Utilizing open standards - an automotive use case example simulation

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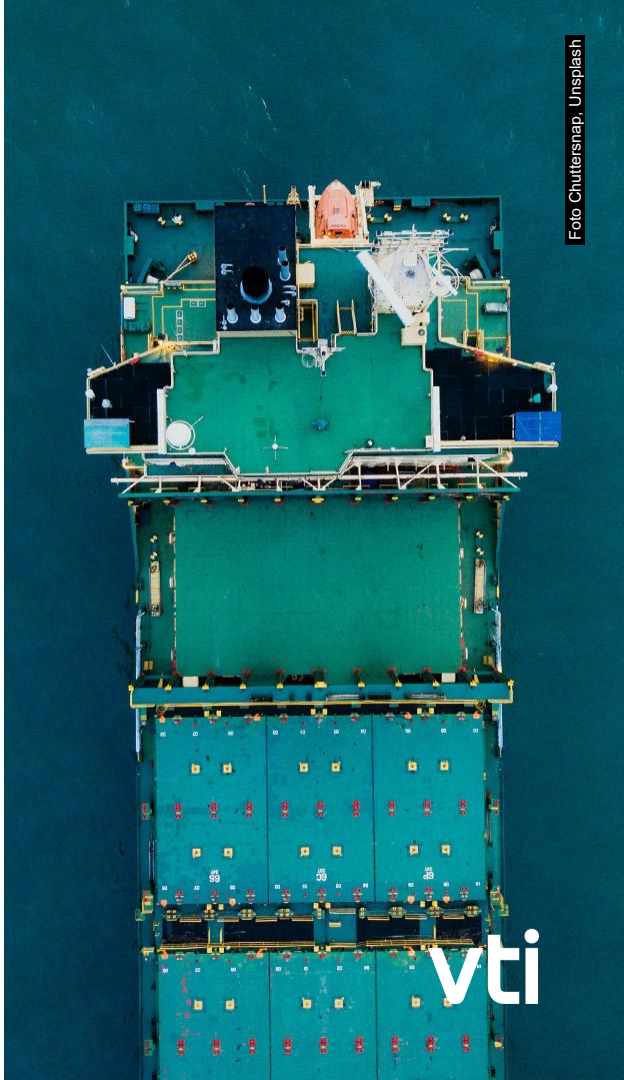

OUR RESEARCH AT VTI

→ 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

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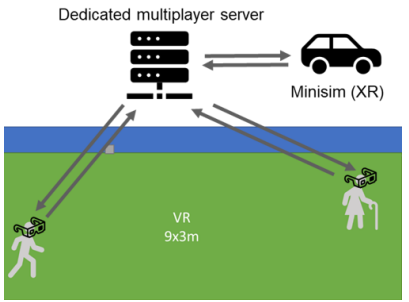
VEHICLE SYSTEMS AND SIMULATION TECHNOLOGY AT VTI

