



Virtual Testing Validation for ADS

Internal research activities status update

UNECE VMAD SG2, March 31st 2021

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Agenda

- JRC experimental campaign
- VeHIL replication
- Early conclusions

JRC experimental campaign

JRC experimental campaign

- Robotized Smart BME
 - Mobileye camera
 - Side-mounted LIDARs
 - Rear-facing RADAR



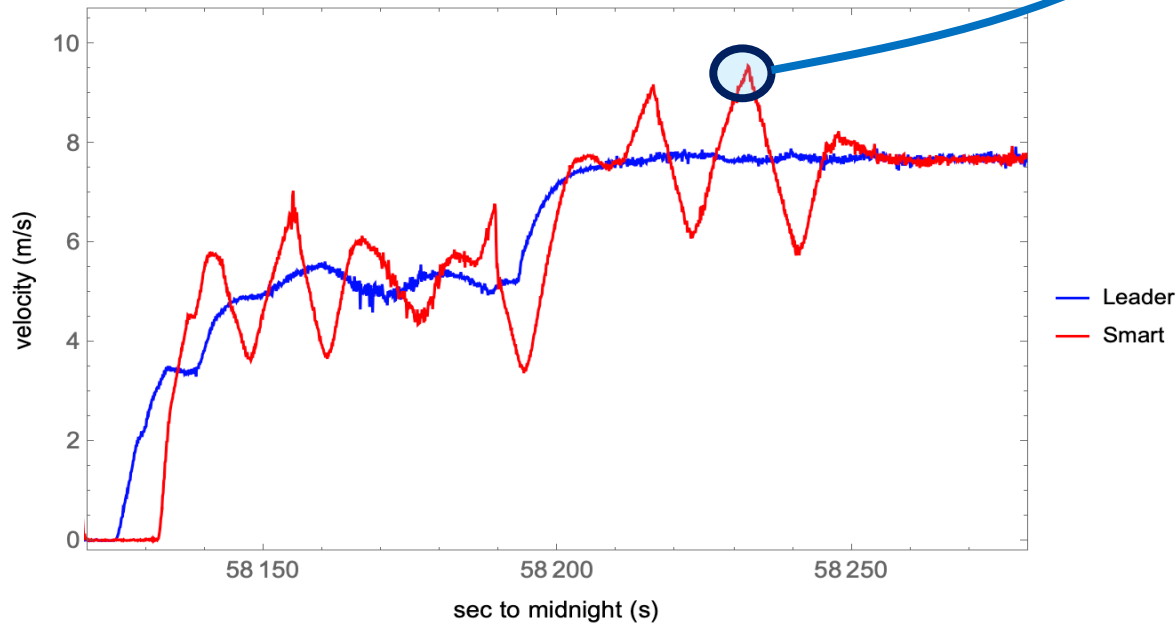
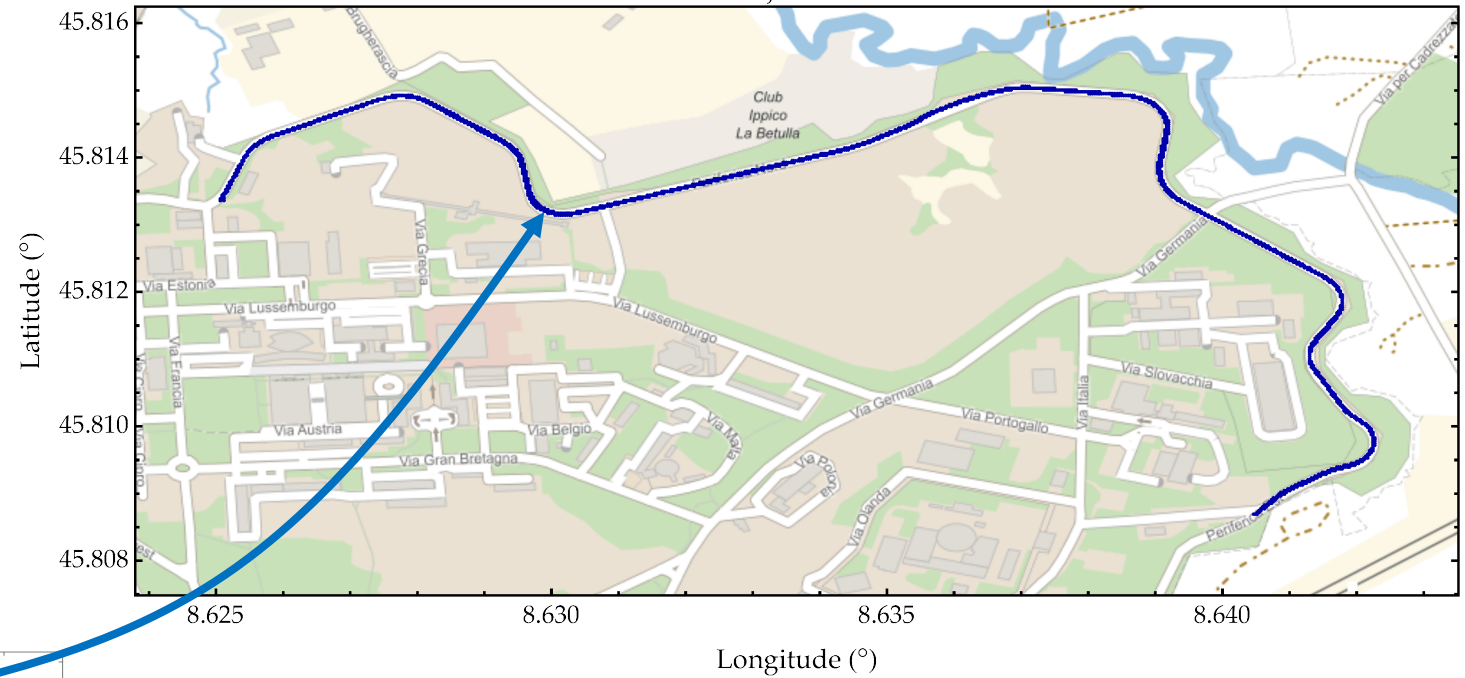
JRC experimental campaign

