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Impact on fuel consumption and emissions

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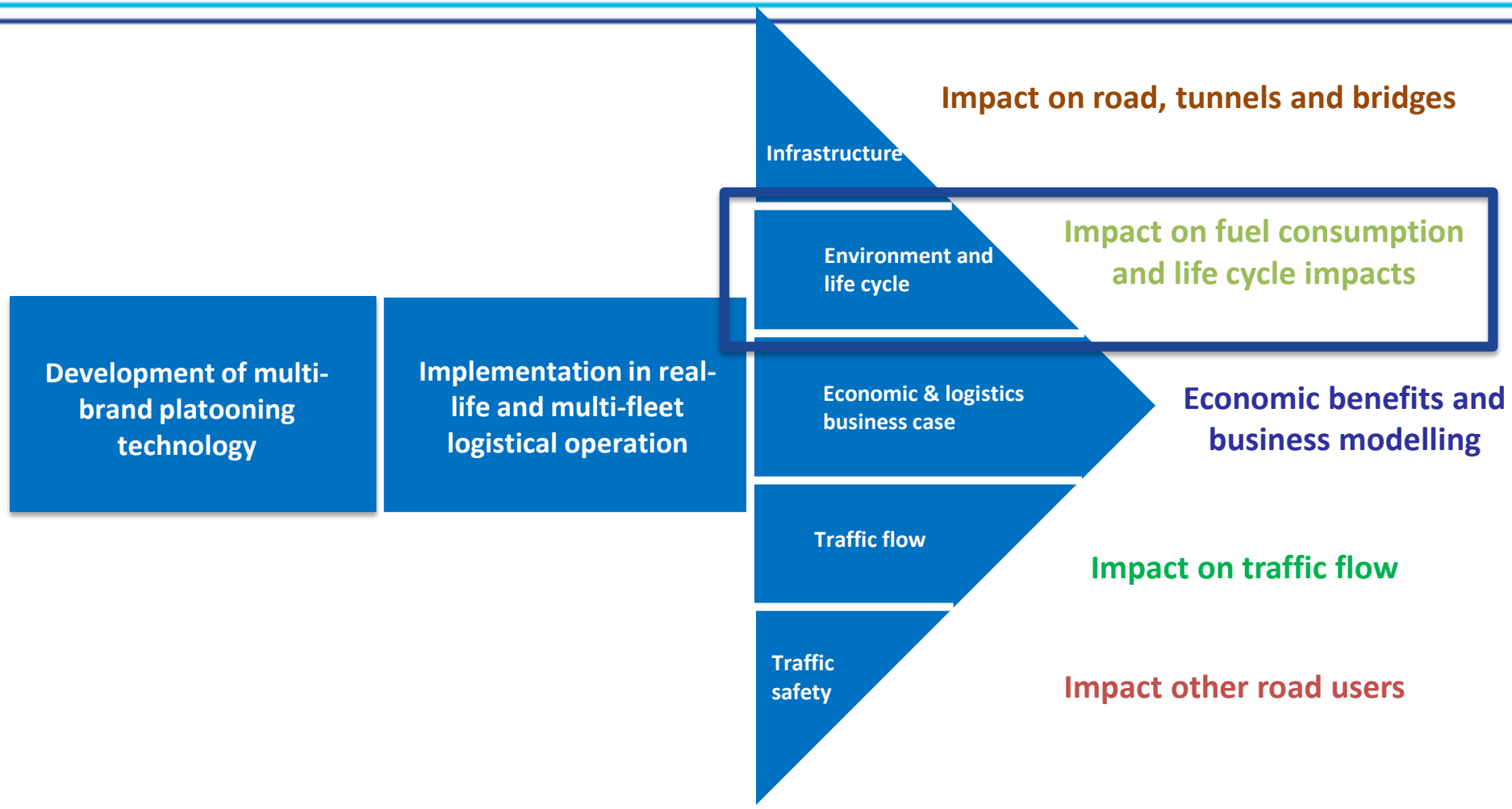
Focus on Fuel Consumption

