and in most of the tables shown each day separately. The key issues we were able to identify in last chapters are listed above.

Defined key issues summary:

1. **A gap between planned and realized hours.** The number of buses planned to operate and the number of buses actually operating are almost never the same. This problem is at its biggest around shift change.
2. **Morning shift change problem.** Between 04:00 and 09:00 all cars are needed due to high demand, but shift change around 6:00 and drivers not driving their shift to the end or starting late causes big gaps to number of operating buses.
3. **Too many buses operating at midday.** From Monday to Friday between 10:00 and 14:00 is one of the quietest times of the day. Kovanen has usually the biggest number of operating buses during this time period.
4. **Afternoon lost opportunities.** From 14:00 to 19:00 is one the busiest times of the day from Monday to Sunday. However, after 14:00 when the peak starts, the number of buses operating is also starting to decrease and therefore opportunities are lost due to capacity shortages. Shift change problem is big around 16.00 to 19:00.
5. **Too many buses operating from 19:00 to 22:00.** After the shift change has been completed, slow demand time of the evening begins. During this time, there is normally too many buses operating.
6. **Late evening peak time.** From 22:00 to 01:00 there is a small peak during the weekdays. Though this time period is not really a problem during the week, the number of buses must be followed to make sure there are no lost opportunities.
7. **Weekend nights' problem.** Friday's and Saturday's are one of the biggest problems that Kovanen has in shift planning. From 22:00 to 07:00 on Friday and Saturday the number of operating buses is very low compared to demand. Kovanen is operating on average 55-60% of their buses during this time, though this time period has by far the biggest demand of the week.
8. **Quarterly demand fluctuations.** Demand changes during the year. Kovanen has to take this into account this in their shift planning as it can cause inability to answer demand or to have too high supply in quiet times.

In overall it is obvious that Kovanen has to make changes to their shift planning based on the problems identified in this analysis. There are times when the amount of busses operating is very high and demand is very low, and on the other hand times when demand is high but amount of operating busses low. It is obvious that Kovanen loses a lot of money because of this, and it also has an effect to the brand image, as customers cannot always be served. Also, it would be important to try to solve the issue of “planned versus realized hours” problem Kovanen has. Planning shifts differently will not help such plan will not realize. Too many buses operating in slow times may cause drivers to leave Kovanen due to the fact that their own salary are linked to bus earnings.

4 EXISTING KNOWLEDGE

In this section existing knowledge will be studied to further understand the problems Kovanen is facing, and also to identify possible solutions and tools that Kovanen could implement to their shift planning process. After a more general overview of literature, possible existing knowledge impacting identified key issues will be addressed with step by step approach.

Existing knowledge in context to this thesis can mostly be found in the areas of demand modelling, fleet optimizing and shift modelling. As the services Kovanen is providing to its customers are very similar to Taxi service, many of the key findings are from a Taxi industry related studies. Also, some public transportation studies may have applicable ideas that can be heuristically applied to this context. Due to the fact that there are no studies solving problems similar to Kovanen, a need to address each problem identified in section 3 individually was identified.

When modelling the fleet size, one must also understand the unique characteristics of the market. According to Hai Yang, S.C. Wong, K.I.Wong, (2001):

> In the taxi market, the equilibrium quantity of service supplied (total taxi-hours) will be greater than the equilibrium quantity demanded (occupied taxi-hours) by a certain amount of slack (vacant taxi-hours). It is this amount of slack that governs the average customer waiting time. The expected customer waiting time is generally considered as an important value or quality of the services received by customers.

Correlation between vacant hours, customer waiting time, fleet utilization and customer acceptance level have also been studied also by many others. Yang, Hai; Ye, Min; Wilson Hon-Chung Tang; Wong, Sze Chun (2005) studied the taxi market in Hong Kong and argued that “Taxi service hours or service intensity are strongly governed by the market profitability. When the business is non-profitable, the owners may simply park their taxis”. They also argue that:

> It is self-evident that, for a given fare and given taxi ride duration, average taxi revenue is directly proportional to taxi utilization. It is generally expected that the taxi utilization rate and average taxi revenue are monastically decreasing functions of the number of taxis in service (or fleet size of taxis in service). Nevertheless, this is not always true. As found in number of studies, taxi utilization rate and hence average revenue increase initially with taxi fleet size.

The correlation of vacant hours and customer waiting time can be shown in figure 4, created by Mark E.T. Horn (2002) who studied fleet scheduling and utilization rate in demand-responsive services, similar to Kovanen's minibus service.

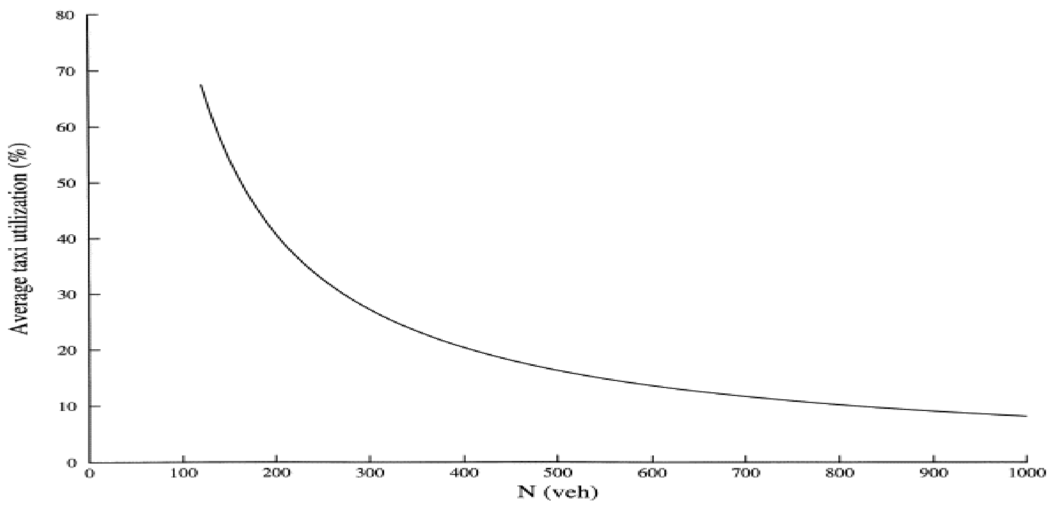

Figure 4. Correlation between taxi fleet size and fleet utilization rate (Mark E.T. Horn, 2002).

Shift planning is very difficult in demand-responsive environment where high demand peaks and very slow demand time periods are normal. In taxi related service, such as Kovanen's minibus service is, high demand peaks and slow demand times are relatively stable in terms of daily and weekly high-demand and low-demand time periods. Direct studies to solve this practical problem in taxi or bus related industries is were not found, but some other similar industries have studied the same problem. A three-step approach for shift planning was proposed in airline maintenance manpower planning (Ta-Hui Yang, Shangyao Yang, Hsuan-Hung Chen, 2003). When applied into this case context the steps would be:

1. Estimation of fleet required at any given time
2. Designing shifts to meet the required fleet requirements
3. Assigning people to these shifts

Maikol M. Rodriques, Cid C. de Souxa and Arnaldo V. Moura (2006) presented a block model for vehicle and crew scheduling. In block modelling the required working hours are assigned into small blocks which then later are integrated into shifts. As a tool for peaking demand Ta-Hui Yang, Shangyao Yang, Hsuan-Hung Chen (2003) proposed the use of flexible shift start strategy and flexible shift length strategy. According to them: “An effective combination of shift starting times and the number of shifts is important to a successful manpower supply plan.”. Mouna Mnif, Youssef Massmoudi and Habib Chabchoub (2011) proposed a graph coloring method for driver scheduling. A.T Ernst, H Jiang, M Krishnamoorthy and D Sier (2004) studied the staff scheduling and rostering problems in general. They claimed that “it is usually not possible to exactly match the staff on duty to a demand that varies on an hourly basis”. Based on A.T Ernst, H Jiang, M Krishnamoorthy and D Sier (2004) research, when applied to case context, Kovanen works in acyclic rostering environment, in which Kovanen should change their approach from drivers being able affect their own working times towards an approach where Kovanen designs shifts and assigns drivers to these shifts.

Currently Kovanen is not utilizing their data in demand modelling. Due to this, shift planning is based on gut-based knowledge of employees and managers. To have an understand when and in what scale the bus fleet should be dispatched, demand modelling is required. Demand modelling is an area that has been studied significantly. Marco Diana, Maged M. Dessouky and Nan Xia created a computational model for calculating required number of cars at any given time period based on demand estimation. When studying this issue Marco Diana, Maged M. Dessouky, Nan Xia, (2005) also realized that “The extensive datasets needed to perform such analyses are usually unavailable.” Usage of streaming- and ad hoc type of data in demand modelling has also been studied by Luis Moreira-Matias, João Gama, Michel Ferreira, João Mendes-Moreira, and Luis Damas (2013), and by Mark E.T. Horn (2002). Study by Mark E.T. Horn (2002) is bases on existing modelling system called LITRES-2, and study by Luis Moreira-Matias, João Gama, Michel Ferreira, João Mendes-Moreira, and Luis Damas (2013) is based on computational modelling. Depending on the accuracy demand of the company and availability of datasets and knowledge one can model demand based from history and adjust it to current situation with a model that updates constantly based on ad hoc demand. Issan Kouatli (2014) based his demand modelling on Fuzzy Taxi Scheduling System, that is based on similar datasets, but can obtain “Fuzzy variables”, such as driver skill capacity and traffic conditions. In this case context, it was identified that required datasets, “hard” nor “Fuzzy” ones, do not exist and cannot be created anytime soon by Kovanen (Iivonen, 2017). James Wong, Albert Chan, Y.H Chiang (2004) made a review of different manpower demand forecasting methods. Based on their research “time series projection” method is the best method when forecasting manpower demand in one year or longer periods.

4.1 A gap between planned and realized operating hours

This problem has been identified as one the most difficult ones. As the problem itself is very holistic, directly related studies were not found. Problem of employees not completing their shifts to the fullest is however a management problem, and given the fact that some employees might actually quit their shift during the most beneficial and highest earned hours, Kovanen could find solution from performance management.

Cardy (2004) states that “performance management is a critical aspect of organizational effectiveness”. He also argues that “Although performance evaluation is at the heart of performance management, the full process extends to all organizational policies, practices and design features that interact to produce employee performance”. Kahn, W. A (1990) states that employee engagement and performance are directly linked to each other.

According to Jamie A. Gruman, Alan M. Saks (2011) the key factors for employee succees management are: Performance agreement, goal setting, psychological contracts, engagement facilitation, job design, coaching and social support, leadership, training and feedback. They also built a figure to demonstrate their model.

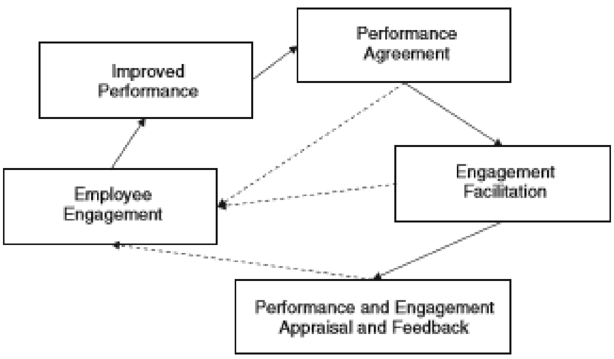

Figure 5. Engagement and performance management model by Jamie A. Gruman, Alan M. Saks (2011). Arrows around the circumference of the model represent the engagement management process. Dotted lines represent the drivers of employee engagement (Jamie A. Gruman, Alan M. Saks (2011)).

As there is a direct link between employee engagement and performance, and in Kovanen’s case in employee performance and company success, Kovanen should, arguably, in some extend start an employee engagement project. There are several benefits to such approach, and one of them would be drivers driving their shifts to the end. Problem of gaps between realized and planned operating hours directly links to driver’s performance, which could be in some extend solved by better training, coaching, managing and engaging of drivers.

4.2 Morning shift change problem

Morning shift change problem was identified in section 3. This problem can be divided into two different sections. First section is the lack of drivers that causes Kovanen not being able to dispatch as much busses as they would want to. As recruitment and HR is not part of this study, we will not address this problem in this Thesis. Second section is the shift change problem. As the shift change time is “normally” at 06:00, it is in the middle of the highest peak demand time of Kovanen’s busses. Ta-Hui Yang, Shangyao Yang, Hsuan-Hung Chen (2003) proposed the use of flexible shift start strategy. Decentralizing shift change and starting times could solve the problem of one single shift change moment where there are not enough busses due to all busses making their driver change. A.T Ernst, H Jiang, M Krishnamoorthy and D Sier (2004) proposed overlapping of night and morning shift to ensure that all duties are taken care of in the moment of shift change. This is however not possible when all vehicles have a morning driver, but applicable when all busses are not operating.

4.3 Too many busses operating around midday and from 19:00 to 22:00

Martin Desrochers, Francois Soumis (1989) and Anthony Wrent, David O. Wrent (1995) were one the many using computational modelling to resolve public transportation crew scheduling problem. Public transportation is in some cases facing some the same problems as Kovanen. During the rush hours of the day, several more “bus lines” are driven, but during slower times much less operating busses are needed. Using block modelling approach by Maikol M. Rodriques, Cid C. de Souxa and Arnaldo V. Moura (2006), both Martin Desrochers, Francois Soumis (1989) and Anthony Wrent, David O. Wrent (1995) came into solution where different types of workdays types are required. According to Martin Desrochers, Francois Soumis (1989) different workdays are:

> In general, three types exist: the tripper, a small piece of work (one or two consecutive tasks) unassigned to a driver and usually performed as overtime; the straight, a workday of one or two pieces of work with a very short break between the two pieces of work; and the split, a workday composed of two or more pieces.

From these three general types, Kovanen is already using two of the first, but the “split” is not used yet. To decrease the number of operating busses around midday and early evening, Kovanen should implement split shifts to decrease the number of operating buses around the midday time. Based on Ta-Hui Yang, Shangyao Yang, Hsuan-Hung Chen (2003) flexible shift start strategy and flexible shift length strategy Kovanen should also not allow drivers to begin their shift in the beginning of the slow time slot, or allow them to quit their shift at the end of slow time slot, such as midday time is for Kovanen.

