



University of Maribor

Faculty of Civil Engineering,
Transportation Engineering
and Architecture

(Micro)simulation in planning and managing of traffic flows

(Mikro) simulacija vo planiranjeto i upravuvanjeto na soobračajni tekovi

Skopje, 7. December 2017

Dr. Matjaž Šraml

Matjaž Šraml redovit je profesor i prodekan za međunarodnoudjelatnostna Građevinskom fakultetu Sveučilišta u Mariboru (FGPA UM). Istraživački i pedagoški djeluje na području prometnog inženjerstva. Deset godina (1995.-2005.) bio je zaposlen na Strojarskom fakultetu Sveučilišta u Mariboru, gdje je 2001. i doktorirao. Istraživački se bavio prije svega primjenom numeričkih simulacijskih metoda na strukturne analize tehničkih sustava i uređaja s primjenom metode konačnih elemenata (MKE) i diskretnih simulacija toka materijala. Od 2006. godine zaposlen je na FGPA UM gdje se bavi prometnom sigurnošću i diskretnim numeričkim simulacijama prometnih tokova, s naglaskom na mikrosimulacije u prometnom inženjerstvu. (Su)autor je 40 izvornih znanstvenih članaka i nositelj predmeta s područja vozila, prometne sigurnosti i simulacija u prometu. Gostujući je profesor na Sveučilišta u Hasseltu i Sveučilišta u Novom Sadu te član međunarodnog društva za prometnu sigurnost ICTCT.



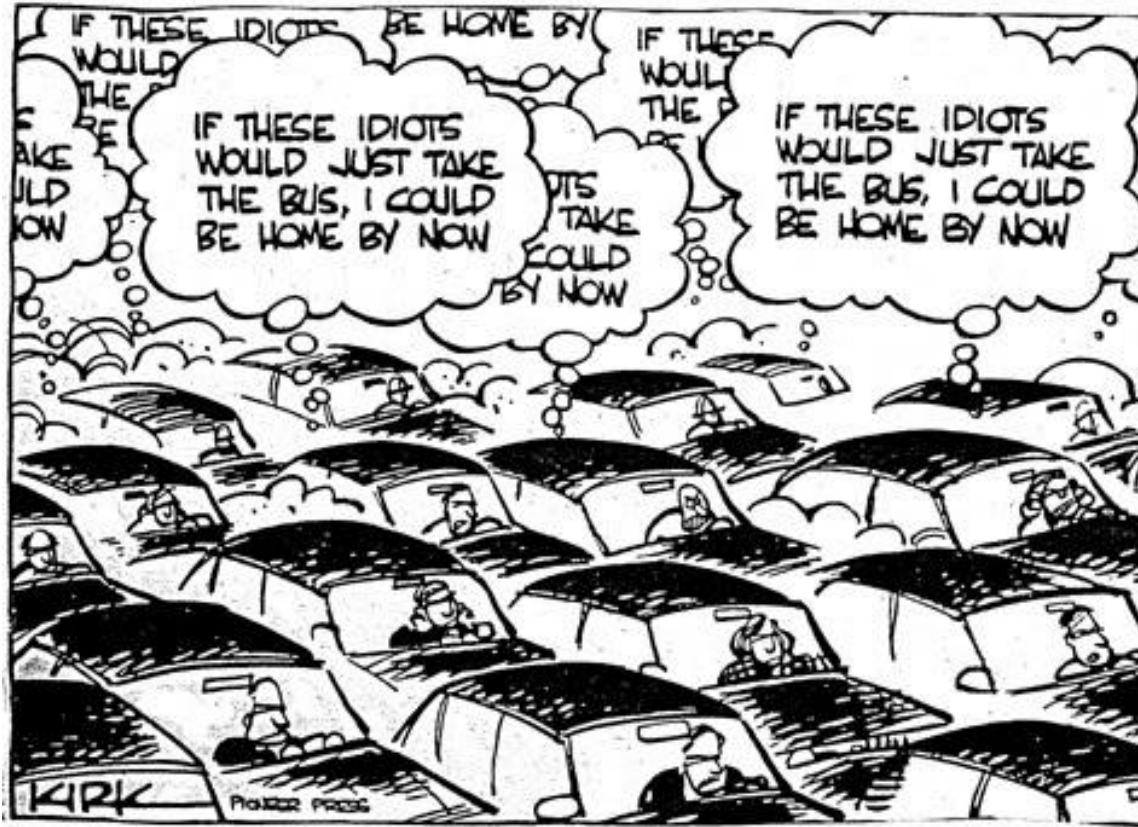


WHY and WHEN/ZAŠTO i KADA

WHERE and HOW / GDJE i KAKO



- Do we need simulation? MOTIVACIJA
- If, how to use it? KAKO PRISTUPITI?
- Case study. PRIMERI IZ PRAKSE
- Conclusion. ZAKLJUČCI

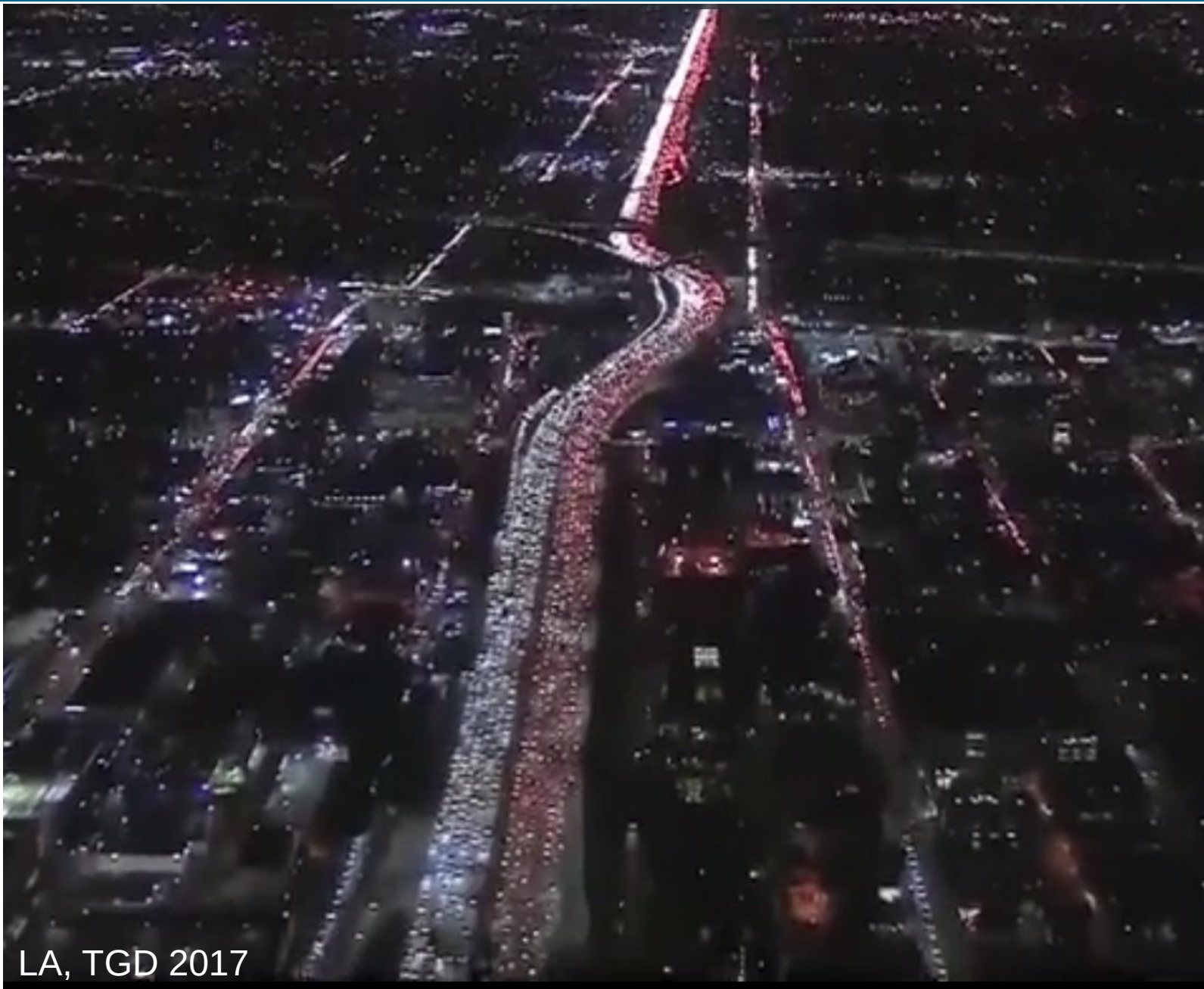


Traffic jams due to:

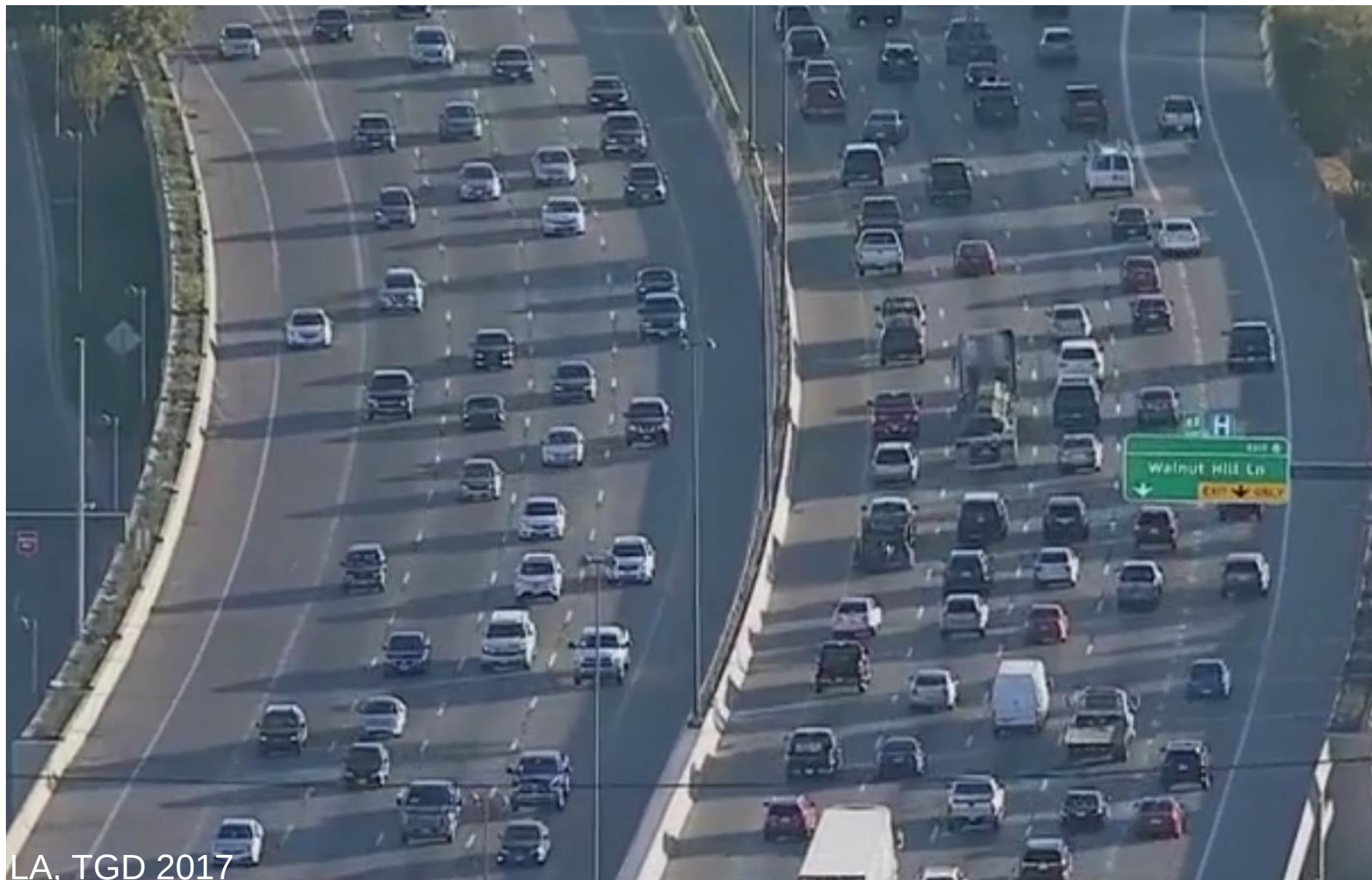
- Accidents
- Work zones
- Not using PT
- Mentality of drivers
- etc.

Effects on:

- Environment
- Economy
- Sustainability
- „Nerves of usres“
- etc.

