ICT infrastructure systems for automated driving

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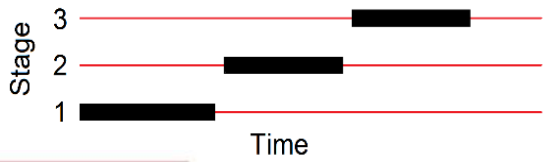
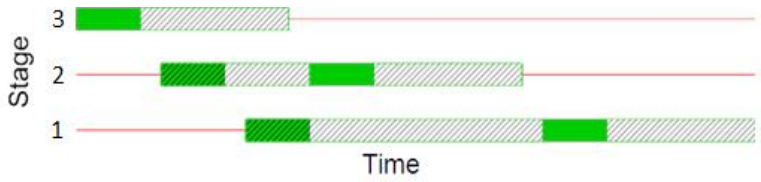
Contents

Traffic signal control methods

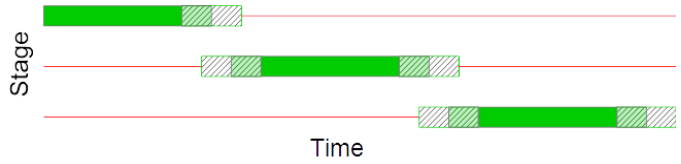
- **Static control or Fixed-time control**



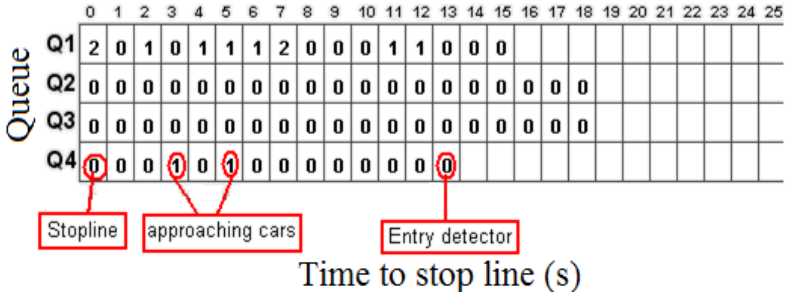
- **Actuated control**



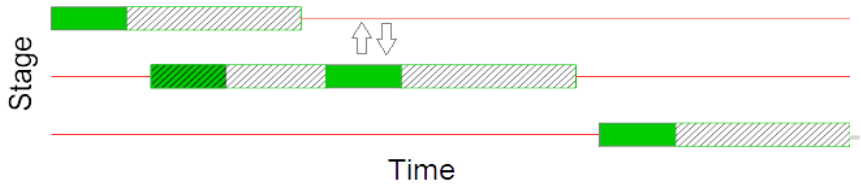
- **Semi-fixed time control**
  - based on a fixed time control plan
  - switching can occur between a configured min/max time



- **Adaptive control**

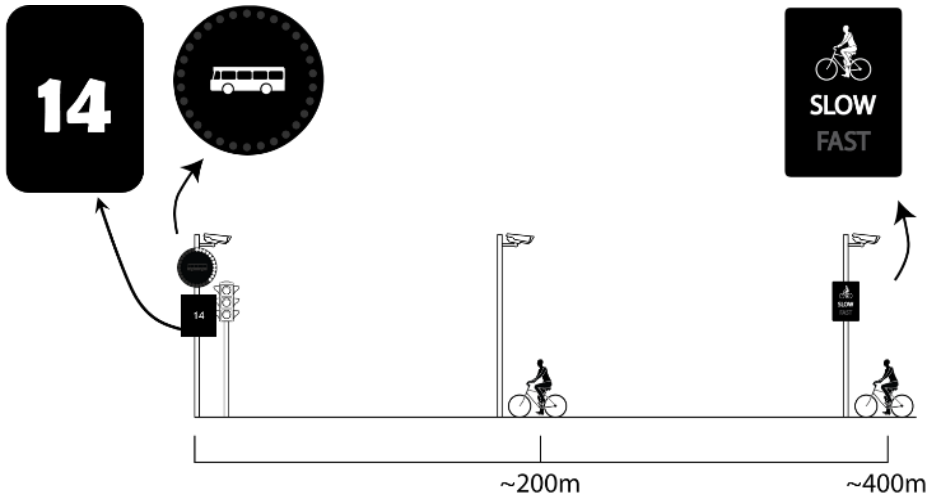


- **Stabilised adaptive control**



Enhanced adaptive control

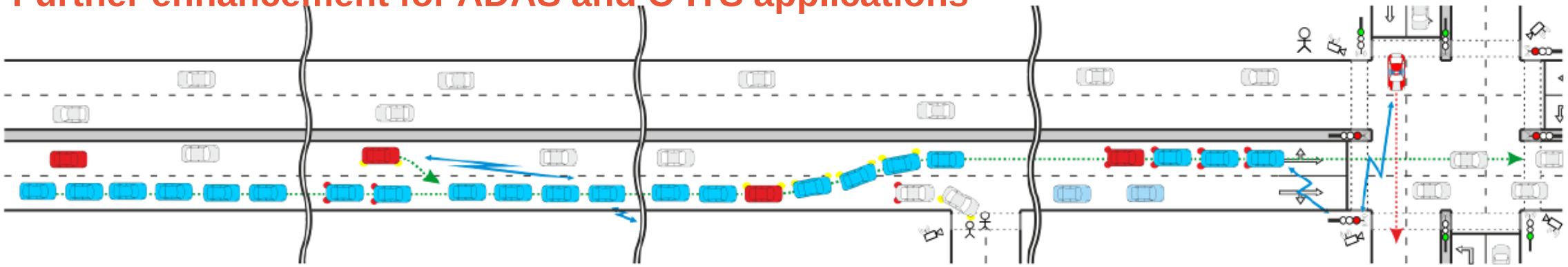
- **Plan stabilisation for adaptive control**
  - extends a configurable cost, prevents the optimiser to change the planning frequently or by a large deviation
- **Results of previous research at one-intersection show an increased stability of the adaptive control system**
  - overcomes the drawback of actuated or traditional adaptive control
  - while ensuring limited to no extra delay for other traffic and a large reduction in average number of stops



MAVEN objectives

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**
  - lane advice, signal optimisation, route advice, speed advice
- **Further enhancement for ADAS and C-ITS applications**



