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THE BENEFITS OF ADAPTIVE TRAFFIC CONTROL FOR EMISSION REDUCTION IN URBAN AREAS

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INTRODUCTION

- The most important cause of pollution is traffic
  - IEA: „By 2050. more than ***50%*** of spent fuel will be caused by traffic and transport”
  - EEA: „Traffic in urban areas causes ***40%*** of CO_2 emission and over ***70%*** of other exhaust emission
- According to the eCoMove research exhaust emissions have different causes;
  - ***22%*** is the consequence of ineffective acceleration/deceleration
  - ***15%*** is caused by congestions
  - ***11%*** is caused by excessive speed and inefficient traffic control

How to solve a problem?

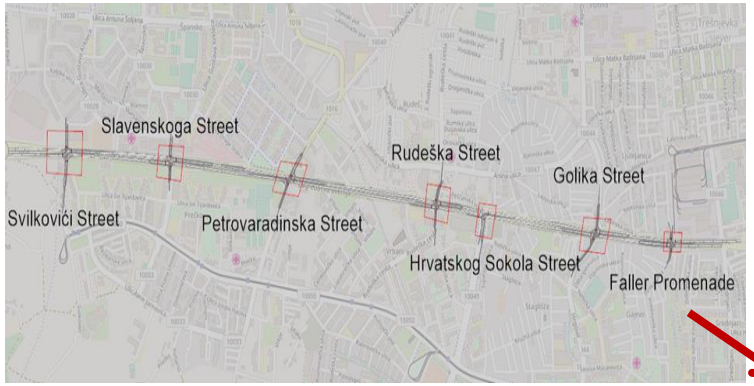
- Rational usage of time and energy with:
  - better traffic management
  - rerouting traffic in congestion areas
  - improving traffic comunication-***V2V*** and ***V2I***
  - increasing awareness within traffic participants

- ITS solution:
  - adaptive traffic management :
    - exhaust emission reduction (***CO_2, NOx, PM_{10}***) } Primary goal
    - stop-and-go action reduction
    - vehicle delay reduction
    - overall ***LOS*** improvement

