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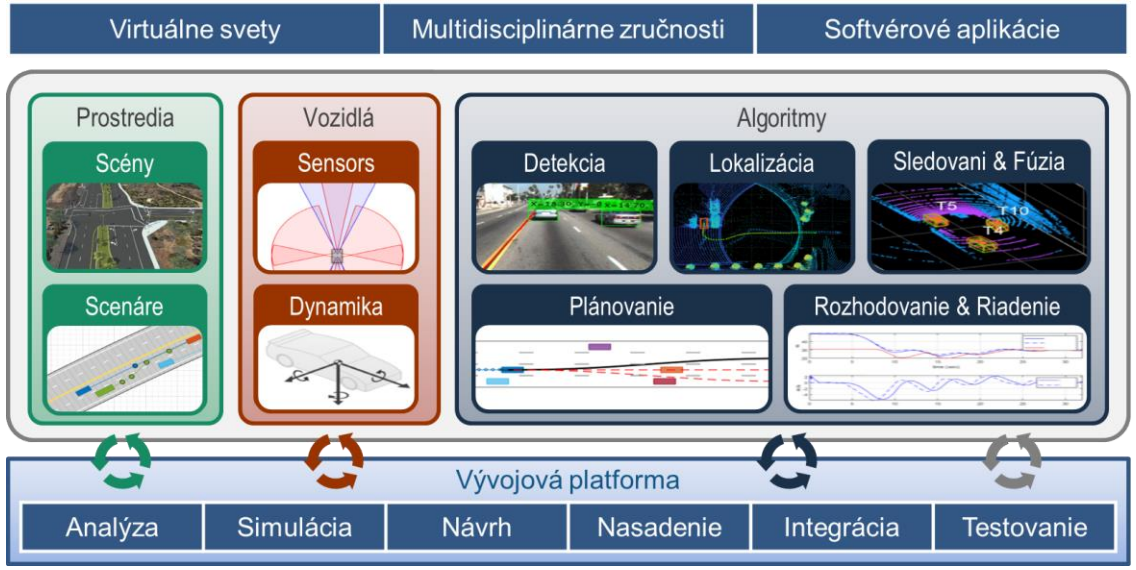
Algoritmy autonómnych systémov



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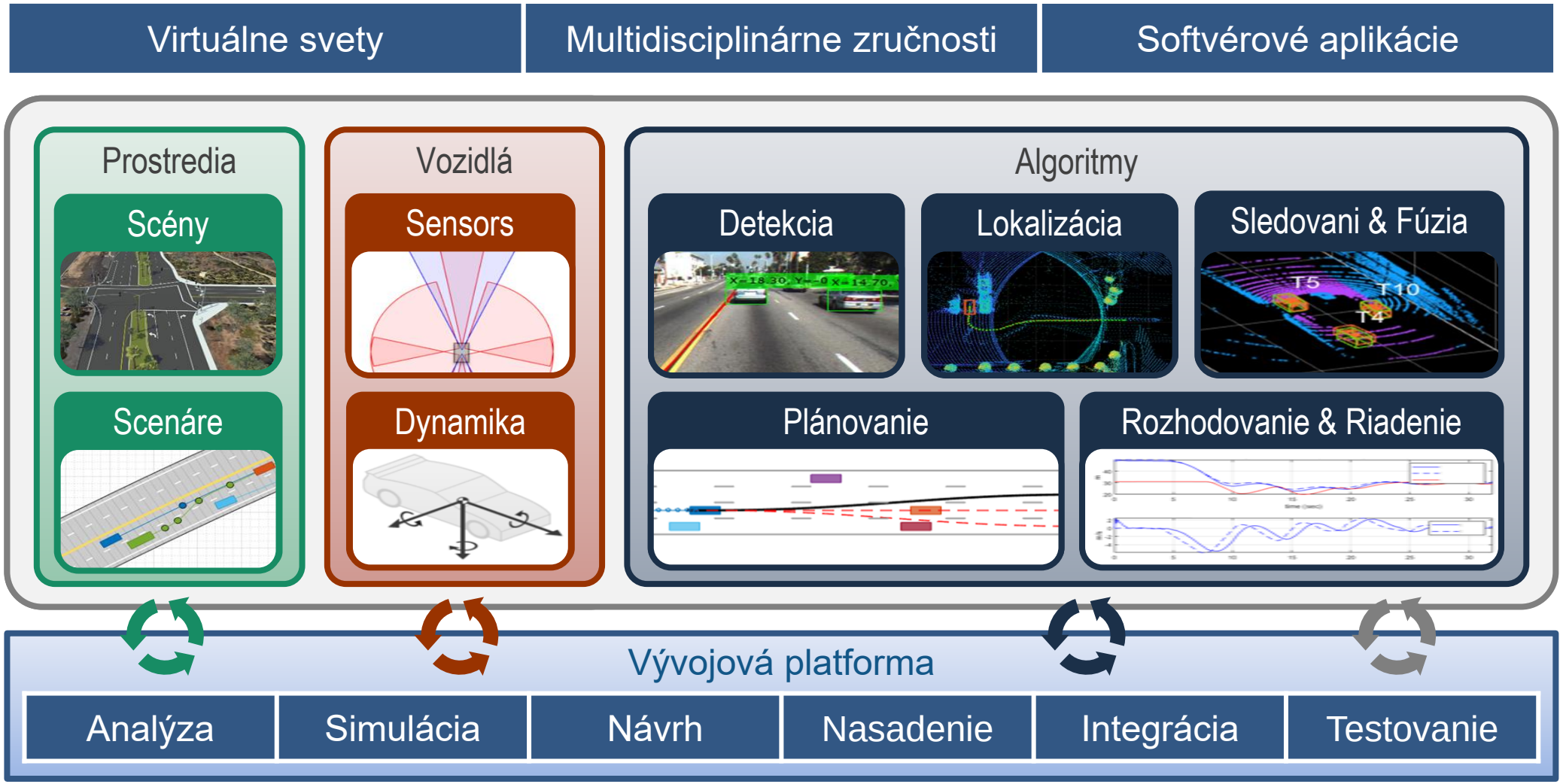
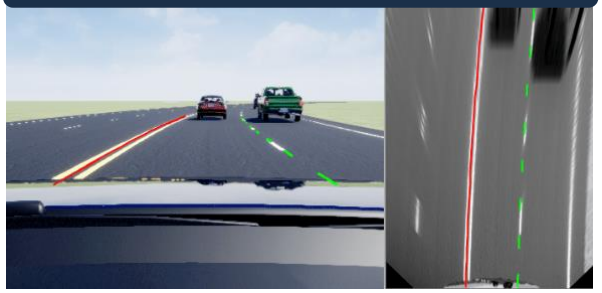
www.mathworks.com

Vývoj systémov autonómneho riadenia



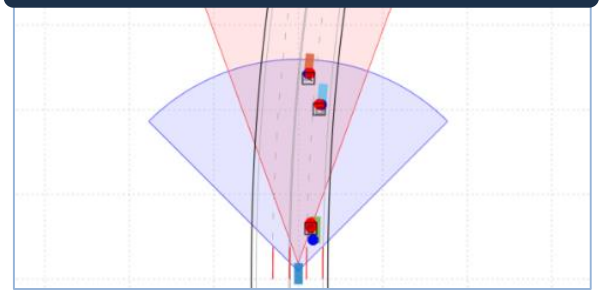
Simulácia autonómneho riadenia vo virtuálnom svete

Detekcia čiar

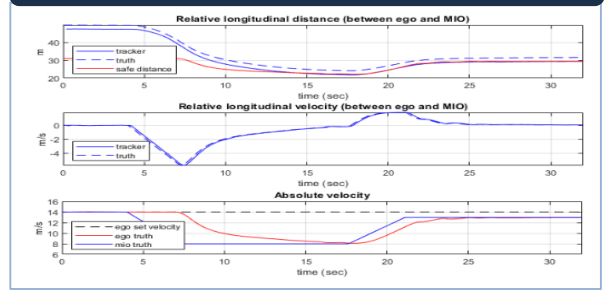


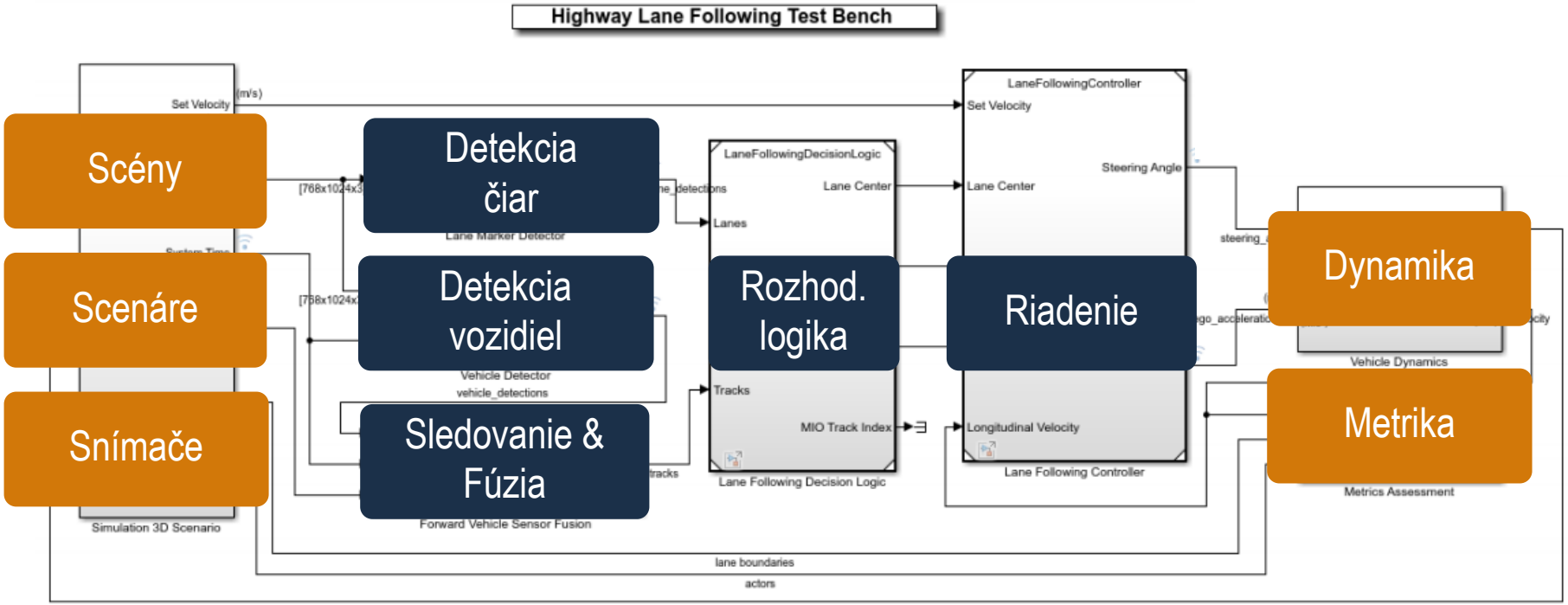
Detekcia vozidiel

Sledovanie & Fúzia



Rozhodovanie & Riadenie





[Highway Lane Following]

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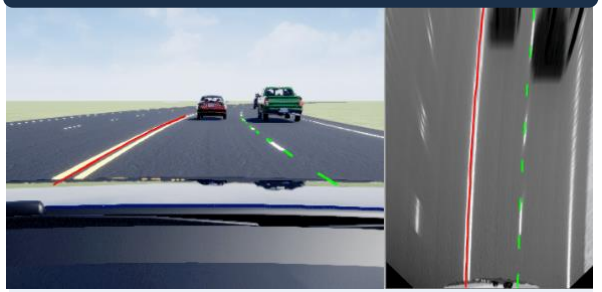
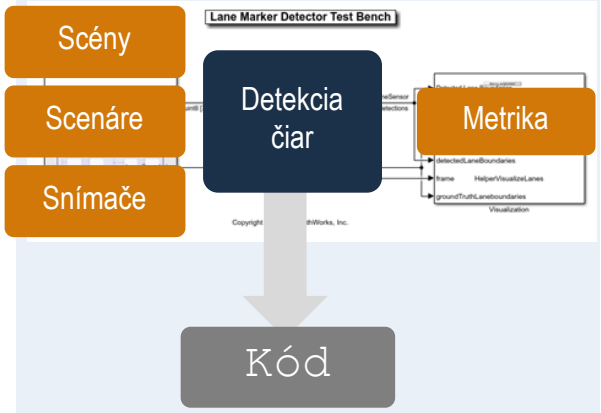
Vývoj algoritmov pre viaceré disciplíny