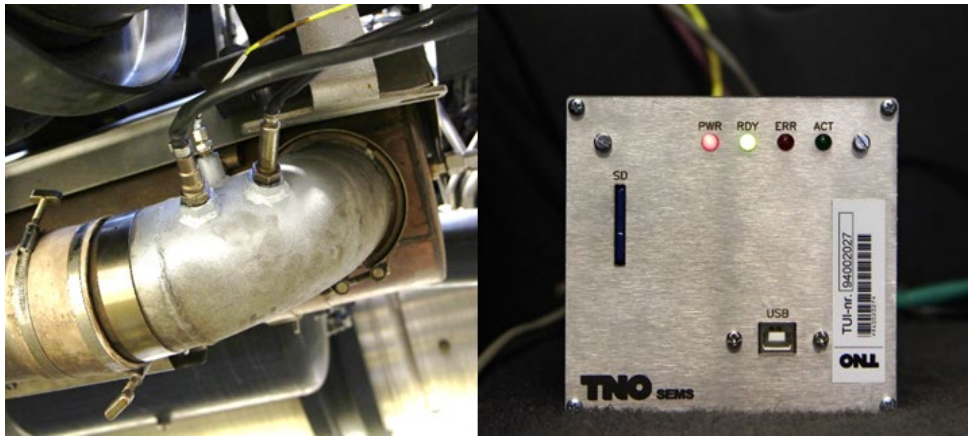


Overview

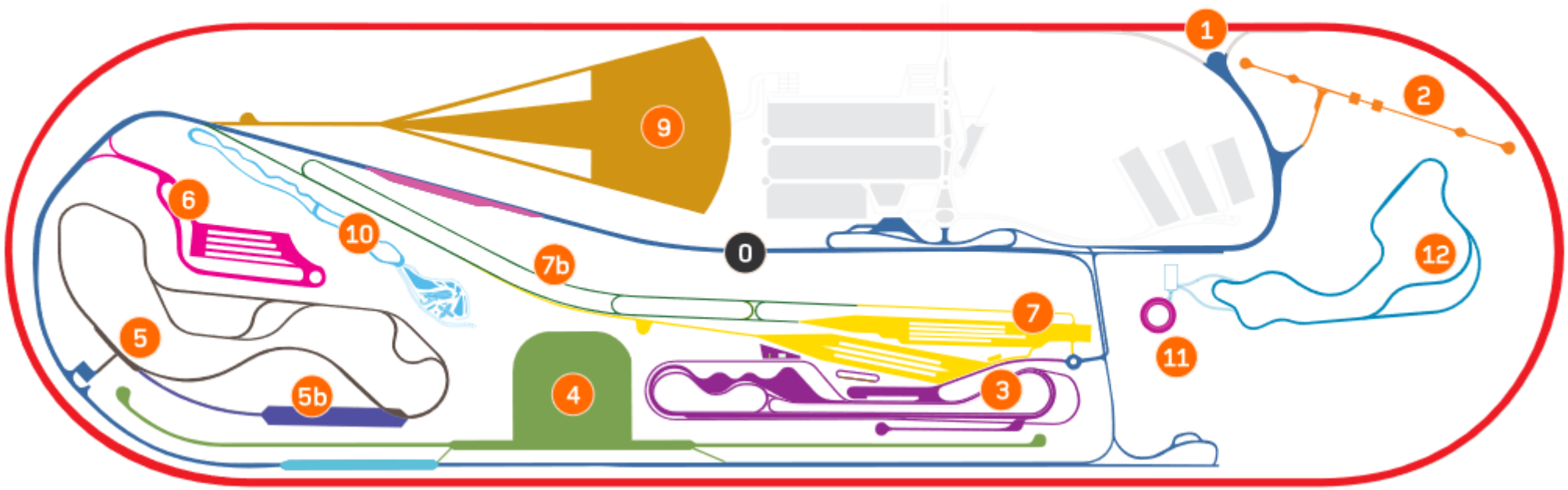
- Objective: identify and understand dependencies of fuel consumption and pollutant emissions on multi brand platooning.

- We measure and compare the emissions and fuel consumption under two conditions: solo driving and platooning.

- Two tests:
  - Test circuit: controlled conditions.
  - Open road: real world case.