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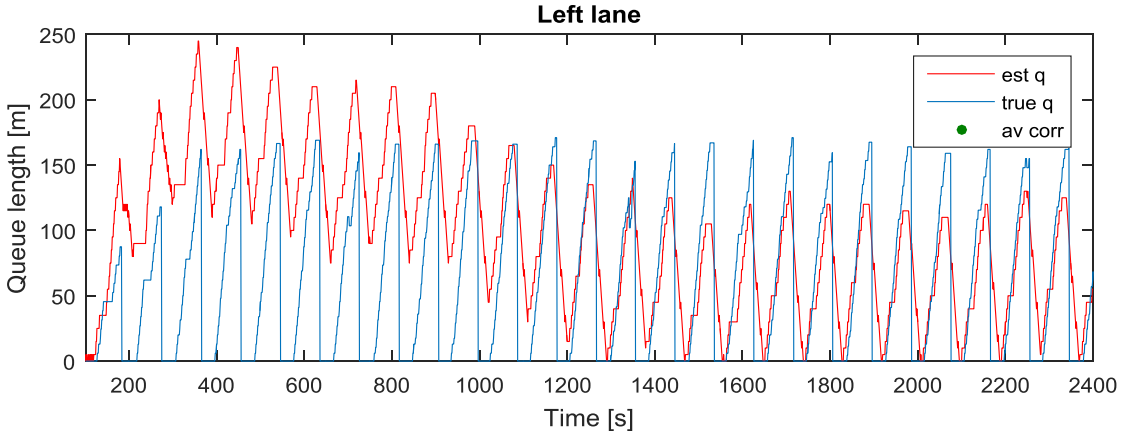
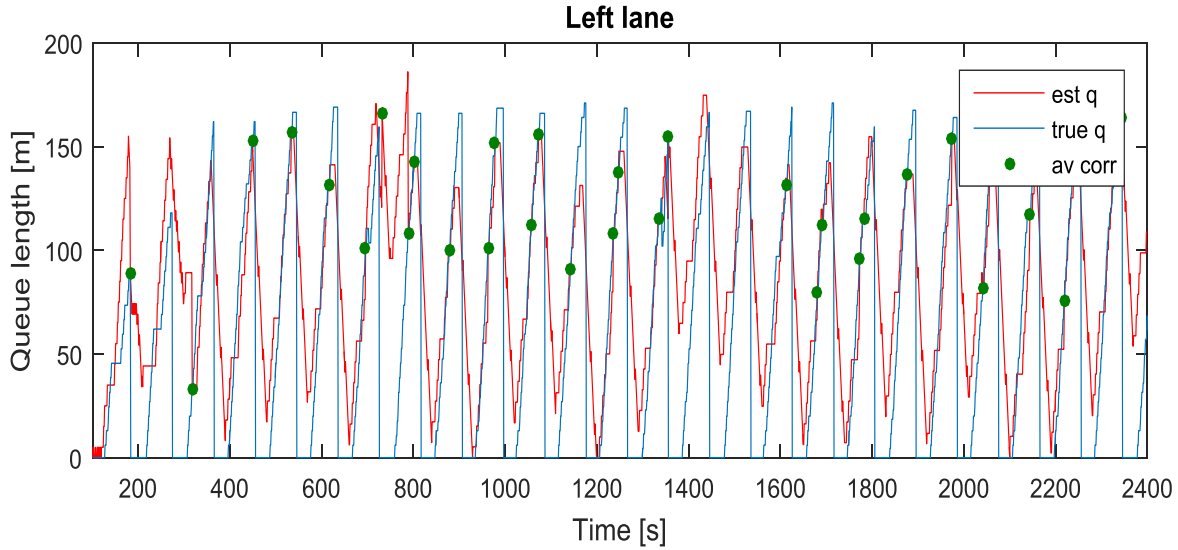
Queue modeling – data fusion

Managing Automated Vehicles Enhances Network





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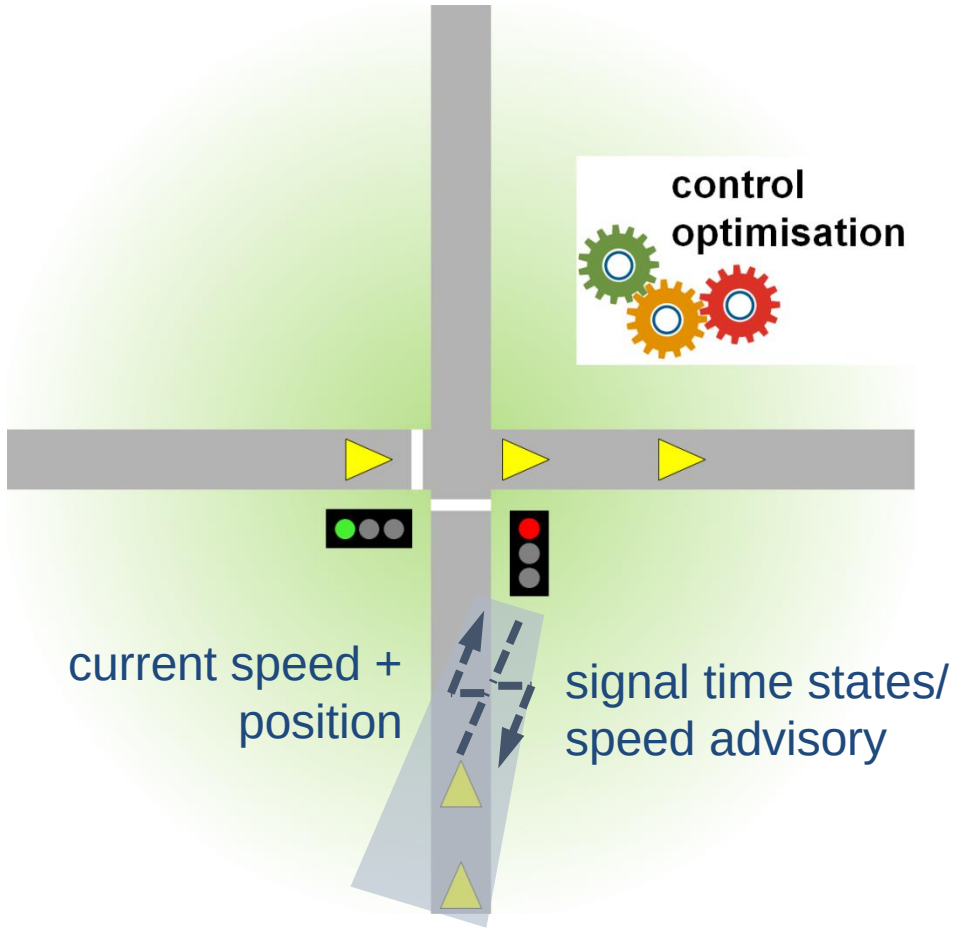
AGLOSA

