

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

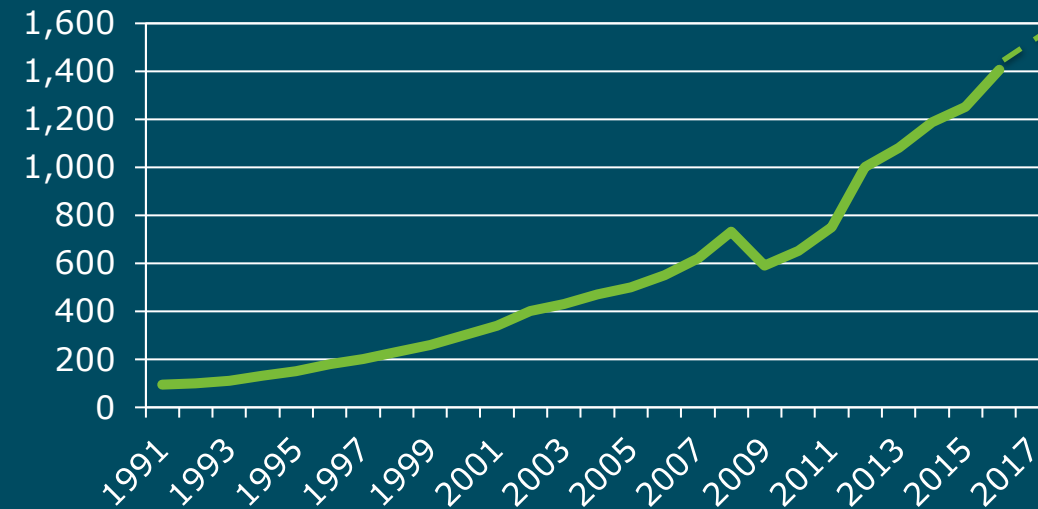
300 engineers in NA

GLOBAL FOOTPRINT

30 engineering locations

- >220 testbeds
- Global customer support network

GROWTH



SALES

1995:
0.15 billion €

2017:
1.55 billion €

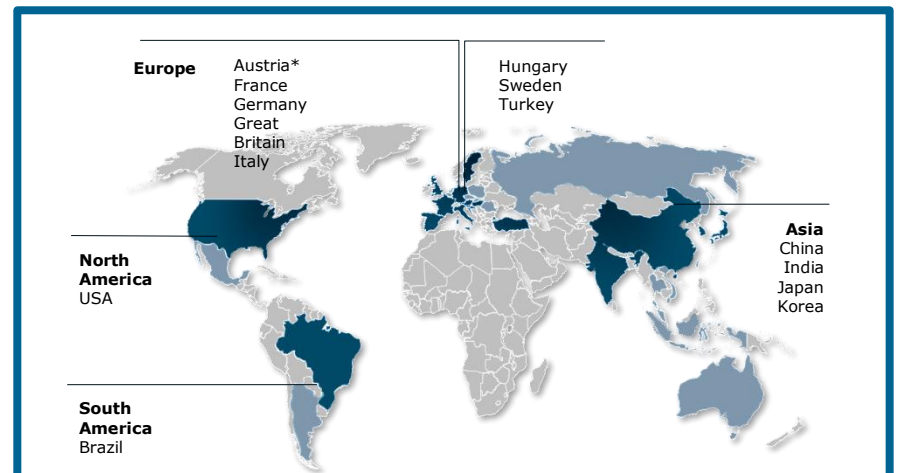
2018:
1.81 billion €

70

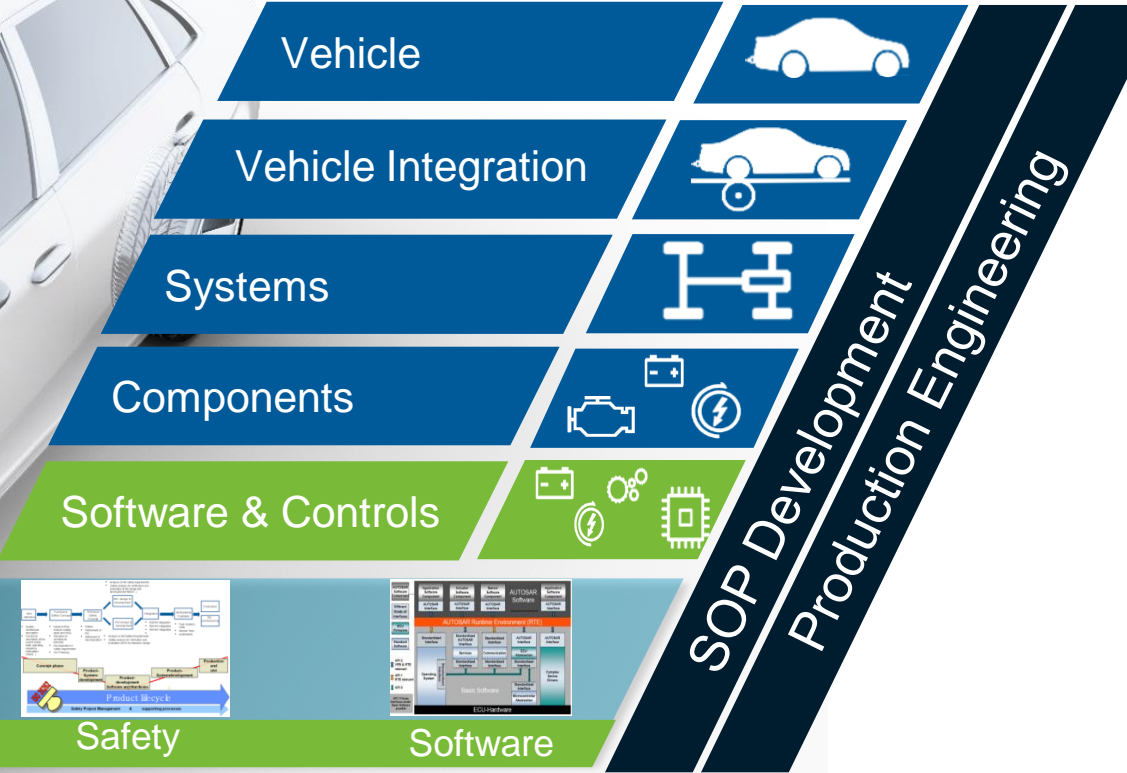
years of experience

SERVICES

powertrain to
vehicle integration



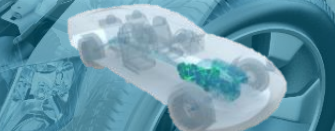
AVL Capabilities – Software & Controls



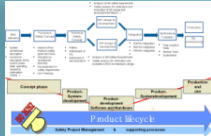
E-Mobility Controls



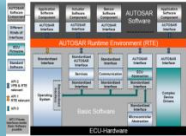
ADAS/AD Controls



Powertrain Controls



Safety



Software

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

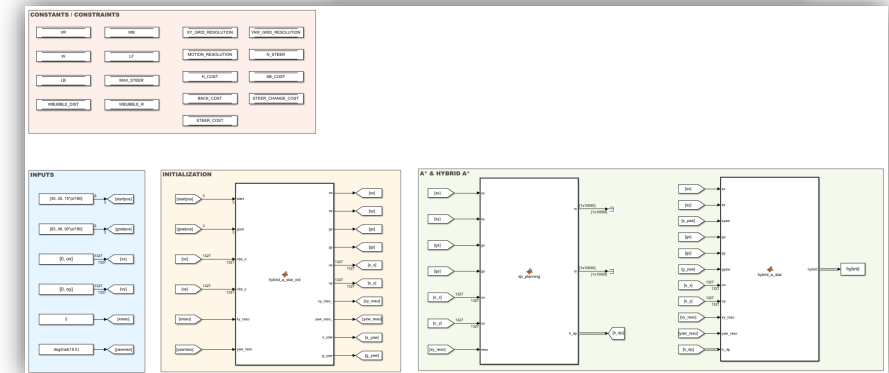


Rapid development & white-box libraries

- 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

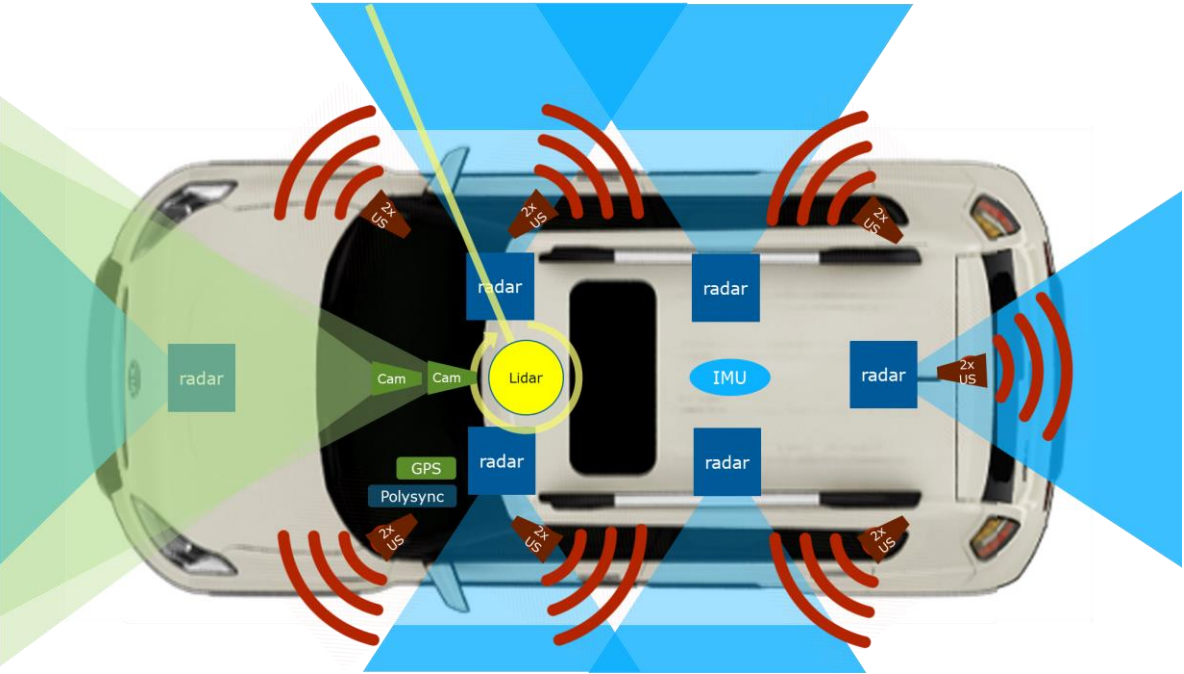
Automatic code generation of complex algorithms

