Development of Steering Assist Model and Integration in DiL environment

VI-Grade Zero-prototype Summit 2023

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in cooperation with

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Content

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Motivation

Motivation

- Steering Feel – direct feedback to driver
- Target – high confidence, unique DNA & consistency
- Frontloading mandatory - simulation of steering feel

FRONTLOADING

Is it good enough?

Too complicated!

SIMULATION?

Is not reality!

Is it feeling realistic?

Research Question: How steering feel can be represented in the virtual environment using model-in-loop approach?

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Virtual Steering Feel

Virtual Steering Feel

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- **Steering Feel – many influencing factors!**

Real

Road & Environment

Tire

Suspension

Kin. & Compliance
Vertical Setup
Weight & Loading Condition

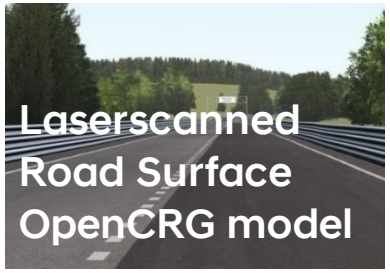
Steering System

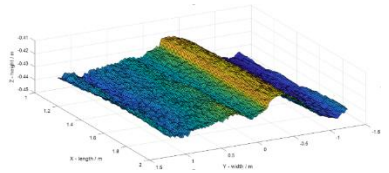
Mass & Inertia
Friction, Compliance & Damping
Motor Control & Logic

Prototype

Virtual

Road Surface Model



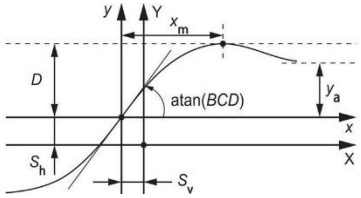


Tire Model

Tire – Road Interface

Tire Forces & Moments

$$[F_{x,y}, M_{x,y,z}] = f(\alpha, r_{slip}, F_z, \gamma)$$



Suspension Model

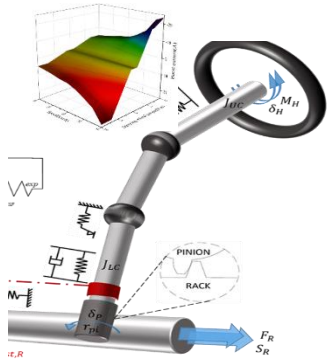
Lookup Table Model for K&C properties

Translation to Tierod Geometry

$$[F_{tierod}] = f(F_{x,y}, M_{x,y,z}, z_{whl}, \delta_{steer}, p_{KnC})$$

VI-GRADE

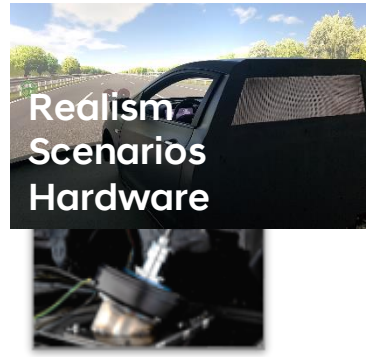
Steering Model



VI-GRADE

MATLAB SIMULINK

Virtual Prototype



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Virtual Testing Environment

Virtual Testing Environment

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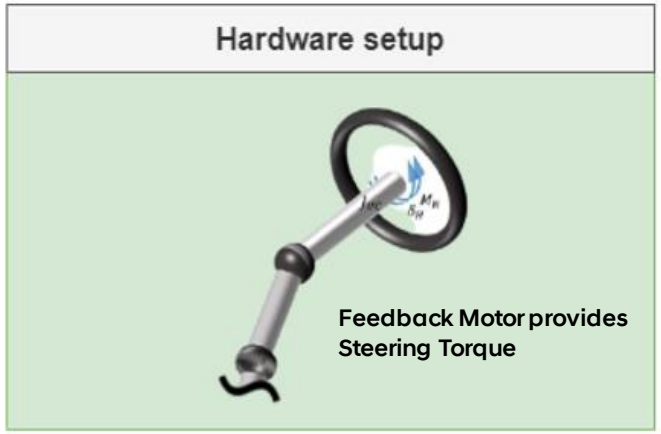
- Subjective Evaluation @HMETC Static Driving Simulator
- Steering Feedback Torque actuator mounted to lower column connection
- Concurrent iHawk as real-time system