- 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

Bicycle

Volvo XC60

Volvo FHM



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

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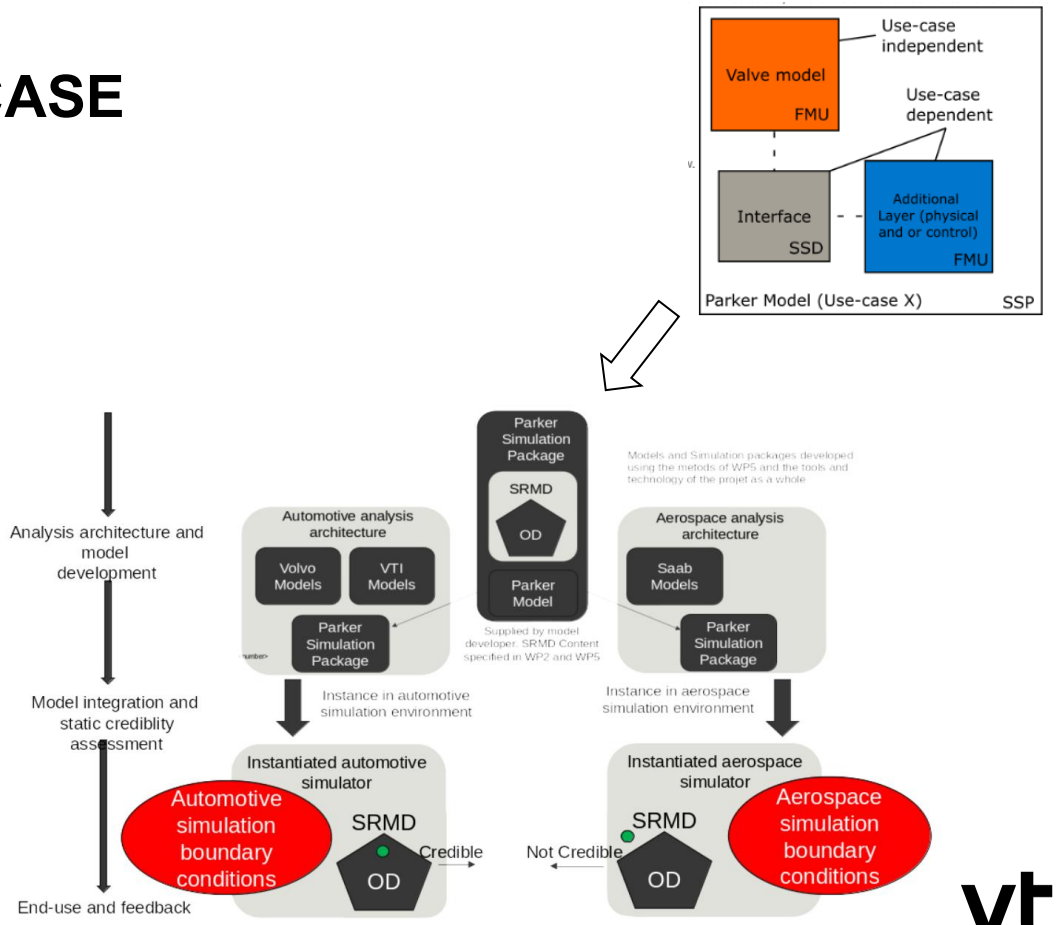
DEMONSTRATOR DESCRIPTION

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

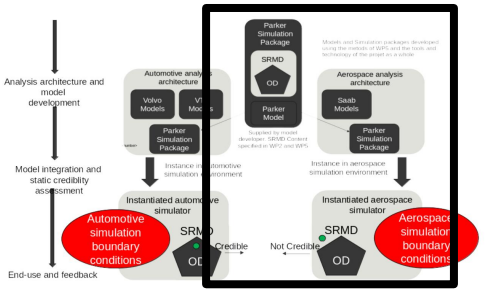
OVERARCHING USE CASE

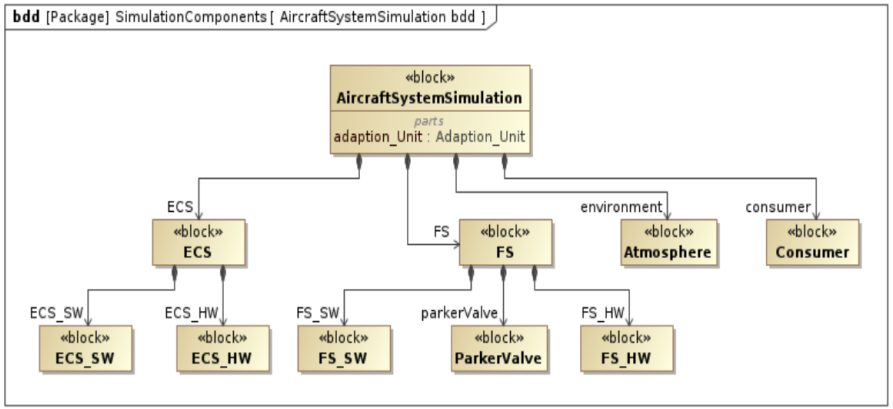
- Two use cases:
  - Automotive
  - Aerospace
- Both application exploit “Third party models”
- Primary goal: Demonstrate the benefit of communicating model meta-data on a standardized format



