Vehicle-Infrastructure Communication for Traffic Management

Meng Lu, Dynniq Nederland B.V. The Netherlands

Twinning workshop: TransAID and US CAMP projects

25 July 2019, CAMP LLC, Farmington Hills, MI

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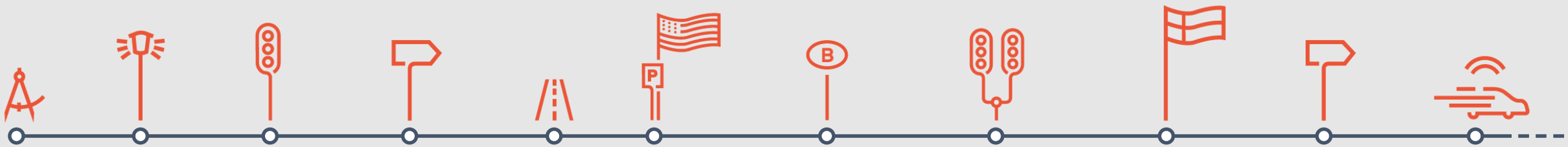
TransAID

Track record



1929

Nettenbouw was founded by H. Keyser.

1936

Nettenbouw was respon-sible for the first sodium lighting in the Netherlands.

1970

Traffic related activities were added.

1972-1973

Internatio acquired full ownership of the company.

1993

Founding Imtech.

1997

The acquisition of WPS added parking to the solution portfolio whilst extending the geography to the USA and Canada.

2004

Imtech Traffic & Infra expanded its activities into Belgium.

2007

Acquired Peek Traffic and rebranded Nettenbouw to Imtech Traffic & Infra.

2010-2012

Acquired YSP and SSR to develop a stronger position in Scandinavia.

2015

The company was acquired by private equity company Egeria.

2016

Dynniq, energising mobility.

NETTENBOUW | Internatio Müller (IM) | Imtech | WPS | PEEK | ysp | dynniq

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Dynniq footprint

UNIQUE in **Energising Mobility**
as **Market Leader** or in **Strong Position**

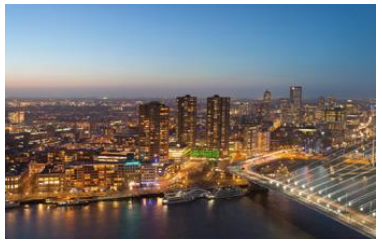
Employees
± 1,800

Around the world market shares grow.
Sustainable profitability growth

Position

Market Leader	Controllers maintenance
No. **2**	Highway management
No. **2**	Urban traffic controllers
20%	Public lighting columns

The Netherlands, with **600 Employees** *and being* **Dynniqs home** *country, is playing a* **key-role** *while* **leading the world** *into a promising and bright* **Future.**



Strong Market Position mission critical connectivity in *Belgium*

UK/Ireland

- **Market Leader** SCOOT
- **35% market share in supply and installing TLCs**
- **35% market share in supply and installing signal heads**

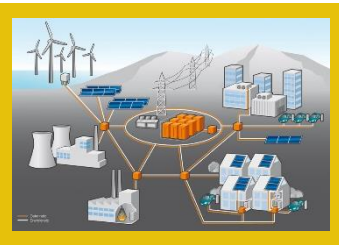
Finland: **Market Leader** infra control and **main contractor** on **largest** ongoing motorway **projects**

> 7,500,000 parking visits handled each month by WPS worldwide

Market Leader:
Brazil

Top 3 position:
Netherlands, Belgium, UK/Ireland

Netherlands



- Knowledge & execution partner **first public direct current networks**
- **1,000,000 kilometres** underground cable accommodated in 2016
- **60%** of light rail traction
- Middle voltage/High voltage automated (sub)stations design & construct

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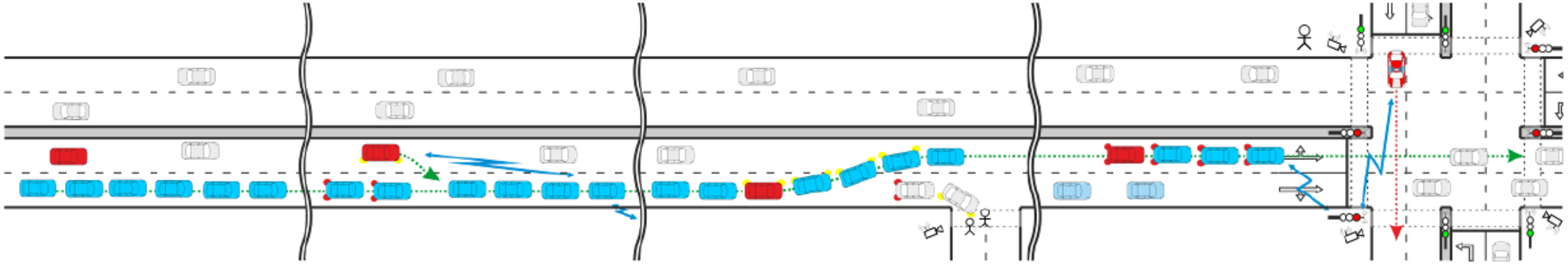
Managing Automated Vehicles Enhances Network

- **Management regimes for automated driving in urban areas**
  - increase safety with collective perception (alternative: very slow driving)
  - increase efficiency by exploiting possibilities of automated driving
- **Monitoring, support and orchestration of movements of road users to guide vehicles at signalised intersections**
- **Further enhancement for ADAS and C-ITS applications**



