

AVL



AVL Powertrain Engineering Inc.



Level 2+ Advanced Driver Assist Algorithm Prototyping via Model Based Design

Yue Sun Et al.

AVL Company Overview – One Global Partner

RESEARCH

10% of turnover in-house R&D

INNOVATION

1,500 granted patents

STAFF

10,300 employees

65% engineers & scientists

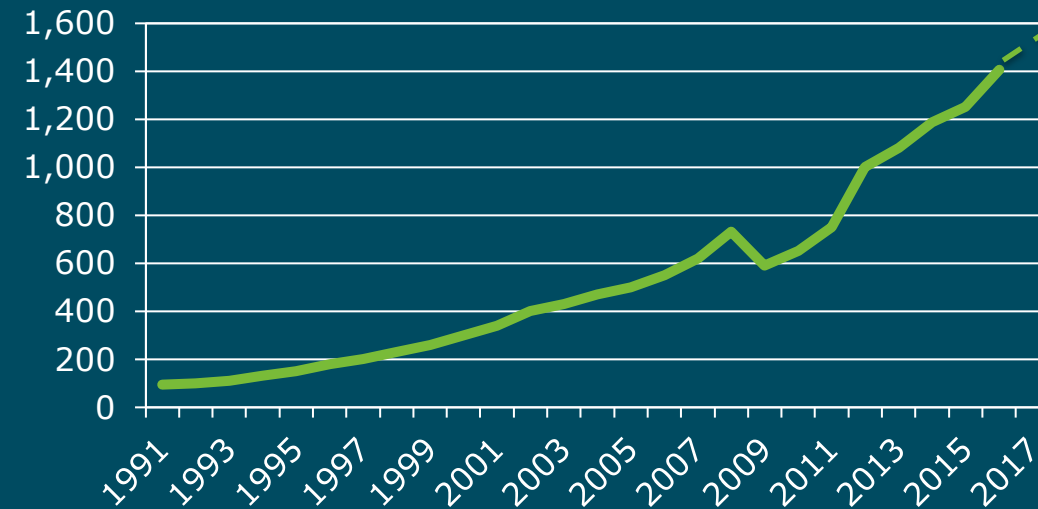
300 engineers in NA

GLOBAL FOOTPRINT

30 engineering locations

- >220 testbeds
- Global customer support network

GROWTH



SALES

1995:
0.15 billion €

2017:
1.55 billion €

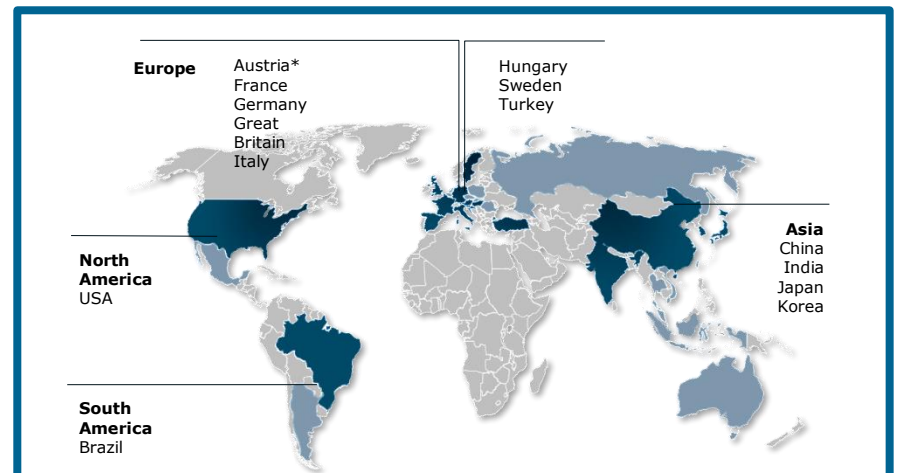
2018:
1.81 billion €

70

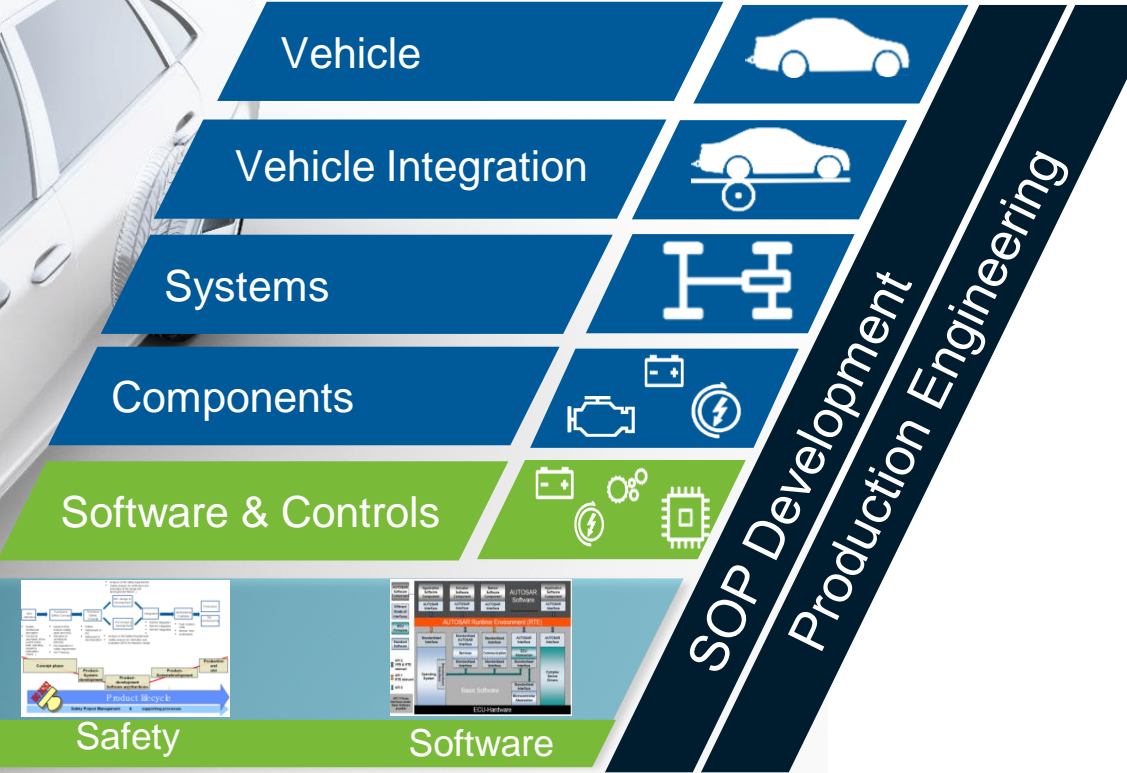
years of experience

SERVICES

powertrain to
vehicle integration



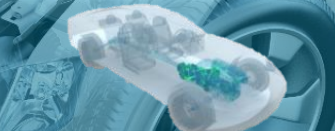
AVL Capabilities – Software & Controls



E-Mobility Controls



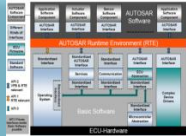
ADAS/AD Controls



Powertrain Controls



Safety



Software

AVL's Lv2+ ADAS/AD Function Offerings Via MathWorks Toolchain (MBD)