4.4 Afternoon lost opportunities

Kovanen has probably, in some extend, been unaware of the magnitude of demand during afternoon rush hour. It is crucial to Kovanen to make sure that all possible busses are operating during this time. Based on flexible shift start strategy Ta-Hui Yang, Shangyao Yang, Hsuan-Hung Chen (2003) starting night shifts very early, in the beginning or during this peak time, could help Kovanen buses to stay operational during this peak time, due to the fact that some drivers will quit their shifts due to early start or just not being able to continue for any reason. Flexible shift length strategy Ta-Hui Yang, Shangyao Yang, Hsuan-Hung Chen (2003) could also be used to create short shifts, for example shifts of 6 hours, from 13:00 to 19:00.

Similar to “gap between realized and planned hours”, afternoon lost opportunities also links to employee engagement and performance issues. Therefore, one solution to afternoon lost opportunities problem could also be found in engagement and performance model by Jamie A. Gruman, Alan M. Saks (2011). At the moment Kovanen and Kovanen’s drivers may or may not be aware that afternoon is one of their best paid operating hours, and therefore improvement may occur with better management and training.

4.5 Late evening peak time problem

Late evening demand peak is not as high as the afternoon, except for Friday and Saturday evenings where the peak is actually very long in terms of time and therefore allowing full length shifts. Increasing the amount of night shifts may not be the best solution to cover this time, due to the slow demand times surrounding it. Using split workdays, introduced by Martin Desrochers, Francois Soumis (1989), starting from afternoon, and using short night shifts with all possible ways, for example Ta-Hui Yang, Shangyao Yang, Hsuan-Hung Chen (2003) flexible shift start strategy and flexible shift length strategy, could be solution to late evening peak. Similar to afternoon, though the peak is not as high as afternoon, late evening peak requires more busses than the surrounding times and therefore requires that shift beginning before this peak will end at the end of late evening peak, and not too many of the shift that last longer it will start too early compared to the start of this peak time. Required number of cars will be calculated in section 5, to more clearly identify the need for change.

4.6 Weekend nights problem

Though the weekend nights are arguably the best and the busiest times of the week, Kovanen has not been able to find a solution how to operate all of their busses during this time. Finding solutions to this heuristic problem from existing literature was found impossible. As Kovanen's operating model is very close to taxi industry it was expected that some knowledge could have been found in taxi related studies. However, this turned out to be the opposite. None of the studies identified such problem. Actually, in conversations with company stakeholders Iivonen (2016,2017) it became clear that usually the problem is vice-versa in the taxi industry. Often taxis have more willing drivers for weekend nights than they have vehicles to operate. According to Iivonen (2016,2017) and Koullias (2016) it is very likely that this is due to the high average age and low number of drivers with a required licence to drive a bus, and it links also directly into the driver issues that Kovanen is currently suffering from.

It was found that there are no simple solutions to this problem. Kovanen could pay a bus driver license to some taxi drivers, but it would be very expensive and the return of investment time would be unacceptable, at least if such drivers are used only for weekend nights. Forcing drivers that Kovanen already have can have an impact of losing drivers, which would then cause decrease in turnover, and therefore might be a risk that Kovanen does not want to take.

Based on literature the only solution that could be applicable for Kovanen would be using block model approach Maikol M. Rodriques, Cid C. de Souxa and Arnaldo V. Moura (2006) and three step approach presented by (Ta-Hui Yang, Shangyao Yang, Hsuan-Hung Chen, 2003). Together these models would create a system where Kovanen designs a shift frame from which a driver chooses his shifts. In this system Kovanen could create sets which would include for example day shifts and one weekend night. In this case, if a driver wants to driver for Kovanen, he would have to except one “unwanted” shift for getting his shifts for any given week.

Similar to “afternoon lost opportunities” -problem and “gap between planned and realized operating hours” -problem, weekend nights problem could also be solved with better employee management and training, at least in some extend.

4.7 Quarterly demand fluctuations problem

Quarterly and monthly demand fluctuations are a very important factor when Kovanen is planning their shifts. As it was pointed out in section 3, demand fluctuates inside a year significantly, both during daytime and night-time.

Based on Ta-Hui Yang, Shangyao Yang, Hsuan-Hung Chen (2003) flexible shift start strategy Kovanen should not offer more shifts to their drivers than required in slow times. Employee engagement and performance studied by Jamie A. Gruman, Alan M. Saks (2011) relates to lack of sufficient management and training at Kovanen, which results in lack of understanding from drivers’ point of view. By training and performance management Kovanen’s drivers could understand what are the correct moments to increase or decrease the number of working hours, and what is the correct time to keep one’s holidays for example.

Michael Mederer, Gerrit Klembert (2008) studied a heuristic problem in the Frankfurt airport, where de-peaking of peak times was a solution for demand fluctuations. In Kovanen’s case de-peaking demand could solve some of the operational problems. De-peaking has been studied mostly in the airline operations, where airlines can in some extend include de-peaking in their manpower planning and operations. As Kovanen is not directly able to effect customers need for transport, de-peaking in Kovanen's industry might turn out to be close to impossible.

4.8 Conceptual framework

Though there is a set of tools and data that can be used for analyzing, required large scale and detailed data for using computational modelling of demand is not available for Kovanen. A case example type of approach has to be taken and demand modelled with building an equation(s) out of datasets available for demand modelling. Based on demand modelling, a model to calculate fleet size and dispatching can be created.

When calculating the required fleet size, one must understand that the financial result of the company is linked to the fleet utilization, and as Yang, Hai; Ye, Min; Wilson Hon-Chung Tang; Wong, Sze Chun (2005) argued, “taxi utilization rate and hence average revenue increase initially with taxi fleet size”. But as pointed out themselves, when taxi utilization increased, earnings per car decrease, momentarily. This has an impact on driver salary, and may cause drivers to leave Kovanen.

A three-step approach for shift planning would fit Kovanen's shift planning environment perfectly, if lack of workforce issue is taken out the equation. This approach is proposed to Kovanen's stakeholders. The fear of losing workforce may however be a risk that Kovanen is not able to take, and the therefore applying a method that decreased the possibility of making compromises could be impossible. Applying flexible shift length and start strategy is a must for Kovanen, in order to create more flexibility to shift planning. Block model represented by Maikol M. Rodriques, Cid C. de Souxa and Arnaldo V. Moura (2006) should be taken into consideration by Kovanen's stakeholders due to the peaking demand identified in section 3.

Management problems have also been identified, and therefore Kovanen should also focus on training and performance management of their drivers. James Wong, Albert Chan, Y.H Chiang stated that “appropriate training can only be developed if training needs are carefully identified”. Is this case context, the need for training can be clearly identified from all the problems identified in current state analysis.

Continuous improvement is a must in always changing demand and supply environment, such as taxi market or Kovanen minibus service market. Action research (McNiff, Jean 2013) -type of circle of improvement and research was identified by author as the best way making sure that Kovanen implements continuous improvement methodology to their shift planning. Based on the idea of continuous improvement and action research, a circle of improvement for shift planning was created as a tool for Kovanen's future shift planning.

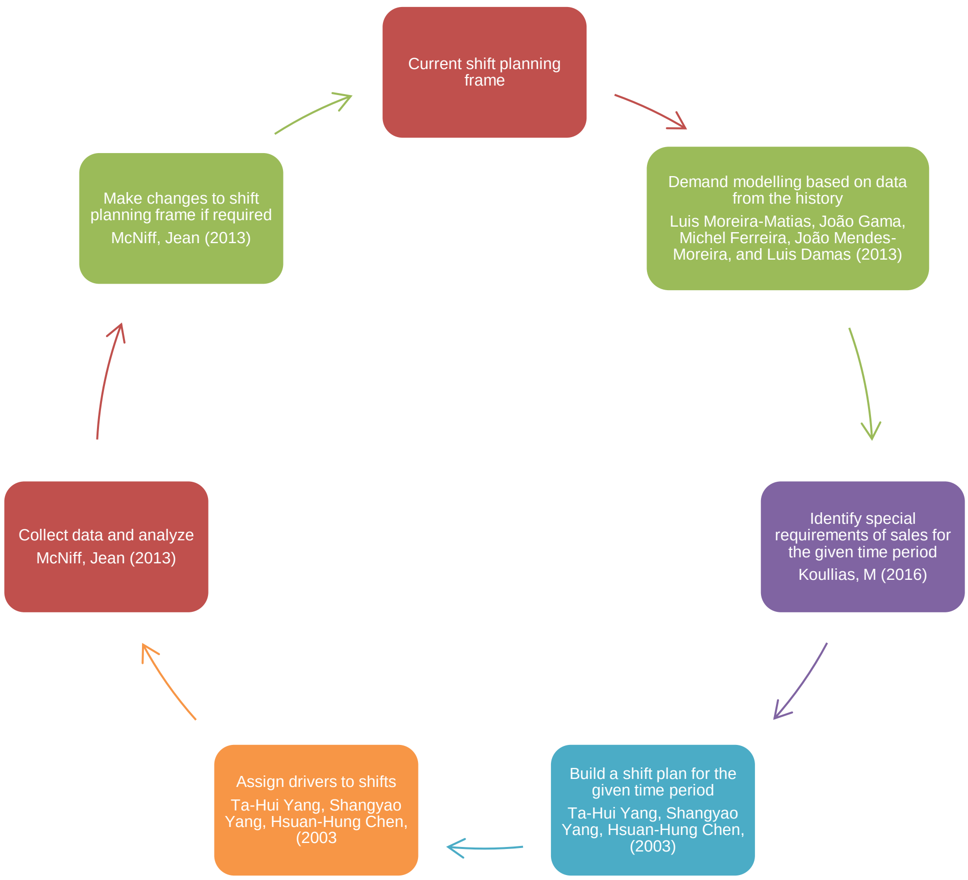

Figure 6. Shift planning frame development circle.

5 BUILDING AN IMPROVED SHIFT PLANNING FRAME

In the beginning of this Thesis basic dynamics of Kovanen's minibus service were told. After a project plan was set, the current situation of shift planning and fleet efficiency was analyzed through many different sets of data. Several problems and problematic times were identified that would require improvements to gain maximum profit and financial outcome, and on the other hand to meet the customer service expectations with best way possible. After the problems were found, a large-scale search of existing knowledge and tools was done to find and identify the key issues and tool for improvement. Though finding useful tools and solutions from existing knowledge was found very difficult, some tools and key insights were found. In this section, an ideal model will be built to be used as shift planning frame. From the basis of this frame, building optimal shift plans for drivers and optimizing the fleet utilization and financial result should be possible.

5.1 Demand modelling

In order to create shift planning frame, demand must be modelled and transformed into a form which shows the number of required buses on any given time. As identified in the previous section, computational models require input data that Kovanen does not possess and therefore seeking for alternative ways to model demand is a must.

As shown in section 3, finding data on lost opportunities as well as bus earnings on any given time is possible. As the bus earnings in any given time period and the amount of lost opportunities are known, it is possible to build a model for required amount of buses if it is possible to calculate value of a lost opportunity. As the drivers are working on profit based salary, a zero variable for bus earnings per hour must be set to make sure drivers salary is in an acceptable level for them.

To model demand, Kovanen’s statistics program is used to print out total earnings by all operating cars with time windows as well as the average price of a completed order.

	Ma	Ti	Ke	To	Pe	La	Su
0:00	3656,5	2637,4	4876,3	5614,8	5613,5	9733,4	10314,9
1:00	3105,6	2507,4	3305,2	3691,4	4126,7	8237,2	9285,3
2:00	2468,1	1404,2	2154,8	3196,7	4294,8	6894,4	7252,9
3:00	3218,3	2478,3	3898,4	5085,4	5084,8	8689,2	7361,5
4:00	4627,5	4314,4	7838,9	8400,9	8661,7	10198,3	9694,6
5:00	6254,1	6726,2	8585,6	9411,6	10189,7	9362,3	9328,8
6:00	6362,7	7693,6	8700,5	10267,4	8874,8	5796,4	7132,9
7:00	4309,1	6582,8	8032,6	8716,6	7822,9	4707,5	5029,0
8:00	5640,3	9324,6	9875,5	10502,0	9169,5	3777,2	4317,5
9:00	5082,2	7651,2	8145,6	9566,8	8703,6	4801,5	5333,1
10:00	5358,8	6012,4	6591,4	7605,4	8191,6	5703,5	5151,5
11:00	5116,5	6573,6	7142,5	8466,5	8901,7	6234,9	6112,5
12:00	5720,8	6773,4	7964,4	9379,7	8742,0	6645,8	6444,9
13:00	5616,5	7111,9	8657,2	9048,9	9836,8	8028,1	6293,5
14:00	6873,5	7910,2	10347,1	10702,2	11467,6	7953,6	6968,0
15:00	5859,9	7892,7	10840,1	11374,6	10775,7	8130,0	7559,5
16:00	5045,9	6691,0	9521,1	9381,7	9914,4	7439,5	5877,4
17:00	4261,0	5947,3	8918,5	8503,5	8415,3	6941,6	5378,3
18:00	3137,5	4885,8	6059,3	6264,4	5981,2	6857,2	3307,7
19:00	1935,1	4219,8	5420,2	4695,7	6281,7	7093,1	2639,5
20:00	1680,5	3388,2	5525,3	4997,5	5979,9	7038,2	2606,9
21:00	2135,2	4122,5	6212,1	5533,8	6258,1	7247,8	1895,3
22:00	2245,2	4917,9	6258,2	5882,1	8568,1	8570,8	2380,3
23:00	2242,3	4080,4	6163,0	5805,4	8858,1	11061,4	4300,6

Table 31. 10-seater total earnings during the analysed 26-week period.

To calculate entire demand, it is required to take into account the lost opportunities and their value. Lost opportunities were already analysed in section 3. Kovanen's statistic program is able to calculate average for completed order based on all driven orders during this 26-week period. In the used time frame average value for completed order for 10-seaters is 28,7 euros per driver order, and for 16-seaters 32,7 euros.

Lost opportunities will be multiplied with average completed order price to create estimated value of lost opportunities.

$$L_{value} = A_{Total} * P$$

Where L_{value} is total value of lost opportunities, A_{Total} is the amont of lost opportunities and P is the average price of completed orders. Results of calculating value of lost opportunities are shown in table 32 below.

