

New Concepts for Urban Highways Control

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- **University of Zagreb, Croatia**
 - Established in 1669.
 - 29 faculties and 3 academies
 - 4.850 research staff members and 50.000 students
- **Faculty of Transport and Traffic Sciences**
 - Established in 1984.
 - 15 departments
 - Cover all transport modes, logistics, ITS, aeronautics
 - 100 research staff members / 2200 students
 - Publisher of the journal
PROMET – Traffic&Transportation
 - Cited in SCIE, TRIS, Geobase, FLUIDEX, and Scopus



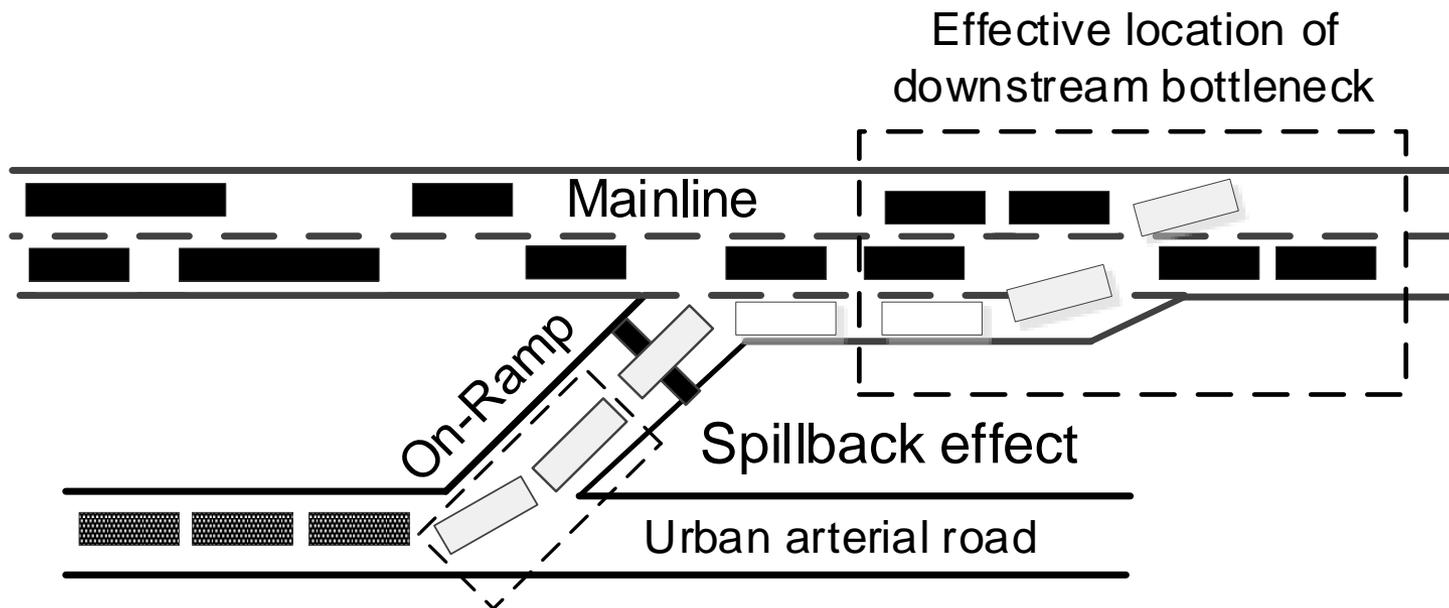
Outline

- **Introduction**
- **Ramp metering traffic control approach**
- **Learning based ramp metering**
- **Cooperation between ramp metering, VSLC and vehicles**
- **Simulator CTMSIM and augmentation**
- **Simulation results**
- **Conclusion & Future work**



- **Today's highways cannot fulfil desired level of service (LoS) due congestions**
- **Especially the case of urban highways**
 - Many on- and off-ramps
 - Lack of space for infrastructural build-up
 - Serve transit and local urban traffic
- **Solution in ITS based highway control systems**
 - Ramp metering
 - Variable Speed Limit Control (VSLC)
 - Prohibiting lane changes system
- **Cooperation between several highway control systems**

- **Uncontrolled platooned vehicle entry from on-ramps into mainstream induce**
 - Slowdowns in mainstream traffic
 - Queues at on-ramps
 - Higher risk of incidents