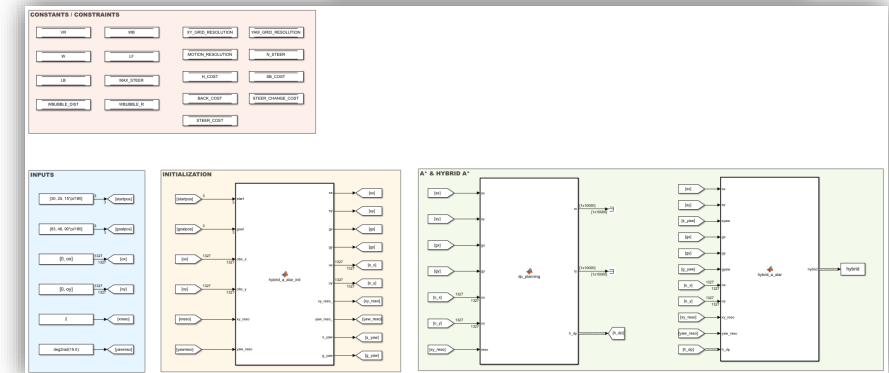


Rapid development & white-box libraries

- Localization
- Motion Planning & Control
- Sensor Fusion

Platform agnostic & open partnership functions

- Highway Pilot
- Urban Scenarios
- Parking Lot



MODULAR

Integration of algorithms executing at different rates

EFFICIENT

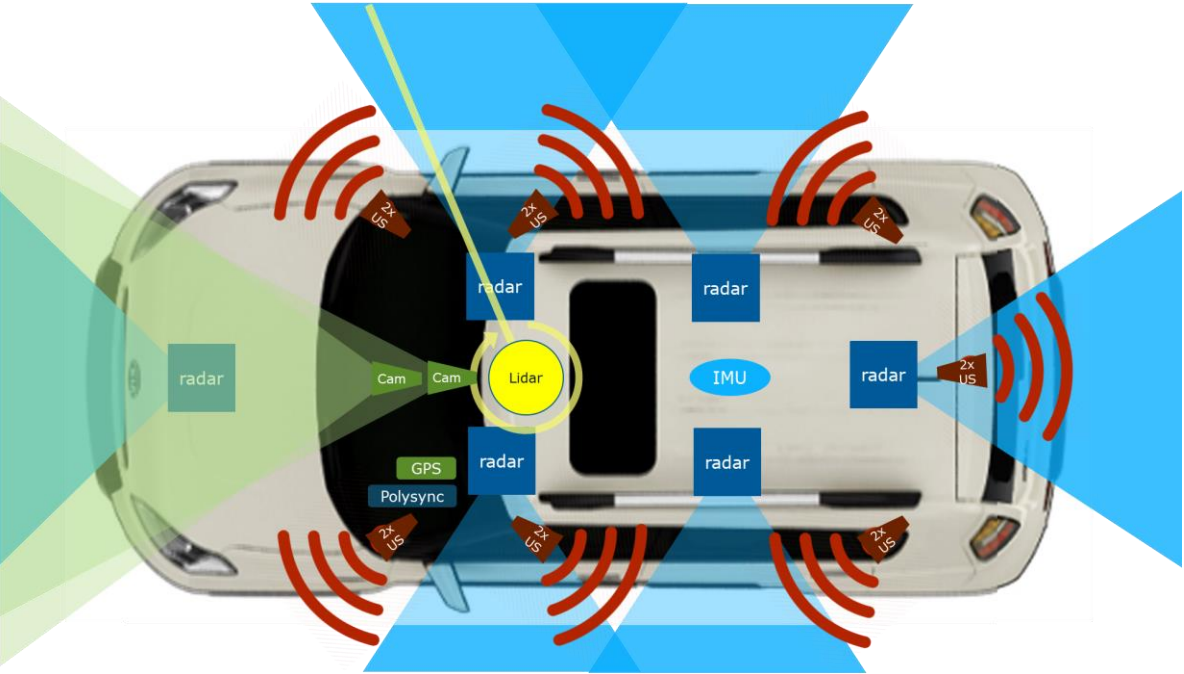
Automatic code generation of complex algorithms

TEAM SYNERGY

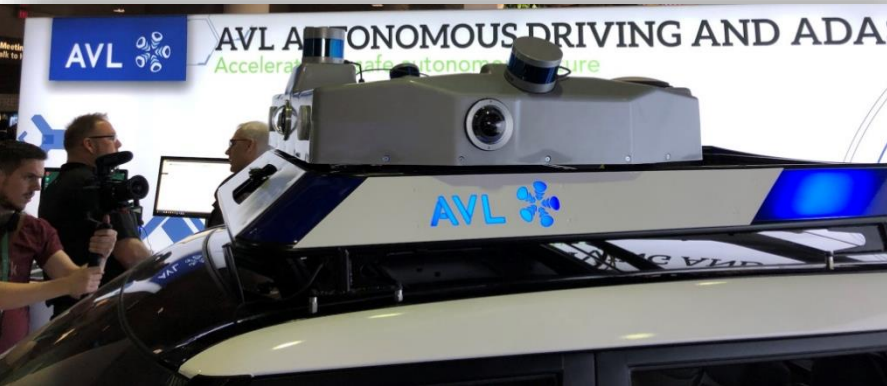
Team collaboration made easy across continents

ADAS/AD Function Development Platform

2018 KIA Soul EV AVL Development Platform

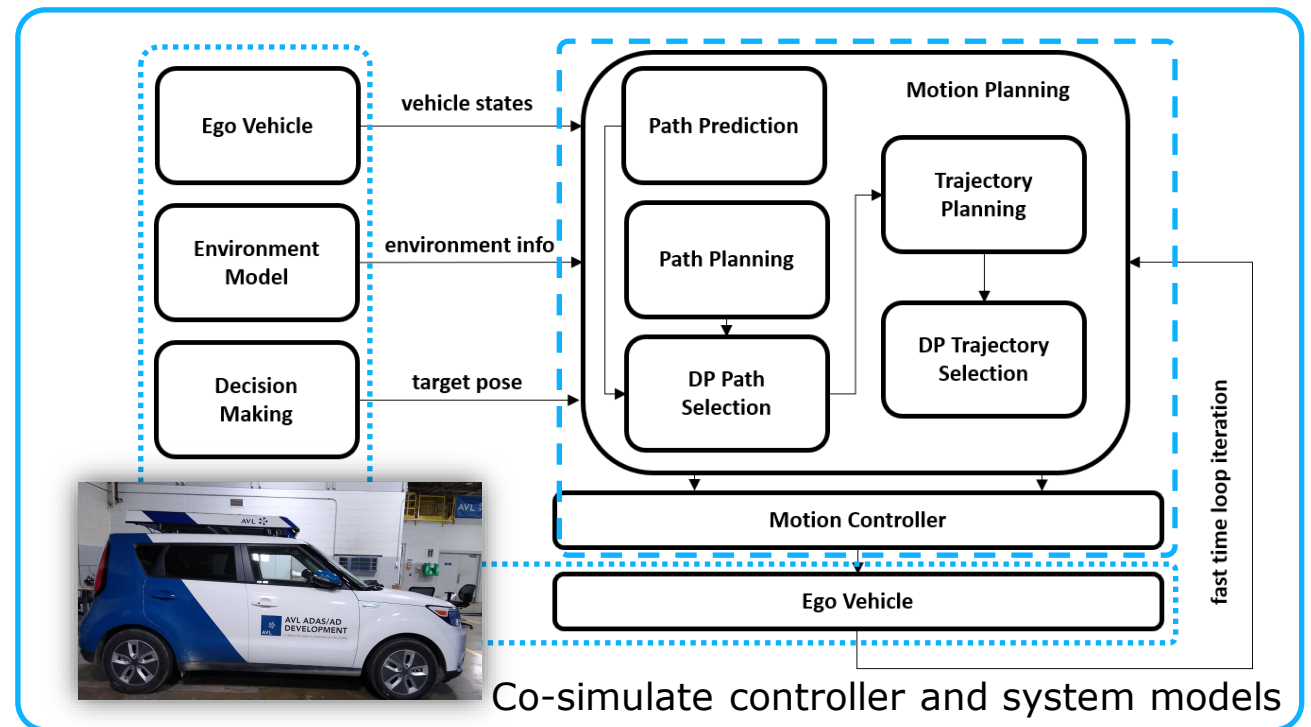
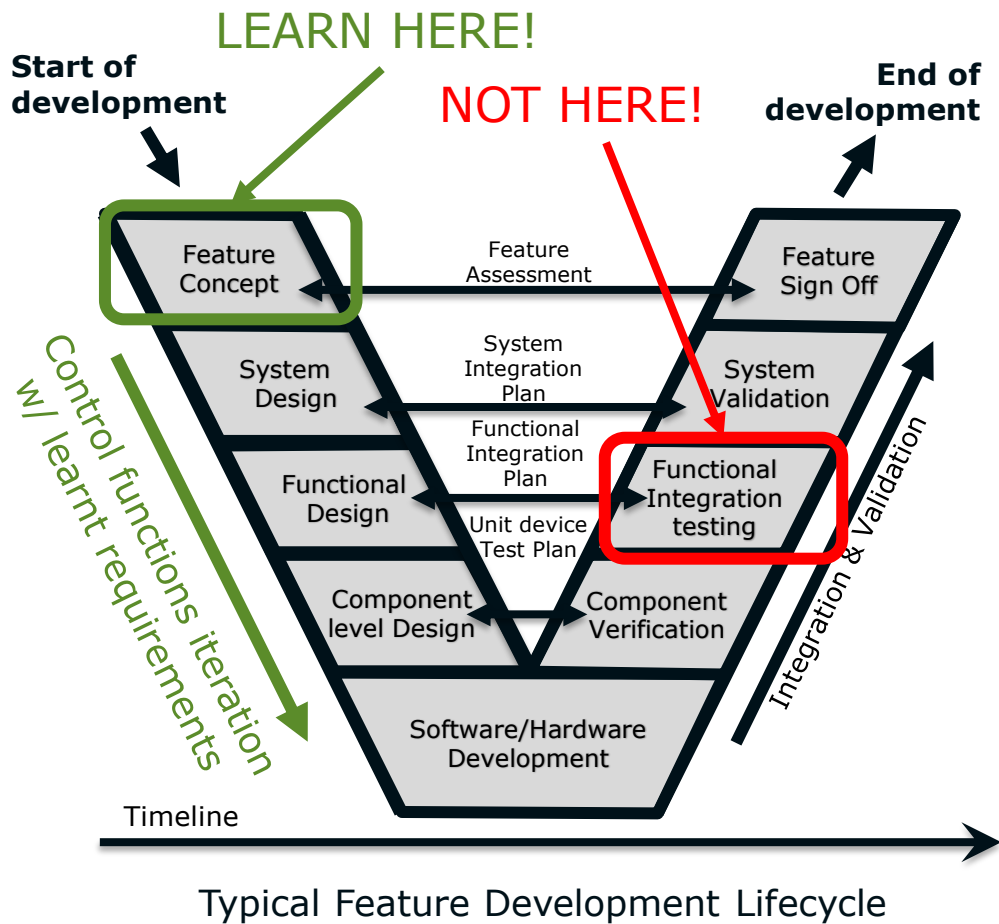