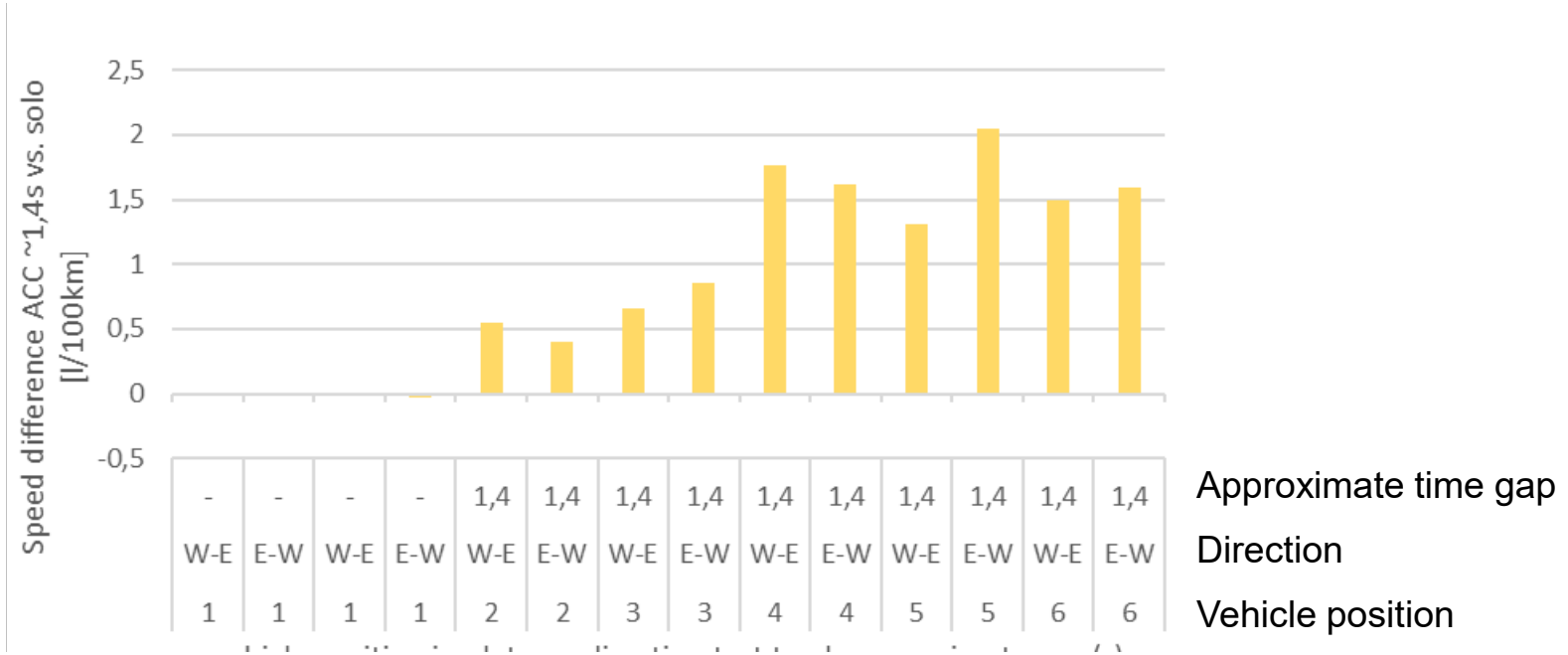
Test track@IDIADA



Lap: 7.5 km
North straight slope is -0.3% & South straight slope is +0.3%

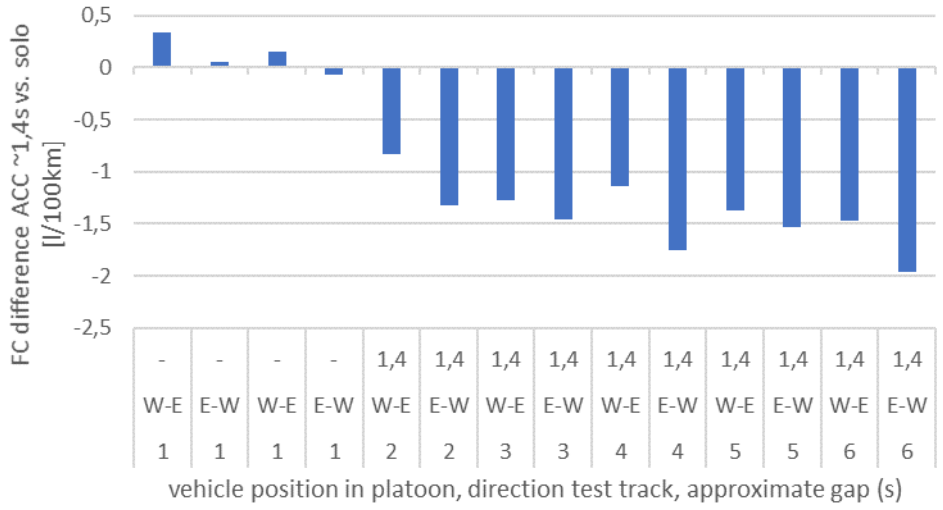
Test track: speed match

- Time gap: 1.4 s
- Speed difference between the conditions similar. Solo case was about 1.5 km/h higher than platooning.