- Perform standard driving scenario involving longitudinal dynamics
 - Free-flows: 5 events
 - Car-follows: 32 events
 - Stop & Go: 4 events
 - Cut Ins: 8 events
 - Cut Outs: 8 events

Distance	~ 70 km
Duration	~ 6.5 h

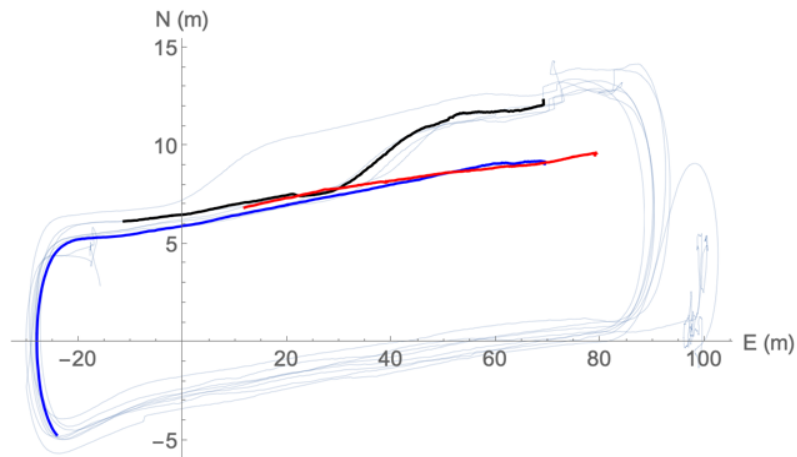
Car-follows

Trajectories

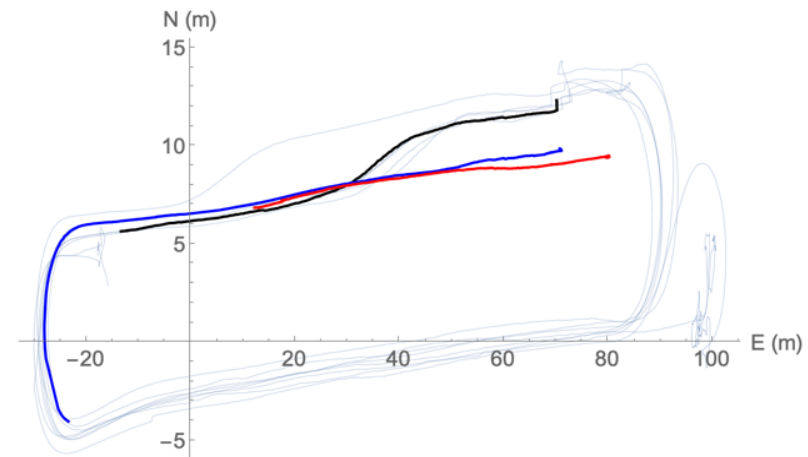


- Jumps in velocity due to camera losing the tracking of the leader (narrow FOV)
- Bad feature for an ADS, interesting *pattern* for validation

