C-ROADS ITALY2 ITALY3

EVENTO FINALE 23 NOV 2023

POLITECNICO MILANO 1863

C-ITS Impact Evaluation

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Ministero delle Infrastrutture e dei Trasporti

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Objective of the evaluation activities

- Estimation of the impacts of the different Use Cases on mobility – road safety, traffic efficiency, environment, users' behavior, etc.
- Coordination of Evaluation activities in C-Roads 2&3 and Chair of C-Roads Platform WG3 Evaluation and Assessment
- Definition of modelling activities and field tests with the Partners

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Use cases evaluated and field tests

- Torino: Signalized Intersections – Signal Phase and Timing Information/Green Light Optimal Speed Advisory (SI-SPTI/GLOSA) (**modelling + in real urban context** with Stellantis-CRF) and Roads Works Warning (RWW) - Lane Closure
- Trento: SI-SPTI/GLOSA (**modelling + in real urban context** with Stellantis-CRF)
- Orbassano: SI-SPTI/GLOSA (**in controlled environment** with Stellantis-CRF)
- Verona: Off Street Parking and Smart Routing (**in real urban context** with Almaviva)
- Autostrada BS-PD: WCW - Weather Condition Warning (**in real motorway context** with Stellantis-CRF)

GLOSA evaluation with modelling

Impacts and benefits of GLOSA are dependent on several factors:

1. GLOSA algorithm implementation and operation modes

   Optimal speed based only on:

   - real time information on the **traffic light phase**
   - **position** of the vehicle in relation to the traffic light
   - presence and **position of other vehicles** in front of the vehicle (and of **queue**) is considered
   - presence of **multiple traffic light intersections** at short distances from each other (crossing of the entire sequence of intersections)

2. Level of **compliance** of the users to speed advice systems

GLOSA evaluation with modelling

3. Configuration of the network and of the signalized intersection
   - **network types** (urban, suburban, or extra-urban roads)
   - features of the single roads entering the intersection (**approaches**):
     - number of lanes
     - lane configuration (presence of dedicated lanes and/or traffic light phases)
   - **duration of traffic signal cycle** and of green times
   - length of **activation zone** of GLOSA
4. Features of traffic flows
   - **traffic conditions** (traffic flow and volume/capacity ratio) and composition (% of heavy vehicles)
   - **market penetration** (MP%) of C-ITS equipped vehicles

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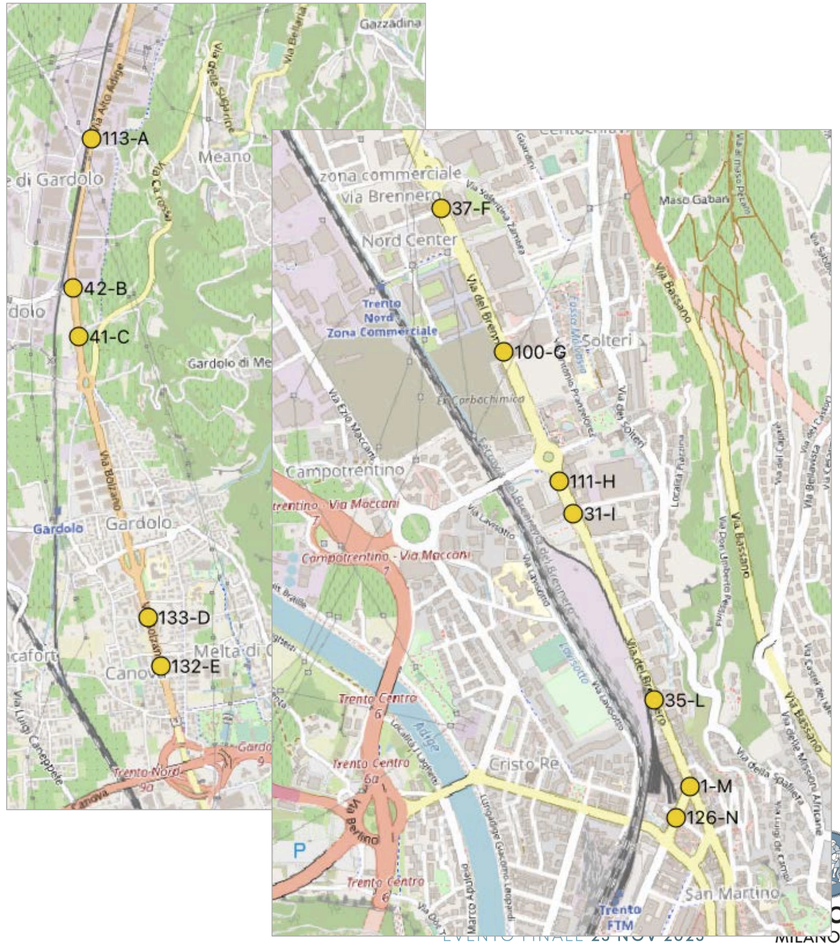
GLOSA evaluation with modelling

Analyzed intersections

City of **Trento:**

12 signalized intersections (many are pedestrian or bicycle crossings)