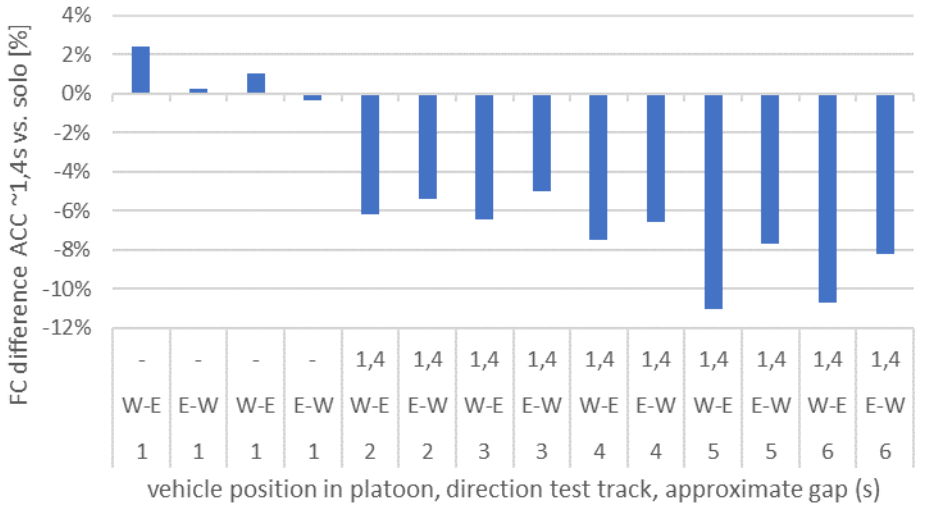


Test track: fuel consumption

- No significant effect for leading vehicle
- For following vehicle(s) 1.4 L/100 km (7%) reduction compared to solo driving
- This result is in line with the previous literature of fuel savings for ACC



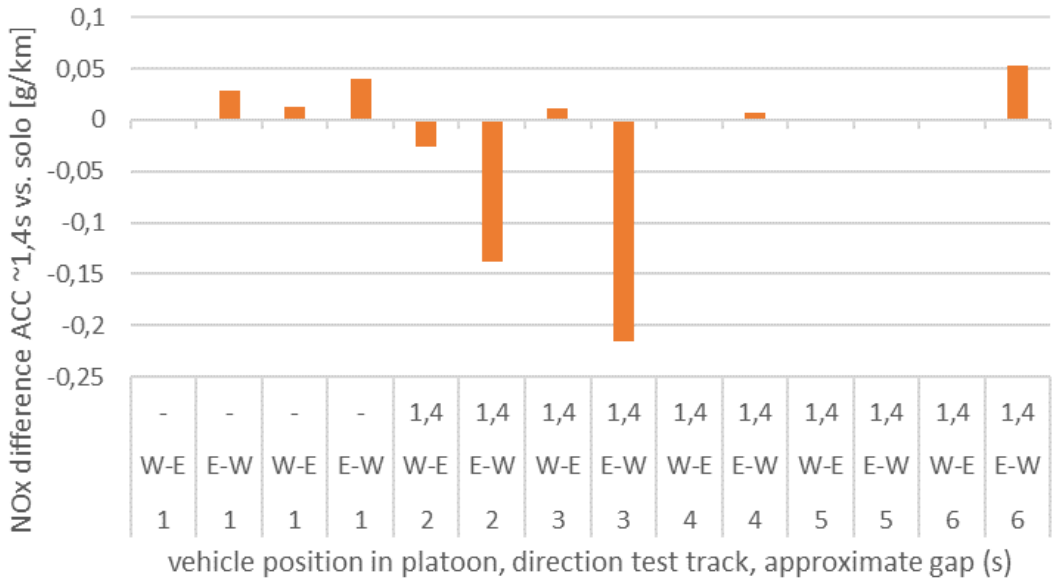
Absolute difference



Relative difference

Test track: NOx emissions

- No clear trend in the NOx variation between scenarios
- Solo vs platooning case varies depending on the OEM and condition
- Percentual differences are negligible



Test track conclusions

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- No significant effect on FC (and CO_2) for leading vehicle
- Following vehicles FC (CO_2) about -1,4 l/100km at ~1,4s gap (~-7%) compared to solo (large gap ~1km)
- Small variations due to nature of the operation of the SCR system but overall, no significant effect for tail pipe NO_x emission

