Graz University of Technology

Transport Modelling LV 209.213

Exercise 2

Vissim Traffic Flow Simulation

Erstellt von

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Inhalt

1 Exercise 2

1.1 Problem statement

Your second homework assignment deals with the capacity of trams at Jakominiplatz in Graz. There you will model the current situation prior to the Neutor construction site as well as scenarios with different number of trams, tram length and signal control. As an objective tram delay has to be computed dependent on number and length of trams.

Abb 1: Jakominiplatz (source basemap.at) with nunmber of motor vehicles and pedestrians at Eisernen Tor (VLSA 103) during peak period

The task is not described in detail. You can take some assumptions or own quick measurements/observations which you have to describe in the project report.

1.2 Task description

a) Model the regular tracks of tram lines 1,3,4,5,6 and 7 genutzten Gleise (service tracks have not be modelled). The stop positions and stop lengths are important (accuracy of 1m). You may use an orthophoto or a visit at the Jako itself. Distances can be measured using https://gis.stmk.gv.at/wgportal/atlasmobile/map/Bilder%20-%20Karten/Orthofoto.
The tracks should be extended up to the stops prior to Jakominiplatz without modeling the traffic lights (eg. Stop Oper without VLSA Gleisdorfer Gasse/Girardigasse). The travel speeds of the tram lines should be realistic. In Herrengasse trams drive up to 20 km/h while the speeds in the other approaches do not exceed 35 km/h.

b) For the time table take the regular time table without any changes due to the construction site Neutorgasse. You can use the time table from Exercise 1 as implemented in Visum or time tables documented in Verbundlinie.at. Use the schedule of the morning peak between

07:00 and 8:30. Each tram should vary with a unique distribution (Gleichverteilung) of 0-150s.

c) Buslines do not have to be modelled.

d) The motorized vehicles have to be modelled according to figure 1 with input volumes from Opernring and Eiserne Tor (in reality they approach from Kaiserfeldgasse). Pedestrian traffic has to be modelled only at the two documented crossings.

e) During the morning peak the Eiserne Tor ist fixed time signal controlled using either program S2 or S3. The signal timing plan and the intergreen matrix is documented on VLSA 0103_TM2022.pdf. In the base model apply signal timing plan S3 with cycle time C=80s. The traffic control settings have a second partial intersection with the pedestrian SG 16 and bicyclists SG 46, which you do not have to model. You can also exclude the tram presignal V31 and T33 and the pedestrians SG 41 and 43. In the stage sequence diagram (Phasenfolgeplan on PDF page number 18) the direction arrows are a bit misleading. SG 33 is only straight on for trams. There is also an arrow because in reality buses can also pass which turn left. SG 11 is a car right-turn movement.

f) If you do not carry out any personal measurement you can take a dwell time distribution at Jakomini for all trams of N(18;3).

g) For each tram line you should define a travel time segment of the same length. The travel time segment should include potential waiting times before and after the Jakomini-stop but not virtual delays, if you model a dummy stop. The node evaluation will be problematic due to the complex structure of Jakomini. Therefore it will be better to evaluate the travel times for each tram line separately. Use either different vehicle classes of generate artificial links and each tram will run across an articifical link/connector separately. The travel times are the key performance indicator.

h) Starting with the base scenario you generate at least three additional scenarios:
1. Tram 5 and 7 with 37m instead of 27m vehicle length and identical time table
2. All trams alternating with 27m and 37m vehicle length and identical time table
3. Twice as many trams on line 3 (double service rate) and 50% more vehicles on line 4; all trams with 27 m

i) EITHER: make VLSA 103 vehicle actuated, to minimize tram delay at Eisernes Tor and take scenario 3. Compare the tram travel times and car delays between scenario 3 and scenario 3 with VAP

OR: produce a Python script which activates the base scenario and the three planning scenarios and generate a travel time comparison automatically.

1.3 Generelle Anmerkungen

a) Wie auch in der Exercise 1 soll der Bericht mindestens zwei Kapitel enthalten. In einem Kapitel wird beschrieben, wie Sie Vissim angewendet haben, um die Aufgabenstellung zu lösen. Hier dürfen auch Bildschirmabzüge reinkopiert u. kommentiert werden; eventuelle Modellierungstricks sind zu beschreiben. Im zweiten Kapitel konzentrieren Sie sich auf die Ergebnisse u. Schlussfolgerungen. Das zweite Kapitel soll als Zielgruppe Verkehrsplaner u. Entscheider haben, die möglicherweise aus dem Ergebnis Entscheidungen ableiten können auch wenn die hier gestellte Aufgabe aufgrund der kurzen verfügbaren Bearbeitungszeit nicht völlig realistisch ist.

b) Die Ergebnisse sollen unter Ex2_Vissim_<FamilyName1>_<FamiliyName2>.zip hochgeladen werden.

   The Abgabe erfolgt bis **21 Juni, 12:00**

c) Das zip-Archiv has to
   - Den Bericht als *.pdf
   - Vissim *.inpx, *.layxDateien
   - *.xlsx and/or *.r der Bewertungen
   - *.vv, *vap, *.pua für verkehrsabhängige Steuerung OR the *.py

2 Base Case

For the first task, a base case for the different tram lines of Graz and the junction Opernring / Am Eisernen Tor had to be modelled. Therefore, different steps were necessary. The following chapters describe the modelling steps.

