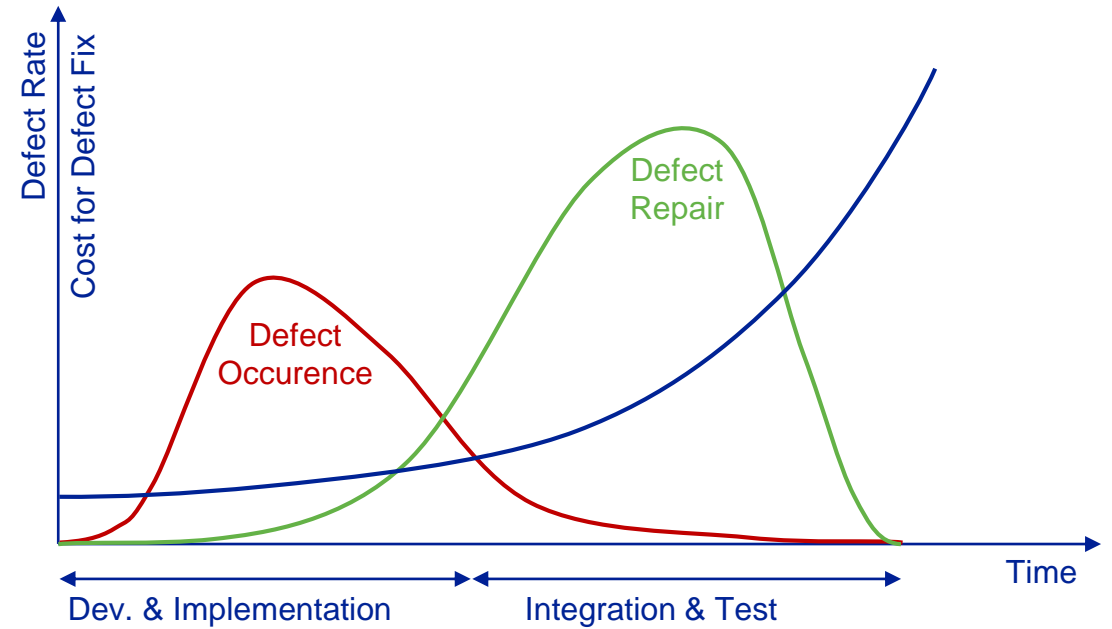
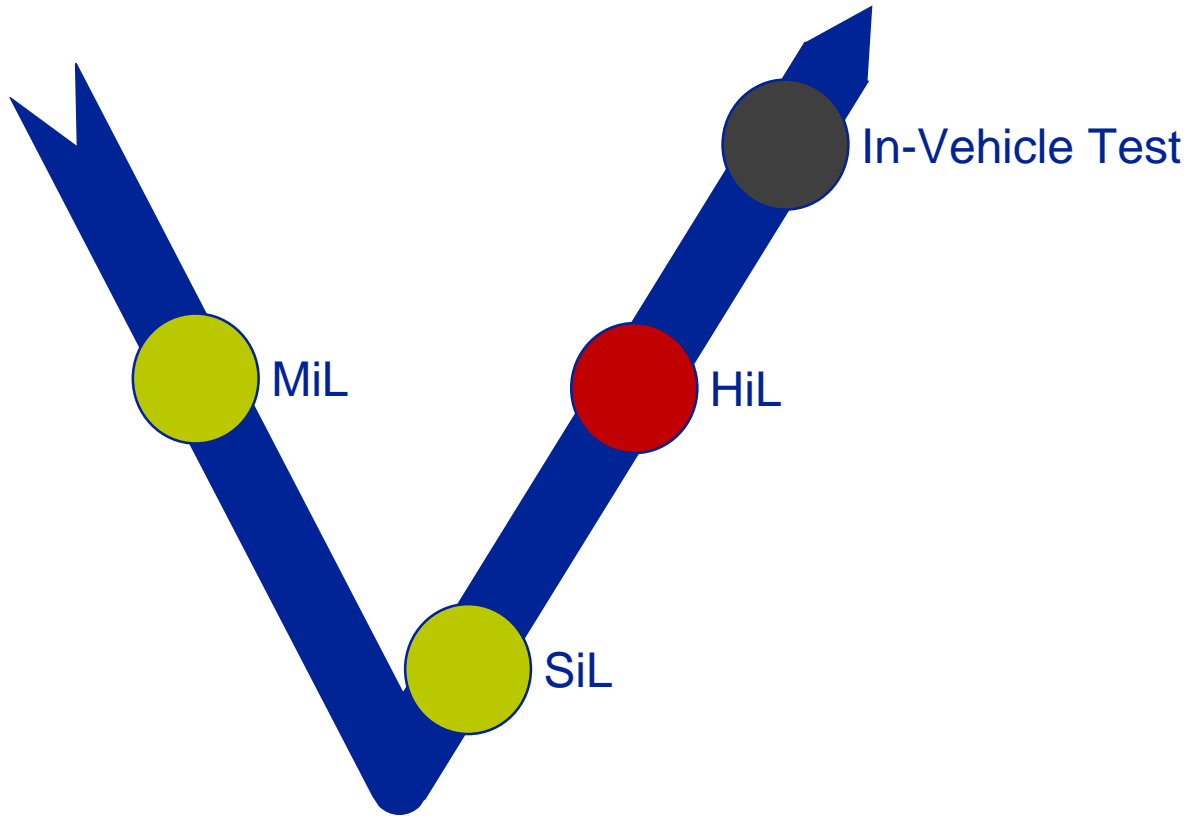