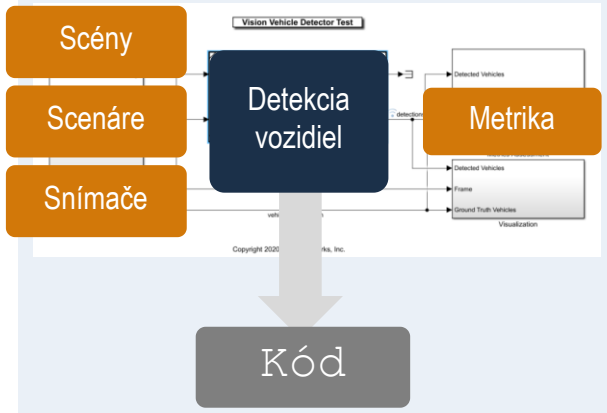
Detekcia čiar





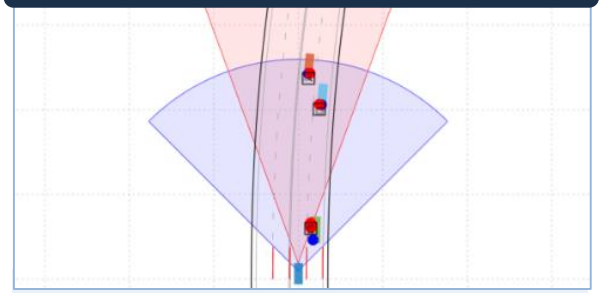
Lane Detector

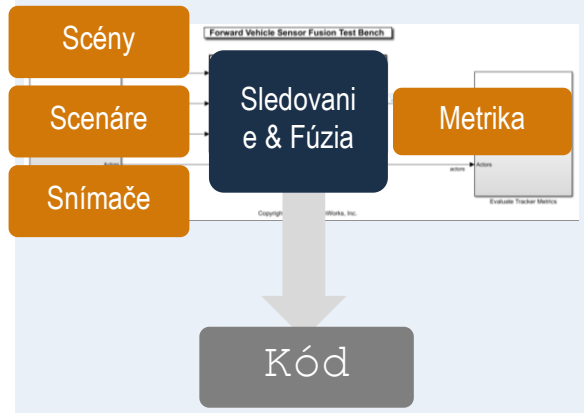
Detekcia vozidiel



Vehicle Detector

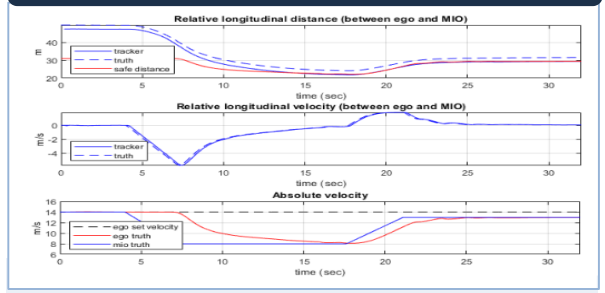
Sledovanie & Fúzia

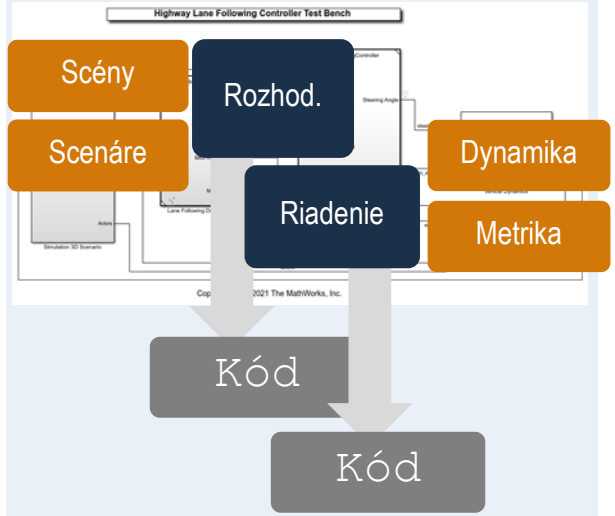




Vehicle Sensor Fusion

Rozhodovanie & Riadenie

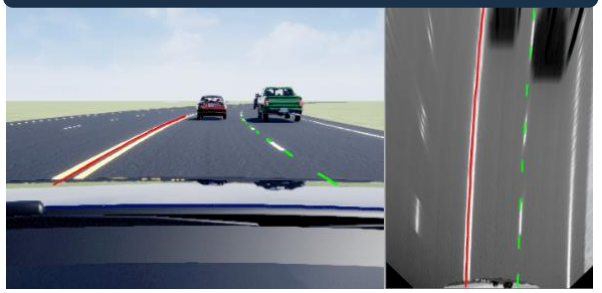




Decision and Controls

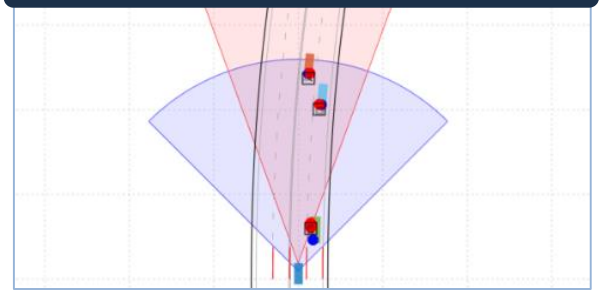
Vývoj softvéru pre autonómne riadenie

Detekcia čiar

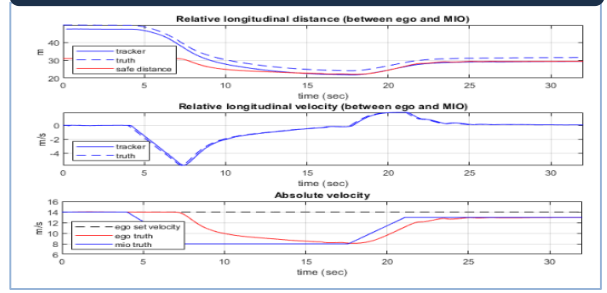


Detekcia vozidiel

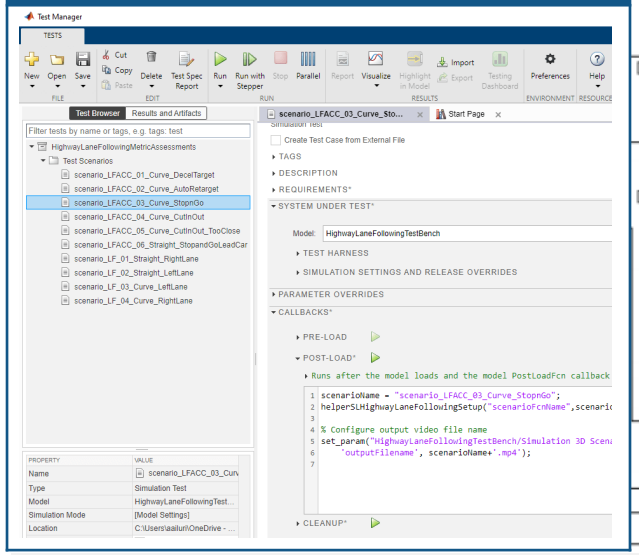
Sledovanie & Fúzia



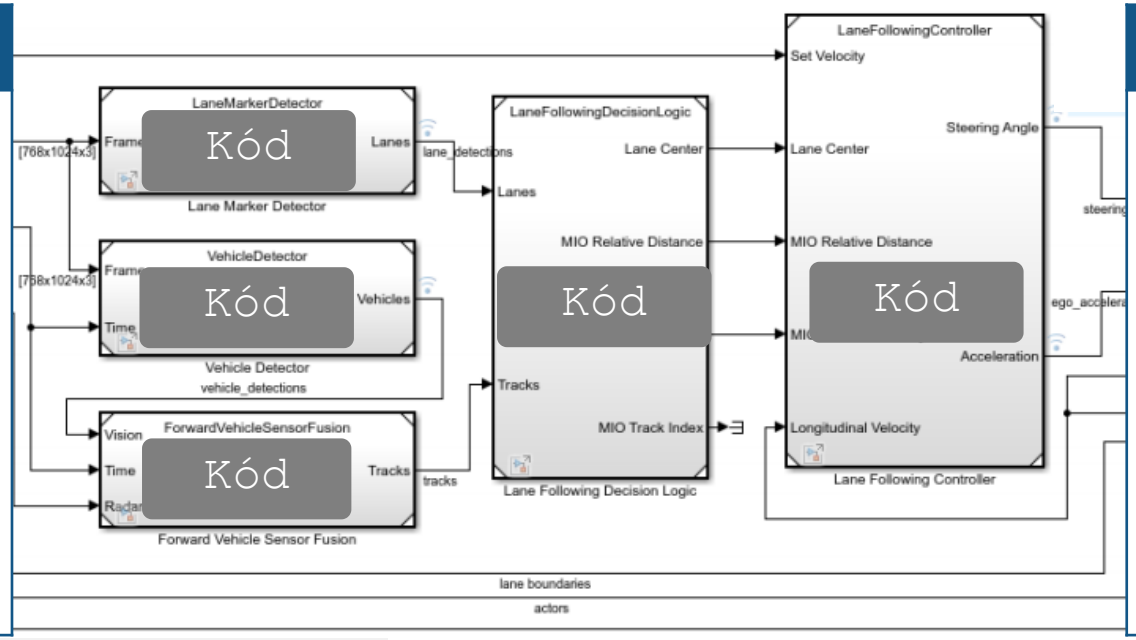
Rozhodovanie & Riadenie



Správa testov



Highway Lane Following Test Bench



Reportovanie

Summary

Name	Outcome
HighwayLaneFollowingMetricAssessments	10 ✓
Test Scenarios	10 ✓
scenario_LFACC_01_Curve_DecelTarget	✓
scenario_LFACC_02_Curve_AutoRetarget	✓
scenario_LFACC_03_Curve_StopnGo	✓
scenario_LFACC_04_Curve_CutInOut	✓
scenario_LFACC_05_Curve_CutInOut_TooClo	✓
scenario_LFACC_06_Straight_StopandGoLea	✓
scenario_LF_01_Straight_RightLane	✓
scenario_LF_02_Straight_LeftLane	✓
scenario_LF_03_Curve_LeftLane	✓
scenario_LF_04_Curve_RightLane	✓

[Automate Testing of Highway Lane Following]

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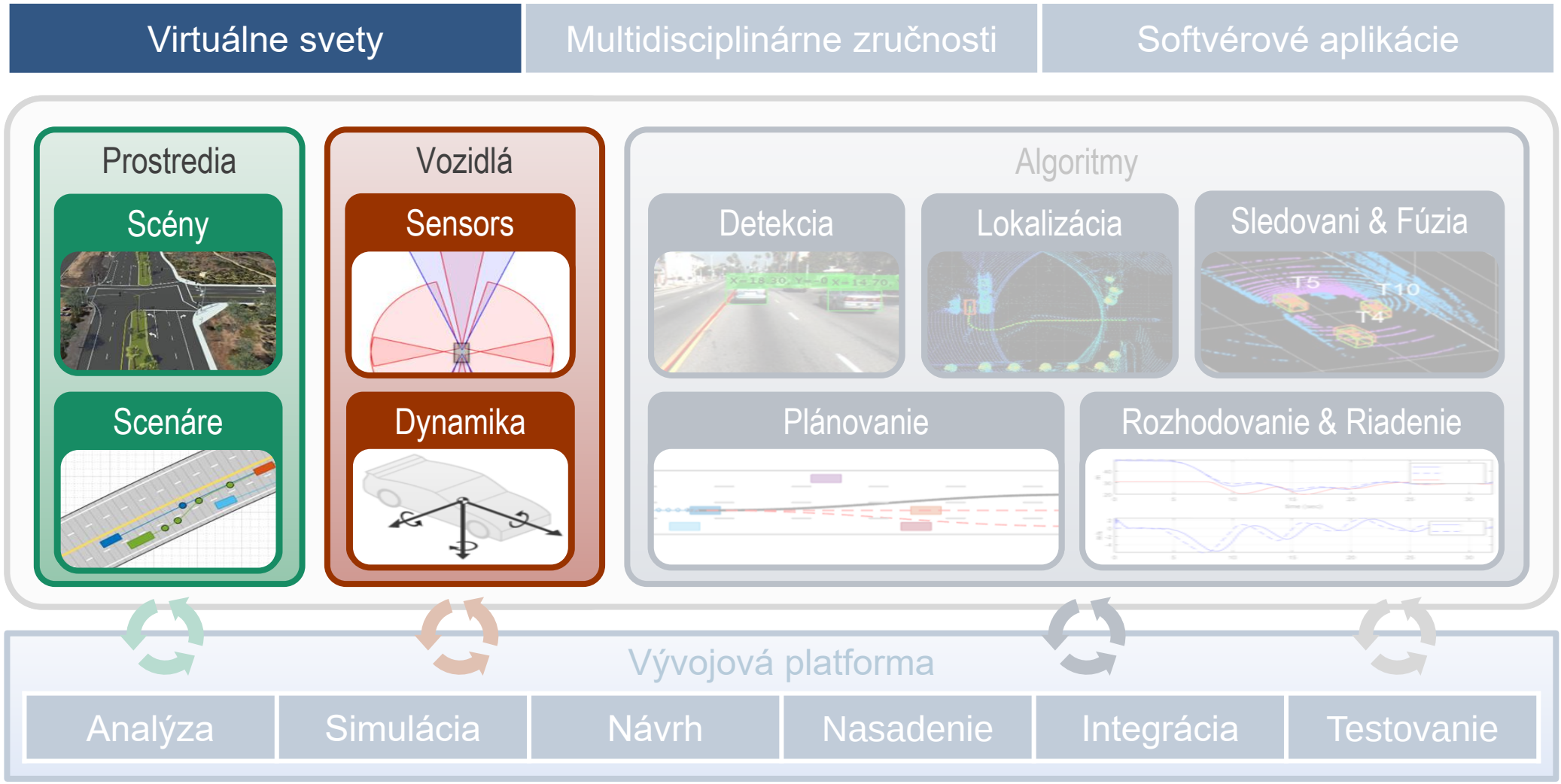
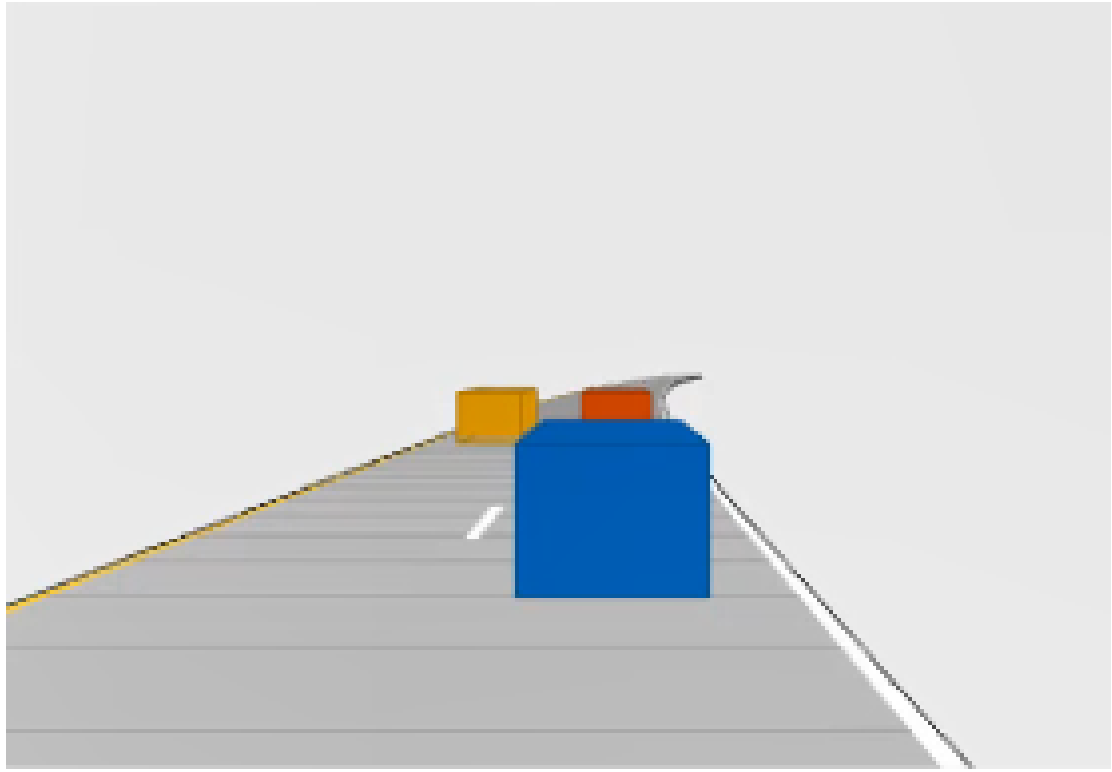
Vývoj virtuálnych svetov



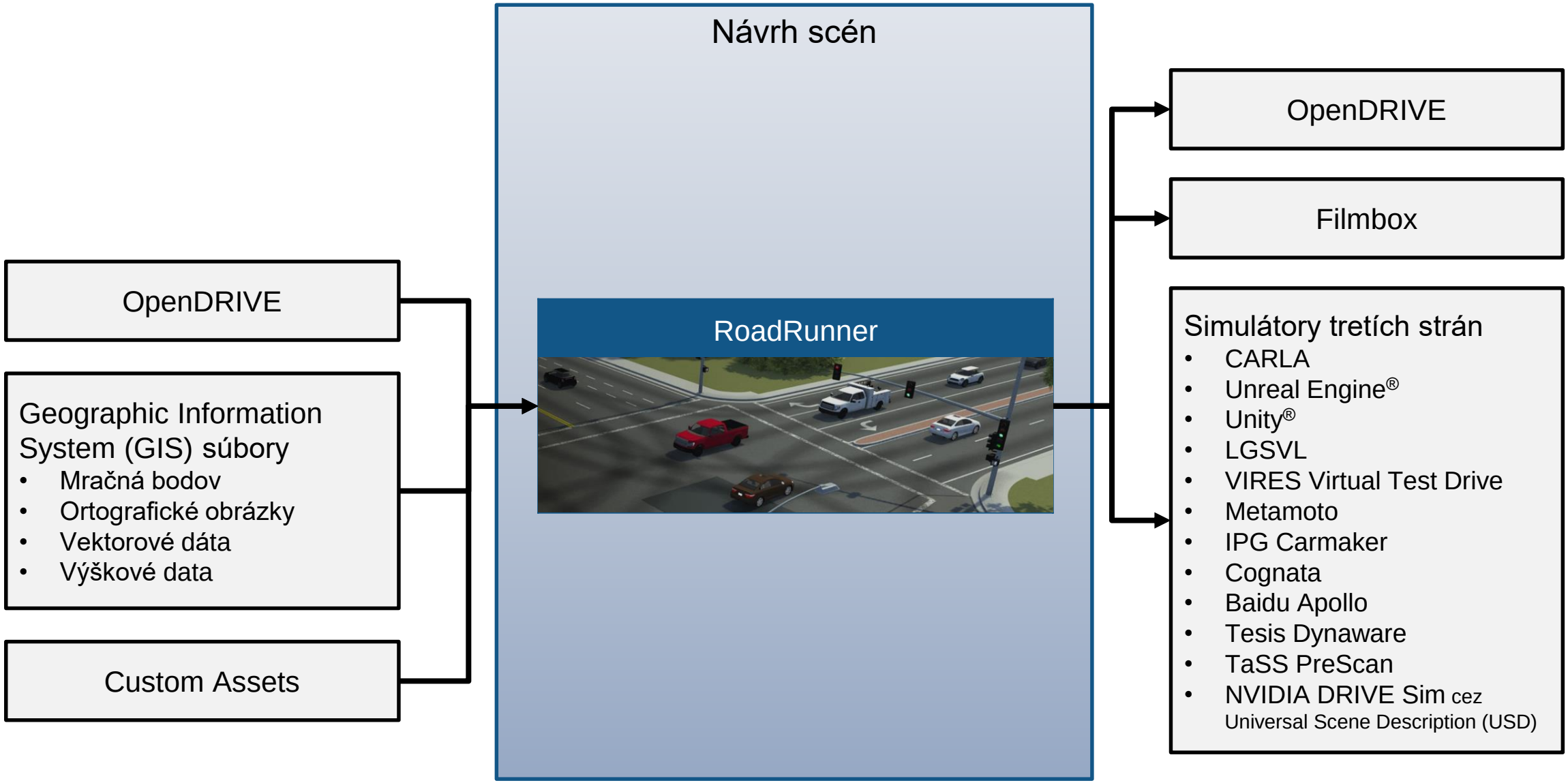
Typy virtuálnych svetov

Unreal Engine

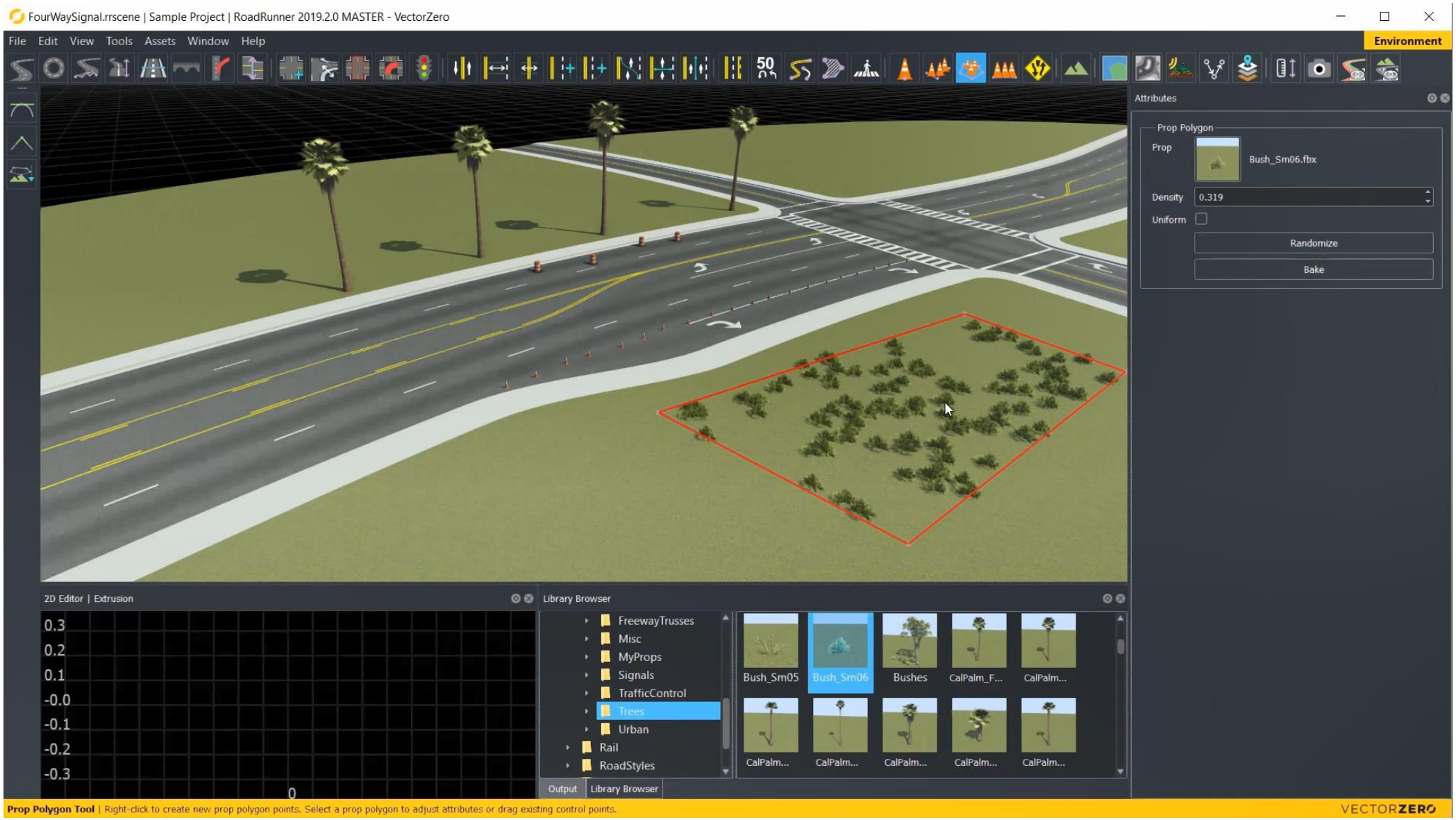
Cuboid



Tvorba 3D scén



Interaktívny návrh 3D scén v RoadRunner



Tvorba 3D scén

Here HD Live Map

OpenDRIVE

Geographic Information System (GIS) súbory
- Mračná bodov
- Ortografické obrázky
- Vektorové dáta
- Výškové data

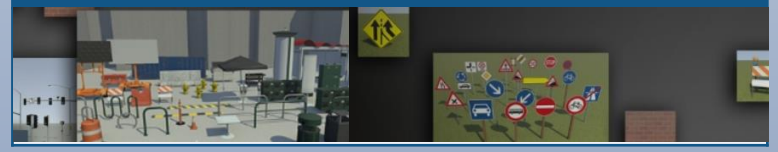
Custom Assets

Návrh scén

RoadRunner Scene Builder

RoadRunner

RoadRunner Asset Library



OpenDRIVE

Filmbox

Simulátory tretích strán
- CARLA
- Unreal Engine®
- Unity®
- LGSVL
- VIRES Virtual Test Drive
- Metamoto
- IPG Carmaker
- Cognata
- Baidu Apollo
- Tesis Dynaware
- TaSS PreScan
- NVIDIA DRIVE Sim cez Universal Scene Description (USD)