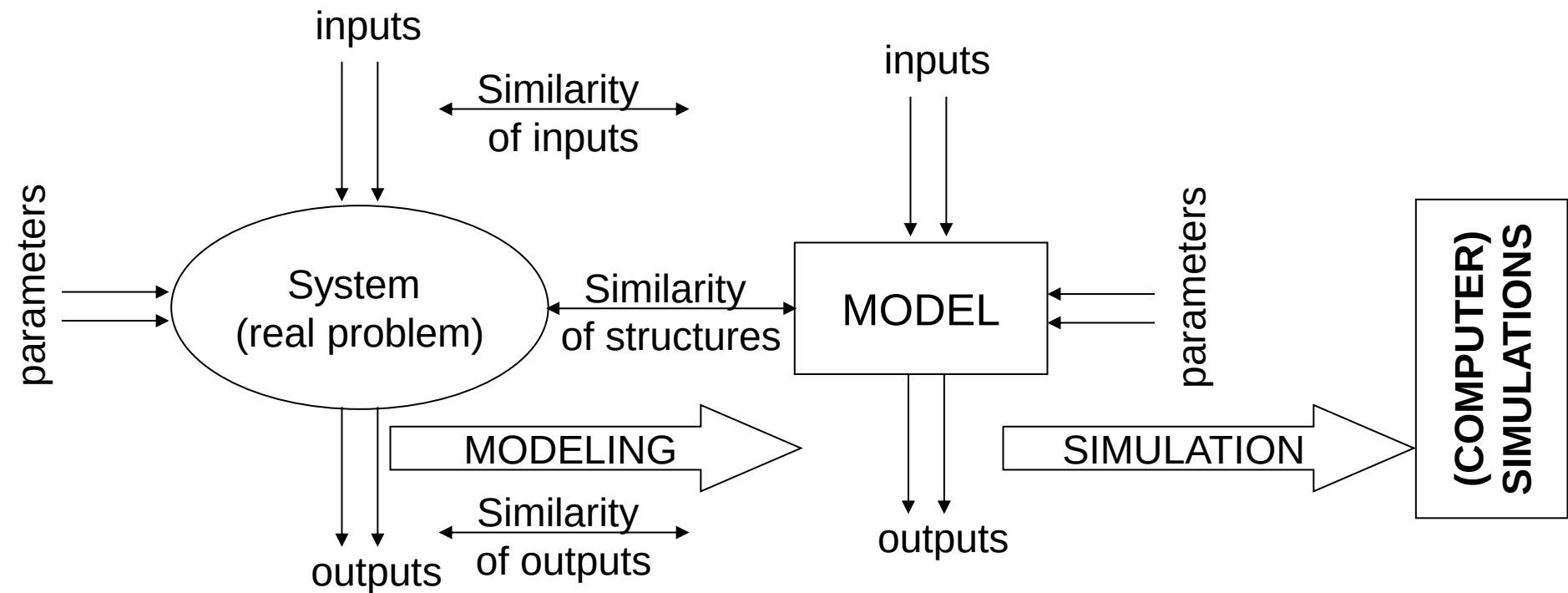


LA, TGD 2017



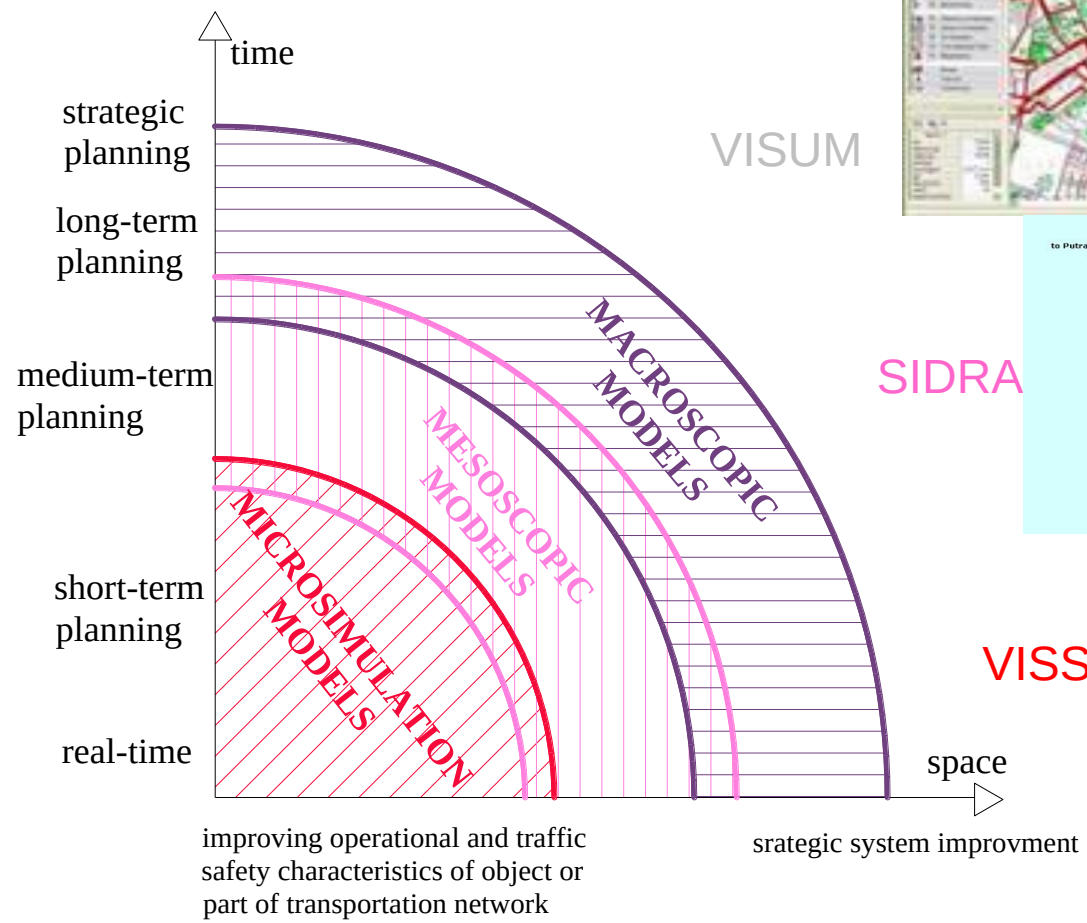
LA, TGD 2017

General approach





Models



SIDRA



VISSIM



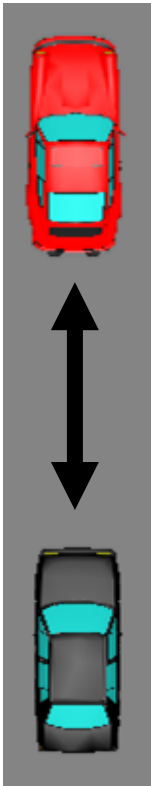


Microsimulation is the dynamic and stochastic modeling of individual *vehicle* movements, within a system of transportation facilities.

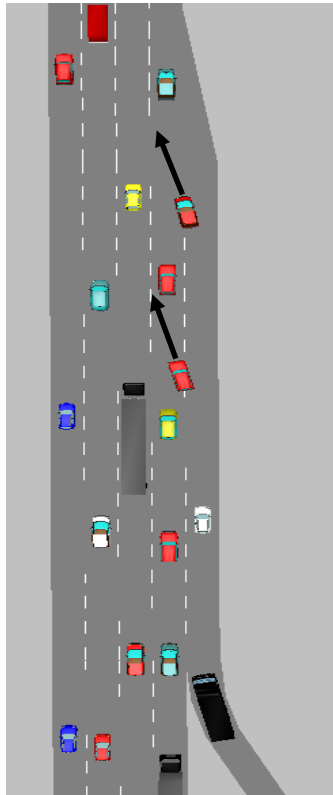


„Equations“

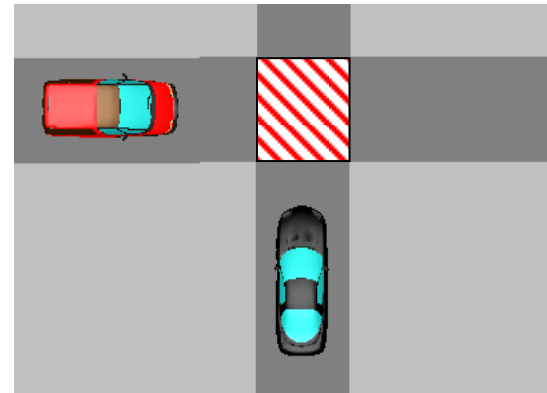
CFM



LC/GAM



Priority rules





➤Traffic engineers often compare traffic to a fluid, assuming that a certain volume must flow through the road system: $q = k \cdot u$

$$\frac{\partial q}{\partial x} + \frac{\partial k}{\partial t} = 0$$

and/or

$$\frac{\partial q}{\partial x} + \frac{\partial k}{\partial t} = g(x, t)$$



...urban traffic may be more comparable to a gas that expands to fill available space
(*kinetic theory of gases*)...



- **Capacity analysis**
- **Planning new routes**
- **Reconstruction of routes**
- **Managing traffic**
- **„What if“ scenarios**

- **Safety analysis (SSAM)**
- **Environmental impacts analysis**
- **Pedestrians, cyclists, ...**
- **The movement of groups of people**
- **etc.**



On-line response dynamic traffic management system in urban areas

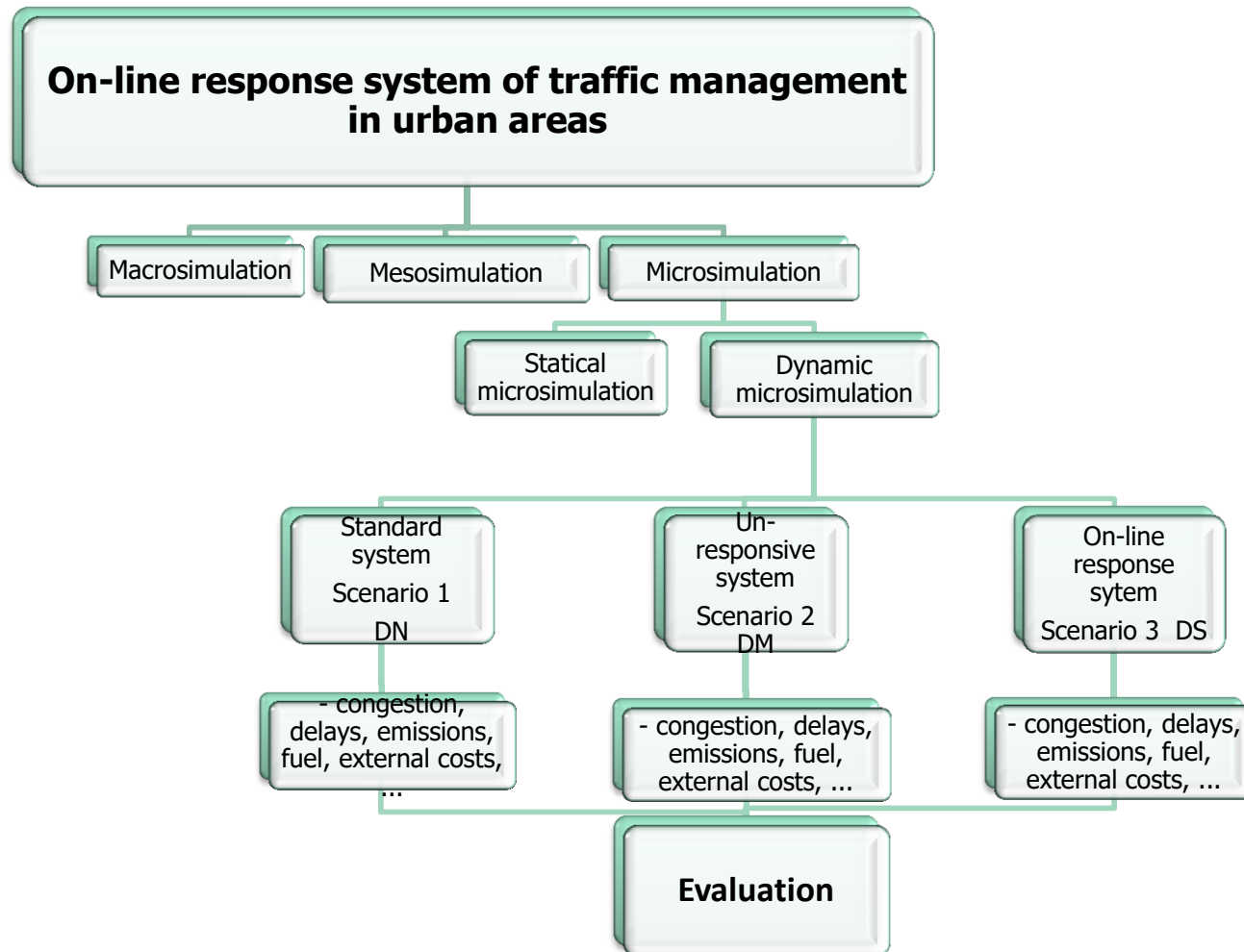
Micro-meso approach

More in Master thesis:

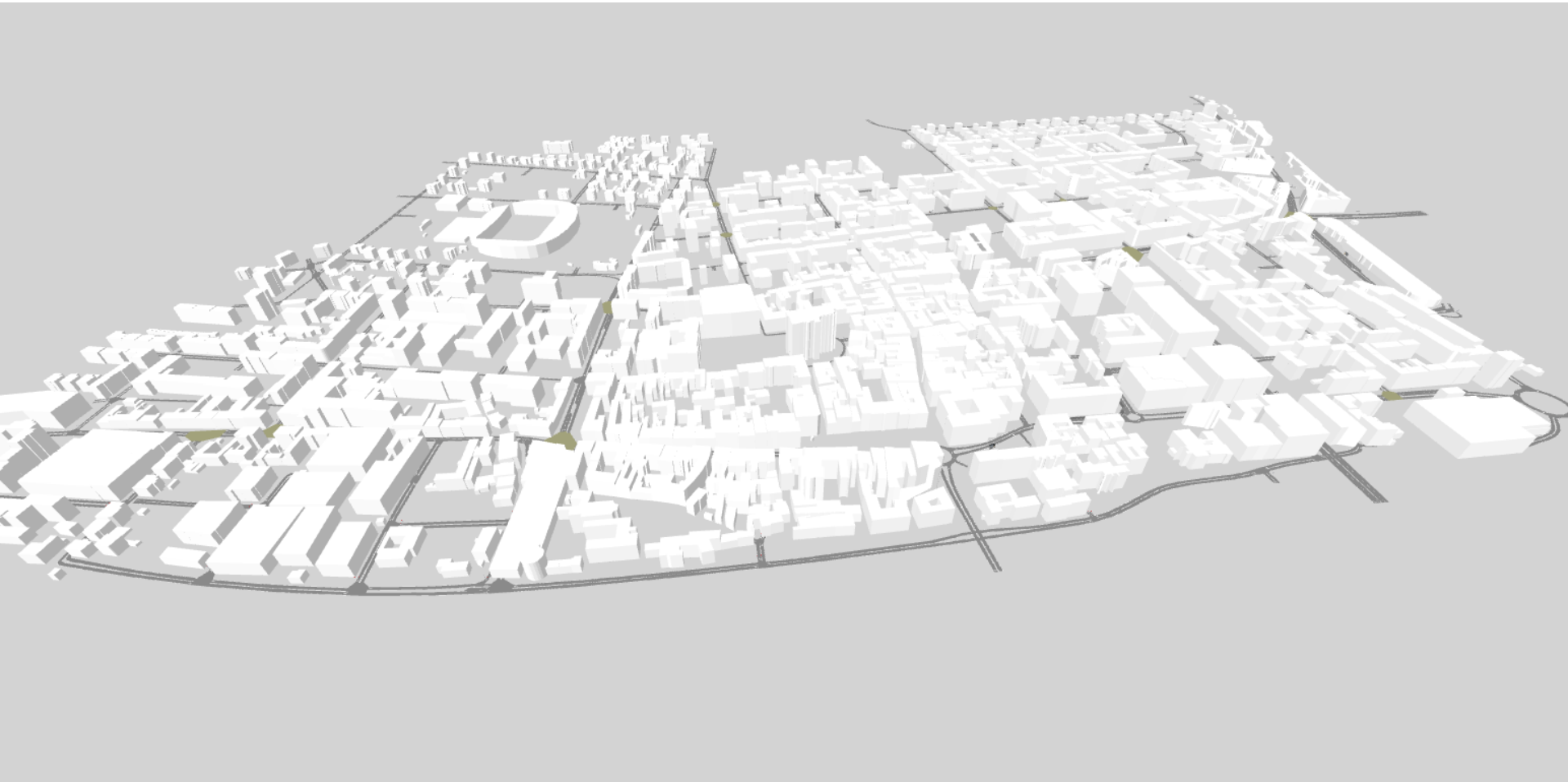
<https://dk.um.si/Dokument.php?id=83624>



Flowchart of the research

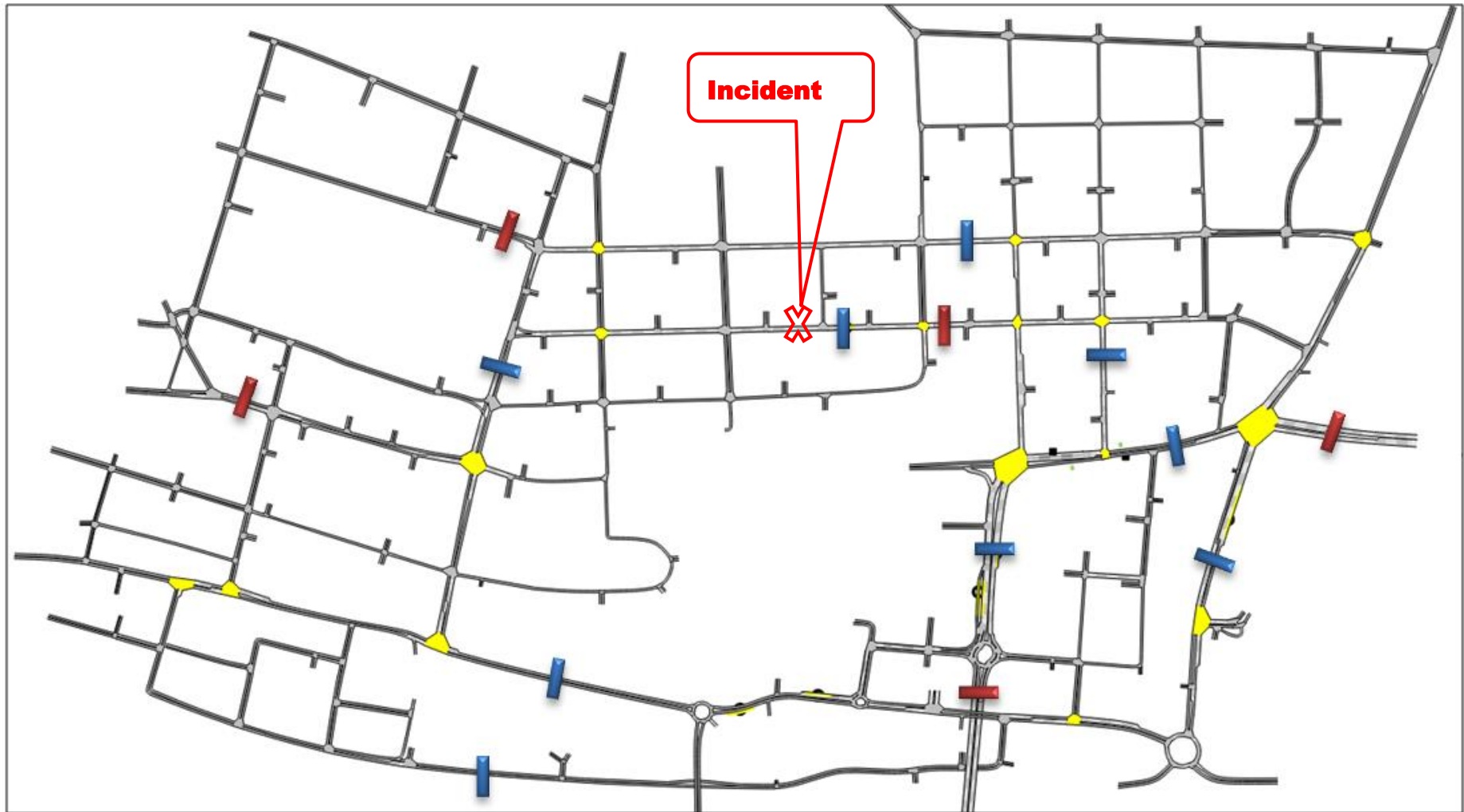


3D network

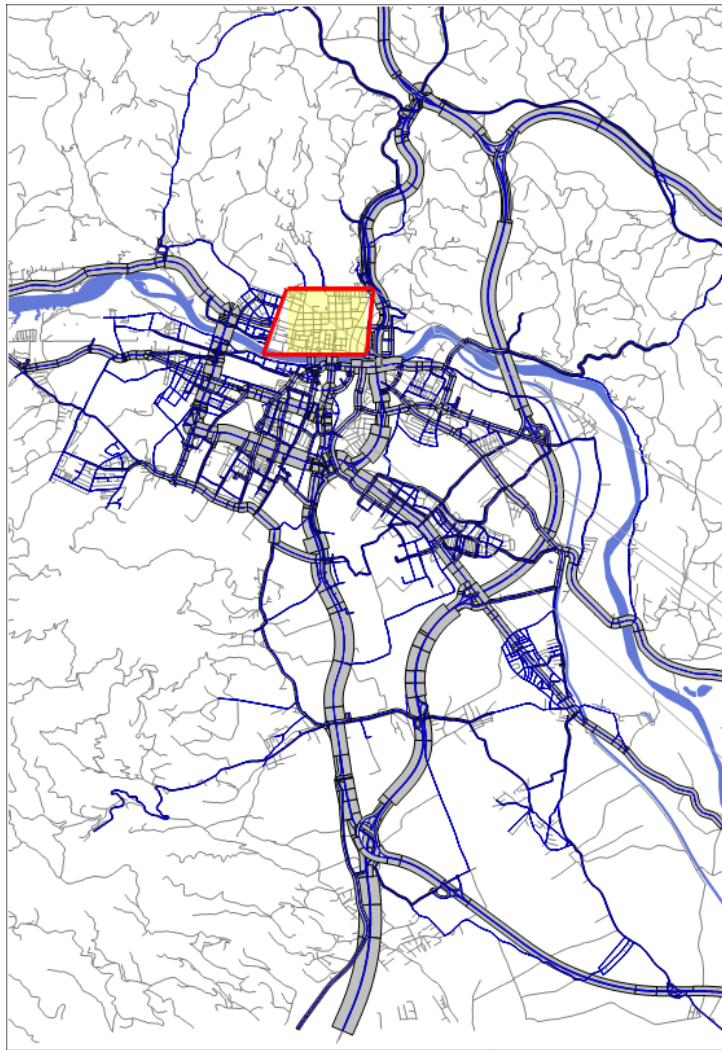




Scenarios



Observed network



$q = q(t)$,

$d \rightarrow d(\max)$

$d \rightarrow d(\min)$



- the number of links - sections: 629,
- the total length of sections: 32 km,
- the total length of traffic lanes: 38 km,
- the number of nodes - intersections: 119
- SSN number of intersections: 15
- number of centroids: 94



Results for the network

Microscopic simulation by the method of dynamic loading	Scenario 1 DN		Scenario 2 DM		Scenario 3 DS		Scenario 2 DM		Scenario 3 DS		Evaluation of scenarios DS/DM	
	Sum	Stand. deviat.	Sum	Stand. deviat.	Sum	Stand. deviation	Sum	Stand. deviation	Sum	Stand. deviation	Share (%)	
Delay Time (s/km)	63,36	48,07	102,9	124,7	88,17	94,27	102,97	124,70	88,17	94,27	-14,37	DS<DM
Density (veh/km)	6,60	-	8,77	-	8,16	-	8,77	-	8,16	-	-6,96	DS<DM
Flow (veh/h)	7610	-	7417	-	7582	-	7417	-	7582	-	2,22	DS>DM
Mean Queue Length (veh)	134,59	-	225,9	-	195,47	-	225,94	-	195,47	-	-13,49	DS<DM
Speed (km/h)	30,59	9.93	27,6	11,76	28,32	11,36	27,65	11,76	28,32	11,36	2,42	DS>DM
Stop Time (s/km)	51,02	46.74	88,6	120,31	72,81	91,02	88,68	120,31	72,81	91,02	-17,90	DS<DM
Total Distance Travelled (km)	8647	-	5817	-	8840	-	5818	-	8840,29	-	51,95	DS>DM
Total Travel Time (h)	324,9	-	421,6	-	404,3	-	421,55	-	404,25	-	-4,10	DS<DM
Travel Time (s/km)	131,98	48,2	171,6	124,4	157,06	94,18	171,57	124,44	157,06	94,18	-8,46	DS<DM
Vehicles Waiting to Enter (veh)	1	-	7	-	1	-	7	-	1	-	-85,71	DS<DM



Scenario 1 – DN

Scenario 2- DM

Scenario 3 -DS

1.



15.10

15.20



15.30

15.40



15.50

16.00

2.





- 3D video (15.50-15.51)