2020 Consumer Electronics Show (CES)



Lv2+ ADAS/AD MBD Process Overview

1. First-principles plant models of the system
2. Develop control algorithms
3. Co-simulate controller and system models
4. Next design iteration



1. First-principles plant models of the system



- AVL deploys various commercial vehicle dynamics tools to provide high-fidelity vehicle and powertrain dynamics within ADAS virtual environments, fully integrated to Simulink for controls development.

AVL VSM™ provides a high fidelity attribute balancing platform which can be embedded within ADAS environments such as **VTD**.



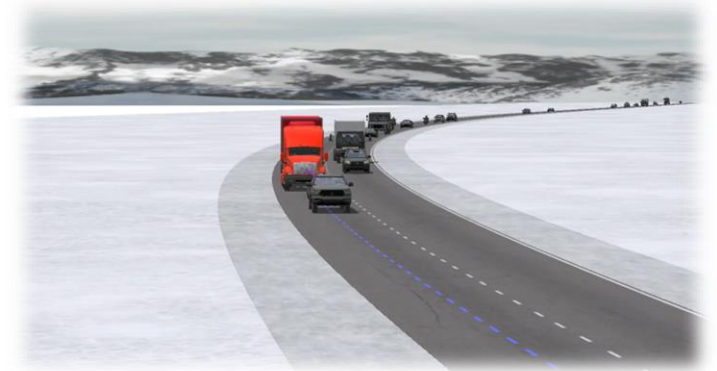
Torque Vectoring Demo



CarSim and **TruckSim** provides additional sensors and environments for ADAS simulation, to close the loop for controls performance assessment via **AVL-DRIVE Autonomous™**



AVL-DRIVE Maneuvers in CarSim/Simulink co-sim



AVL Traffic co-sim with TruckSim (ego in red)



1. AVL-DRIVE Autonomous A tool for the objective assessment



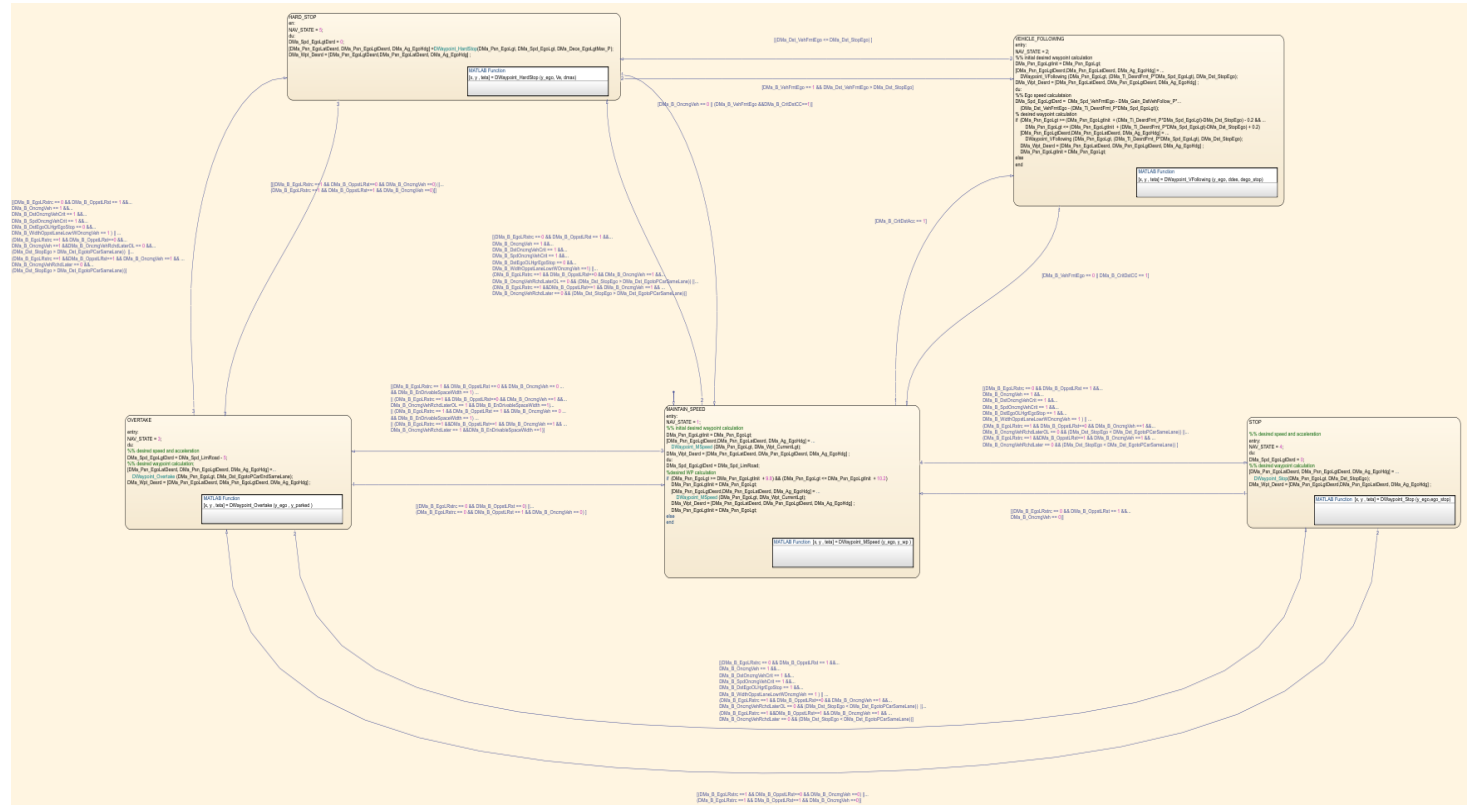
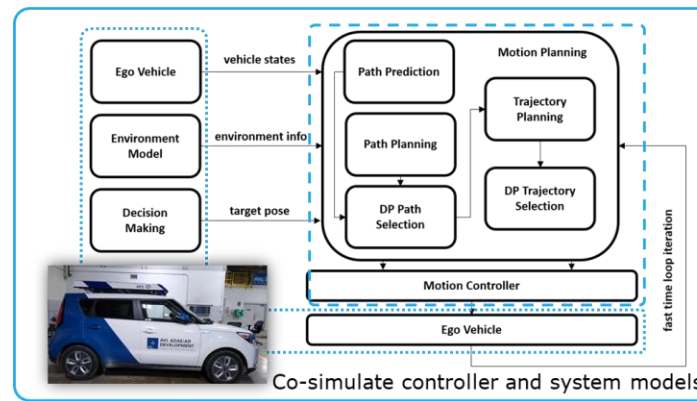
AVL-DRIVE Autonomous™