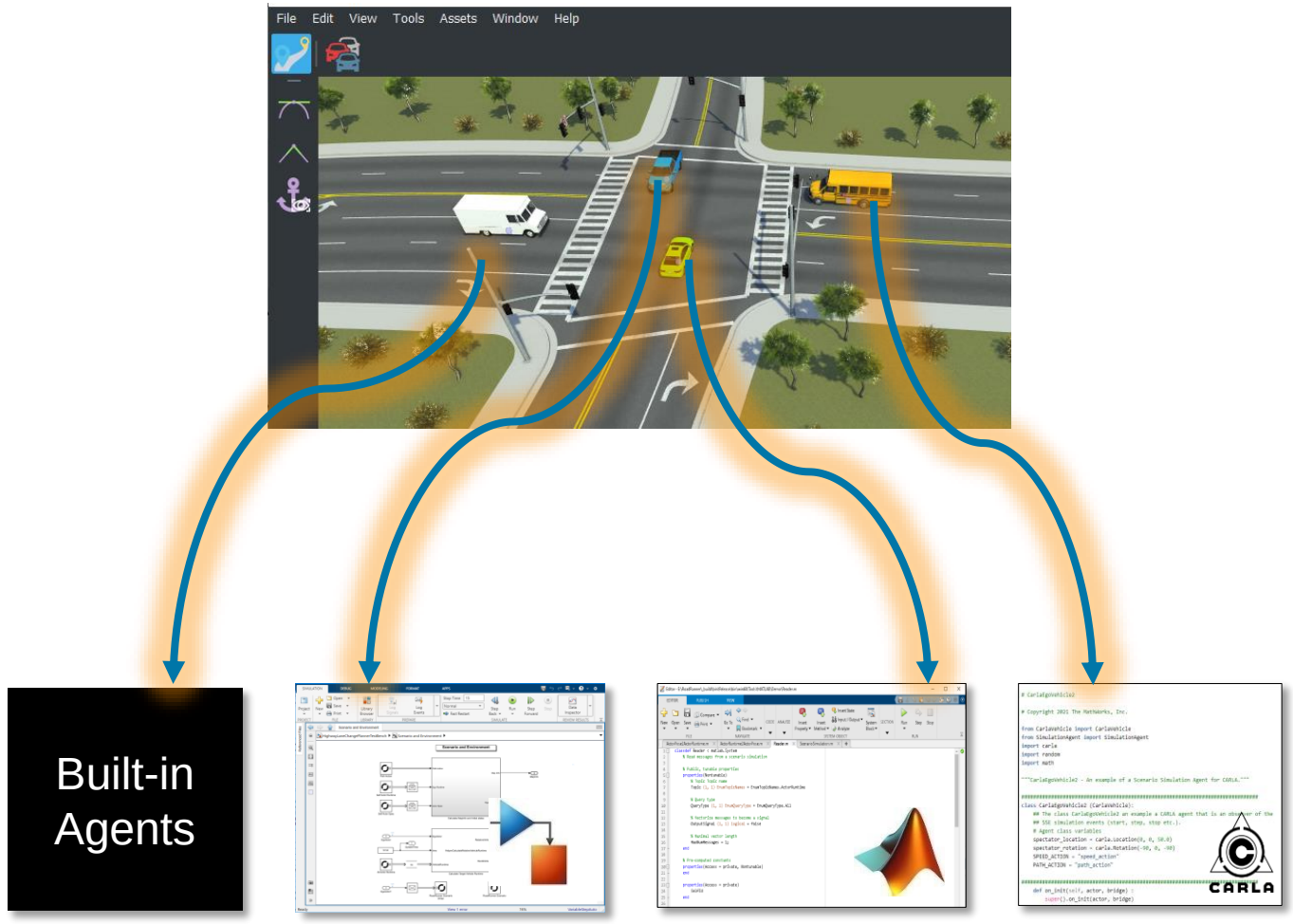
Interaktívny návrh pomocou RoadRunner Scenario

- Pridanie vozidiel
- Sledovanie cesty
- Zmena rýchlosti
- Zmena pruhu
- Laterálna zmena

[Scenario Edit Tool](#)
RoadRunner Scenario

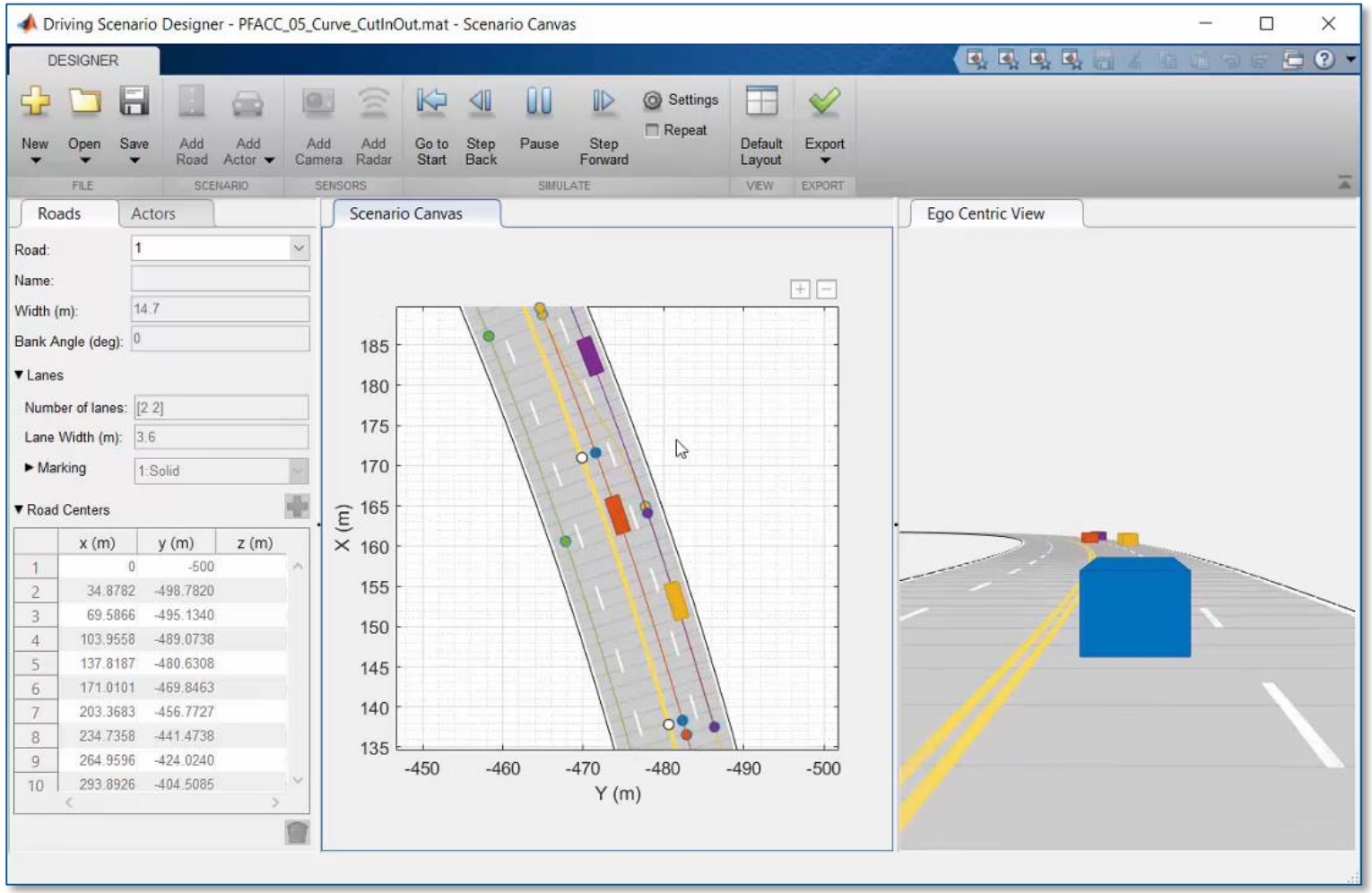
Simulácia scenárov vo viacerých prostrediach

- MATLAB, Simulink, CARLA
- Zmena stavu
  - Póza a rýchlosť v každom kroku
- Čítanie stavu
  - príkazy (cesta, rýchlosť, zmena pruhu, laterálna zmena)
  - Póza a rýchlosť účastníkov
  - Rozmery účastníkov
  - Mapovanie čiar



Grafický návrh scenárov pomocou Driving Scenario Designer

- Návrh scén
  - Cesty, čiary
  - Hotové (Euro NCAP)
- Import ciest
  - OpenDRIVE, HERE HD Live
- Pridávanie aktorov
  - Tvar, snímače
  - Trajektórie
- Export scenárov
  - MATLAB, Simulink model



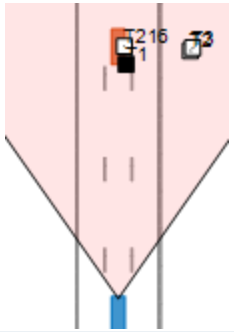
Driving Scenario Designer

Automated Driving Toolbox™

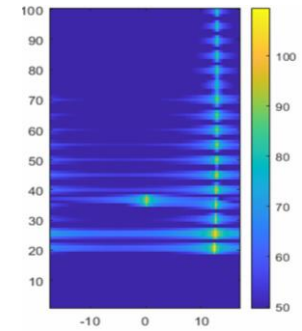
Simulácia snímačov

Cuboid snímače

Radarové sledovanie

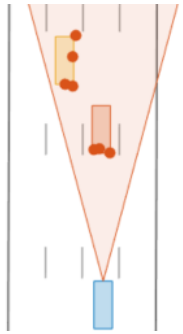


Radarové IQ signály

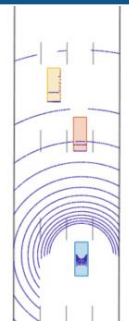


Cuboid a Unreal Engine

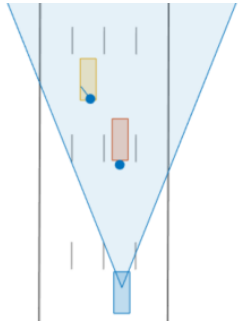
Radarové detekcie



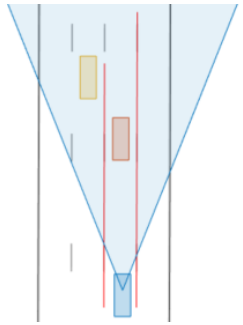
Lidar



Detekcie obrazu



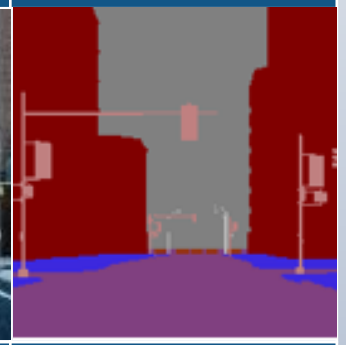
Detekcie čiary



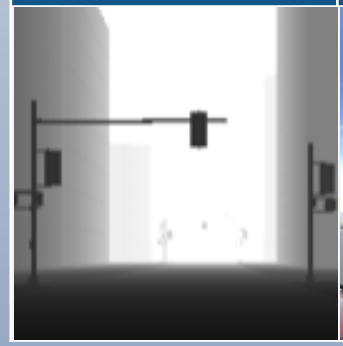
Unreal Engine Sensors

Monokulárna kamera

Sémantická segmentácia



Hĺbková



Fisheye kamera

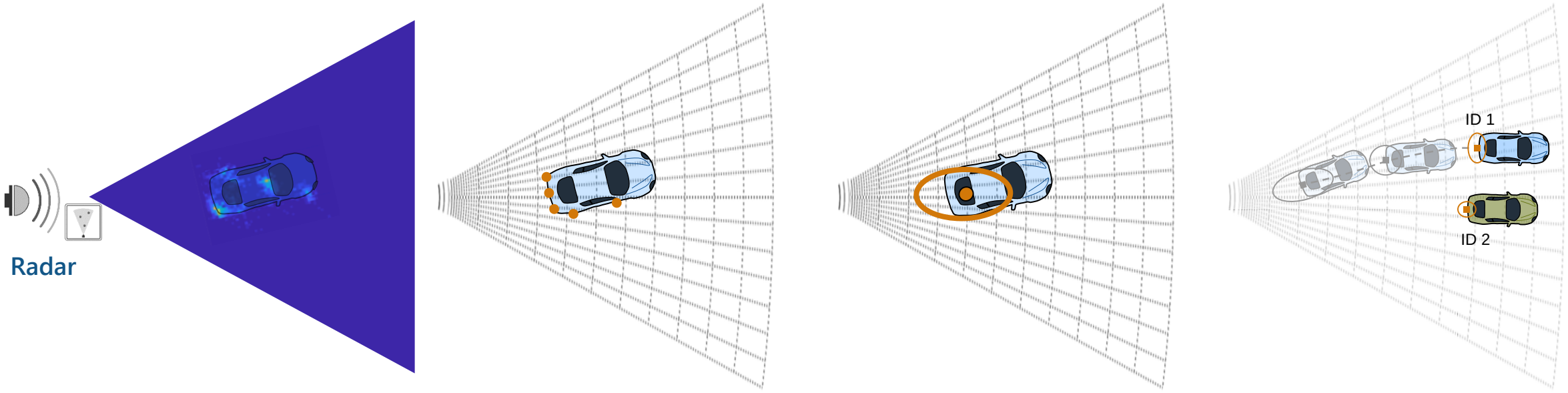
Snímače polohy

- Enkóder kolies
- Global Positioning System (GPS)
- Inertial Measurement Unit (IMU)
- Inertial Navigation System (INS)

Často využívané nástroje: Automated Driving Toolbox™, Radar Toolbox, Navigation Toolbox™

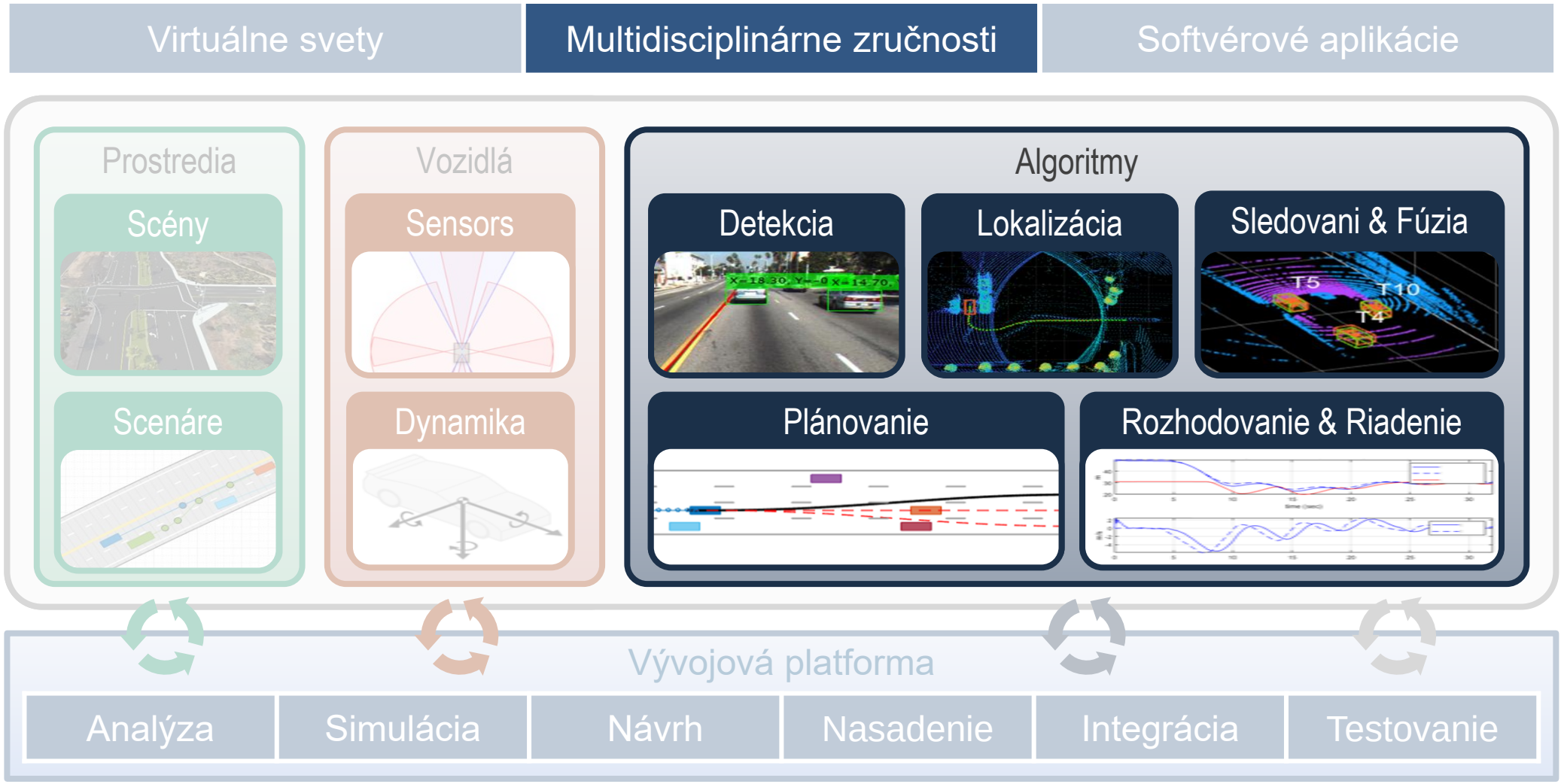
Simulácia radaru na rôznych úrovniach

Surové IQ signály | **Detekcie** | **Kláster** | **Sledovania**

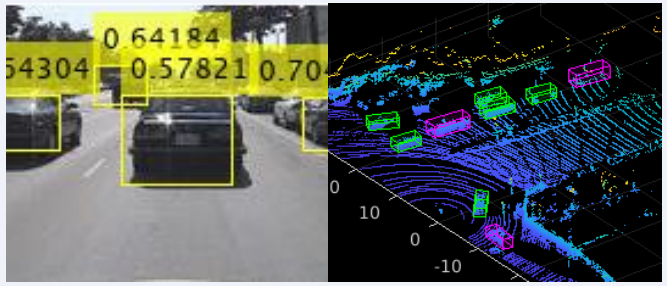
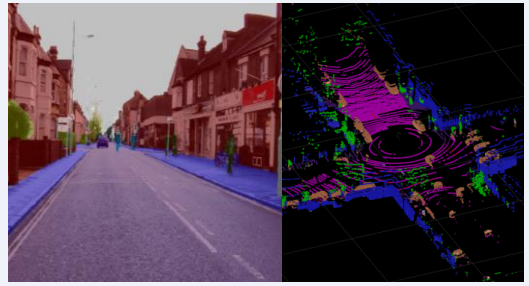
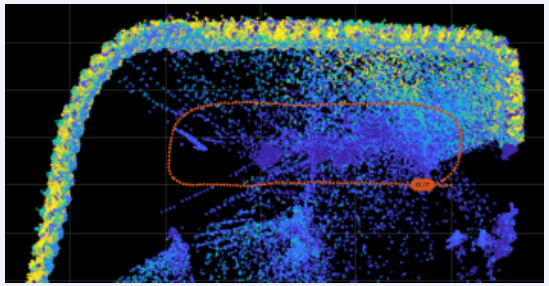
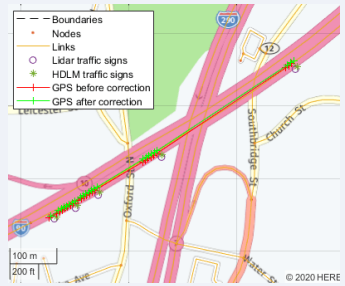
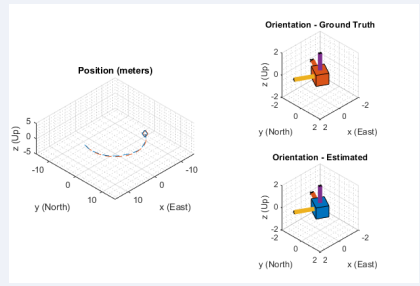


Waveform-level Model	Measurement-level Model
Radar Transceiver *Radar Toolbox*	Driving Radar Data Generator *Automated Driving Toolbox™, Radar Toolbox*