2.1 Modelling of tram network

The first step was to model the different tram lines throughout the city centre of Graz. There are six different lines, which all have a stop at the Jakominiplatz. For the base case, stops in every direction from the Jakominiplatz had to be made. The figure below will show you the stops and also which tram line goes in which direction. Line 1 and 7 go northeast over the Jakominiplatz and Kaiser-Josef Platz. Line 3 and 6 go southeast over Jakominiplatz and Dietrichsteinplatz and Line 4 and 5 go over Jakominiplatz and furthermore south to Finanzamt.

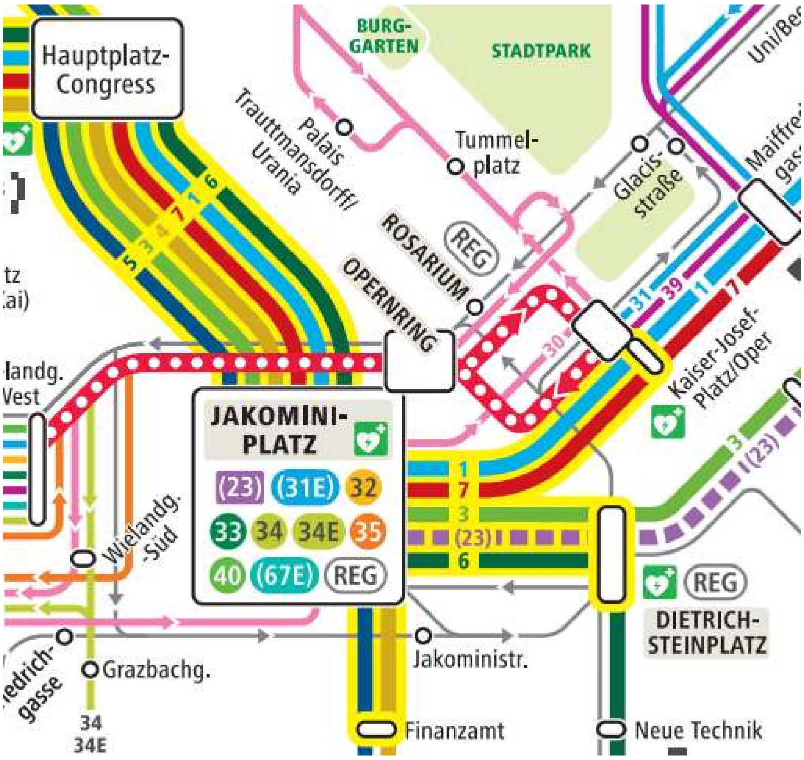

Figure 2: Overview stops Graz city centre

To model a tram line, links and connectors are the base. The connectors and links have the link behaviour type “Right-side-ruled motorized”.

Next step was to establish the public transport stops. Those had to be very accurate (1m) to generate a realistic model. The length of the stops was generated through the orthophoto.

To model the tram lines, some preparations had to be made.
For each tram line a vehicle type was created, as well as a vehicle class. An empirical unique distribution of 0-150s was made, so that every tram lines varies. Additionally, a dwell time distribution, which is a normal distribution, with a standard deviation of 3s and an average of 18s was modelled. The time table for the departure times on Jakominiplatz of the tram lines for the morning peak between 07:00 and 08:30 o’clock was taken from the website of Holding Graz.

As a key performance indicator the travel times for each tram line had to be measured. Therefore, so called dummy links on the tram lines were modelled. Those were always before and after the stop Jakominiplatz. For each tram line, vehicle travel time measurement points were modelled on those dummy links. The distance between two measurement points is always 410 m.

Table 1: Vehicle Travel Time Measurement points

Vehicle Travel Time Measurements

<Single List>

Count: 12	No	Name	StartLink	StartPos	EndLink	EndPos	Dist
1	1	T1-Eggenberg	10024: T1-Eggenberg	4,651	10025: T1-Eggenberg	1,819	410,00
2	2	T1-Mariatrost	10044: T1-Mariatrost	2,095	10045: T1-Mariatrost	3,572	410,00
3	3	T3-Andritz	10028: T3-Andritz	2,202	10029: T3-Andritz	5,135	410,00
4	4	T3-Krenngasse	10040: T3-Krenngasse	4,370	10041: T3-Krenngasse	7,894	410,00
5	5	T4-Reininghaus	10032: T4-Reininghaus	2,217	10033: T4-Reininghaus	2,383	410,00
6	6	T4-Liebenau	10039: T4-Liebenau	2,245	10038: T4-Liebenau	2,819	410,00
7	7	T5-Andritz	10034: T5-Andritz	2,476	10035: T5-Andritz	5,480	410,00
8	8	T5-Puntigam	10036: T5-Puntigam	2,266	10037: T5-Puntigam	3,126	410,00
9	9	T6-SmartCity	10030: T6-SmartCity	3,536	10031: T6-SmartCity	1,366	410,00
10	10	T6-St.Peter	10043: T6-St.Peter	1,723	10042: T6-St.Peter	5,497	410,00
11	11	T7-LKH	10046: T7-LKH	3,201	10047: T7-LKH	1,000	410,00
12	12	T7-Wetzelsdorf	10026: T7-Wetzelsdorf	3,010	10027: T7-Wetzelsdorf	1,000	410,00

For the travel speed of the tram lines, a maximum of 35 km/h was chosen. As the task description says, on Herrengasse a maximum speed of 20 km/h is allowed. Therefore, so called reduced speed areas were created. Also on Jakominiplatz reduced speed areas were made, to ensure the safety of all the pedestrians and bicyclists crossing the stop. The distributions are shown in the following table.