Static Driving Simulator – HMETC

Steering Feedback Loop

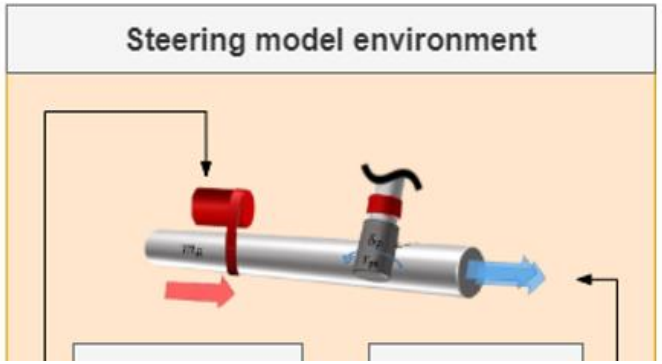
Real

OE Steering Wheel & Steering Column



Virtual

Steering Model from Steering Wheel to Tierod
[Rack-Pinion Model]



EPS Logic Model

Vehicle Dynamics Model

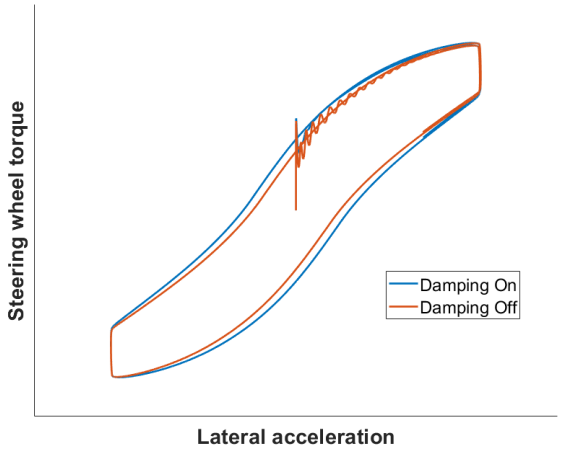
EPS Logic Development

Background & requirements

	As-Is	To be
Steering Feel	▪ Lack of immersion when driving on simulator compared to reality ▪ Artificial representation of steering feedback	▪ Improved driver immersion on driving simulator ▪ Realistic feedback improves driver evaluations of vehicle dynamics
EPS Modeling	▪ Boost function only available natively in rack-pinion steering model ▪ No possibility to influence on-center damping and return feedback	▪ Most important EPS functions available in virtual environment ▪ Possibility to tune functions parameters as in real life

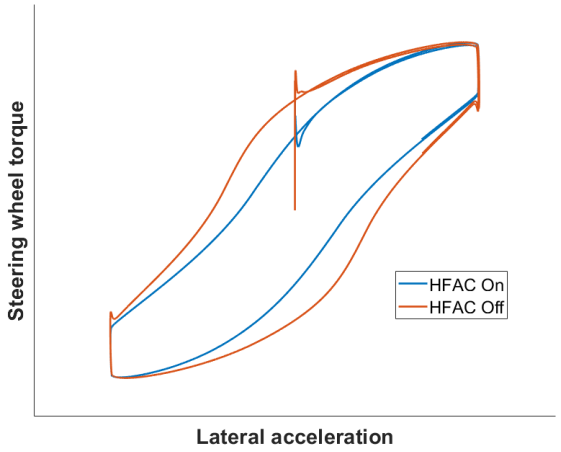
EPS Logic Development

Damping Control



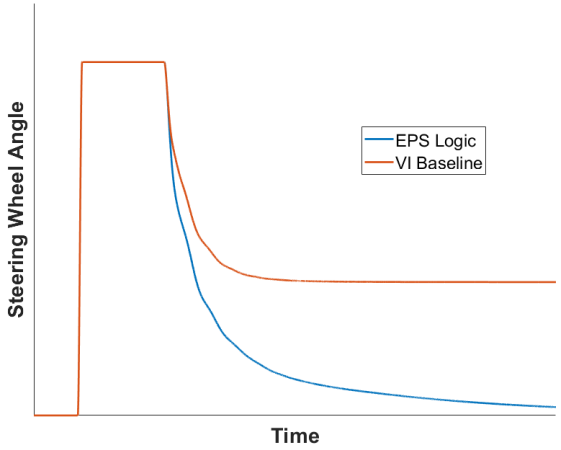
- Main stability control
- Added contribution to overall steering system damping
- Stable and natural return at higher vehicle speed
- Adds hysteresis in the on-center