Intersection code	Name	Description	N° branches	N° approaches
A - 113	Lamar	Pedestrian crossing	2	2
B - 42	Via Bolzano - bivio Spini	3 branches int.	3	3
C - 41	Via Bolzano - bivio Meano	Pedestrian crossing	2	2
D - 133	Gardolo - via Bolzano - via Noce		2	2
E - 132	Gardolo - via Bolzano (case Itea)	Cycle and pedestrian crossing	2	2
F - 37	Via Brennero - rotatoria Bren Center	Pedestrian crossing	2	2
G - 100	Via Brennero - Mediaworld	Cycle and pedestrian crossing	2	2
H - 111	Via Brennero - rotatoria Tridente		2	2
I - 31	Via Brennero - via Marconi	4 branches int.	4	4
L - 35	Via Brennero - Fornaci	Pedestrian crossing	2	2
M - 1	Via Ambrosi - via Brennero	Pedestrian crossing with bus priority	3	2
N - 126 (1bis)	Via Ambrosi - Piazza Centa	4 branches int.	4	3



GLOSA evaluation with modelling

Analyzed intersections

City of **Torino**: 18 signalized intersections

Intersection code	Intersection name	Description	N° branches	N° approaches
2019/FER	Ferraris - Rosselli	4 branches intersection with counter roads	4	6
2016/FEA	Corso Galileo Ferraris - Via Sebastiano Caboto		4	5
5058/FCL	Corso Galileo Ferraris - Via Cristoforo Colombo		4	5
4036/FPD	Corso Galileo Ferraris - Via Pastrengo		3	5
1012/FEU	Corso Galileo Ferraris - Corso Stati Uniti		4	6
10010/AGT	Corso Giovanni Agnelli - Corso Traiano	3 branches int. with tram lane	3	4
10005/UTR	Corso Unione Sovietica - Corso Traiano	4 branches int. with counter roads	4	6
58038/TRG	Corso Traiano -Via Pietro Francesco Guala	4 branches intersection	4	4
58039/TRC	Corso Traiano - Corso Benedetto Croce -Piazza Teresa Confalonieri		4	4
58040/TRP	Corso Traiano -Via Pio VII		4	4
58041/TSC	Corso Traiano - Via Sette Comuni		4	
14028/MCB	Corso Bolzano - Corso Giacomo Matteotti			
[illegible]/NGC	Corso Inghilterra - Via Giovanni [illegible]			

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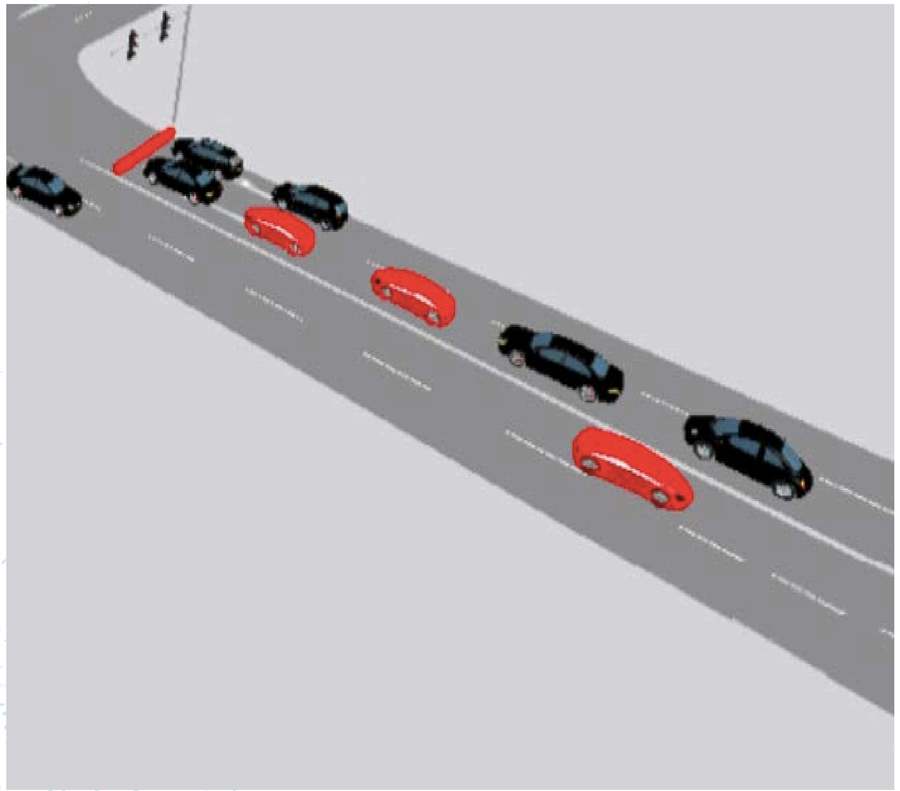
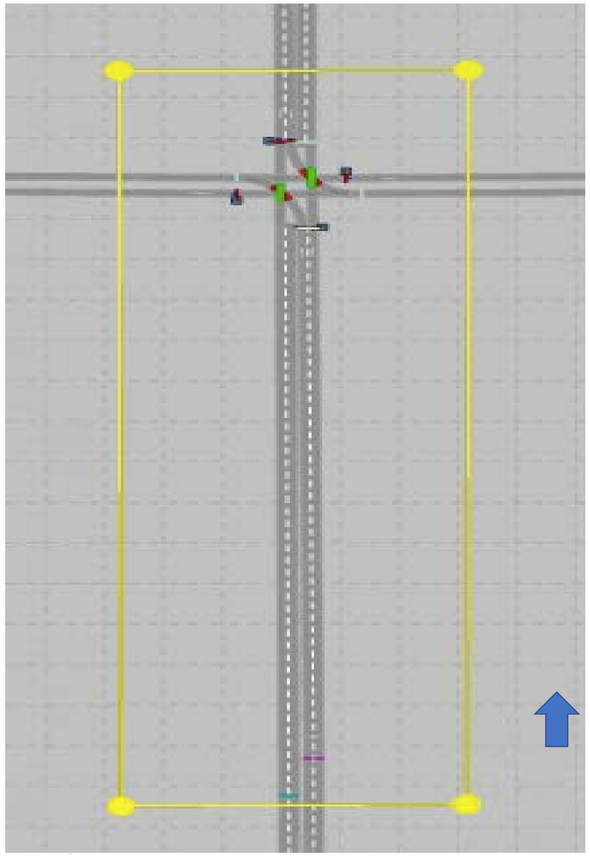
GLOSA evaluation with modelling