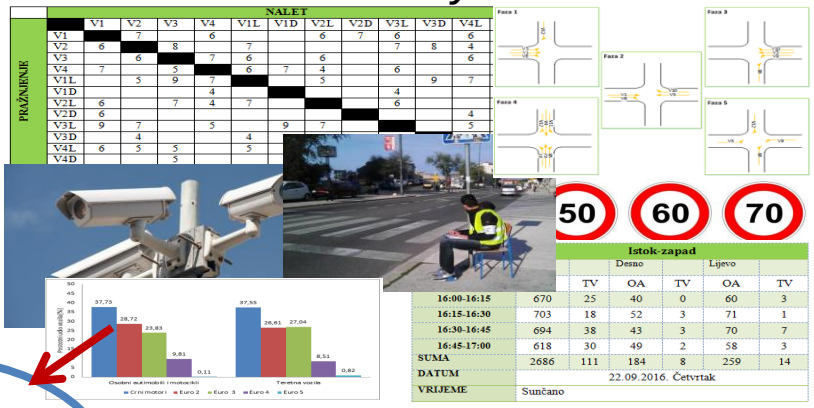
} Secondary goals

Research description

1. Selecting an eligible demonstration corridor

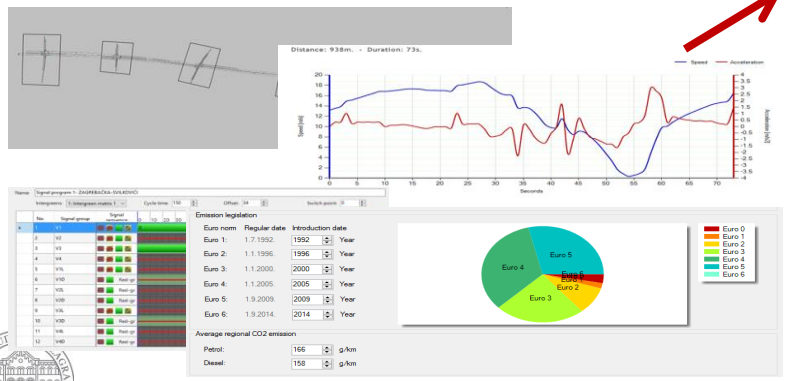


2. Data collection and analysis

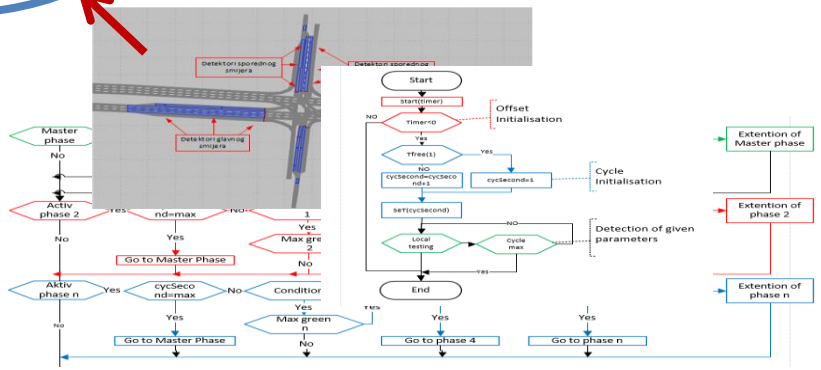


5. Evaluation & Results

3. Calibration of microsimulation and emission models

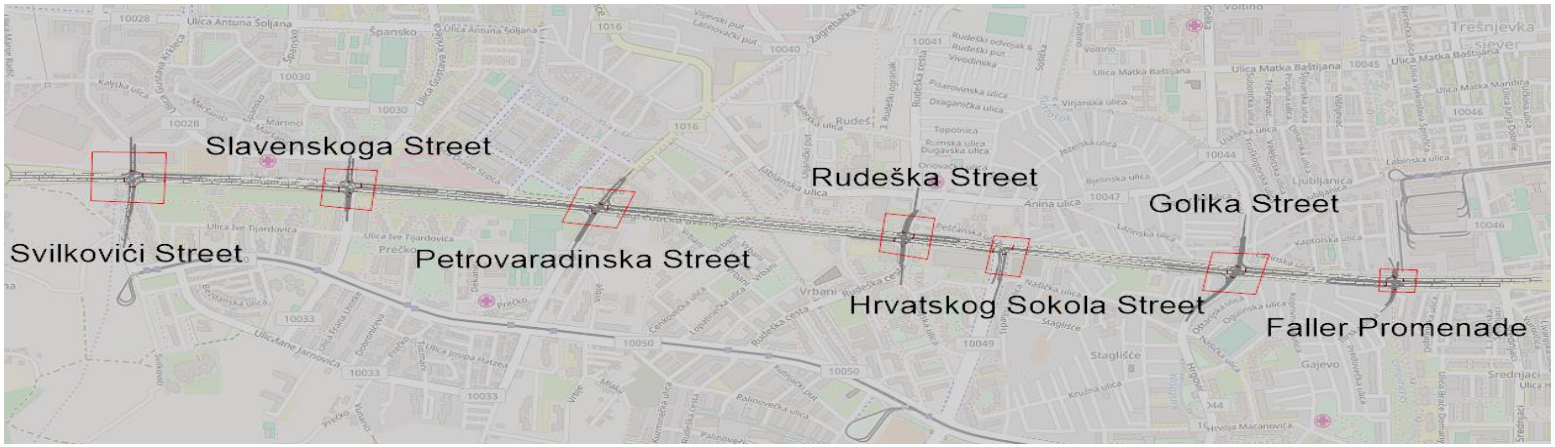


4. Algorithm development



Corridor description

- West part of the Zagrebačka Avenue – Zagreb, Croatia
- 3500 [m] long
- Seven signalized intersections:
  - six intersection with four aproaches
  - one intersection with three aproaches
- Longest distance - 870 [m]
- Shortest distance -150 [m]