Automated Testing in Automotive Software Development using Vehicle System Simulation

Oliver Philipp, Martin Ehmann
Vector Testing Symposium 2017

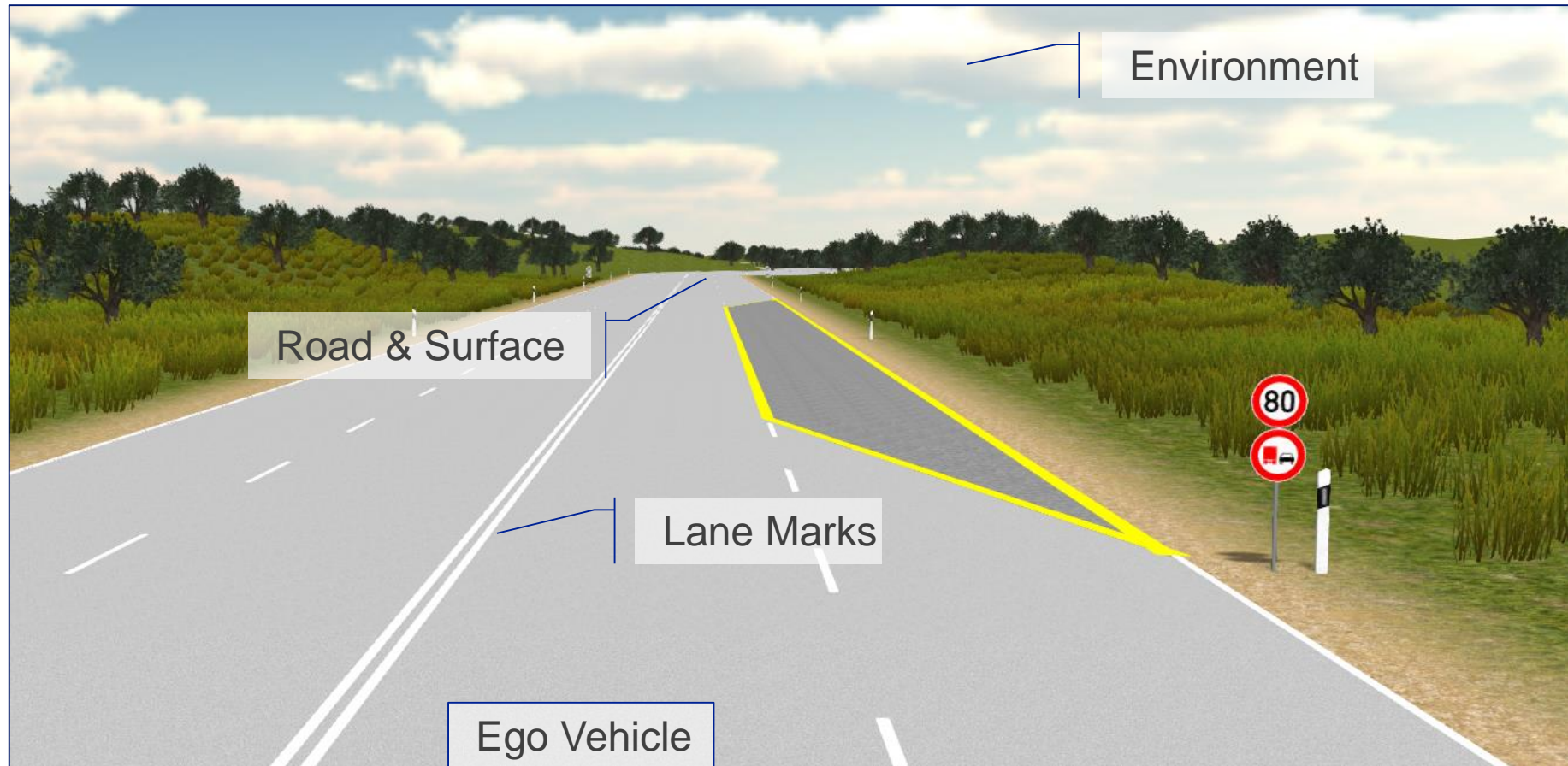
Motivation: Frontloading in ECU Development



Motivation: Extend Testing Capabilities in the Lab

Example ADAS application: LDW/LKA/autonomous steering

- Stimulating a camera-based ADAS can be a lot of work!
- Examination of steering controller (LKA, autonomous steering) requires closed-loop testing