Vývoj multidisciplinárnych zručností



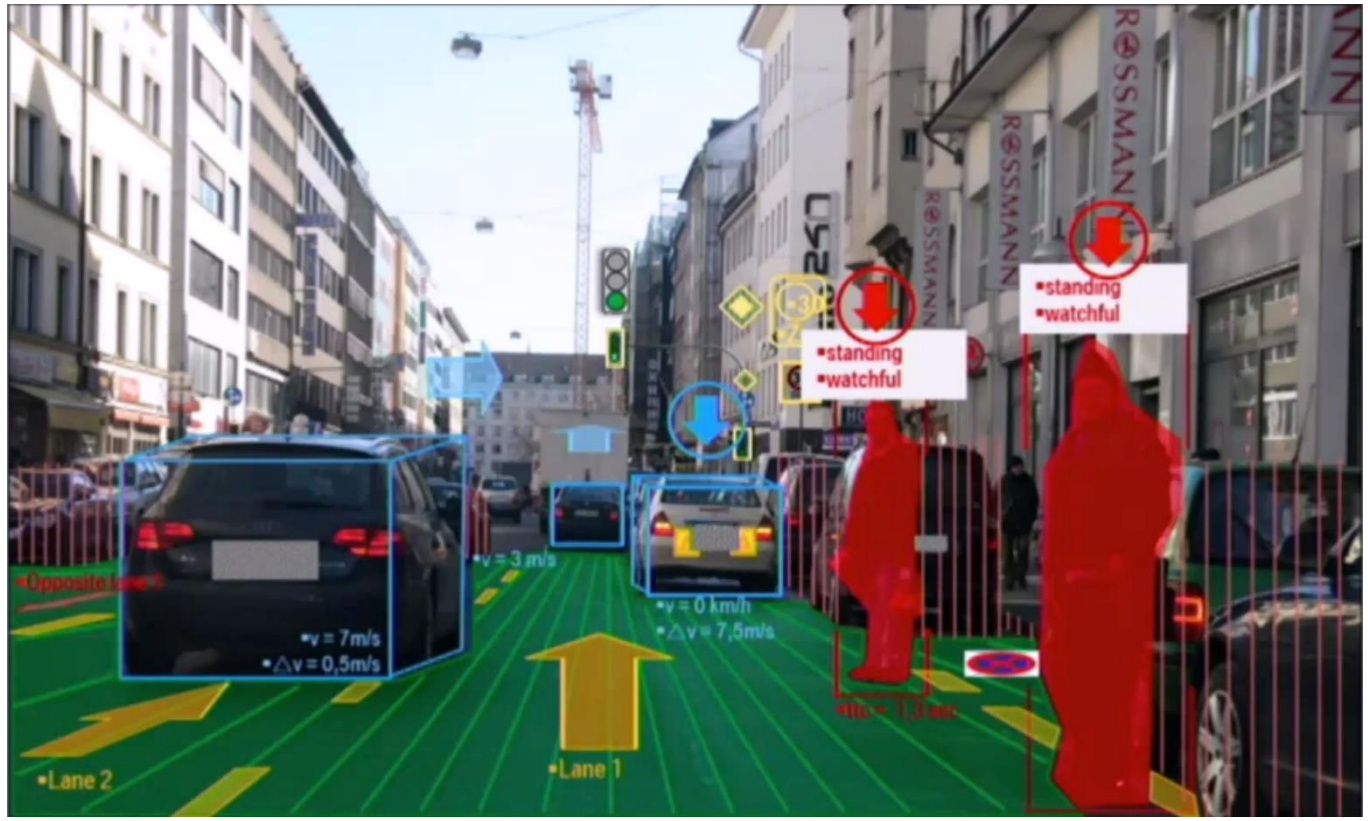
Algoritmy detekcie a lokalizácie

Čiary	Objekty	Sémantická segmentácia
		
SLAM	**Mapy**	**Inerciálna fúzia**
		

Často využívané nástroje: Automated Driving Toolbox, Computer Vision, Lidar Toolbox, Radar Toolbox, Deep Learning Toolbox, Navigation Toolbox

Komplexné vnímanie pomocou AI

- Jazdný pruh / cesta
- Čiary a značky na ceste
- Semafóry
- Iní účastníci
  - Vozidlá
  - Chodci
  - Bicyklisti
- Úlohy
  - Detekcia a predikcia správania



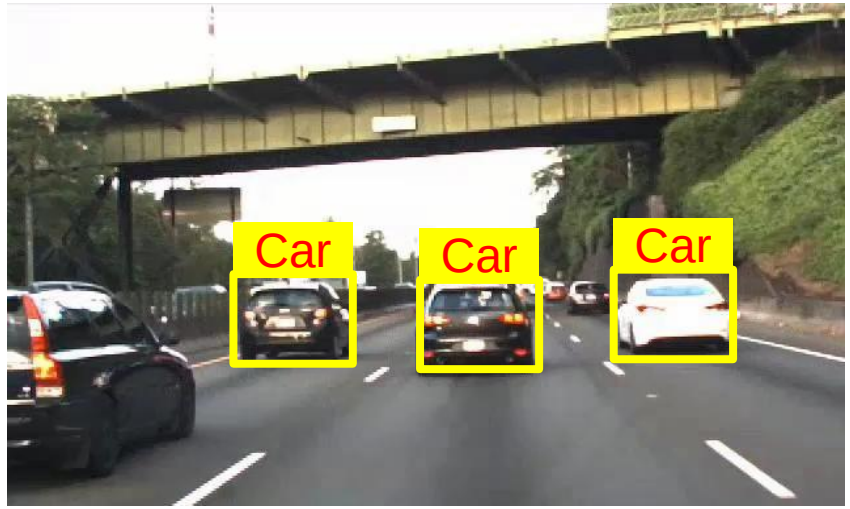
- Tradičné algoritmy nemusia fungovať pre viaceré scenáre

Úlohy vnímania pre AI

Klasifikácia

Regresia

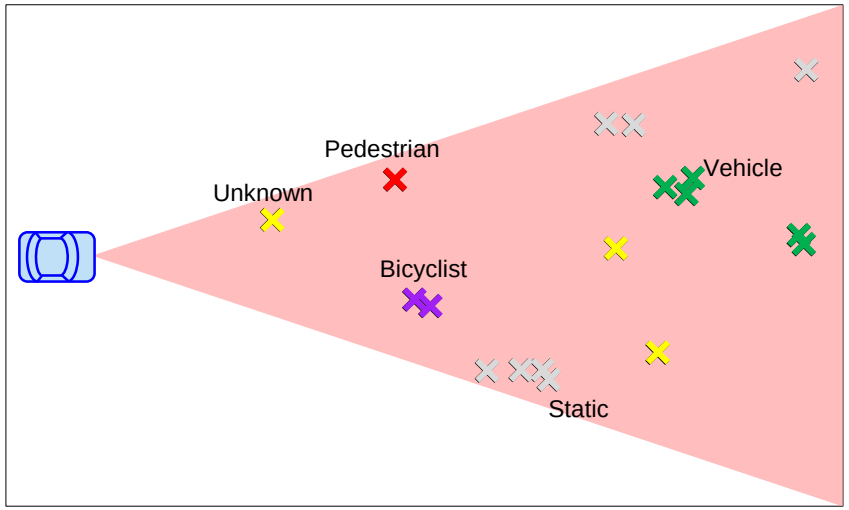
Detekcia

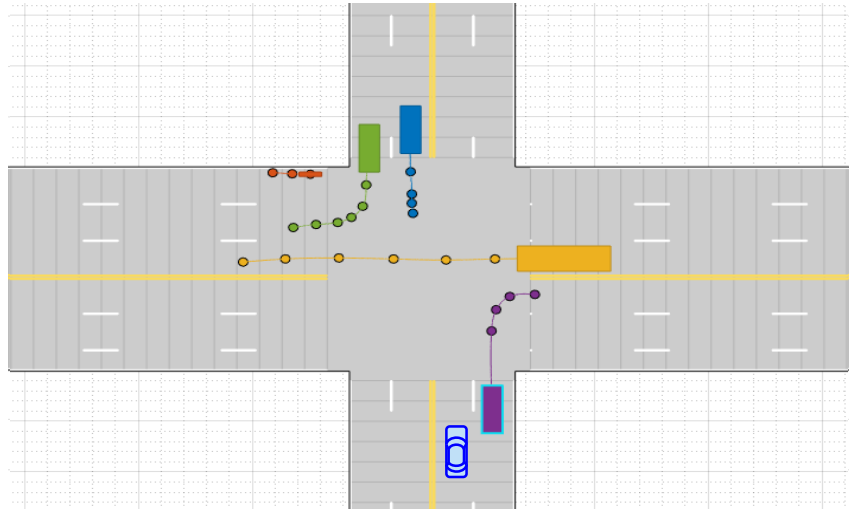


Sémantická segmentácia

Úlohy vnímania pre AI

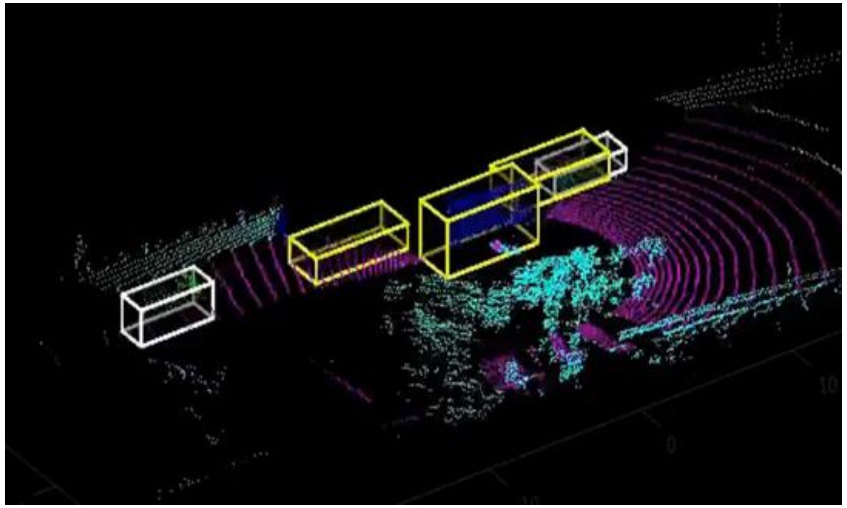
Klasifikácia radaru

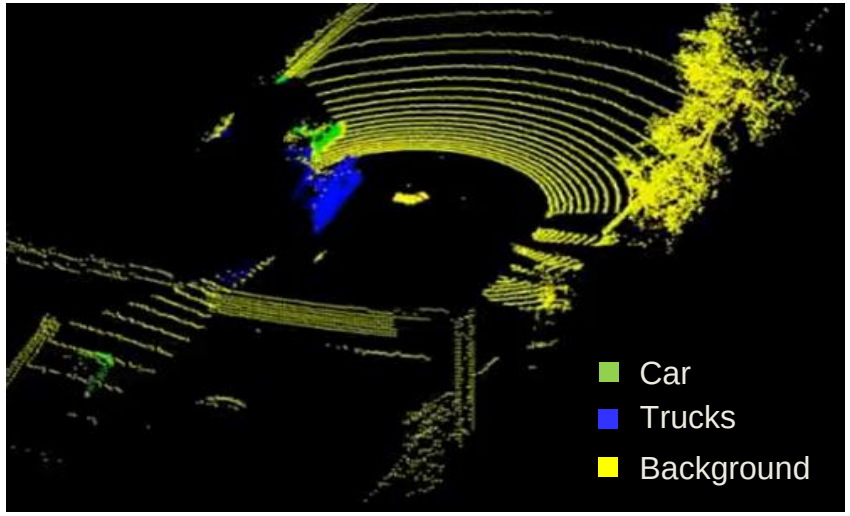




Predikcia cesty (Regresia)

Detekcie lidaru



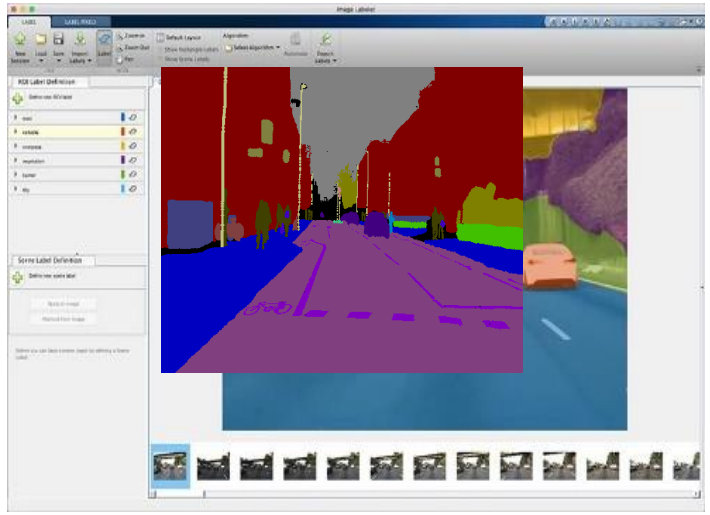


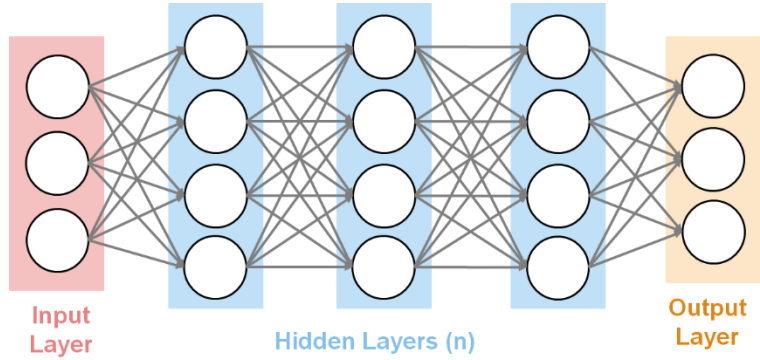
Sémantická segmentácia lidaru

Pracovný postup

Dáta

Popis

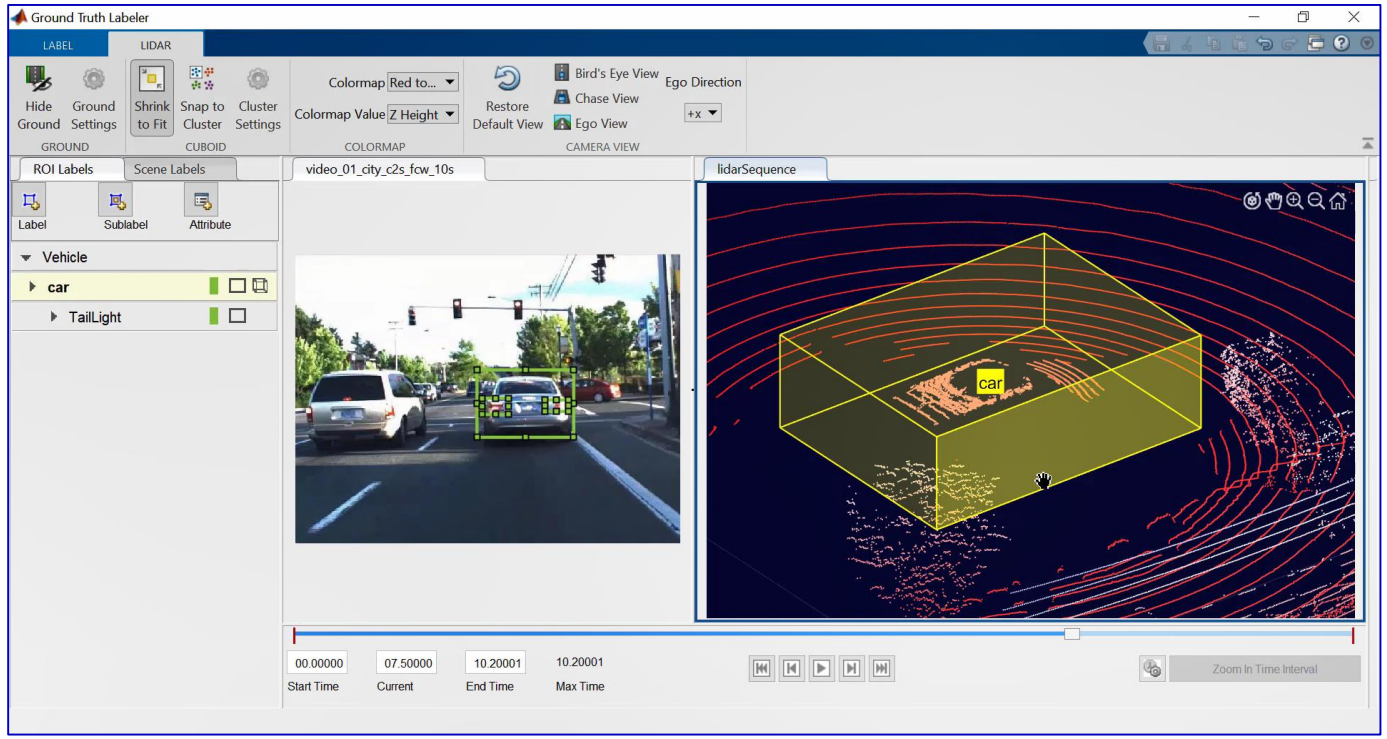




Trénovanie AI modelu

Popis dát pomocou Ground Truth Labeler App

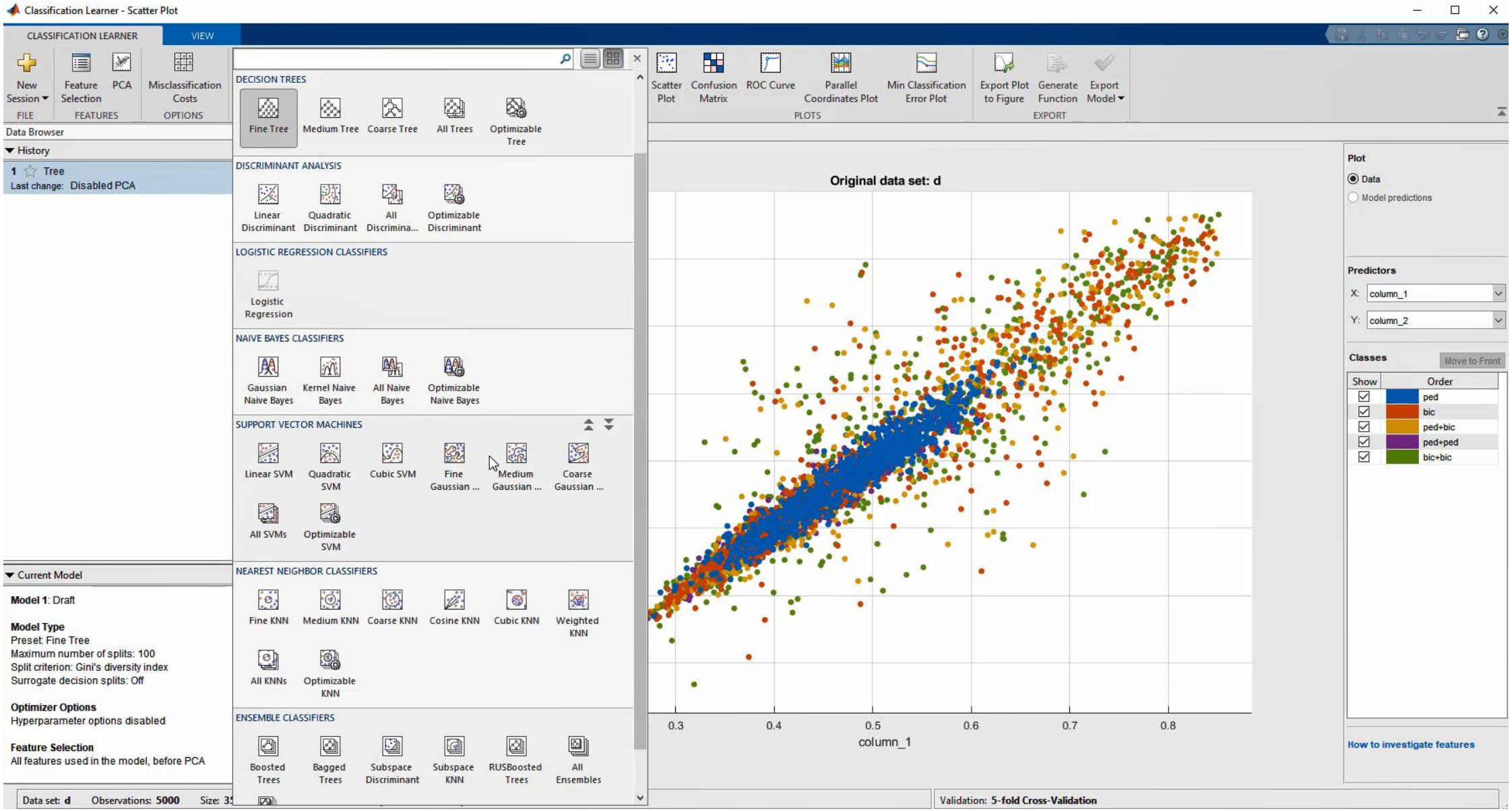
- Interaktívny popis dát
  - Rectangular ROI
  - Polygon ROI
  - Polyline ROI
  - Pixel ROI (sémantic segment.)
  - Cuboid (lidar)
- Vstavané a vlastné algoritmy
- Vizualizácie
- Export popiskov