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
  - …

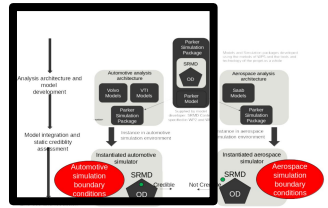


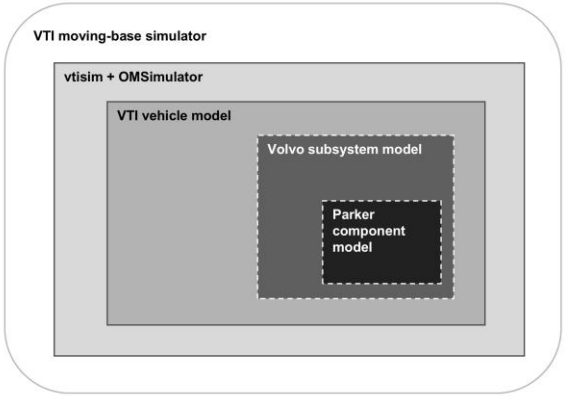


AUTOMOTIVE APPLICATION ARCHITECTURE

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 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/

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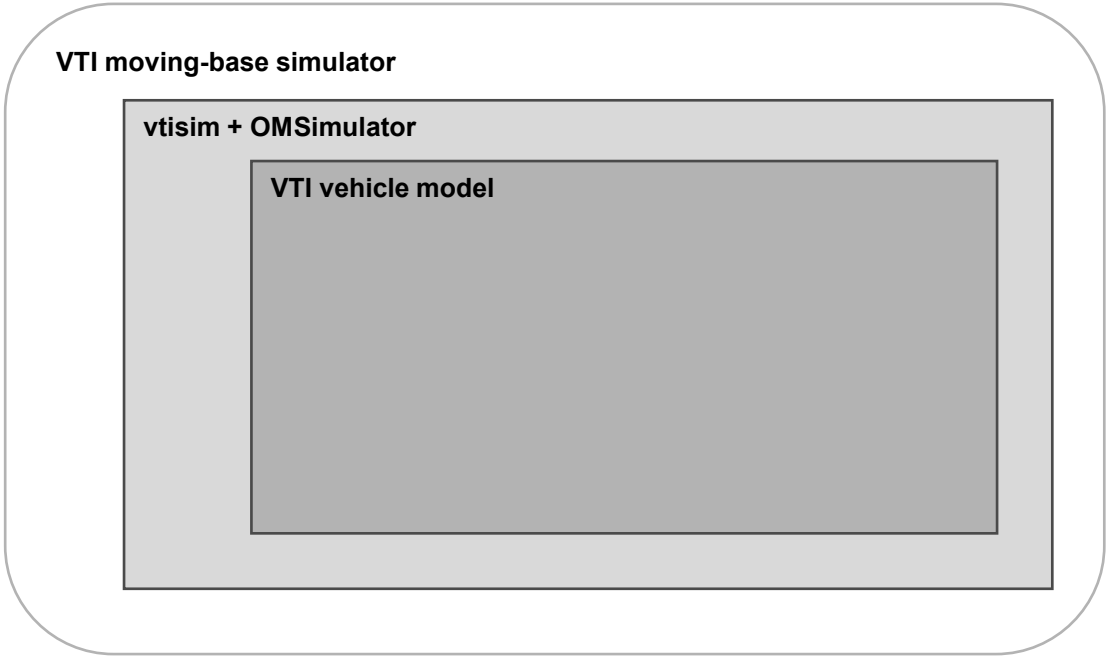
VTI SIMULATION ARCHITECTURE