- **Highway control approach ramp metering**

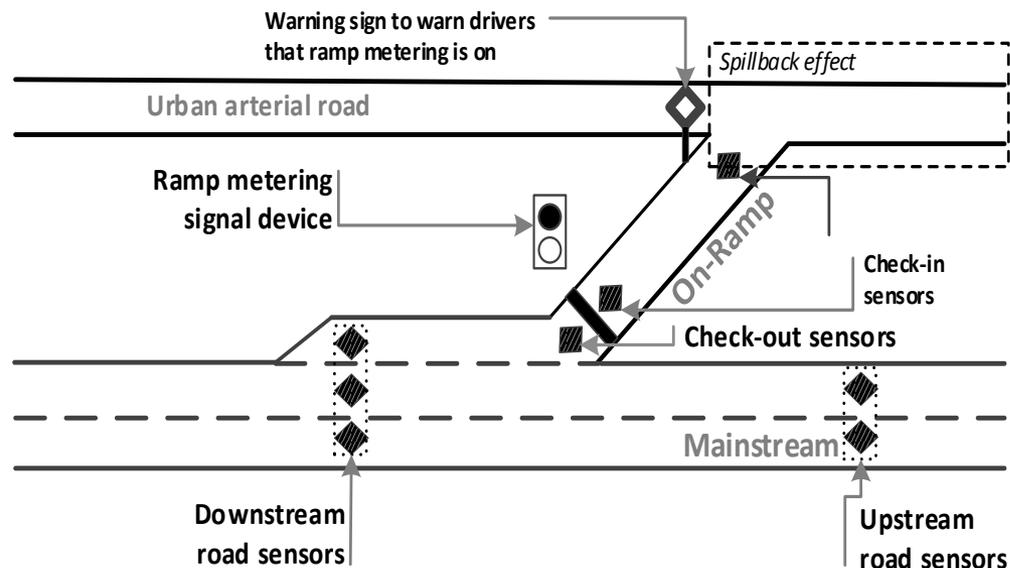
- Special road signals (traffic lights) at on-ramps
- Measured traffic data in real time
- Ramp metering control algorithm

- **Local**

- ALINEA
- Demand-Capacity

- **Cooperative**

- Competitive
 - » SWARM
 - » Bottleneck
- Comparative
 - » HELPER
 - » LINKED
- Integrated
 - » *Fuzzy* logic based
 - » MATALINE, etc.



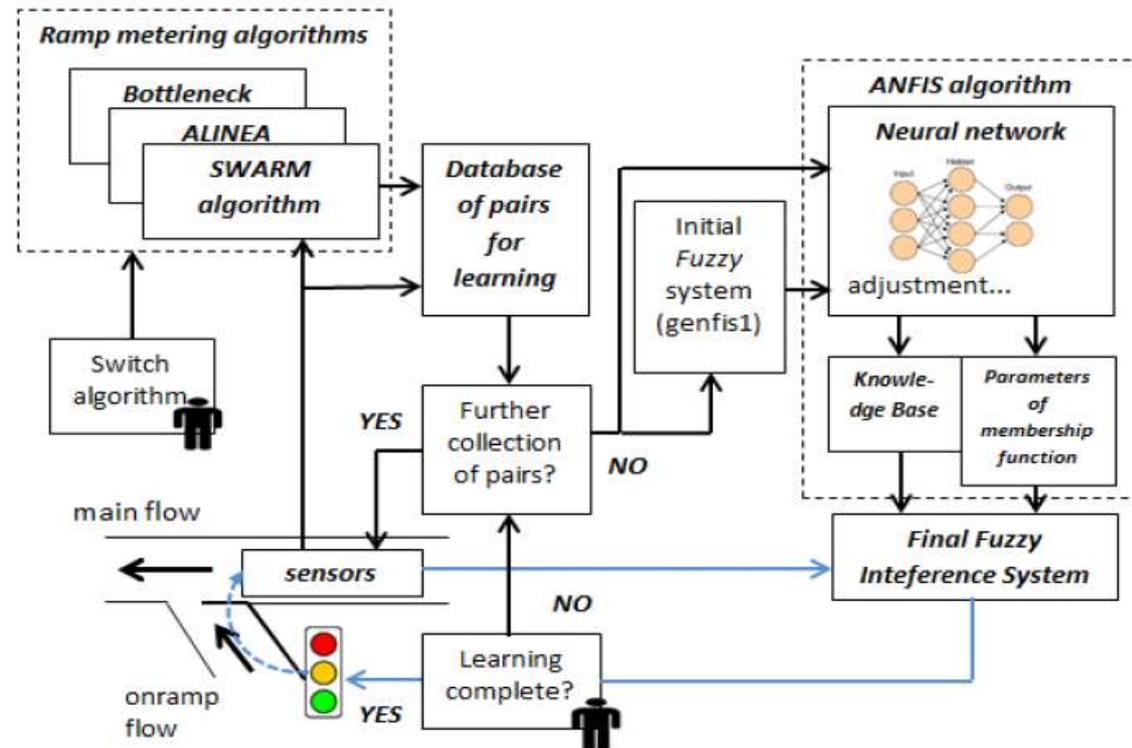
- **Variable traffic demand has to be managed**