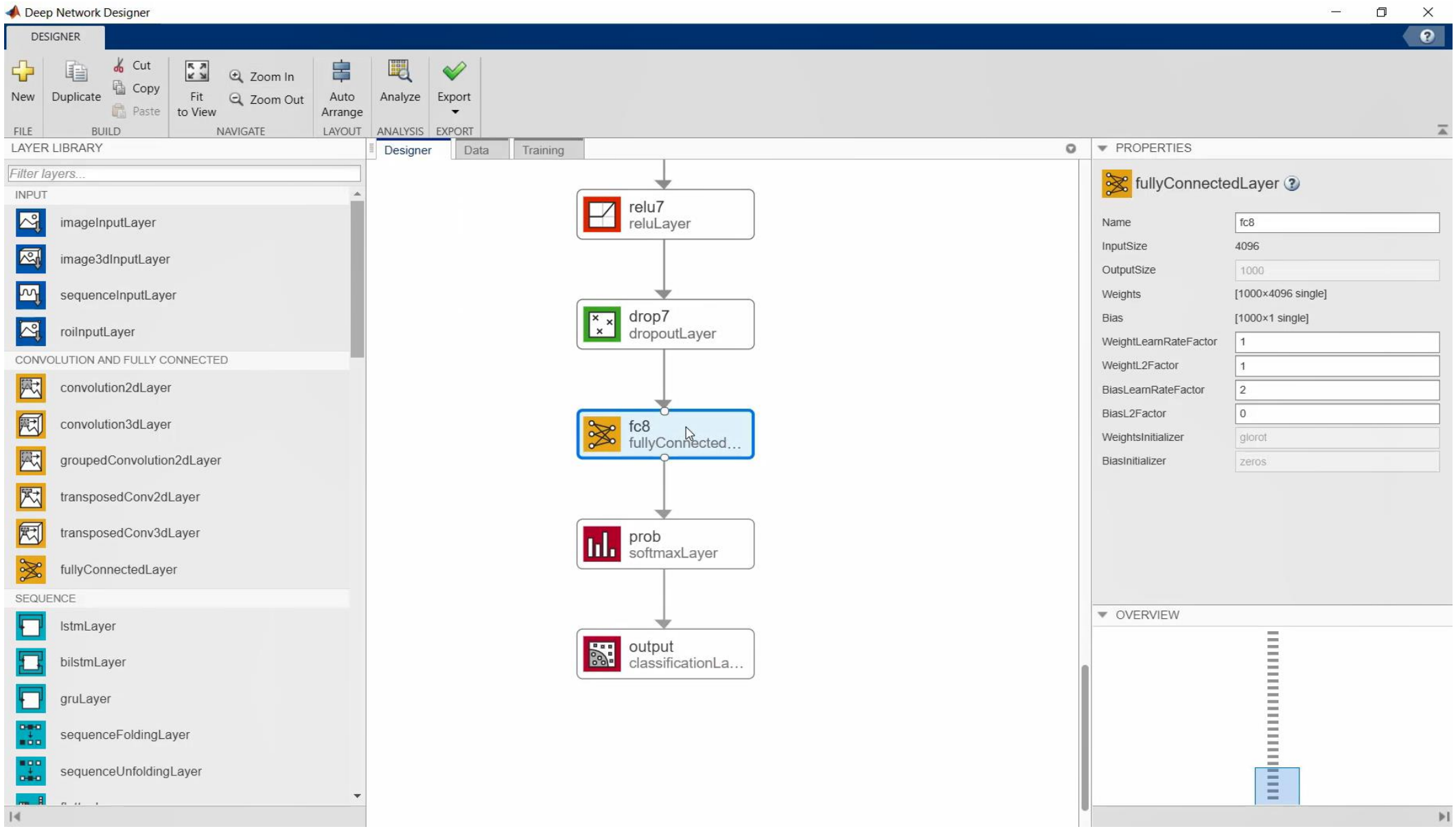
Ground Truth Labeler

Automated Driving Toolbox™

Návrh a trénovanie modelov strojového učenia

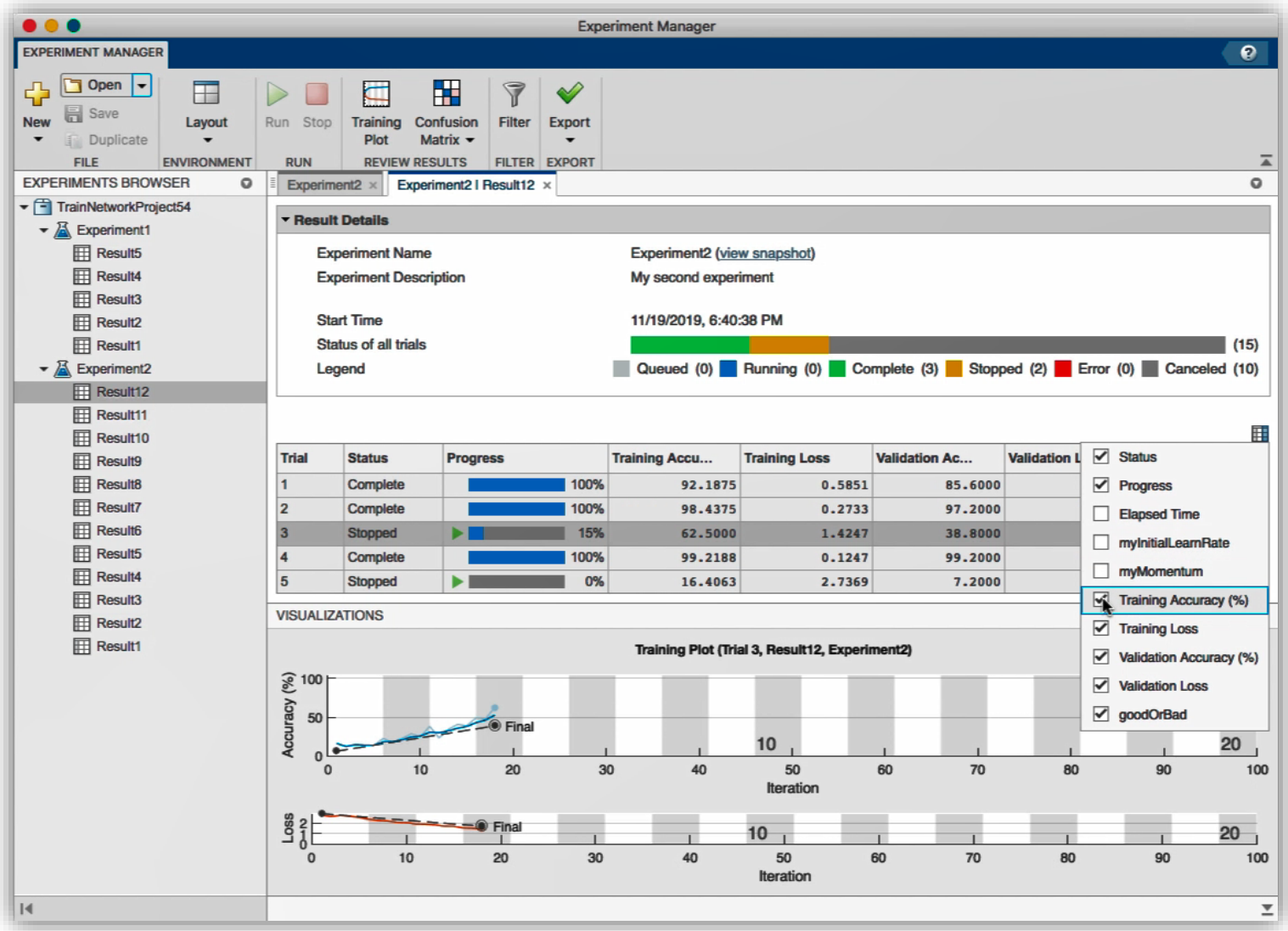


Návrh a trénovanie konvolučných neurónových sietí



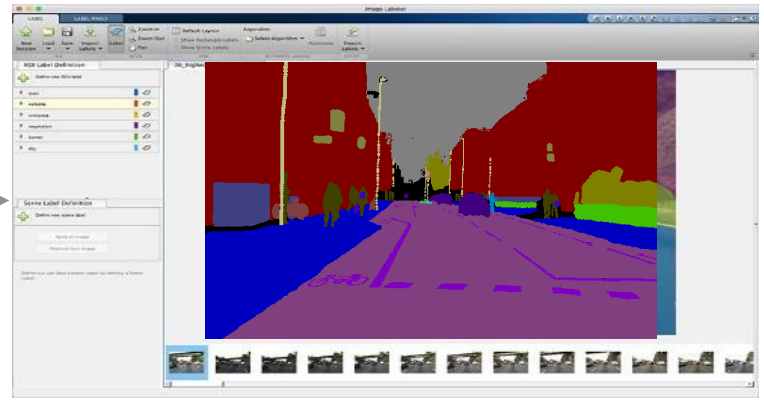
Hľadanie najlepšieho modelu

- Hľadanie parametrov
  - Zoznam hodnôt
  - Bayesian optimization
- Porovnanie
  - Architektúr
  - Dátových setov
- Vlastná metrika vyhodnocovania modelov
- Vizualizácie
  - Graf trénovania
  - Confusion matrix



Urýchlenie popisovania

Dáta



Popisok

Trénovanie

Natrénovaný AI model

Návrh popiskov

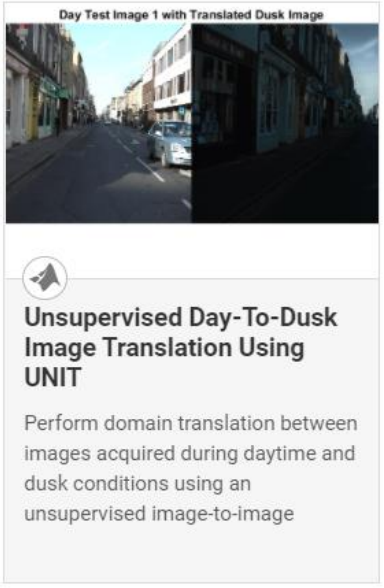
Manuálne overenie

Generovanie obrázkov rôzneho času dňa

Súmrak na deň

Detaily trénovania

- 370 obrázkov
- CAMVID dataset
  - Obrázky dňa: 263
  - Obrázky súmraku: 107
- Na učenie sa nepoužívajú časové informácie

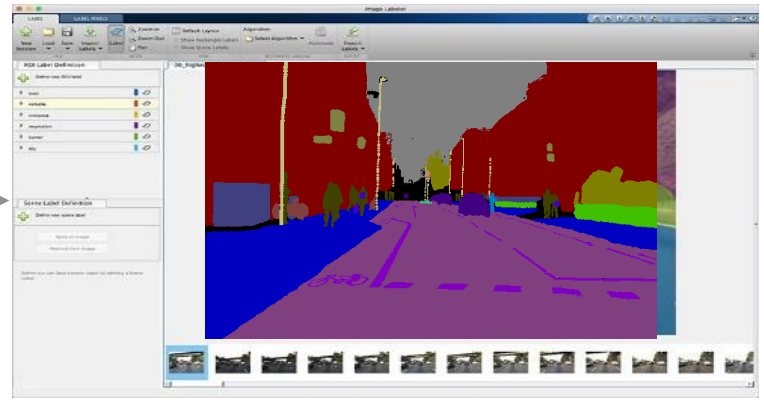


Link to Example

Deň na súmrak

Generovanie popísaných dát zo simulácie

Tradičný postup DL



Dáta **Popis**

Trénovanie

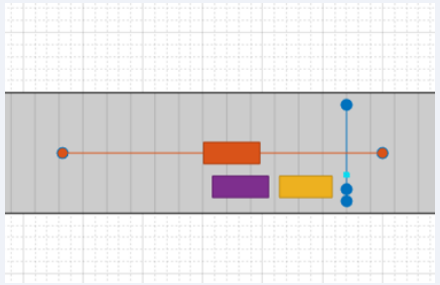
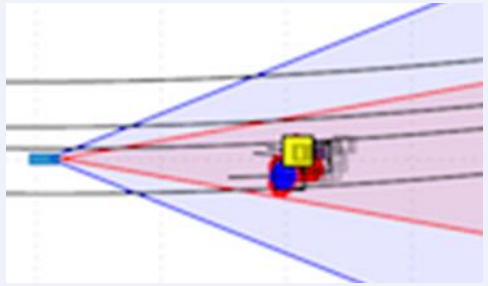
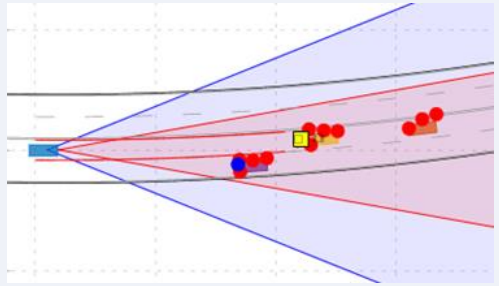
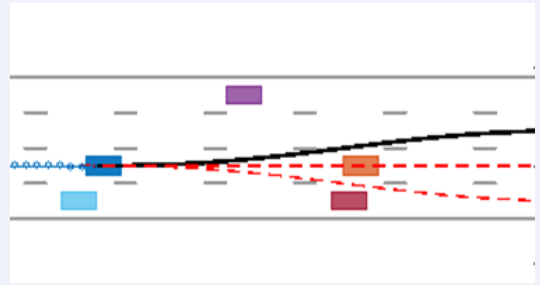
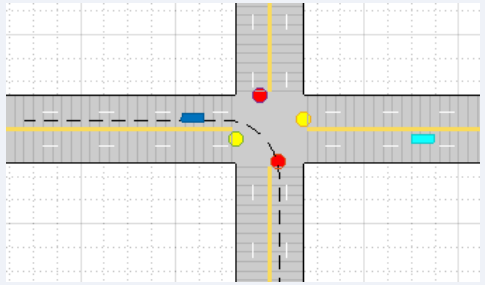
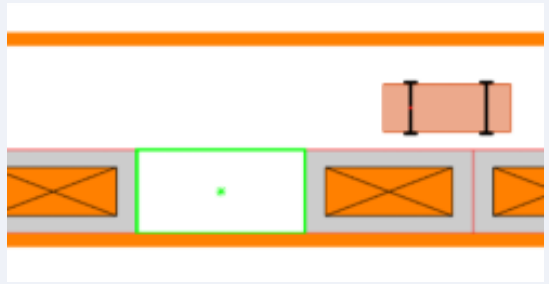
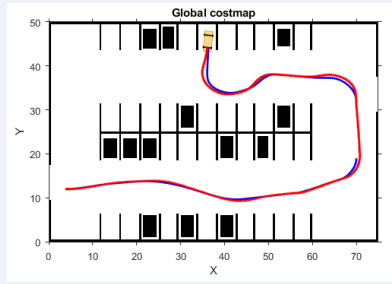
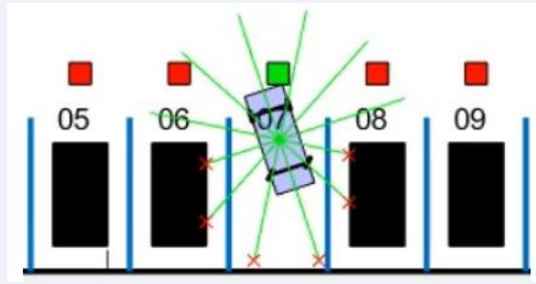
Natrénovaný AI model

Trénovanie

Simulation Environment

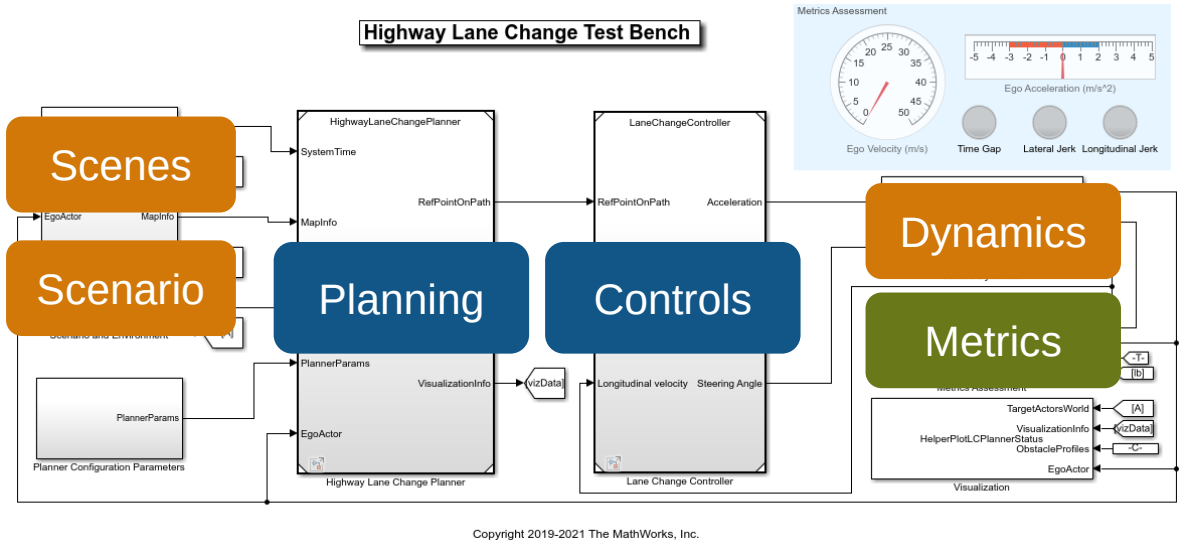
Simulácia **Automatický popis**

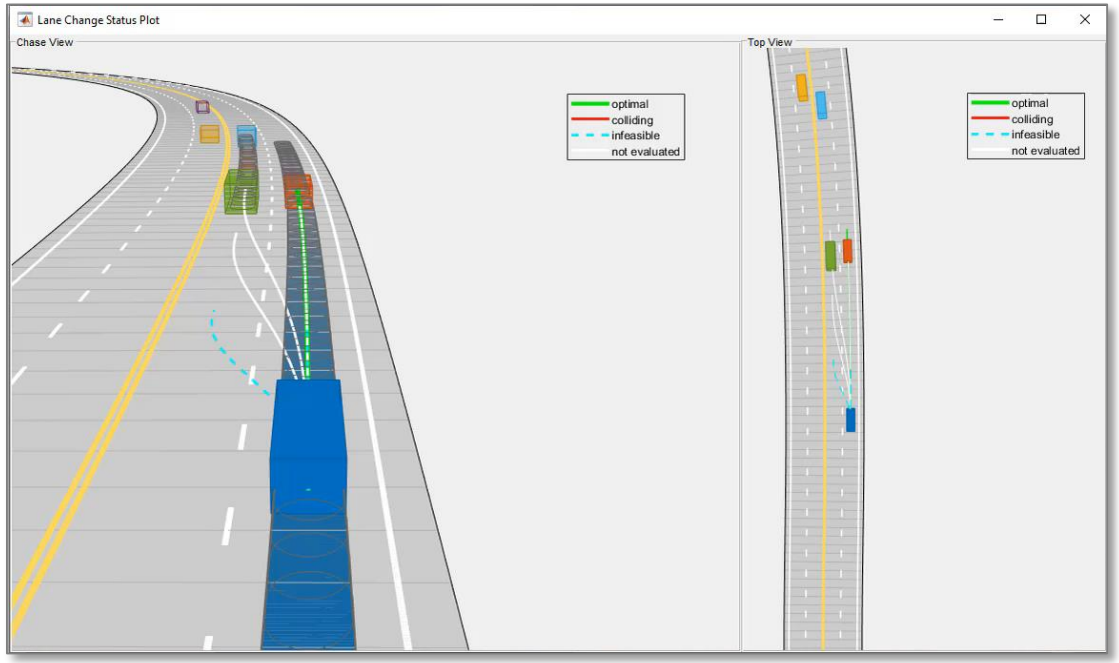
Návrh algoritmov plánovania a riadenia

Núdzové brzdenie	Adaptive Cruise Control	Sledovanie čiary	Zmena pruhu
			
Svetelná signalizácia	**Paralelné parkovanie**	**Parkovisko**	**Reinforcement Learning**
			

