



Utilizing open standards - an automotive use case example simulation

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OUR RESEARCH AT VTI



→ Aviation



→ Bicycling and cycleways



→ Climate Adaptation



→ Environment



→ Highway engineering and maintenance



→ Maritime transport research



→ People in the transport system



→ Rail transport



→ Traffic analysis and engineering



→ Traffic safety



→ Transport economics



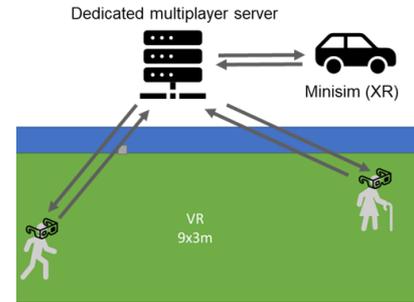
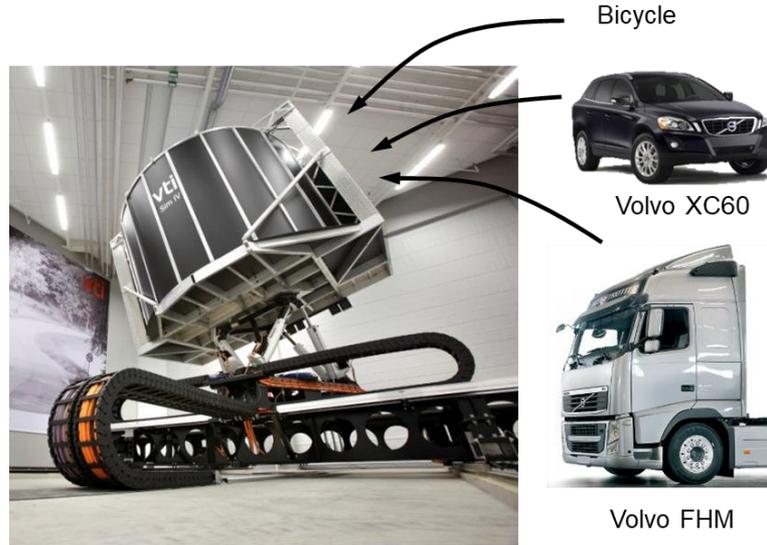
→ Transport Systems Analysis and Logistics



→ Vehicle technology and driving simulation

VEHICLE SYSTEMS AND SIMULATION TECHNOLOGY AT VTI

- Large-scale, moving base driving simulators
- Small-scale dedicated simulators
- Passenger- and freight train simulators, various
- Virtual & Mixed Reality (VR/XR) Lab
- Co-simulation for multi-perspective interaction and design



STANDARDIZED MODEL INTEGRATION

- Need to enable efficient collaboration with external partners, including IP protection
- Need to enable efficient integration of simulation models from various tools/languages
- Need to consider inherent uncertainties of the model and determine its influence on the simulation
- OpenScaling – provide standardized uncertainty, validity and credibility information directly into the models
- OpenScaling – Analysis tools can directly propagate uncertainties, assess credibility before/during/after simulation and enable certified virtual testing



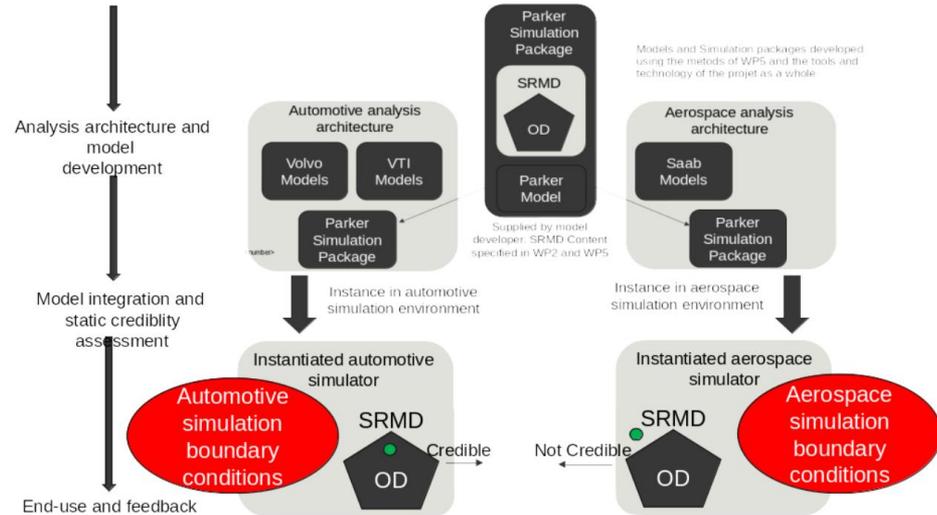
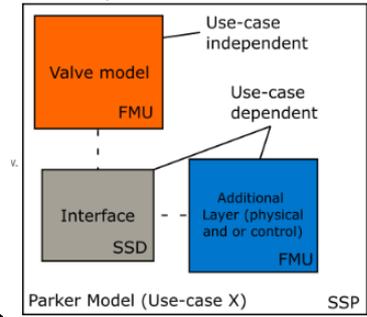
DEMONSTRATOR DESCRIPTION