Demonstration corridor: Zagrebačka Avenue in the city of Zagreb

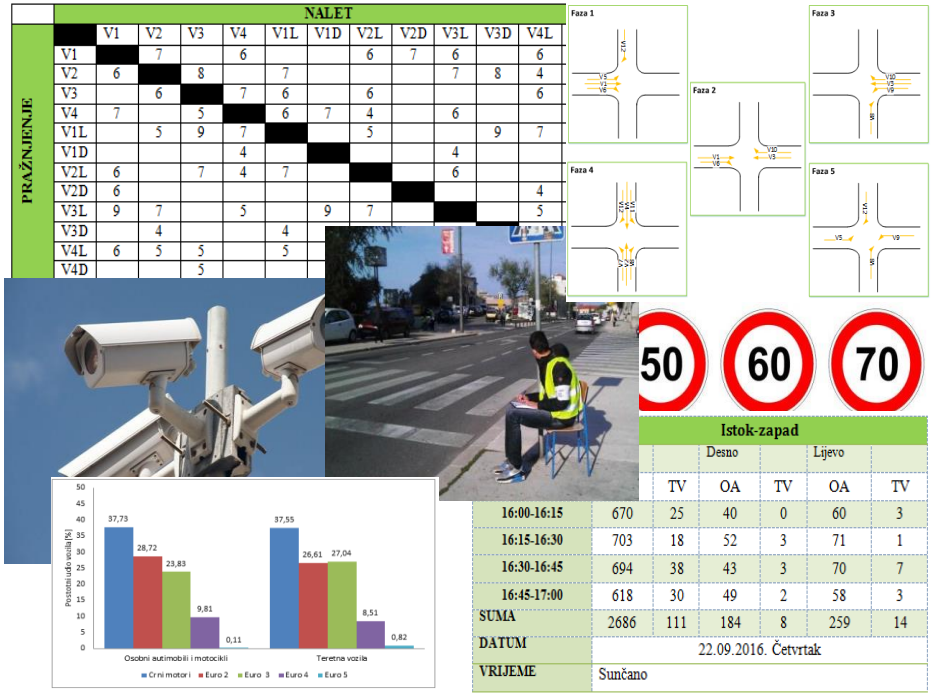
Data collection and analysis

Data collection:

- afternoon peak hour (4 PM - 5 PM)
- ***500*** minutes of video records
- over ***13 000*** recorded vehicles
- vast amount of field research

Data analysis:

- OD matrix
- protection time matrix
- signal plan
- vehicle composition
  - ***95,95 %*** personal vehicles (PV)
  - ***4,05 %*** heavy duty vehicles (HDV)
- saturation flow – oversaturated
  - westbound - ***32,5%***
  - eastbound - ***26,3%***