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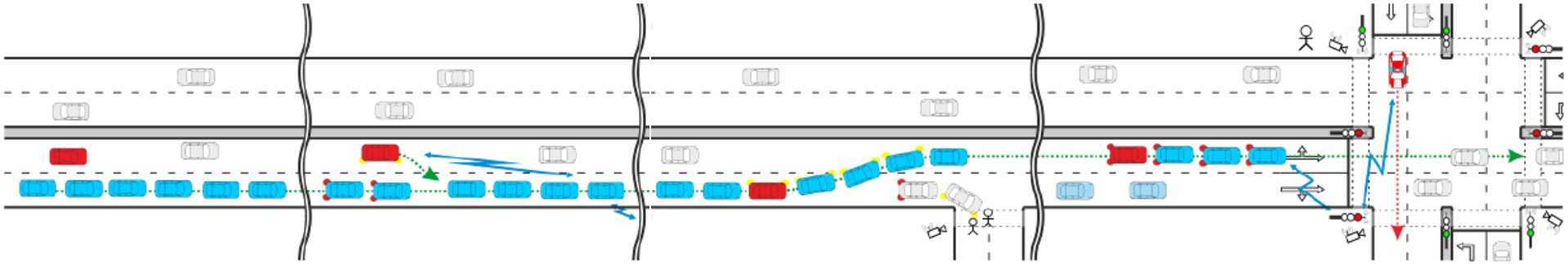
MAVEN use cases overview



- **I2V interactions**
  - ✓ V2I “explicit” probing + I2V speed/lane advisory + V2I feedbacks on compliance to advisories
- **Traffic controllers optimization**
  - ✓ Signal optimization, priority management, queue estimation, green wave
- **Platoon management**
  - ✓ Forming, joining, travelling in, leaving, breaking a platoon
- **Inclusion of conventional traffic and VRUs**
  - ✓ Detection/reaction in presence of non-coop cars & VRUs

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Use cases and new data elements

Managing Automated Vehicles Enhances Network

Cluster/platoon phases	Movement	Flow optimisation	Disruptive
initialisation	speed change advisory	priority	non-cooperation
joining	lane change advisory	queue length estimation	emergency situations
travelling		local routing	
leaving		network coordination	
break-up		signal optimisation	
termination		intersection negotiation	

New data element	Applicable scenario
Number of occupants	Intersection priority management.
Distance to following vehicle	Queue estimation. This information can improve queue model accuracy, leading to more optimal solutions for GLOSA negotiation and signal timing
Distance to preceding vehicle	
Platooning state	Signal optimization and intersection priority
Desired speed	Queue estimation and GLOSA negotiation
Current lane	Lane advice, multiple lanes for a certain direction
Route information	Queue estimation, signal optimization and GLOSA

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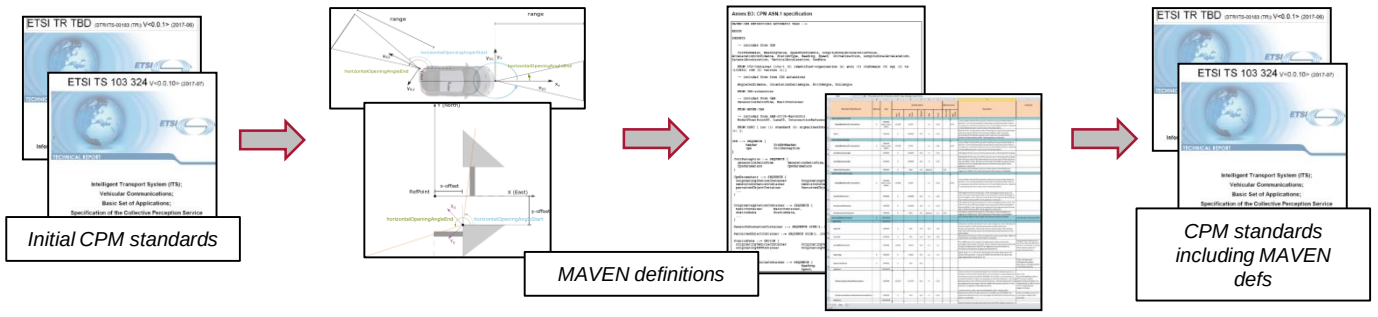
Message sets

Managing Automated Vehicles Enhances Network

- **Extended CAM (Cooperative Awareness Message) for automation and negotiation**
- **Profiled MAP/SPaT for lane specific GLOSA**
- **New LAM (Lane Advice Message)**
- **Extension to CPM (Collective Perception Message)**
  - RSU detections can be included
  - possibility to link to MAP message topology for efficiency



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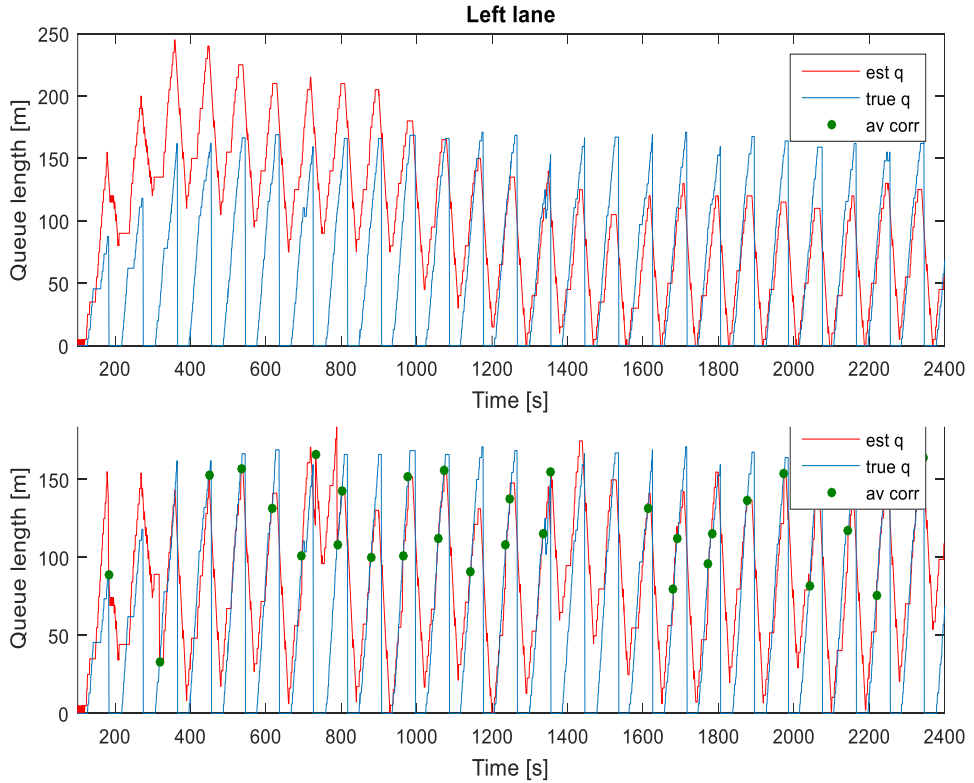
Queue modelling - data fusion