TEAM SYNERGY

Team collaboration made easy across continents

ADAS/AD Function Development Platform

2018 KIA Soul EV AVL Development Platform

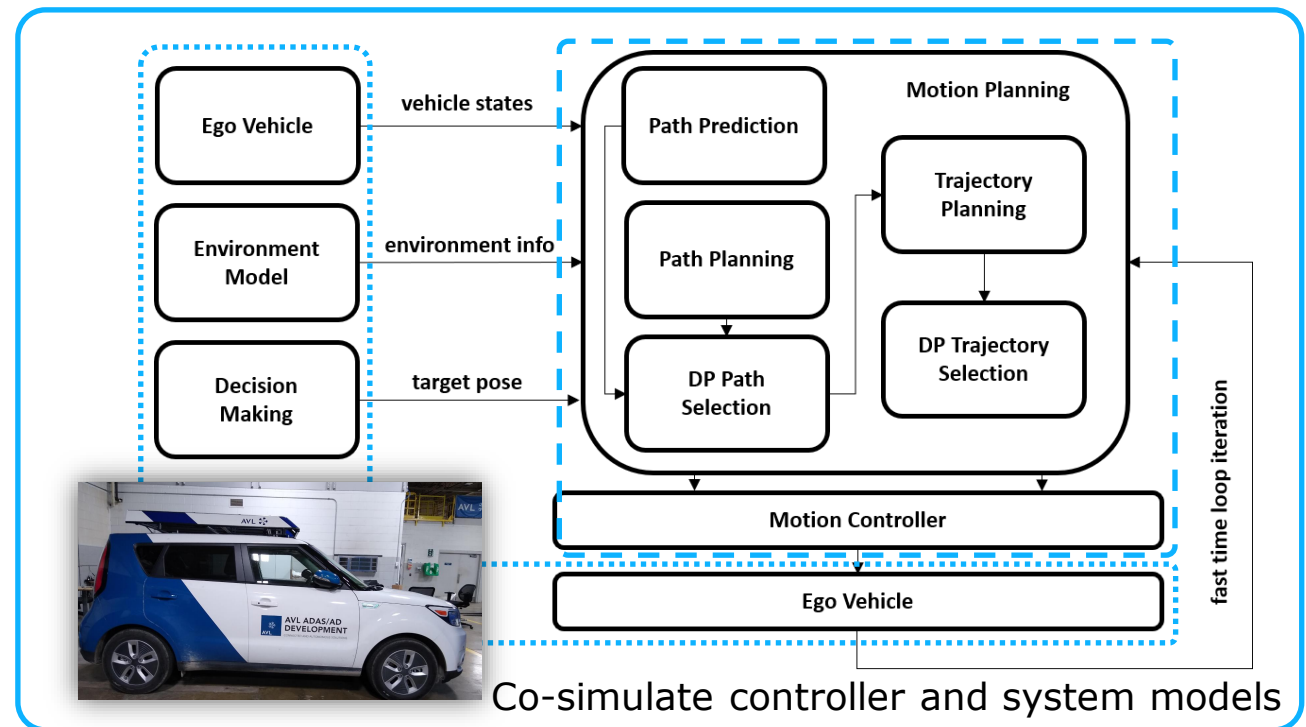
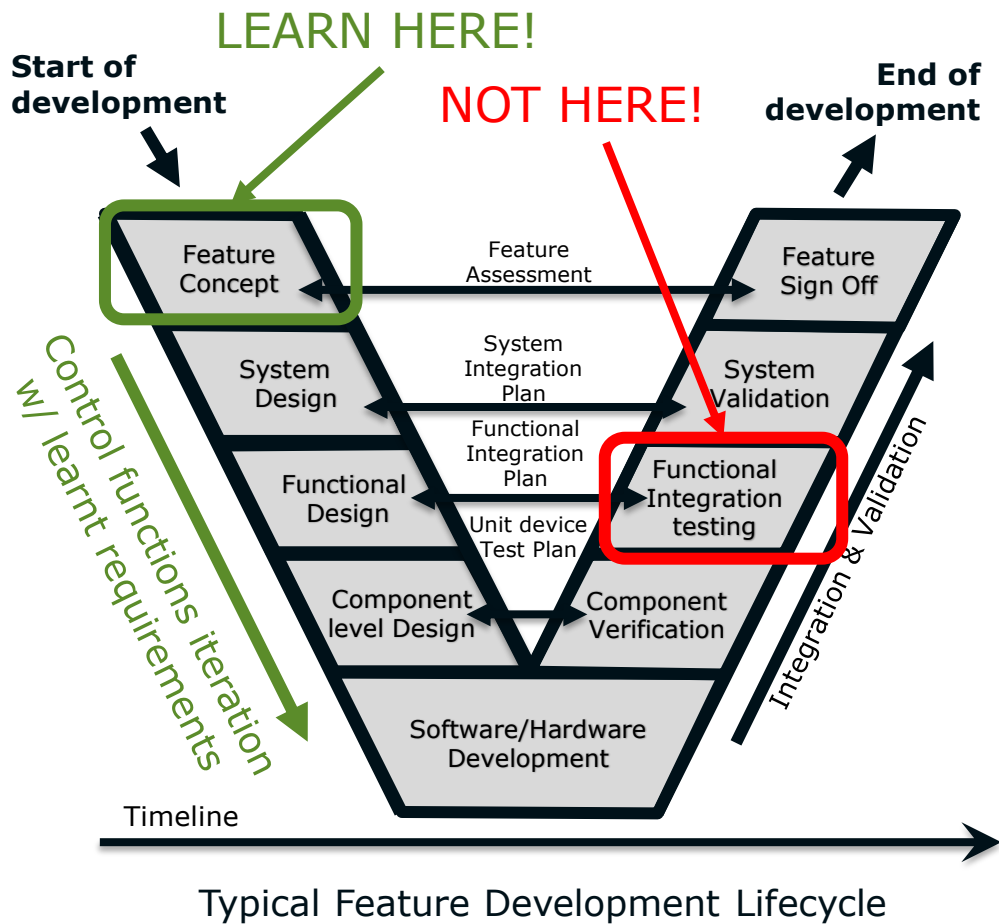


2020 Consumer Electronics Show (CES)



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**.



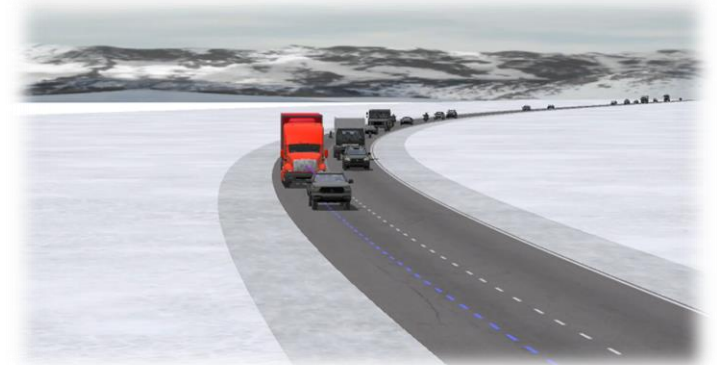