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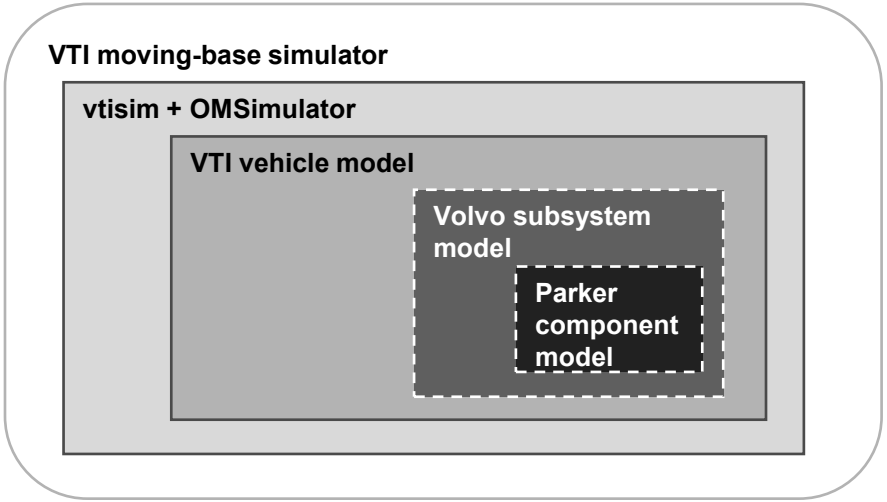
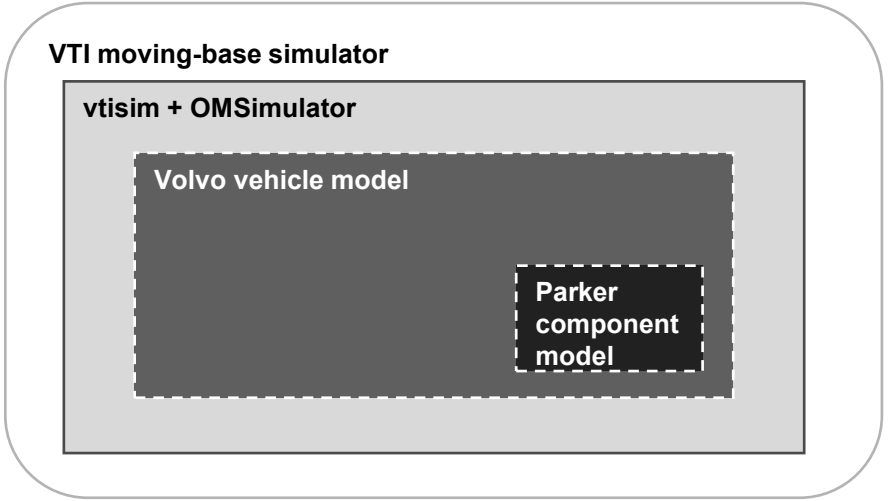
VTI SIMULATION ARCHITECTURE



ALTERNATIVE 1



ALTERNATIVE 2

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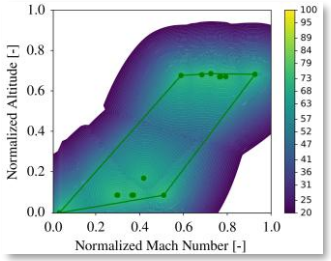
CREDIBILITY ASSESSMENT