Managing Automated Vehicles Enhances Network

- **Automated vehicles have more data available**
  - intended turn direction (6% better traffic efficiency)
  - desired speed
  - number of occupants (priority input)
  - compliance to advice
- **Information enabled more accurate queue modelli**
- **Direct positive effect on several MAVEN systems**
  - lane advice
  - signal optimization
  - route advice
  - speed advice



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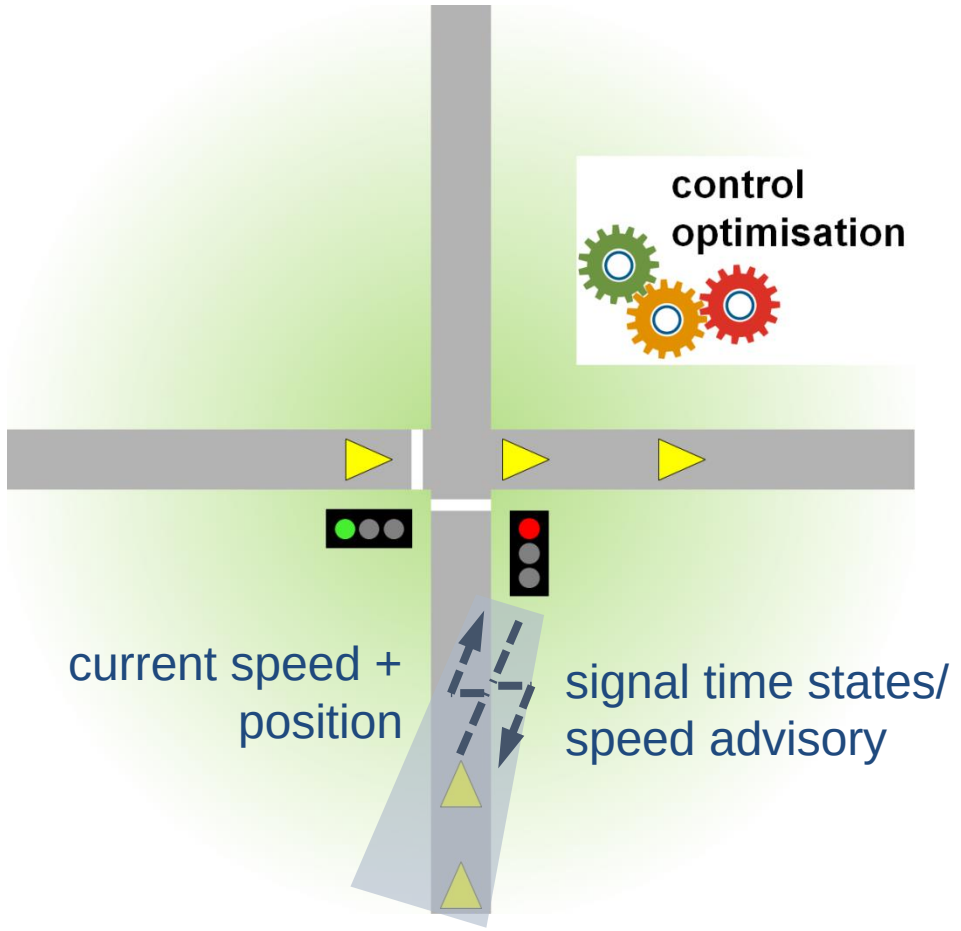
AGLOSA

Agent-Aware Green Light Optimal Speed Advice

- **Combination of vehicle-actuated control and GLOSA**
- **bi-directional communication**
- **Possible detection, e.g.**
  - V2X communication
  - video capturing
  - laser scanning
  - wireless in-road detectors
  - loop detectors