Motivation: Extend Testing Capabilities in the Lab

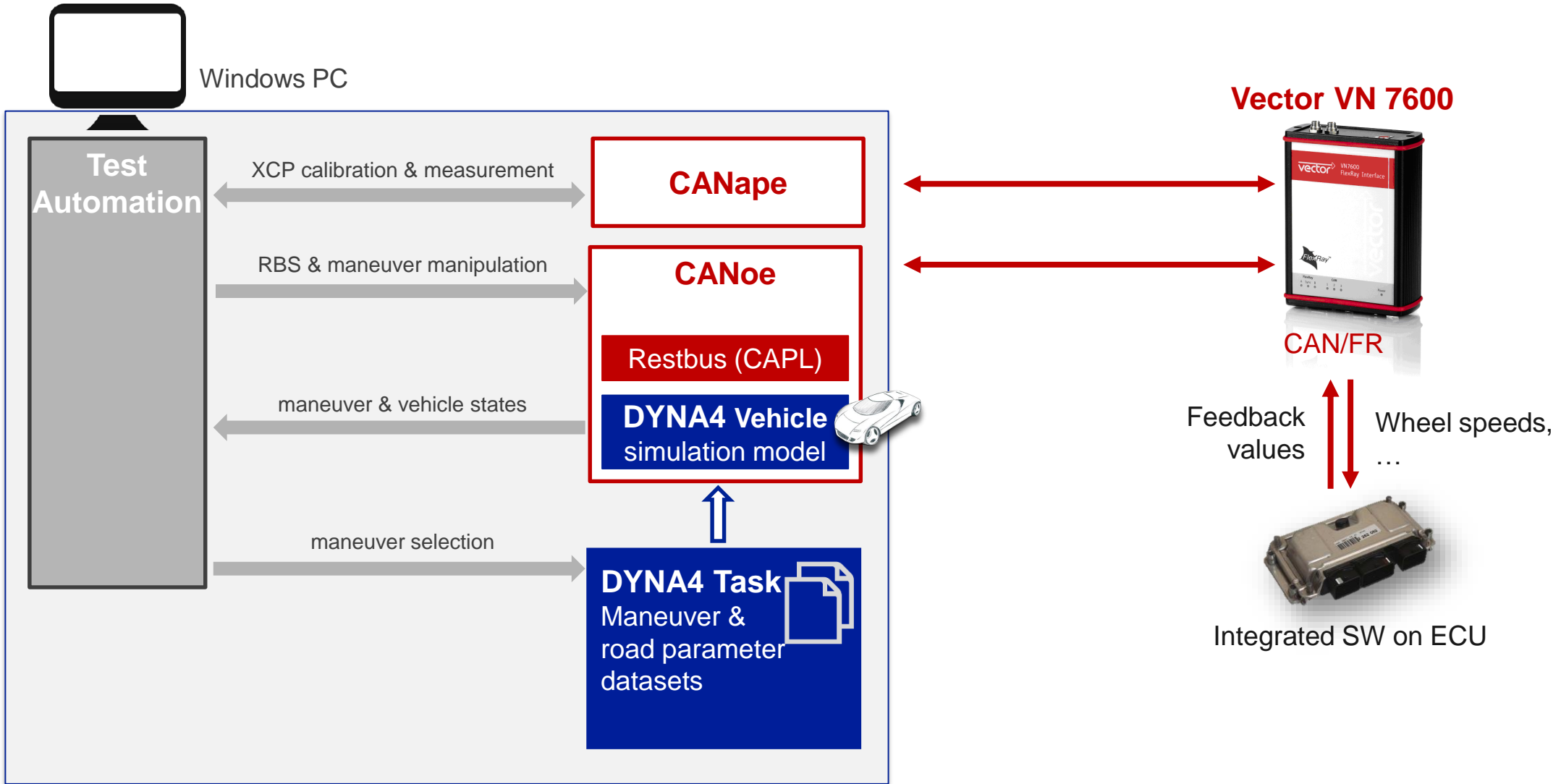
Example application vehicle dynamics:
4WD control

Vehicle Simulation offers:

- Consistent stimulus for ECU
- Closed loop operation:
 - Test controller influence and behaviour
 - Assessment of control quality
 - Pre-Calibration
 - Prepare on-road tests
 - Examine controller changes during on-road-tests