Table 2: speed distribution tram lines

		speed [km/h]	
		minimum	maximum
Herrengasse	trams	10	20
Jakominiplatz	trams	5	15
General speed	trams	20	35

As a lot of different tram lines approaching from different directions cross Jakominiplatz, so called priority rules had to be made. Priority rules say which vehicle is allowed to go first and which one has to wait, till the link is free to pass without colliding with a different vehicle.

For the base case a tram length of 27m was requested. The length is generated in the 2D/3D model segments.

2.2 Junction Opernring/Am Eisernen Tor

For the junction, additional links had to be modelled. One for the three-lane street called Opernring and one for the vehicles, that are coming from Kaiserfeldgasse to the junction. Those links are right-side-ruled as well.
For the pedestrians crossing the three-lane street links with the link behaviour footpath were also created.

In the following picture, the amount of vehicles (red) and pedestrians (green) are shown during the morning peak 07:15-08:15 o'clock.

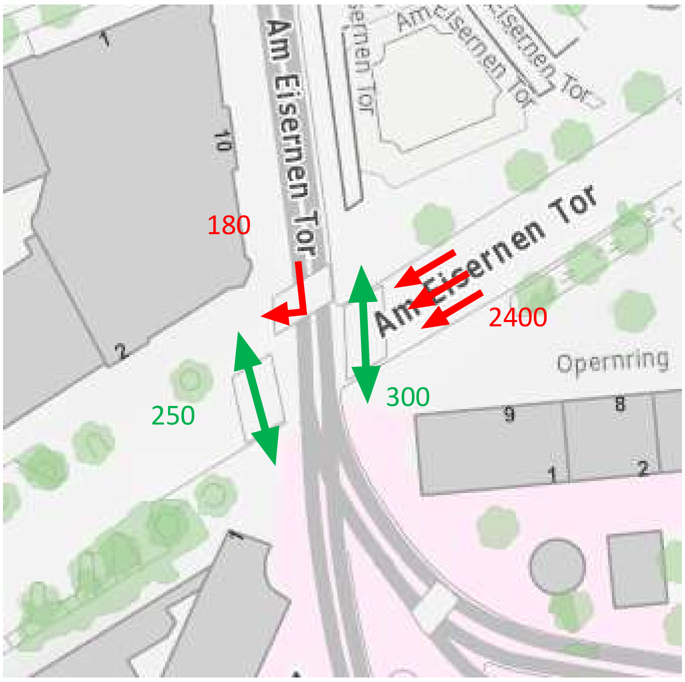

Figure 3: node current load juntion Opernring / Am Eisernen Tor (07:15-08:15)

For the vehicles, a distribution of 95% for cars and 5% for HGV was chosen. The minimal and maximum speed was chosen through a speed distribution. The distributions for the vehicle classes and pedestrians can be seen in the table below.

Table 3: speed distribution for junction Opernring / Am Eisernen Tor

		speed [km/h]	
		minimum	maximum
Opernring	PKW	48	58
	LKW	40	45
Am Eisernen Tor	PKW	48	58
Crossing	Pedestrians	4	6

2.3 Signal time plan

The junction Opernring / Am Eisernen Tor has a signal time plan with a fixed time signal control, which is provided by the Stadt Graz Straßenamt. The signal time plan has to be made in Vissim. The next figure shows the signal group plan:

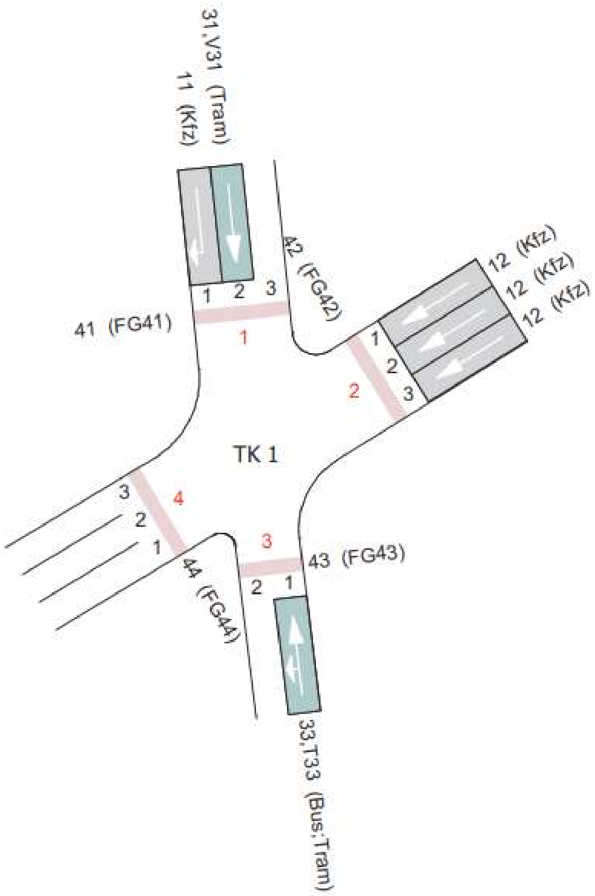

Figure 4: signal group plan Opernring / Am Eisernen Tor

For the base case only 6 signal groups were needed. See next table:

Table 4: Signal groups

No	Name
1	11_KFZ
2	12_KFZ
3	31_Tram
4	33_Tram
5	42_Fuß
6	44_Fuß

The next step is to implement the intergreen matrix between the signal groups, as shown in the following table.

Table 5: Intergreen matrix for used signal groups

	1	2	3	4	5	6
1: 11_KFZ		5				
2: 12_KFZ	5		4	4	4	5
3: 31_Tram		7				
4: 33_Tram		7				
5: 42_Fuß		10				
6: 44_Fuß		9				

To ensure that not every signal group is crossing the junction at the same time, stages are created. In every stage there are different signal groups allowed to pass the junction at the same time. In this task there are 3 different stages and their respected signal groups, which are shown in the next figure.