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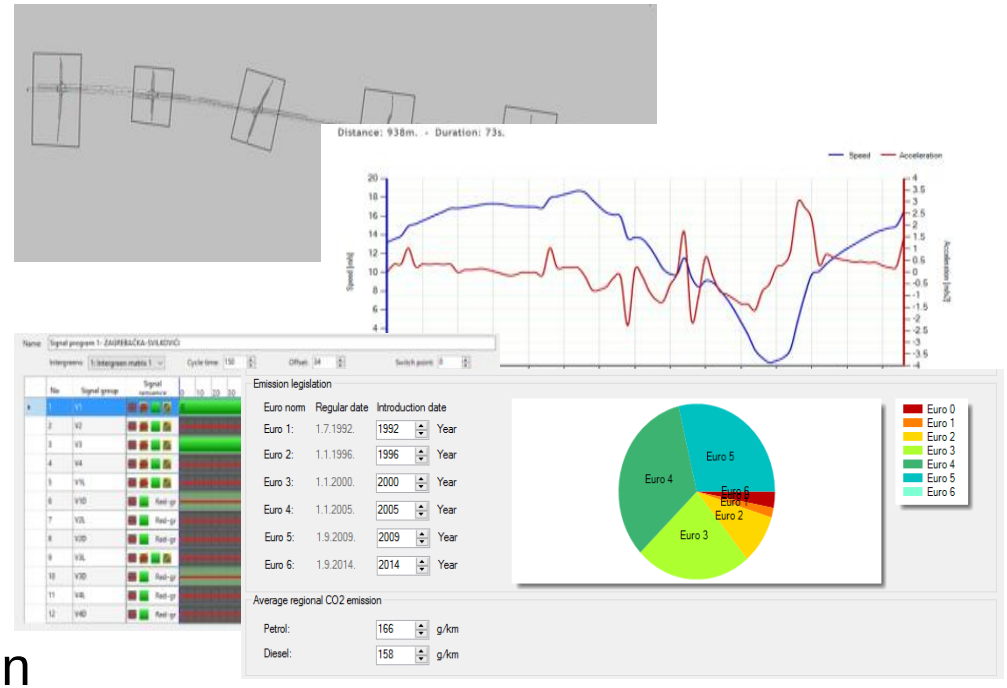
		TV	OA	TV	OA	TV
16:00-16:15	670	25	40	0	60	3
16:15-16:30	703	18	52	3	71	1
16:30-16:45	694	38	43	3	70	7
16:45-17:00	618	30	49	2	58	3
SUMA	2686	111	184	8	259	14
DATUM	22.09.2016. Četvrtak					
VRIJEME	Sunčano					

Examples of data collection

Calibration of microsimulation and emission models

- PTV Vissim
  - creating traffic network
  - vehicle routing (OD matrix)
  - speed limit
  - fixed traffic signalization
  - simulation parameters for evaluation
- EnViVer
  - connecting to Vissim
  - creating vehicle composition
  - EURO norm compatibility



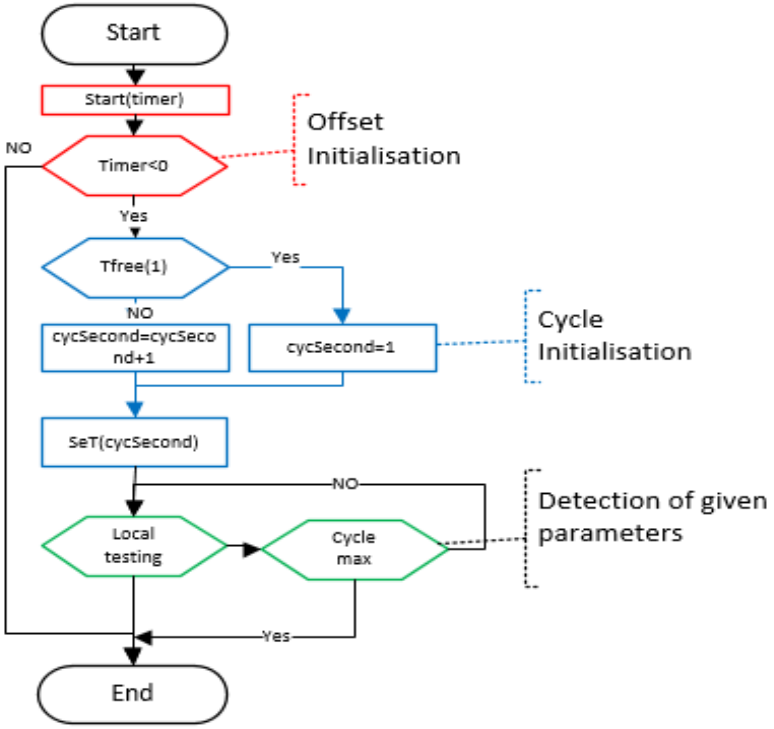
Examples of model's calibration

Algorithm development

- VisVap - algorithm developing softver
- Algorithm for adaptive traffic control:
  - separate implementation on every intersection
  - ***global*** and ***local*** level