On-center Control



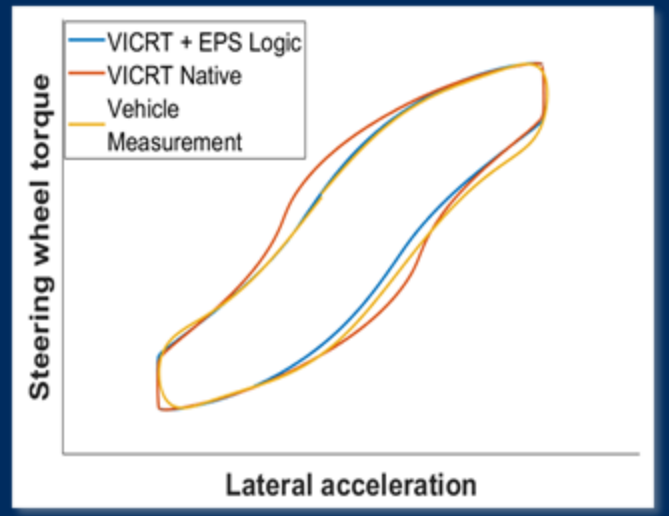
- Aids in the more dynamic maneuvers
- EPS motor inertia and friction compensation
- Improves the on-center feel, reducing the hysteresis

Active Return



- Stable and natural return at lower vehicle speed
- Adds hysteresis in the on-center

Steering Feel

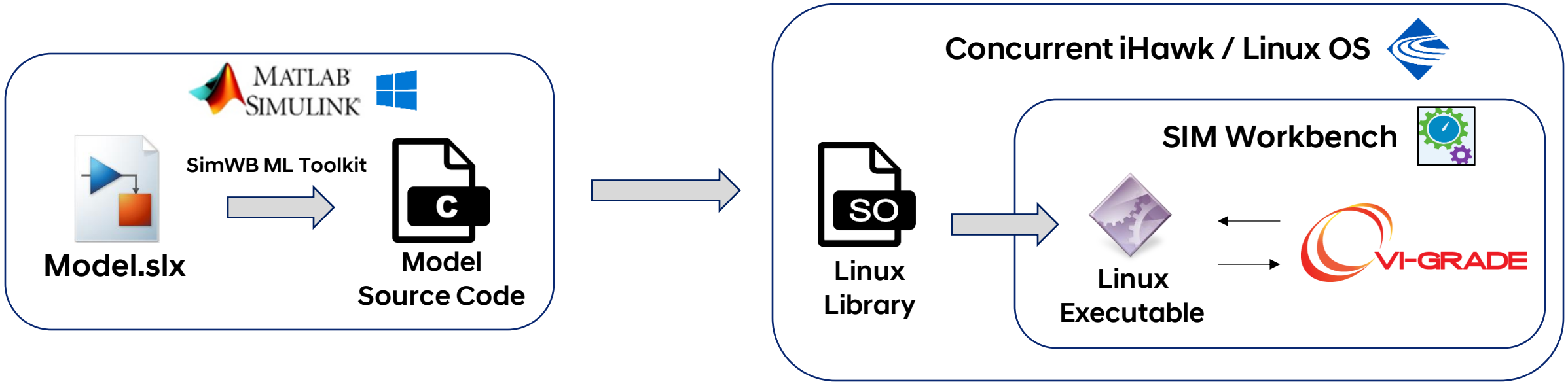


- More realistic mechanical system parametrization
- Better response in the more dynamic maneuvers
- Noticeable improvement in the on-center