Table 6: Stages

	1: Stage 1	2: Stage 2	3: Stage 3
1: 11_KFZ	✗	✗	✓
2: 12_KFZ	✓	✗	✗
3: 31_Tram	✗	✓	✓
4: 33_Tram	✗	✓	✓
5: 42_Fuß	✗	✓	✓
6: 44_Fuß	✗	✓	✓

With all this information the signal time plan can be created. As reference the signal time plan 3 with a cycle length of 80s was used, provided in the document from the Stadt Graz Straßenamt.

Table 7: Signal time plan 3

No	Signal group	Signal sequence	0 10 20 30 40 50 60 70 80						
1	11_KFZ		63 71	61	71			2	3
2	12_KFZ		0 36	78	36			2	3
3	31_Tram	Red-green	45 73	45	73				
4	33_Tram	Red-green	45 73	45	73				
5	42_Fuß	Red-gr	45 65	45	65				
6	44_Fuß	Red-gr	45 65	45	65				

3 Scenarios

After the base case was completed, three different scenarios had to be implemented.

3.1 Scenario 1

In this scenario the tram length of tram line 5 and tram line 7 had to be changed to 37m instead of 27m. This was done by duplicating a default 2D/3D Segment and changing the tram length. In the vehicle types the new generated 2D/3D Model was chosen for tram line 5 and tram line 7. As requested in the task description, the time table stays identical.

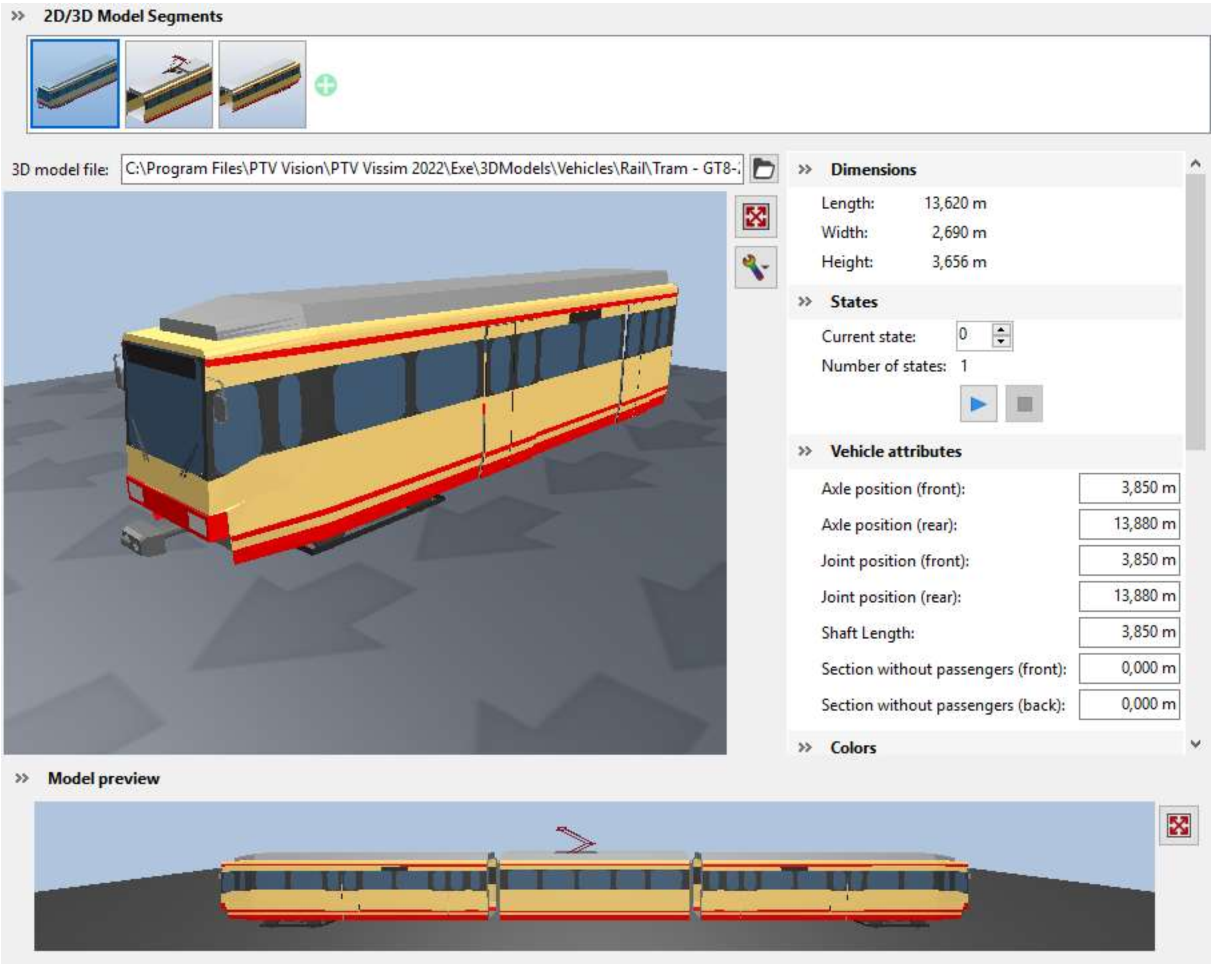

Figure 5: New generated model segment for scenario 1

3.2 Scenario 2

In scenario 2 the time table stays also identical to the base case. For all trams the length alternates from 27m and 37m. To establish the alternation, the first step was to create new vehicle types for trams with a length of 37m. Then the vehicle types had to be chosen for the different vehicle classes. For the next step, all transport lines had to be duplicated and chose the vehicle type of 37m, that was defined before. As the final step, the departure times used in the basic case were splitted in two different parts, the first one used for 27m and the other one for 37m, the unique difference between these two part is the departure times, but the combination of both is the first one. This can be seen in the tables below.