Torque Vectoring Demo



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



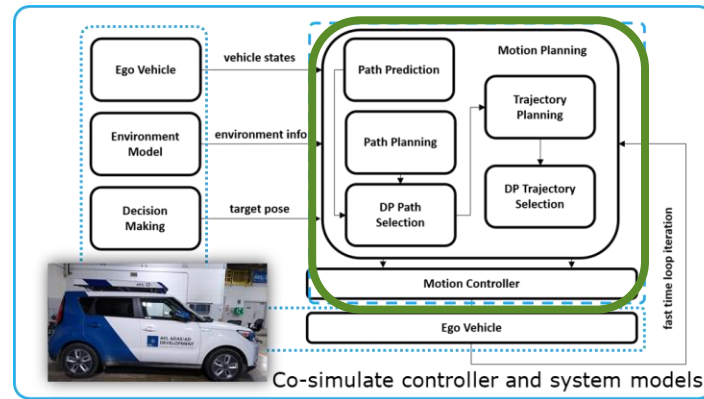
AVL-DRIVE Autonomous™

- 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



2. Develop control libraries

Motion Planning SW development

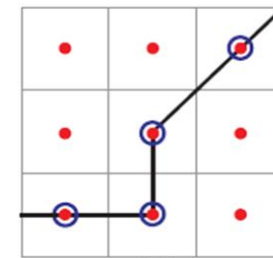
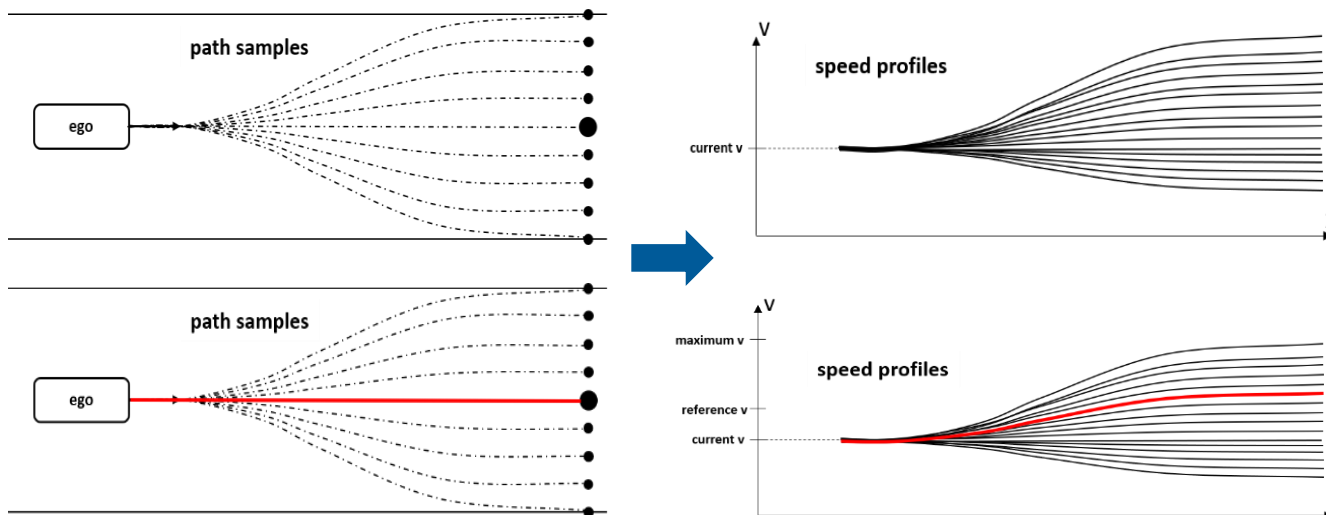