- Vehicle Demonstrator
 - Two Applications: **Aerospace and Automotive**
 - Multiple Vehicle Configurations and Component contributors
 - Multiple Simulation Purposes: Energy efficiency and management, automation, integrated simulation performance



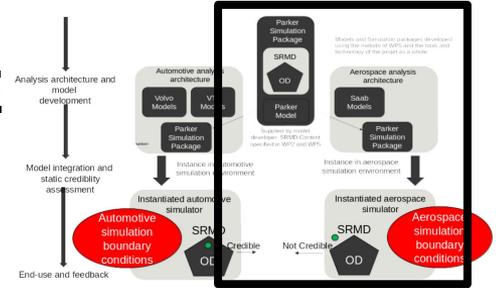
OVERARCHING USE CASE

- Two use cases:
 - Automotive
 - Aerospace
- Both application exploit “Third party models”
- Primary goal: Demonstrate the benefit of communicating model meta-data on a standardized format

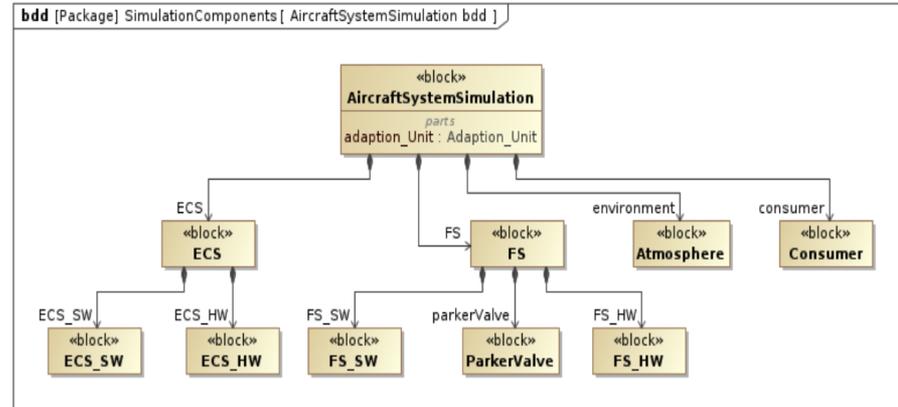


AEROSPACE APPLICATION ARCHITECTURE

- System level model built from several sub-models like:
 - Environmental control system
 - Fuel system
 - Heat sinks



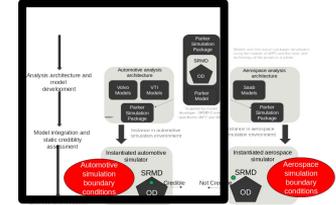
- All developed using different tools:
 - Modelica
 - SysML
 - Simulink
 - ...



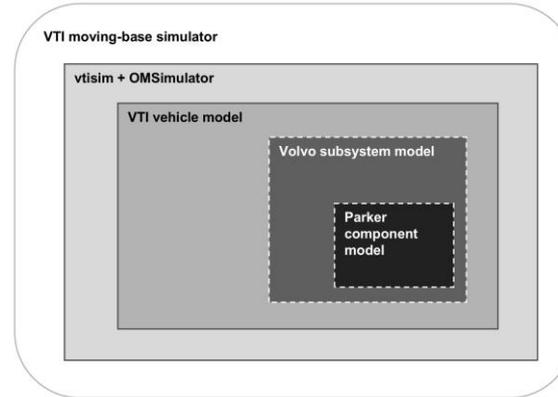
AUTOMOTIVE APPLICATION ARCHITECTURE

Multiple Vehicle configurations and component contributors:

- Parker:
 - Valve model (Parker inhouse tool, C)
 - Rear axle steering assembly (Hopsan)
- Volvo and VTI: Automotive drivetrain model
 - Simulink
 - Modelica



AUTOMOTIVE VEHICLE SYSTEMS



vti

AUTOMOTIVE APPLICATION USE CASE SCENARIO

- The feasibility of implementing rear-axle steering with a hydraulic actuator on a Volvo truck is investigated.
- This is done by integrating models of needed components into a simulator.
- To facilitate integration and credibility assessment of the complete simulation, standardised model exchange formats and credibility information is needed for the models.
 - SSP, SSP Traceability
 - FMI



<https://ssp-standard.org/>

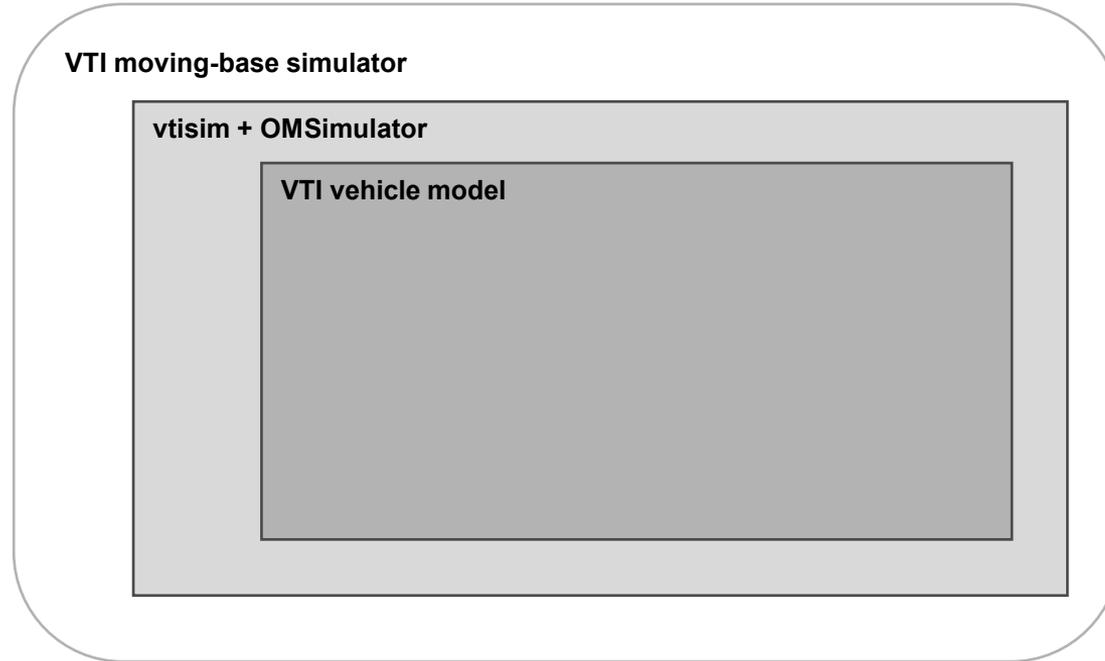


<https://fmi-standard.org/>