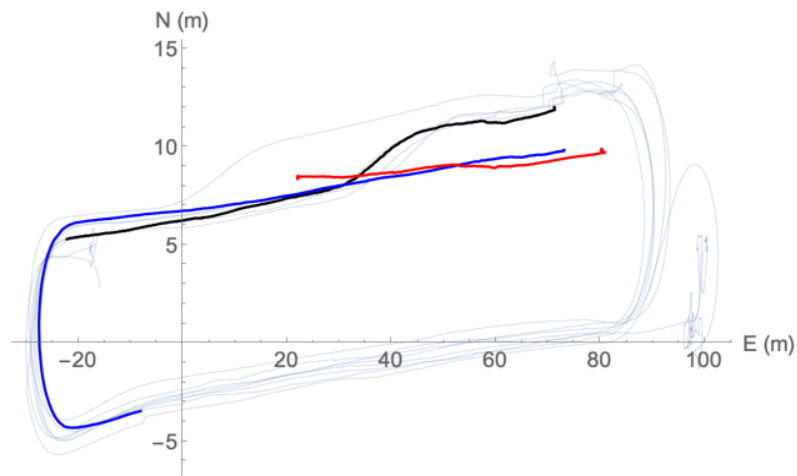
Cut-ins



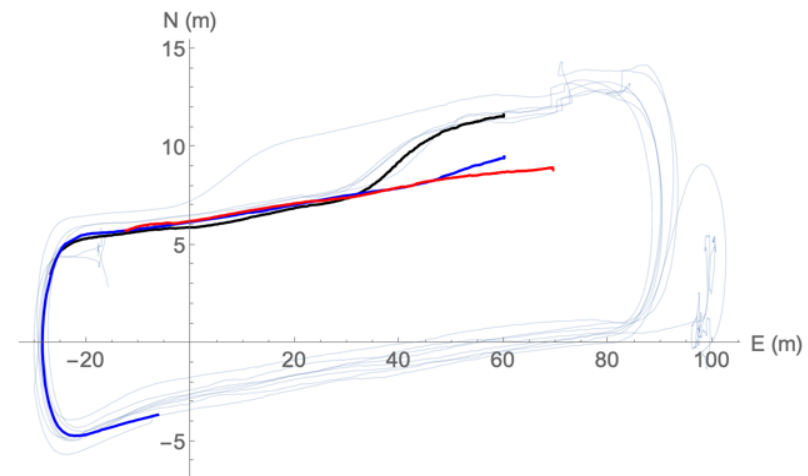
— Ford
— Passat
— Smart



— Ford
— Passat
— Smart