	Ma	Ti	Ke	To	Pe	La	Su
0:00	1492,4	746,2	746,2	746,2	1492,4	4477,2	21639,8
1:00	746,2	746,2	746,2	0	746,2	4477,2	14924
2:00	746,2	746,2	0	0	0	4477,2	12685,4
3:00	746,2	746,2	0	0	746,2	5223,4	16416,4
4:00	1492,4	746,2	746,2	746,2	2984,8	8208,2	26117
5:00	2238,6	746,2	746,2	2238,6	2984,8	5223,4	7462
6:00	2984,8	746,2	746,2	2238,6	2238,6	3731	5223,4
7:00	1492,4	746,2	1492,4	1492,4	1492,4	1492,4	2238,6
8:00	2238,6	4477,2	4477,2	5969,6	2984,8	746,2	746,2
9:00	1492,4	2984,8	2238,6	2984,8	2238,6	746,2	746,2
10:00	1492,4	1492,4	2238,6	1492,4	2238,6	746,2	746,2
11:00	746,2	2238,6	1492,4	1492,4	2238,6	746,2	746,2
12:00	1492,4	1492,4	1492,4	1492,4	2238,6	2238,6	1492,4
13:00	1492,4	1492,4	1492,4	1492,4	2238,6	3731	1492,4
14:00	2238,6	1492,4	2238,6	5223,4	5223,4	6715,8	2984,8
15:00	2238,6	3731	3731	7462	6715,8	6715,8	2238,6
16:00	2238,6	2984,8	3731	7462	4477,2	2984,8	746,2
17:00	2984,8	5969,6	4477,2	6715,8	5223,4	4477,2	746,2
18:00	2238,6	5969,6	2984,8	3731	5969,6	3731	746,2
19:00	1492,4	2238,6	1492,4	1492,4	2984,8	2238,6	746,2
20:00	1492,4	1492,4	746,2	1492,4	2238,6	2984,8	746,2
21:00	1492,4	1492,4	746,2	1492,4	1492,4	2984,8	746,2
22:00	1492,4	1492,4	1492,4	2984,8	2238,6	8208,2	746,2
23:00	746,2	1492,4	746,2	2984,8	4477,2	22386	746,2

Table 32. Estimated value of lost opportunities for 10-seaters.

To understand the value of lost opportunities better, the sum of estimated lost opportunities value in table 32 is 493995,9 euros in 26-week period for 10 seaters. If the turnover of Kovanen's minibuses does not dramatically change and would be 4 million euros in one year, this would mean that in terms of money Kovanen could increase their turnover by 20-25% if they would be able meet demand. As pointed out in section 3, Kovanen also has lost opportunities that are not in the system, and their value is not included into these calculations.

	Ma	Ti	Ke	To	Pe	La	Su
0:00	3726,4	1991,2	1822,0	4820,6	4552,3	7227,2	9316,5
1:00	2658,9	1780,4	1766,5	2497,1	3062,5	6735,4	7125,3
2:00	1712,7	961,1	935,0	2029,0	1996,1	4364,8	5904,1
3:00	3279,2	2121,5	2167,3	3531,4	4048,8	5576,9	5758,1
4:00	3376,4	3246,4	3611,3	3707,0	5373,2	5745,1	6518,8
5:00	3819,8	3839,4	3951,9	3999,2	4614,0	3632,9	4342,8
6:00	3727,7	4107,3	5039,2	4793,5	4474,1	2366,6	2032,5
7:00	3181,4	4517,4	5185,2	5727,5	4703,2	1635,0	1242,9
8:00	4860,5	7199,0	7504,0	8391,2	7149,6	2205,6	2160,7
9:00	4870,9	6622,6	6023,0	7629,7	6420,8	2932,3	1661,2
10:00	4101,2	5136,8	5595,8	6916,8	5828,9	3169,2	2788,5
11:00	4339,8	5857,1	6261,5	6400,4	6358,1	3635,3	3744,6
12:00	4605,7	5915,1	6401,7	7744,2	7163,2	5198,5	4201,8
13:00	4948,6	6156,6	7008,6	8161,8	8162,6	5607,0	4963,4
14:00	5415,1	8059,6	8601,6	9247,9	10306,9	6434,9	5506,1
15:00	6259,3	9041,1	10749,7	10559,5	9976,3	8030,6	5430,1
16:00	5741,3	7962,0	9783,1	9943,2	9243,4	7432,5	6335,5
17:00	5329,7	6772,1	7289,7	9230,8	10175,1	8443,9	6458,0
18:00	3558,3	4805,0	6625,2	6442,8	10221,8	9289,3	5366,9
19:00	2604,1	3366,0	5017,8	5459,3	6834,5	8554,9	4870,3
20:00	2471,3	2351,9	3359,4	4408,5	5675,8	7389,9	2998,7
21:00	2803,9	2706,7	3308,7	4157,3	5216,0	7488,1	2444,7
22:00	2362,8	2674,5	4322,2	5604,4	6943,7	8586,0	2657,6
23:00	2582,8	2251,2	4268,0	5562,7	8166,4	10797,2	3437,1

Table 33. 16-seater total earnings during the analysed 26-week period.

Table 33 is the total earning of 16 seaters in the analysed 26-week period. The average value for completed order for 16 seaters is 32,7 euros. From this table a calculation for value of lost opportunities for 16-seaters can be done.

	Ma	Ti	Ke	To	Pe	La	Su
0:00	0	0	0	0	0	2550,6	14453,4
1:00	0	0	0	0	0	1700,4	7651,8
2:00	0	0	0	0	0	850,2	4251
3:00	0	0	0	0	0	1700,4	5101,2
4:00	850,2	0	0	0	0	2550,6	9352,2
5:00	0	0	0	0	0	850,2	1700,4
6:00	0	0	0	0	0	850,2	850,2
7:00	0	0	0	0	0	0	0
8:00	0	850,2	850,2	850,2	0	0	0
9:00	0	850,2	0	0	0	0	0
10:00	0	0	0	0	0	0	0
11:00	0	0	0	0	0	0	0
12:00	0	0	0	0	0	850,2	0
13:00	0	0	0	0	0	1700,4	0
14:00	0	0	0	850,2	850,2	2550,6	850,2
15:00	0	850,2	850,2	1700,4	1700,4	1700,4	850,2
16:00	0	850,2	850,2	1700,4	850,2	850,2	0
17:00	0	1700,4	850,2	1700,4	1700,4	1700,4	0
18:00	850,2	1700,4	850,2	1700,4	1700,4	1700,4	0
19:00	0	850,2	0	850,2	0	850,2	0
20:00	0	0	0	0	0	850,2	0
21:00	0	0	0	0	0	850,2	0
22:00	0	0	0	850,2	850,2	5951,4	0
23:00	0	0	0	850,2	2550,6	17854,2	0

Table 34. Estimated value of lost opportunities for 16-seaters.

In total the estimated value of 16-seaters lost opportunities is 128380,2 euros.

Based on tables 31-34 it is possible to build figures that show the same information in more graphical view, as bars per time. As pointed out in section 3, weekdays and week-end are very different in terms on demand, and therefore shown in different figures.

Equation for calculation is:

$$D_{Total} = E_{Total} + L_{value}$$

Where D_{Total} is the total demand and E_{Total} is the total value of bus earnings.

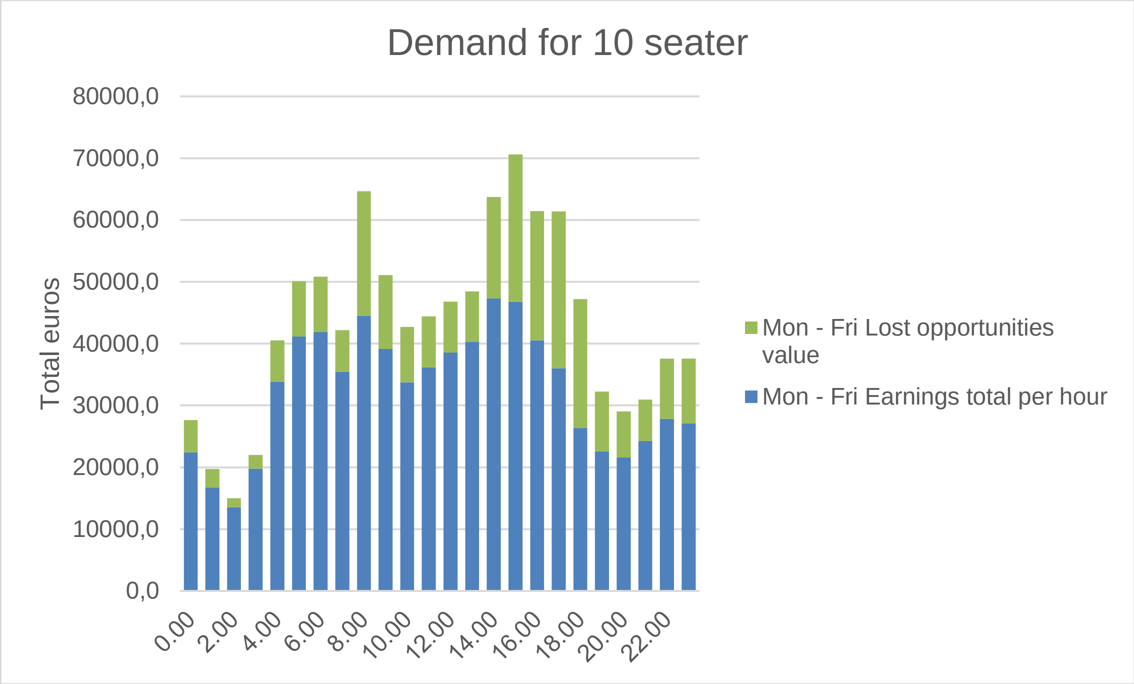

Figure 7. Complete demand for 10-seaters from Monday to Friday.

Figure 6 shows the peak times of the week more clearly than tables presented before. Figure 6 also shows the value of lost opportunities compared to completed orders value.

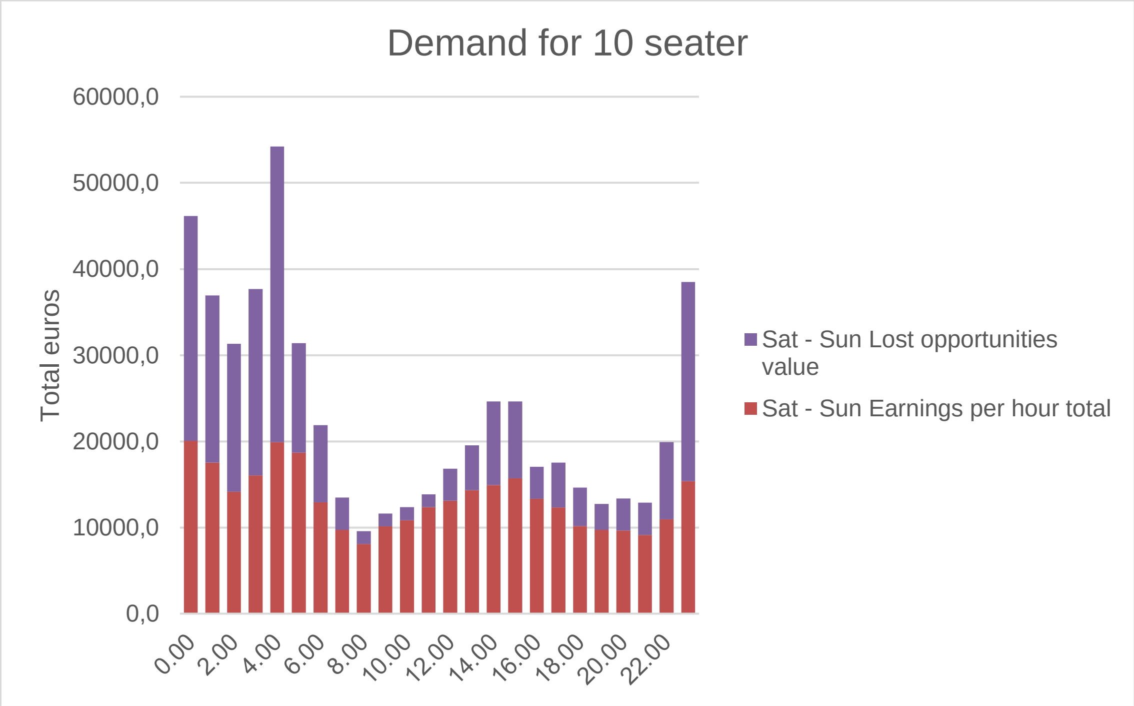

Figure 8. Complete demand for 10-seaters from Saturday to Sunday.

Figure 8 shows the exactly same demand peak times as identified earlier, but added lost opportunities also highlight these problematic times.

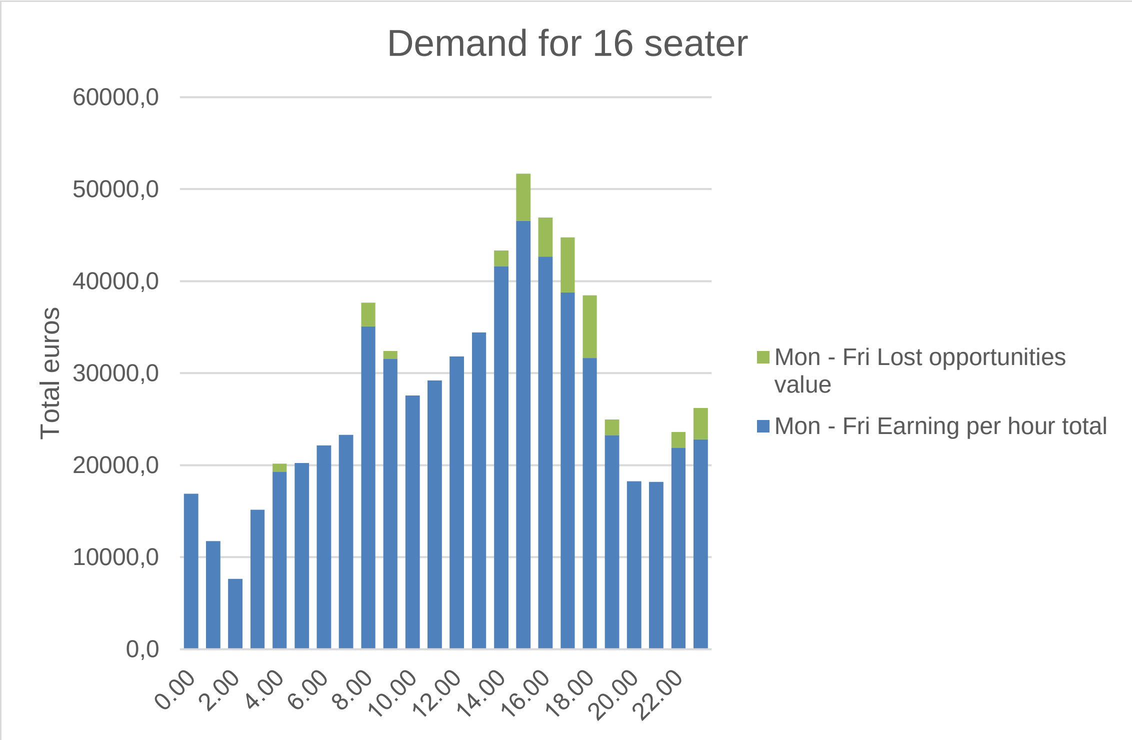

Figure 9. Complete demand for 16-seaters from Monday to Friday.