Table 8: Departure times base case

PT Line

No.: 1 Name: Tram_1_Eggenberg

Base data | Departure times | PT telegrams

Count: 12	Dep	TeleCour
1	0,0	
2	600,0	
3	1200,0	
4	1500,0	
5	1740,0	
6	1980,0	
7	2220,0	
8	2580,0	
9	3240,0	
10	3840,0	
11	4380,0	
12	4920,0	

Table 9: Departure times scenario 2

PT Line

No.: 1 Name: Tram_1_Eggenberg

Base data | Departure times | PT telegrams

Count: 6	Dep	TeleCour
1	0,0	
2	1200,0	
3	1740,0	
4	2220,0	
5	3240,0	
6	4380,0	

PT Line

No.: 13 Name: Tram_1_Eggenberg

Base data | Departure times | PT telegrams

Count: 6	Dep	TeleCour
1	600,0	
2	1500,0	
3	1980,0	
4	2580,0	
5	3840,0	
6	4920,0	

3.3 Scenario 3

In the third scenario all trams have a length of 27m. In comparison to the base case, the service rate of tram line 3 doubles and for tram line 50% more vehicle are generated.

Table 10: Departure times scenario 3 tram line 3

No.: 3 Name: Tram_3_Andritz

Base data | Departure times | PT telegrams

Count: 26	Dep	TeleCour
1	60,0	
2	120,0	
3	300,0	
4	480,0	
5	660,0	
6	840,0	
7	1080,0	
8	1320,0	
9	1530,0	
10	1740,0	
11	1950,0	
12	2160,0	
13	2400,0	
14	2640,0	
15	2880,0	
16	3120,0	
17	3330,0	
18	3540,0	
19	3780,0	
20	4020,0	
21	4230,0	
22	4440,0	
23	4680,0	
24	4920,0	
25	5130,0	
26	5340,0	

No.: 4 Name: Tram_3_Krenngasse

Base data | Departure times | PT telegrams

Count: 24	Dep	TeleCour
1	210,0	
2	420,0	
3	570,0	
4	720,0	
5	900,0	
6	1080,0	
7	1380,0	
8	1680,0	
9	1890,0	
10	2100,0	
11	2280,0	
12	2460,0	
13	2700,0	
14	2940,0	
15	3150,0	
16	3360,0	
17	3570,0	
18	3780,0	
19	3990,0	
20	4200,0	
21	4440,0	
22	4680,0	
23	4890,0	
24	5100,0	

Table 11: Departure times base case tram line 3

No.: 3 Name: Tram_3_Andritz

Base data | Departure times | PT telegrams

Count: 13	Dep	TeleCour
1	120,0	
2	480,0	
3	840,0	
4	1320,0	
5	1740,0	
6	2160,0	
7	2640,0	
8	3120,0	
9	3540,0	
10	4020,0	
11	4440,0	
12	4920,0	
13	5340,0	

No.: 4 Name: Tram_3_Krenngasse

Base data | Departure times | PT telegrams

Count: 12	Dep	TeleCour
1	420,0	
2	720,0	
3	1080,0	
4	1680,0	
5	2100,0	
6	2460,0	
7	2940,0	
8	3360,0	
9	3780,0	
10	4200,0	
11	4680,0	
12	5100,0	

Table 12: Departure times scenario 3 tram line 4

No.: 5 Name: Tram_4_Reininghaus

Base data | Departure times | PT telegrams

Count: 21	Dep	TeleCour
1	60,0	
2	300,0	
3	540,0	
4	900,0	
5	1080,0	
6	1260,0	
7	1620,0	
8	1770,0	
9	1920,0	
10	2220,0	
11	2430,0	
12	2640,0	
13	2940,0	
14	3180,0	
15	3420,0	
16	3840,0	
17	4080,0	
18	4320,0	
19	4740,0	
20	4980,0	
21	5220,0	

No.: 6 Name: Tram_4_Liebenau

Base data | Departure times | PT telegrams

Count: 18	Dep	TeleCour
1	360,0	
2	540,0	
3	720,0	
4	1140,0	
5	1320,0	
6	1500,0	
7	1980,0	
8	2220,0	
9	2460,0	
10	2880,0	
11	3090,0	
12	3300,0	
13	3780,0	
14	3990,0	
15	4200,0	
16	4680,0	
17	4890,0	
18	5100,0	

Table 13: Departure times base case tram line 4

No.: 5 Name: Tram_4_Reininghaus

Base data | Departure times | PT telegrams

Count: 14	Dep	TeleCour
1	60,0	
2	540,0	
3	900,0	
4	1260,0	
5	1620,0	
6	1920,0	
7	2220,0	
8	2640,0	
9	2940,0	
10	3420,0	
11	3840,0	
12	4320,0	
13	4740,0	
14	5220,0	

No.: 6 Name: Tram_4_Liebenau

Base data | Departure times | PT telegrams

Count: 12	Dep	TeleCour
1	360,0	
2	720,0	
3	1140,0	
4	1500,0	
5	1980,0	
6	2460,0	
7	2880,0	
8	3300,0	
9	3780,0	
10	4200,0	
11	4680,0	
12	5100,0	

3.4 Scenario 3.1 – Vehicle Actuated Program

For Scenario 3.1 the fixed time signal plan had to be adapted into a vehicle actuated program. In an actuated vehicle program, the phase durations are not fix which means they can vary from time to time based on the traffic flow. The goal for this one was, to minimize the tram travel times. Therefore, a detector was set in front of the signal heads for the tram lines. The detector detects when a tram is standing in front of the signal head and furthermore can activate the needed phase for trams (Phase 2).