Structured Motion Planning

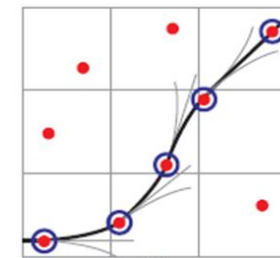
- Algorithms
 - Model Predictive Control Optimization & Dynamic Programming** for Path & trajectory sample generation and selection
- Data Structure
 - ArrayList** to store path and trajectory information

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.

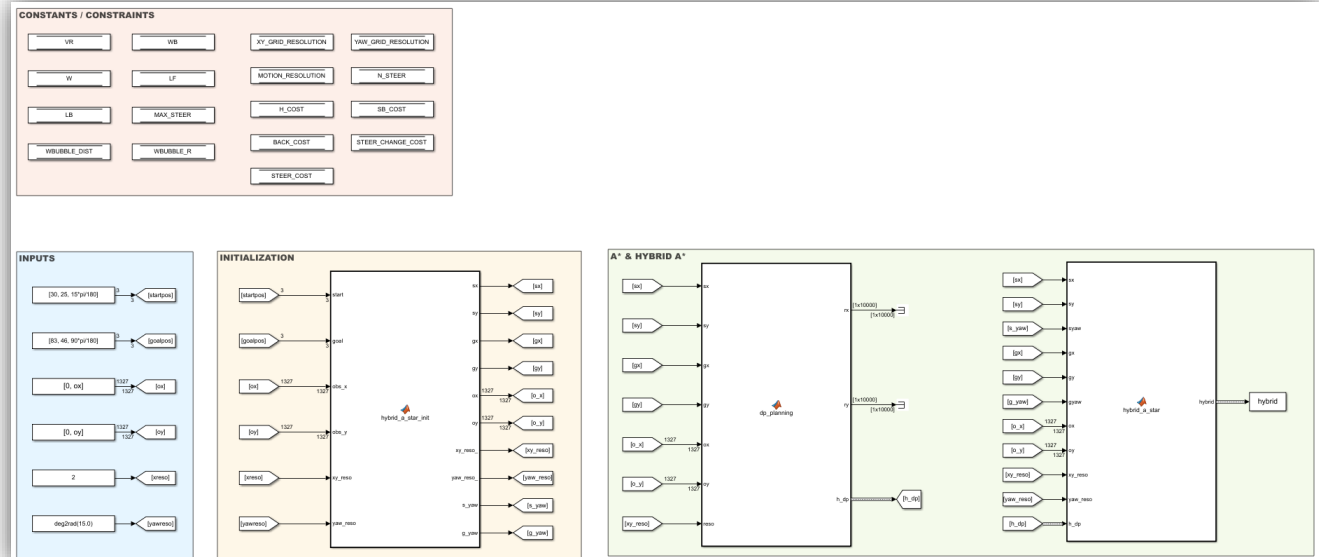
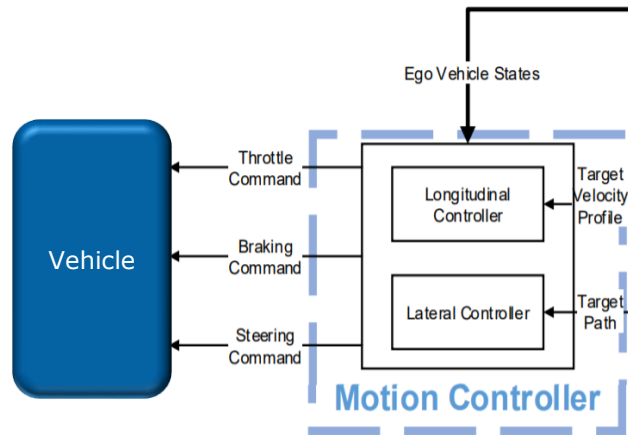
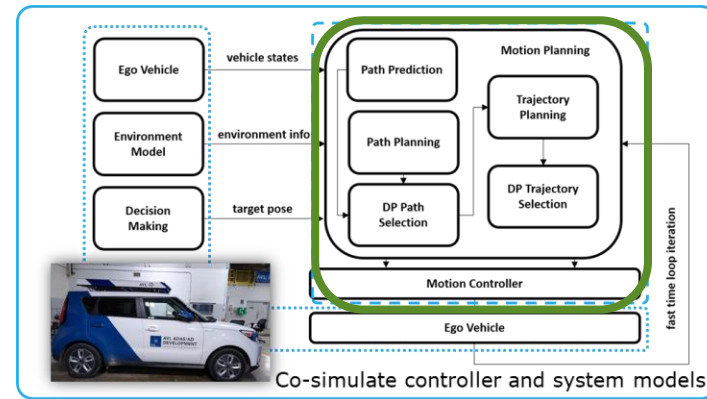


Hybrid A* associates a continuous state with each cell, and the score is the cost of its associated continuous state.