For 16-seaters the peak times are much clearer than with 10-seaters, and lost opportunities are almost non-existing outside demand peaking times.

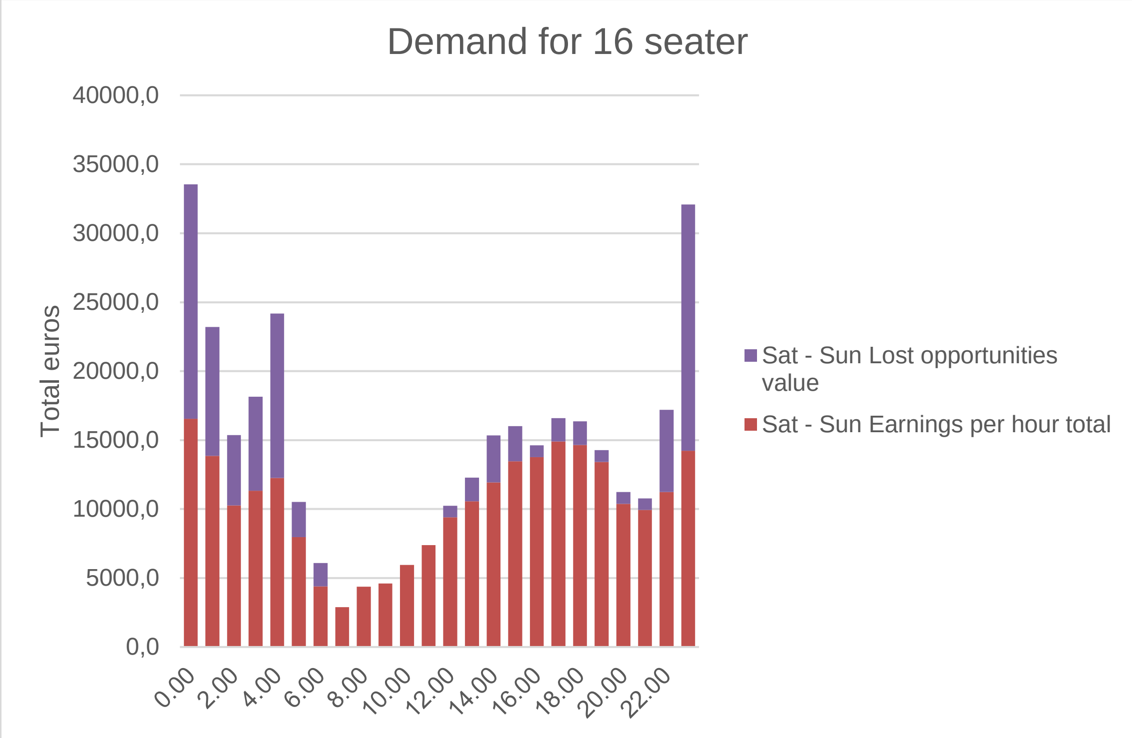

Figure 10. Complete demand for 16 seaters from Saturday to Sunday.

Figure 10 shows the value of Friday and Saturday nights in its full extend. Demand in weekend nights is massive, and Kovanen is not able to fully utilize the potential of these times.

5.2 Workforce issues versus financial result

As told in the introduction section, Kovanen suffers from lack of drivers. Therefore, the earnings zero variable that governs the driver salary base cannot be too low, or too low salary will cause more drivers to leave. On the other hand, too low number of operating buses will cause lost opportunities and financial losses to the company itself.

Though the subject of workforce problems in itself is not a part of this thesis, it is so important that some analysis is required to identify what is the impact to shift planning before the shift planning frame is built. Employee satisfaction, that governs the decision weather if a driver stays with Kovanen or not, is likely to be a combination of many employee related issues, such as working condition, management, etc., but in terms of this thesis only the financial aspect is relevant. As the number of operating buses directly links to earnings of a single car, it is possible model the effects of increasing operating fleet size against driver salary.

As the used reference period does not include radical changes to workforce situation, a different time period where such changes have occurred was chosen. From statistics, a period of January 2017 to March 2017 was chosen. Kovanen had a large increase of driver capacity during this timeframe. Focus is on two main issues: Driver salary change and financial result of minibus were selected. Both of them will be compared to realized operating hours.

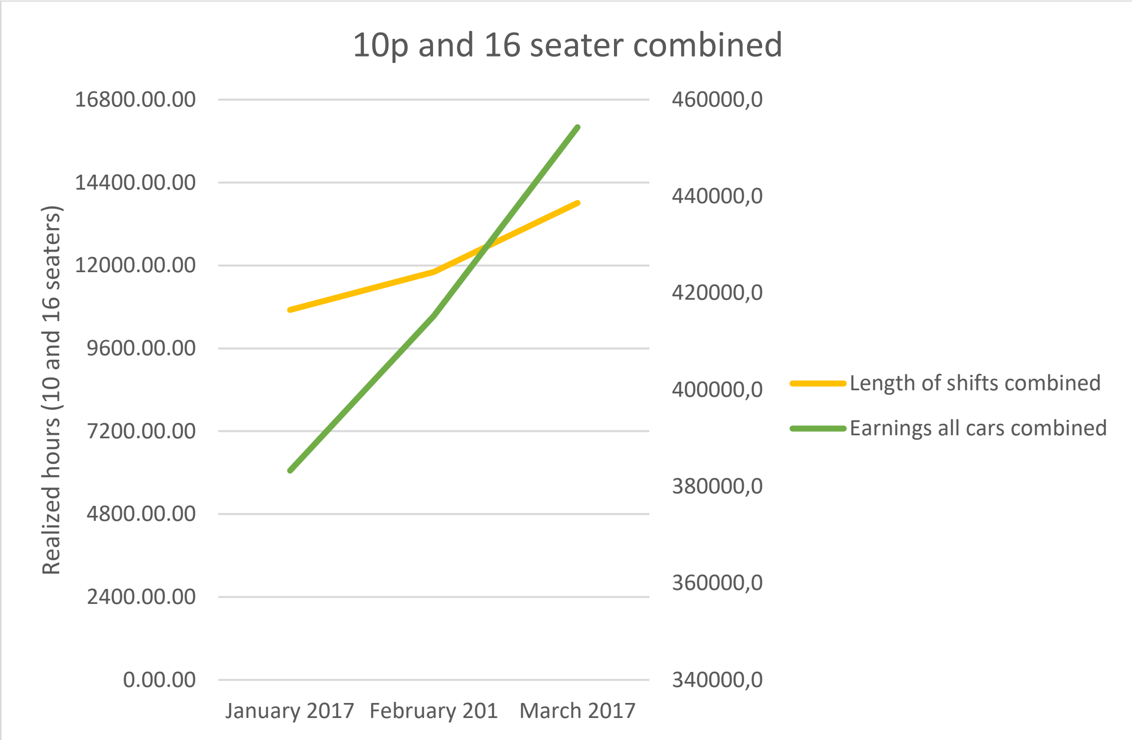

Figure 11. Shift length and earnings for 10- and 16-seaters combined.

From figure 11 it is possible to clearly identify that earnings total is directly linked to total length of operated hours. It is obvious that Kovanen would like to dispatch as much as possible to gain maximum financial result for their minibuses department.

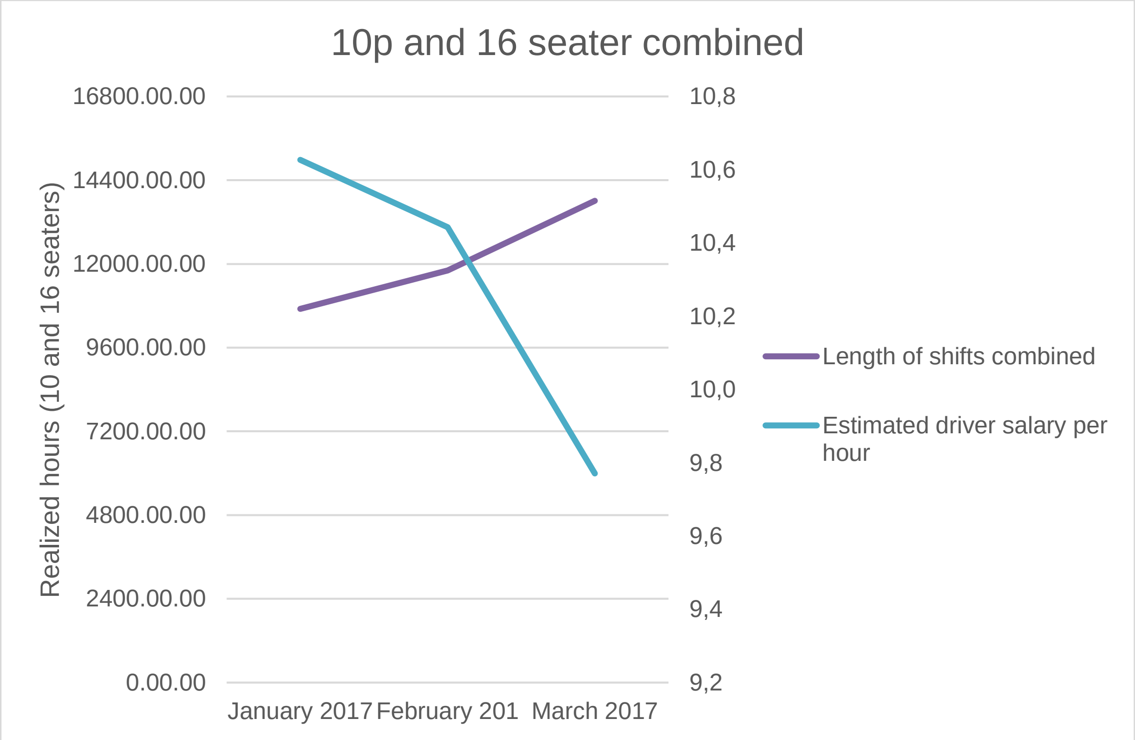

Figure 12. Driver salary and length of operated hours in total,10 and 16 seaters combined.

Figure 12 shows direct link between driver salary and realized operating hours. Though Kovanen would like to dispatch more buses to get better financial result, it may be impossible in a long run as when the driver salary reaches critical point, it will cause drivers to leave and hence causing the lack of workforce to repeat itself. It is important to find balance between fleet dispatching and driver salary to maximize both company financial result and driver salary. According to Hai Yang, S.C. Wong and K.I.Wong (2001) dispatching more vehicles should cause economies of scale and hence increase demand. Though this may be true, it is likely that such increase in demand will come delayed. This approach may cause even bigger problems for Kovanen as if demand increases and drivers start to leave just before demand increase due to low salary, it can cause a situation where Kovanen is not able to meet such demand increase and is not able to deliver their customer promise. Therefore, arguably, Kovanen should dispatch their buses side by side with driver salary and demand development.

5.3 Equation for calculating shift planning frame

From the statistics shown in section 3 it is possible to identify that when hourly earnings drop below 28 euros, the amount of lost opportunities drop very close to zero. This would be an optimal level from Kovanen's point of view.

Driver salary can be calculated (on average) with an equation of:

$$S = E_h \times T \times P$$

In this equation, S = Salary, E_h= Car earnigns per hour, T = Multiplier for tax (1 – tax/VAT level) and P = Salary percentage from takings.

In average situation, the salary of a driver in case of 28 euros' bus hourly earnings would be 8,32 euros per hour. For a full-time worker on monthly basis this would be a salary of approximately 1830 euros per month. Arguably, when compared to Finnish overall pricing and the number of working hours operated by a driver, salary is probably not acceptable from a driver point of view. With hourly earnings of 35 euros per operating bus a driver will reach a salary of 10,4 euros per hour and 2287 euros per month on average. In this thesis context, assumption that this would be an acceptable level of salary for a driver is used, and for that reason it will be used as the zero variable. Zero variable can be changed later according to the needs by either Kovanen or shift planner.

Previously an equation of demand was created in to a form of:

$$D_{Total} = E_{Total} + (A_{Total} * P)$$

As shown before, number of required buses is calculated with demand divided with zero variable.

$$B = \frac{D_{Total}}{Z}$$

Where B is required number of buses and Z is zero variable. As the number of buses is required to calculate the demand, required number of busses in percentages would require dividing with full amount of buses, C_{Total}, which is added to the equation.

$$B_{\%} = \frac{D_{Total}}{Z * C_{Total}}$$

When considering the statistic system that Kovanen uses to download data required for calculating demand it is required to implement a time variable into the function. Time variable T_w is a divider when multiple week are downloaded from the systems. In this case, a time frame of 26 weeks was used to calculate long-term demand.

$$B_{\%} = \frac{D_{Total}}{Z * C_{Total} * T_w}$$

To have a completed equation for calculating $B_{\%}$ there is a need to implement previous equations into one equation. Also, a percentage limitation to 100% is required because Kovanen is not able dispatch more busses than they have. Equation forms into:

$$B_{\%}^{\lim 100\%} = \frac{E_{Total} + (A_{Total} * P)}{Z * C_{Total} * T_w}$$

5.4 Time of the year variable for shift planning

In section 3 it was identified that time of the year has an impact on demand. A variable for monthly demand is required when building a shift planning frame. To simplify the demand fluctuations, such monthly variable will be built in a very simple multiplier form which makes it easy to include into the equation shown in section 5.3, and easy to use and update when building a shift planning frame. If the time variable would be based on hourly demand, it would be required to have an own variable for every single hour and day of the week, which would make updating and using such variable much more difficult.

Time variable is formed directly from average earnings per hour from all buses and both sizes combined. Though such monthly variable is infected with lots of different factors, the most important is the earnings per hour per operating car, because it directly shows if too many or too little buses were operating. If other factors, such as the number of buses operating, demand, big happenings or time of the eastern at spring time would be taken into consideration, forming such equation would become almost impossible and would probably require large-scale computational modelling.