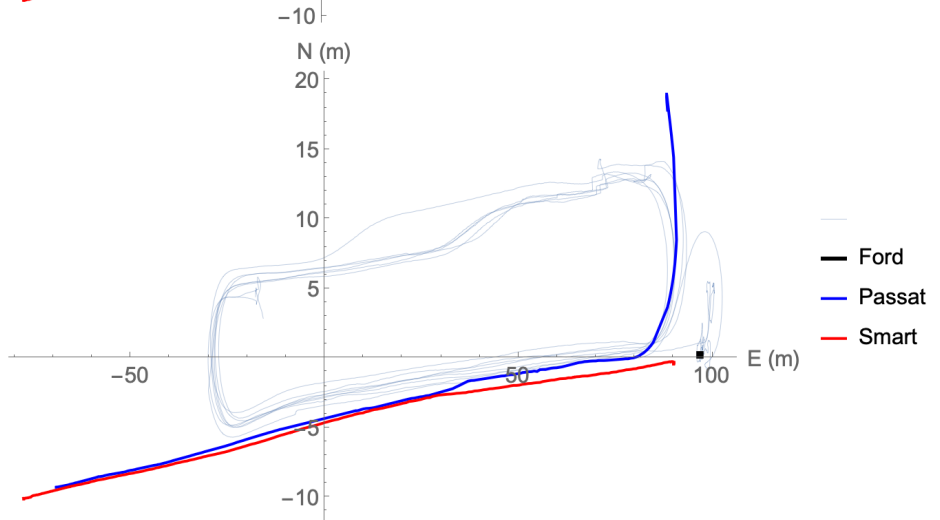
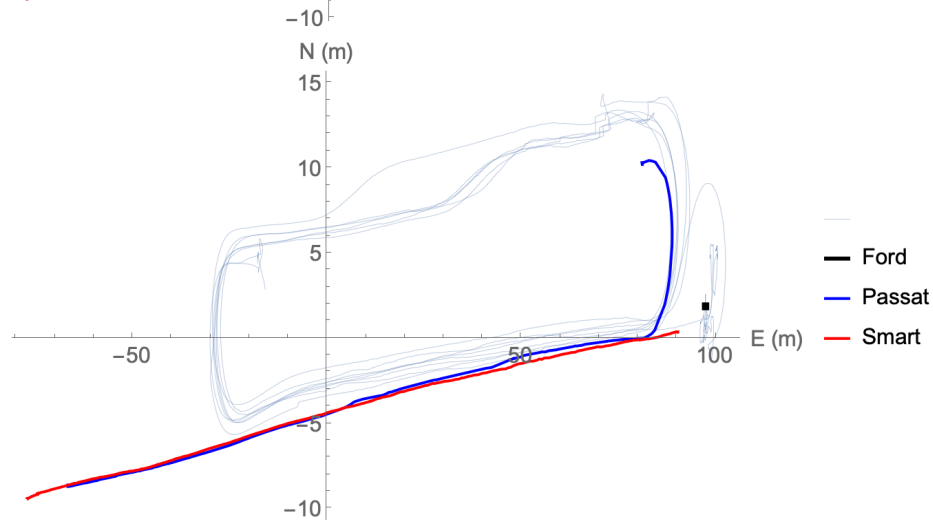
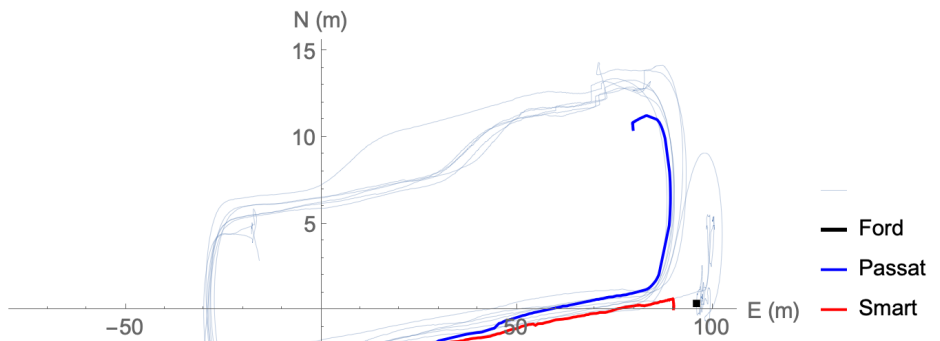
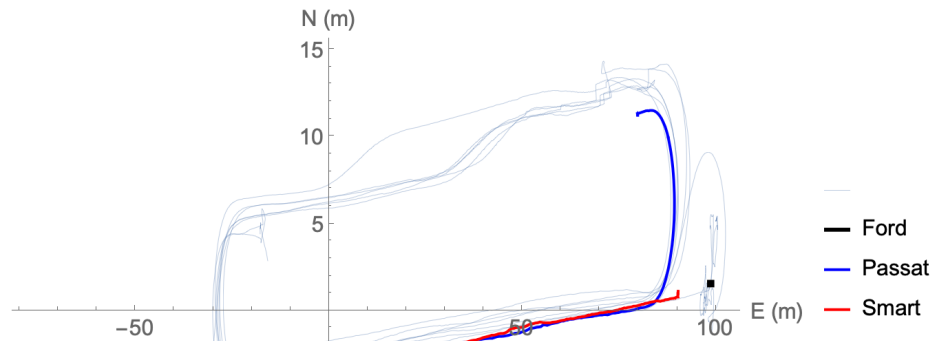