- Enhances the feedback from simulations with perceived safety, safety and comfort assessment
- Provides consistent development and testing tools on road, test bench and virtual environment
- Enable the reuse of office simulation environment for continuing development phases
- Provides maneuvers for scenario variations development to maximize test coverage



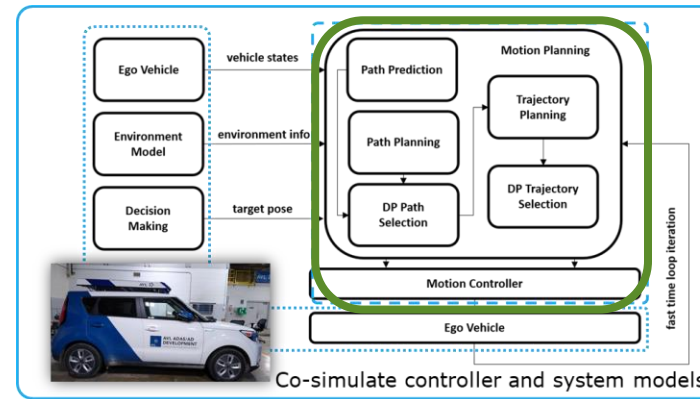
1. Modeling of other key components

- **Environment Model**
 - Occupancy Grid Representation
 - Drivable Space Identification
- **Decision Making**
 - Driving Scenario Identification
 - Target Maneuver Generation
- MBD advantage:
 - **Partnership Open**



2. Develop control libraries

Motion Planning SW development

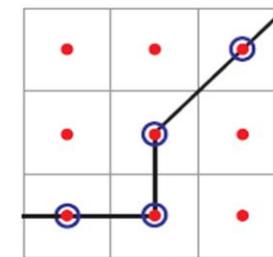
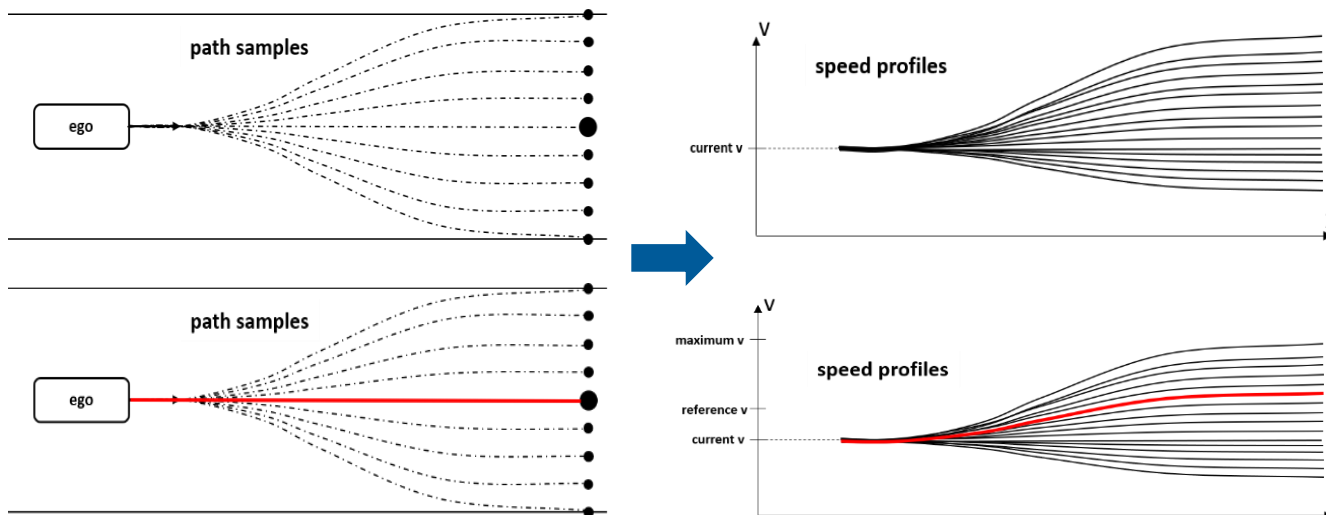


Structured Motion Planning

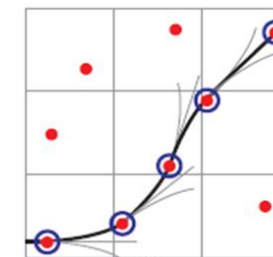
- Algorithms
 - Model Predictive Control Optimization & Dynamic Programming** for Path & trajectory sample generation and selection
- Data Structure
 - ArrayList** to store path and trajectory information

Unstructured Motion Planning

- Algorithms
 - Hybrid A*** and **Post Optimization**
- Data Structure
 - Graphs and Priority Queues** (MIN-Heap) for Forward State Generation & Search State Bookkeeping
 - Hash Tables** for Motion Primitive Look-Up & Cost Association



A* associates costs with centers of cells and only visits states that correspond to grid-cell centers.