Monthly variable will be calculated by dividing monthly average earnings with total average earnings.

	Average earnings per hour	Montly average earnings / Total average
January 2016	30,1	0,94
February 2016	30	0,93
March 2016	29,2	0,91
April 2016	28,9	0,90
May 2016	31,7	0,99
June 2016	34	1,06
July 2016	33,7	1,05
August 2016	33,6	1,05
September 2016	33,8	1,05
October 2016	32,4	1,01
November 2016	33,2	1,03
December 2016	34,6	1,08
Average	**32,1**	**1,00**

Table 35. Calculation and values of monthly variable.

In table 35, a monthly variable M_{time} is created based on bus earnings fluctuations on monthly basis. Though the calculation method itself is very simple and possibly in some ways incomplete, the information is accurate enough to include it to the equation for calculating required fleet percentage. Calculated monthly variable is in itself a constantly changing variable, and it should be used from running 12 months. Used in such way monthly variable changes over time together with demand changes.

When monthly variable M_{time} is added into the equation for calculating required fleet size, the equation is completed into the final form of:

$$B_{\%}^{\lim 100\%} = \frac{E_{Total} + (A_{Total} * P)}{Z * C_{Total} * T_w} * M_{time}$$

5.5 New shift planning frame

In this section, the created equation to calculate required fleet size in any given time period will be used. Monthly variable will not be used in formation of this frame, as the frame is only a starting point for cycle of development in shift planning, and given results are not to represent any specific month of the year.

	Ma	Ti	Ke	To	Pe	La	Su
0:00	31	21	34	39	43	87	100
1:00	24	20	25	23	30	78	100
2:00	20	13	13	20	26	69	100
3:00	24	20	24	31	36	85	100
4:00	37	31	52	56	71	100	100
5:00	52	46	57	71	80	89	100
6:00	57	52	58	76	68	58	75
7:00	35	45	58	62	57	38	44
8:00	48	84	88	100	74	28	31
9:00	40	65	63	77	67	34	37
10:00	42	46	54	56	64	39	36
11:00	36	54	53	61	68	43	42
12:00	44	50	58	66	67	54	48
13:00	43	53	62	64	74	72	48
14:00	56	57	77	97	100	90	61
15:00	49	71	89	100	100	91	60
16:00	44	59	81	100	88	64	40
17:00	44	73	82	93	83	70	37
18:00	33	66	55	61	73	65	25
19:00	21	39	42	38	57	57	21
20:00	19	30	38	40	50	61	20
21:00	22	34	42	43	47	62	16
22:00	23	39	47	54	66	100	19
23:00	18	34	42	54	81	100	31

Table 36. New shift planning frame for 10-seaters.

Table 36 is the new shift planning frame for 10-seaters, based on long time demand analysis from 26-week time period from the end of 2015.

	Ma	Ti	Ke	To	Pe	La	Su
0:00	31	17	15	41	38	83	100
1:00	22	15	15	21	26	71	100
2:00	14	8	8	17	17	44	86
3:00	28	18	18	30	34	62	92
4:00	36	27	31	31	45	70	100
5:00	32	32	33	34	39	38	51
6:00	32	35	43	41	38	27	24
7:00	27	38	44	48	40	14	11
8:00	41	68	71	78	60	19	18
9:00	41	63	51	64	54	25	14
10:00	35	43	47	58	49	27	24
11:00	37	50	53	54	54	31	32
12:00	39	50	54	65	61	51	36
13:00	42	52	59	69	69	62	42
14:00	46	68	73	85	94	76	54
15:00	53	84	98	100	99	82	53
16:00	49	74	90	98	85	70	54
17:00	45	72	69	92	100	86	55
18:00	37	55	63	69	100	93	45
19:00	22	36	42	53	58	80	41
20:00	21	20	28	37	48	70	25
21:00	24	23	28	35	44	70	21
22:00	20	23	37	55	66	100	22
23:00	22	19	36	54	91	100	29

Table 37. New shift planning frame for 16-seaters.

Table 37 is the new shift planning frame for 16-seaters, based on long time demand analysis from 26-week time period from the end of 2015.

In section 4 the need for cyclic development where previous shift planning frame is used to create a new one was identified. Shift planning frame is never completed as demand varies and changes over time, and therefore shift planning frames shown in tables 36 and 37 work only as the starting point for continuous improvement cycle. Also, the frames do not include the monthly variable, which is very important due to high demand fluctuations during the year.

To more clearly show the required need for change, tables for required change on hourly based will be calculated. These tables will show the scale of required change in shift planning. In section 3 a current shift planning frame assumption was calculated. New shift planning frame will be compared to section 3 frame to calculate required change.

	Ma	Ti	Ke	To	Pe	La	Su
0:00	-4	-3	-8	-12	-9	23	41
1:00	-12	-4	-17	-27	-23	14	41
2:00	-16	-10	-29	-30	-26	6	41
3:00	-11	-9	-24	-24	-16	23	42
4:00	2	2	5	1	19	38	42
5:00	8	4	-2	5	18	21	35
6:00	3	-23	-27	-12	-17	12	31
7:00	-19	-31	-27	-27	-28	-9	0
8:00	-7	9	2	10	-11	-23	-18
9:00	-15	-11	-23	-14	-19	-19	-11
10:00	-14	-32	-36	-38	-24	-19	-17
11:00	-20	-25	-39	-34	-20	-17	-11
12:00	-13	-30	-39	-34	-28	-15	-8
13:00	-13	-28	-35	-36	-21	2	-9
14:00	0	-18	-15	5	5	20	4
15:00	3	6	6	15	13	25	9
16:00	-2	-6	-2	15	2	-2	-10
17:00	0	10	2	11	-1	4	-14
18:00	8	18	-5	-1	1	-12	-21
19:00	-4	-8	-18	-24	-15	-16	-22
20:00	-6	-18	-22	-22	-21	-12	-23
21:00	-3	-12	-17	-17	-25	-11	-27
22:00	-2	-5	-9	-3	-5	29	-21
23:00	-6	-9	-10	-1	13	33	-7

Table 38. Required change for 10-seaters in percentages.

Required change versus current situation for 10 seaters is shown in table 38. Table 38 shows that the required change means directly matching the peak demand times and slow demand times with dispatching more or less vehicles. Need for increase is massive during the weekend nights, big during timeframes of 04:00 to 09:00 and 14:00 to 18:00 and the need for decrease is big in timeframes of 01:00 to 04:00, 09:00 to 14:00 and 19:00 to 22:00.

	Ma	Ti	Ke	To	Pe	La	Su
0:00	-5	-5	-8	-1	-9	28	43
1:00	-11	-6	-8	-20	-21	21	49
2:00	-18	-13	-14	-22	-29	-3	39
3:00	-3	-9	-9	-6	-9	17	48
4:00	6	-4	-5	-1	7	36	61
5:00	2	-6	-10	-7	0	15	27
6:00	-9	-17	-16	-17	-10	10	9
7:00	-23	-28	-30	-27	-31	-8	-6
8:00	-12	-7	-13	-2	-22	-12	-3
9:00	-14	-14	-37	-19	-31	-9	-15
10:00	-22	-39	-43	-27	-37	-11	-13
11:00	-20	-36	-39	-35	-36	-17	-12
12:00	-17	-38	-40	-30	-35	-3	-14
13:00	-16	-38	-37	-29	-31	5	-10
14:00	-13	-19	-23	-11	-4	14	0
15:00	-1	2	8	6	4	19	-2
16:00	0	9	10	10	-3	-2	-5
17:00	2	19	2	14	13	9	-7
18:00	4	16	11	3	23	15	-12
19:00	-7	4	-3	-6	-13	4	-12
20:00	-6	-9	-16	-20	-19	-5	-24
21:00	-3	-6	-17	-23	-20	-1	-23
22:00	-6	-6	-8	-3	4	30	-18
23:00	-3	-5	-6	2	30	34	-9

Table 39. Required change for 16-seaters in percentages.

Required change versus current situation for 16-seaters is shown in table 39. For 16 seaters, there is a need to decrease the amount of operating buses almost all other times but from 15:00 to 18:00. Saturday from 14:00 forwards to Sunday morning 06:00 and Friday from 22:00 to Saturday morning 07:00 would need an increase in operating busses.

Required change for both sizes are subject to change when monthly variable is taken into account.

5.6 Solving the identified key issues

Key issues were identified in current state analysis (section 3). After this research from existing literature was done to find solutions for the issues identified. To begin the building, demand was modelled and new shift planning frame was built. To identify the key changes compared to current shift planning frame, required changes were calculated. For solving the identified key issues from section 3, they will be addressed individually to propose solutions to them directly.

5.6.1 Gap between planned and realized operating hours

Based on literature there were no direct solutions. However, some possible solutions were identified. From management and training perspective there were two key issues that Kovanen should focus on. Performance management and management practices in overall should be looked into, to ensure that the drivers are aware what Kovanen as a company wants and needs them to do for them. Best solutions to this would be creating a training that focuses solely on driver earnings and also having face to face timely conversations with drivers about their overall performance. Such training will be called “money training” in the context of this thesis.

It is important to understand that drivers are not willing or able to drive their planned shift fully. There are multiple reasons for this, such as upcoming shift change, physical condition of the driver, willingness to take “one more” order, etc. In conversations with Kovanen representatives (Koullias 2016, Iivonen 2016 and 2017) some key methods to solve such problems were identified:

- Agreeing about the actual length, start and ending times of each shift with drivers. Drivers have to understand the need to know how they actually operate so that Kovanen can plan the effects of them not operating on any given time. This should be done by discussing and agreeing with drivers individually. It is more important for Kovanen to actually know what are operating hours rather than just putting 12 hours shifts to the shift plan. So, if a driver is able or willing to drive only 10h shifts, such shift must be implemented.
- Using shift-start-order approach, where a driver already has assigned order in the beginning of their shift, to make sure they come in time. The purpose of such method is to motivate drivers to start their shifts as agreed. Such method is called shift-start-order.

- When possible, assigning an order to the end of their shift to make shift change more planned and to motivate the driver to continue until the end of their shift.
- Implementing formal conversations with drivers on timely basis
- Creating and implementing a money training for drivers to ensure that they themselves understand the benefits of operating in high peaks and not operating in slower demand times.

5.6.2 Morning shift change problem

In conversations with Kovanen stakeholders (Koullias 2016, Iivonen 2016 and 2017) and based on existing knowledge, such as the flexible shift starting time strategy, the decision to use early start morning shifts, and late-night shifts was made. Early start morning shift with starting time between 03:00 and 05:00 will help the shift change problem as some of the buses have already made their shift change while others will do it later. By decentralizing shift change times Kovanen is able to reduce the effects of shift change and to divide it into large number of hours. If there is use of shifts that start around midday or later, and there is no morning shift in such car, use of long night could help. Such night shift could be from 21:00 to 07:00 for example. This will also help the problematic slow demand time between 19:00 and 22:00. In section 3 the difference between 10- and 16-seaters in demand was noticed. Though 16 seaters are also in some extend useful during morning peak times, they are even more useful in the afternoon peak time. Best solution for Kovanen would be to start 10-seater shifts earlier than before, and to compensate such change with delaying starting times for 16-seaters with roughly equal amount. To make sure that drivers understand the need to operate as agreed in shift plan, a money training and shift-start-order should be implemented. Currently all Kovanen busses are making their shift changes in the same place. Kovanen should pilot test the possibility of drivers making their shift change “at home”. If two drivers live close to one another, significant time savings could be created by making the shift change at or close to their homes.

5.6.3 Too many busses operating around midday

As pointed out in section 4, using different shift lengths and starting times could help Kovanen to control the number of operating vehicles around midday. For this purpose, a shift starting from 14:00 and lasting either until 19:00 or until 02:00 should be implemented. Such shift would also help the late-night peak time, and evening shift change time around 18:00. It is highly important for Kovanen not to allow shifts starts between 10:00 and 12:00, and ending shift between 12:00 and 14:00, to make sure that there are not too many busses operating around midday. Such shift starts and ending times will only cause extra busses in slow time but they will not help in the peak times. If a bus operates during slow time, it should be able to operate in both the peak times surrounding slow demand time. Using short shifts and split shift should also be implemented. Short shifts could include shifts such as 04:00 to 10:00 and 14:00 to 19:00. Split could include shifts such as 05:00 to 10:00 plus 14:00 to 18:00 and 14:00 to 18:00 plus 21:00 to 01:00. In discussion with Kovanen stakeholders (Iivonen, J (2016), Kouallias, M (2016)) it was agreed that short shifts should not be used in the expense of long shifts, and split shift should only be used if a driver is willing to do so. It is also important to understand that when using split shifts Kovanen has to be extra careful in monitoring the driver relief and maximum working times.

5.6.4 Afternoon lost opportunities

Afternoon lost opportunities can never be totally removed, but it is important to exploit such demand with full capacity whenever possible. If Kovanen is to start their shifts earlier in the morning, such drivers will also end their shifts earlier than before. Such change will make an impact to times between 16:00 and 18:00 (Iivonen, J (2016, 2017), Kouallias, M (2016). To compensate such change Kovanen should start their shifts with 16-seater later, and also start 10-seater night shift equally earlier. If there is no driver for daytime, 16-seater night drivers should start their shifts as early as possible, best possible time being at 14:00. If changes to a morning or night shift starting times are made due to shift change problem, it should be compensated with another starting time shift change. Afternoon lost opportunities require that all vehicles are operating during this time period. To make sure this happens, any shifts ending between 12:00 to 18:00 should always have a night shift driver to immediately restart the non-operational bus. It is very important that drivers understand the value and also that they have the full skill set to utilize the afternoon peak times as well as possible. In addition to weekend nights, afternoon is the biggest demand time for busses. With money training and performance management the skill level and understanding of drivers can be increased.

5.6.5 Too many busses operating between 19:00 and 22:00

This problem is very similar to midday slow time. However, there is one difference that must be noted, which the fact that start of the night shift is right after peak time at 18:00 followed by immediate slow demand period. Therefore, Kovanen should implement night shifts that start either than 18:00, such as 16:00. These shifts are also required due to early morning shift. Kovanen should also implement late start times to night shifts, which would mean that some night drivers begin their night shift at 21:00 or 22:00. This also allows them to operate longer during the morning peak time. In discussions with Iivonen, J (2016), Kouallias, M (2016) it was noted that it is possible that some night shift drivers will not be able to extend their night shift until 07:00 or 08:00 due to the physical strain it causes. It is important that such shifts are agreed together with a driver to make sure that he can safely operate later in the morning.