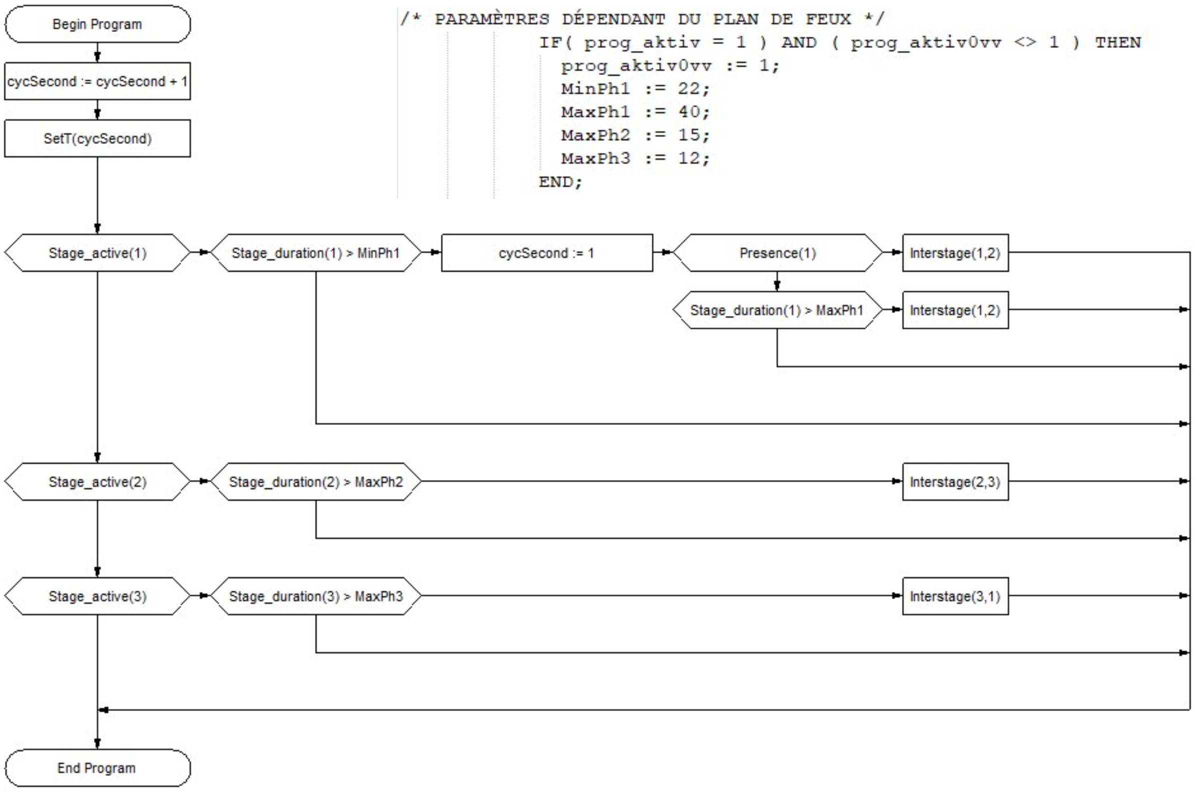

Figure 6: flow chart for vehicle actuated program (VAP) and parameters for maximum and minimum phase duration [s]

Code: Initialization of the period, then initialization of the stages, stage 1 shows the duration of the phase is lower than the minimum of the Phase 1. If this value is lower we will return to the stage 1, the condition will be evaluated and when it is higher than the minimum, the condition will go to the next step. In this case we will be in Presence, this means that if a detector is activated, the detector will activate the next stage (stage 2). Being in the stage 2 the next step is doing an analysation of the max time for phase2. When the value is higher, the stage 3 will be activated, in other case, when the time is lower than the condition will return back to stage 2. Stage 3 has the same condition as stage 2 but the maximum value is different. If the maximum value is reached, stage 1 is activated again and the program starts from the beginning.

4 Comparison Scenarios

In this chapter the different scenarios are being compared and discussed. First the results of the public transport are listed and afterwards the comparison of the private transport is discussed.