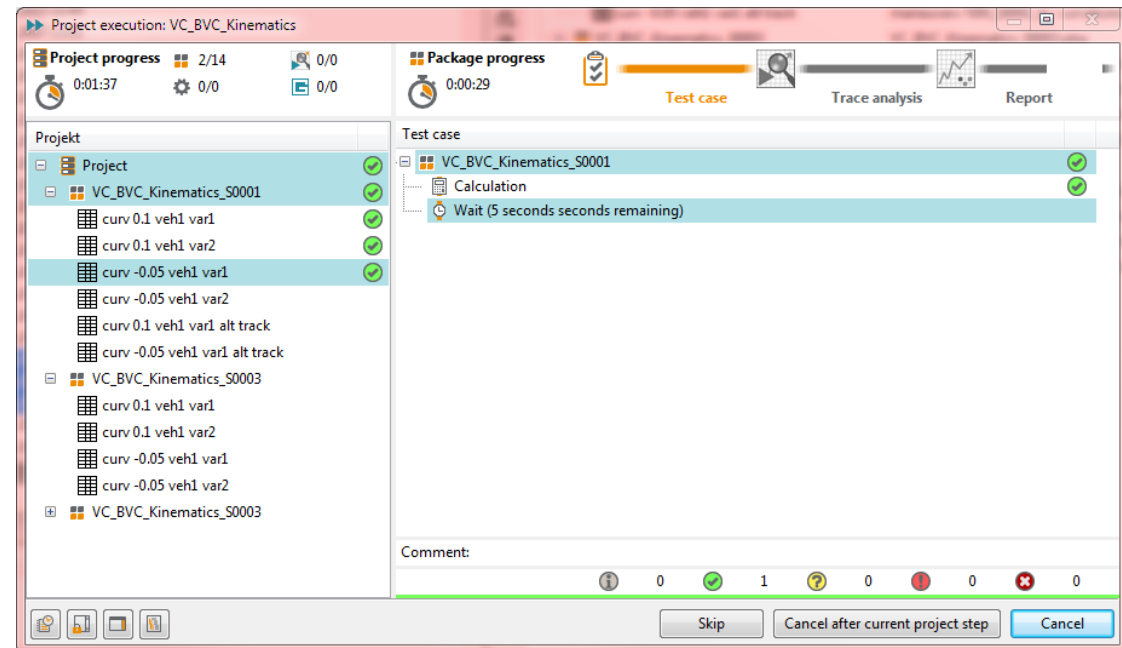


HiL Closed Loop Test Environment for 4WD ECU

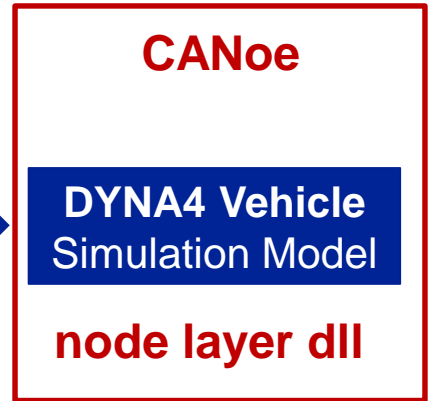
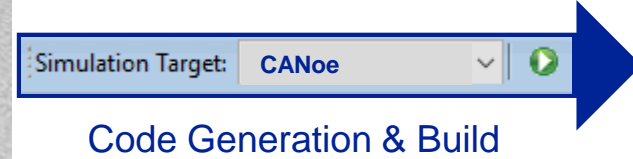
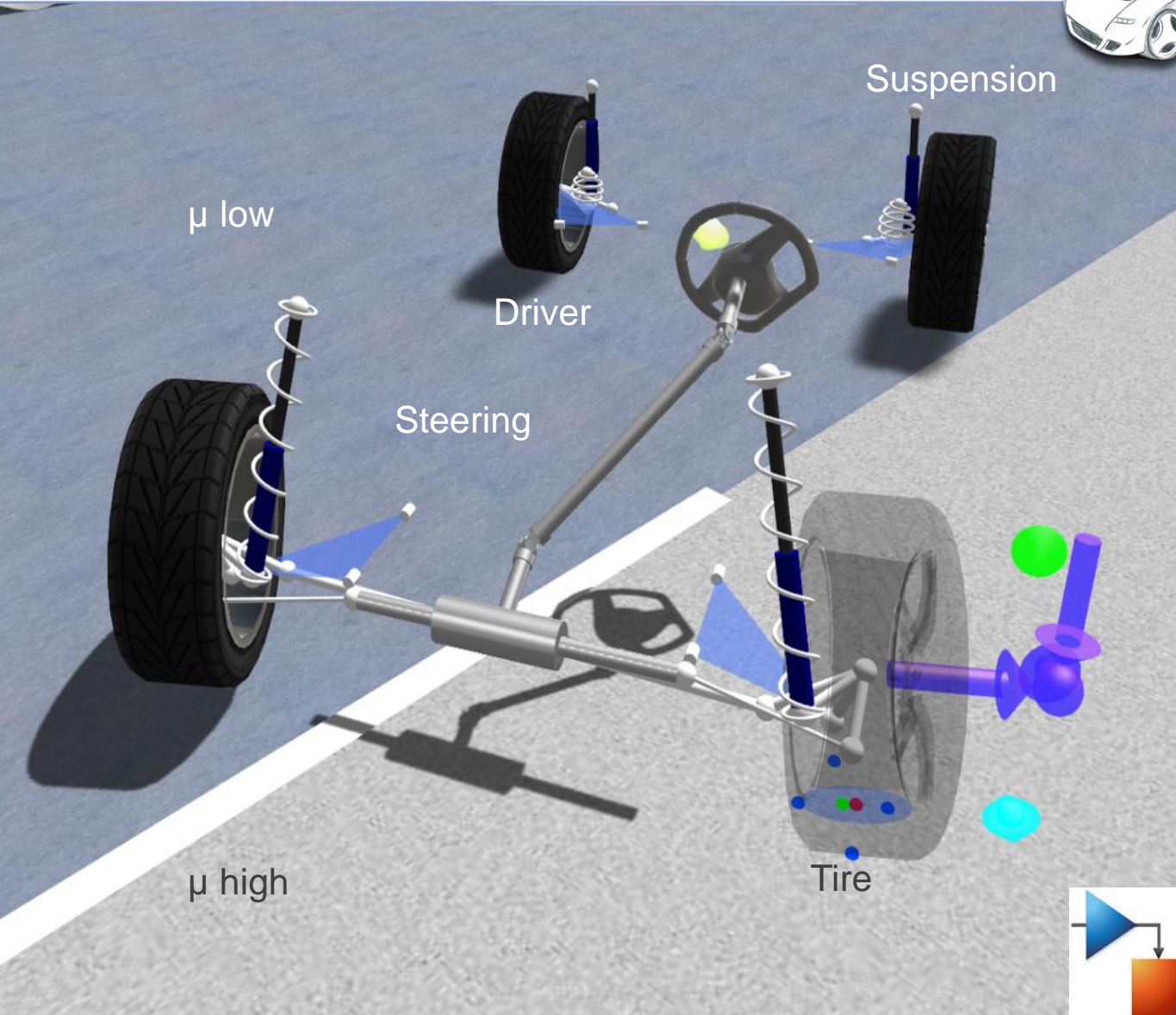
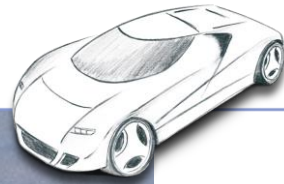