5.6.6 Late evening peak time

Possible solutions to this peak time would be using split workdays, introduced by Martin Desrochers, Francois Soumis (1989), and using short night shifts with all possible ways. Hui Yang, Shangyao Yang, Hsuan-Hung Chen (2003) flexible shift start strategy and flexible shift length strategy provides many possibilities to help cover such time. If shift starting late and busses ending early are used, late evening peak time should be covered without having too many busses in slow times around it. When Friday and Saturday nights are excluded, several night shifts should end between 01:00 and 02:00. During Friday and Saturday nights demand does not decrease and therefore full-length shift should be driven.

5.6.7 Weekend nights problem

In section 4 attempt to find existing knowledge on weekend nights problems was conducted. As this research was found almost futile, Kovanen has to search for heuristic solutions to this problem.

Block model and the three-step-approach for shift planning was introduced in section 4. Using both models together to form, for example, one week sets which drivers could choose their own from, could help Kovanen with this problem. In this model a driver has to choose a set which then could include “unwanted” shifts, such as weekend nights. This solution is however problematic in terms of the fact that Kovanen cannot know in advance how drivers would react to changing into such model. As pointed out, Kovanen cannot risk to lose drivers.

As Kovanen works in a provision salary method, one method of encouraging drivers could be by ensuring some level of payment per hour, or for example fixed payment for the busiest nights. Knowledge about the high level of payment is important, and therefore Kovanen must implement money training for drivers. In this training it is ensured that all drivers understand the possibilities of a very good salary from weekend nights.

5.7 Summary of the proposition

In summary, the key changes suggested to Kovanen are as follows (more specific suggestions can be found in previous sections):

- Kovanen should implement built shift planning frame as soon as possible to increase both company financial result as well as driver hourly earnings.
- Kovanen must start to used 12 month running demand modelling to update their shift planning frame.
- Kovanen should start using block modelling type of approach, added with three step approach. Together these two will combine into system where Kovanen dictates the operating times of a driver.
- To be able to meet demand, Kovanen should implement several different new shift types, both in starting times as well as length. Kovanen should not allow “wrong” shift starting or ending times.
- Kovanen should create incentives for drivers, for example a minimum wage for a shift, etc. to gain maximum profit from the peak times.
- Performance management should be implemented by managers.
- Money training for drivers should be created and implemented.
- Heuristic problems should be solved with testing different approaches, such as drivers making their shift changes at home when applicable.

6 PILOT TESTING FOR PROPOSED SHIFT PLANNING FRAME

Due to the always-in-motion environment of Kovanen's employee and total number of buses situations, pilot testing of formed shift planning frame was quickly proven difficult. In large company which struggles to gain enough workforce it is very difficult to determine driver working hours without compromises with drivers themselves. In conversations with company stakeholders (Iivonen, J (2016), Kouallias, M (2016)) it became clear that some of the tools suggested for Kovanen are not applicable at the moment. Kovanen cannot risk losing a single driver, and hence moving into different type of shift management model, at least without a "smaller" pilot test first, was found impossible. The model implemented and tested is a "soft model", in which some of the suggested methods and changes are implemented. Some of the methods are tested with "softer" approach, and some not at all.

6.1 Pilot building

Due to the workforce issues Kovanen had to make a lot of compromises when piloting formed shift planning frame. It is also important to note that change in large organization is never fast. Though there has been plenty of obstacles and compromises, some changes to shift planning were implemented. Some tools, such as flexible shift start strategy and flexible shift length strategy (Ta-Hui Yang, Shangyao Yang, Hsuan-Hung Chen, 2003) were implemented. Three step approach (Ta-Hui Yang, Shangyao Yang, Hsuan-Hung Chen, 2003) was not implemented due to the employee situation. In this approach shifts are planned before drivers are implemented in them, which means that Kovanen would have to assign drivers to shifts, which is not possible due to risk of losing drivers. Due to the same reason as mentioned above, block model approach was not implemented.

Monthly variable has not yet been used due to the low speed of change, the author has focused on change instead of updating the frame. Also, a test where one bus was allowed make shift changes at home was conducted. Money training was created and implemented.

Using shift planning frame started in some form at March 2016, and there has been an ongoing slow cyclic improvement going on ever sense. To see the results, months of

March 2016 and March 2017 were chosen as our refence time. These two months were selected for number of reasons. Number of buses is very close to one another. In 2017 employee status was probably better than in 2016, but the difference is rather small. Long time period allowed the changes to make an effect on demand and shift structure.

6.2 Implemented solutions step by step

6.2.1 Gap between planned and realized operating hours

Though not stated as a proposal in previous section, a decision to start “planning” for gap between planned and realized operating hours was started. This means that if a bus is required to operate between 06:00 and 10:00, it will be planned to operate from 05:00 to 11:00. Though it might not be the best possible solution, it was found that such model will work in some extend. Kovanen was afraid how drivers would react to “forcing” them to start on time, so a “softer” solution was implemented.

Conversations with drivers were implemented in some extend, and shorted shifts agreed. Some shifts were planned to be from 8 to 11 hours long. Shift-start-order process was implemented to make sure drivers would come on time to their shifts (implemented in march 2017, therefore it is unlikely that is will yet have an impact on statistics). Money training was implemented.

It is expected that the percentage of realized operating hours versus planned operating hours should increase due to the implemented changes.

6.2.2 Morning shift change problem

Flexible shift start time strategy and flexible shift length strategy were implemented, with the idea of decentralizing shift change times. 10-seater shift change times were moved to earlier, and 16-seater later, in some extend. A pilot where one bus was allowed to make shift changes at home was conducted. Money training was implemented to make drivers understand the possibility of good earning early in the morning. Shift-start-order process was put in place so that drivers would start their shifts as agreed.

Combined effects of made changes should result in higher number of operating busses during morning peak time and around the normal shift change time, at 06:00, and therefore increase the financial result during these hours.

6.2.3 Too many busses operating around midday

Split workdays and short shifts were not implemented, at least in large scale. It was found that Kovanen does not have many drivers willing to do so, and also that these changes would come with an expense of current shift, therefore decreasing the total amount of operated hours. Many new shifts were implemented, such as 04:00 to 12:00, 12:00 to 21:00, etc. However, Kovanen has been unwilling, thus far, to totally deny shift endings or starts between 10:00 and 14:00 as proposed. In money training the issue was discussed together with drivers, to make them understand why this time of they would be suitable for lunch break for example.

Though the changes were not in the scale as proposed, implemented changes should have at least minor positive effect on the problem.

6.2.4 Afternoon lost opportunities

In money training the magnitude of the afternoon demand was explained in detail to Kovanen bus drivers. To compensated the early morning starts, several night shifts were moved to begin earlier. In addition to this, shift starts before the afternoon peak time were implemented. Shift-start-order process was also implemented for night shift to make sure night drivers would come on time.

Impact of these changes should increase financial result at least in a minor way.

6.2.5 Too many busses operating between 19:00 and 22:00

Shift start times were significantly moved to both directions from the normal 18:00. The main purpose of such change was that less busses would start their shift during this slow demand time. Several shifts were moved to begin between 14:00 and 17:00. Some were moved later to start at 21:00 or 22:00. However, as suspected beforehand, not too many of the drivers were willing to start later and drive later in the morning due to physical strain it causes. In money training drivers were informed about this slow time so they would understand to start their shift early or late.

Though the impact of the changes is not expected to be big, it is expected that these changes should neutralize the effects of early shift starts.

6.2.6 Late evening peak time

All of the suggested changes were implemented. Flexible shift length and start time strategies were good solutions to help cover this time without effecting slow times around it too much. Short shifts were added as much as possible. Shift starting from 12:00 to 14:00 were implemented to cover this peak time without effecting the slow times around it too much. In some rare cases short shifts, such as 19:00 to 02:00 were added, if driver was willing to do so.

It is expected that some increase in financial result during this time should be gained, and that it should happen without increase of operating busses in surround slow demand times.

6.2.7 Weekend nights problem

Weekend night problems were treated as management and training issue. Because the block modelling nor “forcing” or three step approach were not implemented, Kovanen has to rely on driver knowledge about the possible very high salary from weekend nights. Driver money training was implemented and the value of weekend nights was widely explained in it. Discussion with drivers were made and they were at all times encouraged to take weekend night shifts. Driver performance during weekend nights were coached to ensure they gain maximum profit out of each weekend night. Minimum wage for a shift was not implemented due to payroll department unwillingness.

Though Kovanen was not able to increase the amount of operating buses during weekend night much, it is expected that some impact on the number of operating busses and single driver shift earnings should have been gained.

6.3 Piloting testing results

To identify how implemented flexible shift start time tool has impacted operating times, a graph showing shift starting times was created.

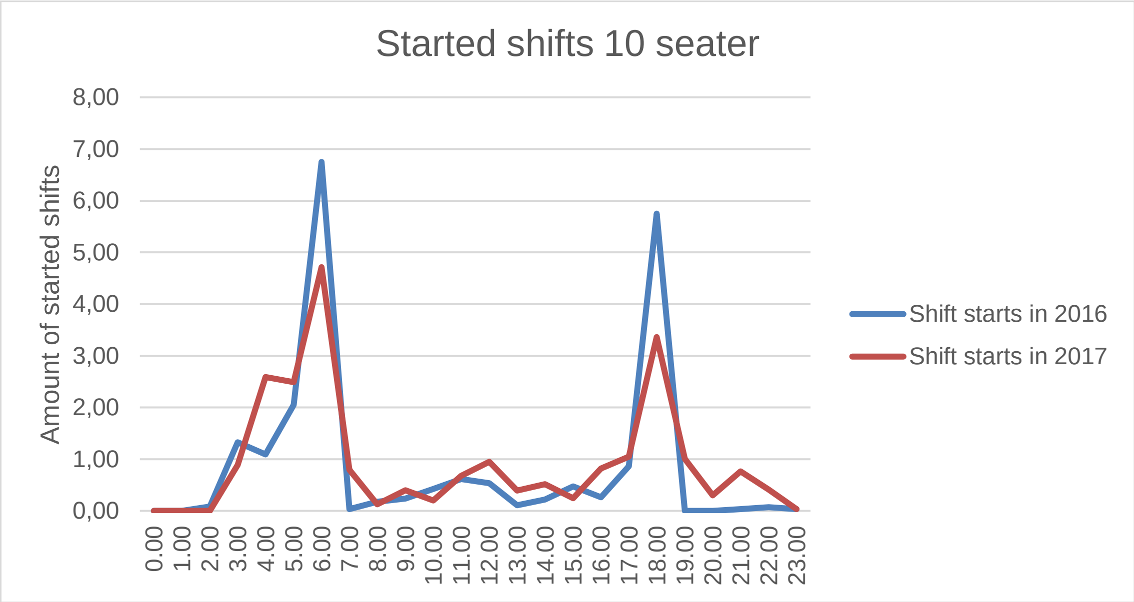

Figure 13. 10-seaters started shifts

For 10-seaters, more shifts start earlier than in 2016, both in the morning and evening. Also shifts starting in the middle of the day and also later in the evening have been implemented. It is possible to identify that in 10-seaters there has been some changes to shift starting times, and mostly towards “early start”.

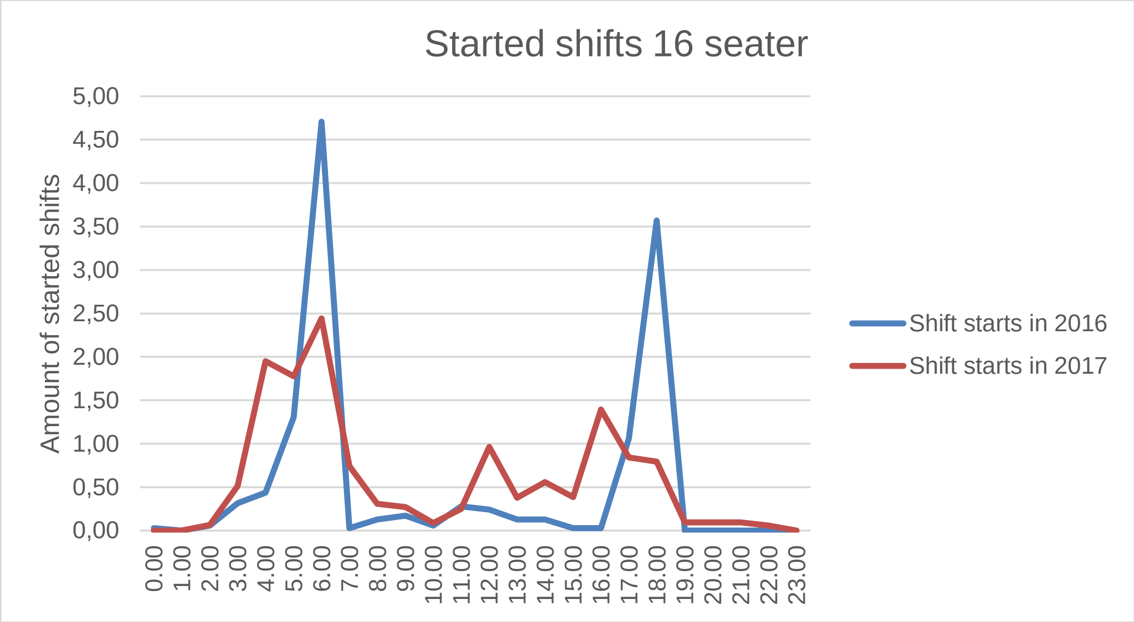

Figure 14. 16-seater started shifts.

In 16 seaters, there has been quite a lot of changes in one year. There are more early starters in the morning, but also later starters. During the midday, there are a lot more shift starts than in 2016. Night shift drivers also start earlier than year before.

In addition to flexible shift start strategy, shift length strategy was implemented. For some drivers changes towards shorter shifts were made. These drivers moved from 12 hour shifts to 8,9,10 and 11-hour shifts. Unfortunately, there is no direct indicator to show such change in form which would show only the magnitude of shift length strategy.

For combined effects of made changes tables of percentage changes from 2016 to 2017 are created.