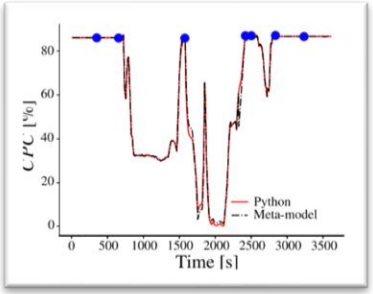
Aerospace Example:

```
<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

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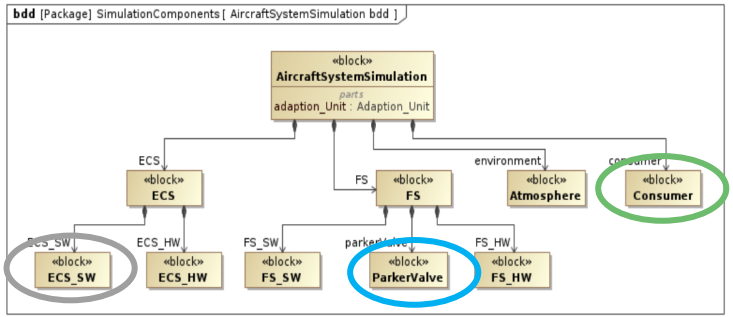
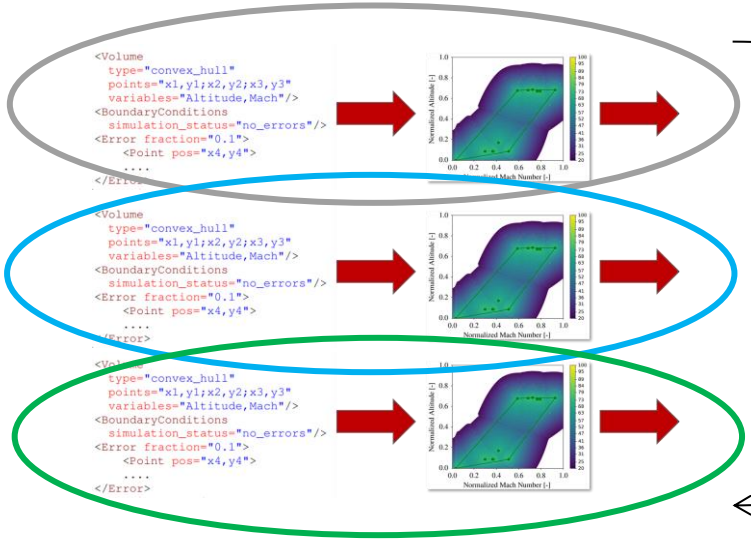