Open road test

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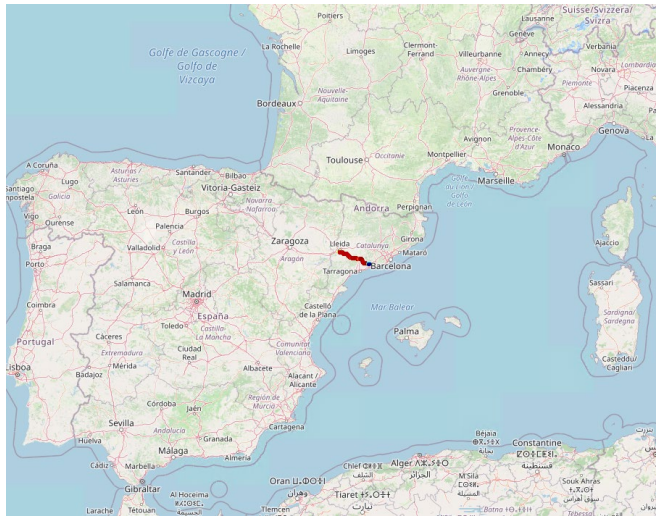
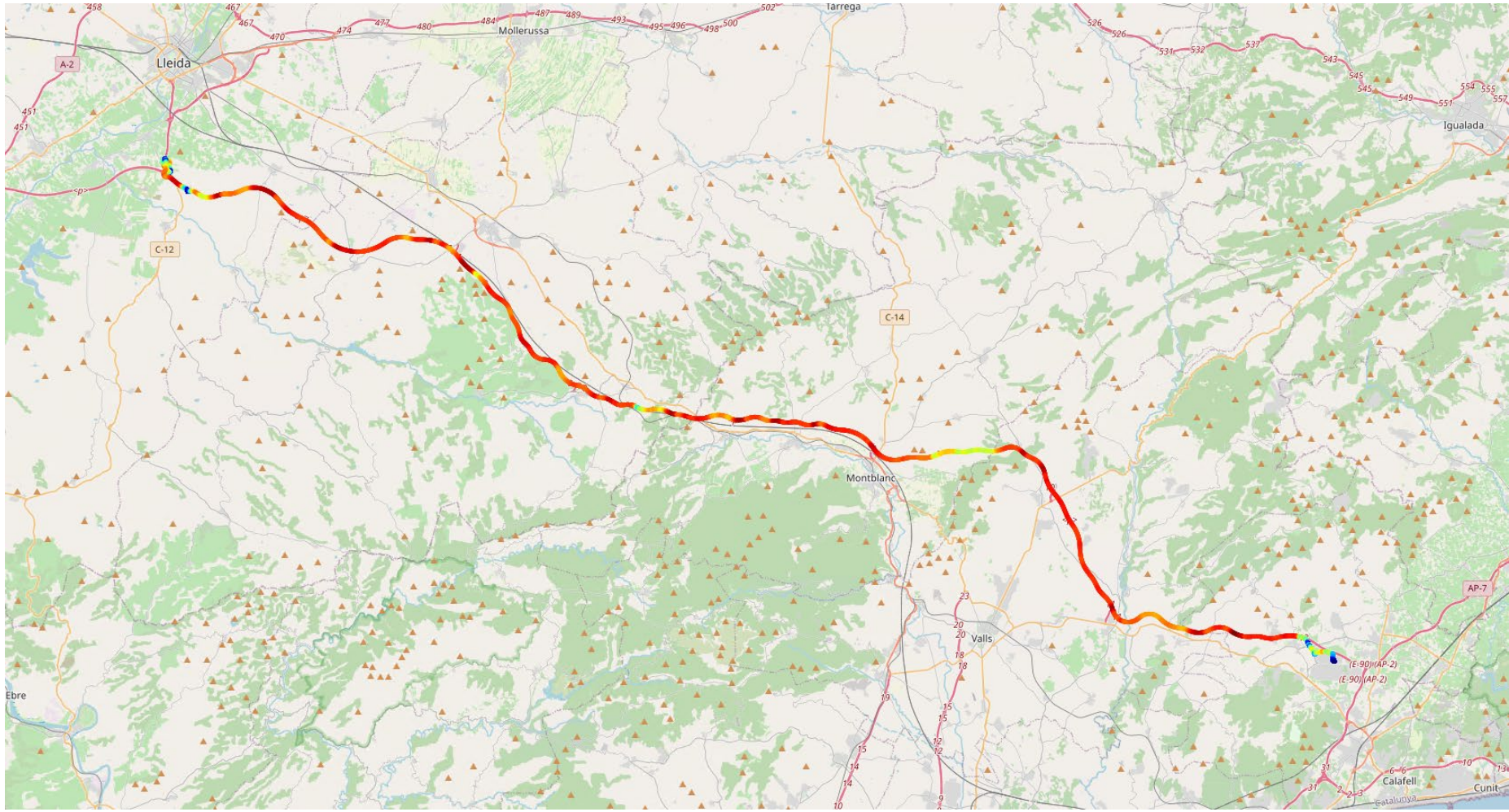
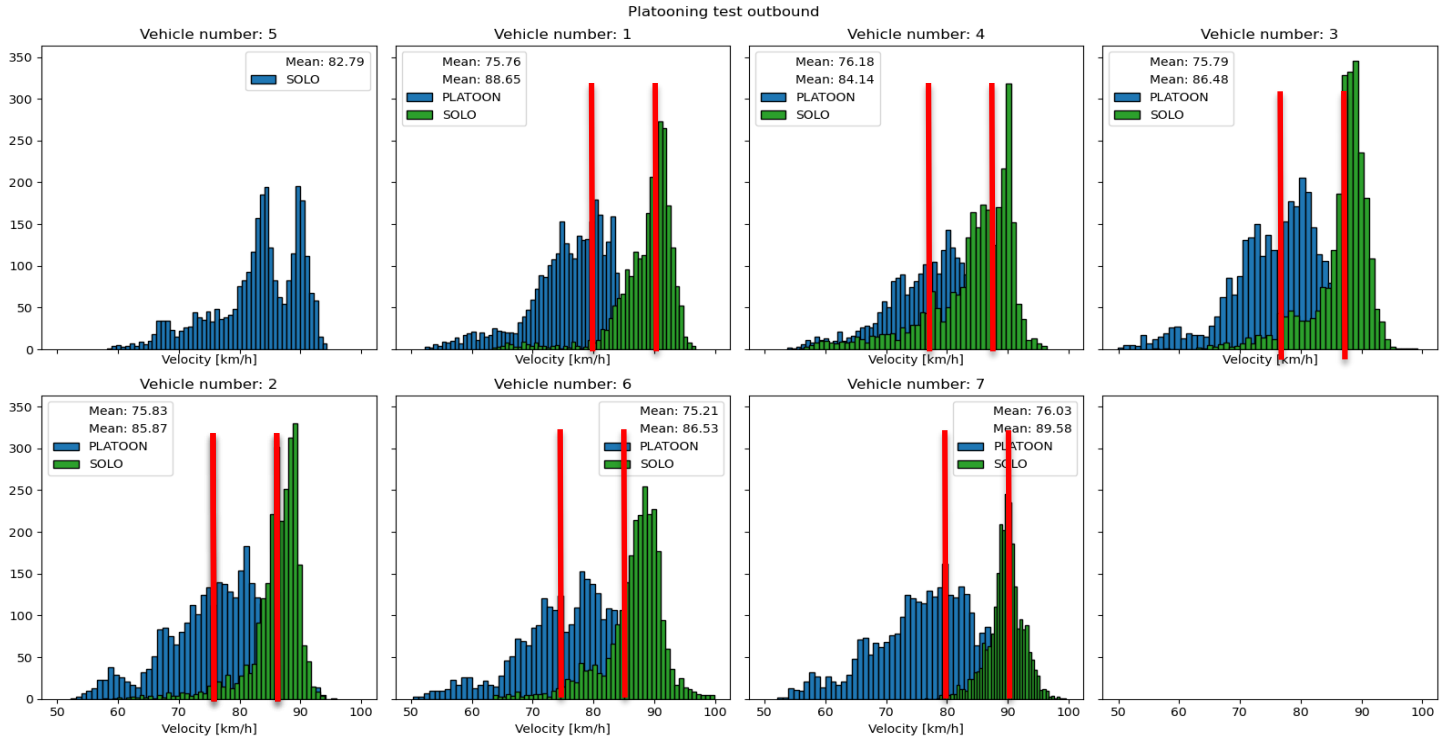