2. Develop control libraries

Motion Control SW Development

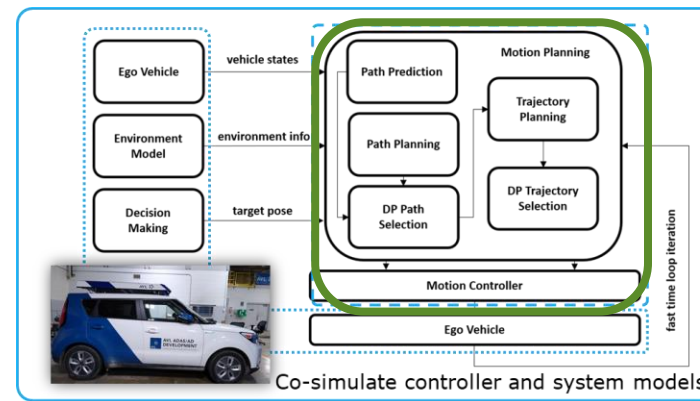
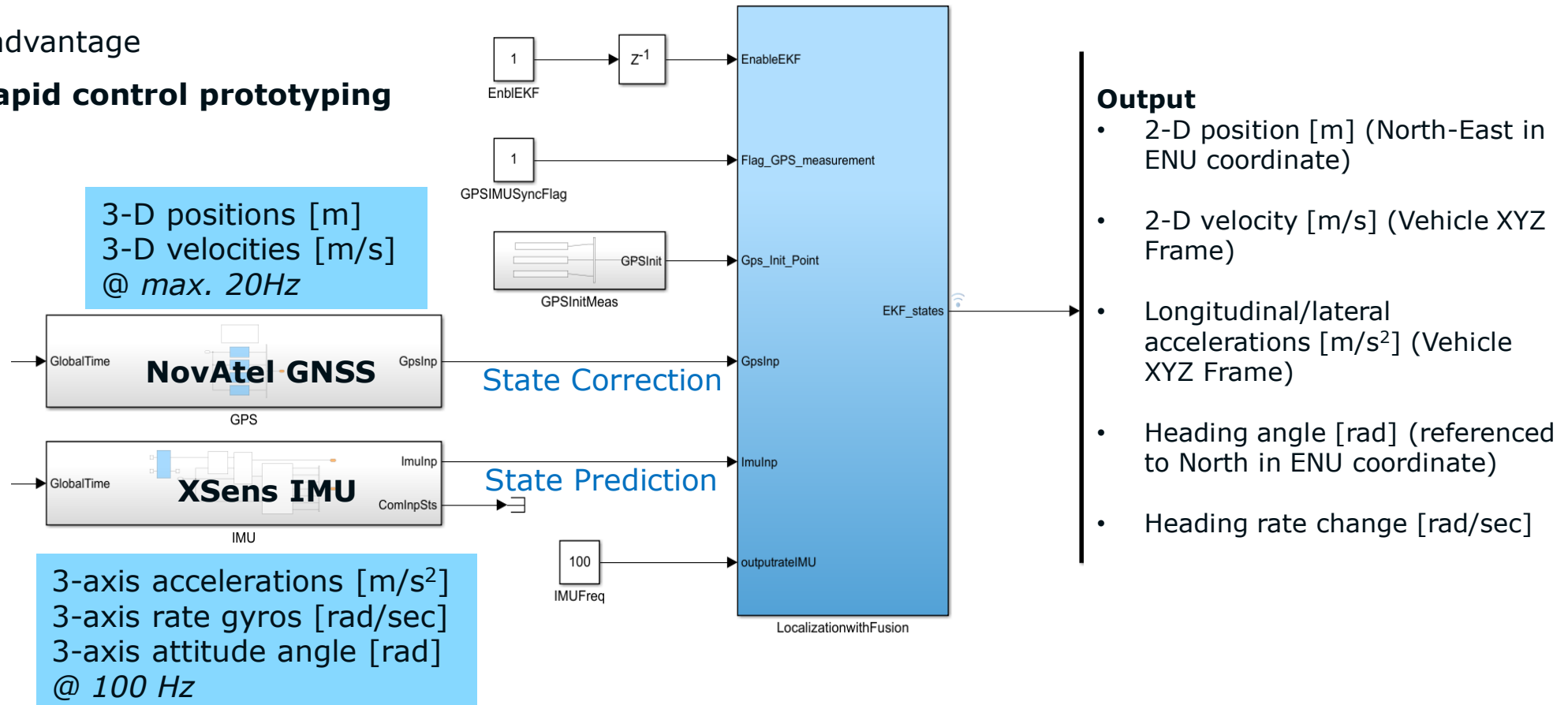
- Algorithms
 - Longitudinal Control
 - Feedforward** and **feedback PI** control for throttle and brake
 - Lateral Control
 - Extended Stanley** method for steering control



2. Develop control libraries

Localization

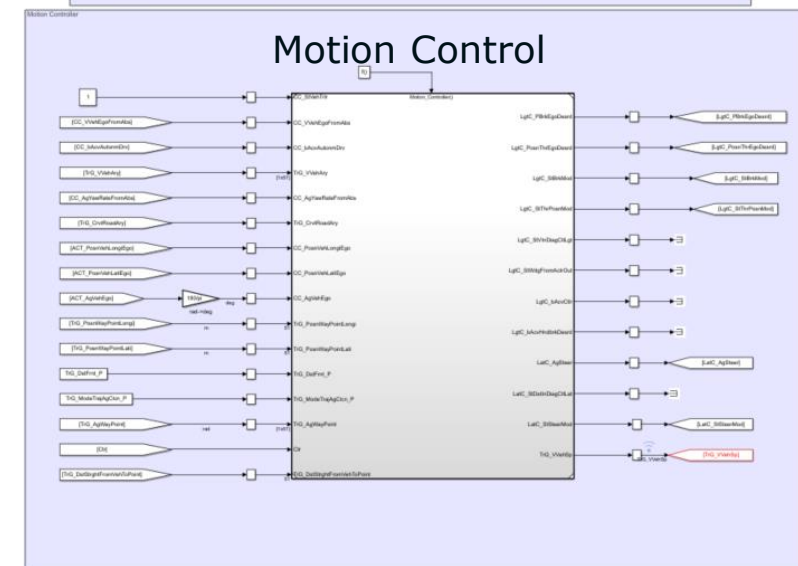
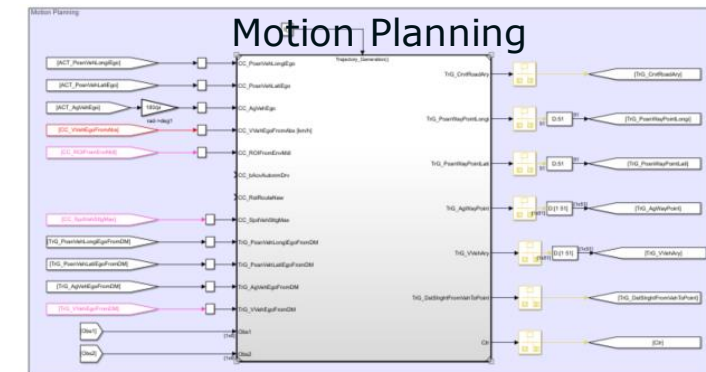
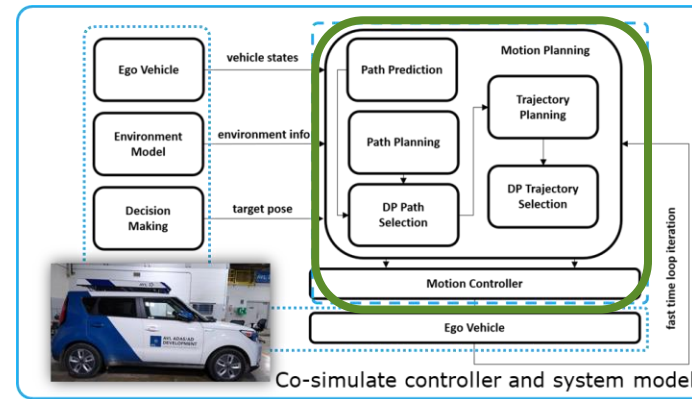
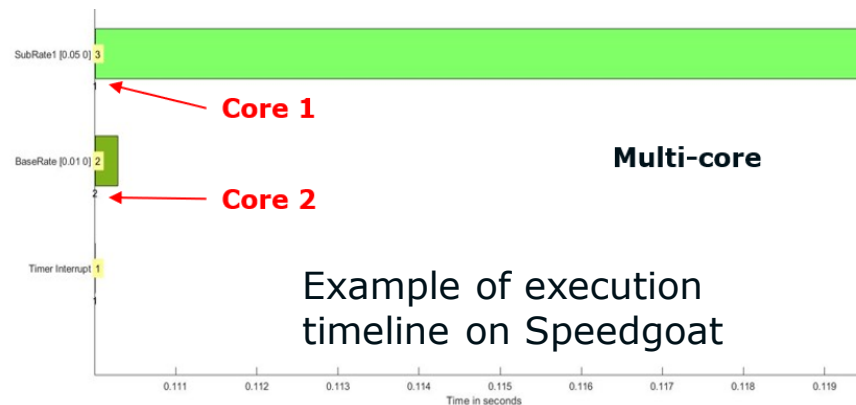
- Algorithms
 - Extended Kalman Filter**
- MBD advantage
 - Rapid control prototyping**