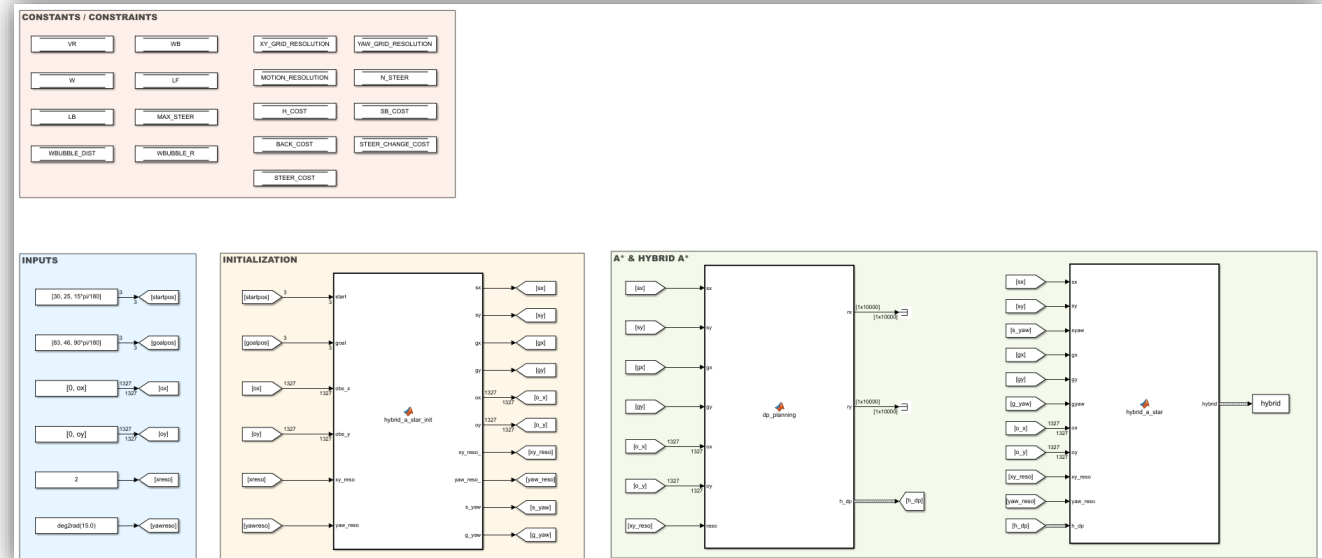
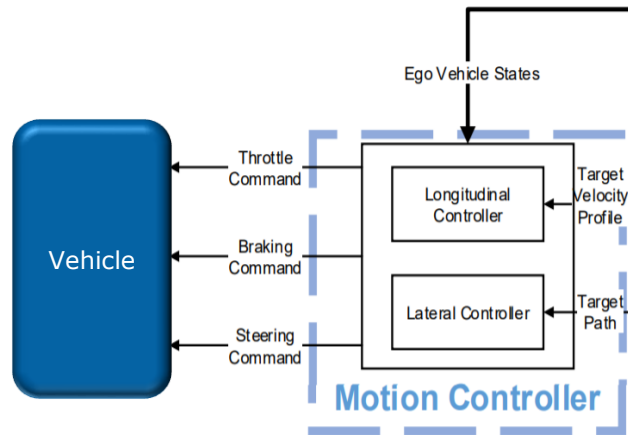
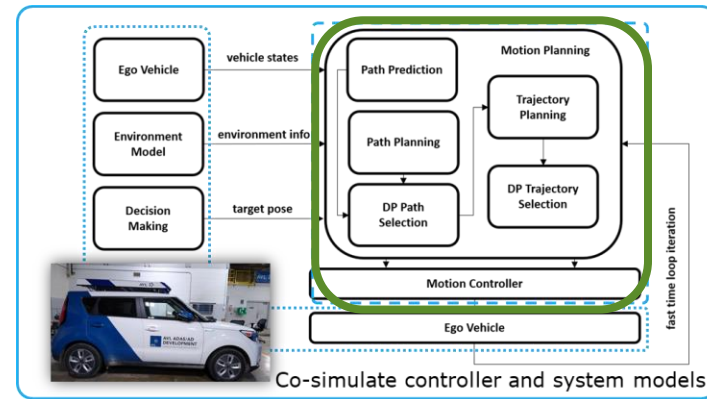


Hybrid A* associates a continuous state with each cell, and the score is the cost of its associated continuous state.

2. Develop control libraries

Motion Control SW Development

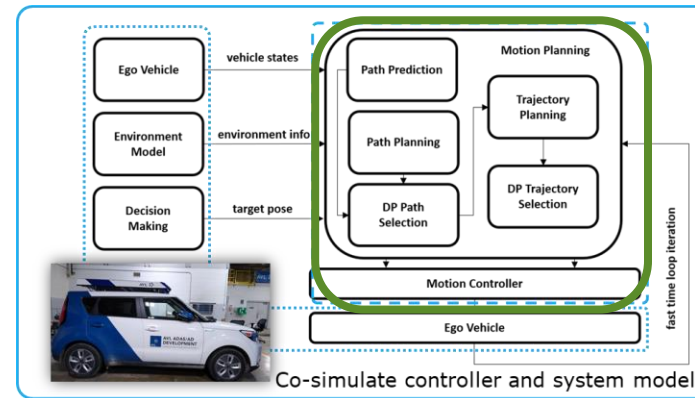
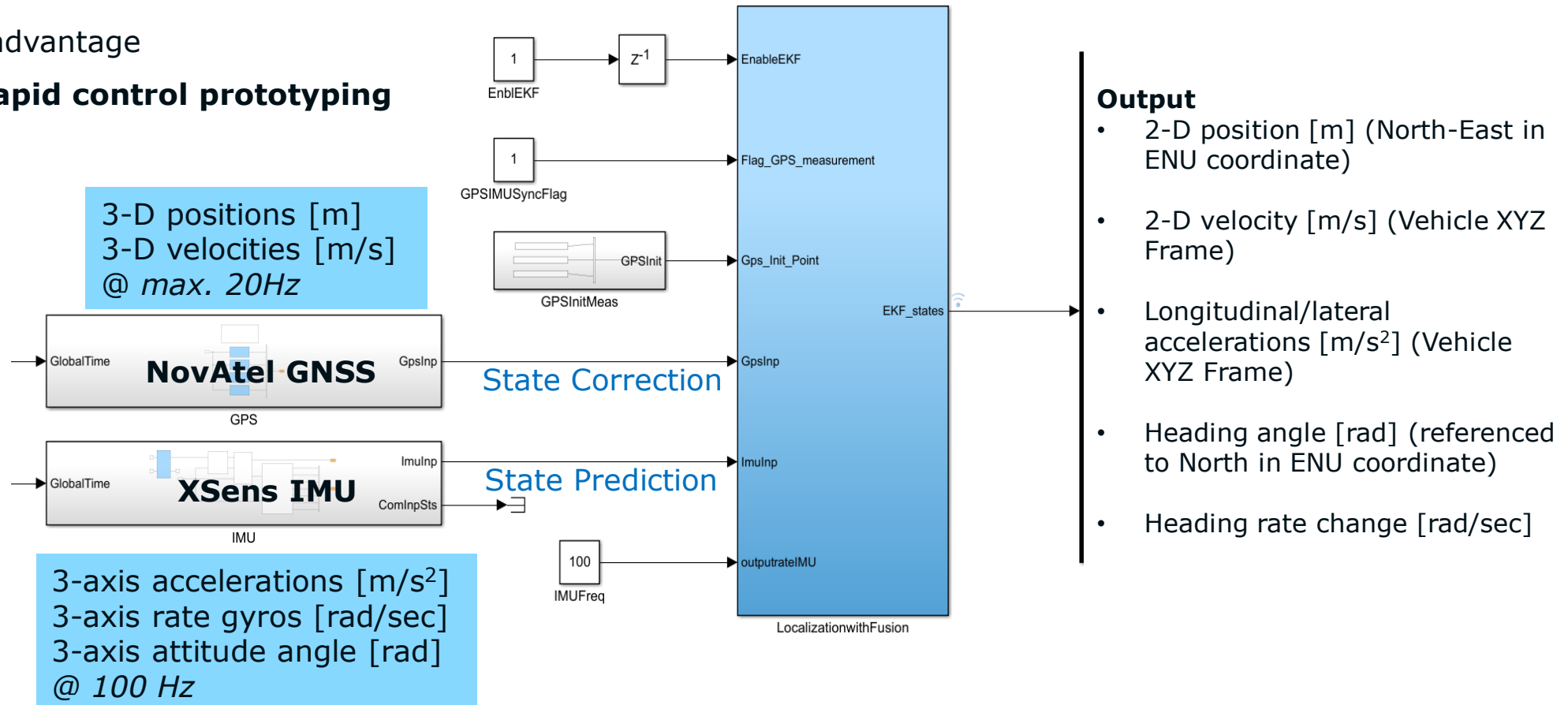
- Algorithms
 - Longitudinal Control
 - Feedforward** and **feedback PI** control for throttle and brake
 - Lateral Control
 - Extended Stanley** method for steering control