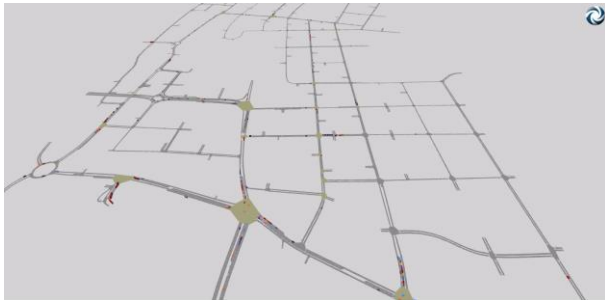
Scenarij 1 - DN



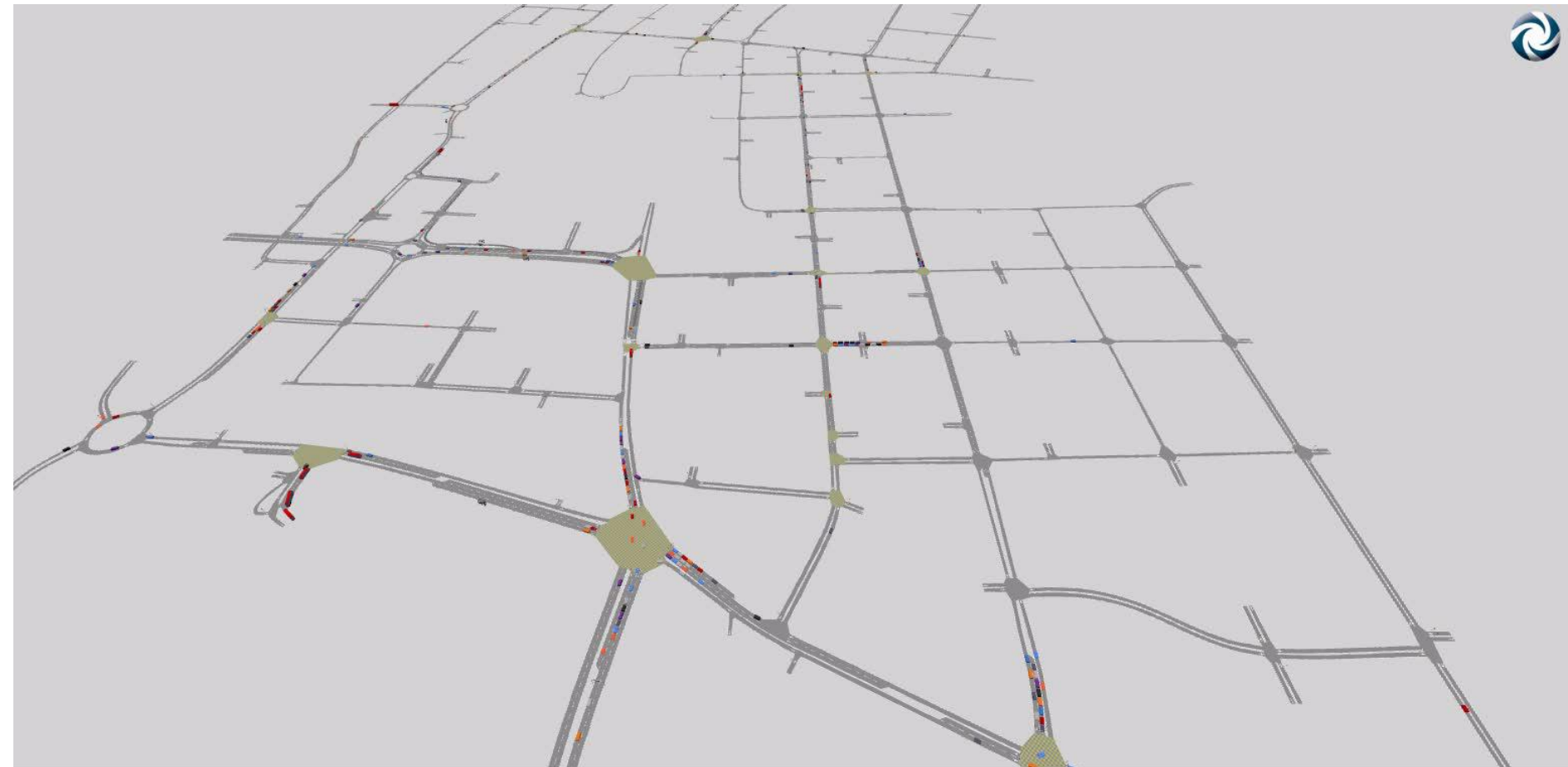
Scenarij 2 - DM



Scenarij 3 - DS



2D video (15.00-16.00)





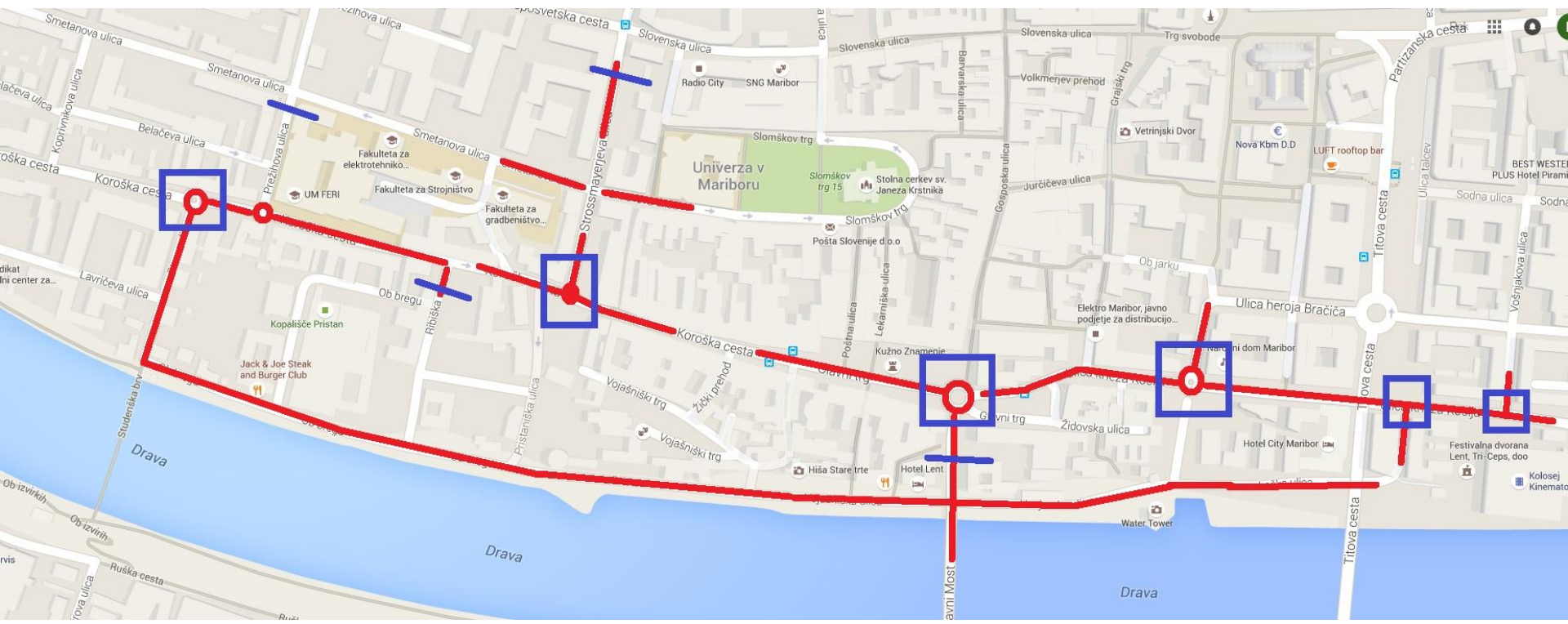


Microsimulation of traffic flows - the city centre of Maribor

Micro-meso approach

More in Master thesis:

<https://dk.um.si/Dokument.php?id=119266>

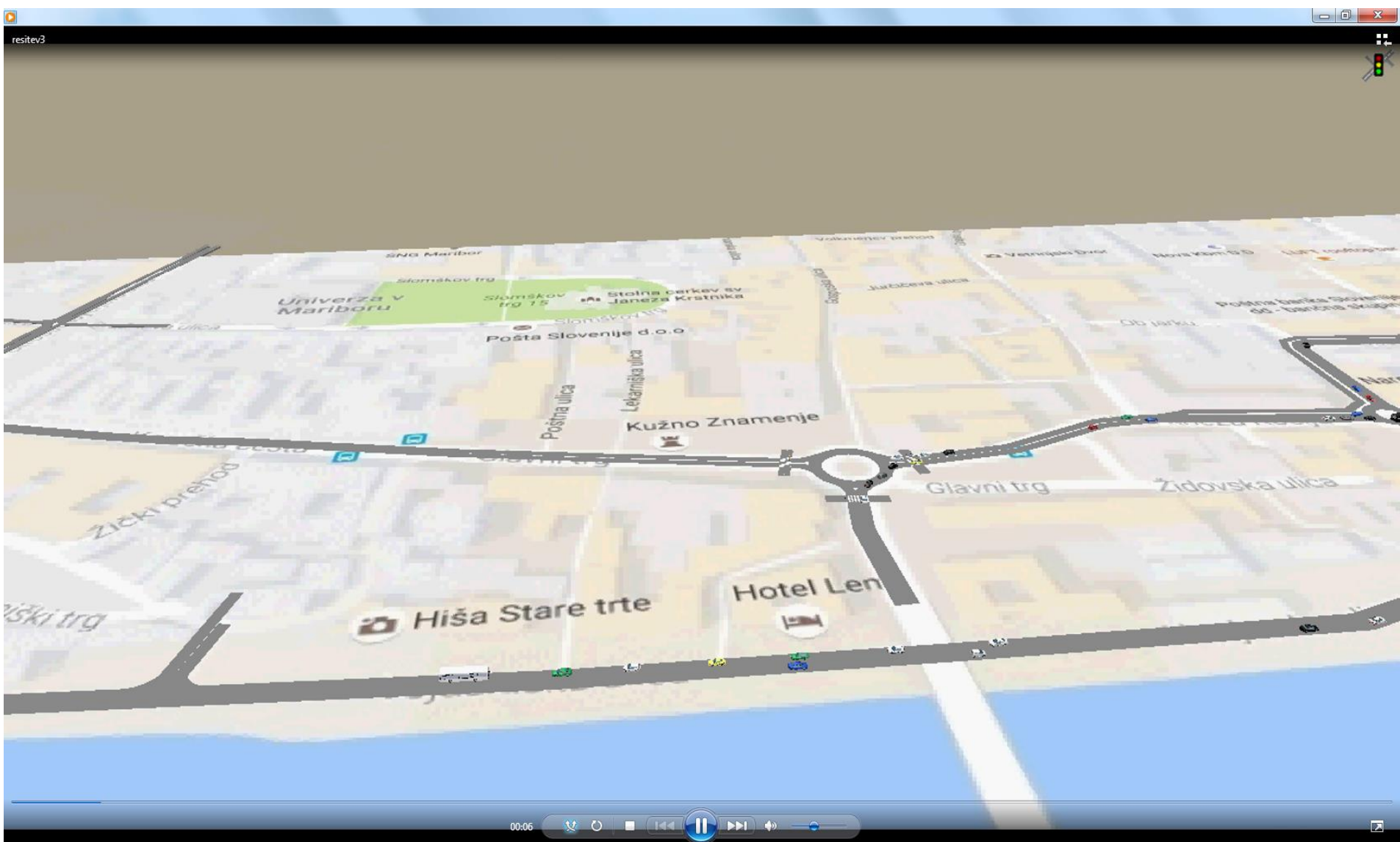


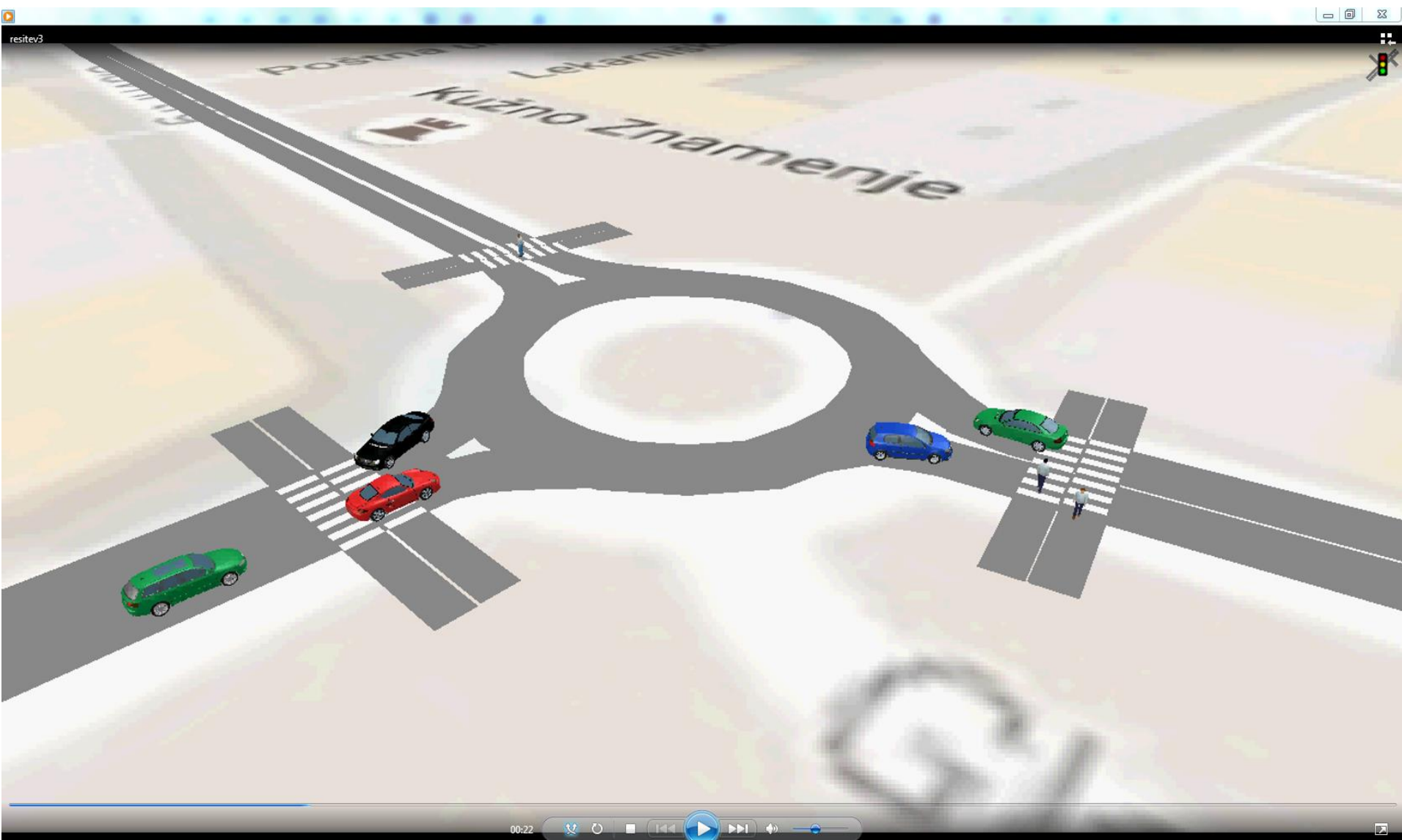
LEGENDA:

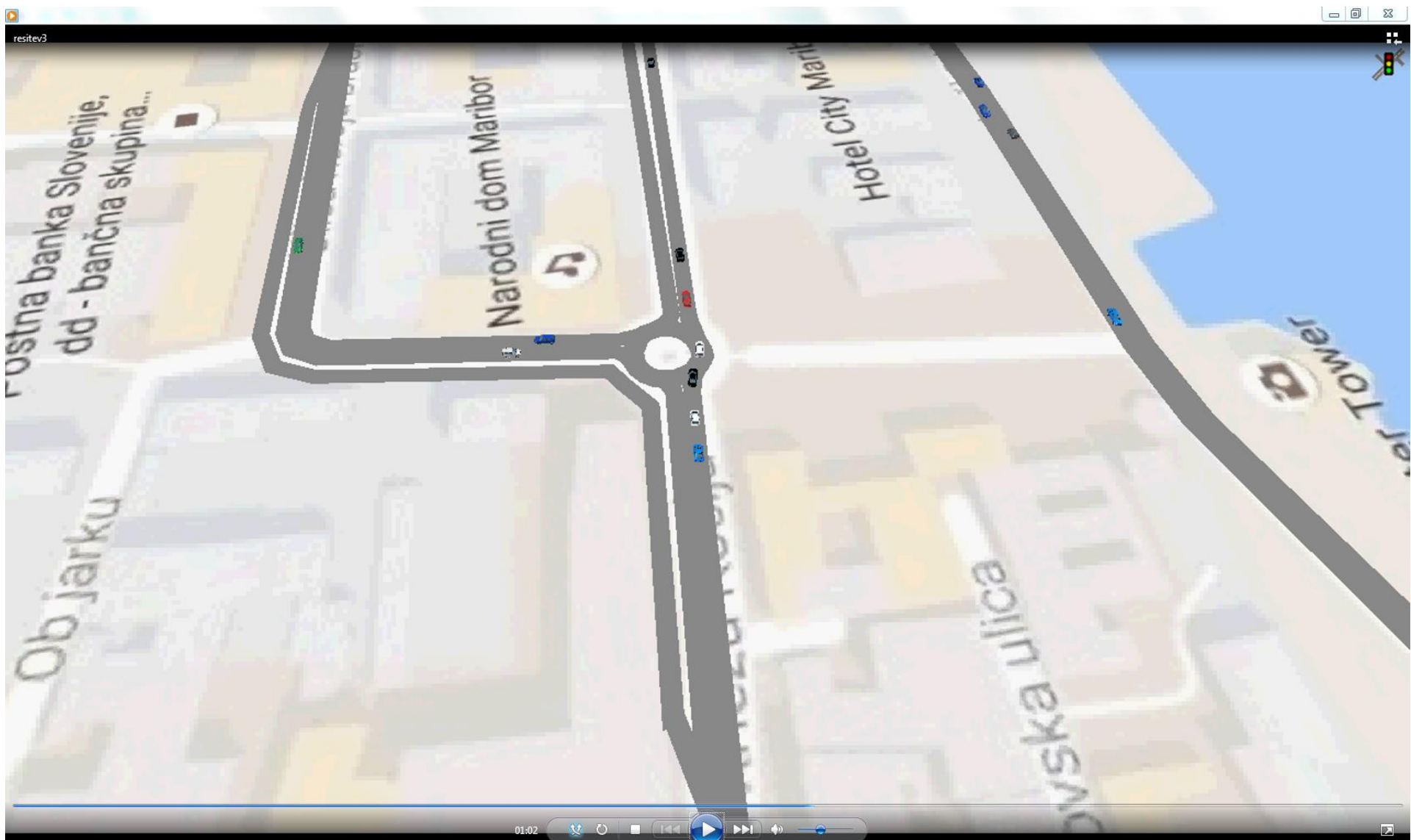
- ŠTEVNA MESTA NA KRIŽIŠČIH S SNEMANJEM
- MESTA VNOSA ŠTEVILA VOZIL V MIKROSIMULACIJI

Legend:

- Caunting and recodring traffic
- Input capacity in the microsimulation









Traffic flows at worksites on motorway

Micro approach

Research project



Infrastructure characteristics:

- Basic Motorway Segment: four lane motorway in length of 24 km.
- Type of work zone: alternately 2+1 lanes.
- Speed limit: successive reduction from 130 km/h to 60 km/h.

Motorway segment: RAVBARKOMANDA AC					
	Vehicles	Queue length		Vehicles	
Time	Direction KP	km -> KP	km -> LJ	Direction LJ	Regime
6:00	534	0	0	441	1 lane KP
7:00	978	1	0	1.050	
8:00	1.222	2	0	1.221	
9:00	1.312	3	0	1.205	
10:00	1.296	6	1	1.312	Change
11:00	1.164	6	3	1.492	1 lane LJ
12:00	1.152	6	6	1.326	
13:00	1.337	3	8	904	
14:00	1.605	0	17	807	
15:00	1.648	1	18	892	Change
16:00	1.204	3	18	828	
17:00	1.258	7	20	1.655	1 lane KP

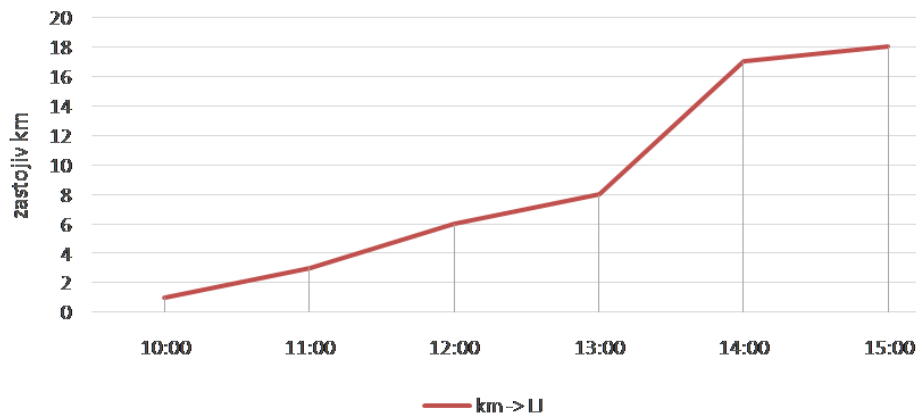




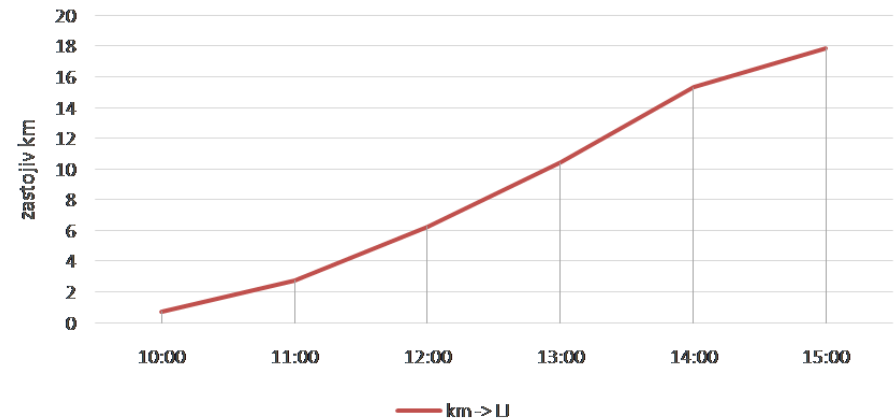
Comparison- direction LJ

- Real traffic flow
- Simulation traffic flow

Zastoj 19.9.2014 (v km)



Simulacija zastoja (v km)



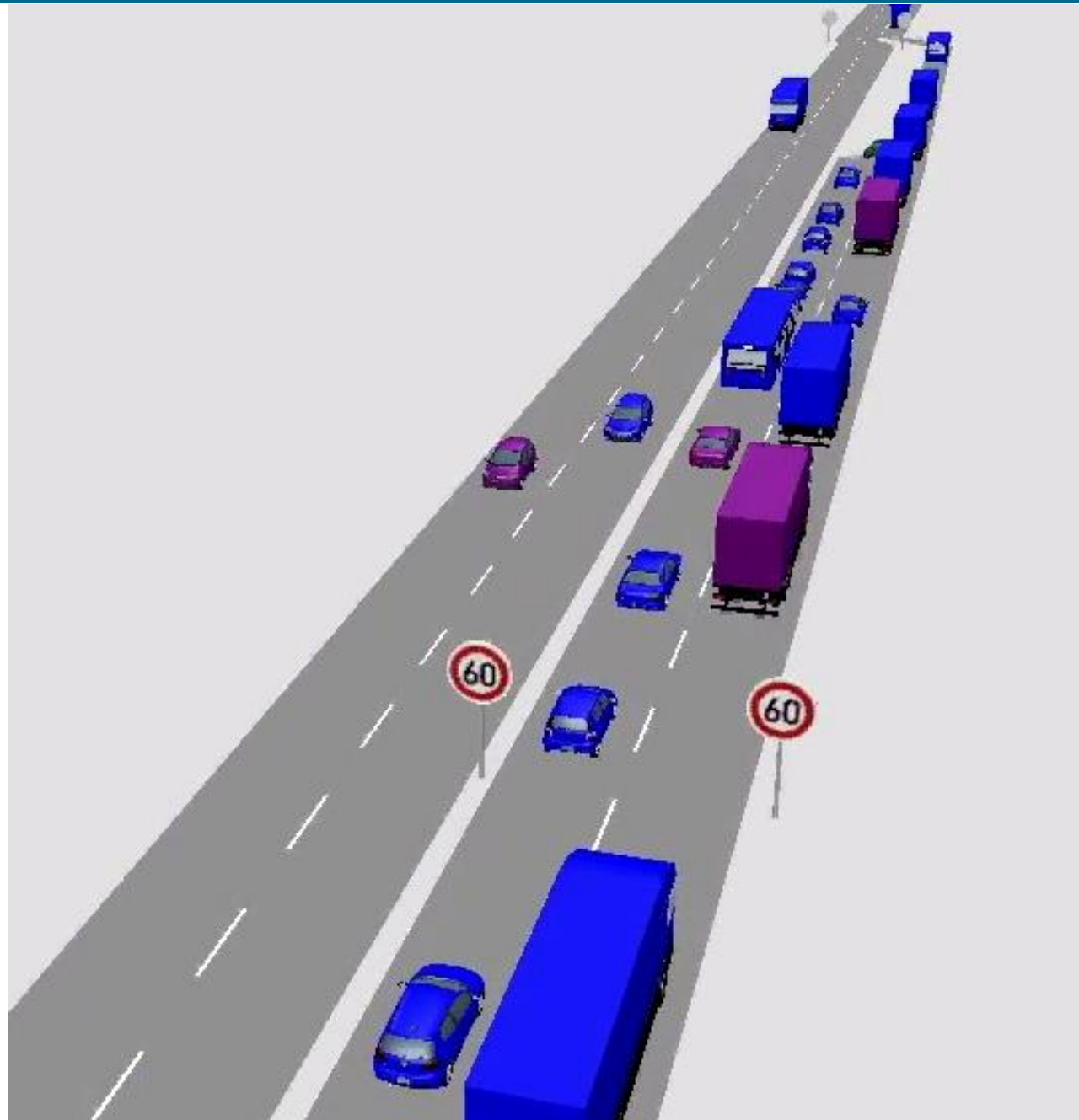


Main goals:

- Prediction of queues at worksites
- Managing of worksites
- LoS of motorway
- Forecast traffic/delays at further worksites



Animation





Traffic safety prediction using microsimulation methods - implementation at motorway intersections

Micro approach

More in Master thesis: <https://dk.um.si/Dokument.php?id=59917>

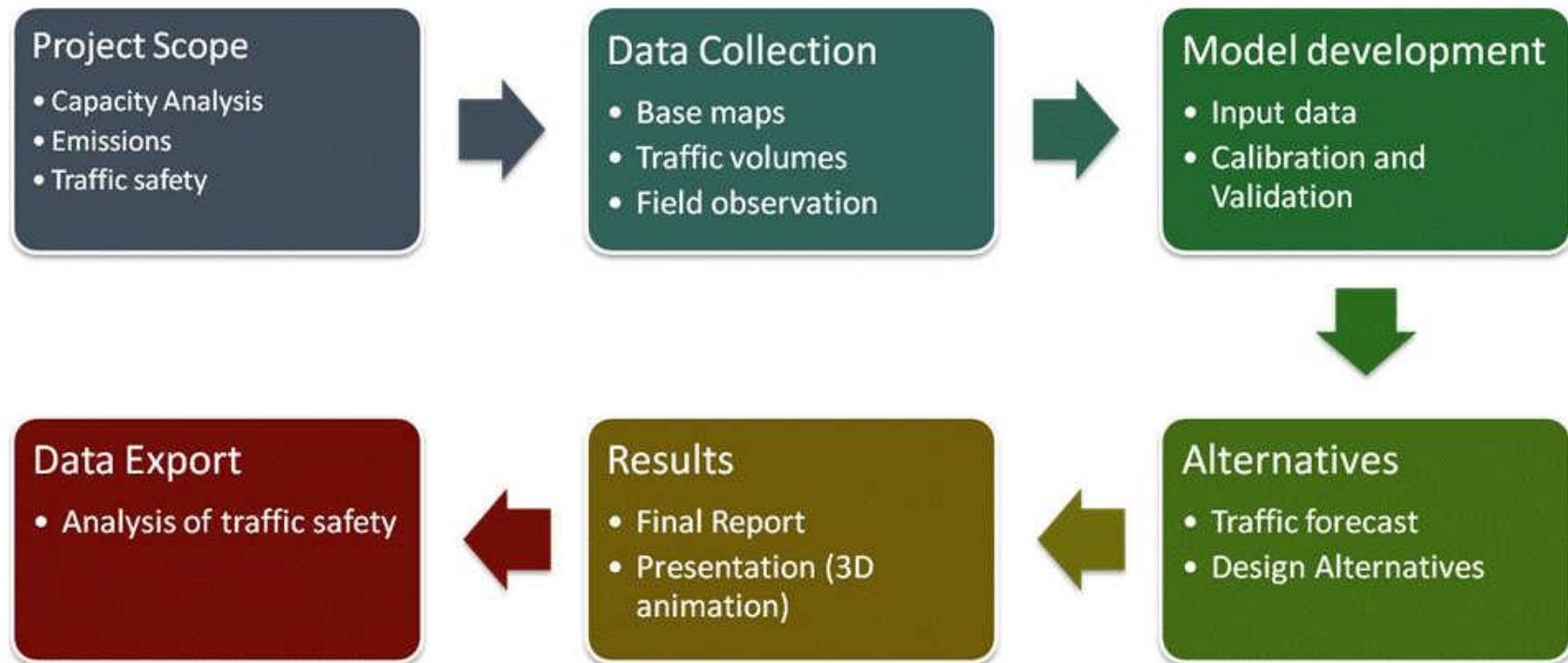


Main goals (and hypothesis):

- Is it possible to predict traffic safety with simulation methods?
- Influence of road geometric design elements on highway safety
- Relation between traffic volumen and traffic safety?
- Can we use simulation methods for Road Safety Impact Assessment (RSIA)?