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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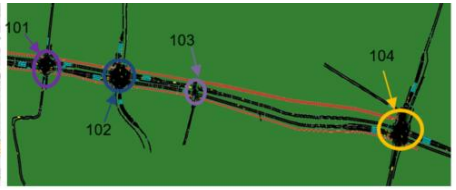
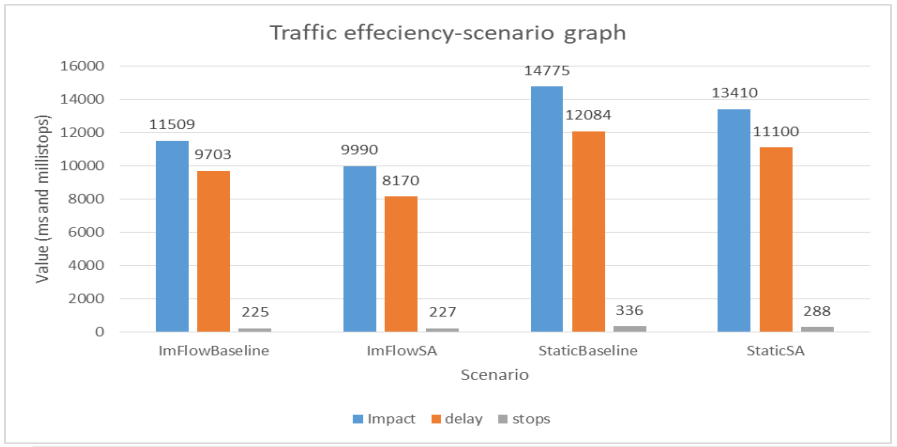
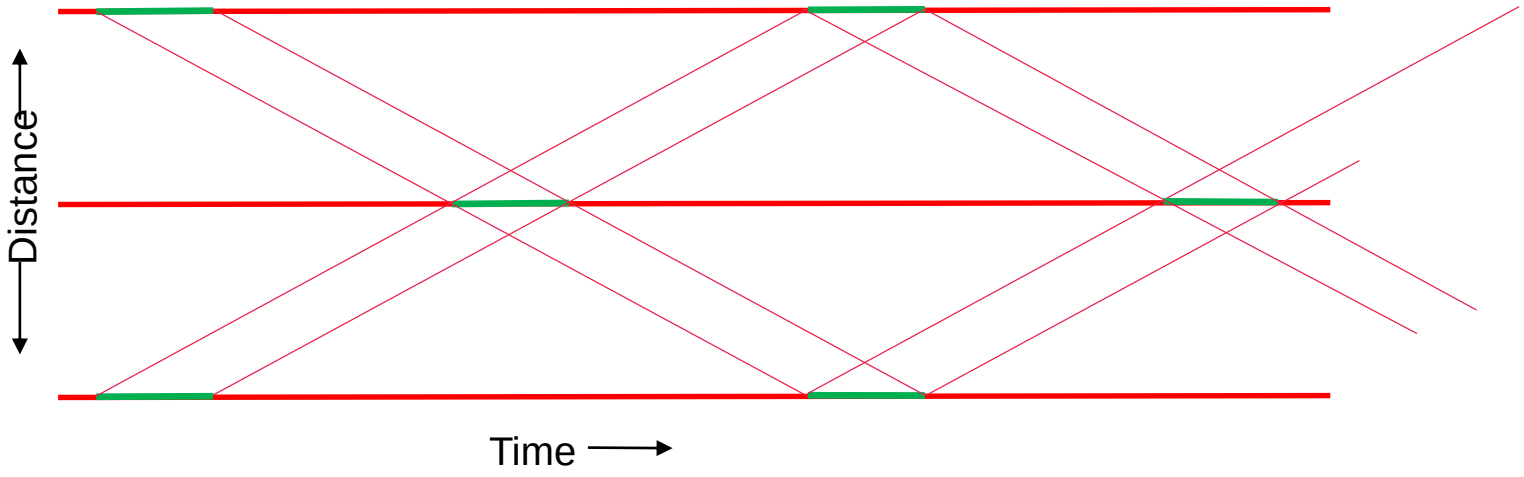
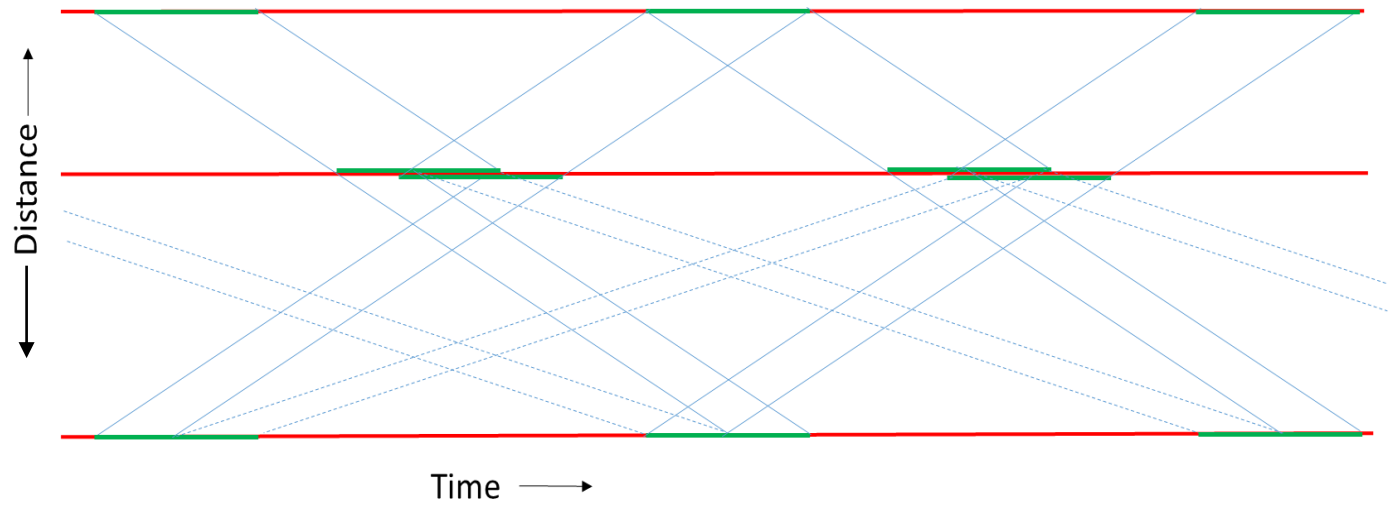
Green wave



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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Transition Areas for Infrastructure-Assisted Driving

- TM during the transition phase towards full AV penetration to increase traffic efficiency and safety
- Focus on AV and preventing them from having to hand over control back to the driver in difficult situations

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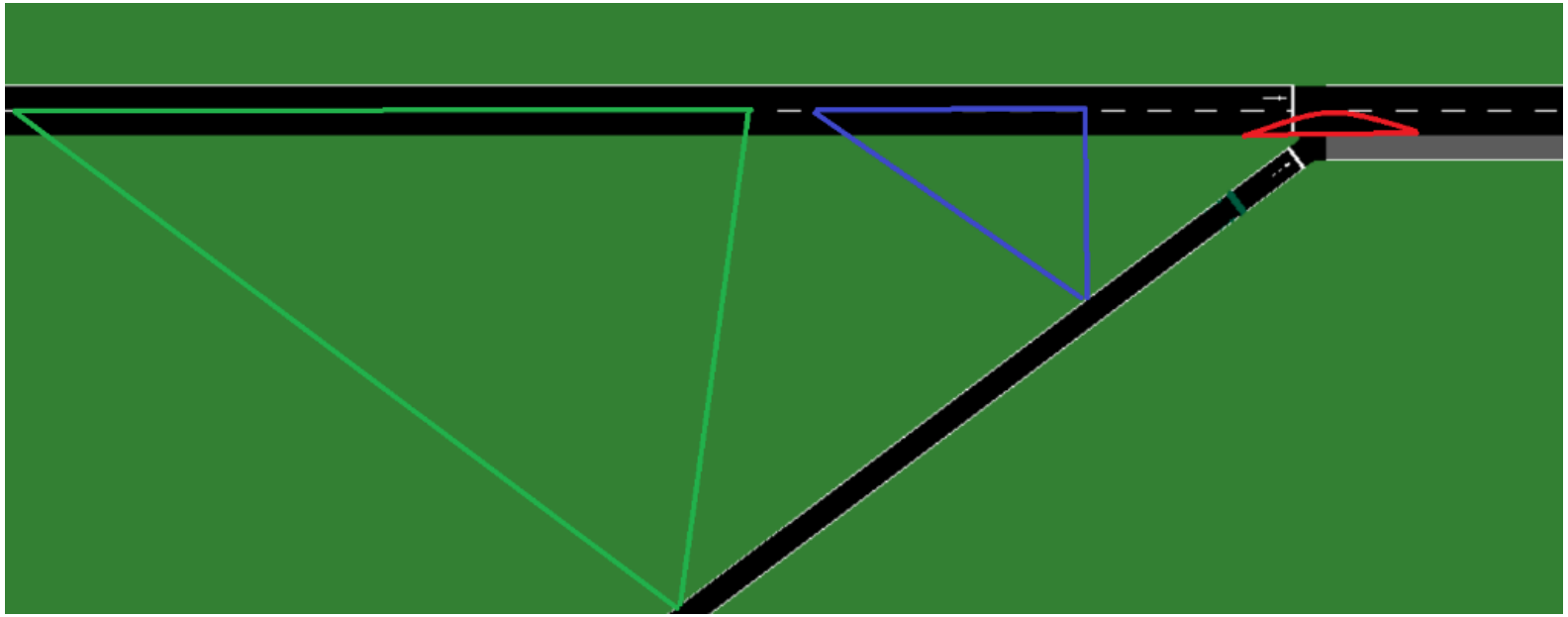
www.facebook.com/transaidh2020/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723390