4.1 Comparison public transport

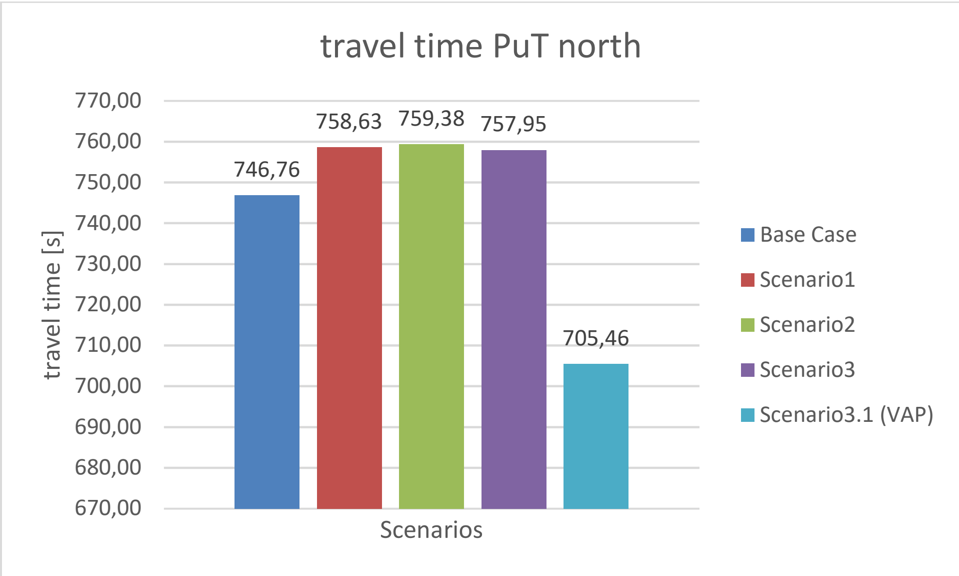

Figure 7: travel times of tram lines in direction north

As in figure 7 can be seen, Scenario 1-3 are pretty similar with each other. This means, that it does not make that much difference, if there are more trams with a shorter length are travelling or if there are less trams but with a longer length, or if we increase the service rate of our lines compared to the base case.

The figure shows also, that the decision to use a vehicle actuated program instead of a fixed one can give a way better result. The decrease of travel time is about 40s compared to the base case and 52s compared to Scenario 3.

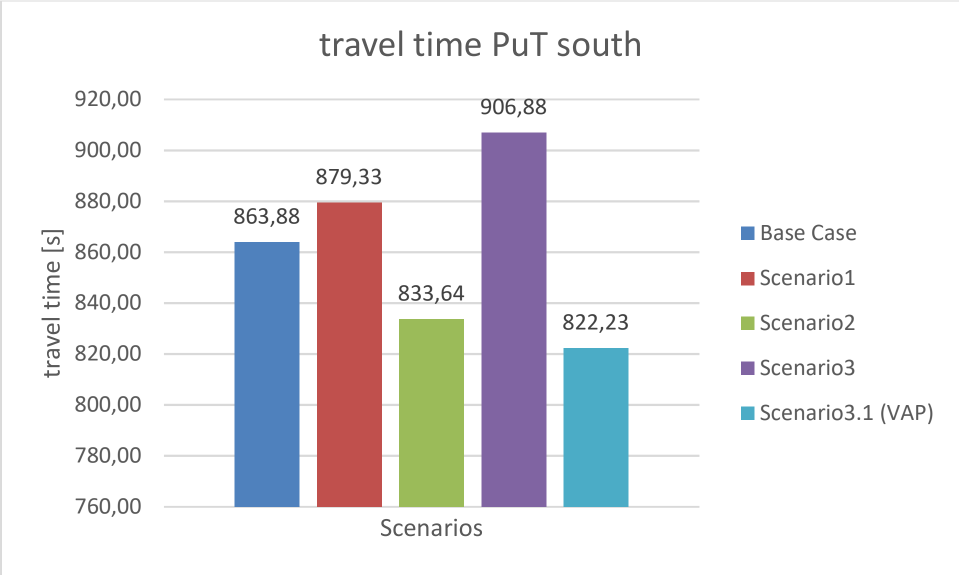

Figure 8: travel times of tram lines in direction south

Figure 8 shows that the travels times of all scenarios vary with each other. One reason could be the shorter stop lengths in the southern direction. A shorter stop length means that only one tram can stop and let people get out and in. This results in a waiting time for the following tram and therefore increases the travel time. Scenario 2 shows a decrease of travel time in comparison to the base case.

Scenario 3 produces a higher travel time because of the increase of number of trams on line 3 and 4. The stops for those two lines are the shortest ones and therefore only one tram can stop there.

The vehicle actuated program shows once again a big decrease in travel times.

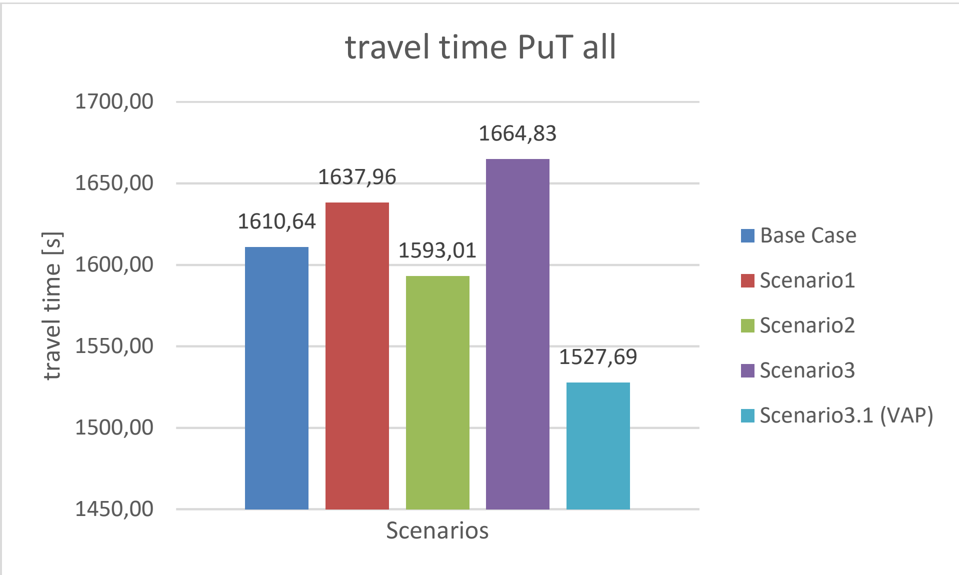

Figure 9: travel times of tram lines in both directions

In the Figure 9, the best result obtained was the scenario 3.1 (VAP). This result has a similar histogram as the Figure 8, because the data introduced in south is predominant over the north data.