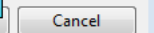
Modelling approach





Analysis

- Identification of typical motorway intersection.
- Data collection (traffic volumes, base maps, statistics etc.).
- Microsimulation model development.
- Prediction of traffic safety.

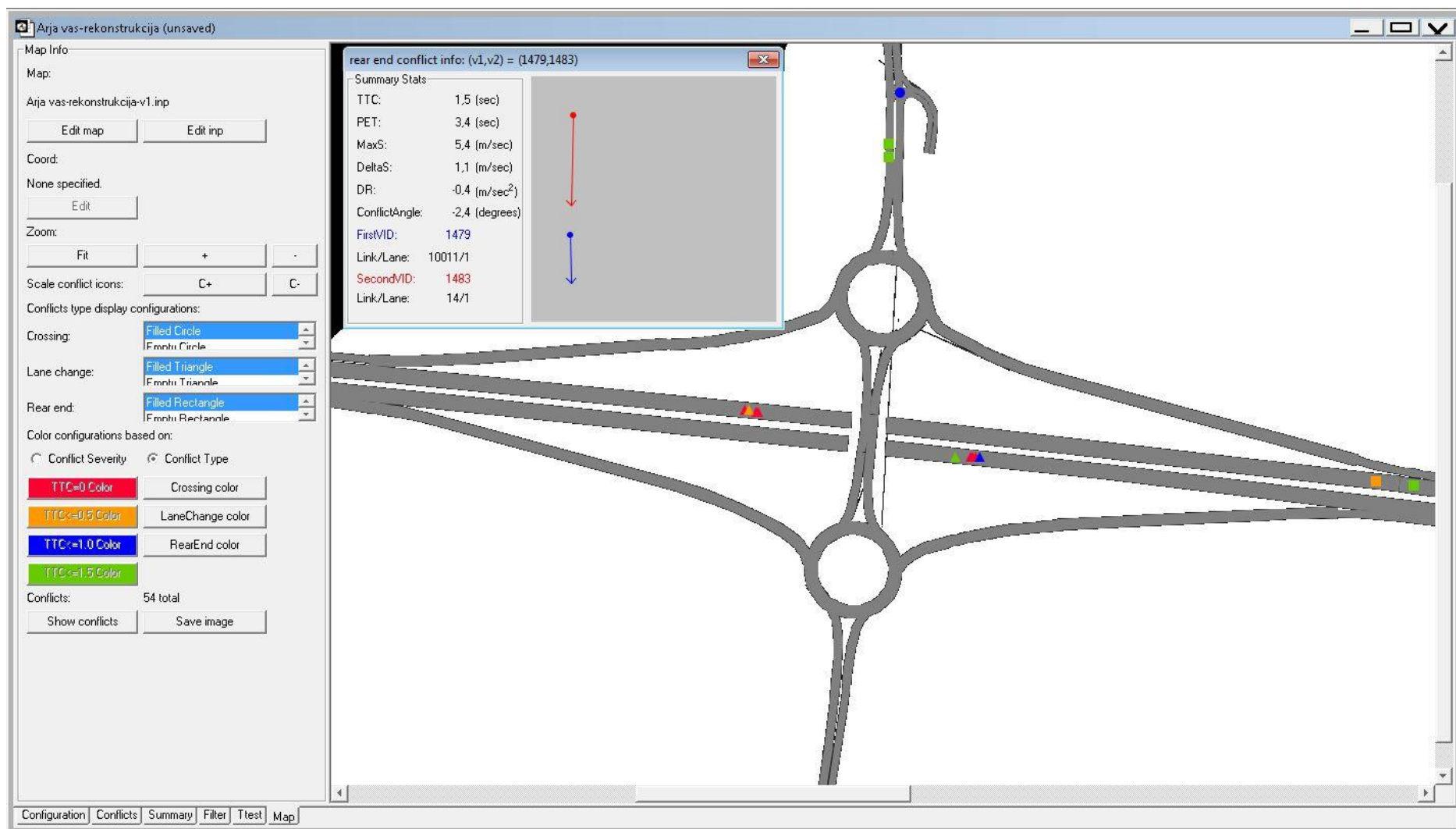


Surrogate safety assessment model (SSAM)