Definition and execution of simulations representative of the different approaches

Example of simulation: vehicles in red are connected (C-ITS enabled)



Area of evaluation of the approach



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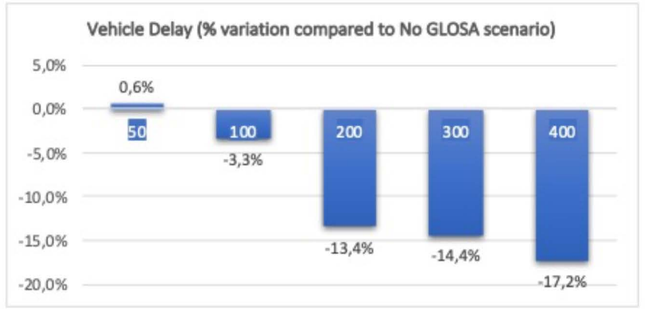
GLOSA evaluation with modelling

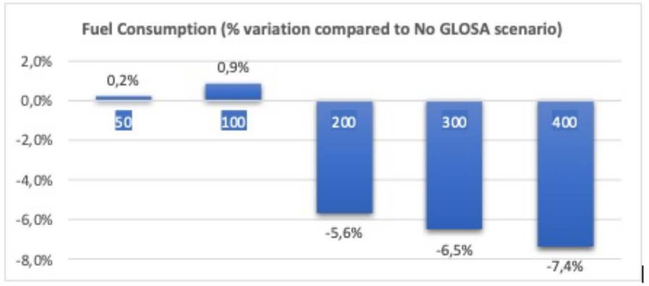
Influence of the GLOSA Reception Distance

Fixed attributes:

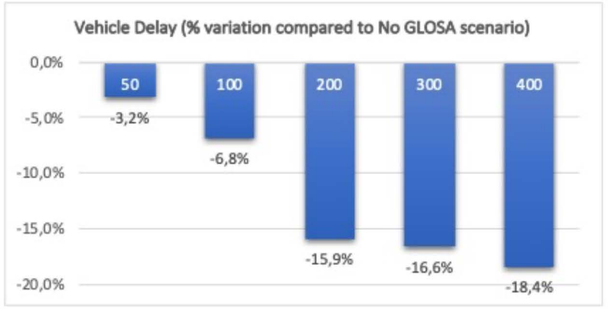
- Market penetration: 25%
- Flows:
  - 500 veh/h (1 lane)
  - 1.000 veh/h (2 lanes)
- Cycle duration: 100 sec
- Green/Cycle ratio: 0,5