— Ford
— Passat
— Smart



— Ford
— Passat
— Smart

Cut-outs



VeHIL replication

DrivingCube by AVL®



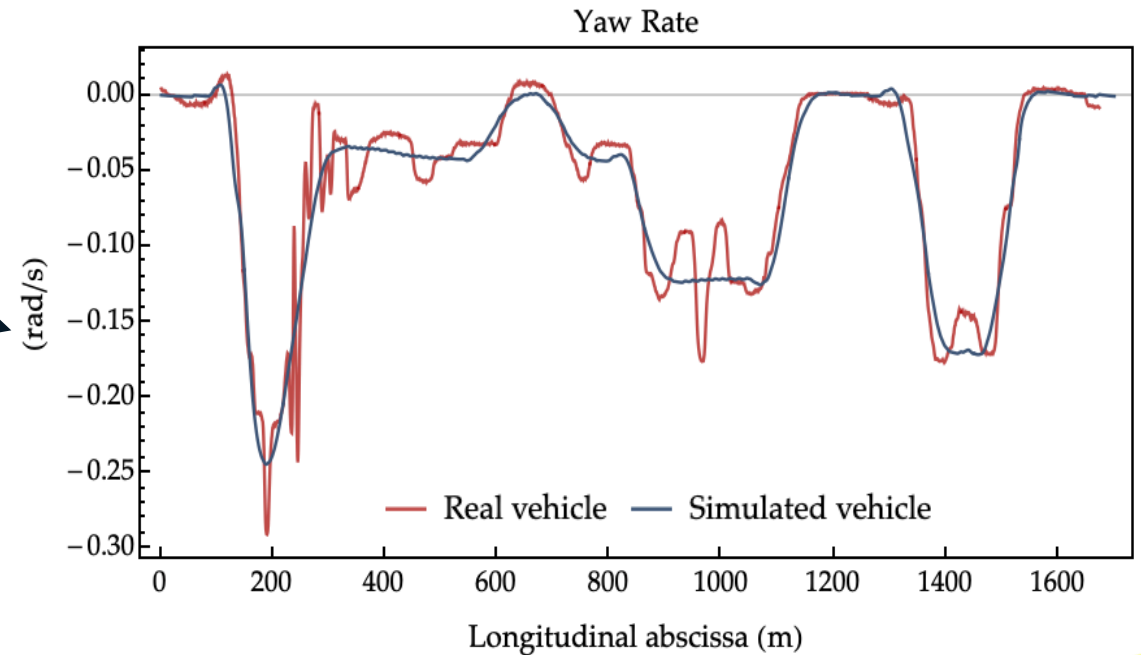
VeHIL replication

- ADS' longitudinal dynamics in closed-loop
- ADS' lateral dynamics in open-loop (scenario re-execution)
- Targets' trajectories from re-execution rather than the nominal ones