Test Automation

Automation project execution



DYNA4 Vehicle Dynamics Simulation



DYNA4 Vehicle and Maneuver Data Management

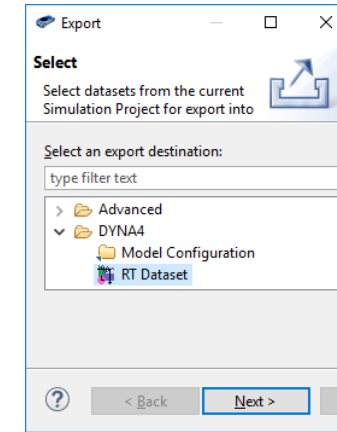


| Name | Model | Model Data | Description |
|-----------------------------|------------------------|--------------|-------------|
| 1 PassengerCar_I4 | PassengerCar.slx | Sedan_I4 | 1.6l |
| 2 PassengerCar_I3 | PassengerCar.slx | Sedan_I3 | 1.2l |
| 3 PassengerCar_Sport | PassengerCar.slx | Sedan_Sport | 2.0l |
| 4 PassengerCar_StationWagon | PassengerCar.slx | StationWagon | 1.6l |
| 5 PassengerCar_Hybrid | PassengerCarHybrid.slx | Sedan_Hybrid | Hybrid |

Vehicle Model & Parameters

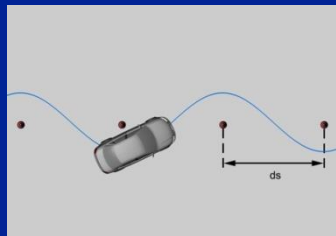
| Name | Description | Execution | Parameter | Variation |
|---------------------------------------|---|-------------------------------------|-----------|-----------|
| ISO14512_BrakingOnMuSplit | ISO14512: Braking on mue split | <input checked="" type="checkbox"/> | (none) | (none) |
| ISO3888_DoubleLaneChange_1 | ISO3888: Double lane change (type 1) | <input checked="" type="checkbox"/> | (none) | (none) |
| ISO4138_SteadystateCircularDriving | ISO4138: Steadystate circular driving | <input checked="" type="checkbox"/> | (none) | (none) |
| ISO7401_OneSine | ISO7401: One sine maneuver | <input checked="" type="checkbox"/> | (none) | (none) |
| ISO7401_PermanentSine | ISO7401: Permanent sine | <input checked="" type="checkbox"/> | (none) | (none) |
| ISO7401_StepSteer | ISO7401: Step steer | <input checked="" type="checkbox"/> | (none) | (none) |
| ISO7975_BrakingInACurve | ISO7975: Braking in a curve | <input checked="" type="checkbox"/> | (none) | (none) |
| ISO9816_PowerOffReactionInACurve | ISO9816: Power off reaction in a curve | <input checked="" type="checkbox"/> | (none) | (none) |
| NHTSA_SineWithDwell | Test case Sine with Dwell maneuver d... | <input checked="" type="checkbox"/> | (none) | (none) |
| RaceTrackBarcelona_CircuitDeCatalunya | Race track Barcelona | <input checked="" type="checkbox"/> | (none) | (none) |
| Demotask_postprocessing | postprocessing mode for Demotask | <input checked="" type="checkbox"/> | (none) | (none) |

Tasks

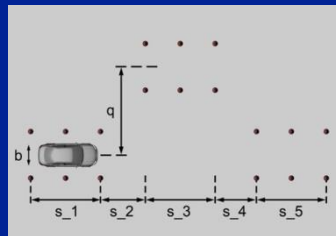


Dataset Export

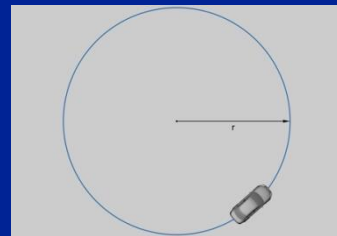
DYNA4 Task
Maneuver & road parameter datasets