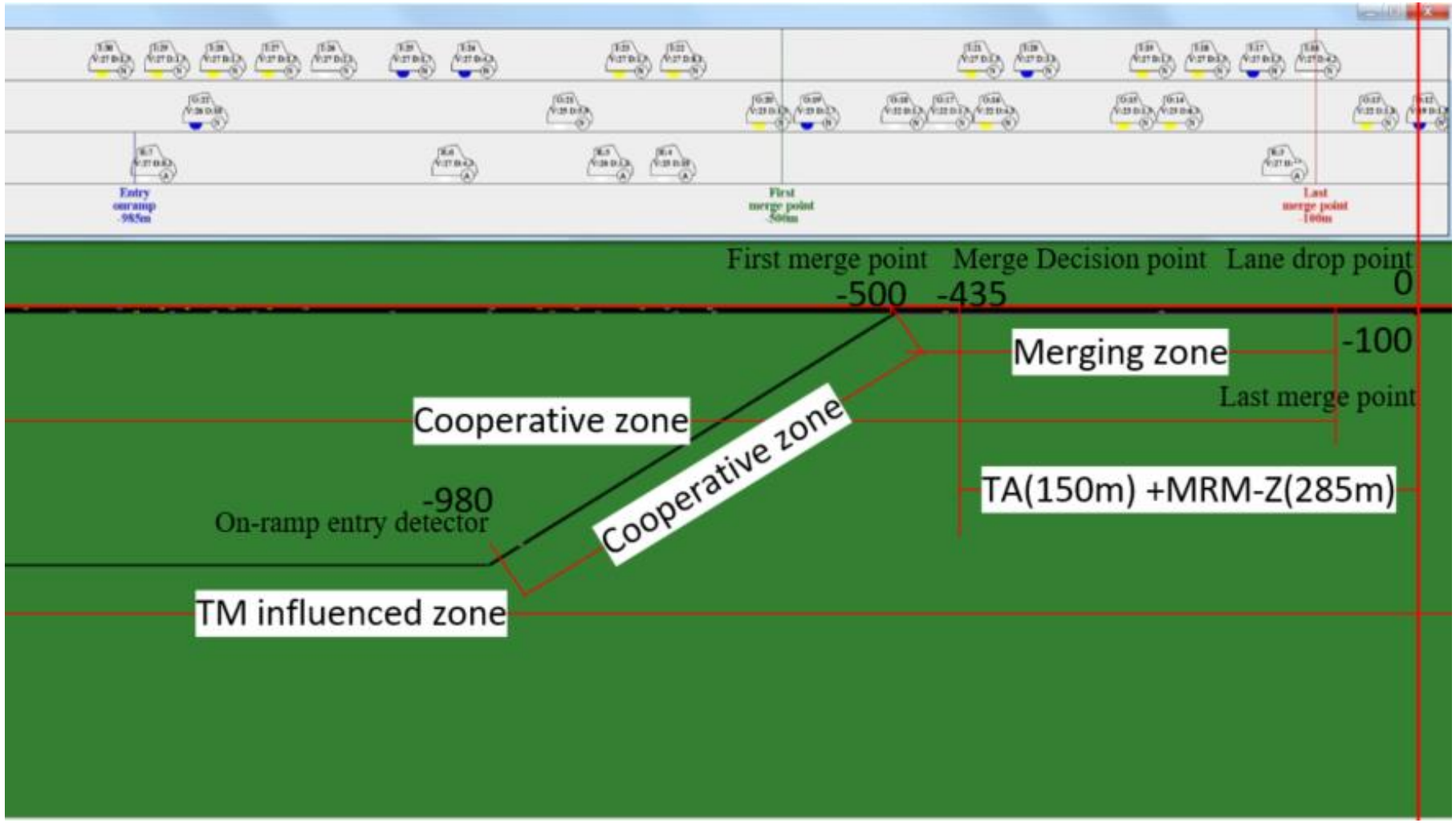
Ramp metering: problem definition

TransAID - Transition Areas for Infrastructure-Assisted Driving

- Automated vehicles have limited sensory view
- Transition of Control (ToC) required to guarantee safety
- With infrastructure guidance more information can be used than for human controlled vehicles