- Carried out multiple repetitions of the same scenario to establish a confidence level

Early results

Computational tools

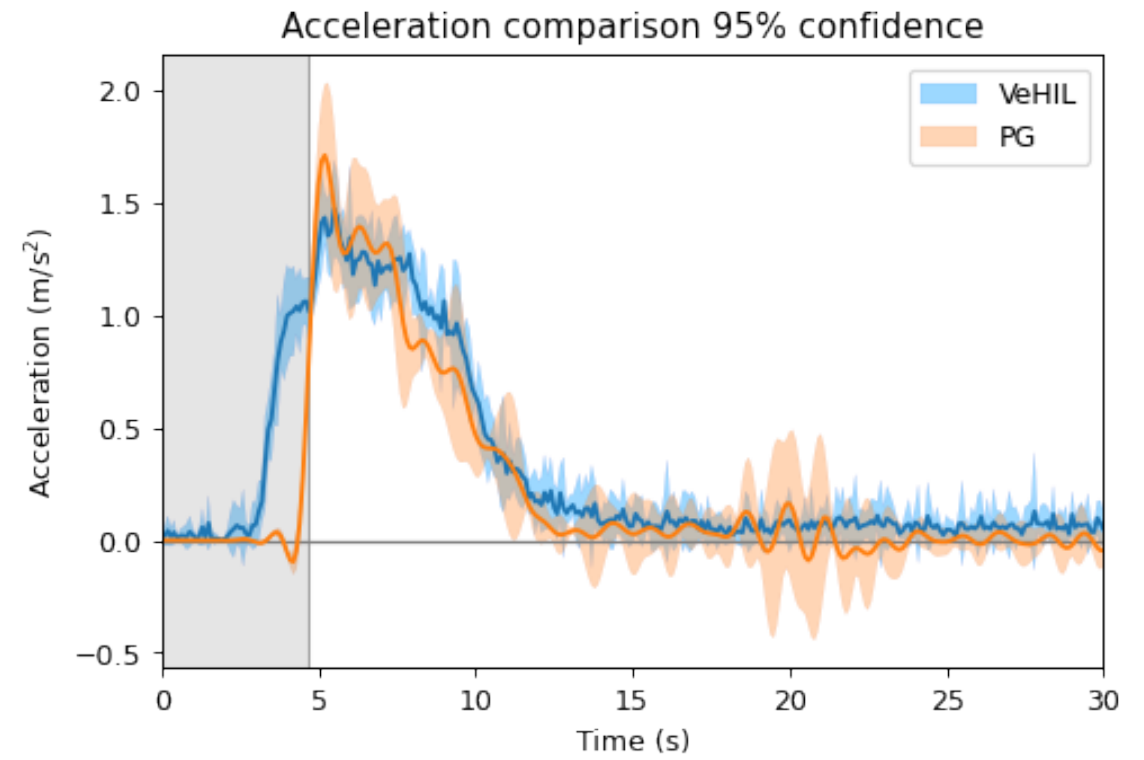
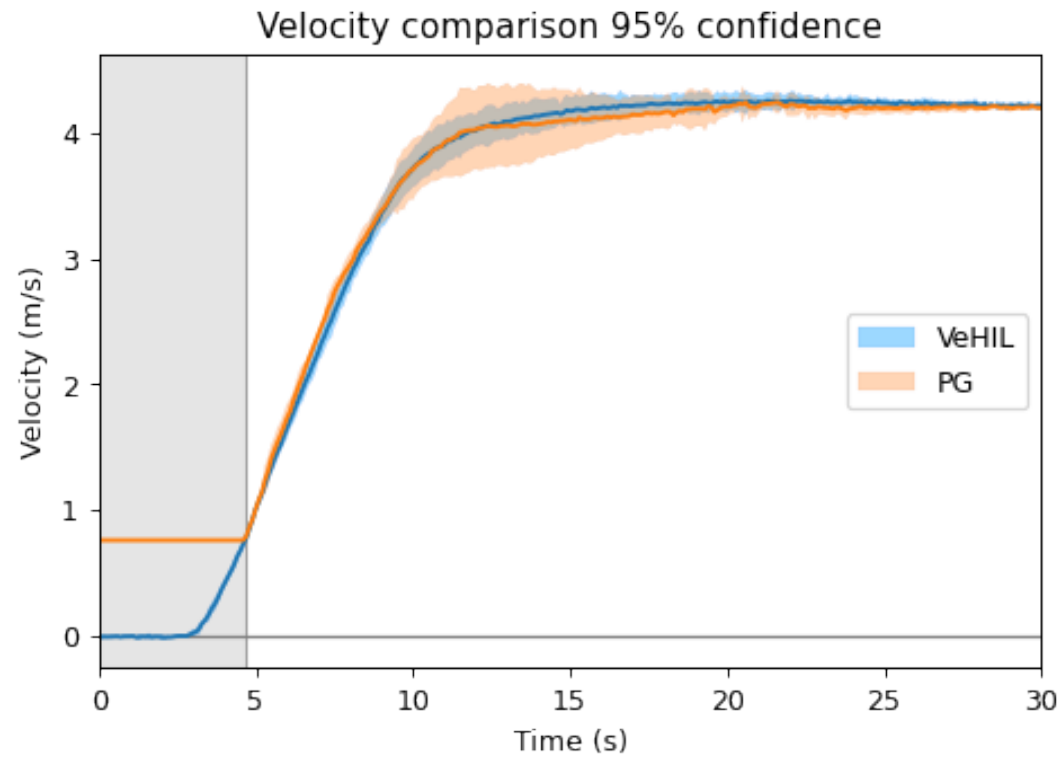
- Graphical comparison
 - Intuitive but subjective
- Scalar data
 - Quantitative but limited information
- Time series (upon synchronization) computations
 - Mean, median, σ , (N)RMSE, MAE
 - Correlation, R^2