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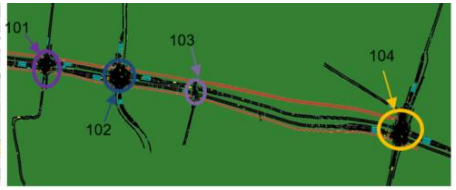
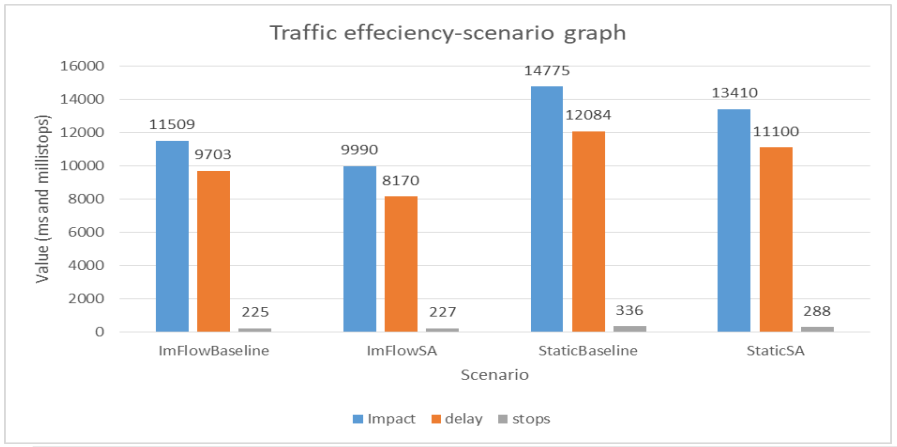
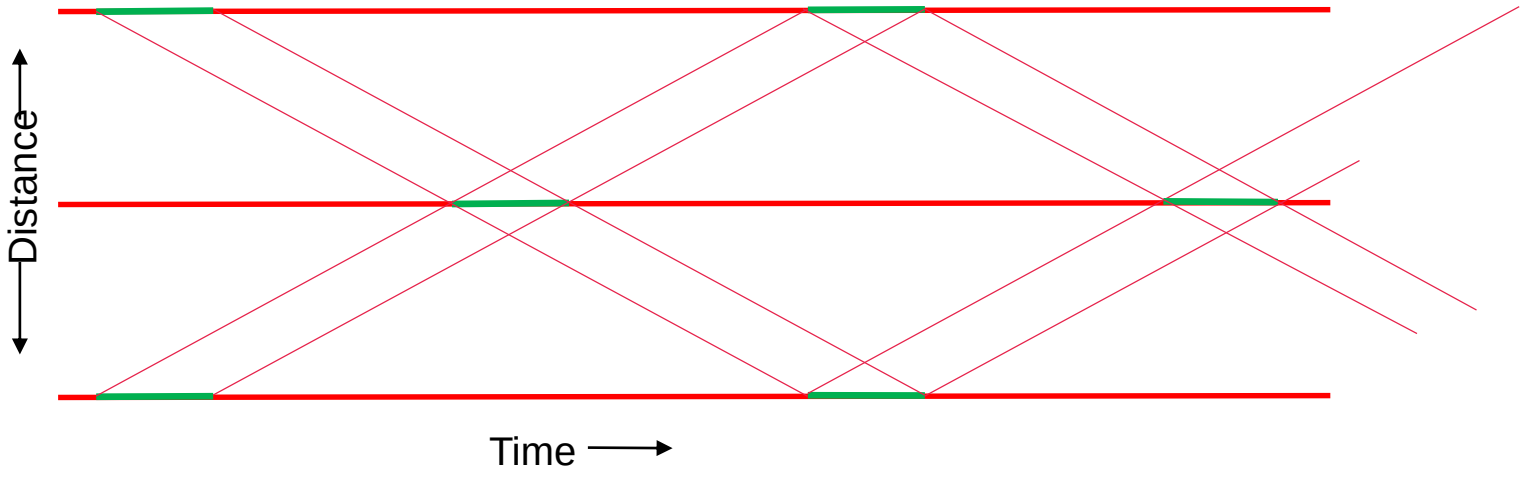
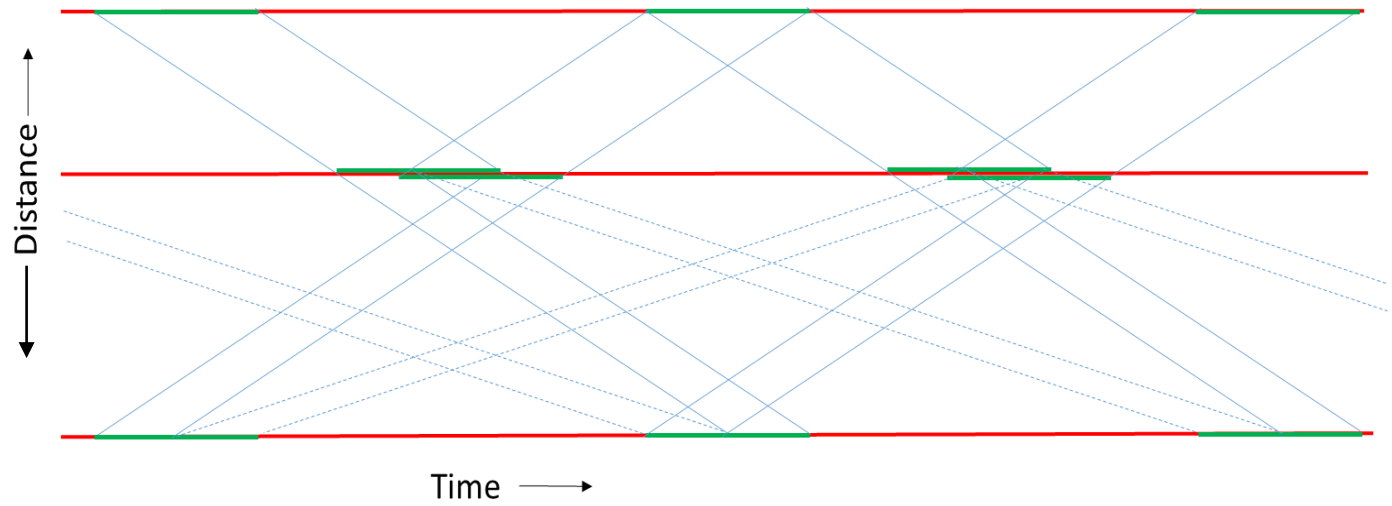
Green wave



Scenario	Description
ImFlow BL	Current adaptive traffic plan in operation
ImFlow SA	Current adaptive traffic plan with speed advice, 23km/hr and 18km/hr between intersection 101 and 102
Static BL	Static traffic plan with no speed advice
Static SA	Static traffic plan with speed advice, 23km/hr and 18km/hr between intersection 101 and 102







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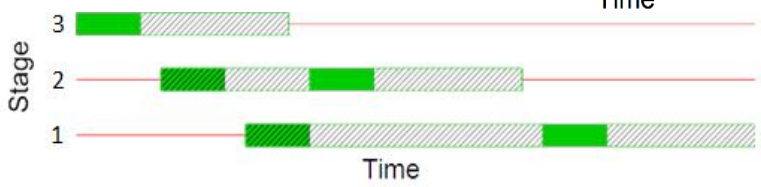
Traffic signal control methods