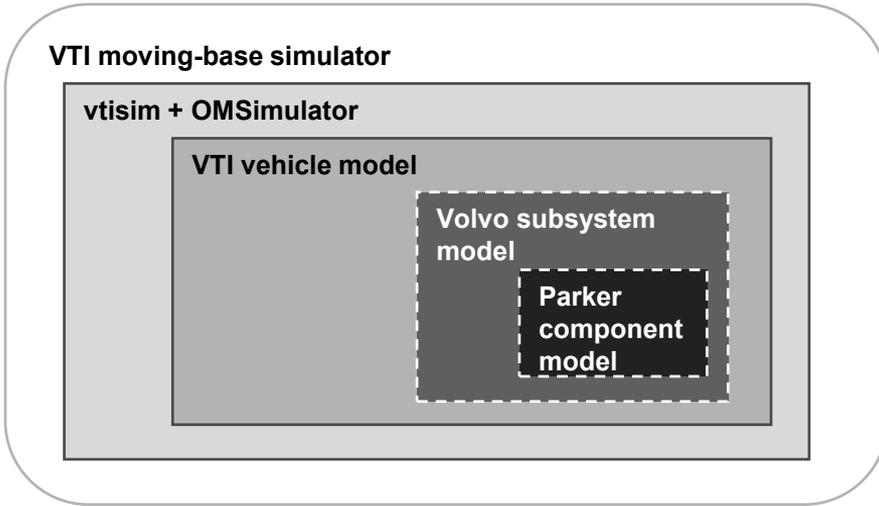


<https://www.east-adl.info/>

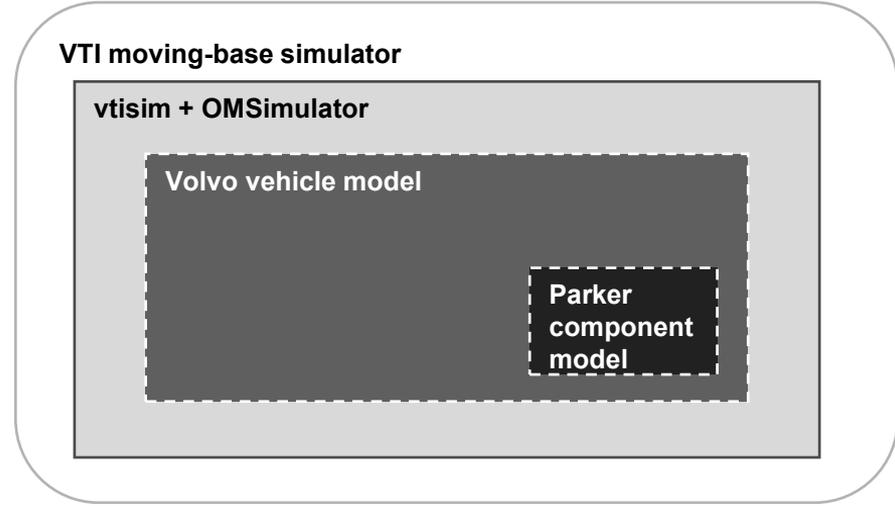
VTI SIMULATION ARCHITECTURE



VTI SIMULATION ARCHITECTURE



ALTERNATIVE 1



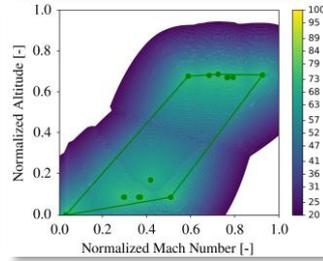
ALTERNATIVE 2

CREDIBILITY ASSESSMENT

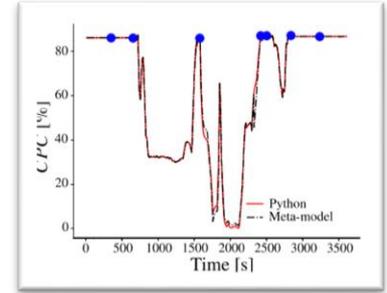
Aerospace Example:

```
<Volume  
  type="convex_hull"  
  points="x1,y1;x2,y2;x3,y3"  
  variables="Altitude,Mach"/>  
<BoundaryConditions  
  simulation_status="no_errors"/>  
<Error fraction="0.1">  
  <Point pos="x4,y4">  
    ....  
</Error>
```

Static
information in
standardized
format



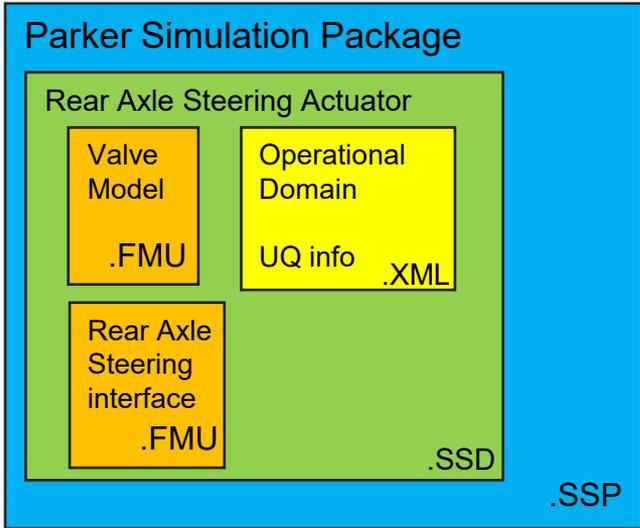
Model estimating selected
aspects of credibility in
untested operating conditons