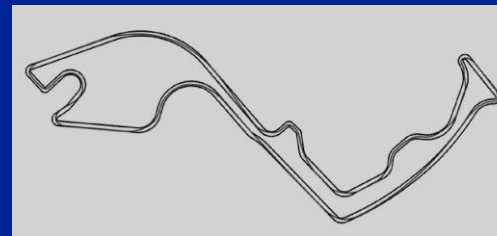
Slalom



Double Lane Change

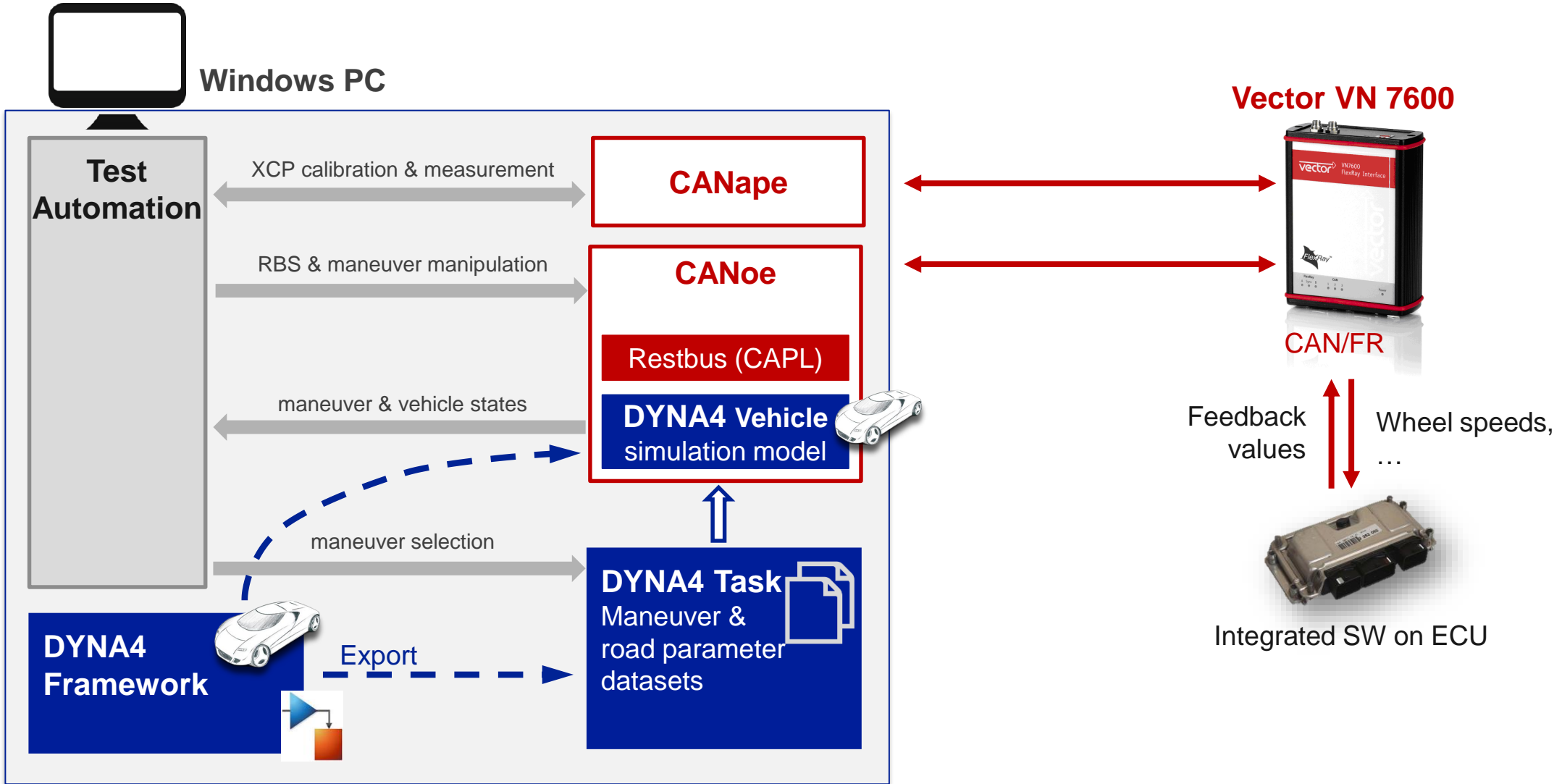


Circle

