ENVIRONMENTAL BENEFITS OF CONNECTED MOBILITY

FOR 5GAA - 5G AUTOMOTIVE ASSOCIATION E.V.

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APPROACH OF THE STUDY

5GAA Automotive Association

The overall goal of the study was to conduct an environmental study of C-V2X, to identify the emission reduction potential of V2X large-scale deployment including and beyond the first deployed services.

European Green Deal

The different elements of the study are:

- Literature research – looking for evidence of the emissions reduction potential of various use cases
- Interviews with stakeholders about potential future use cases with expected substantial benefits
- Identification of promising C-V2X use cases (in addition to use cases found in literature and interviews)
  - What do we see as emerging mobility concepts using C-V2X services? How can connectivity be used to address inefficiencies in the transport system?
- Impact analysis – emissions reduction potential of promising use cases (qualitative, quantitative)
- Possible implementations with current and future communication technologies

- Out of scope for this study are: electrification of the powertrain, vehicle downsizing/resizing, CO_2 emissions as a result of manufacturing (less) vehicles, operation of (digital/physical) infrastructure and the carbon footprint from 5G deployment

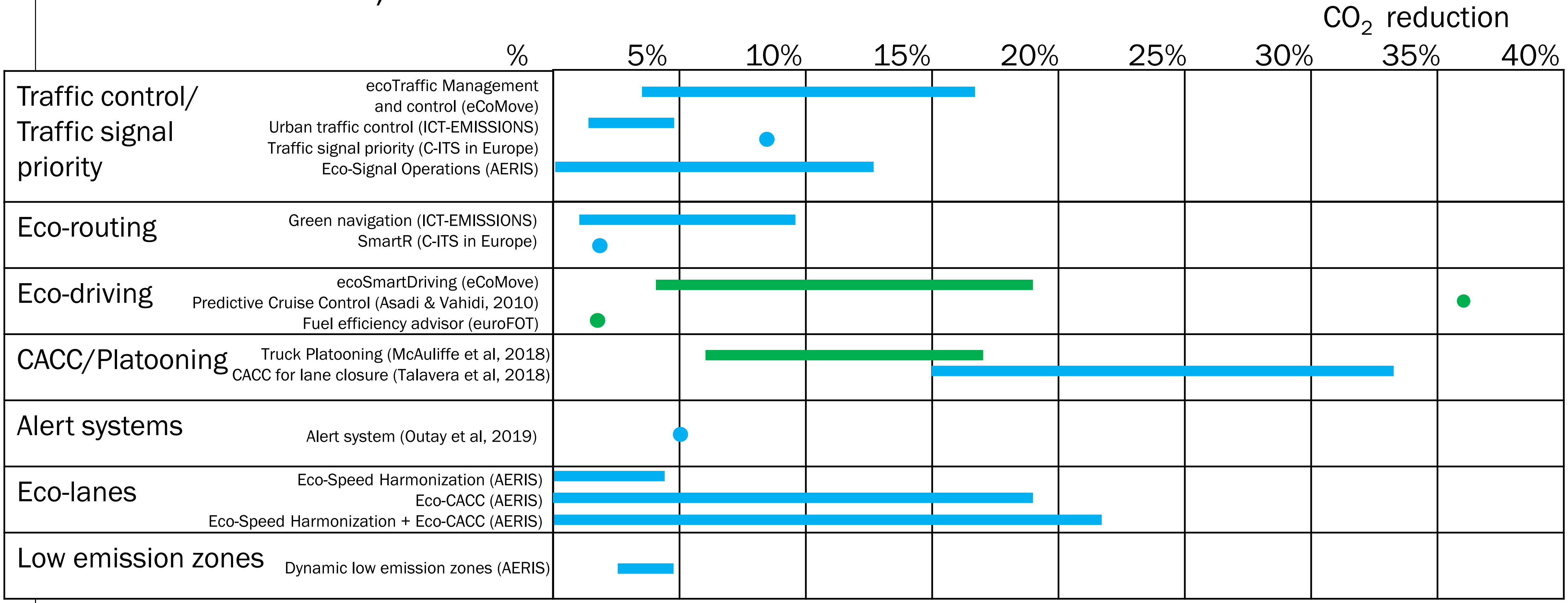
USE CASES AND IMPACT MECHANISMS (IN ALPHABETICAL ORDER)

Use cases \ *Impact mechanisms*	Reduction of trips	Reduction of kms driven and/or departure time shift	Modal shift	Reduction of vehicle dynamics	Powertrain operation
Automated Intersection crossing				X	
Bike-to-everything			X	X	
CACC				X	
Continuous Traffic Flow via Green Lights Coordination				X	
Continuous Traffic Flow via Green Lights Coordination (priority request for high emitters)				X	
Cooperative Lane Merge				X	
Cooperative Driving Maneuver				X	
Dynamic Geofencing	X		X		
Dynamic pricing	X	X			
Dynamic ride sharing		X			
Eco-trip planning		X		X	
En-route/ on-trip (eco-driving) advice				X	
"Everything connected to everything"		X	X	X	
Flexible road use (e.g. Dynamic Tidal Flow lanes)				X	
Group Start				X	
Location-based automatic switches hybrid to electric					X
On-street parking service		X			
Real-time optimal route advice		X		X	
Shared mobility route planning		X	X		
Shockwave damping				X	
Speed Harmonization				X	
Traffic Jam Warning and Route Information		X		X	
Vehicles Platoon in Steady State				X	