2. Develop control libraries

Integration – Threading & Parallelization

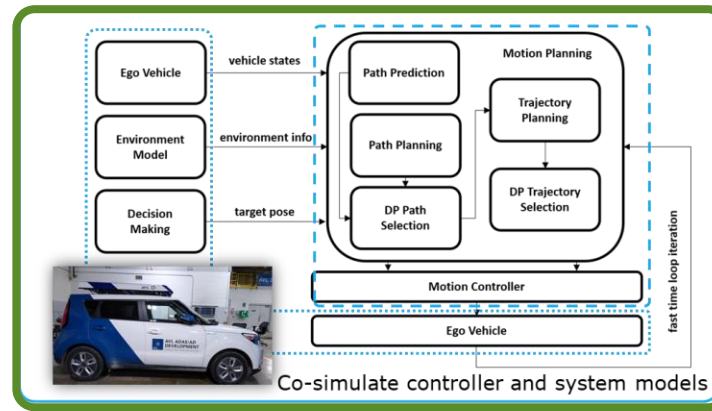
- Modules implemented as **model reference** function-call subsystems to enable:
 - Different execution rates
 - Core partitioning on the hardware
- MBD Advantage
 - Hardware platform **agnostic**
 - Available **tools** for synchronization and memory configuration to grant successful threading and parallelization



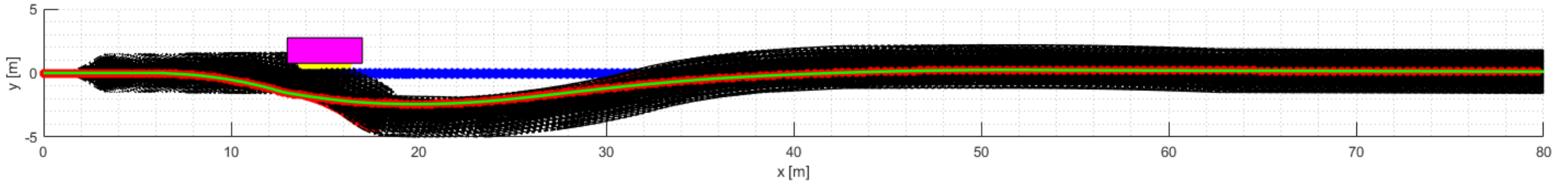
3. Co-simulate controller and system models