Ramp metering: scenario



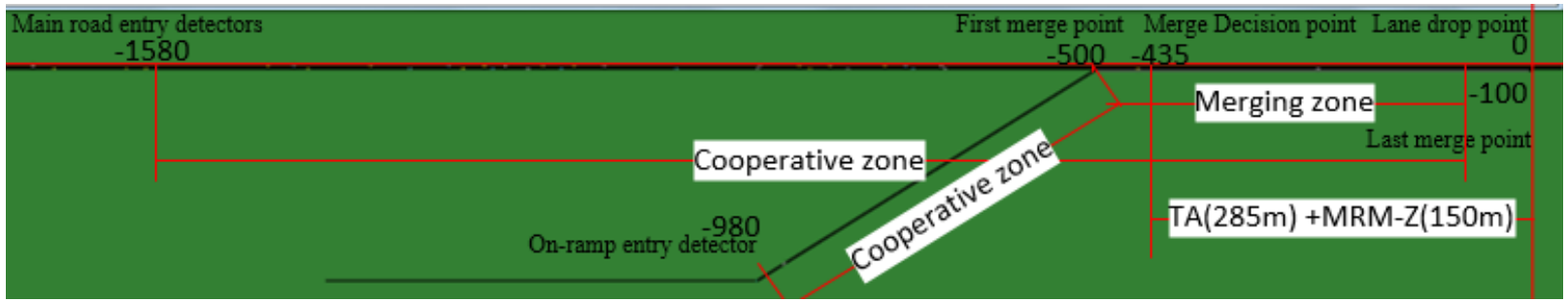
Ramp metering: interactions

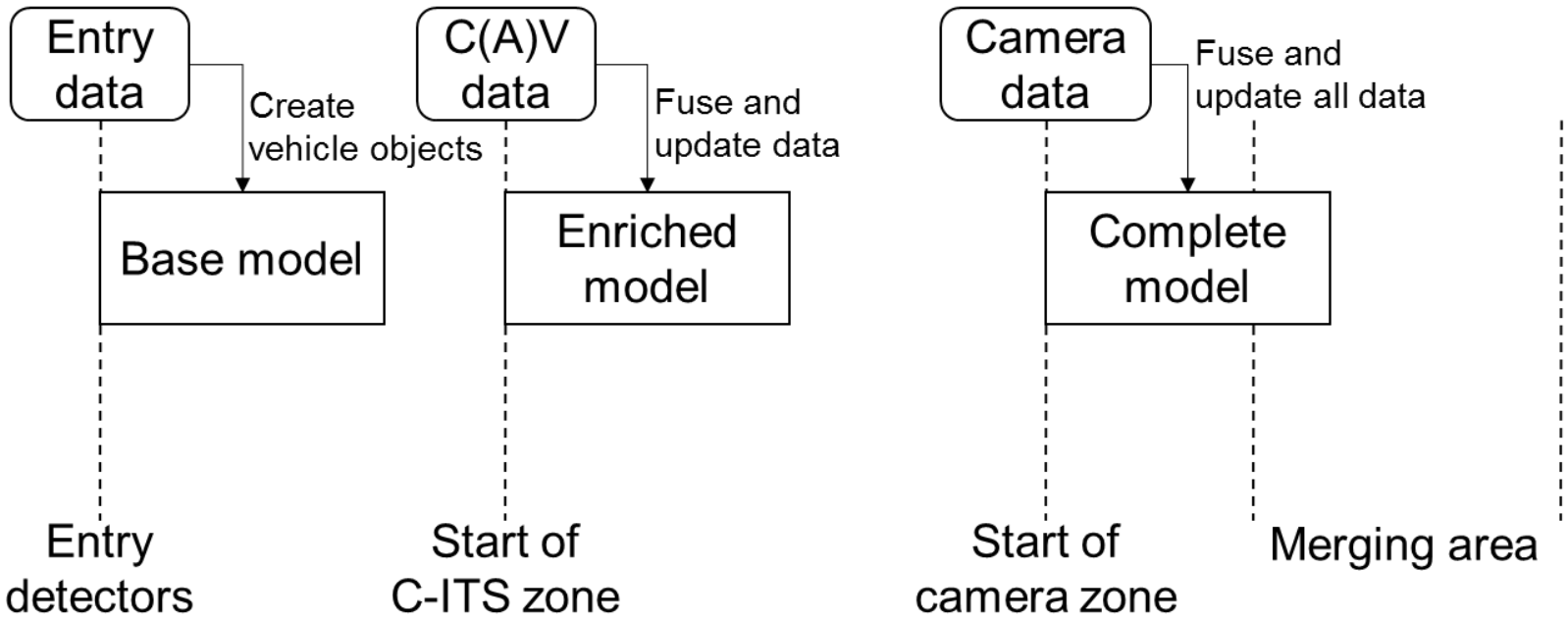
- **Non-cooperative vehicles**
  - monitor at entry detector and with the tracking camera
  - turn ramp meter to green near gaps
- **Cooperative vehicles**
  - CAM (Cooperative Awareness Message) gives regular speed and position update
  - possibility to send lane and speed advice with app
- **Automated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

Ramp metering: algorithm

- **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 (automated) vehicle**
- **Turn on ramp meter**

Ramp metering: approach model





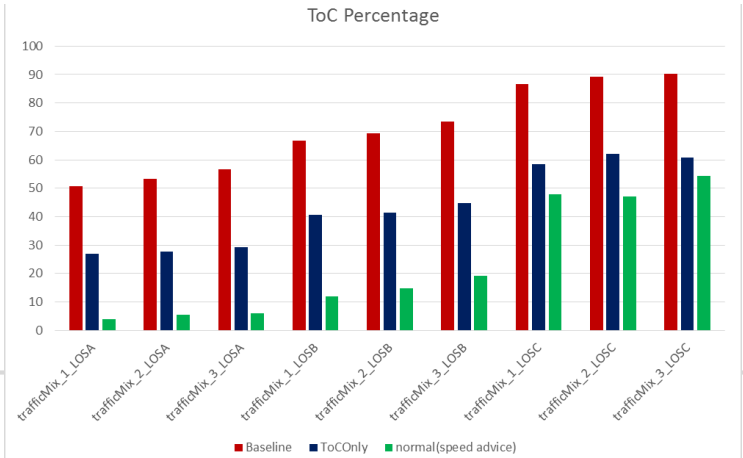
Ramp metering: solutions

TransAID - Transition Areas for Infrastructure-Assisted Driving

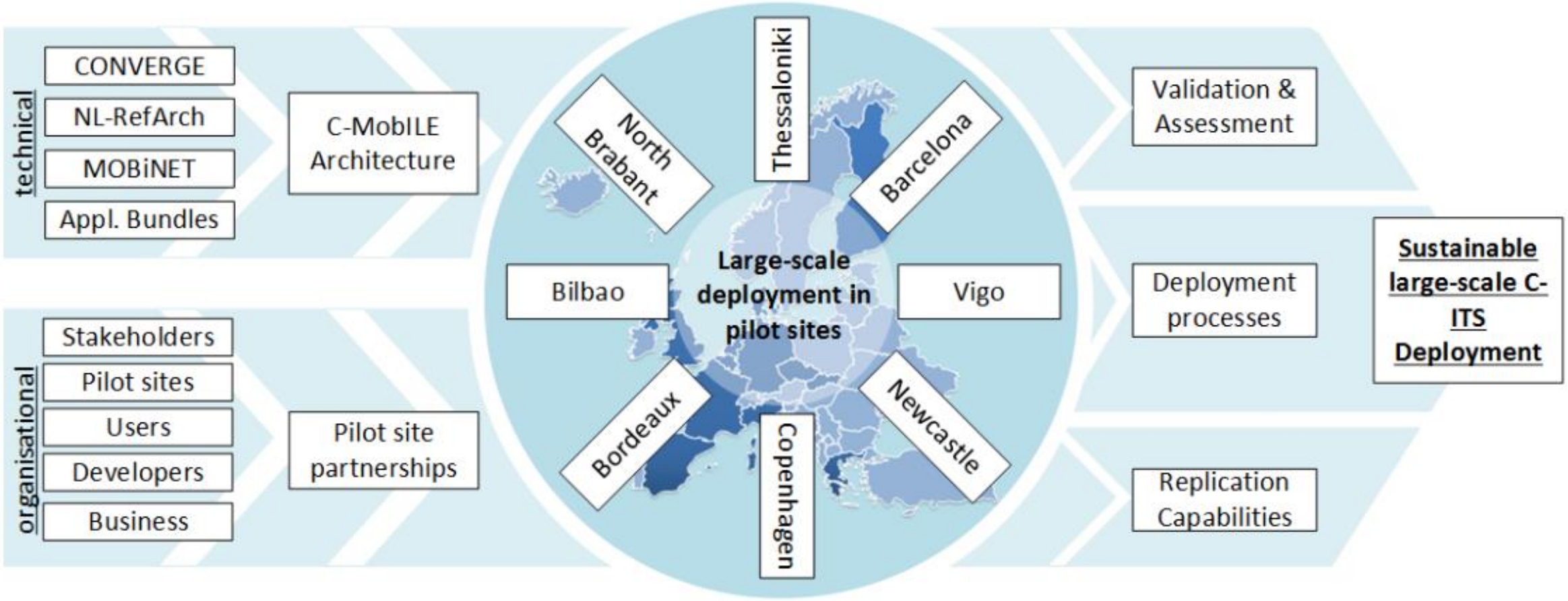
- ToC and MRM fail-safe
- Merging guidance - onramp
- Lane advice on the mainline left lane
- Cooperative speed advice for gap creation
- Cooperative lane advice for gap creation
- Intelligent ramp metering
- Results
  - system can handle any degree of penetration
  - 92% ToC reduction
  - 87% stops reduction
  - 7.3% CO2 reduction