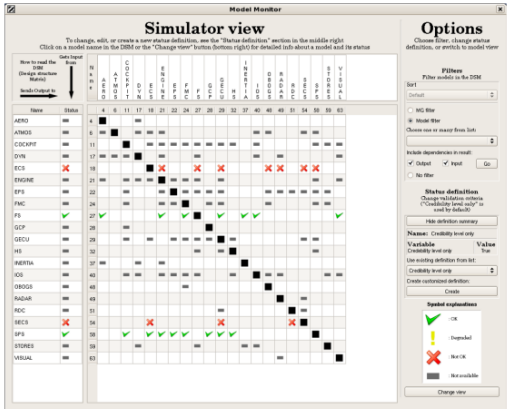
CREDIBILITY ASSESSMENT

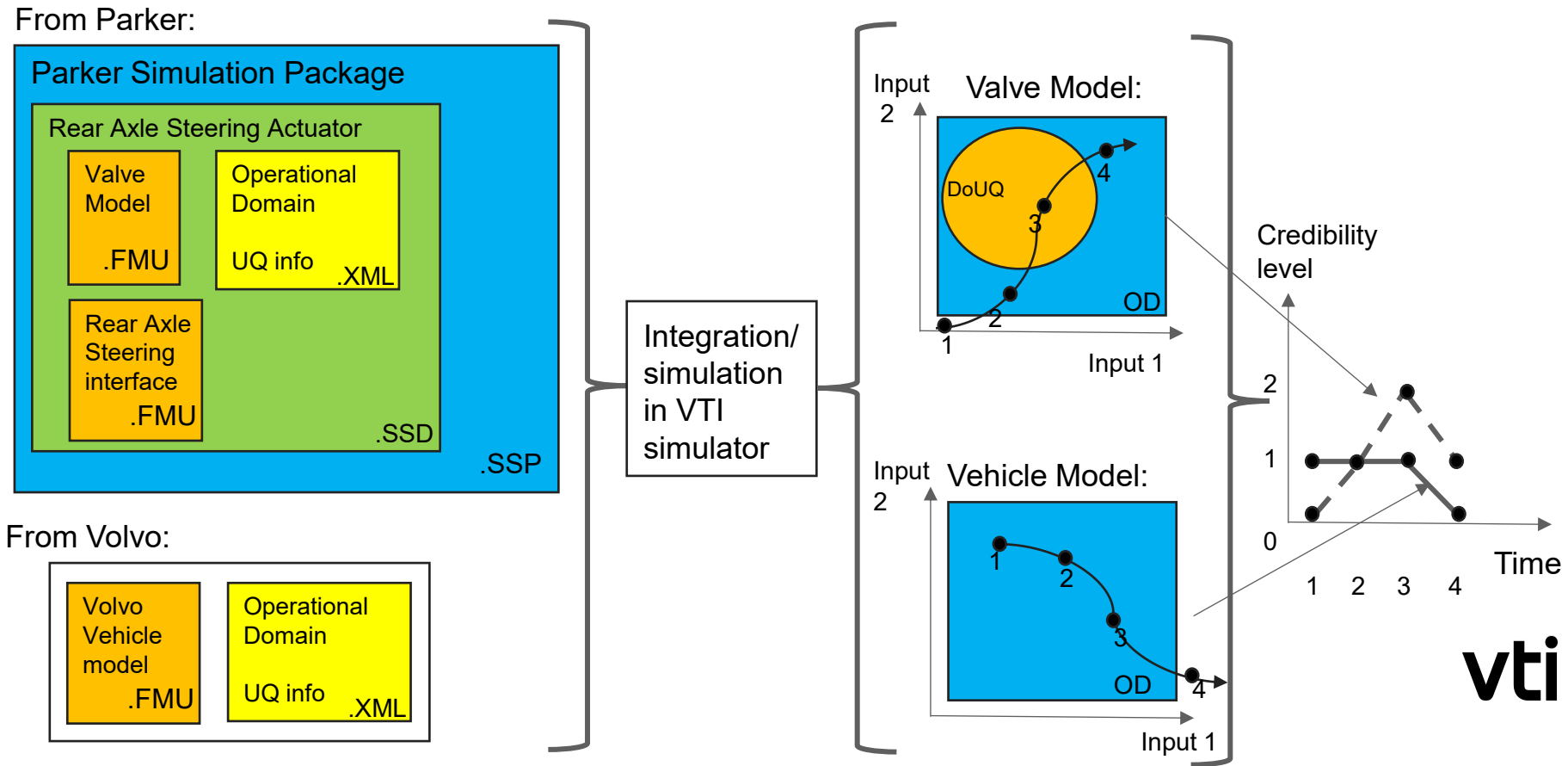
Aerospace Example:





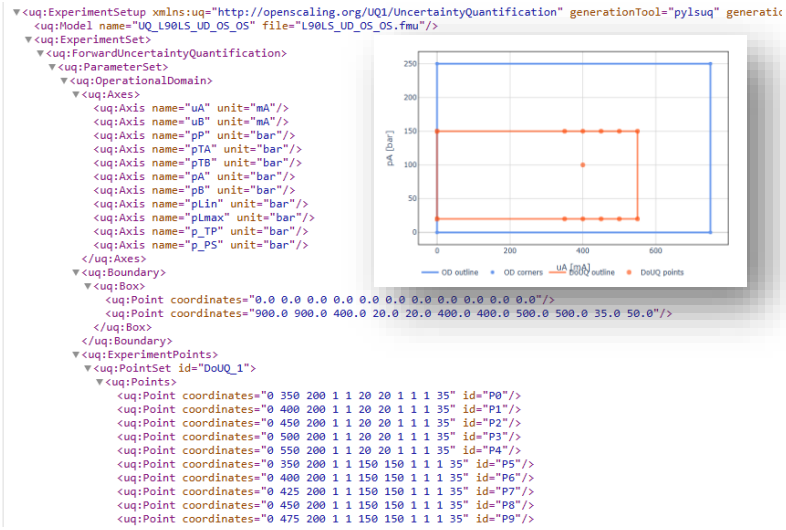


AUTOMOTIVE APPLICATION USE CASE RESULTS AIM



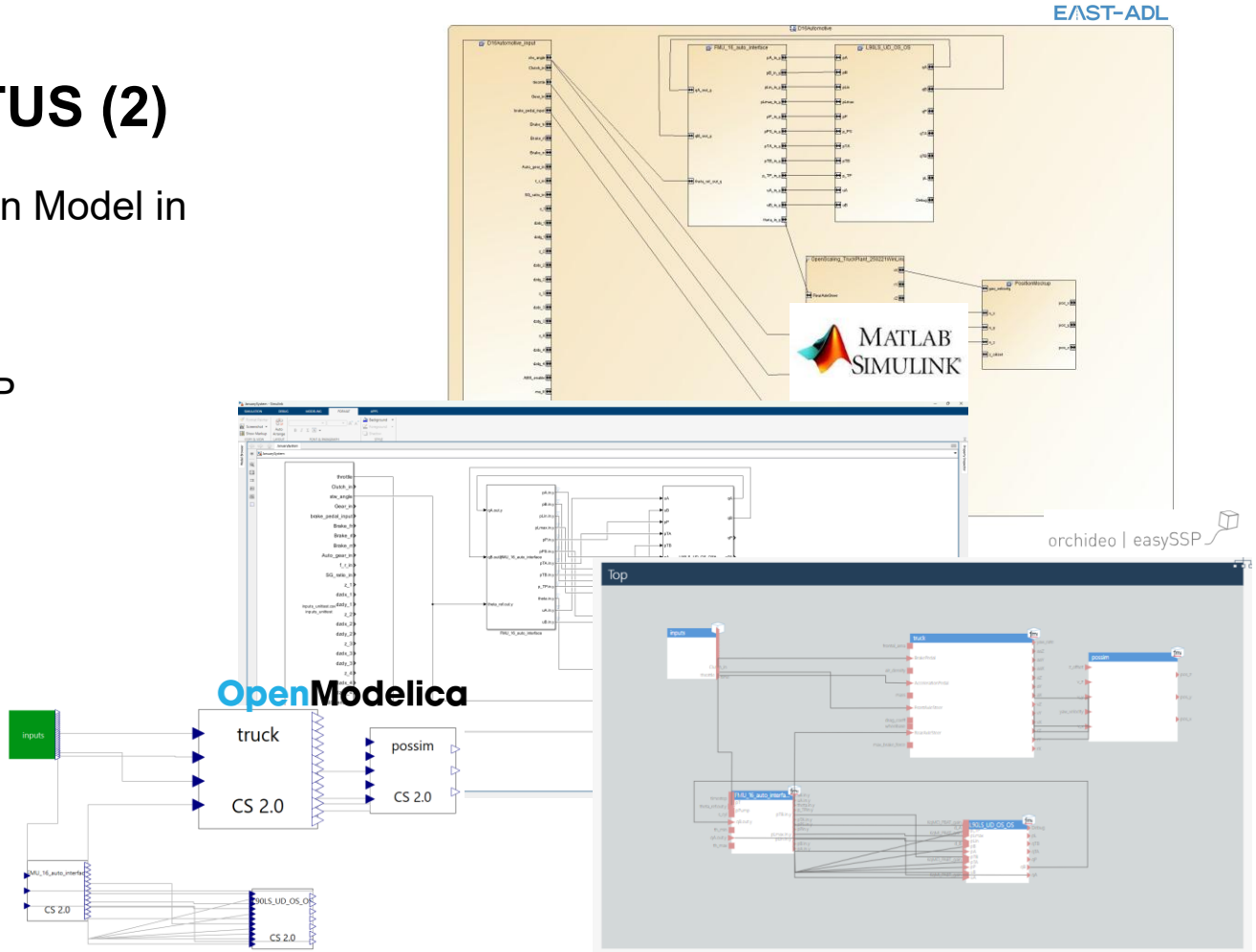
CURRENT STATUS (1)