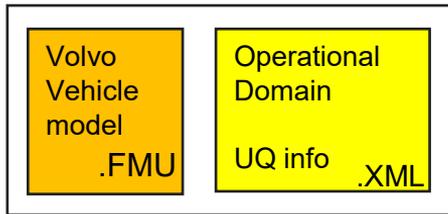
Information
presented to the
end-user during
simulation

AUTOMOTIVE APPLICATION USE CASE RESULTS AIM

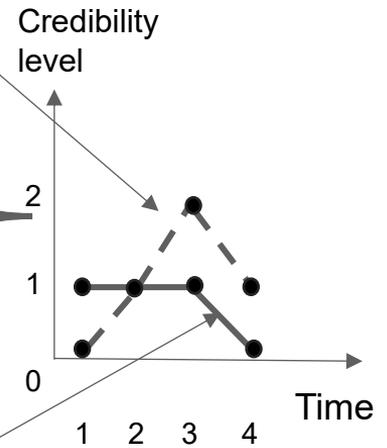
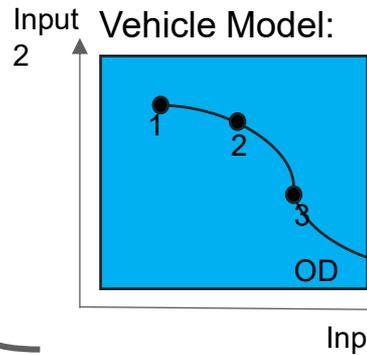
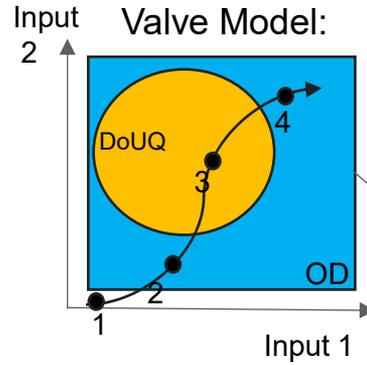
From Parker:



From Volvo:



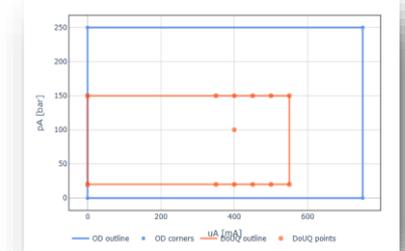
Integration/
simulation
in VTI
simulator



CURRENT STATUS (1)