- ***Global level***
  - *traffic flow harmonization*
  - *elimination of stop-and-go-actions*

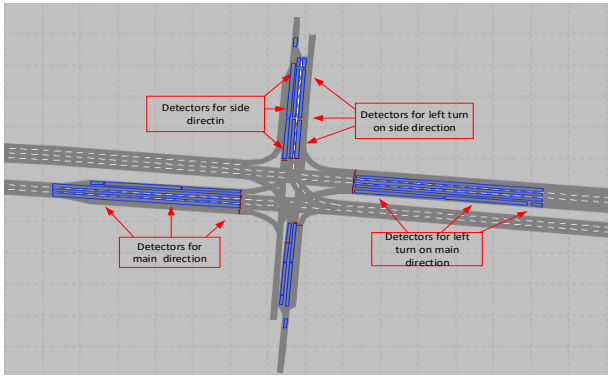
- ***Consisted of:***
  - *offset initialisation*
  - *cycle initialisation*
  - *local level testing*



Global level of the algorithm

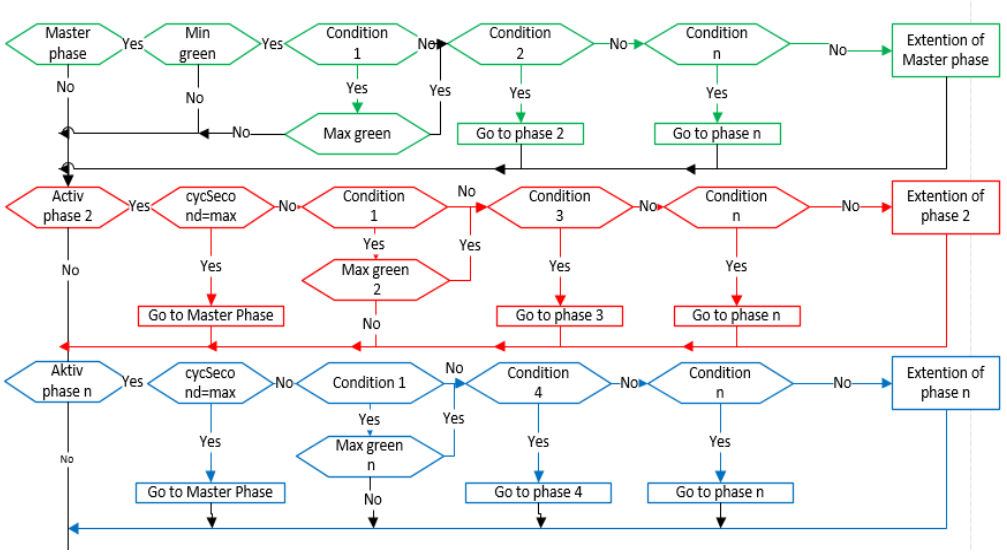
Algorithm development cont.

- ***Local level***
  - *controled by Global level restrictions*
  - *conected to Vissim by detectors*
  - *second-by-second mesuremant*
  - *phase activation in every cycle*
  - ***maximum utilization of effective green times***



Example of the detector implementation

- ***Consisted of:***
  - three master phases
  - four aditional phases
  - adapting phase activation
  - vast amount of condition for traffic optimization



Local level of the algorithm

Evaluation

- Vissim
  - two scenarios
    - fixed control simulation
    - adaptive control simulation
  - ***10*** simulation runs for each scenario
  - random seed number increment of 1
  - node and link evaluation (*LOS*)
    - ***7*** nodes
    - ***178*** links
- EnViVer
  - samples of ***10*** simulations from both scenarios
  - evaluation of exaust gases:
    - CO_2 - carbon dioxide
    - NO_X - nitrogen oxides
    - PM_{10} - particulate matter