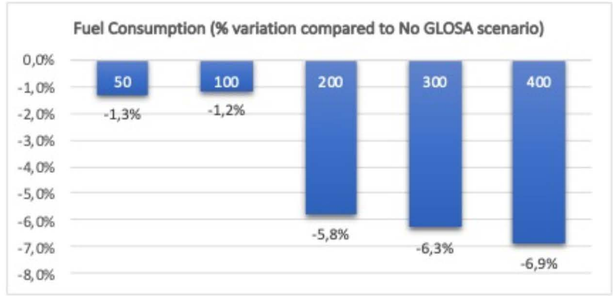
1 lane





2 lanes





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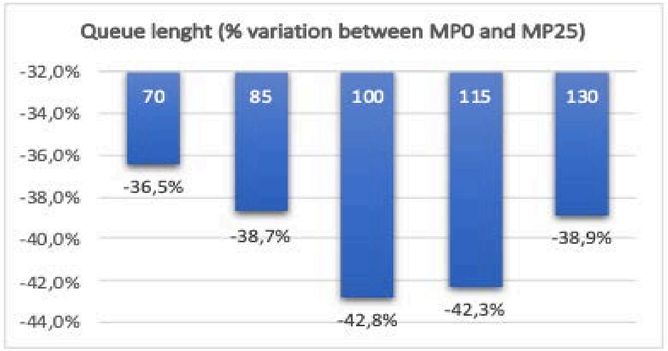
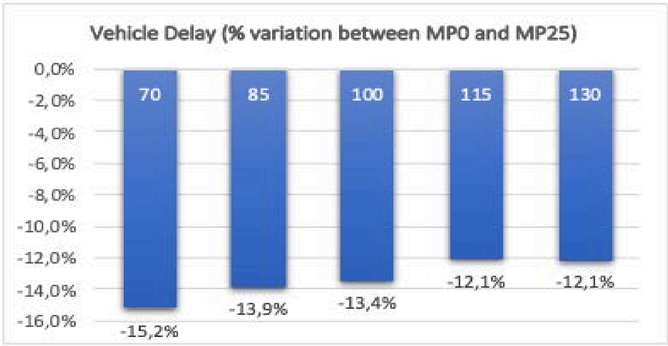
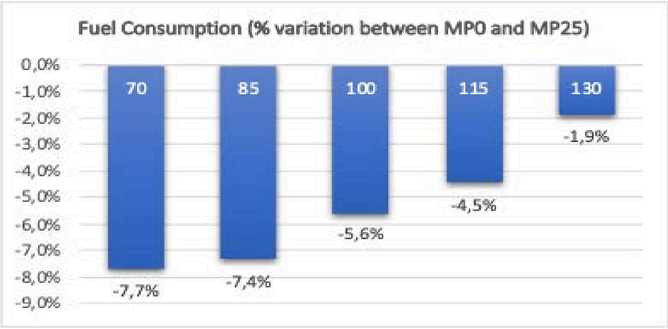
GLOSA evaluation with modelling