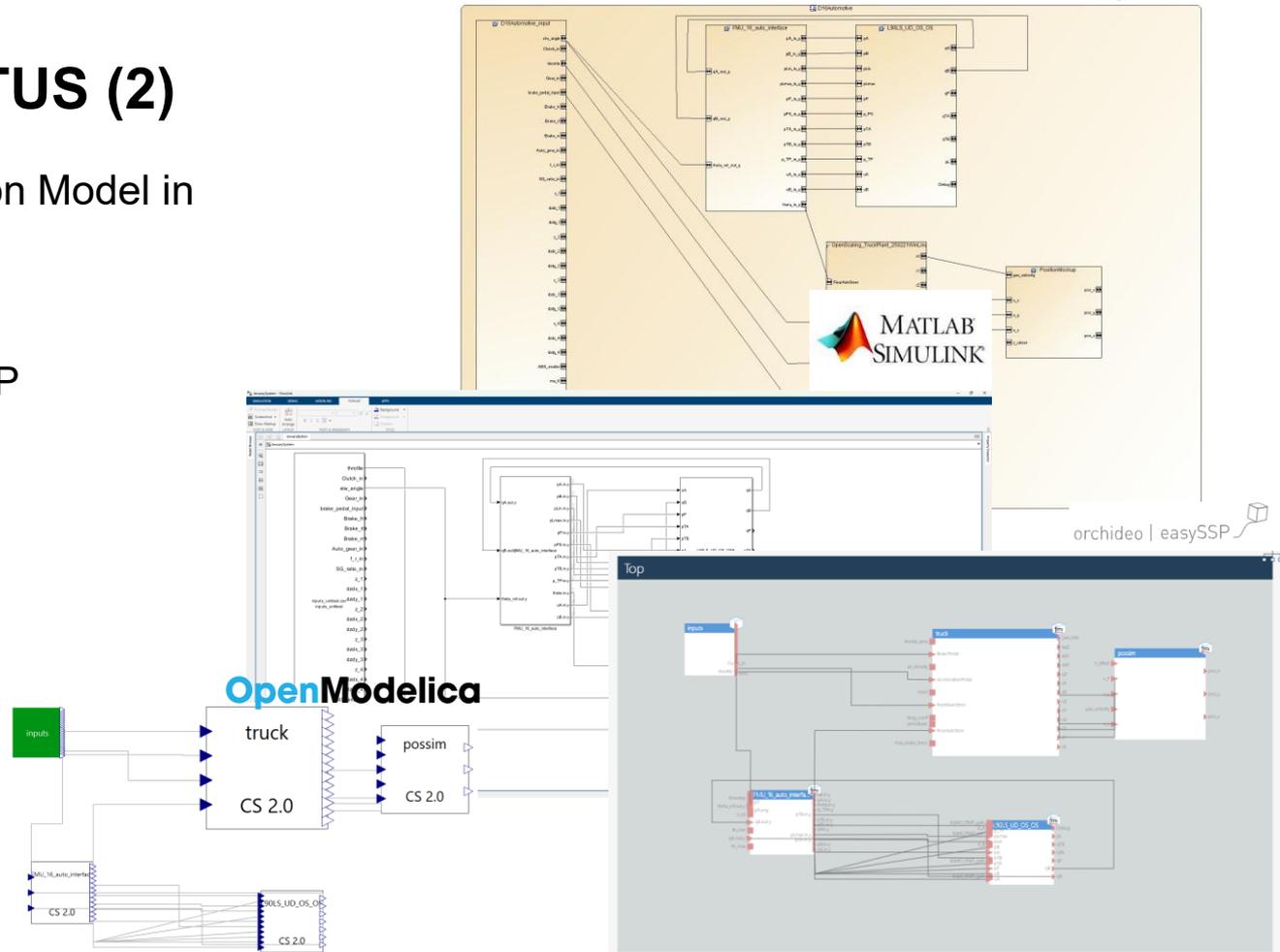
- Parker simulation package compiled as .ssp file
 - With credibility info attached in .xml format derived in WP2 in openSCALING
- Volvo vehicle model compiled as .fmu file
 - With credibility info attached in .xml format derived in WP2 in openSCALING
- VTI road integration function compiled as .fmu file
- Integrated Simulation compiled as .ssp file

```
<uq:ExperimentSet xmlns:uq="http://openstg.org/UQ/UQ1/UQ1UncertaintyQuantification" generationTool="pylsq" >
  <uq:Model name="L90LS_UD_05" file="L90LS_UD_05.fmu"/>
  <uq:ExperimentSet>
    <uq:ForwardUncertaintyQuantification>
      <uq:ParameterSet>
        <uq:OperationalDomain>
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            <uq:Axis name="uB" unit="mA"/>
            <uq:Axis name="pP" unit="bar"/>
            <uq:Axis name="pTA" unit="bar"/>
            <uq:Axis name="pTB" unit="bar"/>
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            <uq:Axis name="pB" unit="bar"/>
            <uq:Axis name="pLin" unit="bar"/>
            <uq:Axis name="pLmax" unit="bar"/>
            <uq:Axis name="p_TP" unit="bar"/>
            <uq:Axis name="p_PS" unit="bar"/>
          </uq:Axes>
          <uq:Boundary>
            <uq:Box>
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              <uq:Point coordinates="900.0 900.0 400.0 20.0 20.0 400.0 400.0 500.0 500.0 35.0 50.0"/>
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              </uq:ExperimentPoints>
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        </uq:ParameterSet>
      </uq:ForwardUncertaintyQuantification>