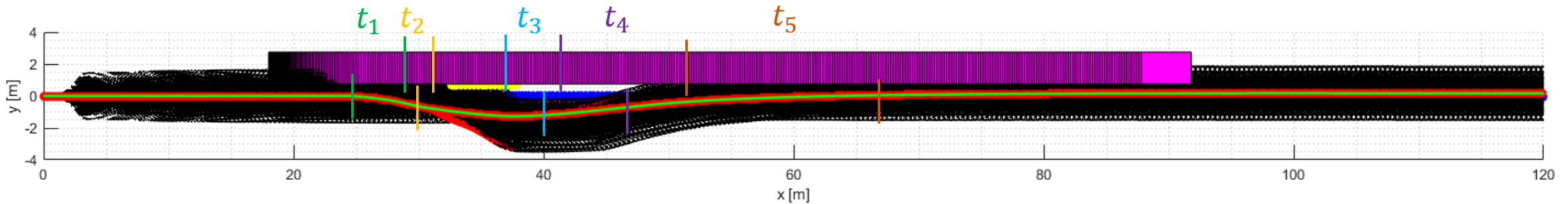
MIL Simulation Results



Static Vehicle Take Over



Dynamic Vehicle Trajectory Prediction and Take Over

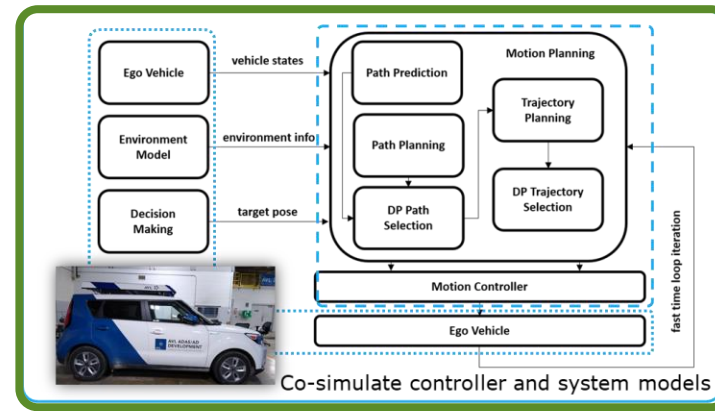


3. Co-simulate controller and system models

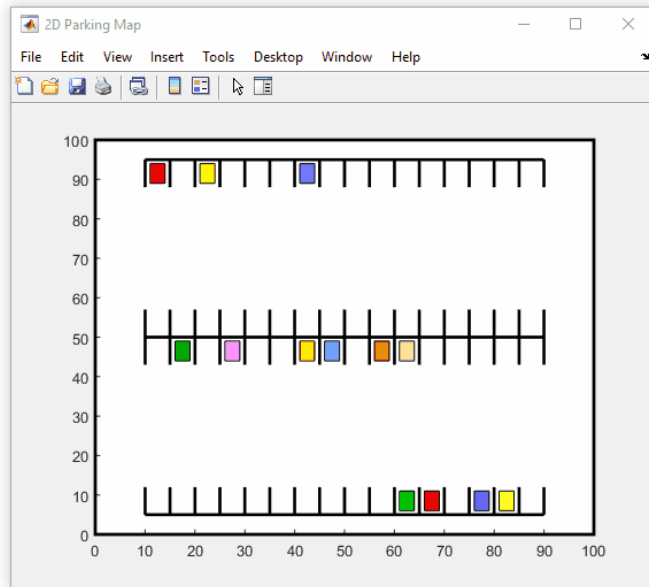


MIL Simulation Results in Parking Lot

Pose = (x, y, Θ)

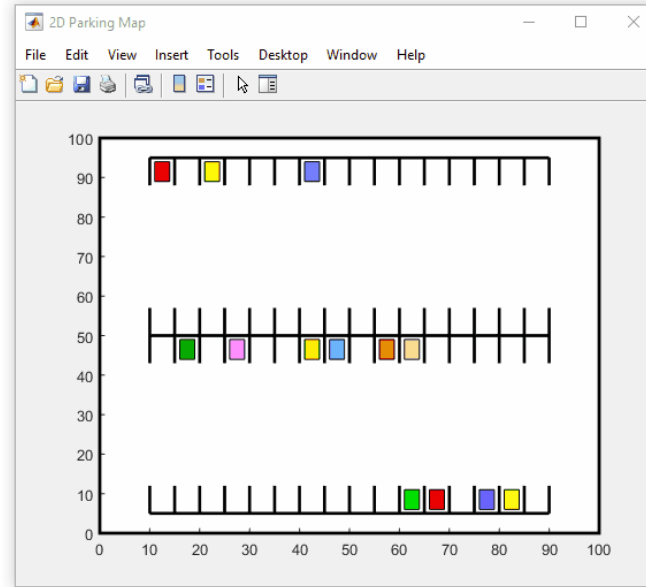


*: **A***
 ○: **Hybrid A***



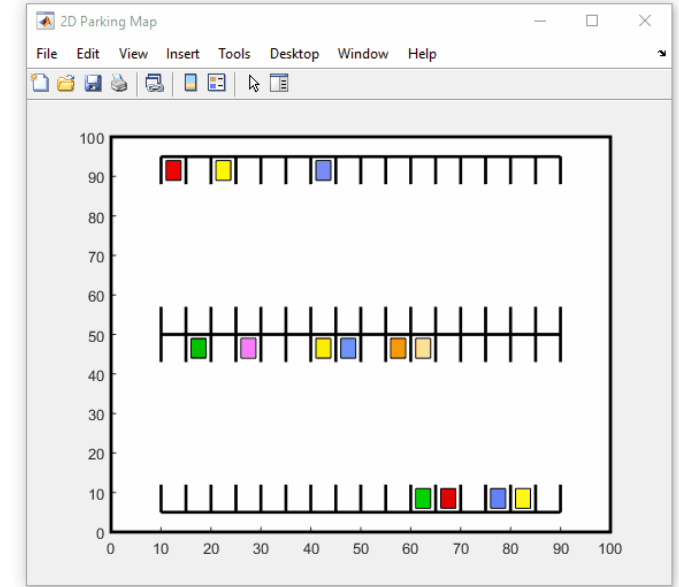
Start Pose: $x=30, y=25, \Theta=15^\circ$

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



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

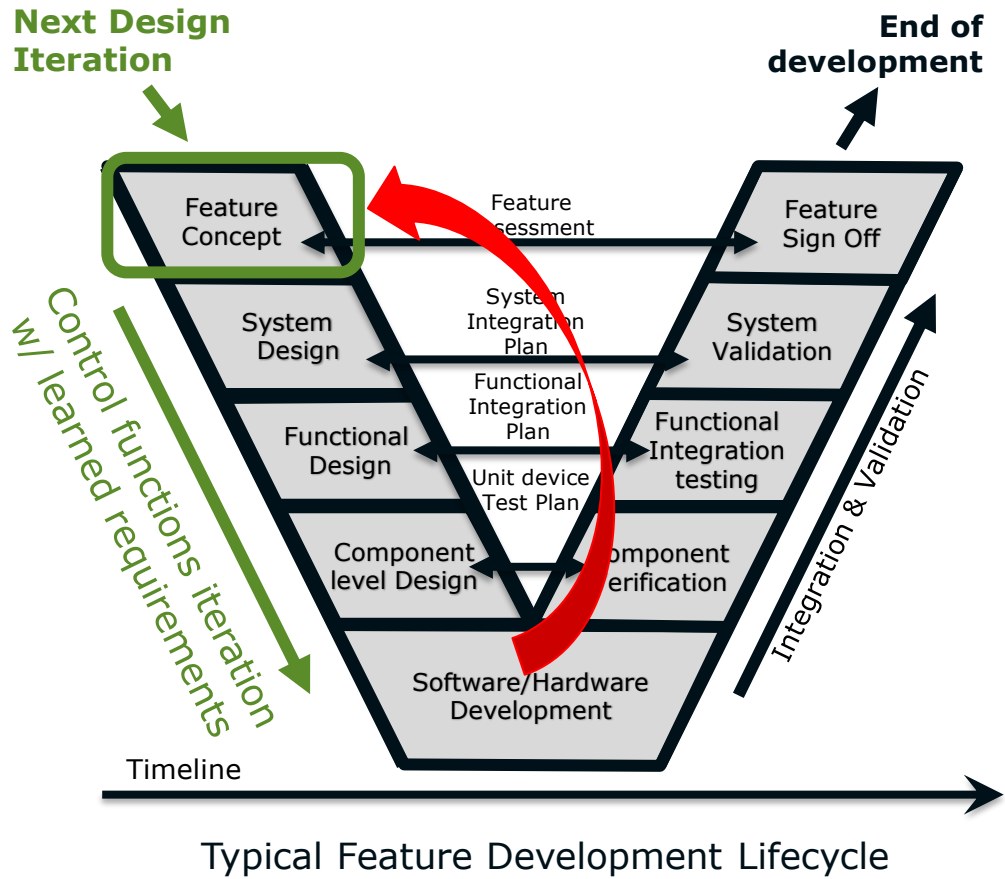
Goal Pose : $x=57, y=92, \Theta=-90^\circ$