Influence of the duration of the traffic light cycle

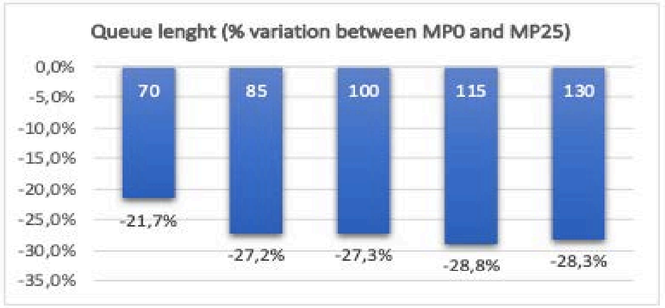
1 lane

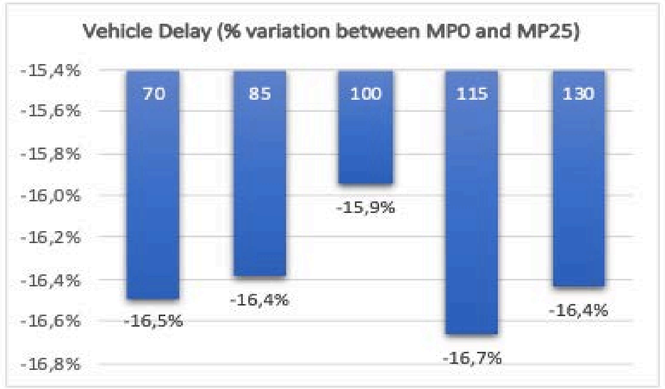


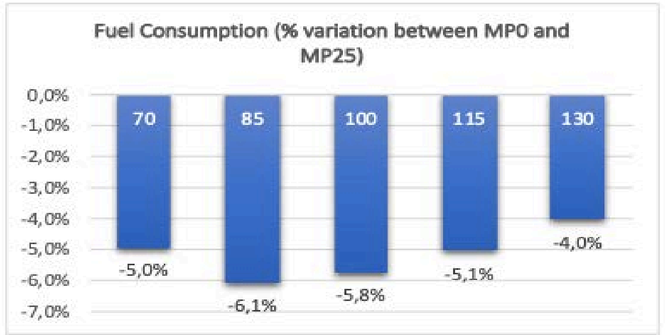




2 lanes



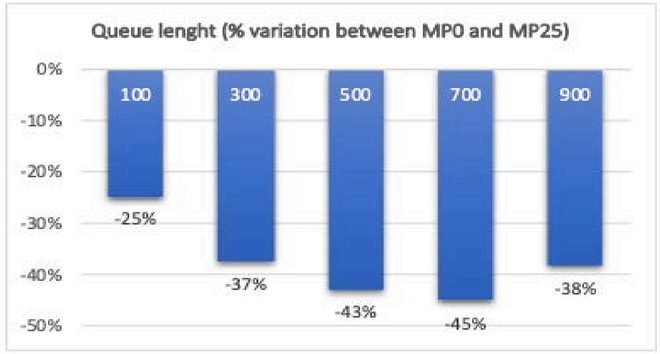


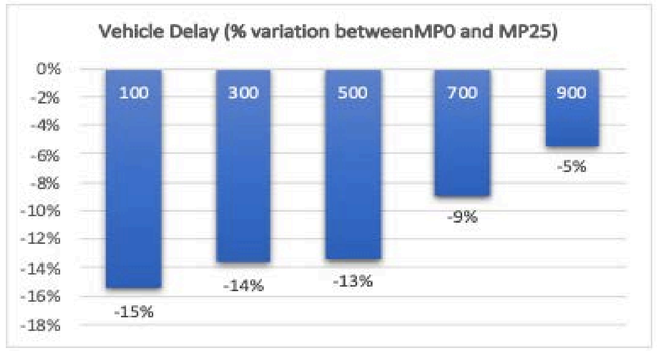


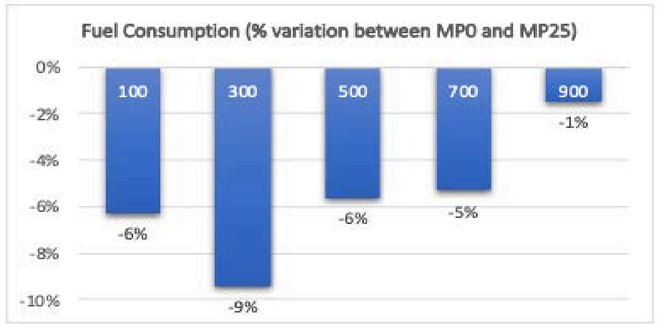
GLOSA evaluation with modelling

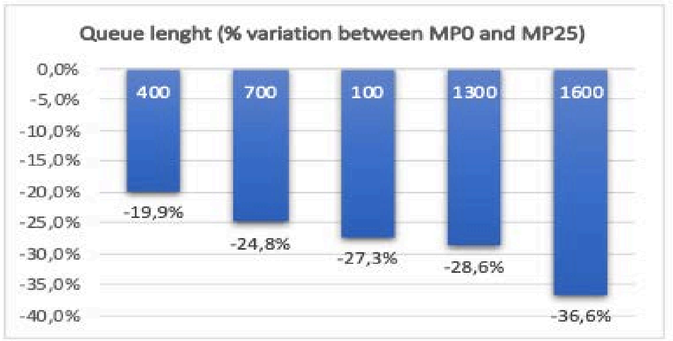
Influence of vehicular flow

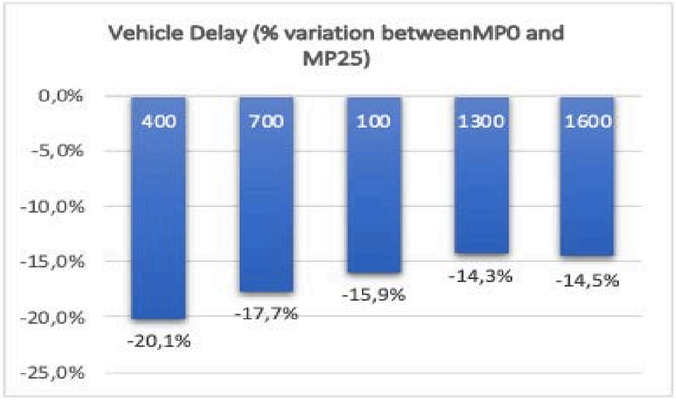
1 lane	2 lanes

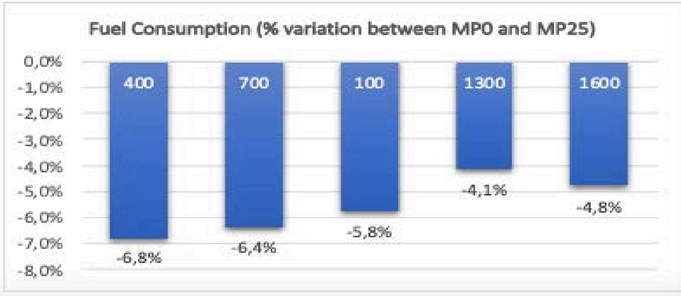












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GLOSA evaluation with modelling

Summary of the impacts:

The results obtained show benefits of GLOSA already starting from a low market penetration (5%):

- **-5% queue reduction, -5% delay reduction and -1% fuel savings** for the city of Torino
- **-7% queue reduction, -4% delay reduction and -1% fuel savings** for the city of Trento

The benefits progressively increase as market penetration grows. Assuming a market penetration of 100%, the following results are achieved:

- **-14% queue reduction, -29% delay reduction and -4% fuel savings** for the city of Torino
- **-56% queue reduction, -42% delay reduction and -9% fuel sa**vings for the city of Trento