- 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



CURRENT STATUS (2)

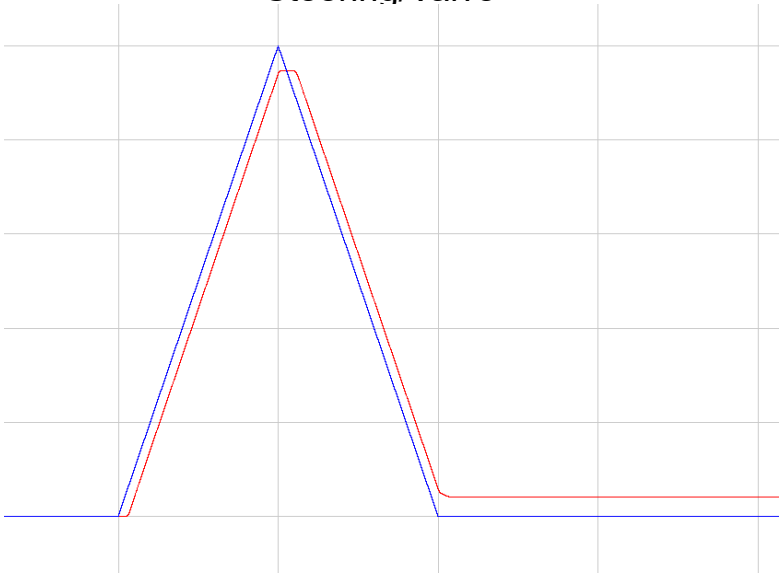
- Integrated Simulation Model in
  - EAST-ADL
  - Simulink
  - OMSimulator SSP
  - EASY-SSP SSP



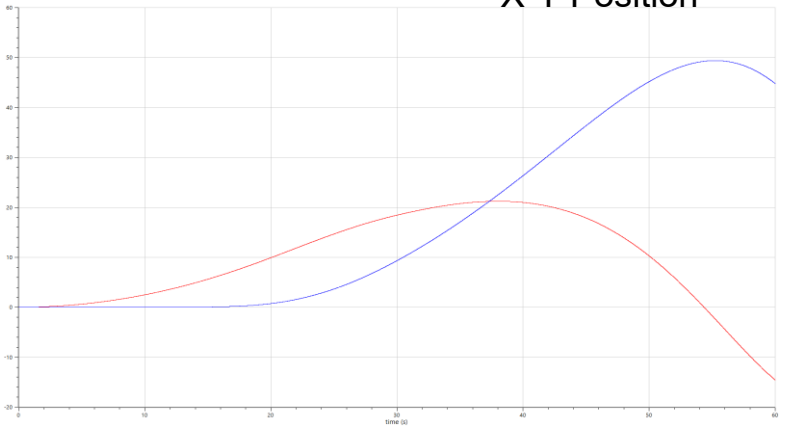
CURRENT STATUS (3)

- Simulation results

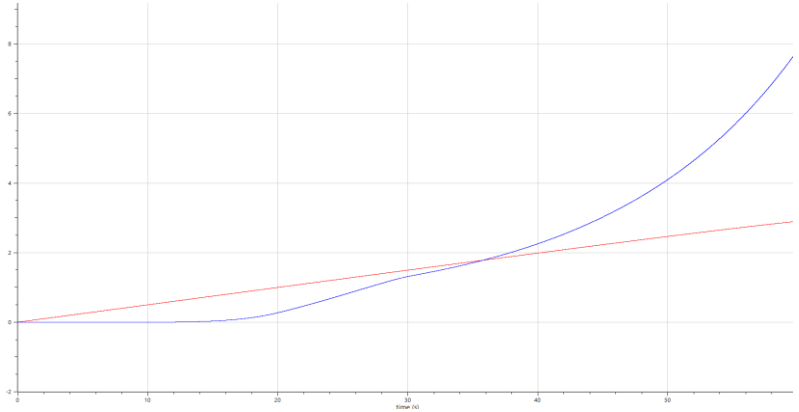
Steering/Valve



X-Y Position



X-Y Speed



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.

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Thank you

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