4.2 Comparison private transport/public transport

To compare the private transport on junction Opernring / Am Eisernen Tor, a queue counter was modelled on both streets. The queue counter measures the queue length.

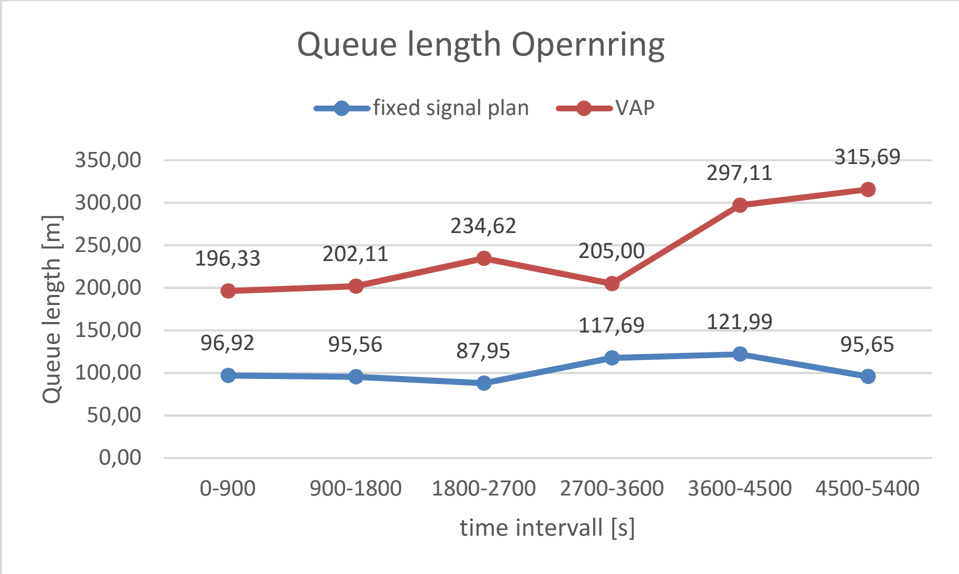

Figure 10: Queue length on Opernring

Figure 10 compares scenario 3 with the fixed signal plan and scenario 3 with a vehicle actuated program. The difference of the measurements is the detector that was implemented in VAP and not in the other simulation. In VAP, the detection of a new element over the road will reduce the maximum green phase of stage 1. Therefore, this means the queue length will increase because less vehicle can pass the junction. For example, in the Figure 10, between 1800-2700s the queue increased for that reason.

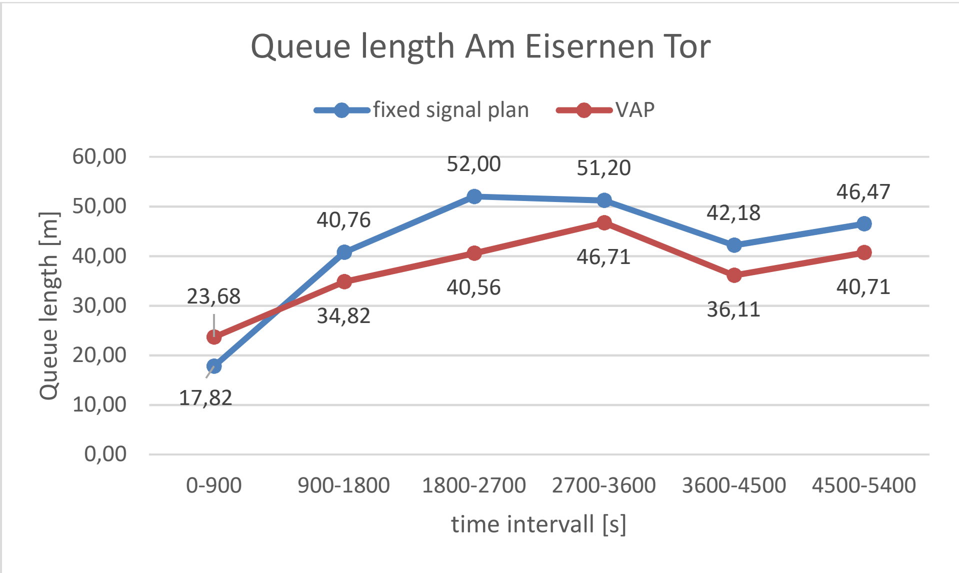

Figure 11: Queue length on Am Eisernen Tor

Figure 11 shows that there is not a big difference between scenario 3 and scenario 3.1.

The trend still shows a lower queue length for scenario 3.1. The reason for this is, that phase 3 (vehicles coming from Am Eisernen Tor) is more often used because the detector will end phase 1 earlier as in the fixed signal plan.

5 Conclusion

In general, the Jamokiniplatz is a highly frequented stop position for either trams and buses because it is located in the Grazer city centre.

After simulating different scenarios with a fixed signal plan, a general increase of travel times was evident. In Comparison a scenario with a dynamic signal plan was simulated, that showed a significant decrease of travel times. The problem with the dynamic signal plan is, that other travel times and queue length, for example the private transport, could possible increase. The advantage on the other hand is the faster connection between stops for the public transport system, which makes it more attractive.

In conclusion it can be said that if the City Graz decides to introduce more or longer trams, the Jakominiplatz has to be rebuild. For example, longer stop positions or new stop positions.

6 Figures

7 Tables

References

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