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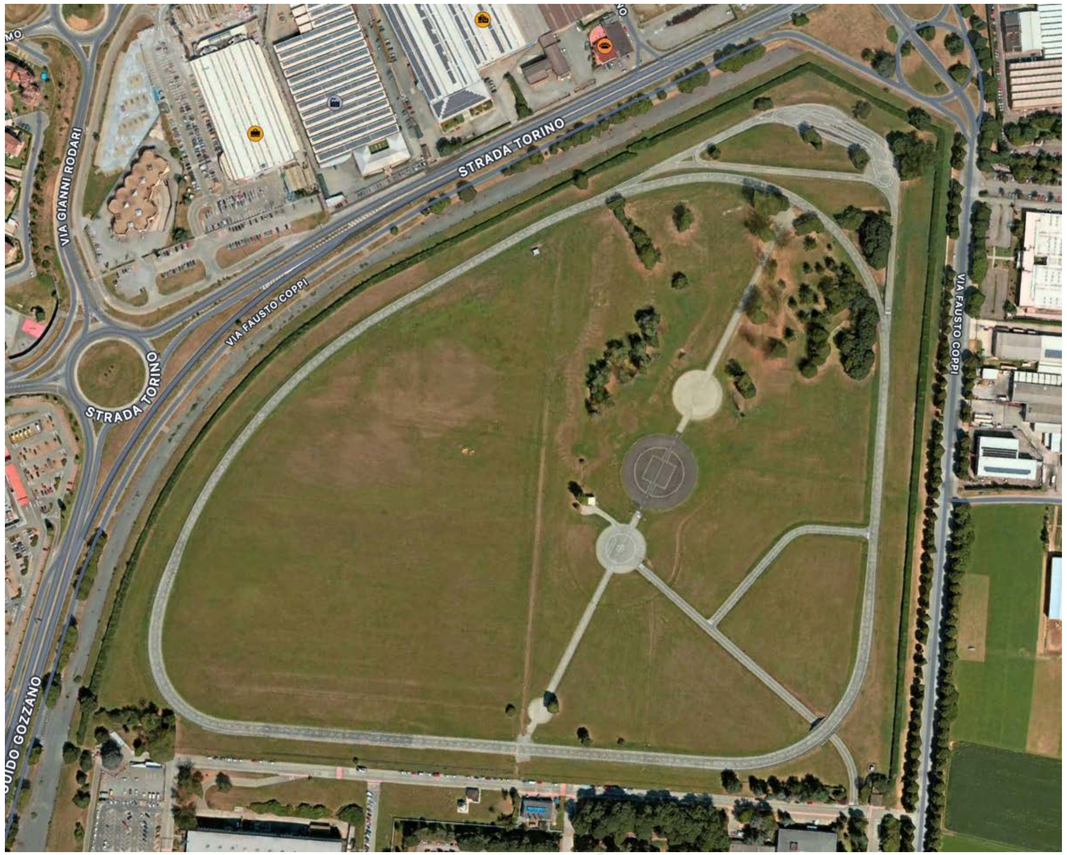
GLOSA evaluation - field test (Orbassano)

Location: Stellantis safety center in Orbassano -> 2.5 km loop circuit equipped with a configurable traffic light system -> controlled environment



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GLOSA evaluation - field test (Orbassano)

- Test **objectives** and **scenario definition**:
  - to evaluate the effectiveness of **GLOSA** (declined in two different algorithms) compared to the same scenarios in the absence of the service (**NO GLOSA**)
  - evaluate the sensitivity of the system in relation to a set of parameters/conditions, namely:
    1. the influence of the **duration** of **traffic light cycles**
    2. the influence of the **maximum activation distance** of the GLOSA
    3. the influence of the **minimum and maximum speeds** advisable by the algorithm
    4. the **interaction between vehicles**: a vehicle with GLOSA traveling immediately behind one without GLOSA (or vice versa)
  - two or more scenarios were defined for each type of test performed, in addition to the corresponding NO GLOSA reference scenario.

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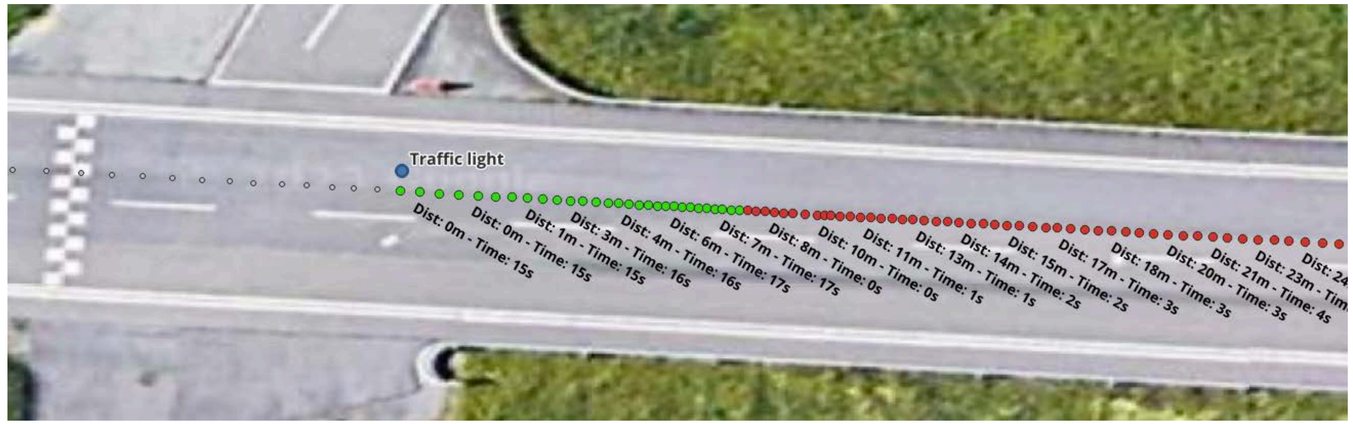
GLOSA evaluation - field test (Orbassano)