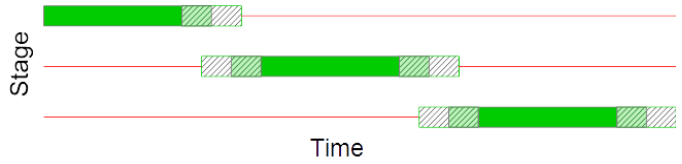
- **Static control / Fixed-time control**

- **Actuated control**

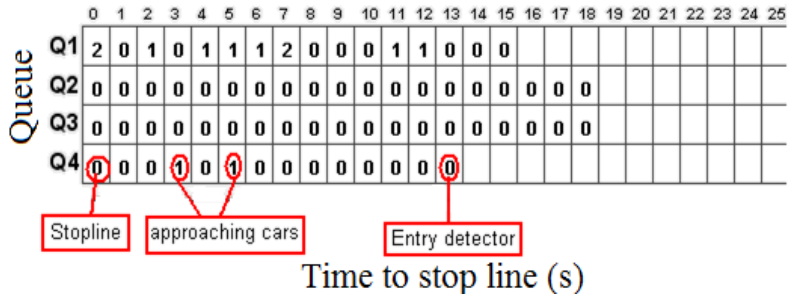


Scenario	Impact(s)	Delay(s)	Stops	GLOSA(%)	MSE(s²)	MRE(%)	PC(%)
Static	43.2	36.7	0.81	25	0	2.35	0.91
Semi-fixed	37.4	31.0	0.80	27	62	41.89	3.82
Actuated	36.3	29.6	0.84	19	182	84.67	7.62
Stabilized50	35.6	29.7	0.73	51	22	7.95	2.66
Stabilized	32.7	27.0	0.71	53	17	15.01	3.52
Adaptive	32.7	27.0	0.72	46	46	25.86	5.76
AdaptiveNG	33.7	27.0	0.83	6	47	26.90	5.54

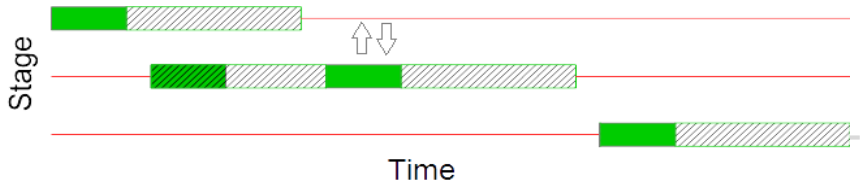
- **Semi-fixed time control**
  - based on a fixed time control plan
  - switching can occur between a configured min/max time



- **Adaptive control**



- **Enhanced adaptive control**



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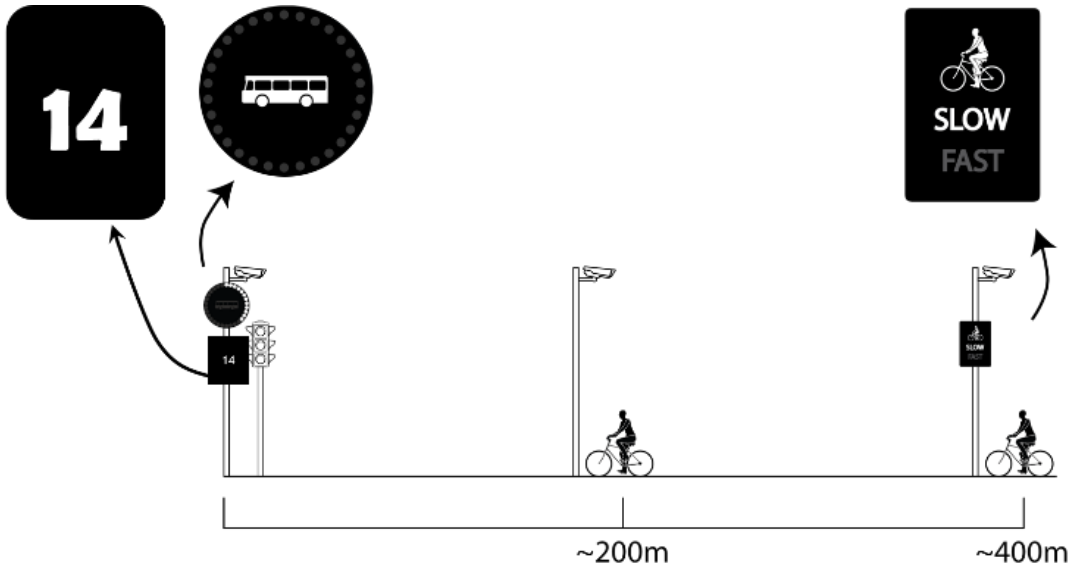
Enhanced/Stabilised adaptive control

Plan stabilisation for adaptive control

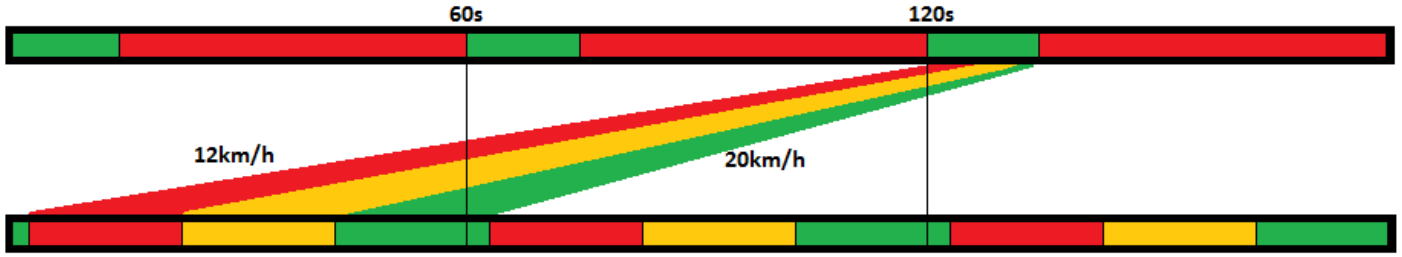
- **Problem definition**
  - classic green wave only works with fixed time control; adaptive control can offer green wave based on high priorities for specific traffic; both approaches result in increased delay for all other traffic; traditional actuated or adaptive control is too unpredictable for a green wave or speed advice
- **Dynniq solution**
  - increase stability of adaptive control plan; give speed advice and show countdown at large distance to bicycles; limited extra delay for other traffic; high success rate for green wave