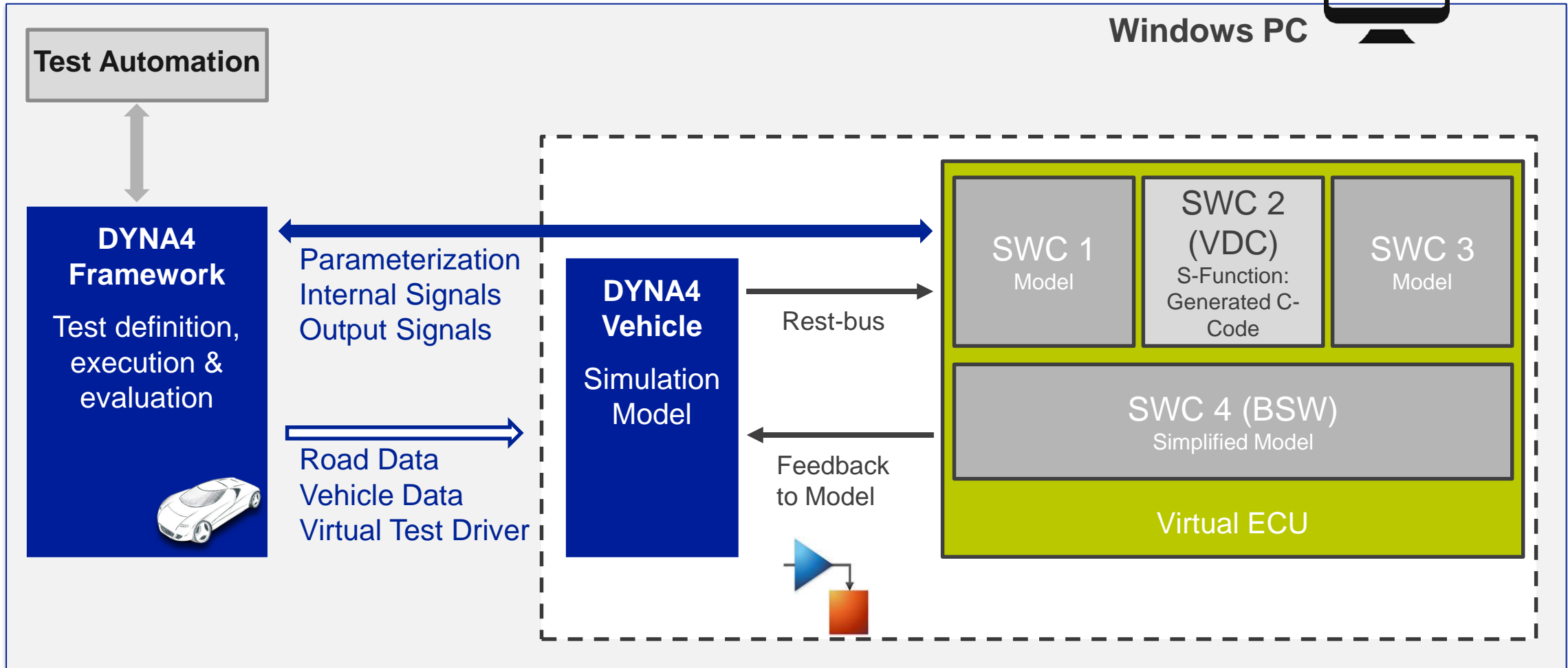


Race Track

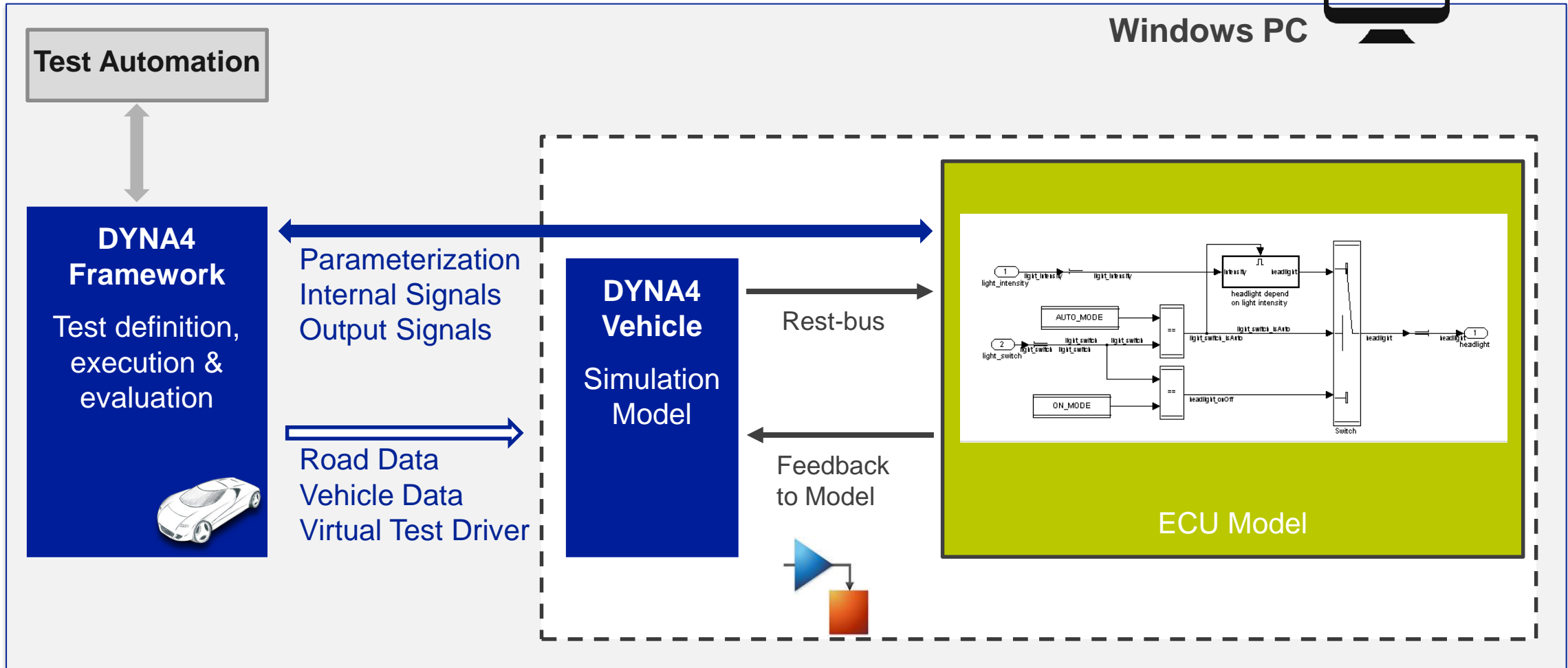
HiL Closed Loop Test Environment for 4WD ECU