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

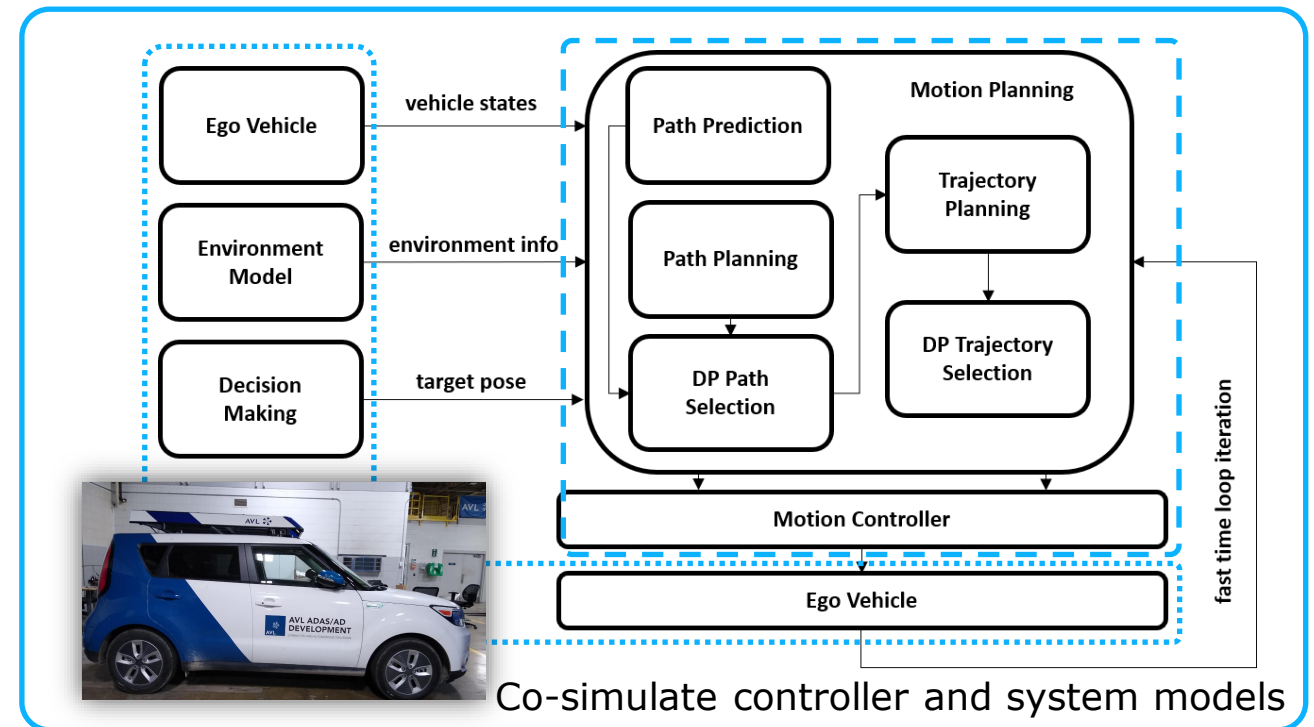
Goal Pose : $x=78, y=90, \Theta=90^\circ$

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)

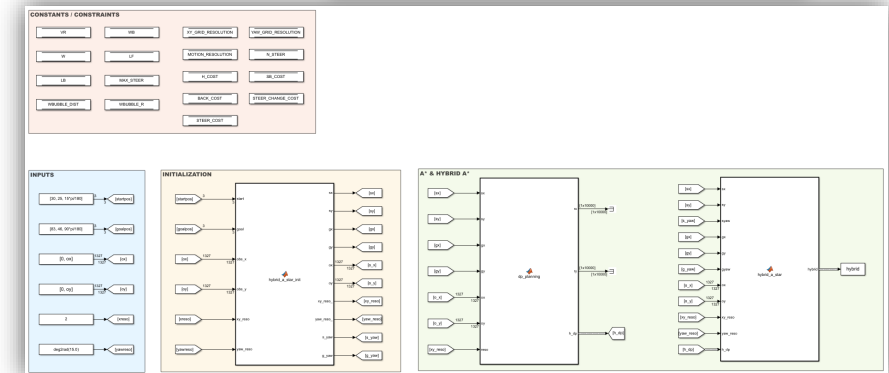


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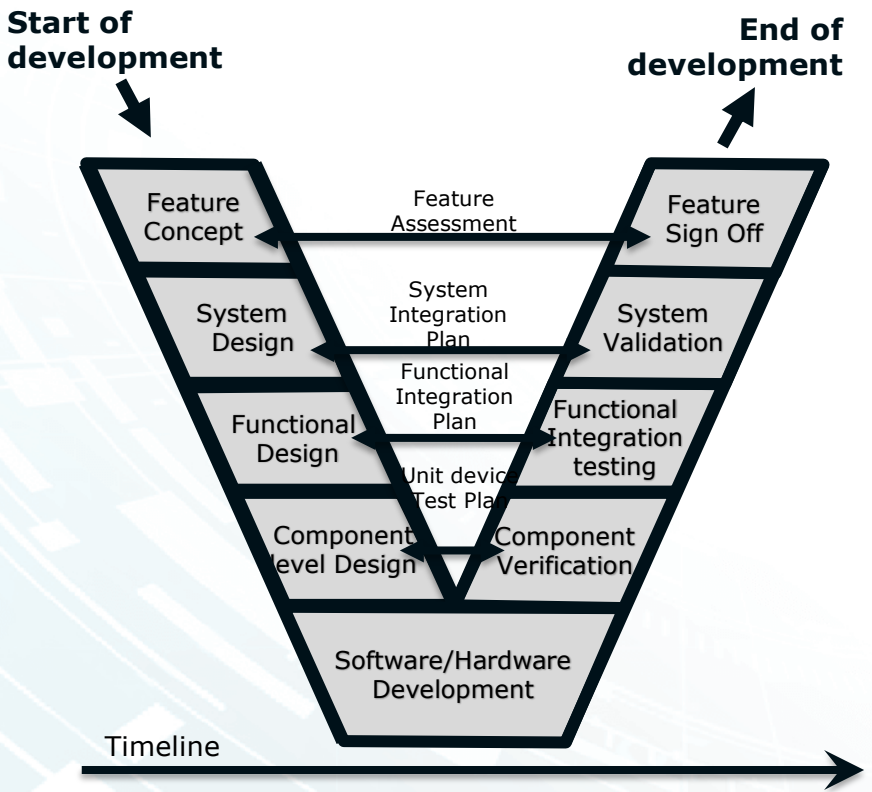
EFFICIENT

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TEAM SYNERGY

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Additional AVL Offerings in ADAS/AD Domain



Timeline
Typical Feature Development Lifecycle

Key Contacts & Contributors

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Thank You



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