From literature, interviews + TNO additions

POTENTIAL FOR ENVIRONMENTAL BENEFITS

IMPACT SIZES, BASED ON LITERATURE REVIEW



Traffic
Individual vehicle

When no CO_2 reductions are available, it is assumed that these are equal to fuel reductions

RESULTS INDICATIVE EMISSION CALCULATIONS
(RESULTS ONLY FOR THESE SPECIFIC SITUATIONS)

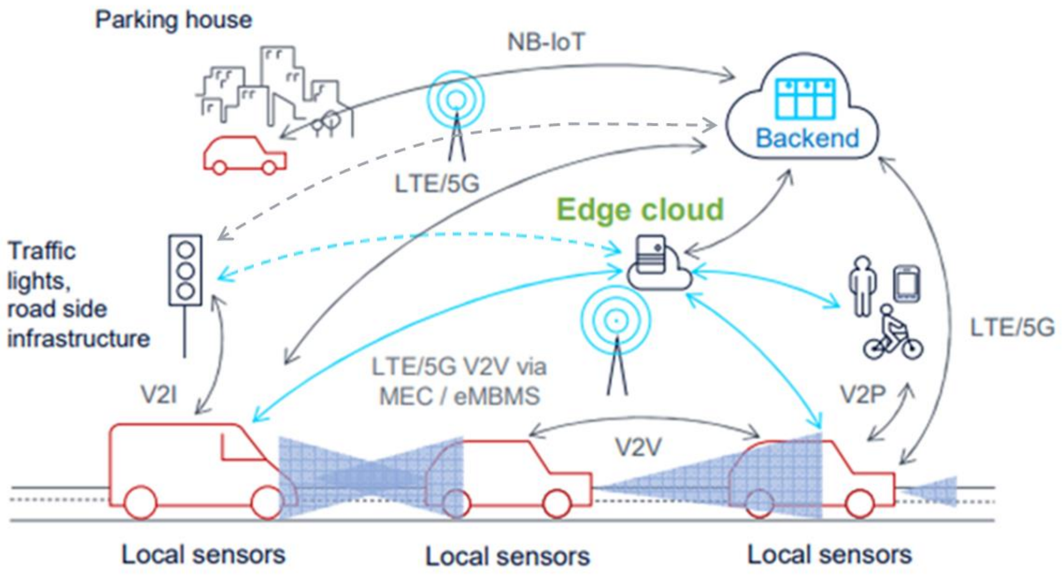
- **CACC compared to ACC on rural road**
  - CO_2 reduction 6% per km on average for seven 20 min trip pairs (due to smoother speed patterns)

- **Eco-driving on motorways**
  - CO_2 reduction 6% per km averaged over all traffic (cars, vans & trucks) during 1 hour and 20 min in situation with congestion (due to accident) compared to same situation without congestion (no accident)
  - CO_2 reductions of 4, 6, 7 and 3% per km for cars driving at varying speeds compared to cars driving at smoothened speeds, all with average speeds of 20, 40, 70 and 90 km/h respectively

- **Intelligent intersections**
  - CO_2 reduction 22% on average for trucks driving at about 80 km/h on a 2 km traject with intelligent intersection and comparing one to no stop
  - CO_2 reductions of 13, 21, 18 and 14% per km for passenger cars driving at constant speeds of 30, 50, 80 and 100 km/h respectively and comparing one stop to no stop (up to 45% for multiple stops per km, e.g. in dense urban network)

C-V2X IMPLEMENTATIONS

- Existing communication technologies can already meet the requirements of many of the identified promising use cases, in terms of bandwidth and latency;
- More advanced features, featured on several technological roadmaps, could address requirements in terms of Quality-of-Service guarantees and massive equipment deployment;
- For the V2V, V2I and V2N use cases, and combinations of them, several possibilities using short and/or long range communication exist;
- Some features are only planned at the moment; whether all possible functionality will become available is not just a technical question, but among others also a business case question.
- The same applies for the deployment possibilities: whether all possibilities will become available depends on many factors.



GENERAL CONCLUSIONS

- Real-world pilots, simulation studies and driving simulator studies have shown the potential to reduce emissions
- Effect sizes found were in the order of 5-20%
  - As found in literature, and in our indicative emissions calculations using real-world and simulated data
  - Services helping to avoid stops and reduce driving dynamics of individual vehicles
  - Services helping to optimise traffic flows
- A high reduction potential was identified for an “everything is connected to everything” scenario
  - Where services help optimise each part of a trip – from eco-driving advice in low-density traffic to merging assistance in high-density traffic.
- Many services were originally designed for other purposes, e.g. safety or throughput. Emission reduction potential of these services can be optimised further by tuning algorithms/parameters for emission/energy use reduction.
- Additionally, there is much potential in MaaS-like services (e.g. shift to more sustainable modes, shared mobility services)
- Note that results presented are only for specific situations and penetration rates. There may be rebound effects (more/longer trips). Effect sizes may be smaller for future vehicle fleets. We did not consider aspects such as vehicle resizing/downsizing, CO_2 emissions from manufacturing of vehicles, and carbon footprint from 5G deployment.
- Successful implementation depends not only on technology, but also on the business cases that are possible

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THANK YOU FOR YOUR TIME AND INTEREST

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