	Ma	Ti	Ke	To	Pe	La	Su
0:00	0,6	9,9	10,2	11,0	8,9	3,5	9,9
1:00	2,1	8,1	11,0	11,4	7,8	4,4	9,1
2:00	5,8	8,8	10,3	10,4	4,6	2,9	7,6
3:00	8,0	8,7	8,1	8,7	6,4	2,7	7,0
4:00	9,0	7,0	7,2	6,6	0,5	3,5	8,6
5:00	10,4	13,2	15,2	10,3	7,5	-3,1	4,4
6:00	8,2	16,9	10,3	15,3	16,7	-1,0	5,7
7:00	9,2	14,1	2,0	5,1	16,8	-7,9	0,8
8:00	8,2	13,6	2,6	5,4	15,7	-3,3	1,1
9:00	4,4	11,5	-2,0	3,9	10,1	0,5	0,3
10:00	2,4	11,3	-1,4	5,5	6,6	-2,7	-0,4
11:00	1,0	12,8	-1,7	4,7	9,3	-6,7	-1,4
12:00	5,1	14,7	-2,1	3,6	9,0	-7,8	-0,6
13:00	8,9	14,0	-3,8	3,7	2,5	-6,6	-1,4
14:00	9,5	11,4	-0,1	4,6	3,4	-6,2	0,0
15:00	6,1	11,2	0,2	13,3	0,7	-3,4	4,1
16:00	6,8	8,8	-1,1	11,1	1,1	-1,5	1,9
17:00	11,9	16,3	4,9	15,0	4,8	-1,2	-1,3
18:00	7,8	17,4	12,1	16,8	8,9	-5,6	6,0
19:00	6,3	9,9	14,8	10,4	9,9	-6,6	-0,2
20:00	11,6	9,5	12,5	13,5	5,9	-5,9	1,1
21:00	10,1	9,9	8,0	8,4	2,9	-6,2	3,9
22:00	13,4	13,3	12,3	10,7	4,8	-1,3	5,7
23:00	13,1	12,3	11,8	7,2	1,8	7,9	1,4

Table 40. Percentage change in operating fleet size for 10-seaters.

Changes for 10 seaters can be seen from table 40. As a negative effect, there are more buses operating in the night shift from 19-04, which causes unwanted increase in operating buses from 01:00 to 04:00 during week nights. From 04:00 to 08:00 there is much more operating buses, even up to 17% more. As shown previously in section 3, this is a very high demand time. From 15:00 to 19:00 there is also a lot more buses operating. In section 3, this was identified as problem period, and the biggest amount of lost opportunities during week time was in this time period. Saturday night from 23:00 to 06:00 has also more busses operating than before. On the negative side, Saturday from 11:00 to 18:00 has negative values, though it is also a time of high demand.

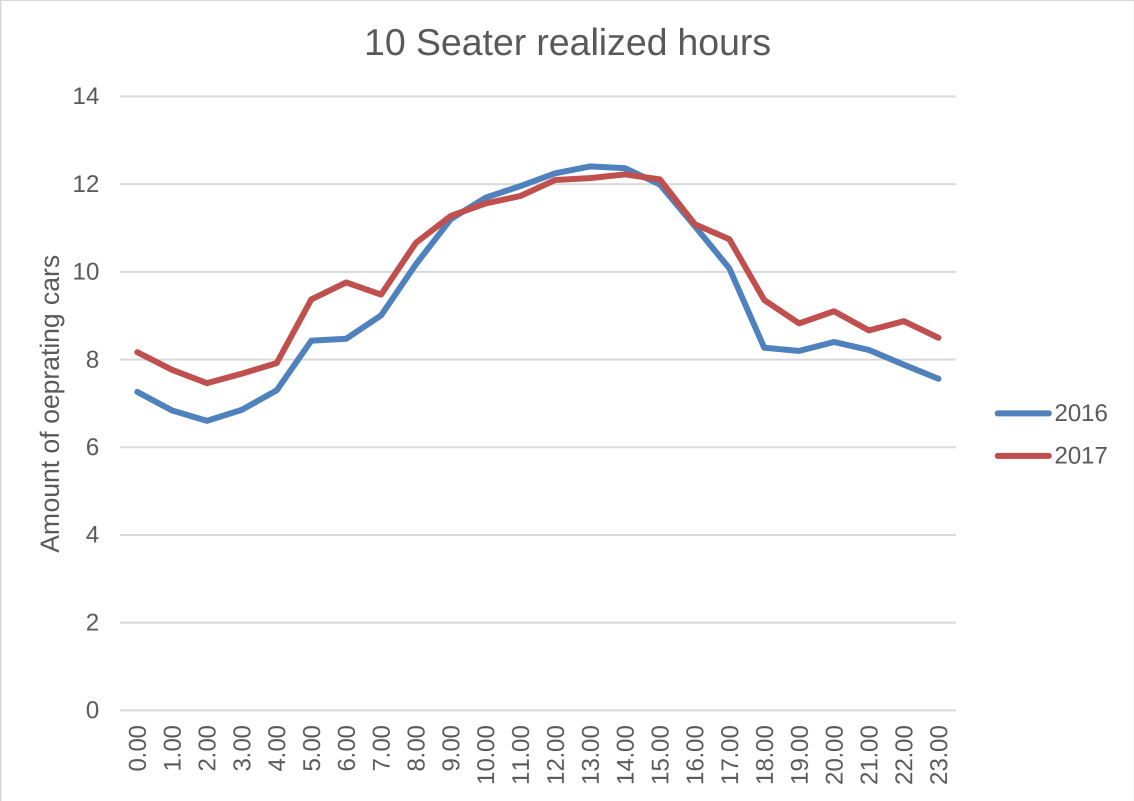

Figure 15. 10-seater realized hours average.

Figure 15 shows identified changes in a different form. From this figure one can identify the increase of operating busses in peak times, and small reduction of operating busses around midday.

Though it is possible to identify that there are plenty of positive improvement, there is still a lot more room for improvement. Still, there are too many busses operating on low demand times, and not enough in the high demand periods of the day.

For 10-seaters, financially, March 2017 was a good month compared to year before. With an increase of 5,3% in total operated hours for 10 seaters, Kovanen had a 15,0% increase in the financial result of 10-seaters. Kovanen had one bus less in 2017 than in 2016. When looking at the earnings per operating bus, the financial increase per bus is +21,7%. It is therefore, arguably, clear that the made changes have had significant positive impact on Kovanen's financial result for 10-seaters.

	Ma	Ti	Ke	To	Pe	La	Su
0:00	-5,7	-3,8	2,8	13,7	-10,8	14,0	-0,5
1:00	-3,6	-3,2	-3,3	7,5	-14,8	11,1	-2,4
2:00	-8,1	-4,3	-10,2	-3,1	-19,5	2,4	-2,5
3:00	-7,0	0,0	-6,2	-4,7	-19,4	-0,6	-6,5
4:00	-4,0	-9,9	-6,8	-5,6	-15,0	-11,5	-12,8
5:00	4,1	-15,5	-4,8	6,9	0,6	-3,0	-1,3
6:00	21,2	-10,9	-0,4	2,3	18,8	12,6	6,6
7:00	19,6	-8,5	1,5	-3,1	20,5	22,4	15,4
8:00	15,9	-2,9	-5,6	-10,4	15,3	16,3	18,6
9:00	22,1	-4,1	-4,2	-9,7	10,7	12,6	9,8
10:00	22,7	-4,5	-2,8	-6,7	12,5	17,3	8,8
11:00	24,2	-2,0	-0,3	-4,9	18,6	16,9	5,4
12:00	20,1	-5,2	-0,5	-7,2	17,6	17,0	7,6
13:00	19,6	-5,0	6,4	1,1	17,2	18,5	7,4
14:00	23,1	0,4	14,6	8,6	16,3	19,3	7,6
15:00	21,7	3,0	19,4	12,1	13,3	24,8	7,1
16:00	23,3	7,7	17,4	20,2	15,6	21,0	8,6
17:00	16,4	19,5	27,2	23,1	23,5	13,0	2,1
18:00	16,7	16,5	35,5	15,0	17,5	8,4	-6,6
19:00	12,4	20,0	35,3	14,8	15,6	-3,2	-5,8
20:00	9,5	20,0	33,5	14,9	21,9	1,0	-6,4
21:00	10,1	17,8	30,1	5,2	22,6	3,1	-3,9
22:00	5,5	11,7	21,0	-2,7	22,9	-2,5	-3,3
23:00	0,9	8,4	13,2	-7,5	12,3	-0,8	-2,2

Table 41. Percentage change in operating fleet size for 16 seaters.

16-seater changes are much different from 10 seaters, but as identified in sections 3 and 5, the need for change was also different from 10-seaters. In section 3 it was identified that during the week, in night shifts, less 16-seaters are required. High demand for 16-seaters is from 08:00 forwards, and specially from 14:00 to 19:00. From 23:00 to 06:00 the amount of operating 16-seaters has dropped. From 07:00 forwards, depending on the date, the amount of operating 16-seaters has increased slightly. From 14:00 to 23:00 there is a massive increase in amount of operating 16 seaters. Identified change for 16-seaters is to start their shifts later and to drive later. Based on demand 16-seaters are more needed later than earlier during the day. Also during Saturday and Sunday an increase during the day can be identified as a positive sign. Unfortunately, Saturday nights, a small negative trend can be identified. This is likely to be the biggest problem with 16-seaters at the moment.

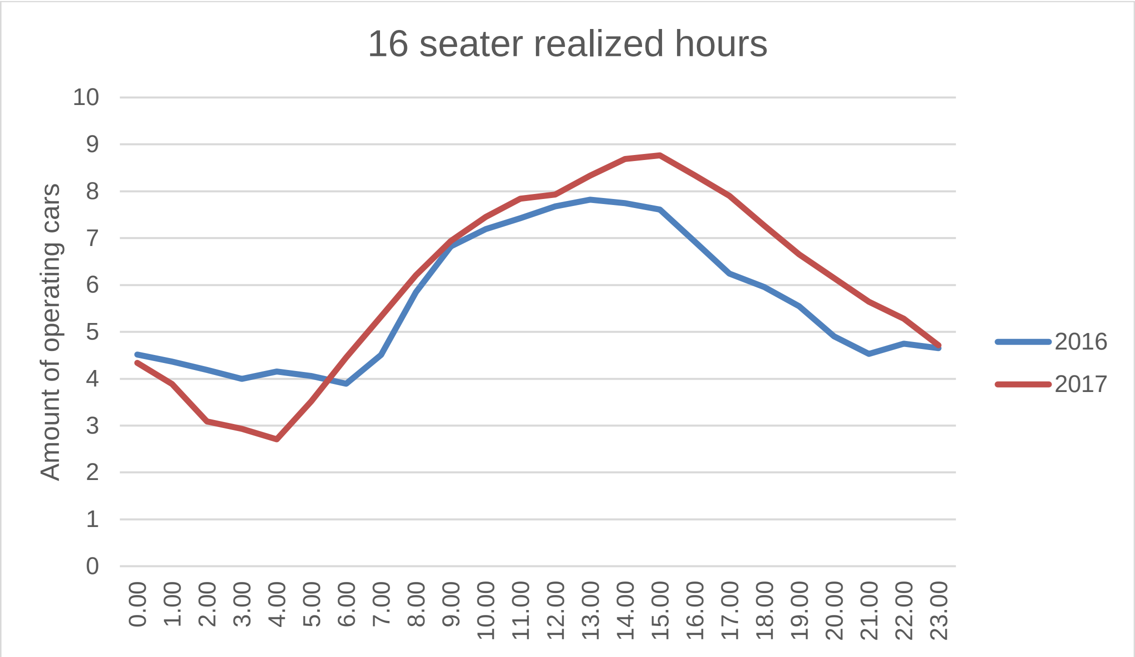

Figure 16. 16-seater realized hours average.

Figure 16 shows a different graph about the same change identified earlier. During the night there is less busses, but during the evening and late afternoon there are more operating 16-seaters.

From 2016 to 2017 in 16 seaters had a drop of -5,1% in total operated hours. Even though there are less operated hours, 16 seaters made a financial result of +5,0%. As there is also one less 16-seater, per bus the financial result is +13,7%. Financial result indicates that also in 16-seaters, changes made have had a positive effect in financial result.

6.3.1 Effect to realized hours percentage

One the issues to Kovanen was the realized hours vs planned hours problem, in overall.

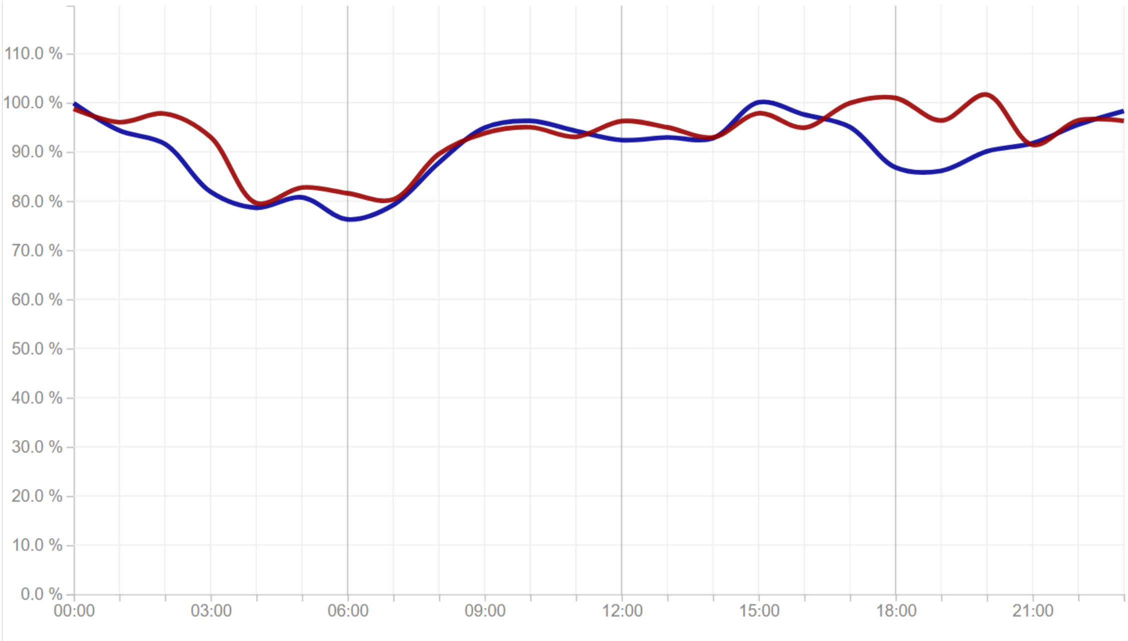

Table 42. Realized operating percentage for 10-seaters. March 2016 in blue, and March 2017 in red.