SiL Closed Loop Test Environment for Virtual ECU

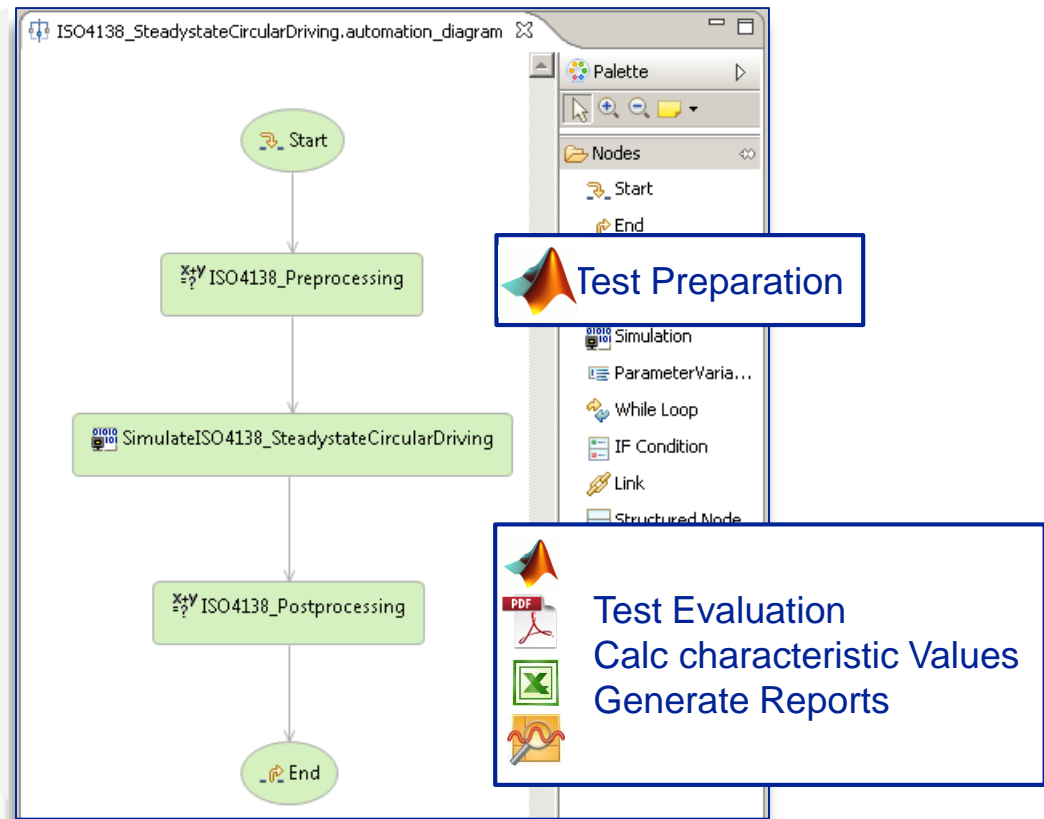


MiL Closed Loop Test Environment for ECU Model



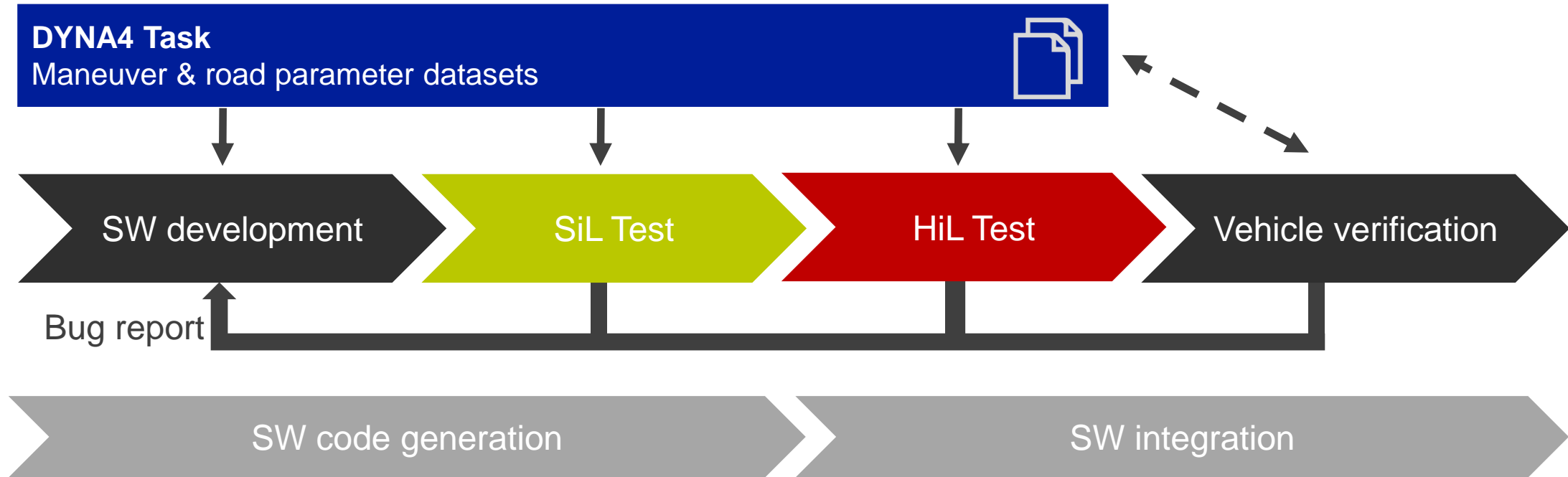
DYNA4 Task Flow Diagram

| Name | Description |
|---------------------------------------|---|
| ISO14512_BrakingOnMuSplit | ISO14512: Braking on mu split |
| ISO3888_DoubleLaneChange_1 | ISO3888: Double lane change |
| ISO4138_SteadystateCircularDriving | ISO4138: Steady state circular driving |
| ISO7401_OneSine | ISO7401: One sine |
| ISO7401_PermanentSine | ISO7401: Permanent sine |
| ISO7401_StepSteer | ISO7401: Step steer |
| ISO7975_BrakingInACurve | ISO7975: Braking in a curve |
| ISO9816_PowerOffReactionInACurve | ISO9816: Power off reaction in a curve |
| NHTSA_SineWithDwell | Test case Sine with dwell |
| RaceTrackBarcelona_CircuitDeCatalunya | Race track Barcelona Circuit De Catalunya |
| Demotask_postprocessing | postprocessing manual |



- Test Tasks: Run Maneuvers
- Postprocessing Tasks:
 - Generate reports
 - Summarize results of multiple tests

Software Development Process with Vehicle Simulation



Conclusions

- Advantages of vehicle system simulation
 - Quick validation of SW features with different vehicle variants
 - More Bugs can be found & fixed earlier (Front-Loading)
→ High SW quality & maturity
- Advantages of the presented test environments (MiL, SiL, HiL)
 - Reuse of models, maneuvers & tests throughout development process
 - Engineers keep the tools they are used to:
Tight integration DYNA4 – CANoe
 - Portability, always available
 - Highly automated and reproducible test execution

More: www.thesis.de/canoe