Často využívané nástroje: Automated Driving Toolbox, Model Predictive Control Toolbox, Stateflow, Navigation Toolbox, Reinforcement Learning, Robotics System Toolbox

Návrh plánovania a riadenia zmeny jazdného pruhu



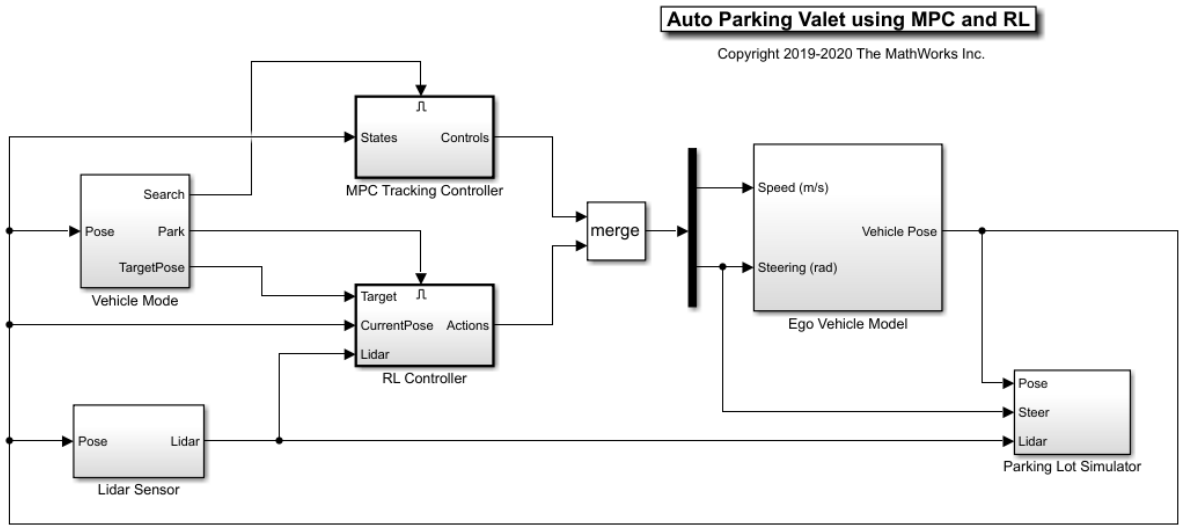


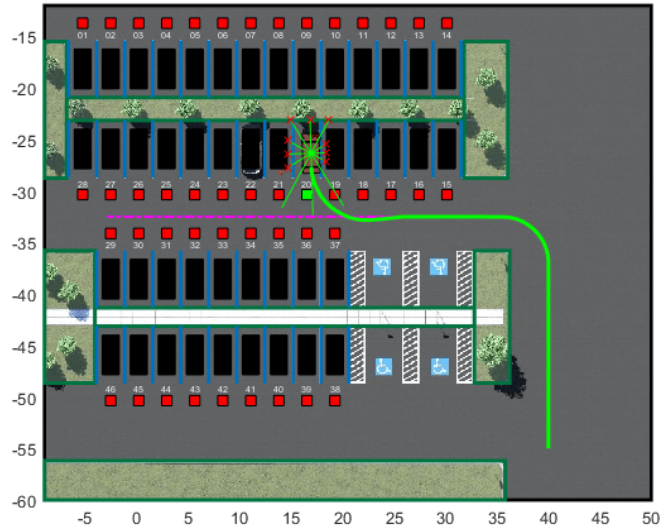
- Generovanie optimálnej trajektórie v priestore Frenet
- Implementácia manévra v závislosti na okolí
- Kontrola kolizií

[Highway Lane Change]

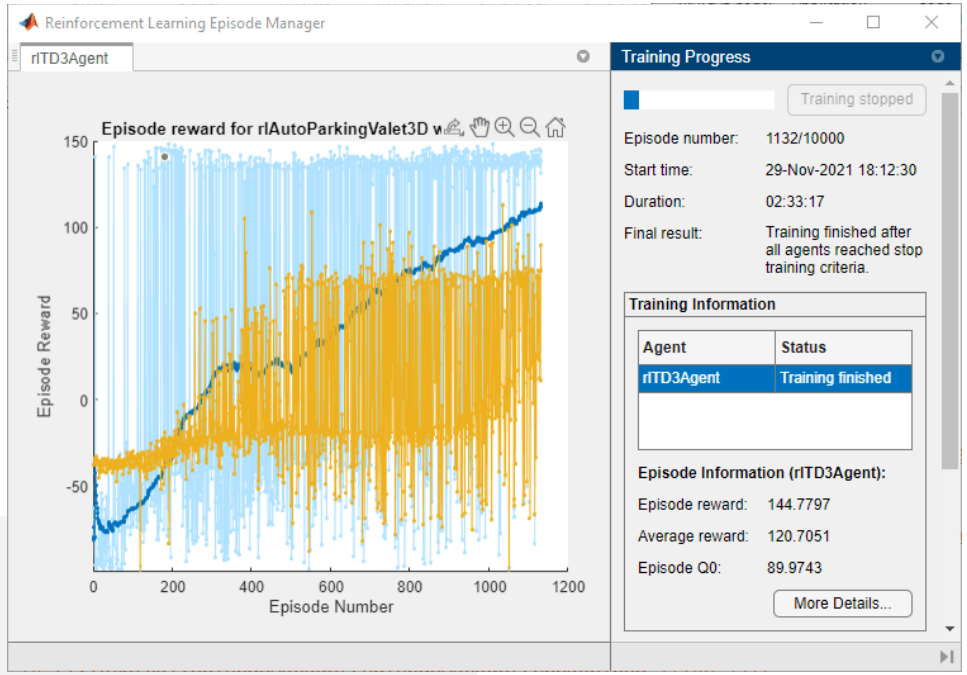
Navigation Toolbox™, Model Predictive Control Toolbox™, Automated Driving Toolbox™

Parkovanie vozidla





- Hybridný regulátor na sledovanie trajektórie a parkovanie
- Model Predictive Control – sledovanie referenčnej trajektórie
- Reinforcement Learning – parkovací menéver

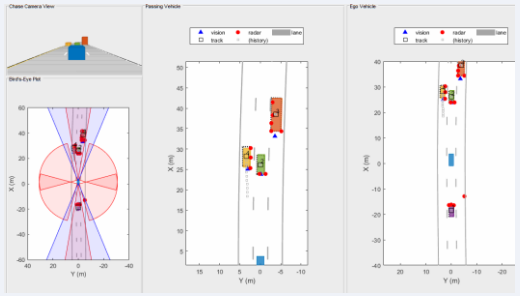
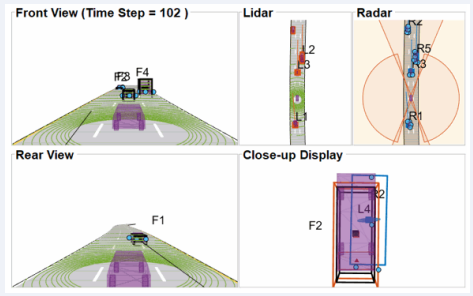
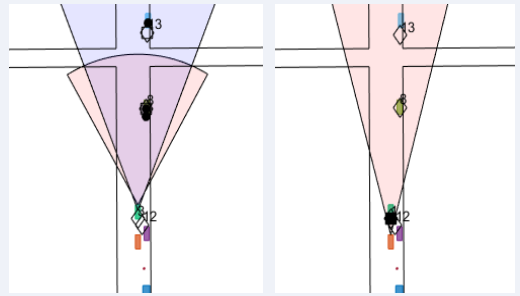
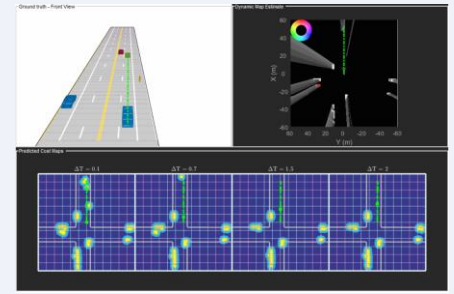
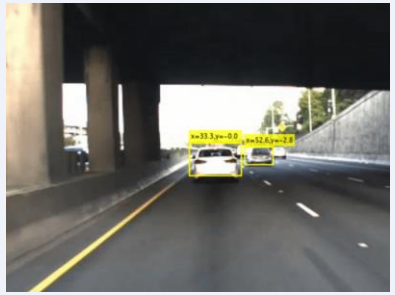
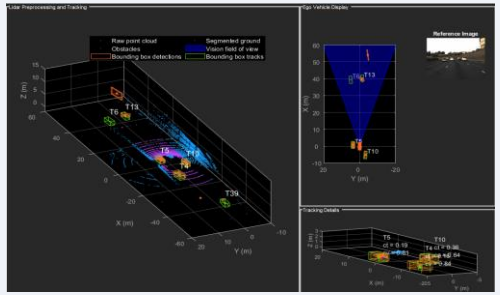
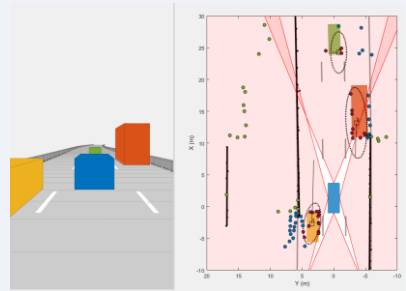
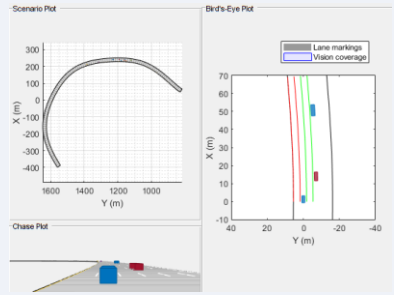


[Train PPO Agent for Automatic Parking Valet]

[Automatic Parking Valet with Unreal Engine Simulation]

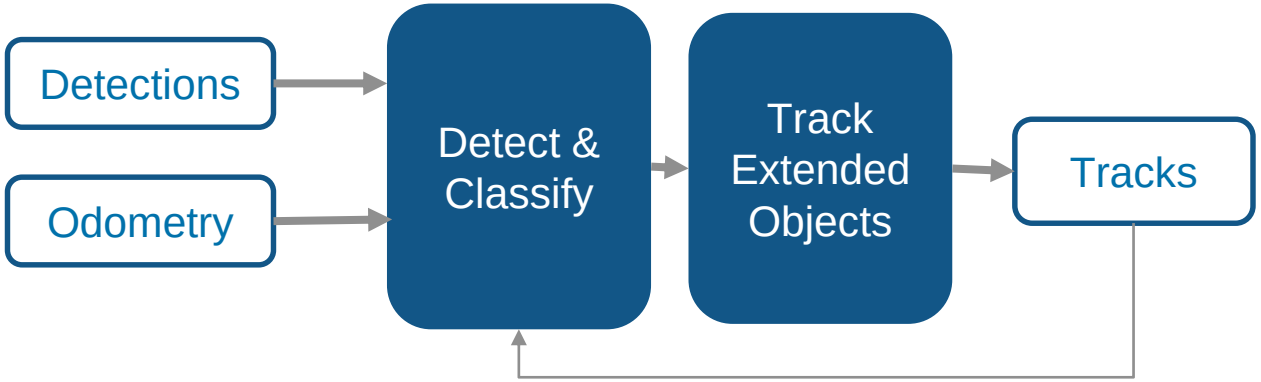
Reinforcement Learning Toolbox™,Model Predictive Control Toolbox™

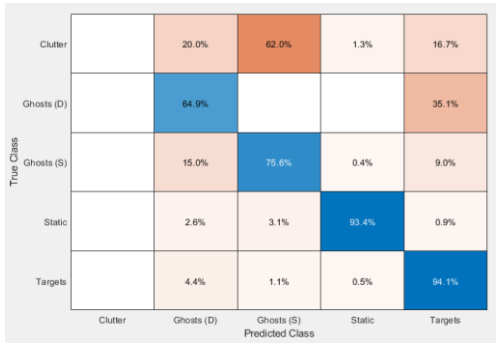
Algortimy sledovania a fúzie

Radar a kamera	Lidar a radar	Vehicle to Vehicle	Mriežky obsadenosti
			
Kamera	**Lidar**	**Radar s odrazmi**	**Hranice čiary**
			

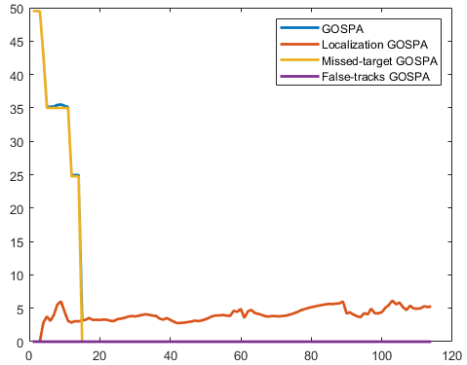
Často využívané nástroje: Automated Driving Toolbox, Tracking and Fusion Toolbox, Radar Toolbox

Sledovanie vozidiel v prítomnosti odrazov radaru

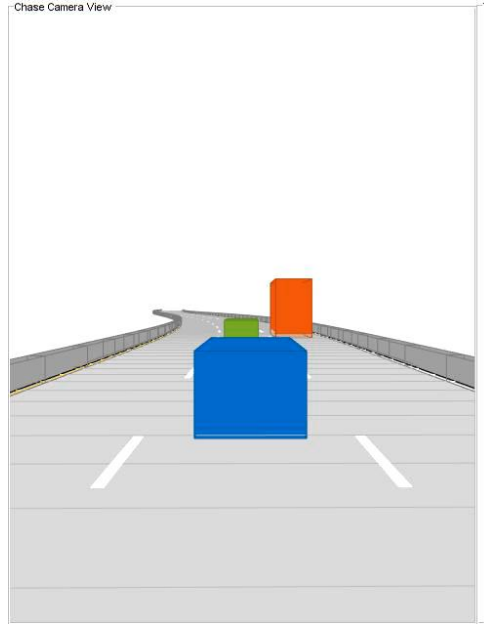


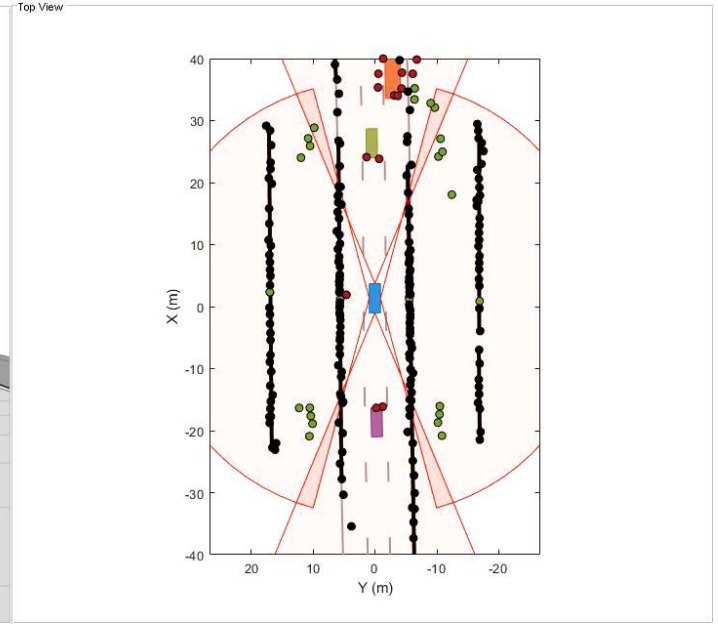


Classification metrics



Tracker metrics





[Highway Vehicle Tracking with Multipath Radar Reflections]