2. Develop control libraries

Localization

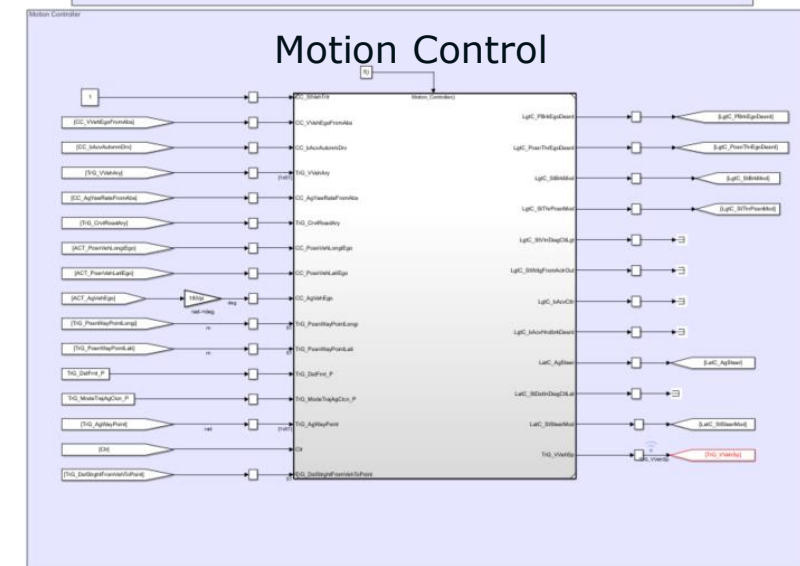
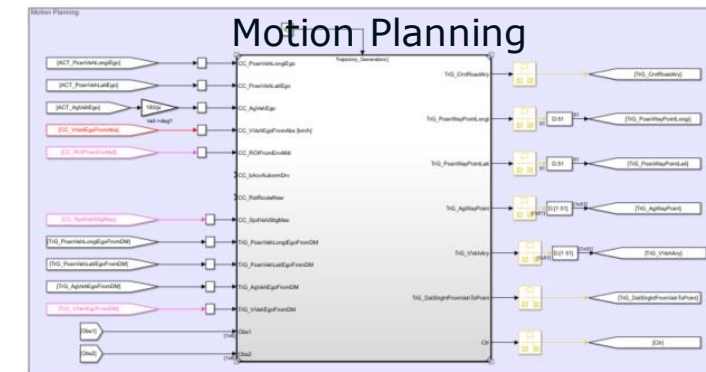
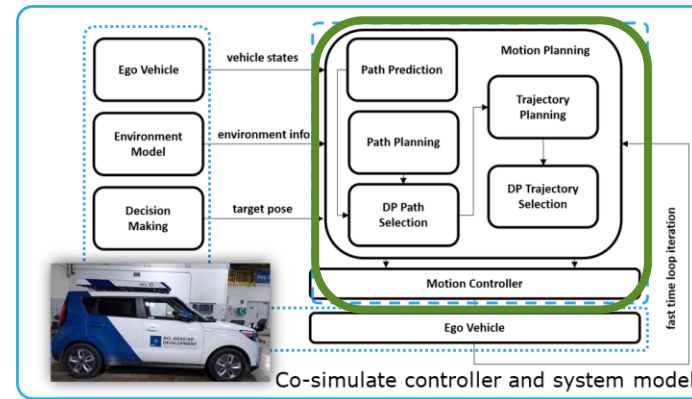
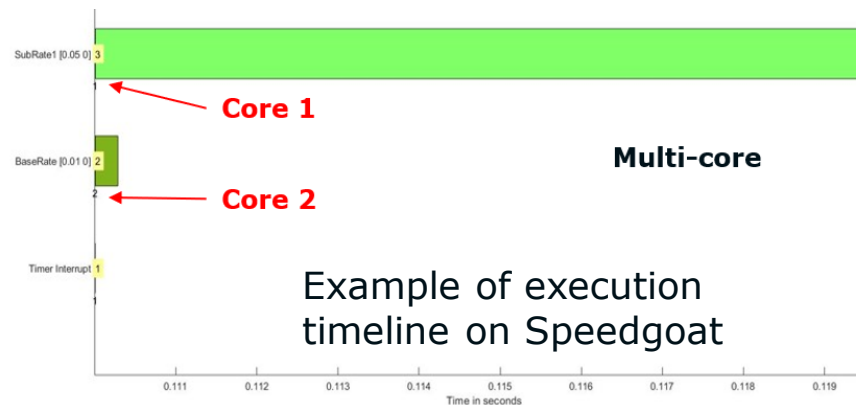
- Algorithms
 - Extended Kalman Filter**
- MBD advantage
 - Rapid control prototyping**



2. Develop control libraries

Integration – Threading & Parallelization

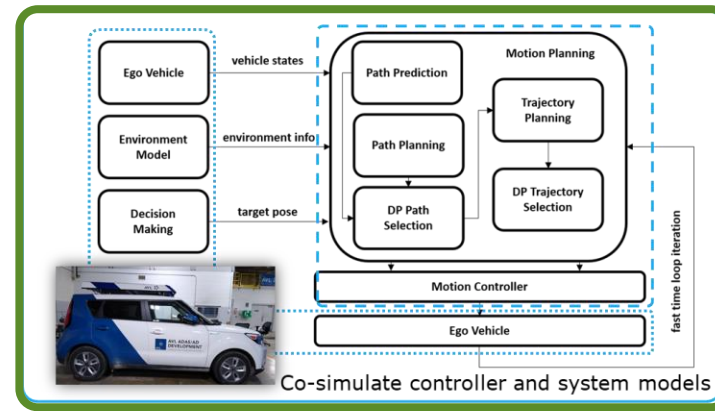
- Modules implemented as **model reference** function-call subsystems to enable:
 - Different execution rates
 - Core partitioning on the hardware
- MBD Advantage
 - Hardware platform **agnostic**
 - Available **tools** for synchronization and memory configuration to grant successful threading and parallelization



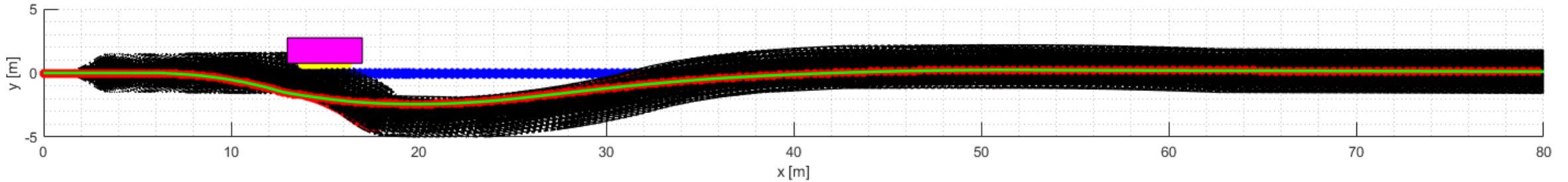
3. Co-simulate controller and system models