Facility Type	Capacity (veh/h/l)	Level of Service (LOS)		
		A	B	C
On-ramp (100km/h)	1650 veh/h/l	462	726	1056
Capacity (IC or VC) ratio		0.28	0.44	0.64
Motorway (100 km/h)	2000 veh/h/l	600	960	1400
Capacity (IC or VC) ratio		0.3	0.48	0.7

Fleet mix	Legacy Vehicle	Cooperative	Automated
1	70	15	15
2	50	25	25
3	20	40	40



ACCELERATING C-ITS MOBILITY INNOVATION AND DEPLOYMENT IN EUROPE /



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C-MobILE C-ITS Services /

ID	Service
1	Rest-Time management
2	Motorway parking availability
3	Urban parking availability
4	Road works warning
5	Road hazard warning (incl. jams)
6	Emergency Vehicle Warning
7	Signal Violation Warning
8	Warning system for pedestrian
9	Green priority
10	Green Light Optimal Speed Advisory (GLOSA) / Dynamic eco-driving

ID	Service
11	Cooperative traffic light for pedestrian
12	Flexible infrastructure (peak-hour lane)
13	In-vehicle signage (e.g. Dyn. speed lim.)
14	Mode & trip time advice
15	Probe Vehicle Data
16	Emergency Brake Light
17	Cooperative (Adaptive) Cruise Control
18	Slow or Stationary Vehicle Warning
19	Motorcycle approaching indication (including other VRUs)
20	Blind spot detection / warning (VRUs)

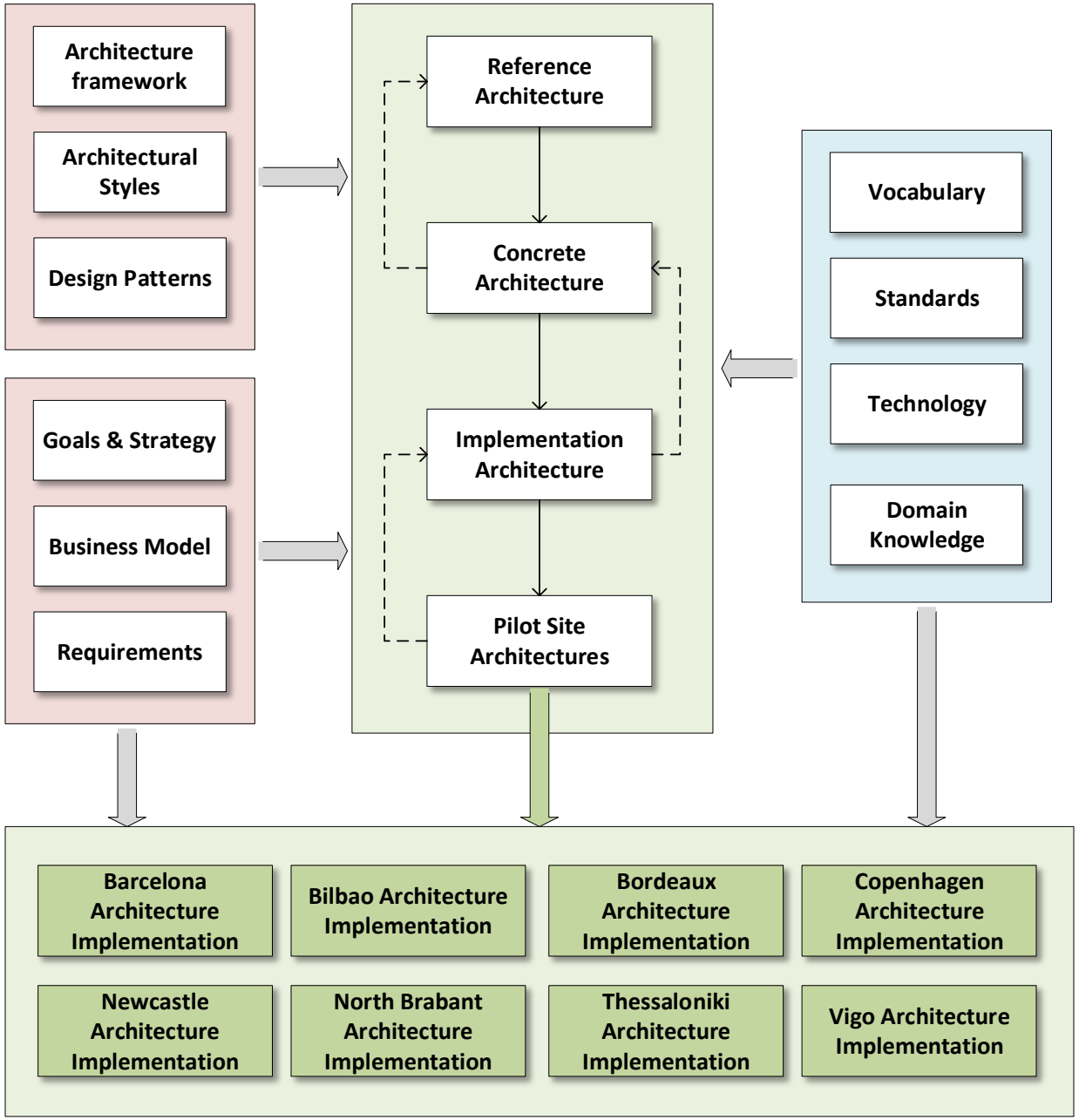
C-ITS Services and Use Cases (1/2) /

ID	Service	Use Cases
1	Rest-Time Management	UC1.1 - Rest time indication
2	Motorway Parking Availability	UC2.1. Information on parking lots location, availability and services via internet UC2.2. Information on parking lots location, availability and services via I2V UC2.3. Information about a truck parking space released by a user UC2.4. Reservation of a truck parking space released by a user UC2.5. Guide the truck in the port (terminal or truck parking)
3	Urban Parking Availability	UC3.1. Information about a vehicle parking space released by a user UC3.2. Reservation of a vehicle parking space released by a user UC3.3. Information about on-street parking availability for urban freight (loading zones) UC3.4. Information about on-street parking availability for private car drivers
4	Road Works Warning	UC4.1- Road works warning for 4 situations
5	Road Hazard Warning (incl. jams)	UC5.1- Hazardous location notification UC5.2- Traffic condition warning UC5.3- Weather condition warning
6	Emergency Vehicle Warning	UC6.1- Emergency Vehicle Warning for 3 situations
7	Signal Violation Warning	UC7.1- Red light violation warning
8	Warning System for Pedestrian	UC8.1- Warning Signage to drivers about pedestrians
9	Green Priority	UC9.1- Green Priority for Designated Vehicles
10	GLOSA	UC10.1 - Optimized Driving with GLOSA