- Adaptive neural-fuzzy inference system (ANFIS)

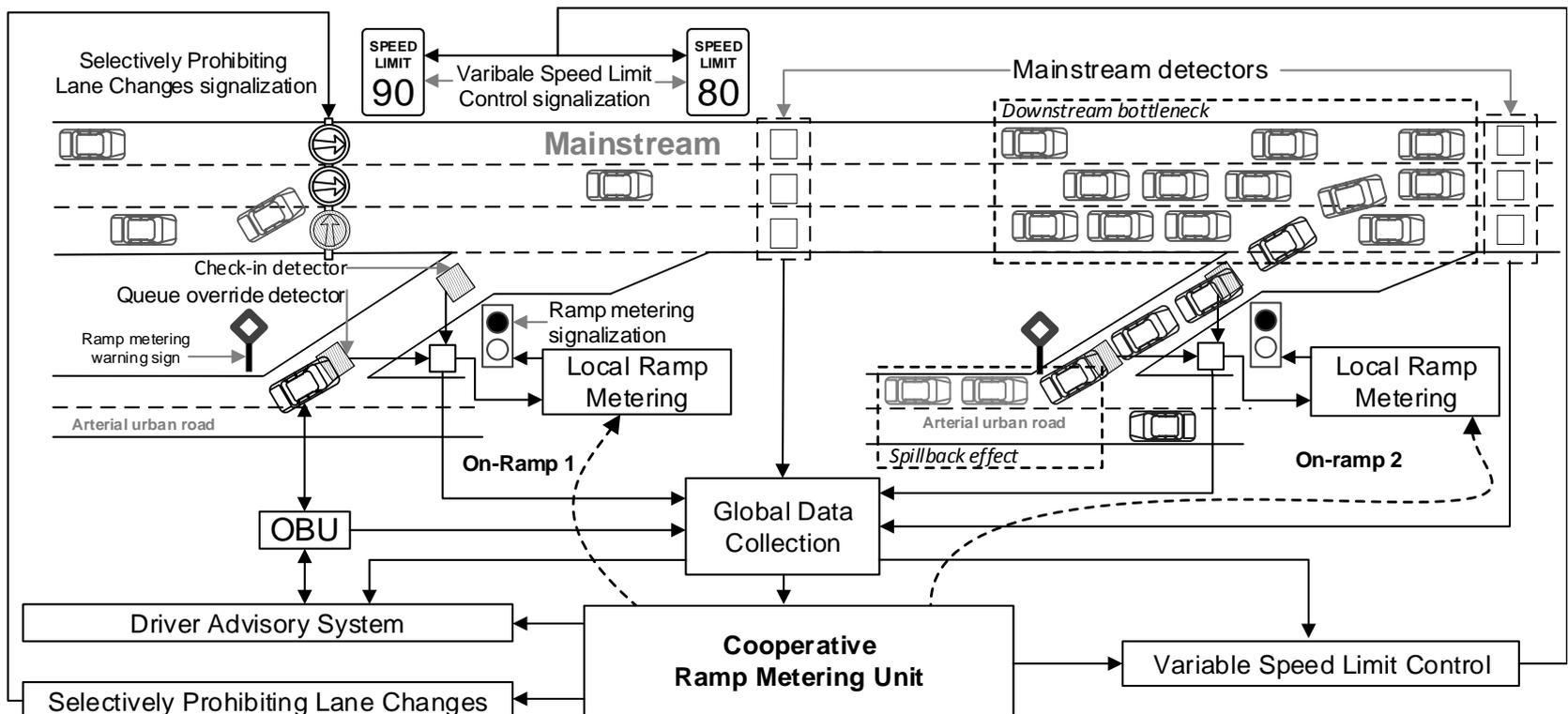
- Neural Network (ANN)
- Fuzzy Inference System (FIS)