    </uq:ExperimentSet>
  </uq:Model>
</uq:ExperimentSet>
" >
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      <uq:OperationalDomain>
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          <uq:Axis name="AccelerationPedal"/>
          <uq:Axis name="BrakePedal"/>
          <uq:Axis name="air_density"/>
          <uq:Axis name="drag_coeff"/>
          <uq:Axis name="frontal_area"/>
          <uq:Axis name="mass"/>
          <uq:Axis name="max_brake_force"/>
          <uq:Axis name="wheelbase"/>
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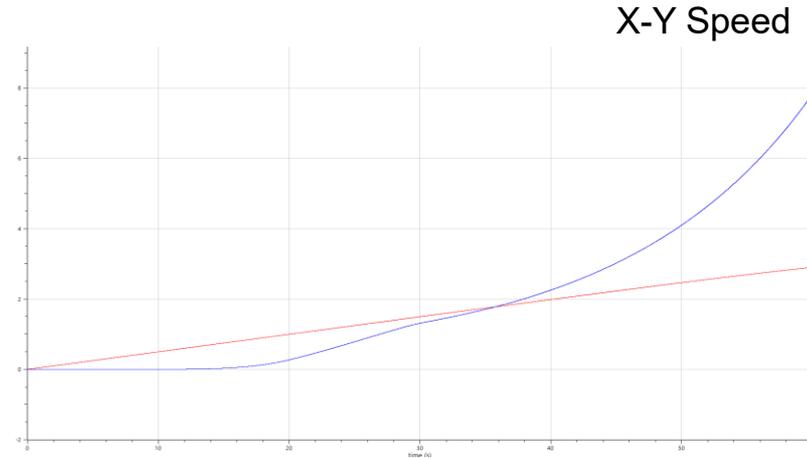
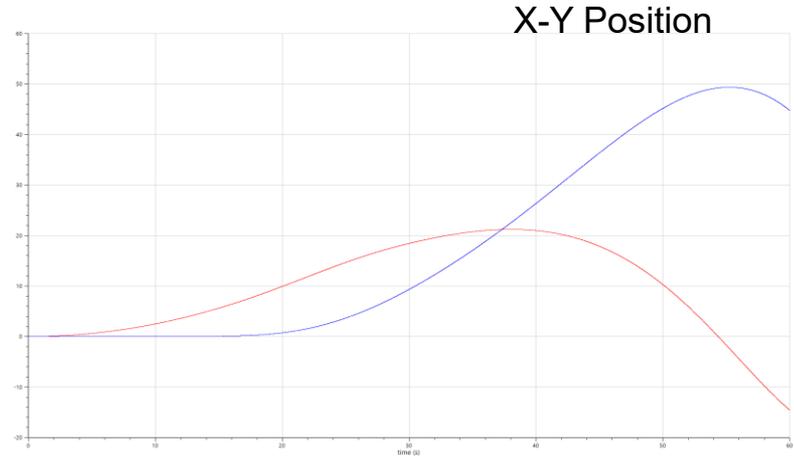
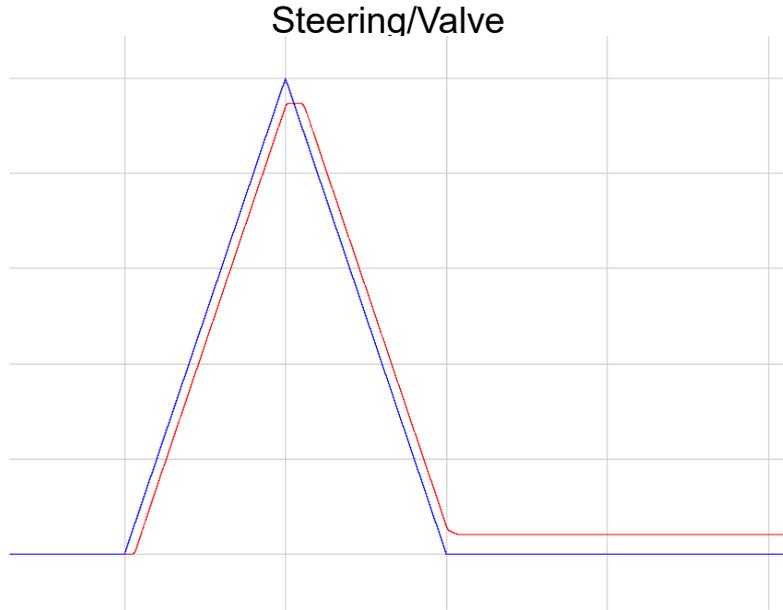
CURRENT STATUS (2)

- Integrated Simulation Model in
 - EAST-ADL
 - Simulink
 - OMSimulator SSP
 - EASY-SSP SSP



CURRENT STATUS (3)

- Simulation results



CONCLUSIONS AND OUTLOOK

- The aim of the demonstrator is to use operational domain information of included model components to make credibility assessment of a system simulation of a truck with added rear wheel steering.
- Credibility assessment when dealing with models from multiple sources relies on standardised format of credibility information shipped with the models.
- Models with credibility information on standardised format have been integrated and simulates successfully.
- Next steps are to track the path in the models' operational domain as a measure of simulation credibility as well as propagating uncertainty quantification results of the valve model to steer angle uncertainty of the vehicle.



Thank you

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