Two algorithms tested:

- **Minimum jerk**: it performs a maneuver characterized by high smoothness of driving (minimizing jerks and variations from the initial state of motion of the vehicle)
- **Smart e-coasting**: it is aimed at maximizing the energy recovery of a hybrid vehicle during slowdown
  - if it is not possible to pass with green, the algorithm from a given position suggests the driver to release the accelerator pedal and then handles regenerative braking automatically (applying the correct braking torque)
  - otherwise (if it is possible to pass with green), the algorithm follows the Minimum Jerk algorithm



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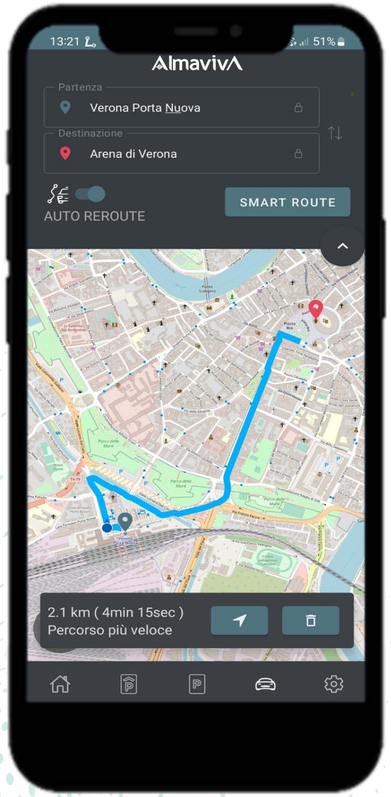
Field tests - Pilot in Verona

- **Use Cases tested (day 1.5 services):**
  - **Traffic Information and smart routing**
  - **Off street parking information**
- **Partners involved:**
  - 3 test users equipped with C-ITS application (Almaviva)
  - 3 test users with no C-ITS application (Comune di Verona)
  - 3 people for technical/organizational support (Polimi)
  - staff/managers of the Traffic Control Center of Verona

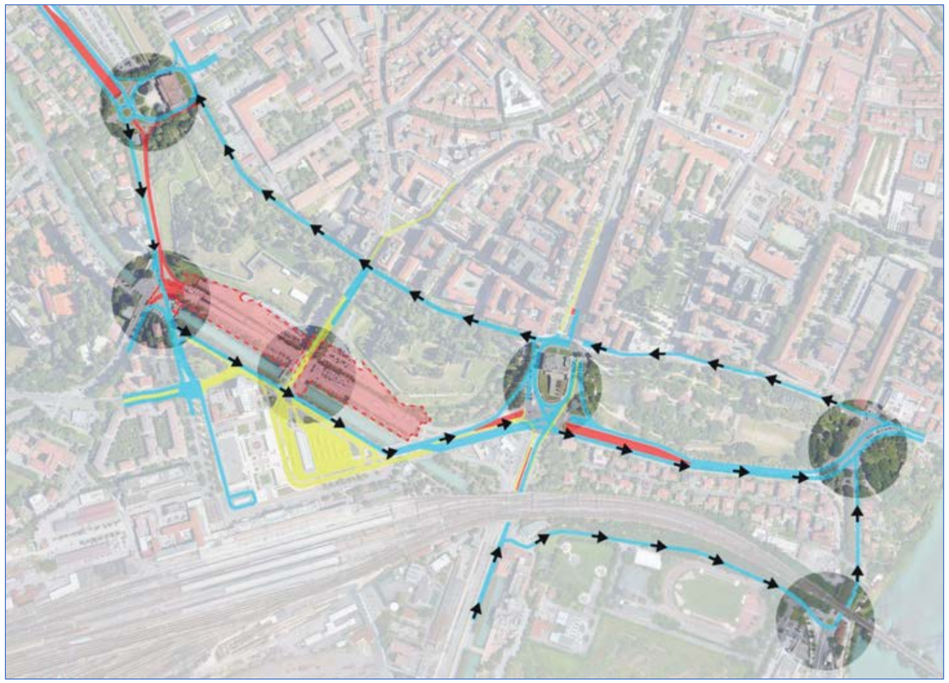
Field tests - Pilot in Verona

Traffic Information and smart routing

- test scenario: test users had to transit through the construction site of new underpass of "City of Nimes" street



Test users with the C-ITS application could benefit from route information that also consider current traffic events