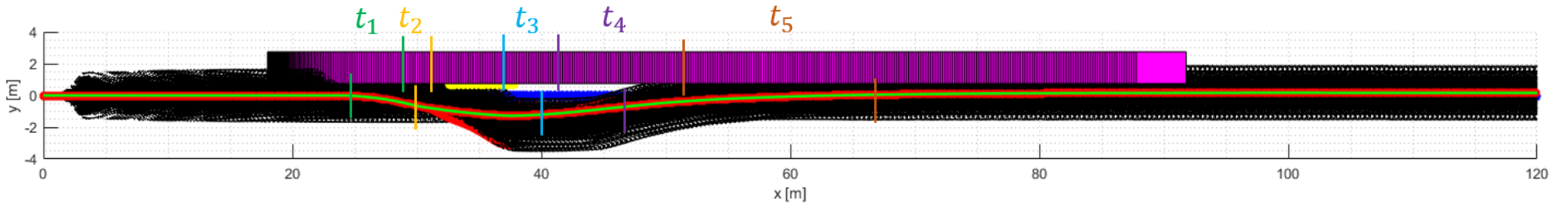
MIL Simulation Results



Static Vehicle Take Over



Dynamic Vehicle Trajectory Prediction and Take Over

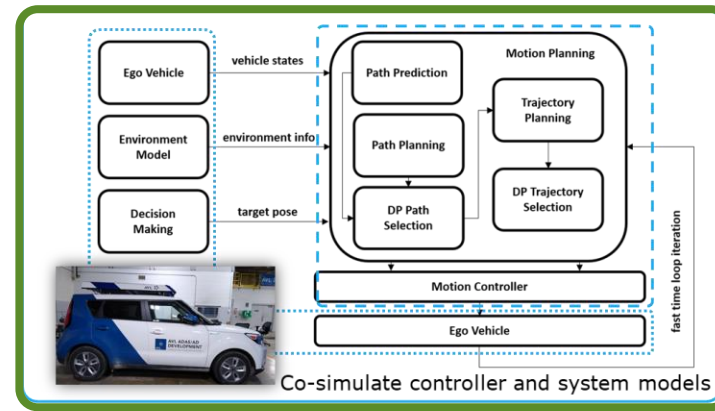


3. Co-simulate controller and system models

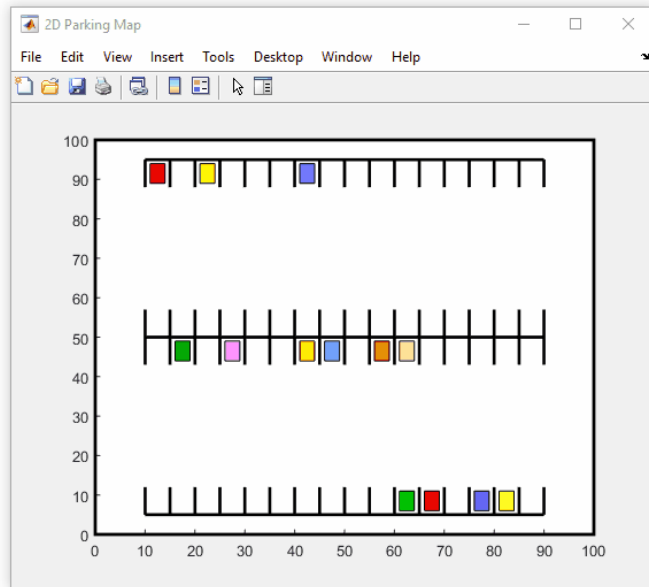


MIL Simulation Results in Parking Lot

Pose = (x, y, Θ)

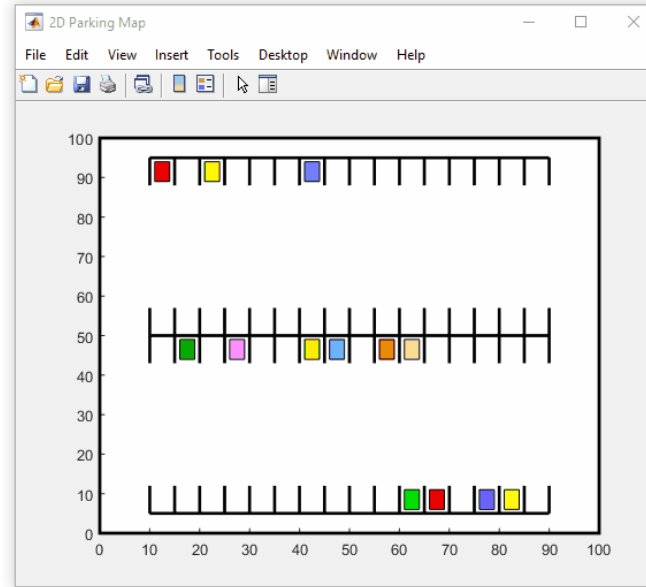


: A
 ○: Hybrid A*



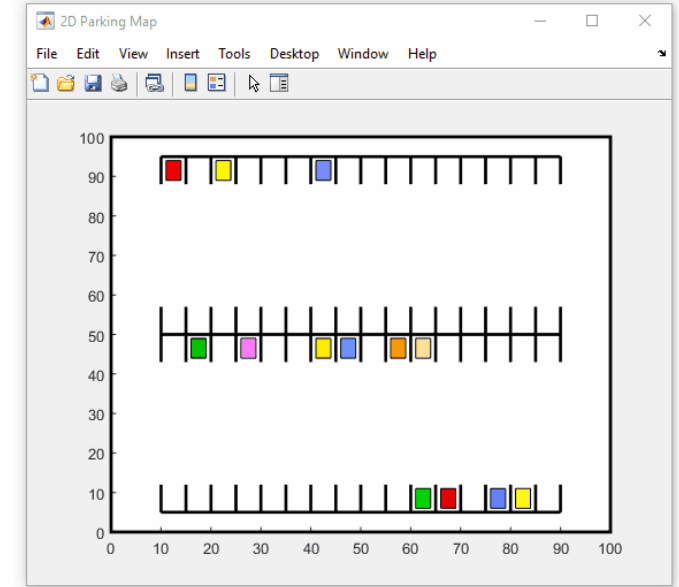
Start Pose: $x=30, y=25, \Theta=15^\circ$

Goal Pose : $x=83, y=46, \Theta=90^\circ$



Start Pose: $x=10, y=80, \Theta=0^\circ$

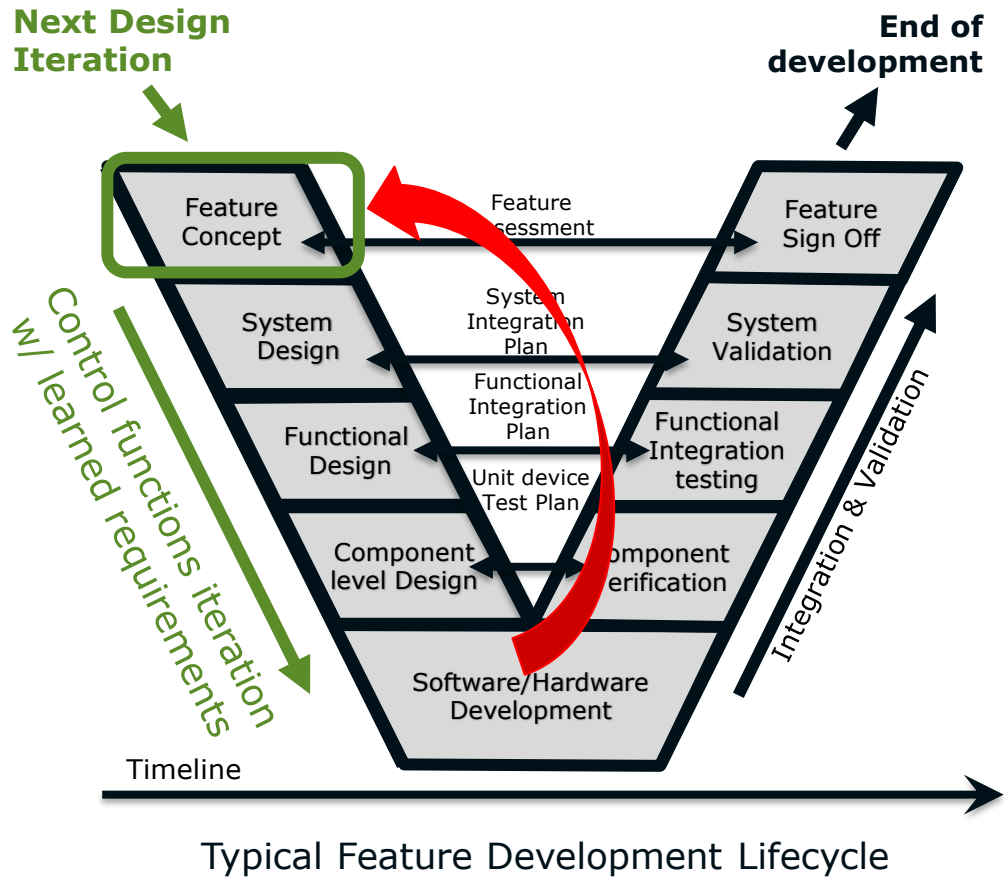
Goal Pose : $x=57, y=92, \Theta=-90^\circ$