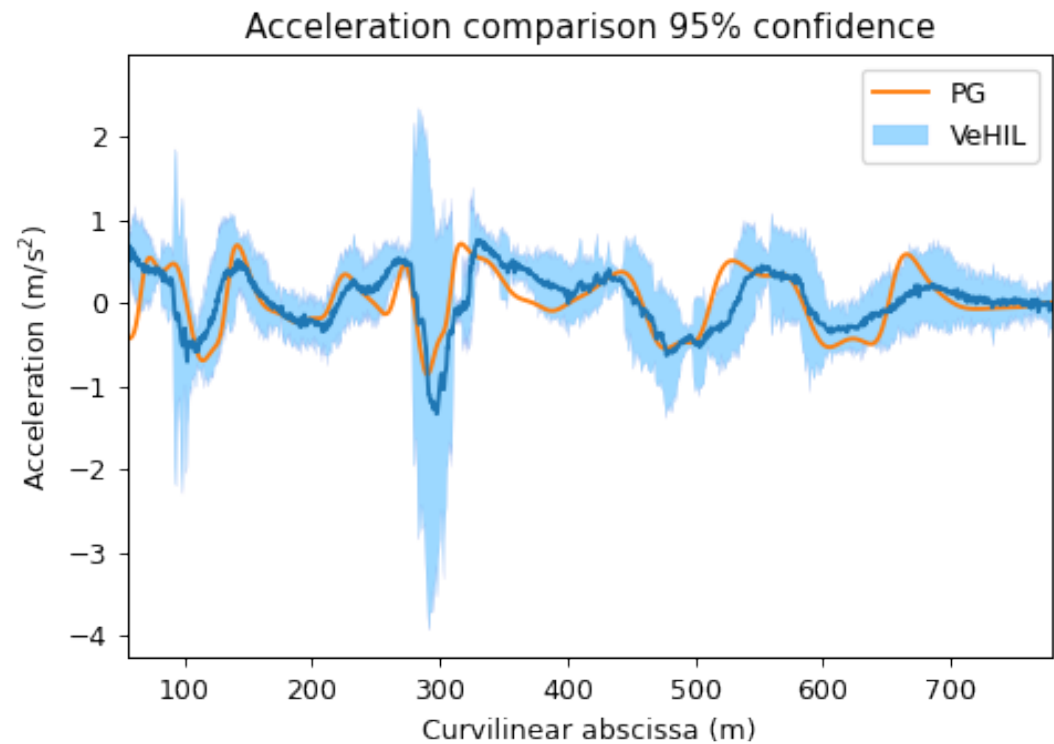
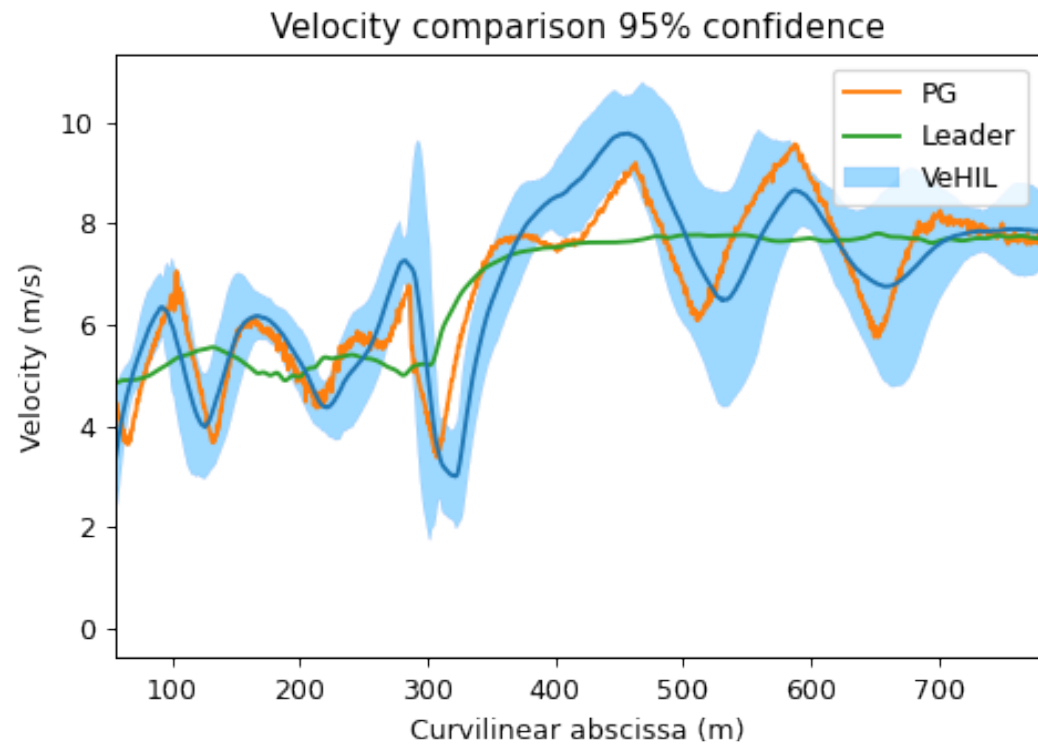
Free-flow