- ANFIS algorithm learned using several different ramp metering algorithms

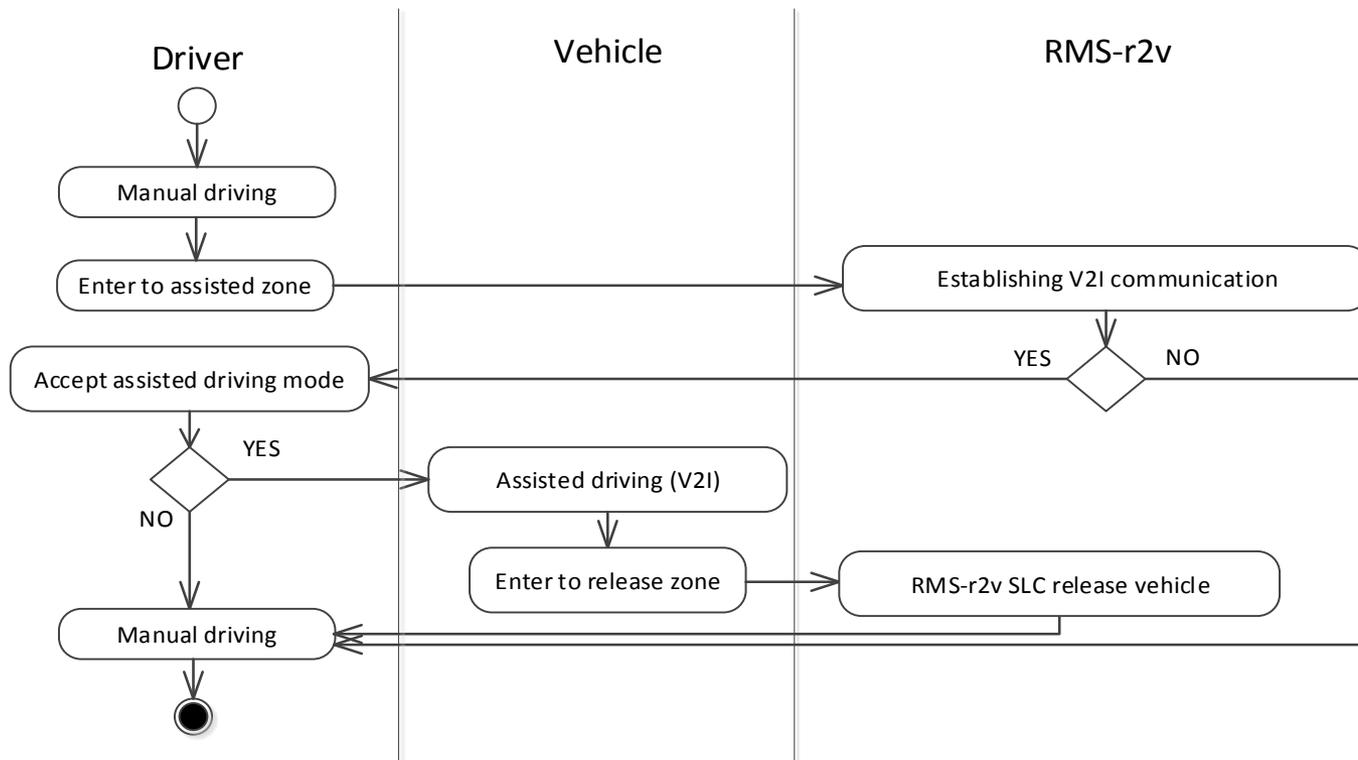
- ALINEA
- SWARM
- HELPER



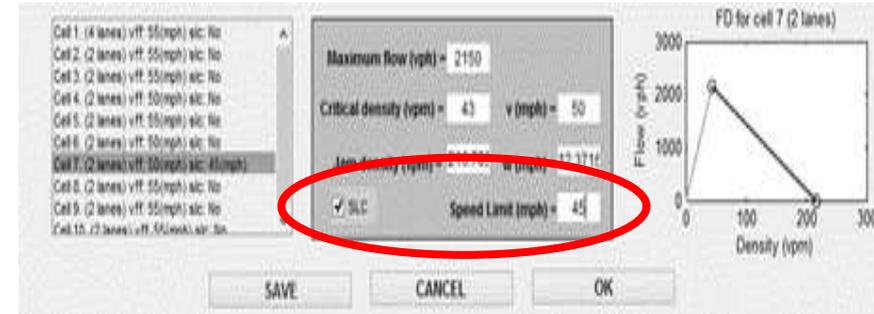
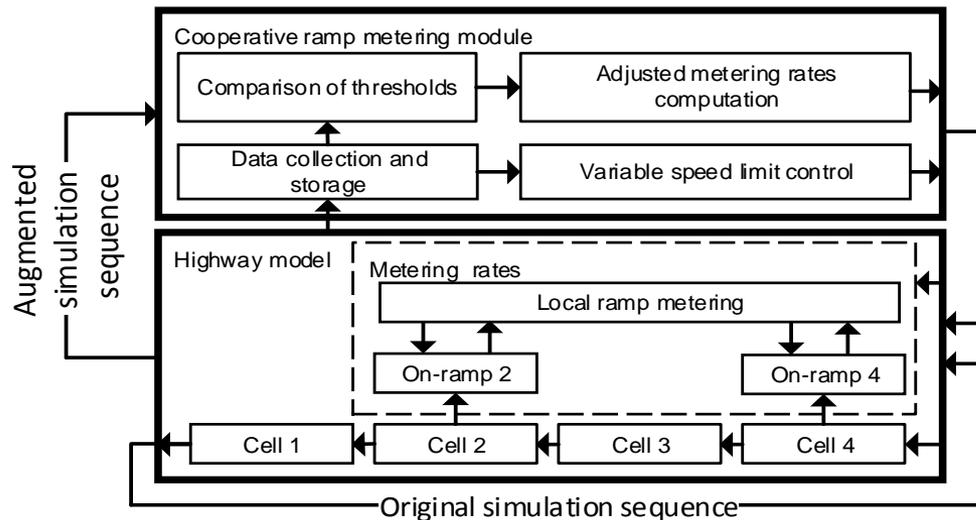
- Standalone urban highway control strategy not efficient enough to resolve congestions
- Cooperation between ramp metering and
 - VSLC, Selectively prohibiting lane changes, Vehicle On-Board-Unit (OBU) and Driver information systems



- **Cooperation between vehicle OBU and on-ramp control computer (RMS-r2v) provide semi-automatic support to driver**
 - Oriented to the inexperienced drivers
 - Problem with hesitation in merging and failed engine starts



- **Matlab based macroscopic highway traffic simulator**
 - Based on the Asymmetric Cell Transmission Model
- **Original version contains local ramp metering only**
- **Augmentation for cooperative ramp metering and VSLC**