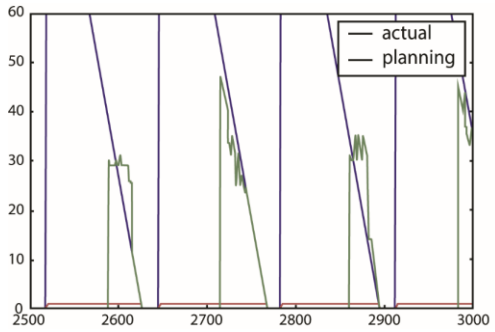
Greenwave results

Plan stabilisation for adaptive control

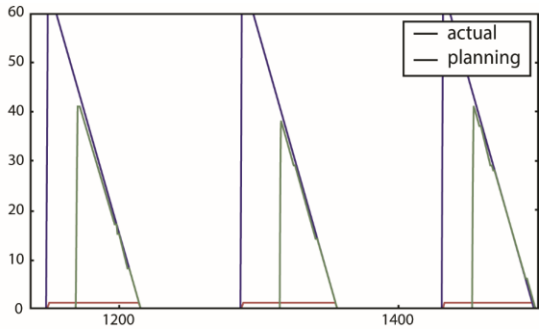
- **Speed indication at long distance**



- **Plan stabilisation in ImFlow**



Normal



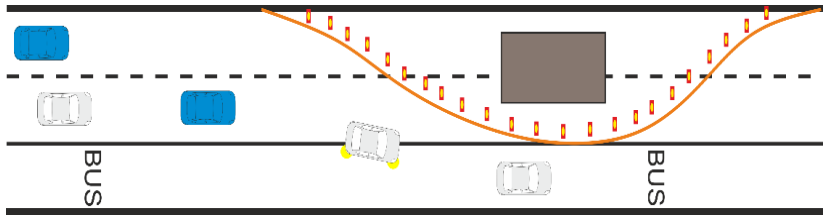
Stabilized

For more information, see:
http://maven-its.eu/
www.xcycle-h2020.eu/

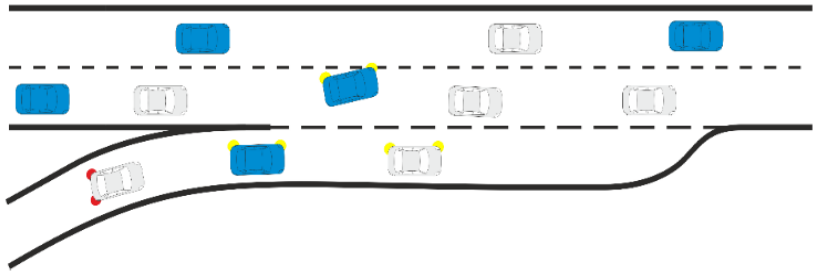
Use cases (examples)