DiL Integration

Standard Work-flow

- Model compilation using SimWB ML-Toolkit

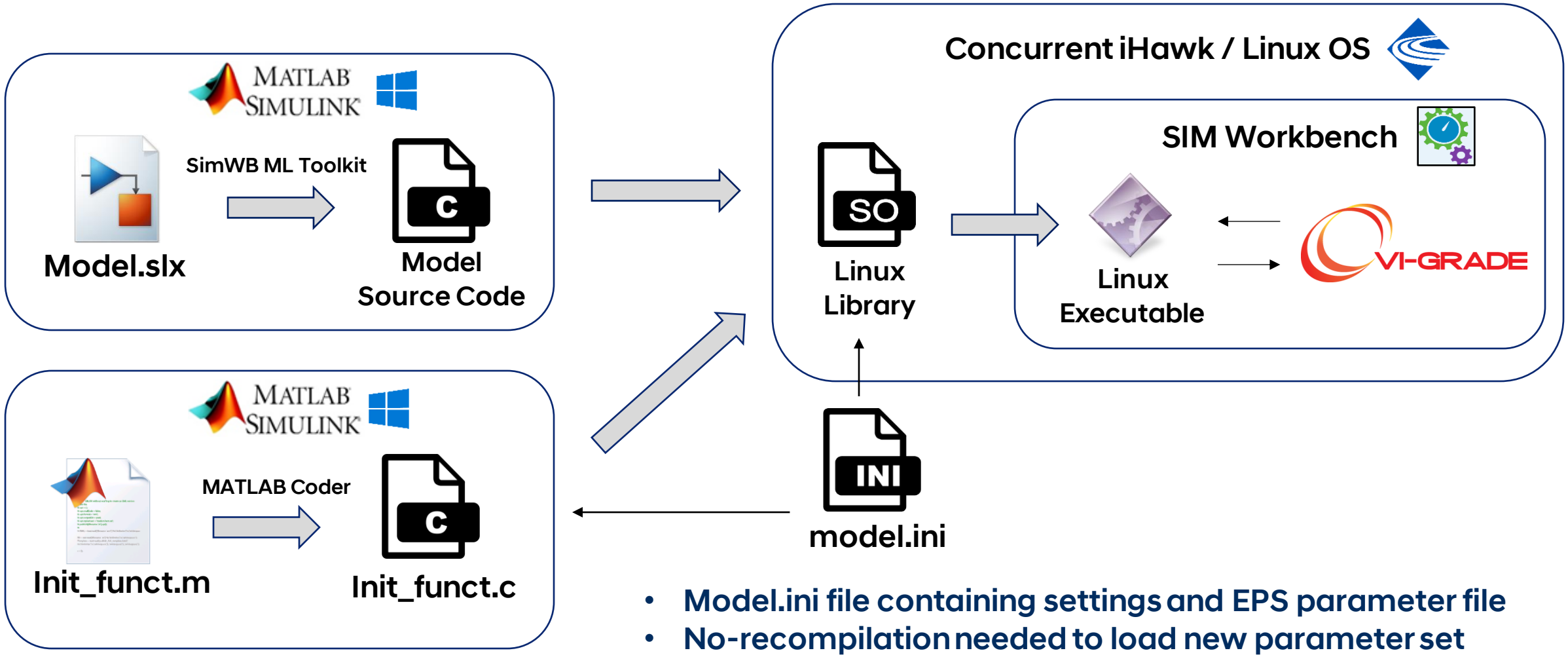


< Parameter Modification >

- Manually from the RTDB
- Use a C-/Python script to load new parameter set after model initialization
- Re-compile the model w/ new set of parameters

Alternative 1: Initialization File

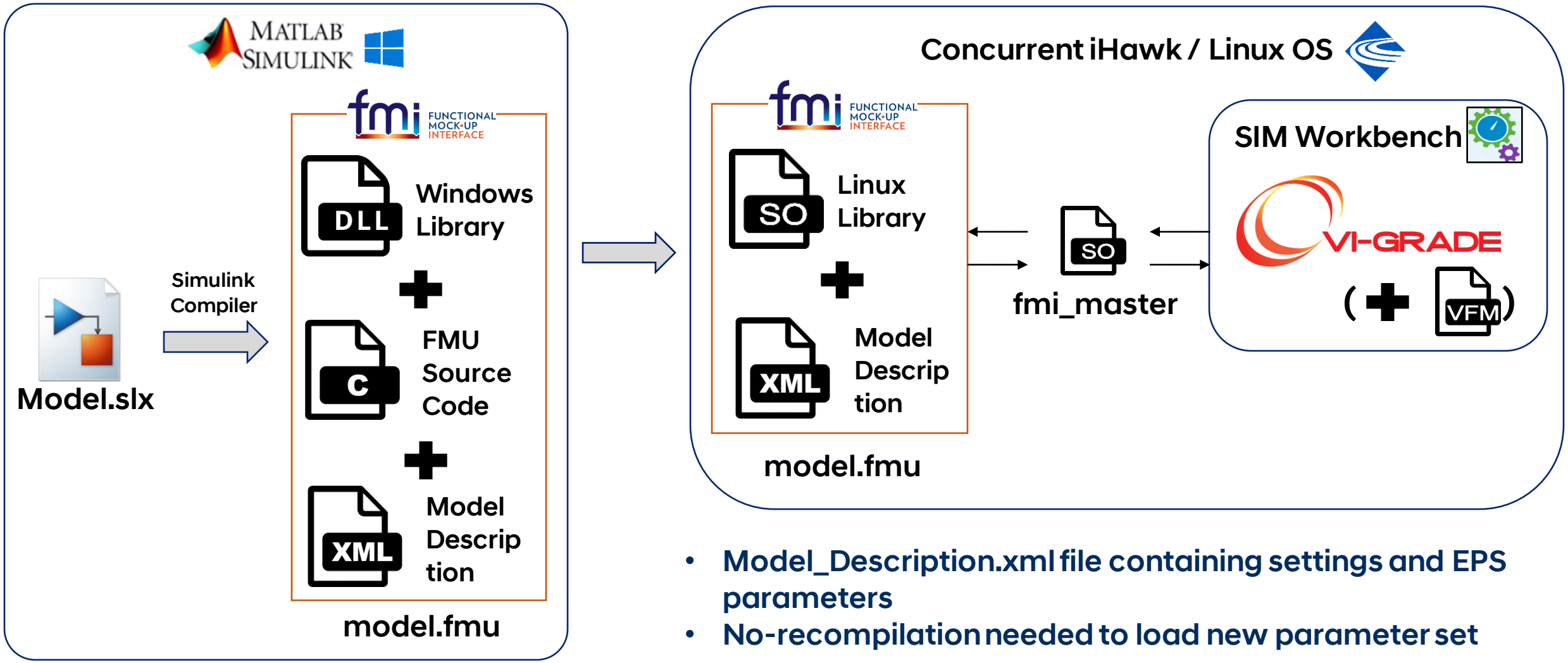
- Update the source code to call the initialization function