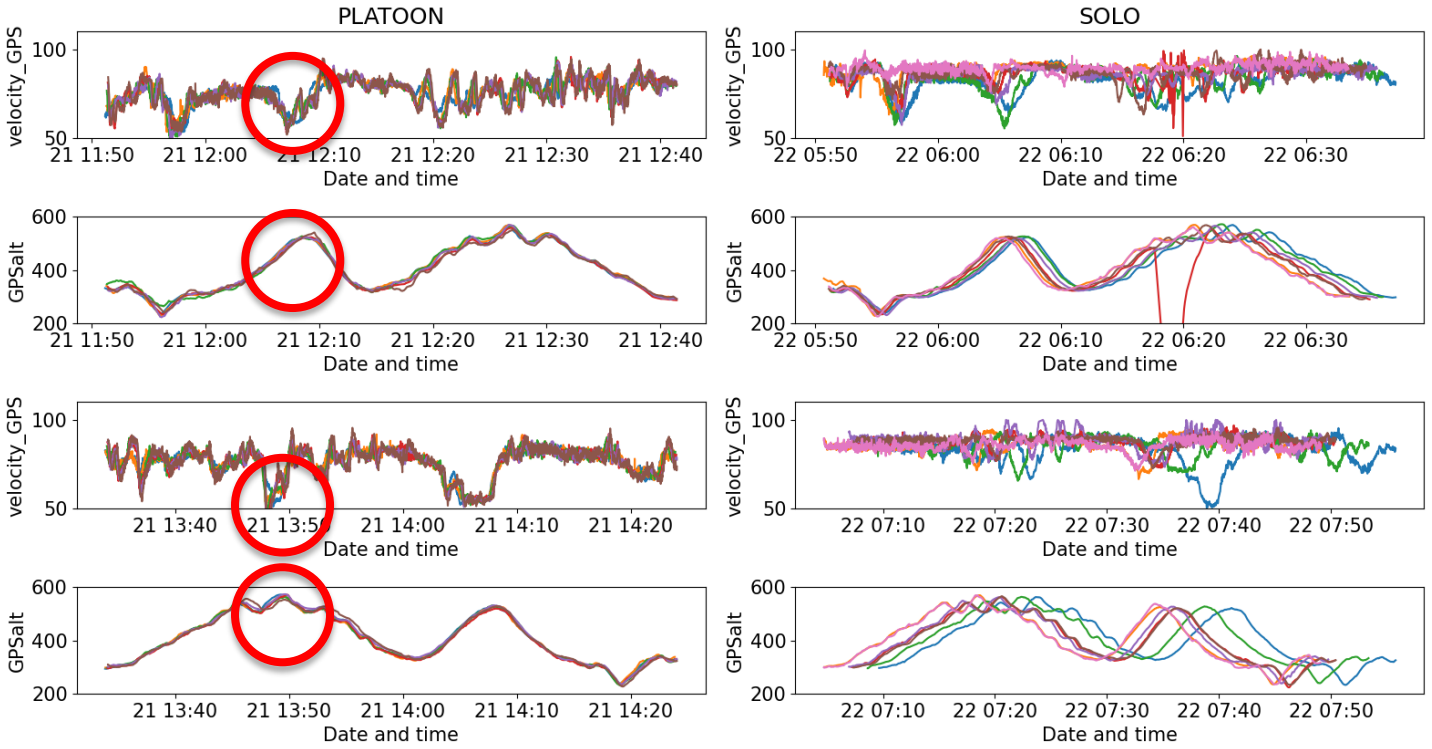
Open road: speed variance

- In the platooning case there is higher speed variance compared to solo driving
- The average speed between solo and platooning differs in about 10 km/h