TransAID - Transition Areas for Infrastructure-Assisted Driving

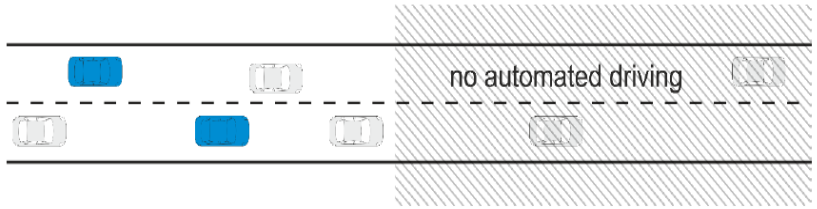
- Roadworks/ bus lane usage



- Motorway merging



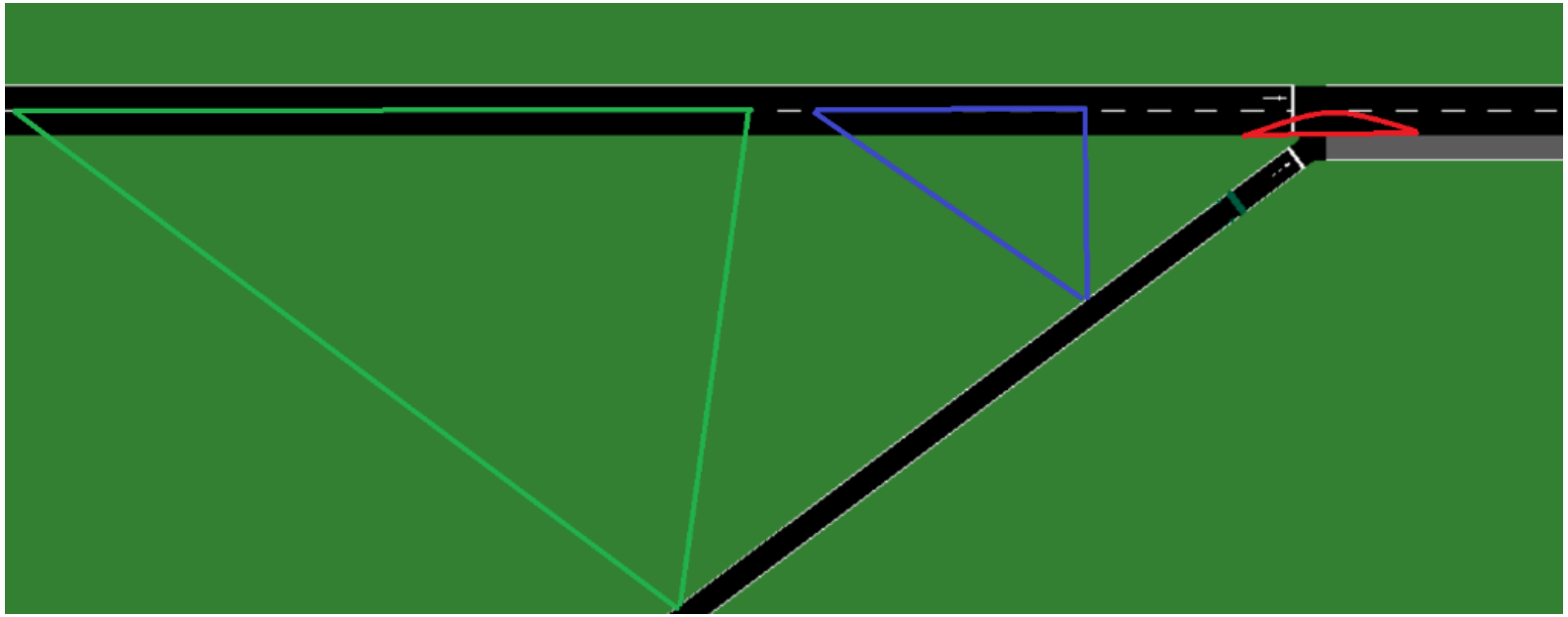
- No automation zone, TOC (Transition of Control) spread



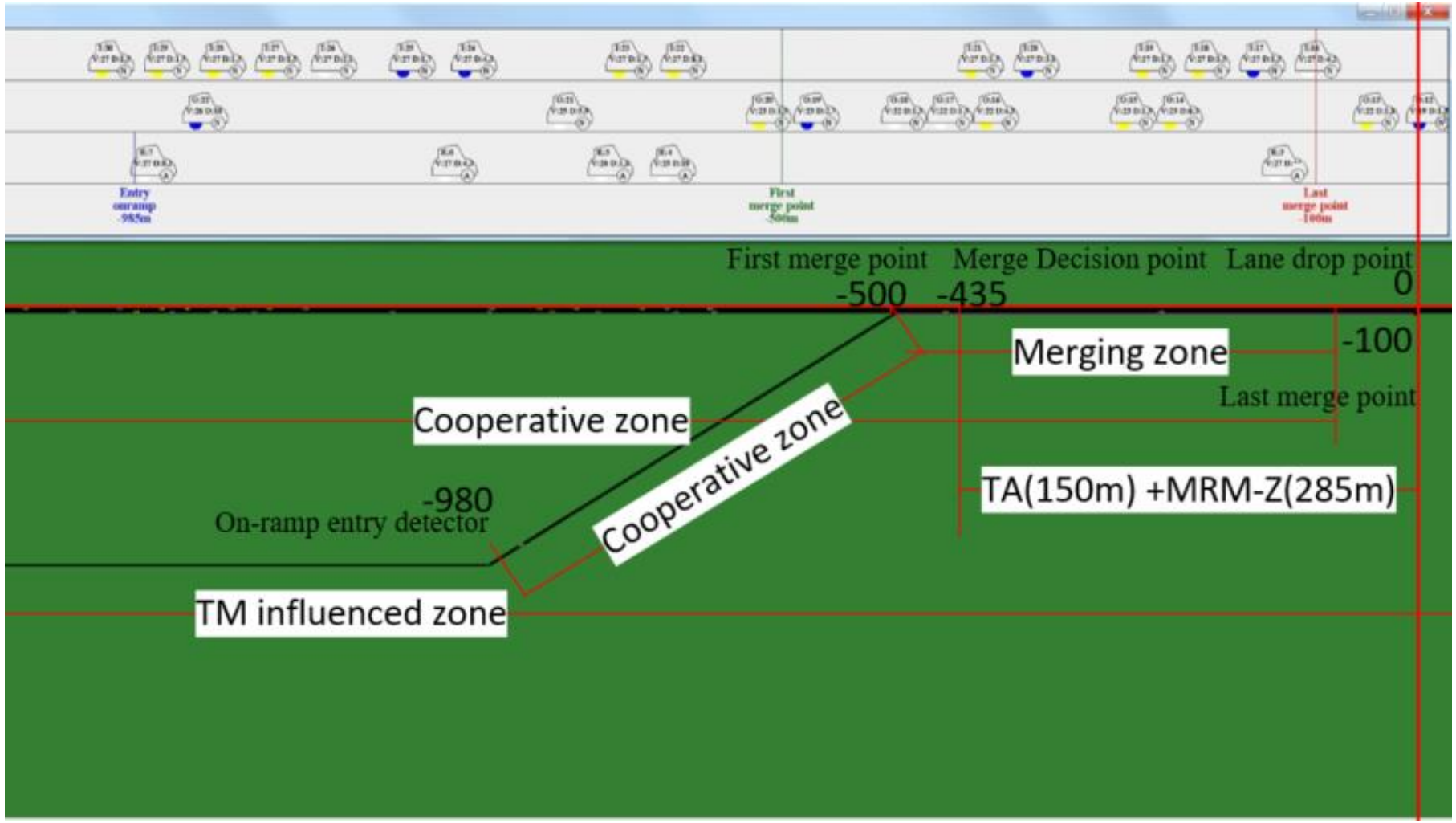
Ramp metering: perception area

TransAID - Transition Areas for Infrastructure-Assisted Driving

- New ramp metering algorithm
- New C-ITS application to assist safe merging at on-ramp
- Modelling tools for simulation of motorway on-ramp situations
- Extended message sets for providing advice for traffic merging situations to cooperative and automated vehicles