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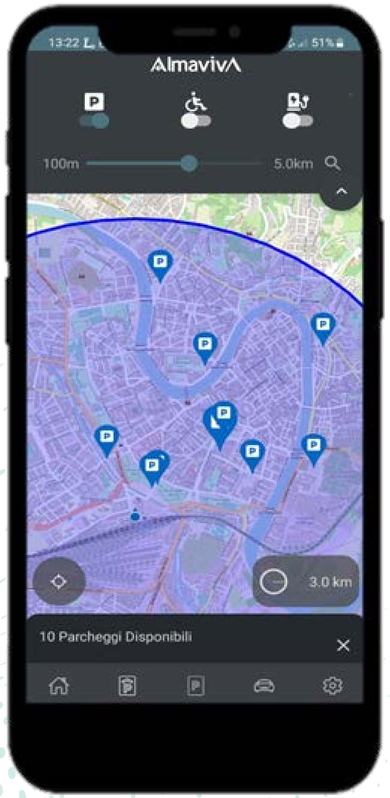
Field tests - Pilot in Verona

Off-street parking information

- test users had to choose a parking facility (from those proposed) where they would go to park their vehicle and then walk back to the meeting/destination point



Test users with the C-ITS app could know the filling status of parking lots and avoid driving to full ones

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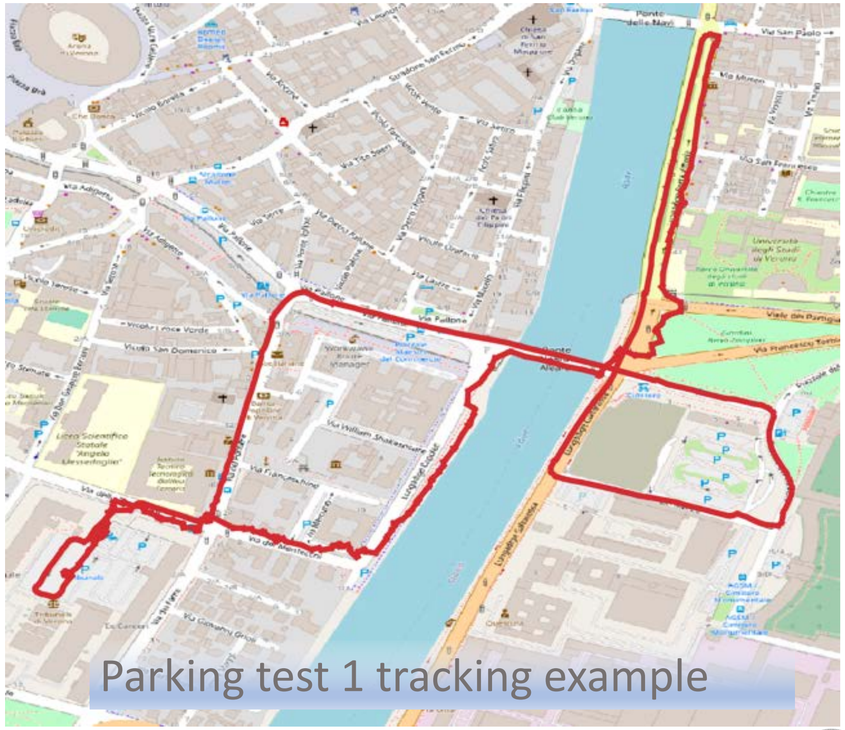
Field tests - Pilot in Verona

Data collected:

- start and finish time of routing/parking operations (for each test user)
- GPS track of the routes followed (M-Sense App)

Numerous data logs about data received from the DATEX node and processed by the C-ITS app (traffic events and parking fill states)



Parking test 1 tracking example

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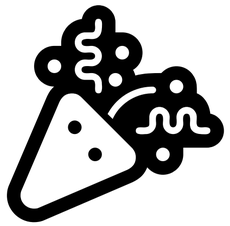
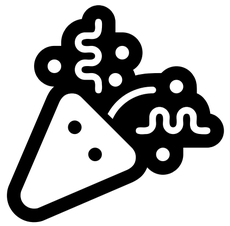
C-ITS Impacts: the WG3 results



- **Users DO react** to C-ITS. They change their behavior, rarely they are neutral
- Impact on **Road Safety is very relevant**: speed, acceleration, deceleration and lane change differ significantly
- Impact on **Traffic Efficiency**: when it is the main objective of the C-ITS message, **the change is relevant**. For road safety aim, TE effect can be negative or neutral
- Impact on **Environment**: not always the primary objective. **Good changes** especially for Intersections but effects should be further investigated
- **User Acceptance**: **very well accepted**, low willingness to pay
- **Socio-Economic impacts**: Overall, the socio-economic benefits are **evident and relevant** in most of the cases.

C-ITS Impacts: the WG3 results



- The wide-scale **impacts** of C-ITS are **imminent**: encouraging experiences – they should be improved with the next and wider implementations; especially at urban level - From Behavior's change to overall impacts
- Impact Assessment will be **more accurate** once the C-ITS will be increasingly up and running – larger database of effectiveness
- An **increased MPR** will allow to measure the impacts on traffic flows directly – new results can appear – more measurements than estimations

Thank you for your attention!

For more details:
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