C-ITS Services and Use Cases (2/2) /

ID	Service	
11	Cooperative traffic light for pedestrian	UC11.1- Cooperative Traffic Light for Designated VRUs UC11.2- Cooperative Traffic Light based on VRU detection
12	Flexible infrastructure (peak-hour lane)	UC12.1- Flexible infrastructure as in-vehicle signage
13	In-vehicle signage (e.g. Dyn. speed lim.)	UC13.1- In-Vehicle Signage, dynamic traffic signs UC13.2- In-Vehicle Signage, static traffic signs
14	Mode & trip time advice	UC14.1- Mode and Trip Time Advice for Event Visitors UC14.2- Mode and Trip Time advice for Drivers
15	Probe Vehicle Data	UC15.1- Basic probe vehicle data UC15.2- Extended probe vehicle data
16	Emergency Brake Light	UC16.1- Emergency electronic brake lights
17	Cooperative (Adaptive) Cruise Control	UC17.1 - CACC passenger vehicles approaching urban environment UC17.2 - CACC passenger vehicles approaching semi-urban environment UC17.3 - Truck Platooning UC17.4 - Cooperative Adaptive Cruise Control
18	Slow or Stationary Vehicle Warning	UC18.1 - Slow or stationary vehicle warning
19	Motorcycle approaching indication (including other VRUs)	UC19.1 - The approaching two-wheeler warning (V2V) UC19.2 - The approaching two-wheeler warning (V2V and V2I)
20	Blind spot detection / warning (VRUs)	UC20.1 - Digital Road Safety Mirror

ARCHITECTURE DEFINITION APPROACH /



Key perspectives for large scale demonstration of C-ITS systems:

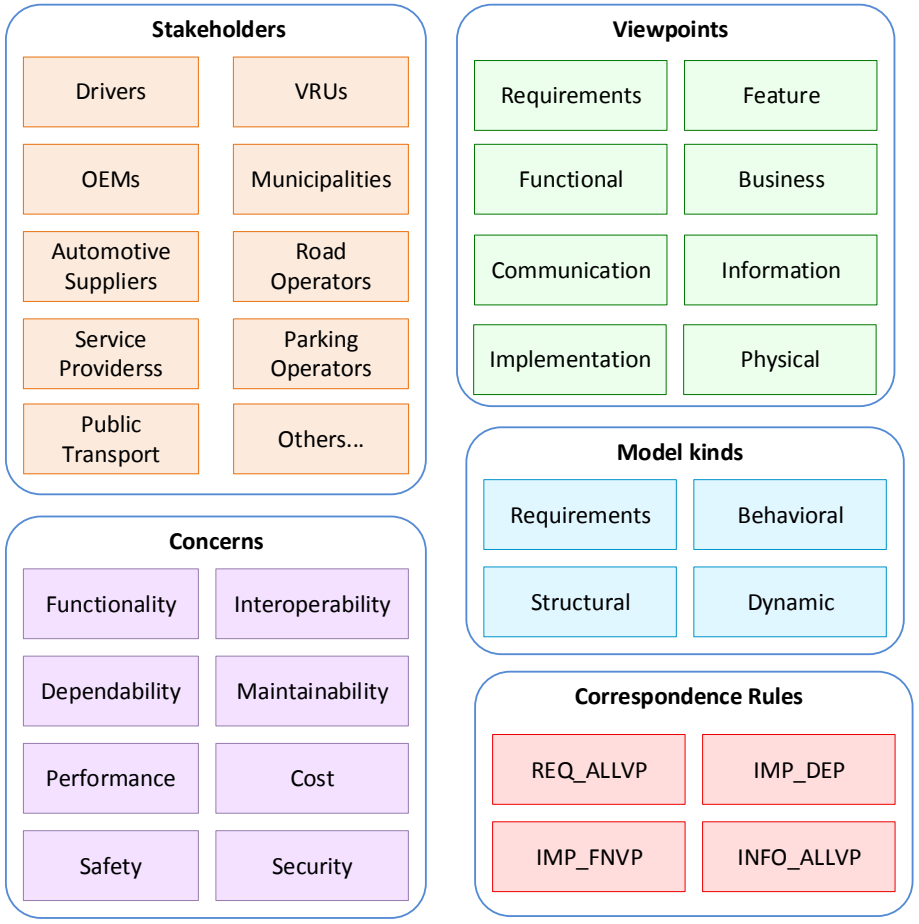
- interoperability
- security
- performance
- usability
- reliability
- availability
- adaptability

C-MobILE Reference Architecture /

Reference Architectures capture the *essence of existing architectures*, and the *vision of future needs* and *evolution to provide guidance* to assist in developing new system architectures. [Cloutier, 2008]

CONVERGE
MOBiNET
Dutch ITS
Compass4D
SCOOP@F
NordicWay
US ITS

Existing Architectures



Reference Architecture

Concrete Architecture

Implementation Architecture

- **Architecture Framework**
- **Architecture Patterns**

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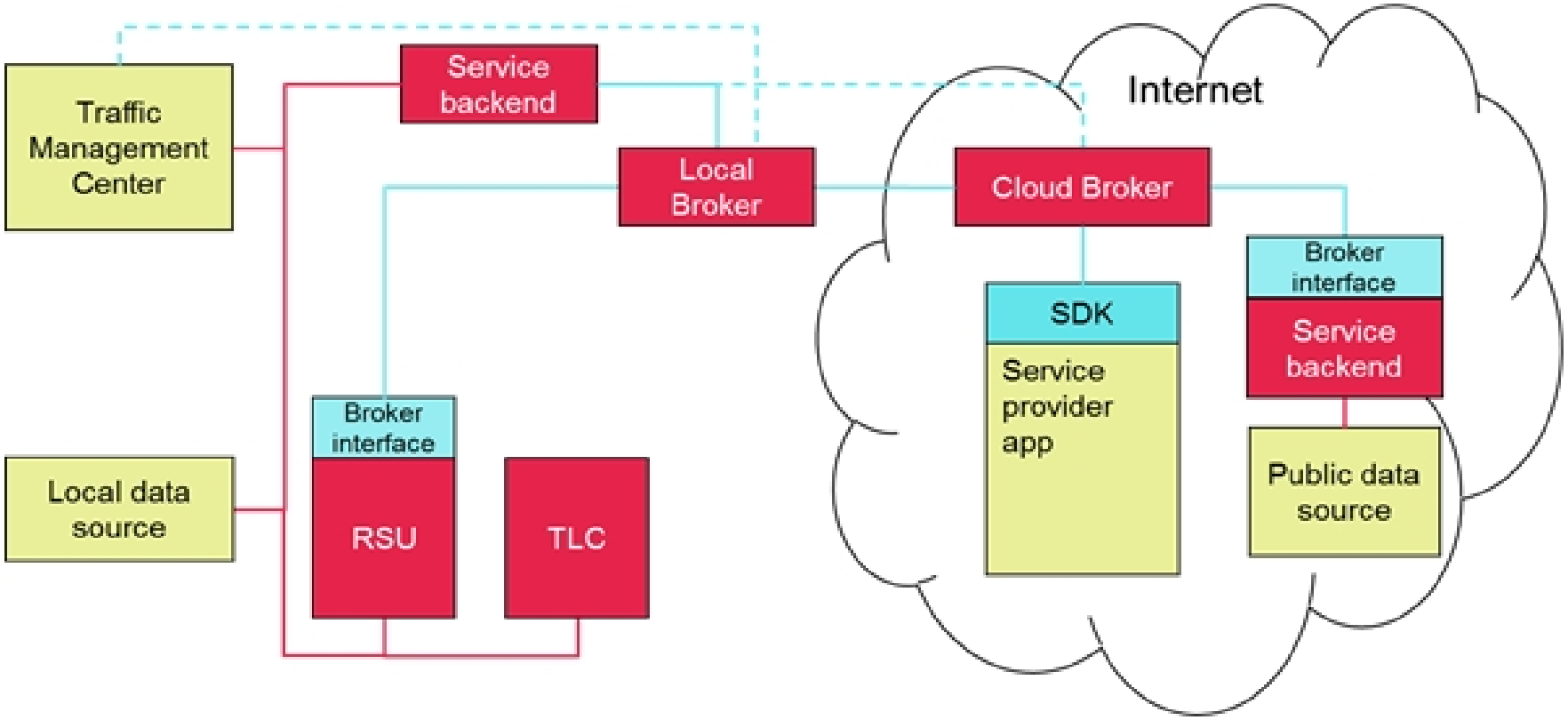
CONNECTION TO LOCAL DATA SOURCES /