Results

The results of exhaust emission for fixed traffic control situation

	CO_2	NO_x	PM_{10}
PV	278,236 g/km	666,605 mg/km	55,381mg/km
HDV	1922,519 g/km	13,3112 g/km	289,7118mg/km

The results of exhaust emission for adaptive traffic control situation

	CO_2	NO_x	PM_{10}
PV	261,530 g/km	615,945 mg/km	52,1993 mg/km
HDV	1785,776 g/km	12,3195 g/km	272,0898 mg/km

- Reduction regarding PV:
  - ***CO_2*** emission ***6,014 %***
  - ***NO_X*** emission ***7,593 %***
  - ***PM_{10}*** emission ***5,740 %***
- Reduction regarding HDV:
  - ***CO_2*** emission ***7,115 %***
  - ***NO_X*** emission ***7,452 %***
  - ***PM_{10}*** emission ***6,081%***

Results cont.

Node evaluation of fixed traffic control situation

	Q-length average [veh]	Q-length max [veh]	Traffic flow [veh/h]	Vehicle delay [s]	Average number of stops	Fuel consumption [mg/m/s]
1.Svilkovići street	24,46	314,70	6119	34,13	0,67	114,813
2.Slavenskog street	21,07	290,73	6246	33,84	0,64	104,870
3.Petrovaradinska	20,36	216,15	6380	29,33	0,46	96,620
4.Rudeška street	34,41	508,50	6670	37,12	0,60	115,976
5.Hrvatskog S. street	11,20	244,86	5789	17,65	0,33	62,330
6.Drvinje street	42,98	510,21	6706	35,45	0,51	112,629
7.Faller promenade	29,02	384,80	6250	22,74	0,37	75,179

Node evaluation of adaptive traffic control situation

	Q-length average [veh]	Q-length max [veh]	Traffic flow [veh/h]	Vehicle delay [s]	Average number of stops	Fuel consumption [mg/m/s]
1.Svilkovići street	30,40	323,35	6180	37,69	0,67	126,509
2.Slavenskog street	17,63	225,08	6322	25,56	0,44	86,524
3.Petrovaradinska	24,82	230,20	6455	32,99	0,54	105,854
4.Rudeška street	27,19	458,66	6884	35,59	0,61	117,924
5.Hrvatskog S. street	6,98	156,84	6033	9,07	0,17	47,352
6.Drvinje street	19,51	194,77	7041	20,78	0,34	88,620
7.Faller promenade	25,33	383,88	6564	22,07	0,38	79,047

Results cont. II

- Reduction in:
  - Q-length average [veh] by ***17,24 %***
  - Q-length max [veh] by ***20.1*** *%*
  - Vehicle delay [s] by ***12,60 %***
  - Fuel consumption [mg/m/s] by ***4,48 %***
  - Averege number of stops by ***11,93*** *%*
- Improvement in:
  - Traffic flow [veh/h] by ***2,9****%*
- Increased performances of *LOS*

Level of service comparison

LOS	Fixed control	Adaptive control
1.Svilkovići street	C	D
2.Slavenskog street	C	C
3.Petrovaradinska	C	C
4.Rudeška street	D	D
5.Hrvatskog S. street	B	A
6.Drvinje street	D	C
7.Faller promenade	C	C

Conclusion

- Sustainable growth of traffic in urban areas is not possible without the advanced ITS solutions

- Research show the impact of adaptive traffic control on:
  - exhaust gases emission reduction
  - trafic flow harmonization
  - quality improvemant of urban traffic network

- Future research:
  - upgrade of the algorithm with the self-learning ability
    - AI- based algorithm
    - q-learning algorithm

References

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Questions