Ramp metering: scenario

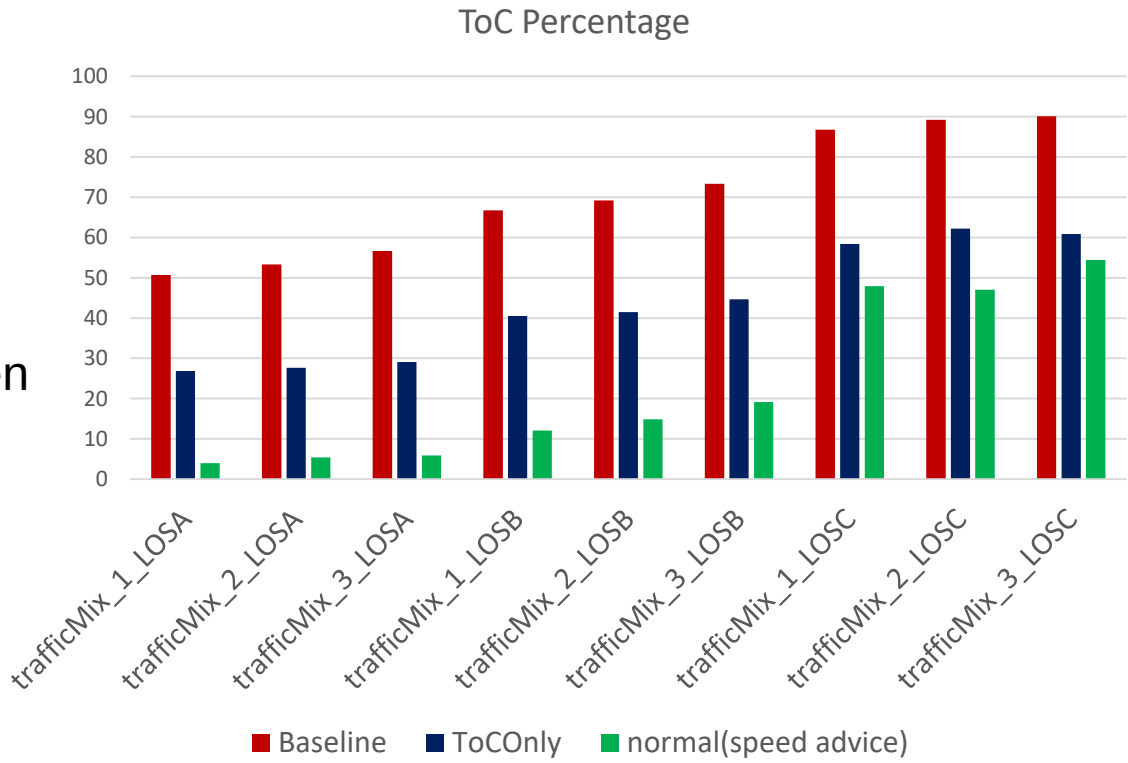


Ramp metering: interactions

- **Non-cooperative vehicles**
  - monitor at entry detector and with the tracking camera
  - turn ramp meter to green near gaps
- **Cooperative vehicles**
  - CAM (Cooperative Awareness Message) gives regular speed and position update
  - possibility to send lane and speed advice with app
- **Automated vehicles**
  - report distance to leader vehicle
  - more precise instructions

Ramp metering: algorithm and result

- **Restrict return to rightmost lane**
  - more space for merging
  - increase model accuracy
- **Speed advice**
  - find first acceptable gap for vehicle when entering on-ramp
- **Transition of control fallback**
  - as soon as possible conclude whether merge is possible
  - more time for human driver to adjust
- **Create gap with another cooperative or automated vehicle**
- **Turn on ramp meter**



LOS A: 1662 veh/h

LOS B: 2646 veh/h

LOS C: 3856 veh/h

Recent results - summary

Vehicle-Infrastructure Communication for Traffic Management

- At low traffic required ToC (Transitions of Control) dropped from 50% to 4%
- Higher traffic volume also demonstrated improvement from 90% to 54%
- Baseline model clearly needed improvement for more realistic merging behaviour, especially in high traffic scenarios
- Number of stops also reduced significantly by up to 87% and a CO_2 reduction of up to 7%
- High traffic volume scenarios are expected to improve further with main road speed advice and ramp metering
- The final goal is to have no stops at all at a saturation flow that is higher than with only human drivers in the network

References

Vehicle-Infrastructure Communication for Traffic Management

- Blokpoel, R.J., Zhang, X., Koutras, D., Mintsis, E. "Motorway merging assistant for automated vehicles", Proc. European Congress on ITS, 3-6 June 2019, Eindhoven/Helmond.
- Blokpoel, R.J. et al., Deliverable D4.4 Cooperative adaptive traffic light with automated vehicles. MAVEN (Managing Automated Vehicles Enhances Network) Consortium. 2018.
- Blokpoel, R.J., Lu, M. "Signal plan stabilization to enable eco-driving", Proc. The 20th IEEE Intl. Conf. ITSC, 16-19 October 2017, Yokohama. IEEE Xplore pp.133-138.
- Lu, M. (Ed.) (2019). Cooperative Intelligent Transport Systems: Towards High-Level Automated Driving. IET, London. ISBN: 978-183953-012-8 (print) / 978-183953-013-5 (eBook) (in press)
- MAVEN Consortium. MAVEN (Managing Automated Vehicles Enhances Network), 2016. Available from: www.maven-its.eu
- TransAID Consortium. TransAID (Transition Areas for Infrastructure-Assisted Driving), 2017. Available from: www.transaid.eu
- Zhang, X. Blokpoel, R.J., Lu, M. "Adaptive green wave with speed advice for automated vehicles", Proc. European Congress on ITS, 3-6 June 2019, Eindhoven/Helmond.

Thank you for your attention.

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