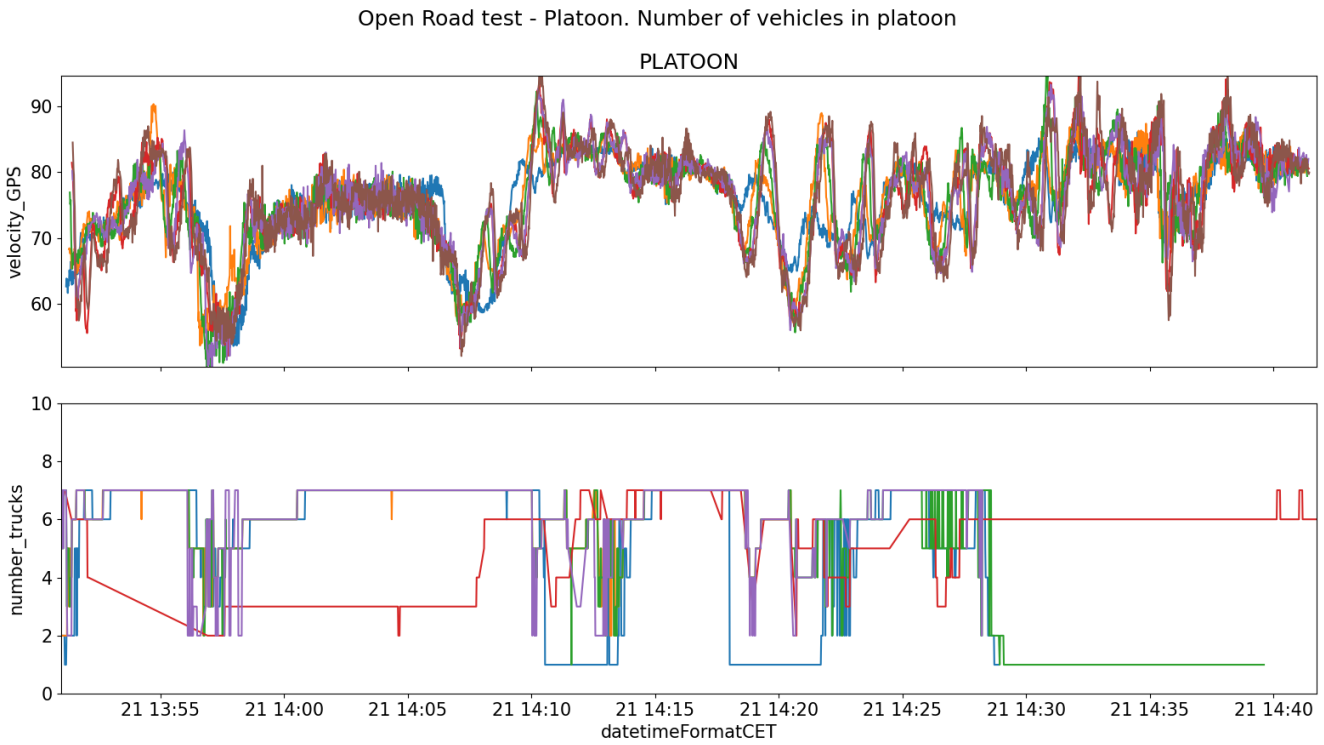
Open road: dynamics and speed variance

- Higher speed fluctuations in the speed while platooning are associated with changes in speed slope



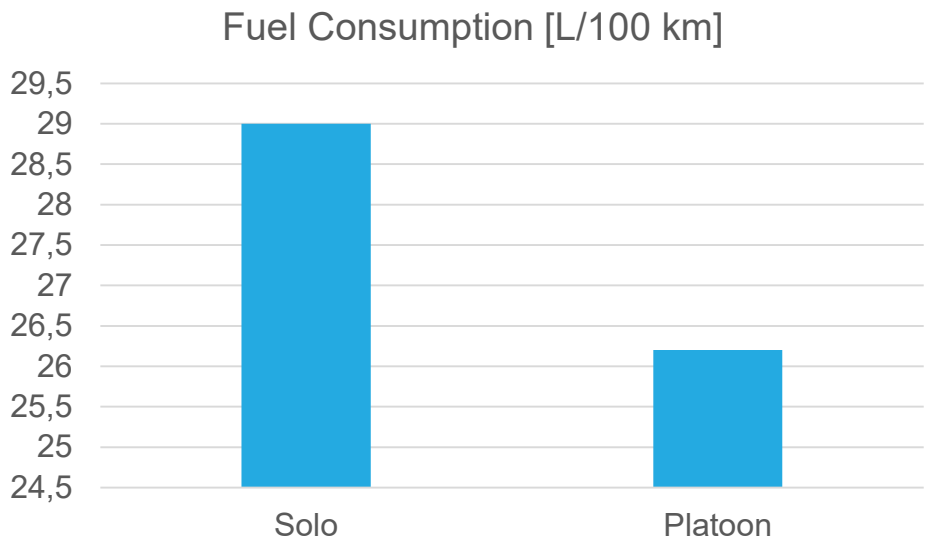
Open road: platoon stability

– The platoon reaches stability when the speed is uniform, but it becomes unstable when the speed between the vehicles vary (which matched those cases in which the slope of the road changes).



Open road: fuel consumption

– The test show a lower fuel consumption and CO2 emissions for vehicles in platoon. But this cannot be attributed to platooning because the speed varies significantly between the two conditions.



Open road test conclusions

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- Platooning scenario (vs solo scenario case)
  - Speed instability
    - Higher variance in speed
    - Lower average speed
  - Lower fuel consumption*
- The variation in speed makes it impossible to attribute the reduction in fuel consumption to the platoon.
- Potential reasons of the speed difference and variation
  - Difference in the power-to-mass ratio between vehicles
  - Grade of the road plays an important role
  - Toll stations

Circuit tests provide an upper bound

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- **Platooning opportunity (<100% of the time)**: roads and speeds where platooning isn't possible, roads with grades (power/mass matching), speed matching, proximity of other vehicles (van Ark, 2021)
- **Base case in not solo driving**: gap distribution with significant share of convoys (Dicke-Ogenia, 2020)
- **ACC is current state of technology** and should be the baseline

Overall conclusions

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- Speed stability of multi brand platoon in open road is challenging.
- Platooning Support Function: gap ~ 1.4 s
  - Negligible reduction of FC and emissions compared to ACC
- No significant effect in NOx emissions
- Platooning Autonomous Function: gap < 1 s
  - Potential for additional FC reduction

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Thank you for your attention

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