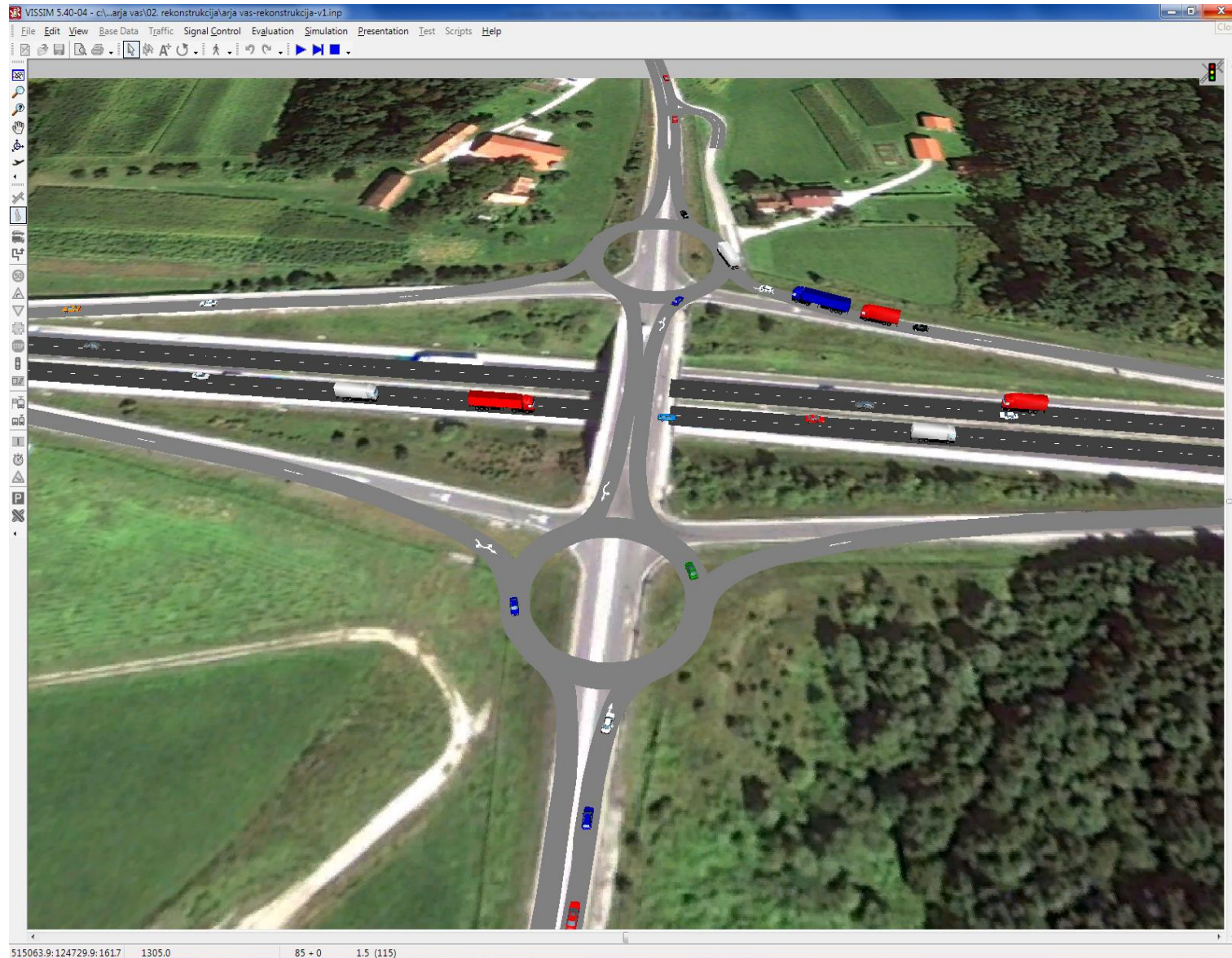


SSAM results



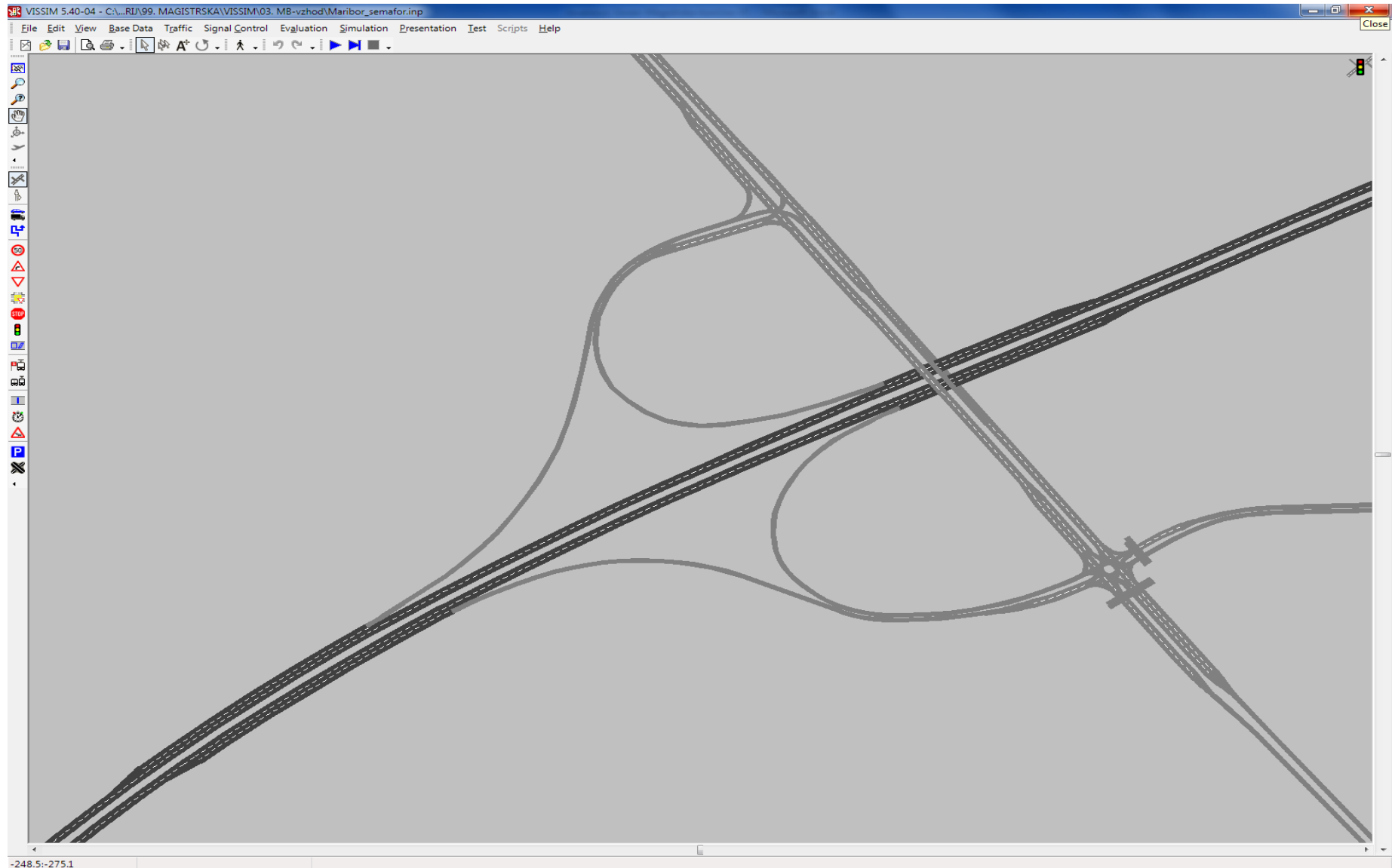


(Possible) Reconstruction



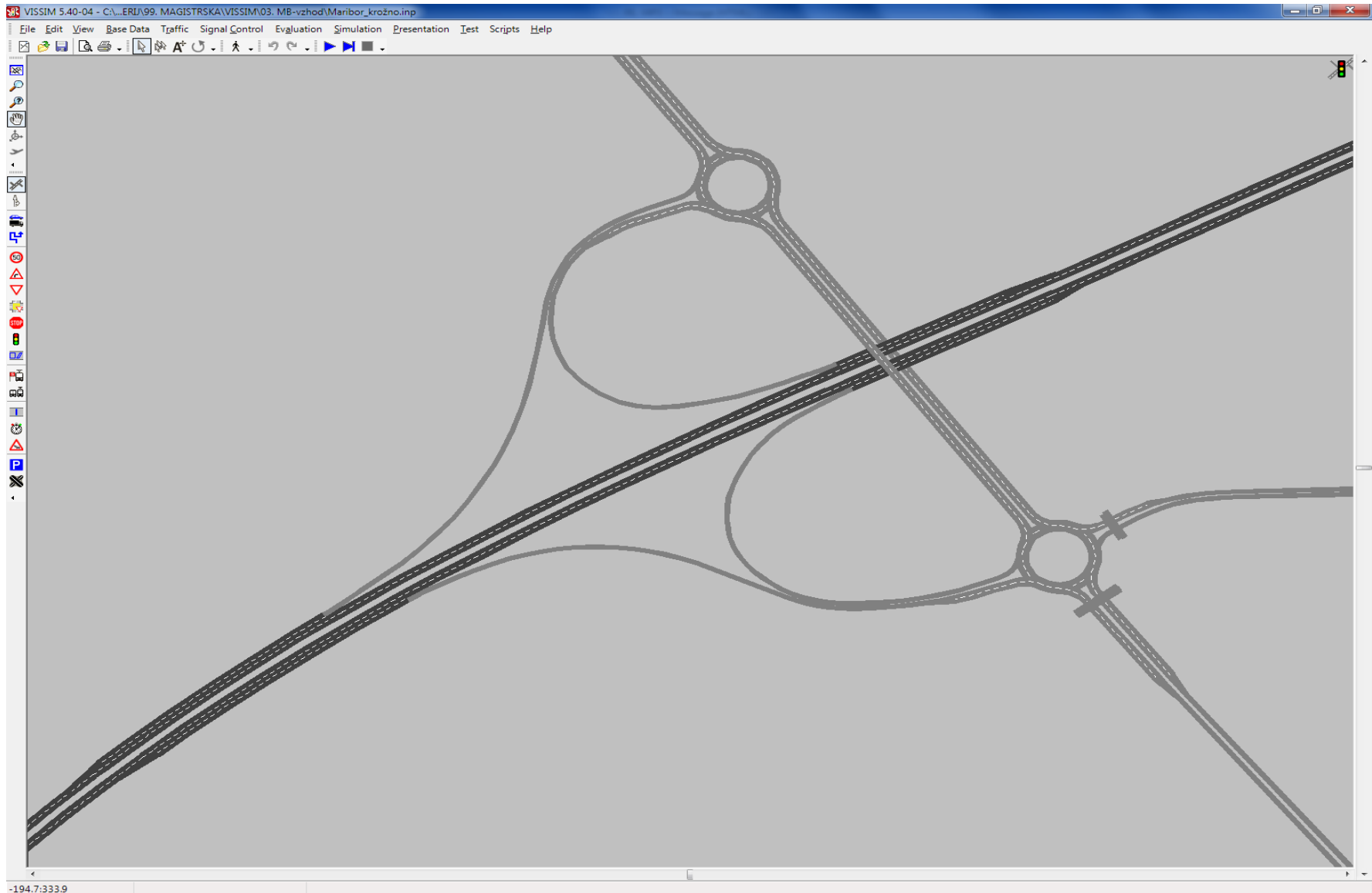


Currently...



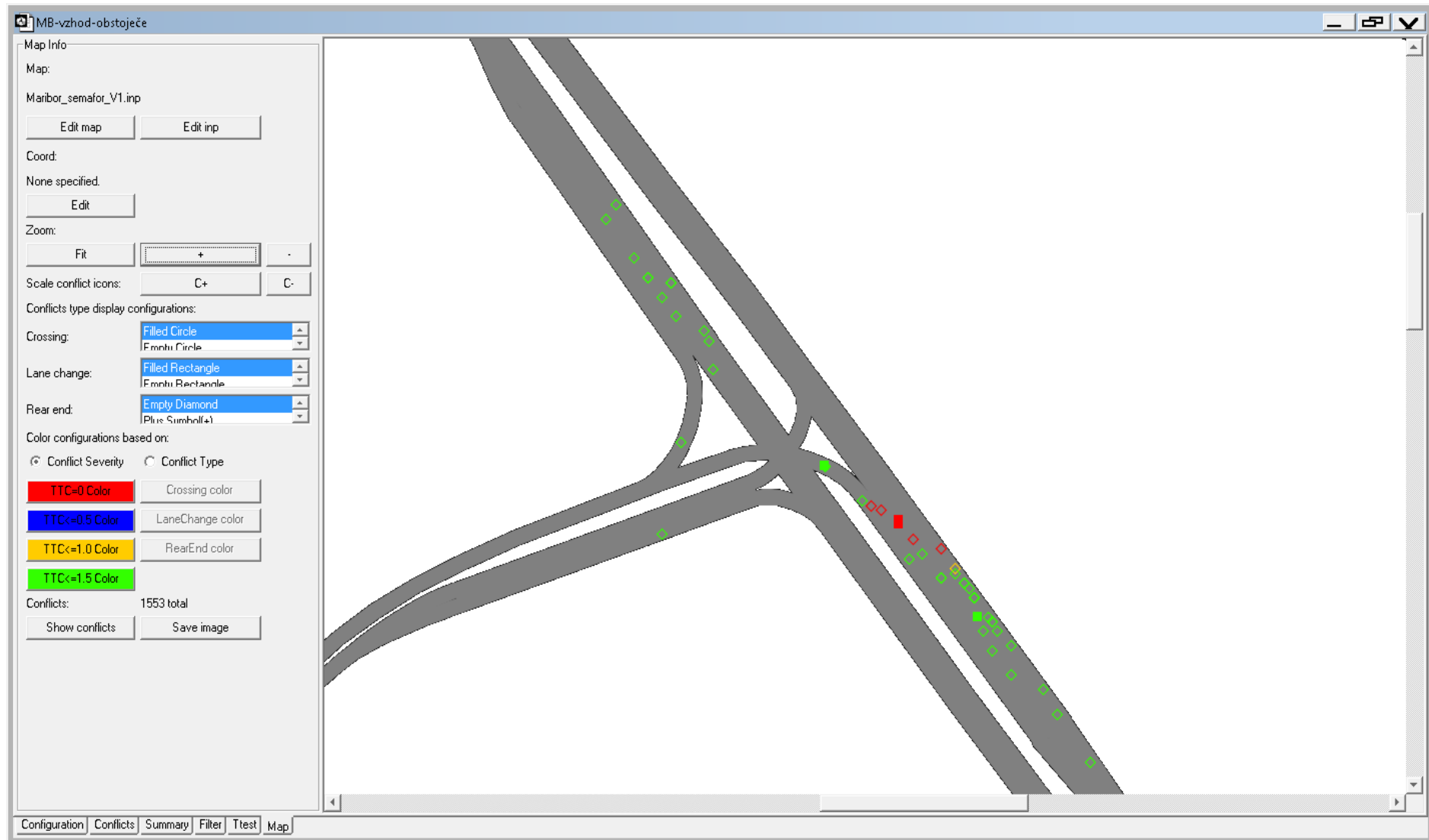


Proposed...



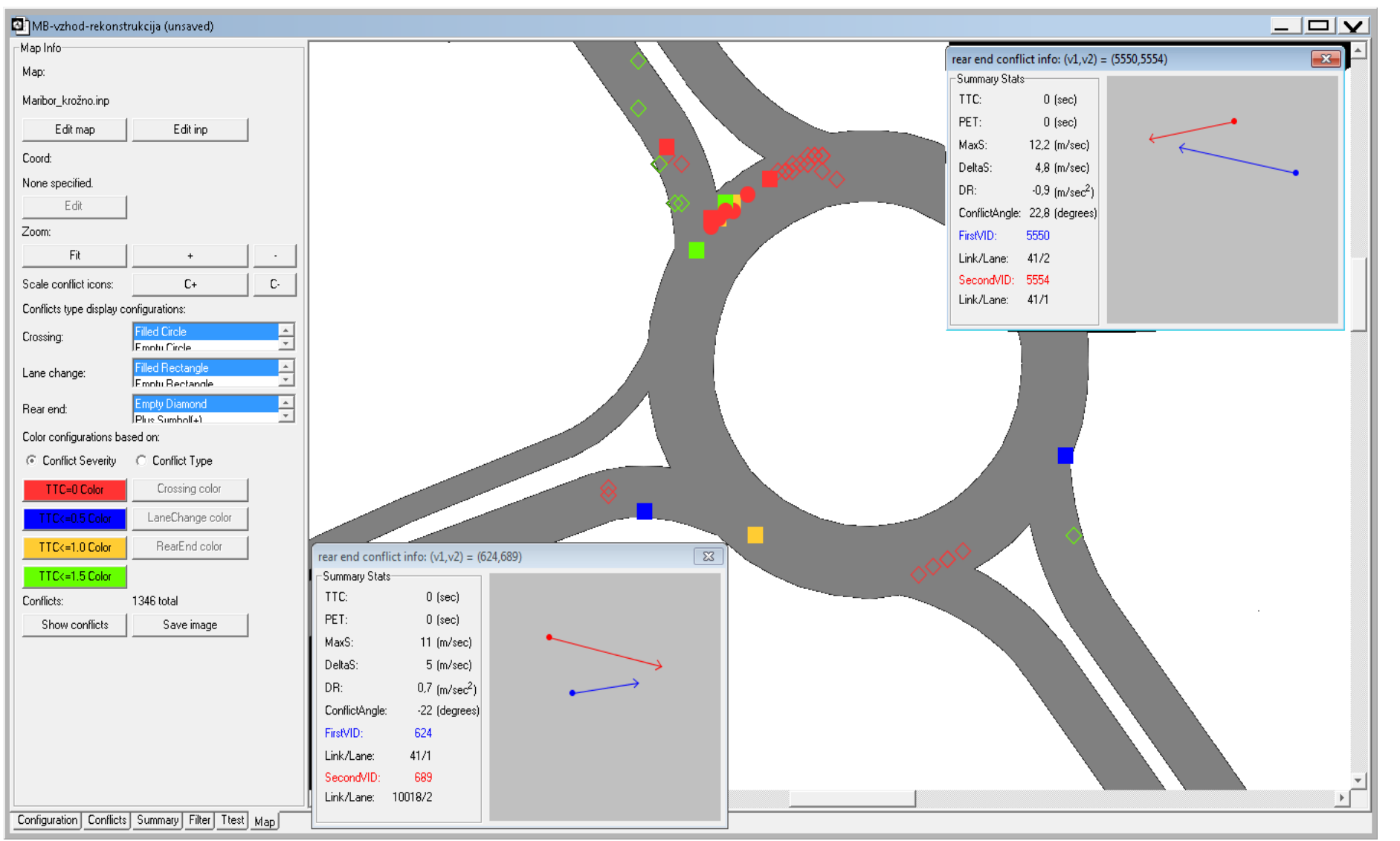


SSAM results





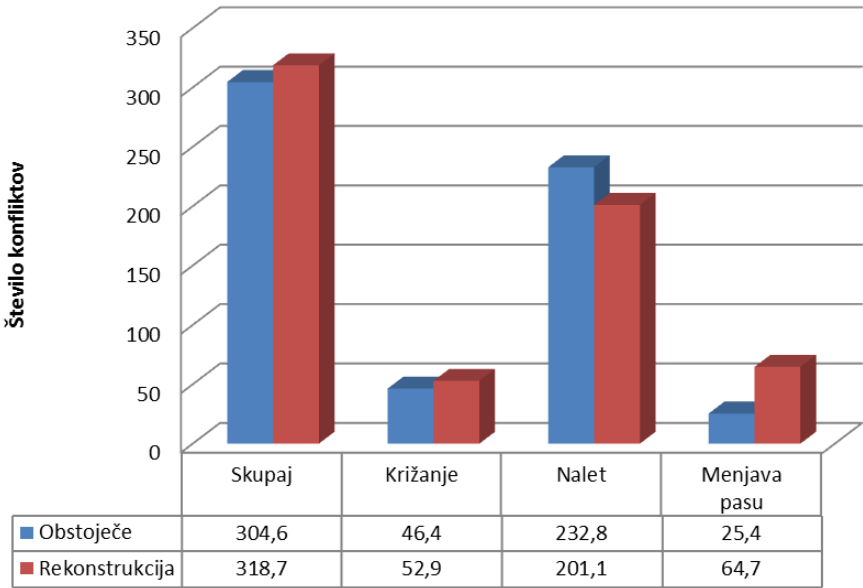
SSAM results



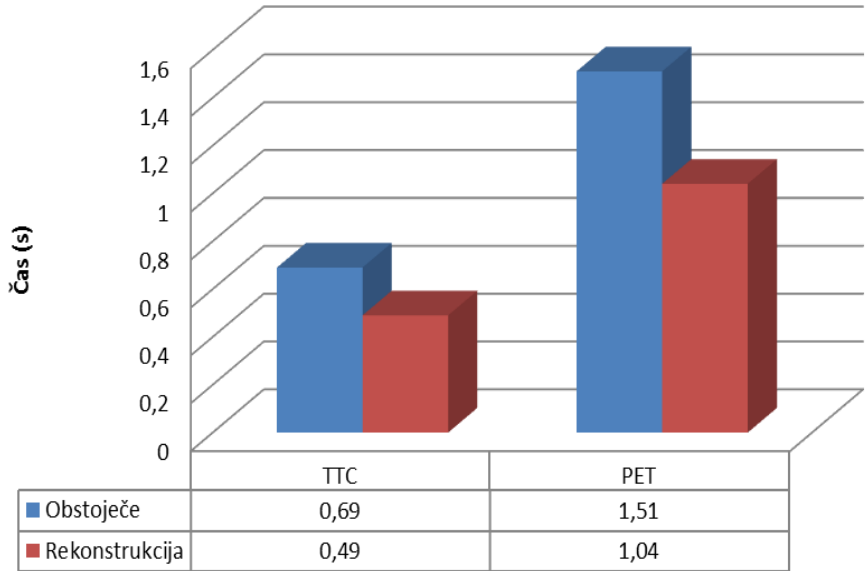


Comparison of the results

PRIMERJAVA KONFLIKTOV



PRIMERJAVA ČASOV TTC IN PET





Modelling of traffic flows:

- (Modern) Approach to traffic optimization (capacity, safety, ecology, planning, managing, maintenance,... *animation*)
- Different commercial tools (basics: mathematics and traffic technique)
- More than one simulation (due to stochastic nature of SM)
- Engineering approach (first step, comparison of the results)
- Calibration, validation...



Urban mobility:

- (Microscopic) traffic modelling useful approach to optimise urban mobility
- Probably the most advanced area of application of microsimulation in urban models is „travel modelling“
- Activity-based travel models
- Why and how?



Evaluation of the calibrated microsimulation traffic model by using queue parameters. *Road and rail infrastructure IV : proceedings of the 4th International Conference on Road and Rail Infrastructures - CETRA 2016, 23-25 May 2016, Šibenik, Croatia, 2016*, str. 59-65.

Analysis of neural network responses in calibration of microsimulation traffic model. *E-GFOS*, 2015, no. 10, str. 67-76, ilustr. <http://e-gfos.gfos.hr/index.php/arhiva>.

Calibration of microsimulation traffic model using neural network approach. *Expert systems with applications*. Nov. 2013, vol. 40, iss. 15, str. 5965-5974, doi: [10.1016/j.eswa.2013.05.003](https://doi.org/10.1016/j.eswa.2013.05.003).

Analysis of the influence of car-following input parameters on the modelled travelling time. *Tehnički vjesnik : znanstveno-stručni časopis tehničkih fakulteta Sveučilišta u Osijeku*, 2013, vol. 20, no. 5, str. 919-925.

Roundabout arm capacity determined by microsimulation and discrete functions technique. *Promet*, ISSN 0353-5320. 2008, vol. 20, no. 5, str. 291-300.

Traffic safety prediction of road elements using microsimulation methods - implementation at motorway intersections. *Sustainable and safe road design from a human behaviour point of view - Challenges for interdisciplinary work in road safety*. International Co-operation on Theories and Concepts in Traffic Safety, 26th ICTCT Workshop in Maribor, Slovenia, on 24-25 October 2013.

Simulation of the pedestrians' influence to the capacity of motorised vehicles in a roundabout. *American journal of applied sciences*, ISSN 1546-9239, 2008, 5, 1, str. 34-41.

The use of micro-simulation in determining the capacity of a roundabout with a multi-channel pedestrian flow. *Strojniški vestnik*, 2008, letn. 54, št. 5, str. 334-346.

The analysis of pedestrians stream on the roundabout capacity using micro-simulation model. *EUROSIM 2007 : proceedings of the 6th EUROSIM Congress on Modelling and Simulation, 9-13 September 2007, Ljubljana, Slovenia. Vol. 2, Full papers*, 6th EUROSIM Congress on Modelling and Simulation, 2007, str. 1-10.

Discrete simulation of traffic flows in highway tunnels. *EUROSIM 2007 : proceedings of the 6th EUROSIM Congress on Modelling and Simulation, 9-13 September 2007, Ljubljana, Slovenia. Vol. 2, Full papers*, 6th EUROSIM Congress on Modelling and Simulation, 2007, str. 1-10.



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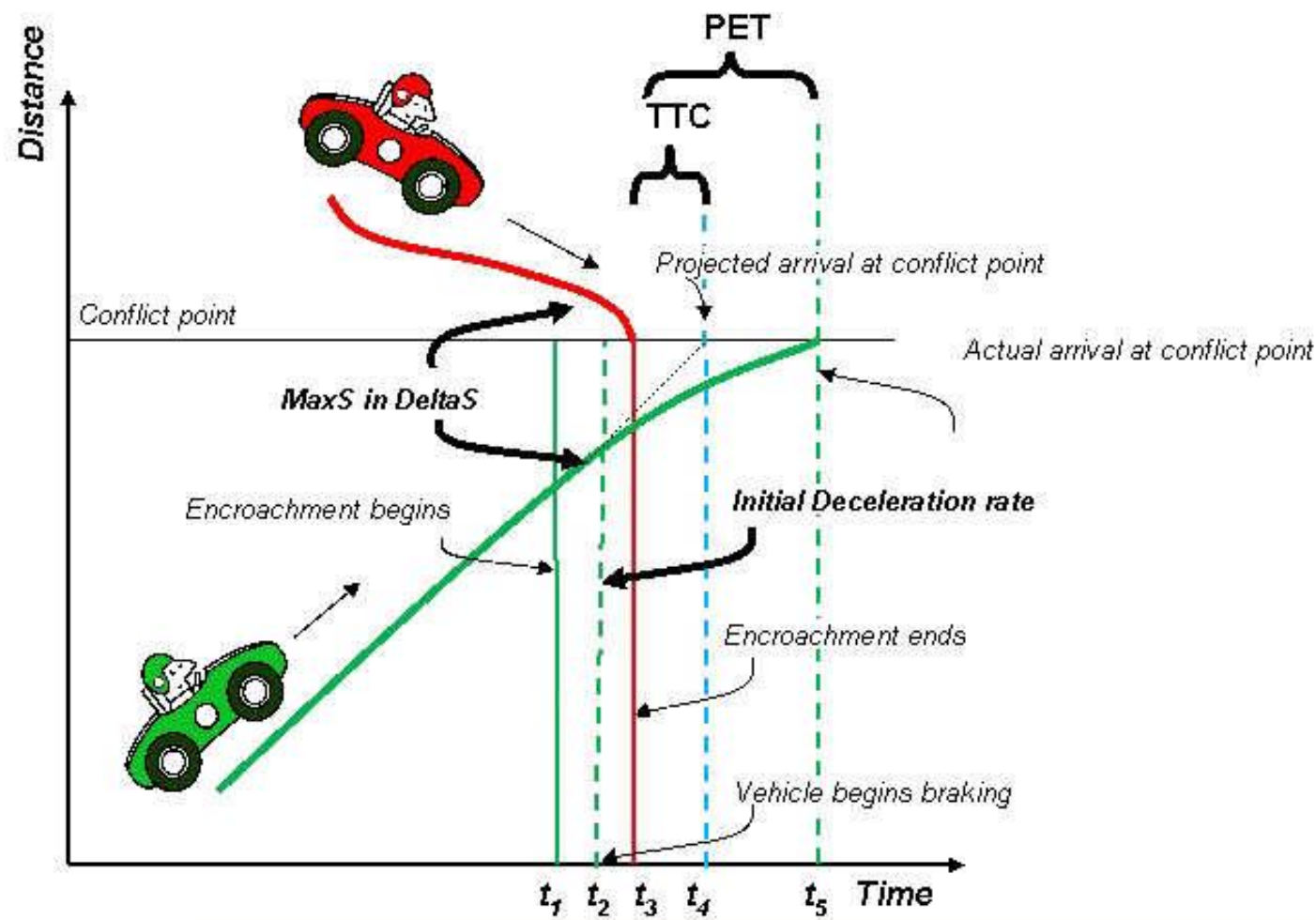
prof. dr. Matjaž Šraml matjaz.sraml@um.si

FGPA web page: <http://www.fgpa.um.si>

Thank you
Hvala
Vi blagodaram



>Surrogate safety conflict measures.





Putting together some parameters

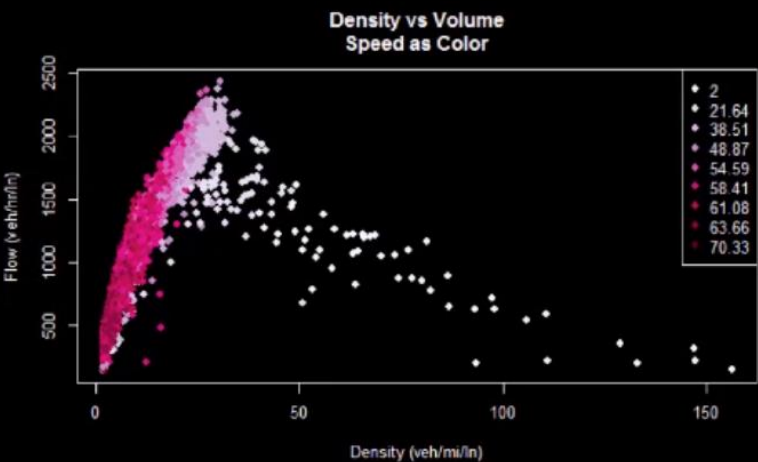
Consider dimensional analysis.

Parameter			Units
Flow	q	vehicles/time	#/t
Frequency		buses/time	#/t
Headway	h	time/vehicle	t/#
Density	k	vehicles/distance	#/x
Spacing	s	distance/vehicle	x/#
Speed	v	distance/time	x/t
Pace	p	time/distance	t/x



<https://www.youtube.com/watch?v=vJG44iy5dGE>

Traffic Flow Theory I

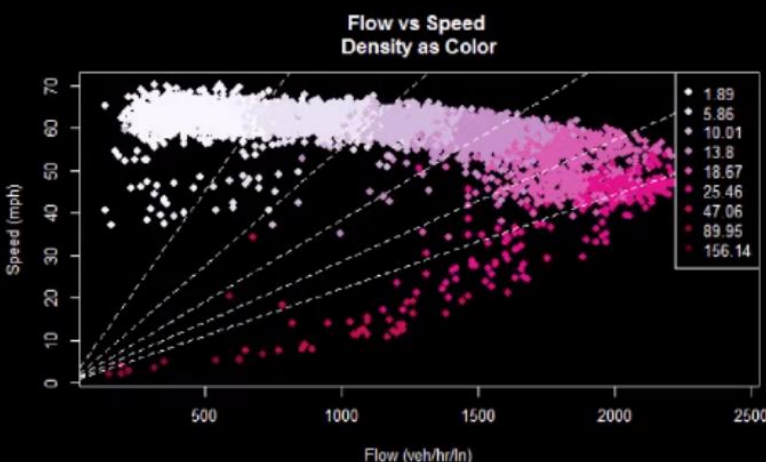
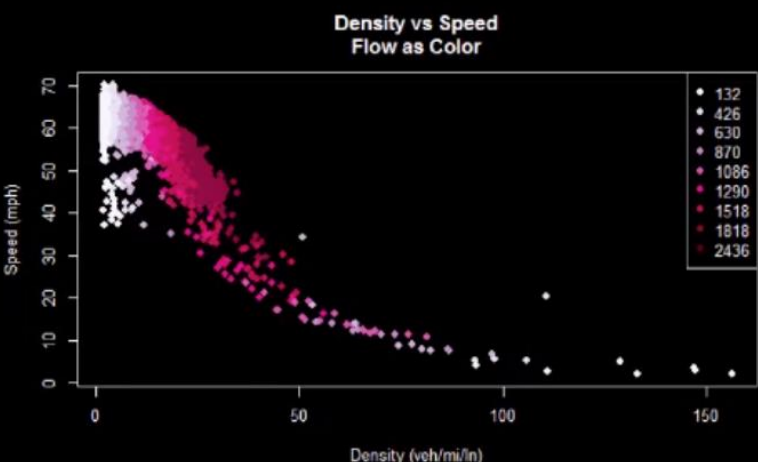


5 minute observations
5,817 data points

Records subsetting: Volume ≥ 120 veh/hr/in; Occupancy ≥ 1

Density Estimated from Loop Occupancy

Source: <http://portal.its.pdx.edu>





Conclusions

- We discussed the basic traffic flow measurements based on the premise that you can go out into the field and take simple measurements.
- We then emphasized the importance of paying attention to the units of these measures.
- Dimensional analysis was then used to derive the fundamental theory of traffic flow.
- We looked at a diagram illustrating the theory.
- Finally we compared the theory to real measured “big data” from a freeway.



Links

- <https://www.youtube.com/watch?v=RfZvKUY3WvQ> (Braess Paradox)