RMSE Velocity ~ 0.040 m/s

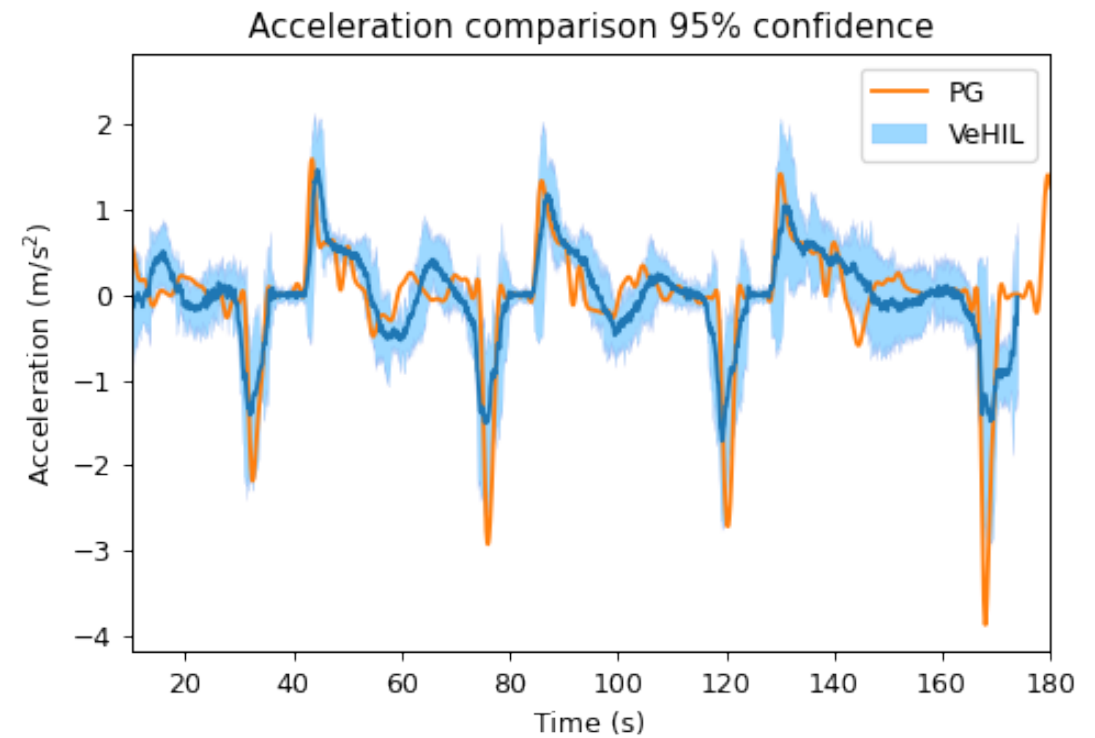
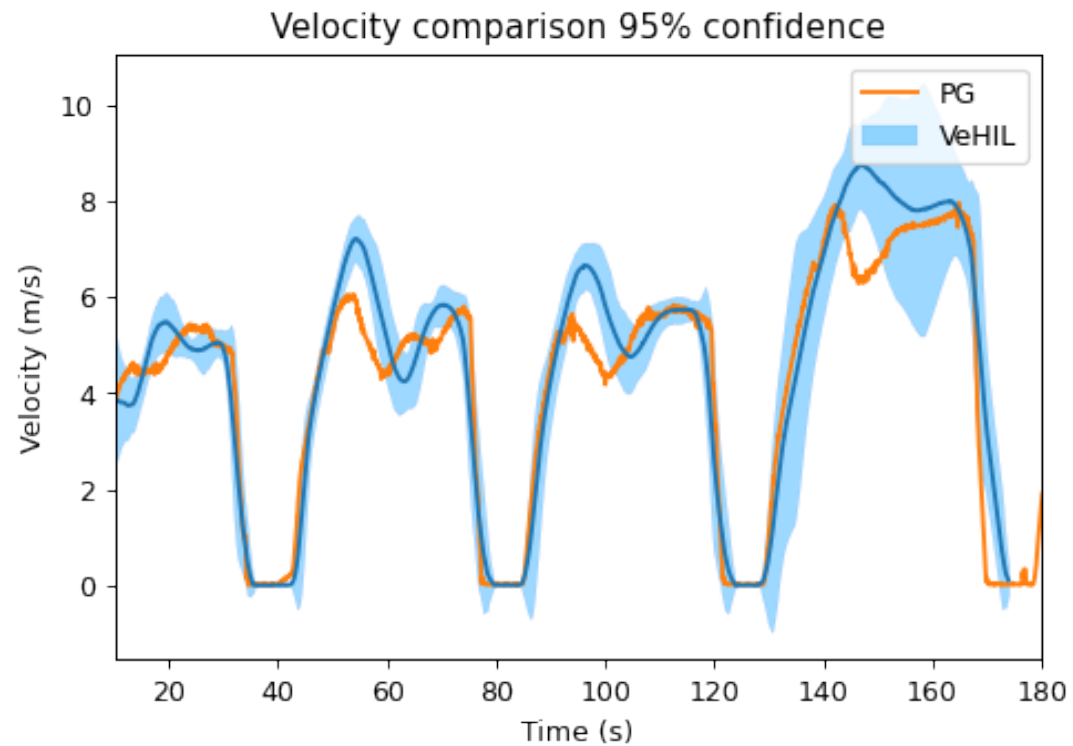
RMSE Acceleration ~ 0.088 m/s²



Car-follow



Stop-and-go



Conclusions

- Difficulties:
 - VeHIL requires some **craftmanship** to be carried out correctly especially using trajectory reconstruction;
 - Reproduction of **hard braking** on the **dyno chassis** typical resulted in locking the wheels (probably the tires were getting too hot);
 - Instantiation of the **initial conditions** of the simulation. Given the unstable ADS minor mismatches propagated throughout the duration of the virtual experiments;
 - Loss of **synchronization** in long virtual tests with respect to the real world due to minor **velocity discrepancies** accumulating.

Thank you

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