Automated Driving Toolbox™, Sensor Fusion and Tracking Toolbox™, Radar Toolbox™

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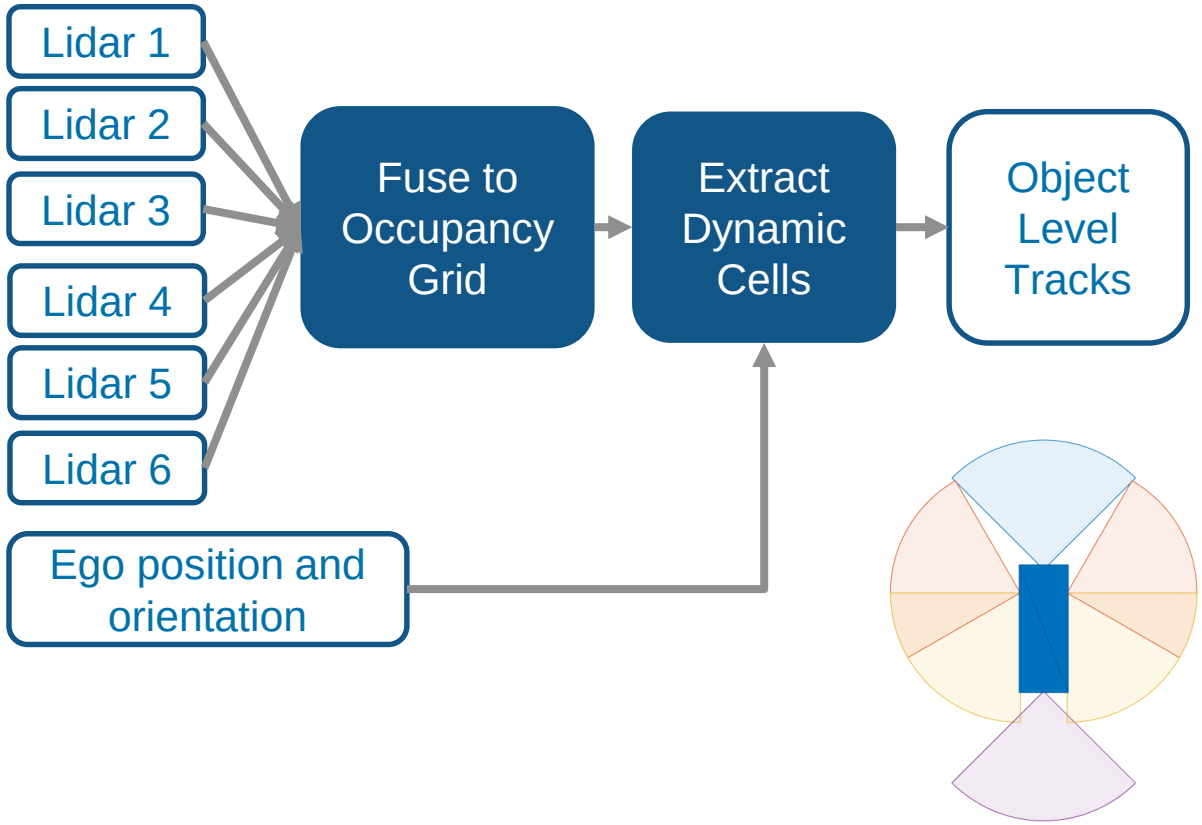
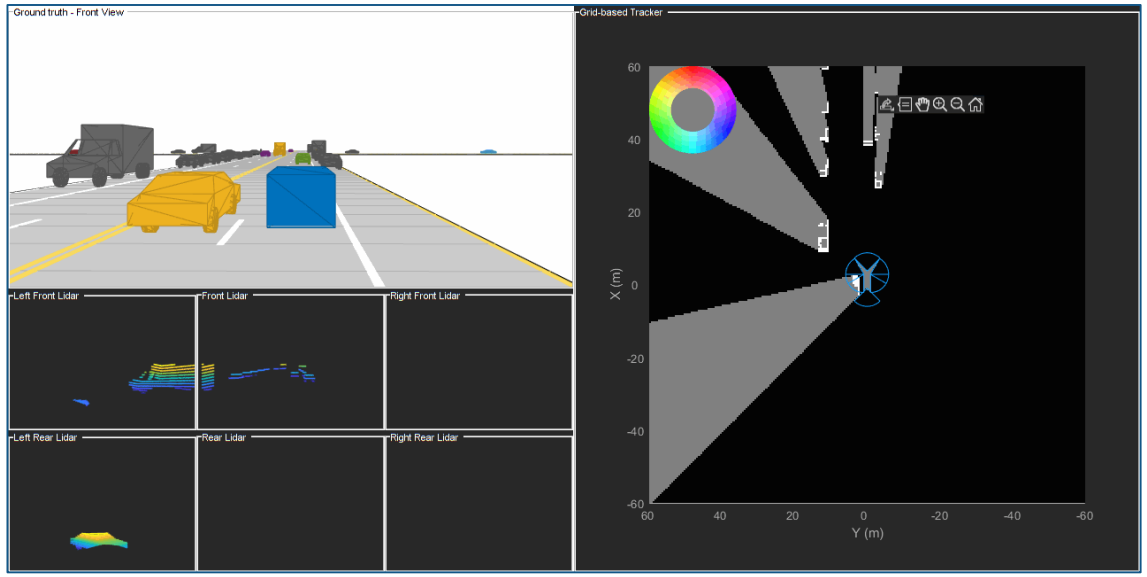
Sledovanie objektov v prostredí

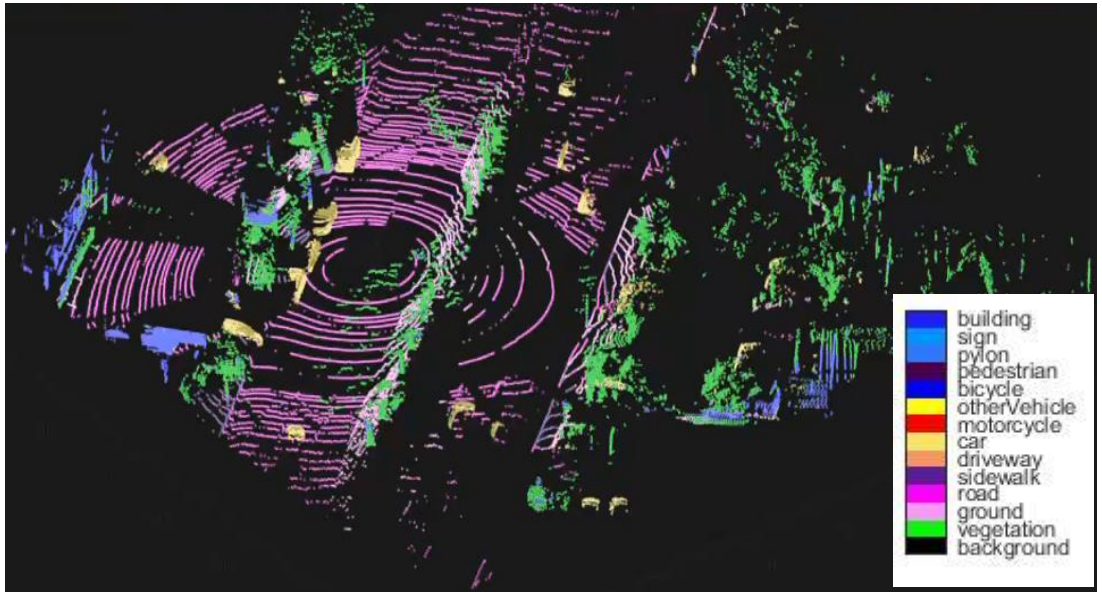


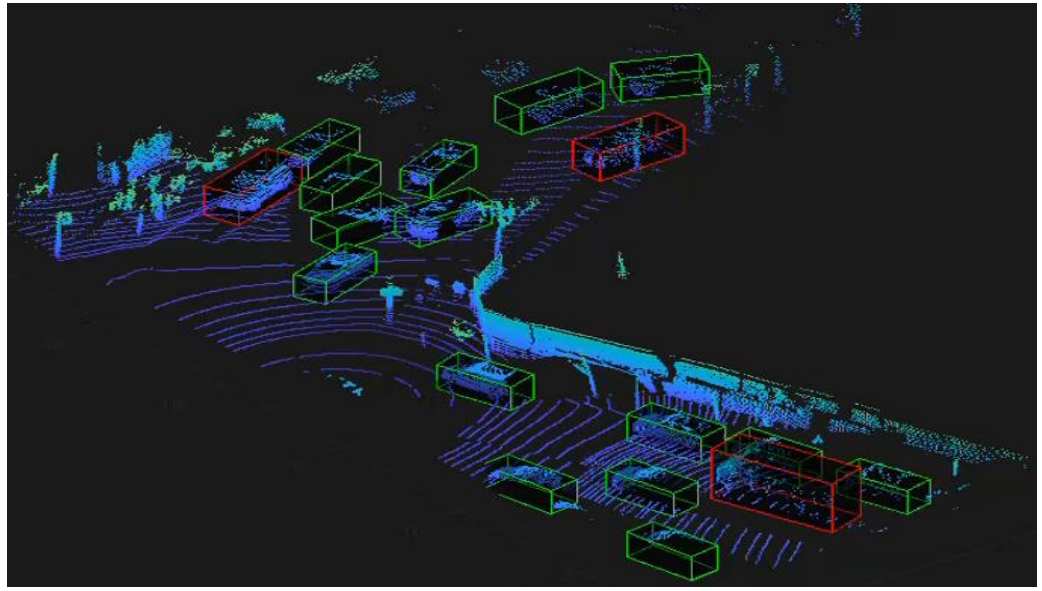


[Grid-based Tracking in Urban Environments Using Multiple Lidars]

Automated Driving Toolbox™, Sensor Fusion and Tracking Toolbox™

Detekcia objektov a sémantická segmentácia s lidarom



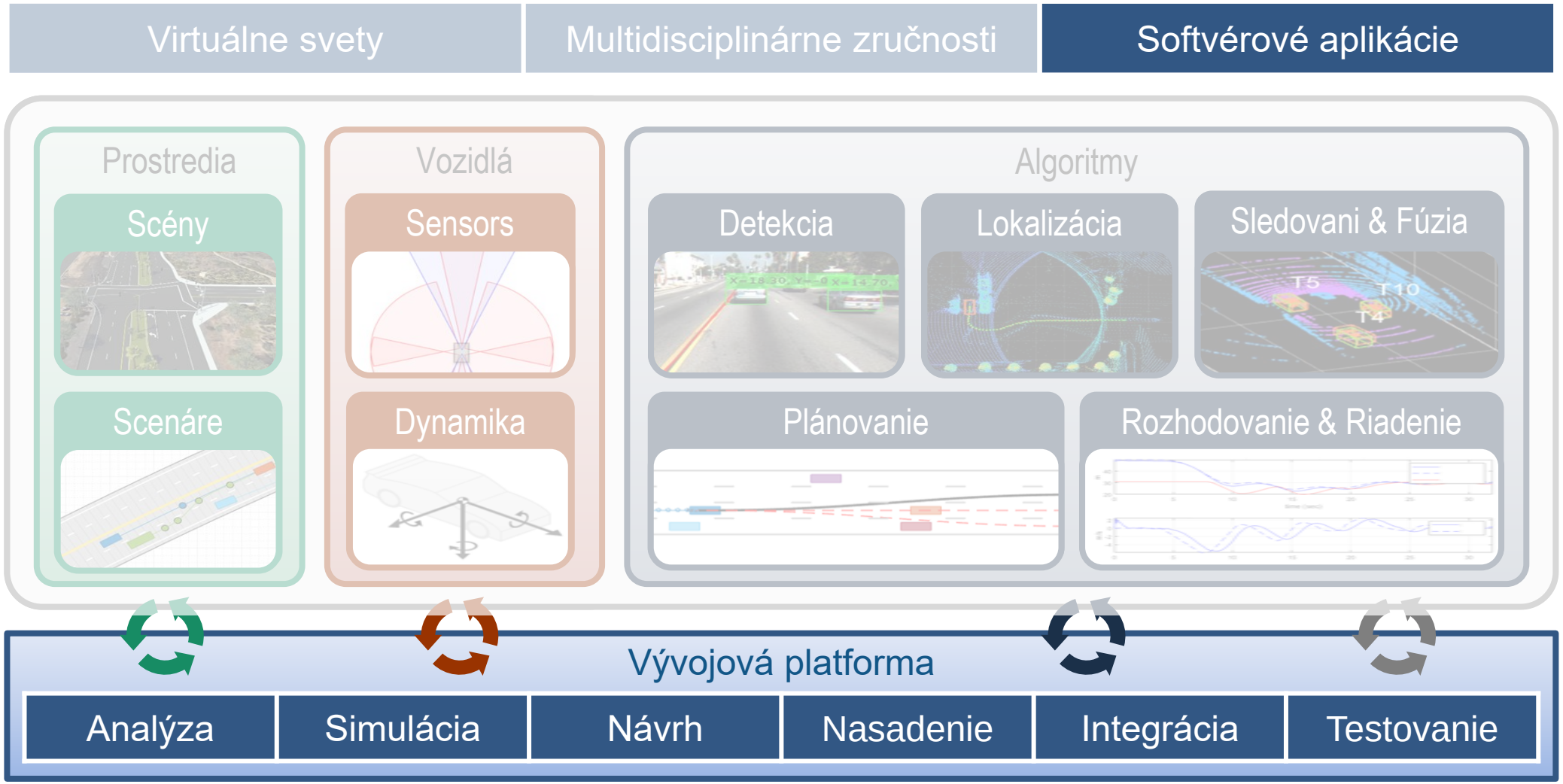


- Detekcia a klasifikácia viacerých objektov
- Podpora viacerých sietí: SalsaNet, RangeNet++, SqueezeSegv2, PointNet
- Funkcie pre prácu s PointCloudom a podpora generovania kódu

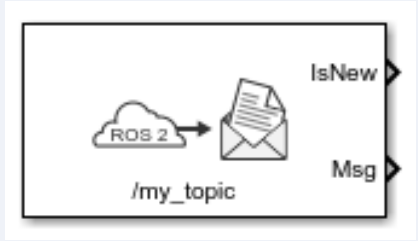
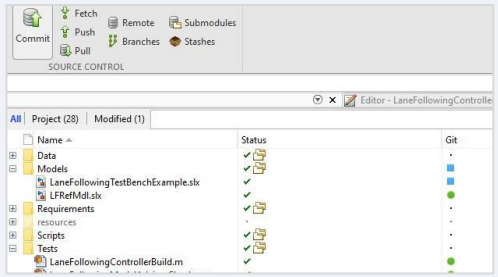
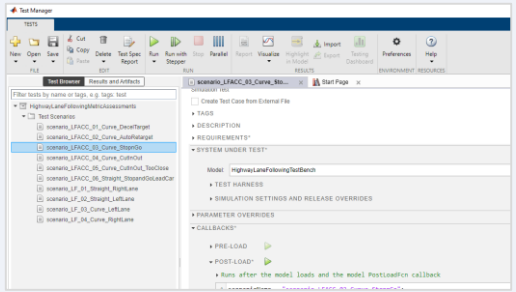
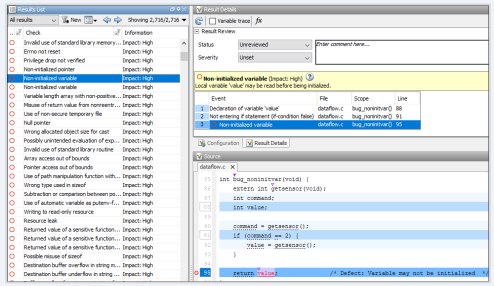
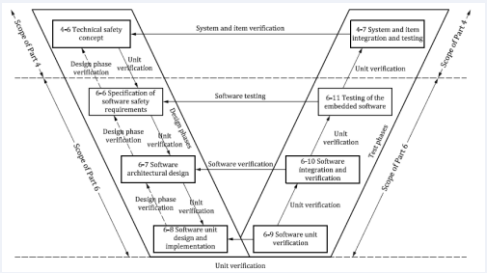
Lidar 3-D Object Detection Using PointPillars Deep Learning

Lidar Toolbox™

Vývoj systémov autonómneho riadenia

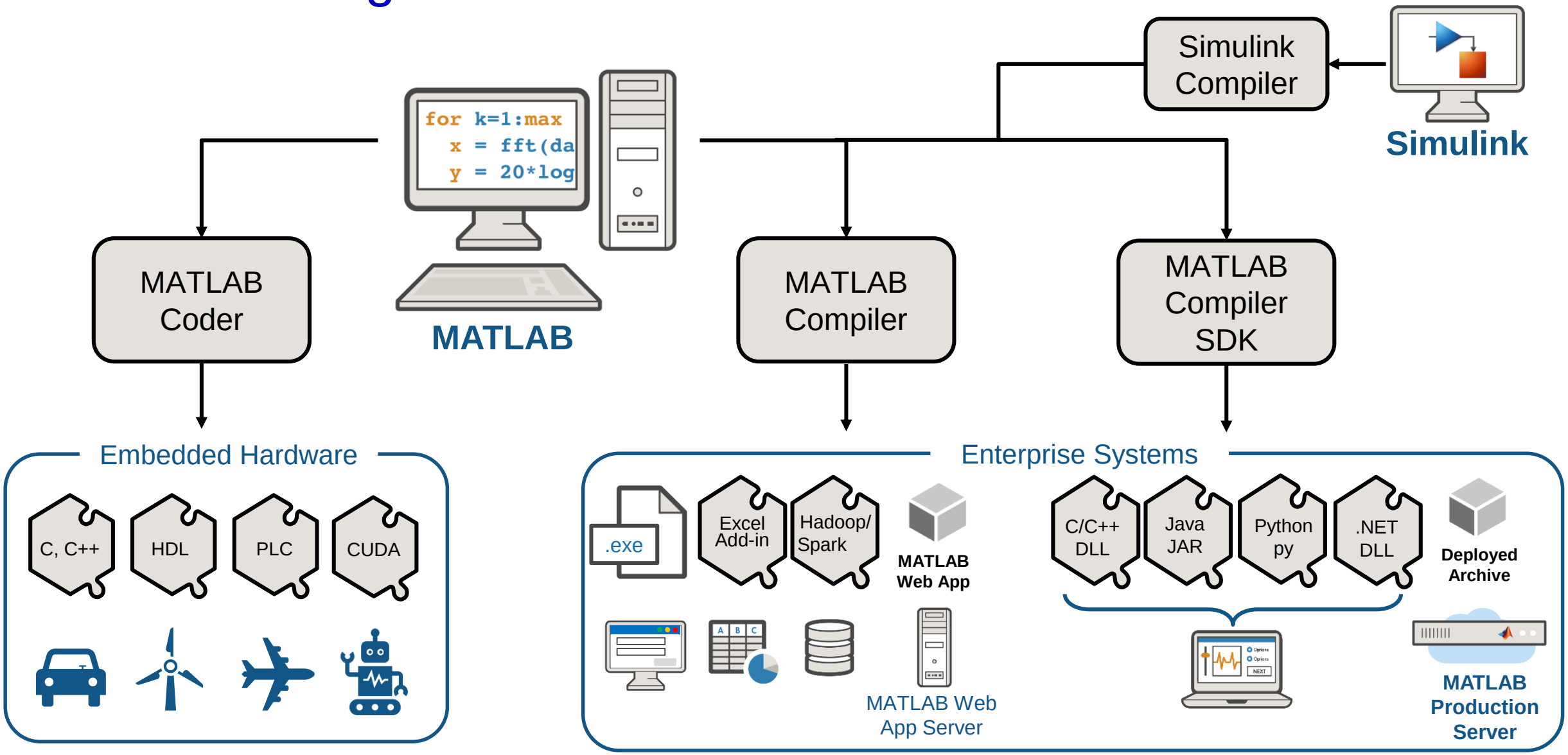


Vývoj softvérových aplikácií

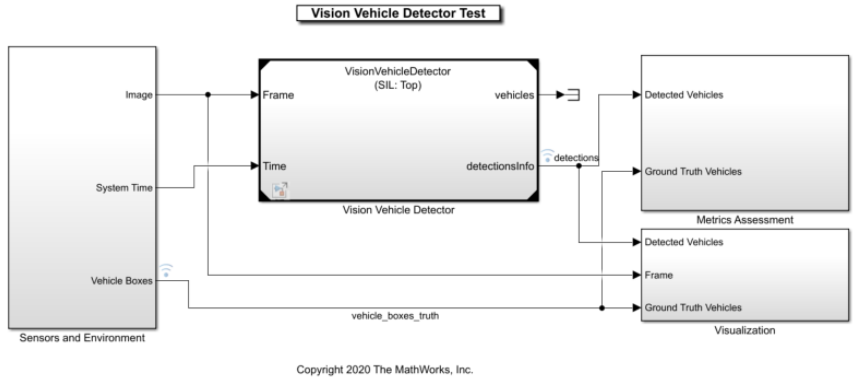
Kód	ROS / ROS 2.0	AUTOSAR	DDS
C C++ GPU HDL			
Continuous Integration	**Automatické testovanie**	**Analýza kódu**	**ISO 26262**
			

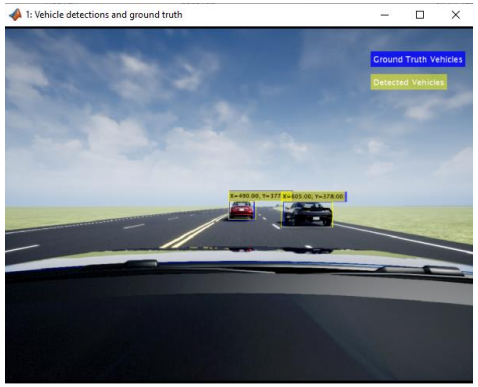
Často využívané nástroje: MATLAB Coder, Embedded Coder, GPU Coder, HDL Coder,
ROS Toolbox, AUTOSAR Blockset, DDS Blockset,
Simulink Test, Simulink Coverage, Polyspace, IEC Certification Kit,