C-MobILE solution /

Open architecture for cloud-based communications

- overall architecture
  - connections with local infrastructure
    - ✓ Offering services through cloud needs data acquisition from local sources
      - ➢ local infrastructure does not always offer interfaces to access relevant data
      - ➢ security of the local systems: TLCs connected via VPN, instead of direct access from the cloud to TLCs
    - ✓ C-MobILE protocol - MQTT (Message Queuing Telemetry Transport)
  - geocasting facilities
    - ✓ MQTT broker - a key element for the design of the geocasting solution
      - ➢ analysis of protocols of GeoNet/SCOOP@F, MOBiNET, and CONVERGE (tiling concept)
    - ✓ C-MobILE solution - one step further in the efficiency of the tile system
      - ➢ tile edges are no longer exchanged between the vehicle and the broker
      - ➢ use of Google XYZ standard, enabling any system to calculate the relevant geographic tiles for its current location
  - security and authorization mechanisms
    - ✓ Security policy: EC mandated the C-ITS Platform with the definition of a security policy
    - ✓ Trust model used for all messages that are standardized for IEEE 802.11p
- business models supported by the architecture
  - *secure*, pragmatic, cost-effective, and easily operational for authorities to implement C-ITS services
  - allows *neutral brokers* to operate, and avoids vendor-locked situations
  - even possible to have *multiple brokers* of different vendors in parallel

ACKNOWLEDGEMENTS /

EU-funded project C-MobILE

Horizon 2020 RIA

Grant Agreement No 723311

Coordinator

Applus+ IDIADA

Project period

1 Jun 2017 / 30 Nov 2020

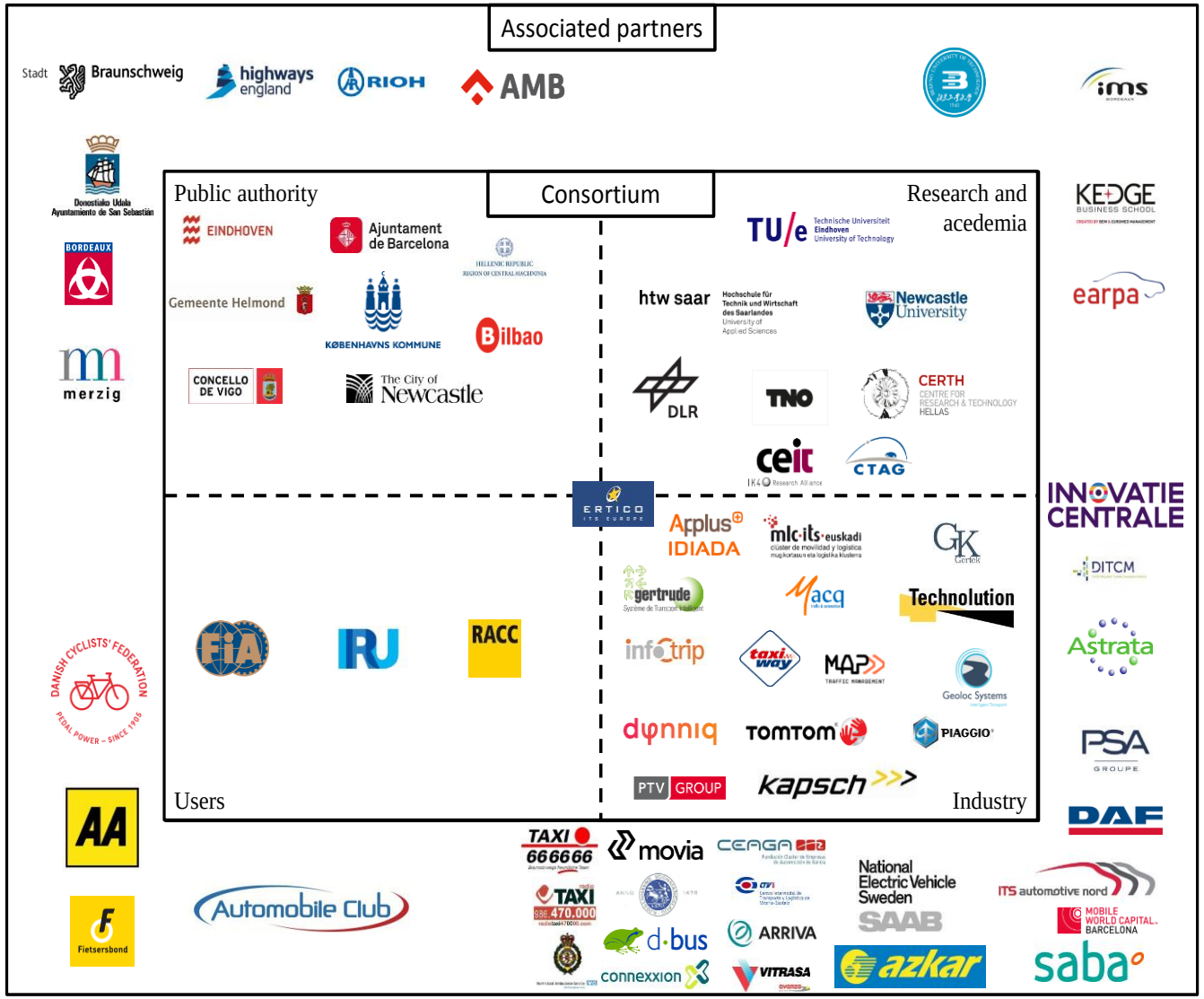
Budget

total budget ~ €15 mil.

total EC funding ~ €12.6 mil

Web site

http://c-mobile-project.eu/



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C-MOBILE

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Thank you for your attention.

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