Start Pose: $x=5, y=20, \Theta=90^\circ$

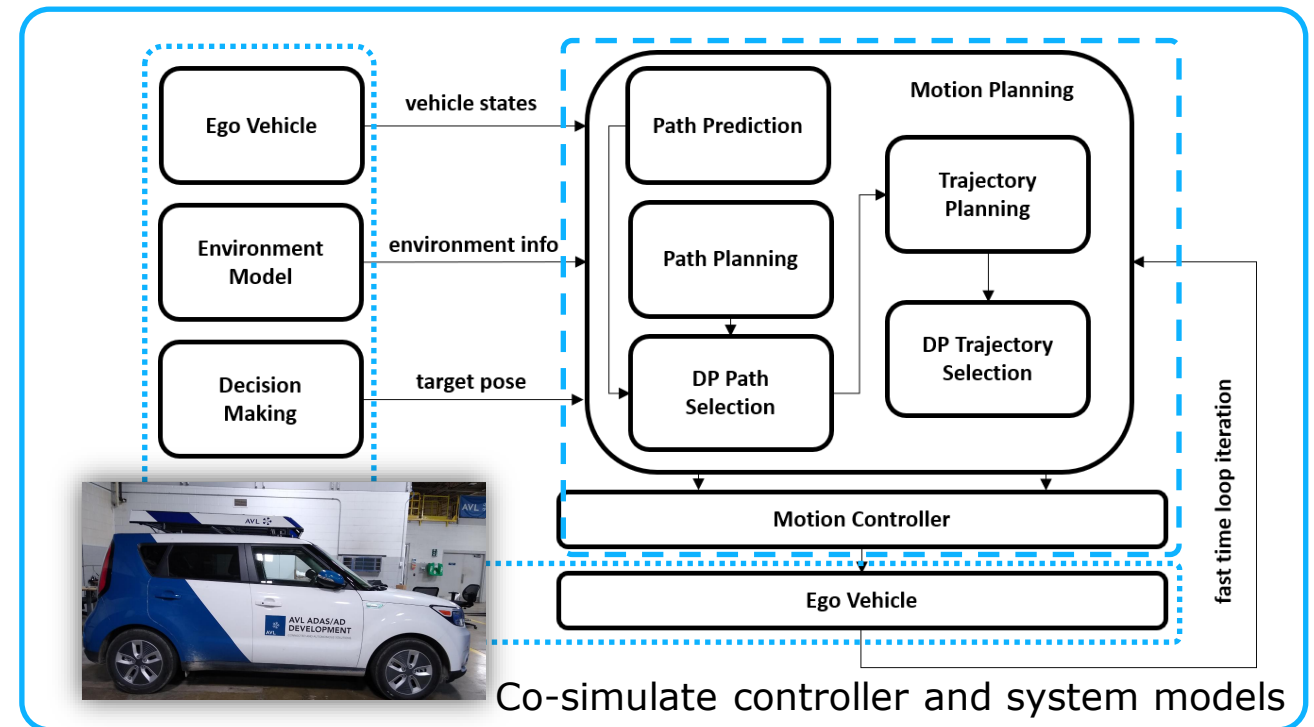
Goal Pose : $x=78, y=90, \Theta=90^\circ$

4. Next design iteration



Simulation output used to increase feature maturity resulting in:

- Honed requirements
- Feature performance improvements
- Library iteration



AVL's Lv2+ ADAS/AD Function Offering Via MathWorks Toolchain (MBD)

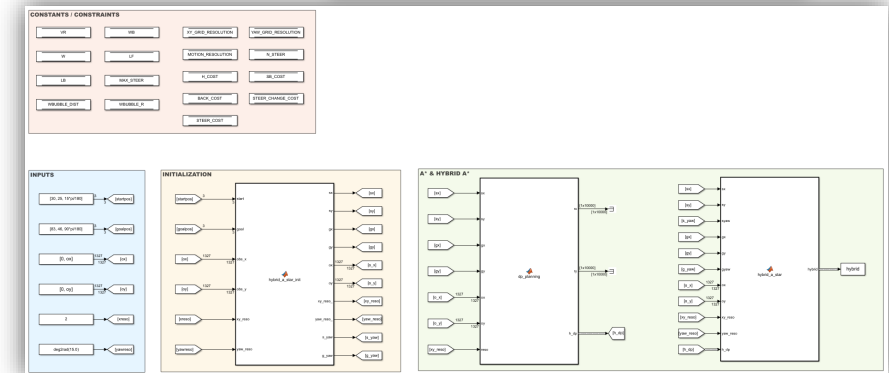


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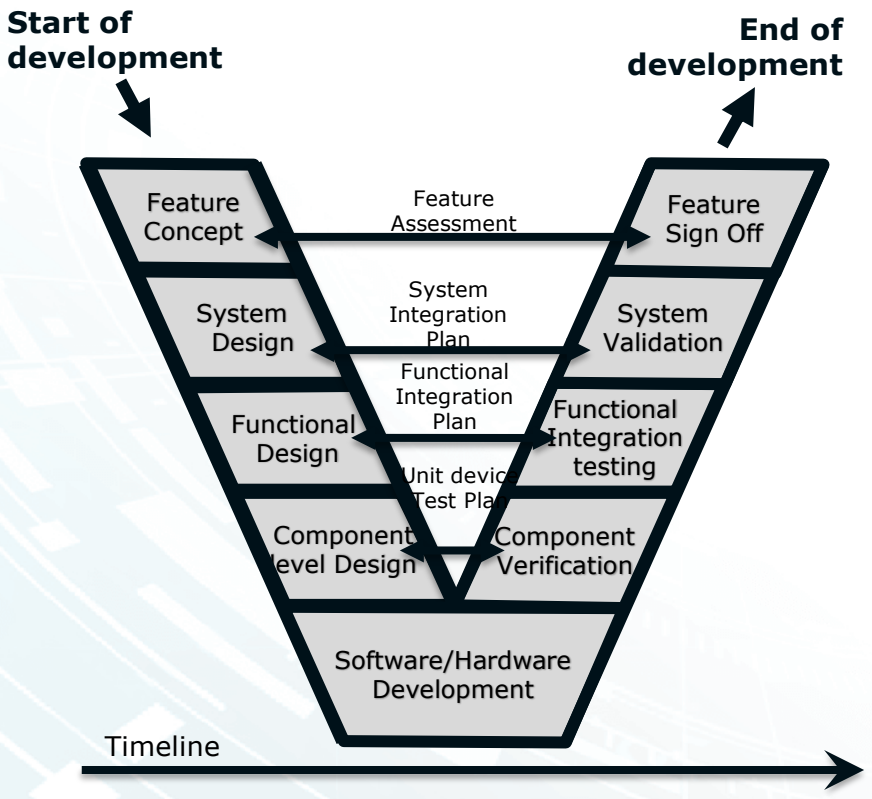
EFFICIENT

Automatic code generation of complex algorithms

TEAM SYNERGY

Team collaboration made easy across continents

Additional AVL Offerings in ADAS/AD Domain



AVL VSM™
Precise vehicle dynamics simulation

Sensor Simulation
Models for Radar, Lidar, Camera and Ultrasonic

Environment Simulation
Traffic, road and environment modelling

Test Case Generator
Based on scenarios

Cloud Master
Parallel computing

Model.CONNECT
Co-Simulation Platform

AVL-DRIVE™
Objective evaluation of Automated Driving (Incl. perceived safety)

AVL CAMEO™
Active DoE test optimization

AD Controller
e.g. ACC/LKA, AEB, Highway Pilot, Traffic Jam Pilot, Automated Parking

Key Contacts & Contributors

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Thank You



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