- Model.ini file containing settings and EPS parameter file
- No-recompilation needed to load new parameter set

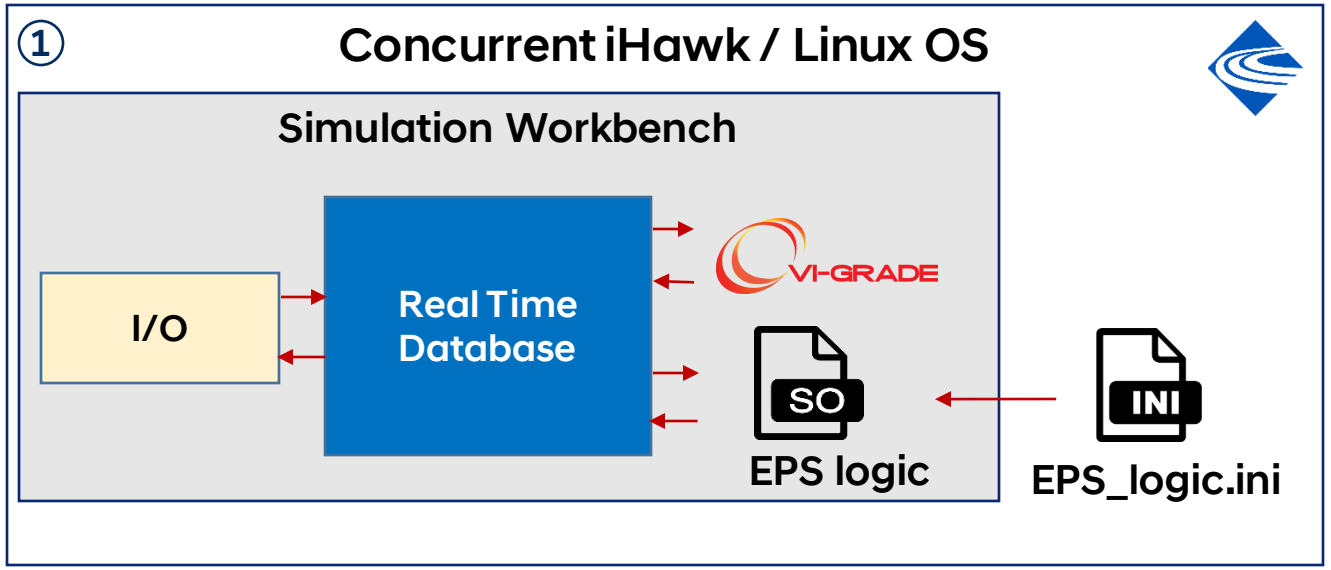
Alternative 2: FMI

- Model compilation as FMU and co-simulation via VI-CarRealTime FMI-Master



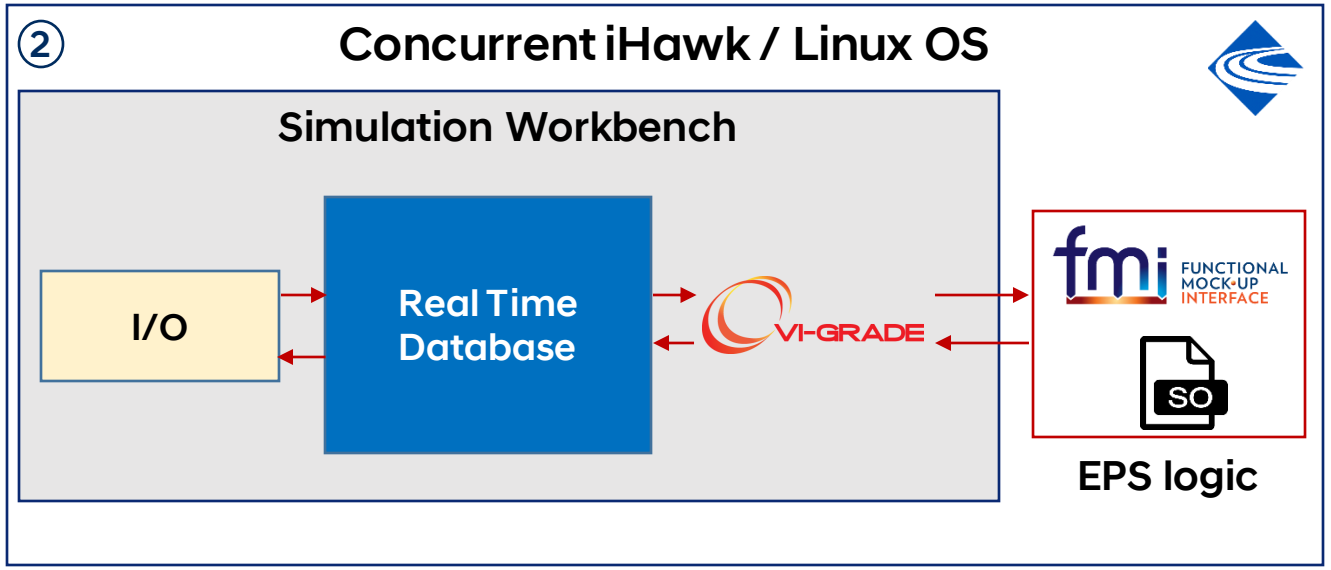
- Model_Description.xml file containing settings and EPS parameters
- No-recompilation needed to load new parameter set

Real Time Environment



- Simpler parameter modification by model.ini file
- Real-time access to the I/O variables and parameters on SimWB

- Complex implementation (C-programming skills required)
- Different environment offline vs. online



- Simpler implementation by FMI standard
- Grey-box model (useful for Model sharing with other teams/external partners) w/out IP disclosure
- Same environment offline vs. online

- Parameters update via “vfm” or “Model Description.xml” files
- Real-time parameter access not available

Subjective Evaluation

Subjective Evaluation

- Standard steering model as reference for steering feel
- Most popular comments between participants

W/out EPS Logic

- No-big difference over speed
- Overdamped feeling
- Un-realistic/Digital on-center
- Return damping is not there, difficult to control the car during limit maneuvers
- No feedback from the road

Main problems in On-center Feel, Returnability & Road Feedback

W/ EPS Logic

- Good/Natural reproduction of on-center feel & torque build-up
- Returnability is much better, feeling like in real-car
- Car reactions feel more precise
- Improved feedback from the road

Clear improvement, can be used for steering tuning and training

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Conclusion

Conclusion

- Simulation of realistic steering feel is not that far away anymore!
- Influence of EPS Logic improves model fidelity and driver immersion

	Native Rack-Pinion Steering Model	Enhanced Steering Model w/ EPS Logic
Application	▪ Good in very early phase for steering effort definition ▪ Not detailed enough for steering feel development	▪ Very good through the entire development process & to study new functions in early phase ▪ Possibility to quickly exchange EPS parameters
Implementation	▪ Natively implemented in all commercial vehicle-physics codes ▪ Parametrization to be adapted to run stable on driving simulator	▪ Different possibilities (C-code vs. FMU), depending on usecase ▪ EPS Logic can be used in both offline and online environments

Conclusion


Too complicated!
Is it good enough?
Is it feeling realistic?
SIMULATION!
Is not reality!

Thank You!