Nasadenie algoritmov



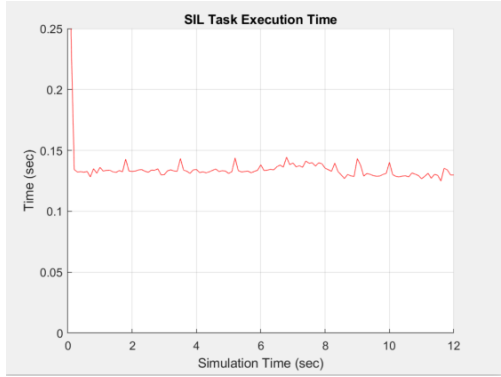
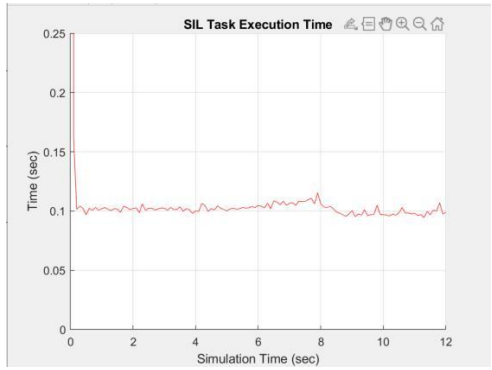
Generovanie C/C++ a GPU kódu v Simulinku





- Generovanie kódu, verifikácia funkcii a meranie času vykonávania pomocou Software-In-the Loop (SIL)

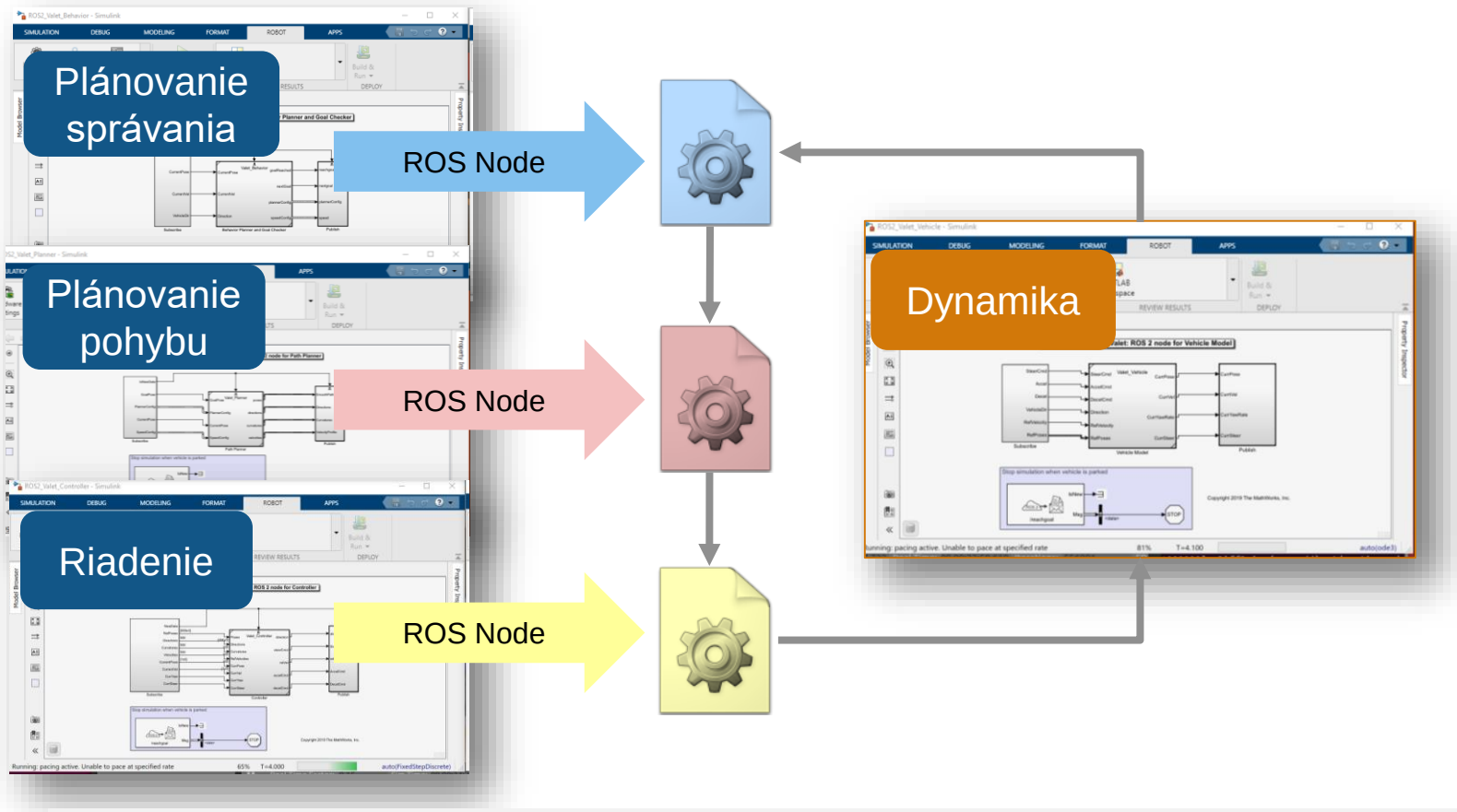
CPU: Intel® Xeon® @ 3.60GHz, GPU: Quadro K620

YOLOv2 CPU - MKLDNN	YOLOv2 GPU - cuDNN	YOLOv2 GPU - tensorRT
		

[Generate Code for Vision Vehicle Detector]

Automated Driving Toolbox™, Embedded Coder®, Computer Vision Toolbox

Nasadenie plánovania a riadenia do ROS / ROS 2.0

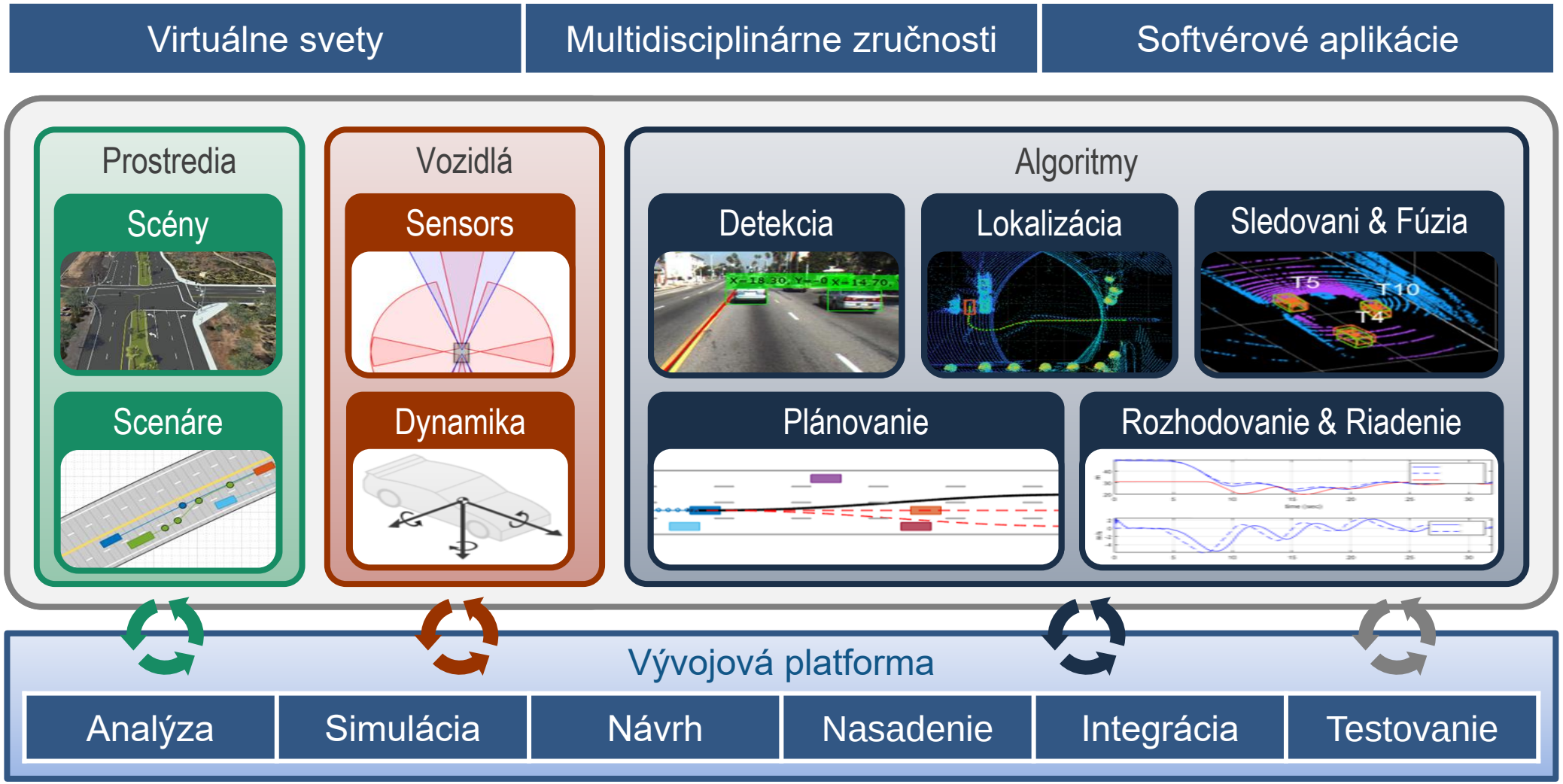


[Automated Parking Valet with ROS in Simulink]

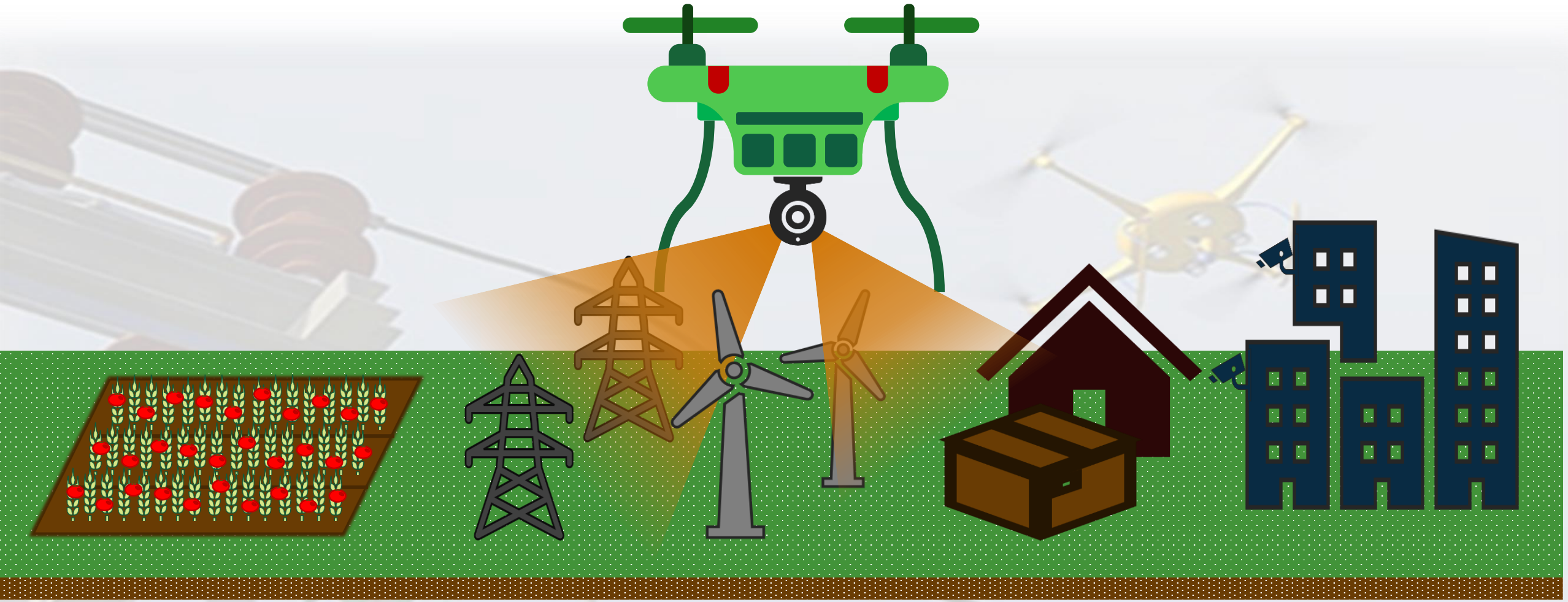
[Automated Parking Valet with ROS 2 in Simulink]

ROS Toolbox, Embedded Coder®, Automated Driving Toolbox™, Model Predictive Control Toolbox™

Vývoj systémov autonómneho riadenia



Autonómne UAV



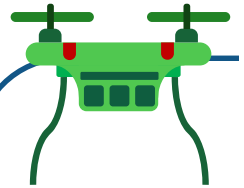
Mapovanie a prieskum

Inšpekcie a monitorovanie

Doručovanie a doprava

Bezpečnosť a obrana

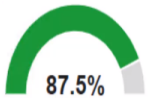
Vývoj UAV aplikácií



MATLAB® Simulink®

Architektúra Systému

Verifikácia & Validácia

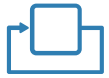


DO-178

UAV Model

Návrh algoritmov

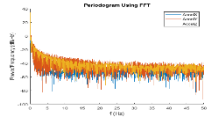
Vnímanie



Riadenie

Plánovanie & Logika

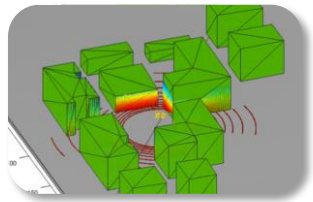
Analýza dát



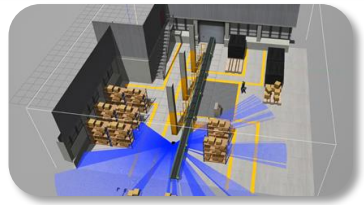
Implementácia

Spojenie

Simulácia so snímačmi



Cuboid



Gazebo

Unreal Engine

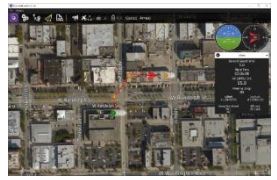
Nasadenie na hardvér

PX4®

NVIDIA® Jetson®

Prepojenie

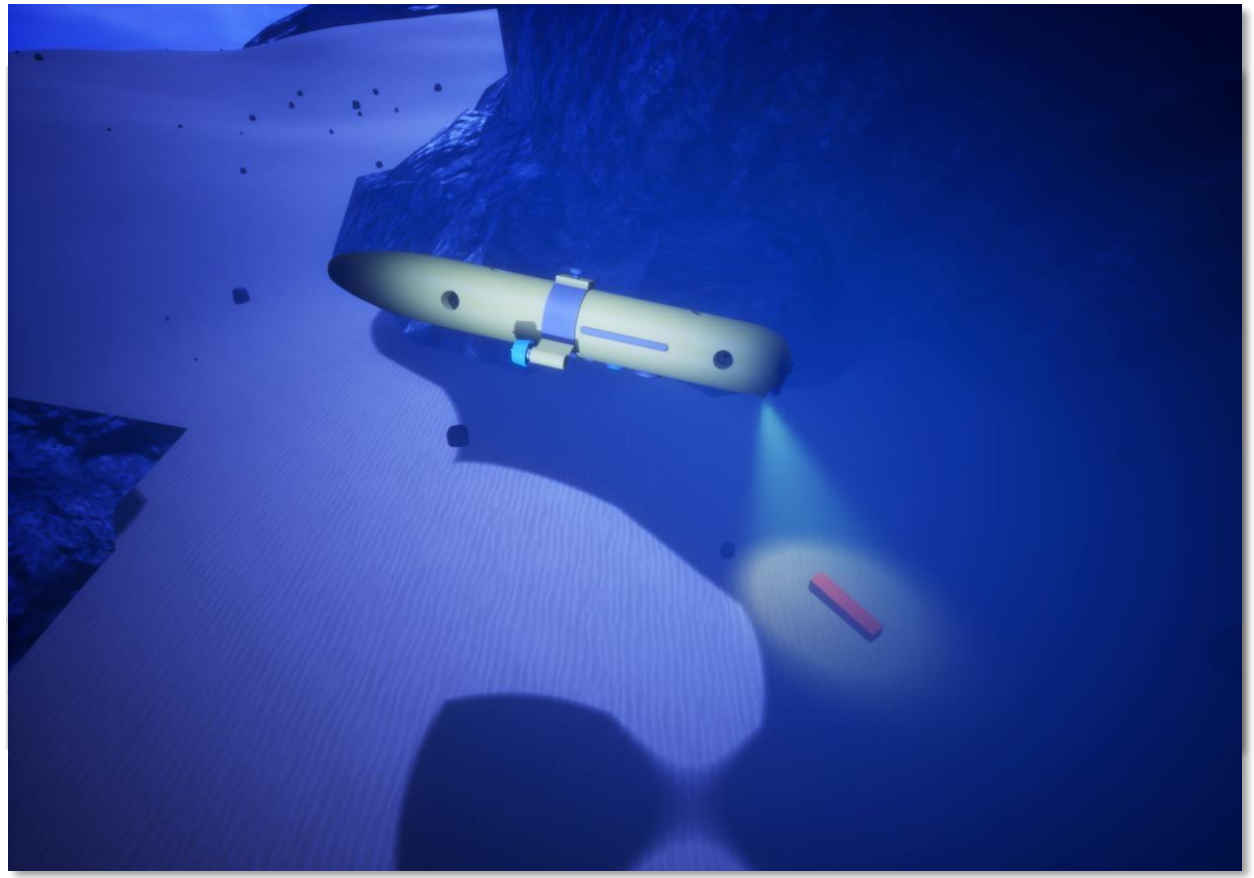
UAV



Ground Control Station

Vývoj AUV aplikácií

- Nástroje pomáhajú vývoj AUV aplikácií
  - Systems engineering
  - Modelovanie platformy
  - Prostredie a snímače
  - Autonómne algoritmy
- Hľadanie objektu pod vodou
  - Navigácia na miesto
  - Vyhýbanie prekážkam
  - Skenovanie plochy
  - Spojenie s povrchom



Vývoj AUV

Návrh systému

Požiadavky | Architektúra | Verifikácia a Validácia | Certifikáty

Autonómny algoritmus

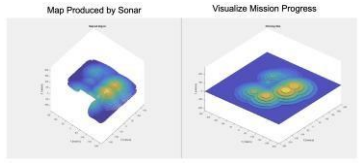
Snímanie

IMU | GPS | Kamera | Sila/Moment | Tlak | Sonar | Vytekanie | DVL

Vnímanie

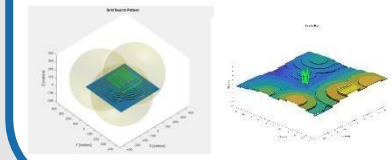
Mapovanie prostredia

Objekty Detekcia/Sledovanie



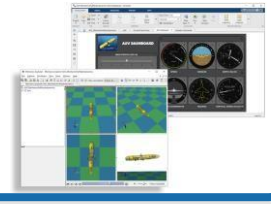
Plánovanie

Localizácia | Trasa | Prekážky



Riadenie

Spätná väzba | Stavová log. | Gain Scheduling | Trajektória



Nasadenie

Generovaine kódu | ROS | DDS

Platforma

Model systému | Hardware-in-the-loop | Software-in-the-loop | Hardvér

Ďakujem za pozornosť