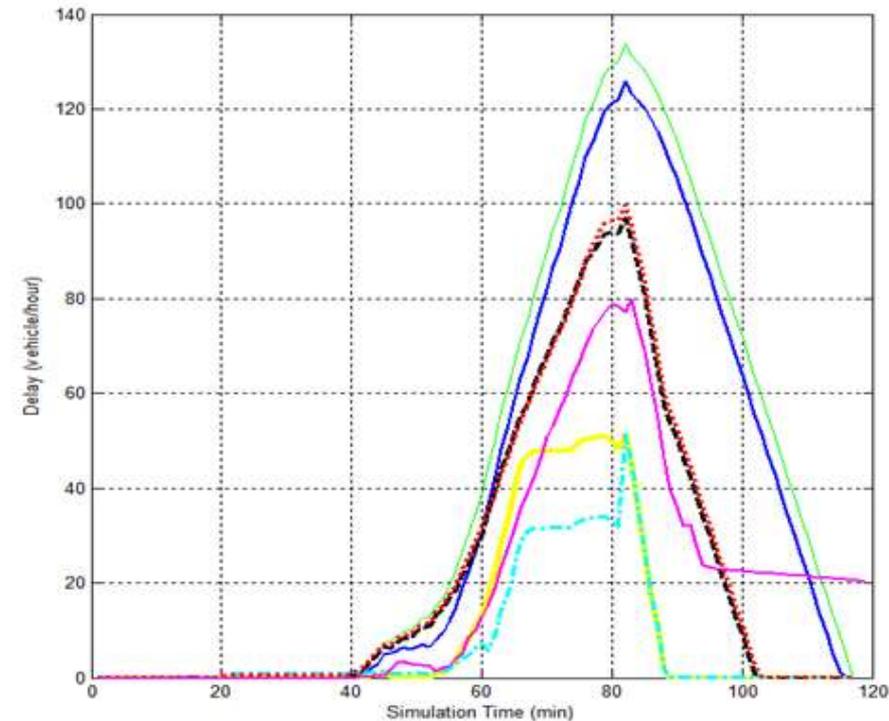
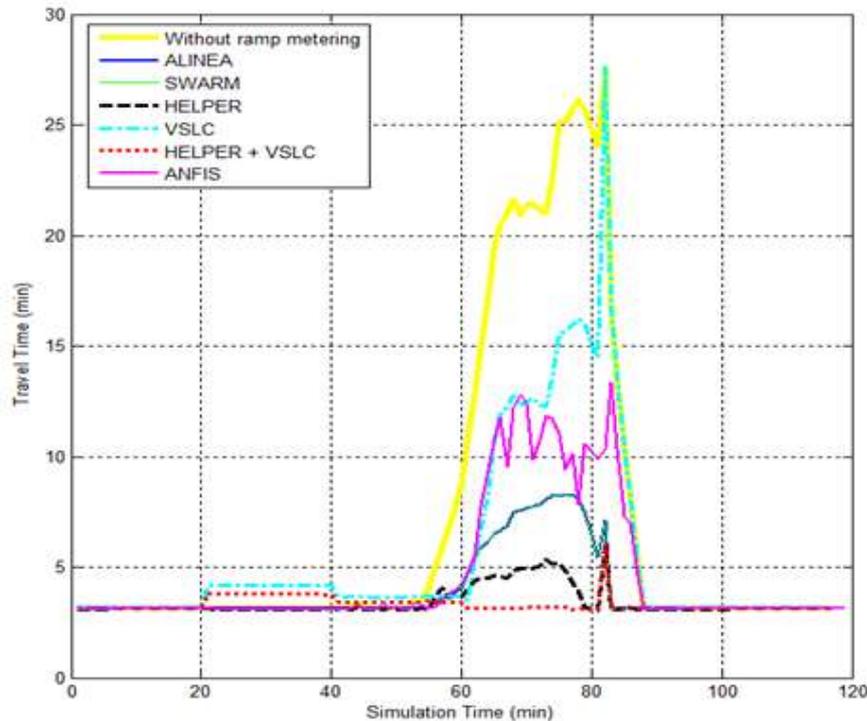


- **Zagreb bypass urban highway,**
 - Section between nodes Lučko and Jankomir as use case
- **Congestion created near *Lučko node***
- **Quality measures**
 - Travel time (TT)
 - Delay



Traffic control algorithm	TT (min)	Delay (vehicle-hour)
None	7.06	15.87
ALINEA	3.90	36.88
SWARM	3.71	41.49
HELPER	3.40	22.63
VSLC	5.59	12.24
HELPER + VSLC	3.30	21.50
ANFIS	4.10	19.75

- Cooperation between HELPER ramp metering algorithm and VSLC produces smallest TT
- ANFIS delay values are lower than other ramp metering algorithms





- **Cooperation between standalone traffic control systems proposed**
 - Ramp metering, VSLC and vehicles
- **Cooperative control concept between ramp metering and VSLC is presented and tested**
 - Best ratio between TT and delay
- **ANFIS based learning approach for ramp metering developed**
 - New platform for cooperation between different ramp metering algorithms
 - First results promising
- **Developed algorithms tested in simulations with Zagreb bypass (nodes between Lučko and Jankomir) as use case**
- **Future work - adjustment of learning criterion function for ANFIS based ramp metering**
 - Augmentation with VSLC cooperation



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