As expected, the changes implemented have impacted the percentage of realized hours. The most important fact identified is that the percentage has increased around shift change times, which indicates that implemented methods have made an impact.

For 10-seaters, on average the realized hours percentage in March 2016 was 90,6% and in March 2017 it was 93,4%.

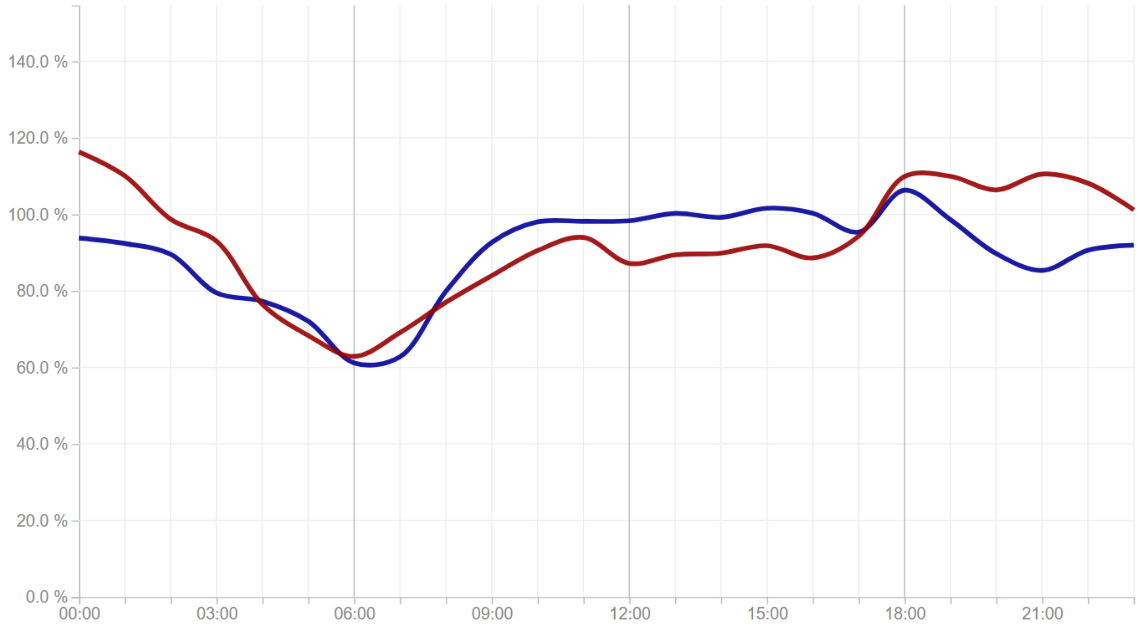

Table 43. Realized operating percentage for 16-seaters. March 2016 in blue, and March 2017 in red.

For 16-seaters, the results are very similar to 10-seaters. On average the realized hours percentage in March 2016 was 89,8% and in March 2017 it was 92,8%.

6.3.2 Home shift change effects

As told earlier, one bus was allowed to make shift changes at home. Though making shift change at home was not always possible, depending on who the drivers were, at least two thirds or the shift changes were made at home during pilot period. As the pilot was conducted in October to December 2016, a month of November was 2016 was chosen for analysing.

The bus allowed to make home shift change had a realized operating hours percentage of 95,5%. Other 16 seaters had a percentage of 92,8%. Financial result was +2% per operated hour compared to other 16 seaters.

Drivers making a shift at home were very happy about it. They said that it saves them a lot of time when not required to travel before and after work. As a negative side it was noted that the bus used for home shift change was found dirty at times, and sometimes driver paperwork's were delayed.

In overall the pilot was positive, and though large-scale use of home shift change would require a lot more process planning and monitoring, the results of this pilot were encouraging in many ways. One the most significant values of this pilot were the understanding that percentage of realized hours was increased with almost 3%, and that there was also a financial benefit of +2% when not having to drive to depot for all shift changes.

6.4 Shift planning process

In this thesis the objective was to create a new shift planning frame. As the new shift planning frame was built, required changes were clearly identified. In section 5 some new tools and procedures were suggested. A large-scale change in shift planning process was proposed, as well as several smaller changes.

Current process is:

1. Shifts are agreed with a driver
2. Shift are built based on driver agreements
3. Built shifts are compared to statistics and known demand
4. Required changes are made together with drivers

Suggested process was:

1. Sigle shifts are built from blocks
2. Based on blocks and single shifts week sized sets are built
3. Drivers are assigned to the built sets
4. Required changes are made together with drivers

The process of shift planning in Kovanen has always started with agreement with a driver to identify how he is willing and able to drive. Due to the difficult driver situation this approach was not changed in context of this thesis. However, Kovanen was given several tools to identify what driving times to suggest for a driver, and also training and coaching tools to steer their drivers into right direction. Even using soft methods, we were able to identify significant increase in financial result.

6.5 Pilot testing conclusions

Though changes in a large company that struggles to get workforce can make implementing large scale changes very difficult, changes made in this thesis were implemented without any large problems. Many of the drivers did not argue to changing their shift times or length, once the reasons were clearly explained to them. As the resistance was rather small, it is likely that even bigger changes could have been made. From an operations point of view the implemented changes were a success, though only a scratch of surface in shift planning problems. As identified in this section, Kovanen should keep changing their shift planning process towards suggested method to ensure maximum profit per bus.

7 CONCLUSIONS

7.1 Summary of the project

During this thesis, the problems that Kovanen is having with demand and supply equilibrium, and how it impacts their financial result, was analyzed. The market and operating environment, as well as Kovanen as company was represented. A project plan was created to identify the required key steps of this project. Data collection points were identified, and statistics program was created by Kovanen to support this analysis.

In section 3 supply and demand was analyzed very deeply to make sure all key problems and issues were identified. Key issues identified were:

- A gap between planned and realized hours. The number of buses planned to operate and the number of buses actually operating are almost never the same.
- Shift change problem between 04:00 and 09:00.
- Too many cars operating at midday, from Monday to Friday between 10:00 and 14:00
- Too much lost opportunities between 14:00 to 19:00
- Too many cars operating from 19:00 to 22:00
- Late evening 22:00 to 01:00 peak time
- Weekend nights lack operating busses
- Quarterly demand fluctuations effect the demand

In section 4 existing literature was researched to find tools and practices how problems identified in section 3 could be solved. Helpful tools were identified and carried out to the next section. In section 5 a new shift planning frame was built. Equations for calculating required amount of fleet in percentages was created and used to calculate required number of operating buses in any given time during the week. A monthly variable was calculated to make sure shift planning frame would always be up to date, even during yearly fluctuations of demand.

In section 6 the proposed new shift planning frame was piloted to see if it has positive effects on financial result. Positive effects and positive financial result was identified, and the usability of such frame proven. Tools that were implemented and those that were not were identified and the reason for not implementing explained.

7.2 Suggested next steps

To continue the improvement started by this project, Kovanen has to keep analyzing demand and changing their shift planning to meet demand much better than they currently are. A circle of shift planning improvement was created in section 4. This circle must be implemented to keep track of the demand changes. It is very important the monthly variable is implemented and new shift planning frame are calculated on timely basis, for example every 3 months.

Demand peaks and slow times of the market is one of the largest problems for Kovanen. Shift planning is very difficult in peaking demand environment, where customers want their service immediately when they need it, or they will use an alternative service, such as public transport. Kovanen has to make sure that their full capacity is working during these demand peaks, but also, Kovanen has to make sure that during the slow times they are not operating too many busses. Implementing the three-step approach and block model presented in section 4 could solve many supply and demand equilibrium problems.

Suggested new shift planning process is:

1. Sigle shifts are built from blocks
2. Based on blocks and single shifts week sized sets are built
3. Drivers are assigned to the built sets
4. Required changes are made together with drivers

It is obvious that changing current process into suggested one is a slow, massive and even in some ways risky project. In section 6 the results of piloting period were shown. Even though not all of the suggested changes were made, and many of the suggested changes were done with “soft model”, the results were very promising. One could argue that Kovanen could take a risk of losing several drivers and even then change project would create a positive financial result. As the driver hourly salary goes hand in hand with bus earnings, and therefore company’s financial result, one can argue that such change would increase driver salary per working hour, which could then lead to more drivers coming to work for Kovanen once the full change project is complete.

In addition to matching demand better than Kovanen currently is, Kovanen should also start to think about how to change demand if possible. If Kovanen could somehow affect their customers travel plans from high peak times to slower times, they could serve more customers and increase their financial result. Changing demand may not be possible, but it would be worth trying. One way of effecting customers’ decision is price. If a customer could travel with half the price two hours earlier, it is possible that he or she might at least consider the possibility. Another possibility would be to create new products, for example as flexible pick up time with discount.

Kovanen should also use all possible resources in trying to sell their services to customers that use such services in slow demand times. Author is aware that this is a very difficult task, but success in this area would also make increasing fleet size possible. Increasing the number buses is difficult when demand is only in peaks, because buses will only earn money on peaks due to the fact that in slow times there is not enough demand for buses already operating. If Kovanen would have more demand in slow times, and the number of added buses would also have earnings in slow time, these added buses would help Kovanen to meet demand in peaks. One could argue that increasing fleet size goes hand-in-hand with slow time demand increase.

Management and performance management would definitely require more resources and attention from Kovanen. Kovanen's managers should use more time in training, coaching and managing the performance of their drivers. It was identified in piloting section that actually Kovanen drivers were surprisingly willing to make changes if one could prove that it has a positive effect on their salary.

Kovanen needs to find more flexible workforce. Short shifts and part-time employees would make shift planning easier and more flexible, which would lead into better supply and demand equilibrium. For a driver, it is difficult to live with salary that comes from 4-6-hour shifts, but for some groups, such as students, this could be possible. Using short shifts that last only for the peak time would solve many problems for Kovanen. This could also solve the weekend nights' problem that Kovanen has with their minibuses.

It is suggested that all proposed changes are implemented in the near future. Though there might be some risks for Kovanen, the possible benefits are high.

7.3 Evaluation of the project

Glyn Winter (2000) states that "The choice of language and selection of 'relevant data' are the greatest threat to 'validity' ". To evaluate the project validity, approach by Shenton A. K (2004) was applied. In this model the project is evaluated through four main criteria: Credibility, Transferability, Dependability and Confirmability.

Credibility

Measures of credibility	Applicability in this research
Adoption of appropriate, well recognized research methods	Researcher has used mostly standard quantitative method with statistical approach and mixed with qualitative method in form of interviews. A longitudinal approach was used.
Development of early familiarity with culture of participating organizations	Researcher and stakeholder interviewed for this thesis all work for Kovanen, and therefore are very familiar with organizational culture of Kovanen.
Random sampling of individuals serving as informants	Not applied. Targeted interviews and data gathering points were the only possible sources of information at Kovanen.
Triangulation via use of different methods, different types of informants and different sites	Not applied fully. Kovanen has only two stakeholders holding required information and under-

	standing to participate. Both of them were interviewed alone and together to triangulate as much as possible.
Tactics to help ensure honesty in informants	During interviews the participants were aware that the thesis will require operational changes and therefore the accuracy of information has to as correct as possible. If stakeholders were not sure, they were told to not answer such question. Any information suspected to be unsure were dismissed.
Negative case analysis	Not applied.
Debriefing sessions between researcher and superiors	Face-to-face meetings with thesis supervisors and Kovanen stakeholders on regularly basis.
Peer scrutiny of project	Thesis was reviewed by several stakeholders in many different situations, and no comments received.
Use of “reflective commentary”	Not applied.
Description of background, qualifications and experience of the researcher	Presented briefly in introduction section.
Member checks of data collected and interpretations/theories formed	Several checks and possibilities to comment interpretations and theories were given to Kovanen stakeholders and thesis supervisors.
Thick description of phenomenon under scrutiny	Presented in sections 1, 2 and 3. Reviewed in required extend in several other sections.
Examination of previous research to frame findings	Existing knowledge and tools were reviewed and researched, and results presented in section 4 and applied in section 5.

Transferability

Measures of transferability	**Applicability in this research**
The number of organizations taking part in the study and where they are based	Kovanen was a single participating organization and the location was Helsinki region in Finland.
Any restrictions in the type of people who contributed data	All data was collected from Kovanen statistics program and from Kovanen employers and stakeholders.
The number of participants involved in the fieldwork	Only the researcher himself was participant in the actual fieldwork.

The data collection methods that were employed	Quantitative statistical data gathering, interviews of Kovanen stakeholders.
The number and length of the data collection sessions	Numerous data collection sessions from Kovanen statistics program. 5 meetings with Kovanen stakeholders, approximately 60-80 minutes each.
The time period over which the data was collected	Starting from March 2016 for Current State Analysis, ending in June 2017 for Piloting results.

Dependability

Measures of dependability	Applicability in this research
The research design and its implementation, describing what was planned and executed on a strategic level	Reseach design and plan can be found from section 2. Execution can be found mostly from section 6.
The operational detail of data gathering, addressing the minutiae of what was done in the field	Data collection plan was followed. Data gathering was designed to be extensive for the purpose of deleting all seasonal, technical and oscillational disruptions and misleading's from data.
Reflective appraisal of the project, evaluating the effectiveness of the process of inquiry undertaken.	Not addressed during research. Process was found slow but relevant and useful, as pointed out in section 6.

Confirmability

Measure of confirmability	Applicability in this research
Triangulation to reduce the effect of investigator bias	Stakeholder interviews were conducted to make sure that the investigator did not make interpretations that are bias or misleading.
Admission of researcher's beliefs and assumptions	Beliefs and assumptions were proven to be correct in sections 3 and 6.
Recognition of shortcomings in study's methods and their potential effects	Recognized shortcomings were not identified.
	Full description of research method in section 2.

In-depth methodological description to allow integrity of research results to be scrutinized	
Use of diagrams to demonstrate “audit trail”	Research process description in section 2. Research is based on statistical data which has been transformed into diagrams to interpret data.

Though not fully without problems, trustworthiness of this research was found to be acceptable and valid.

The assumptions set in the beginning of this thesis were proven to be correct and based on existing literature and identified key issues a proposal to improve Kovanen’s minibus service level and financial result was proposed. Proposition was piloted in extend that was approved by Kovanen stakeholders, and the pilot was a success. Based on these key success factors author claims that thesis research as a whole was found to be a success.

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