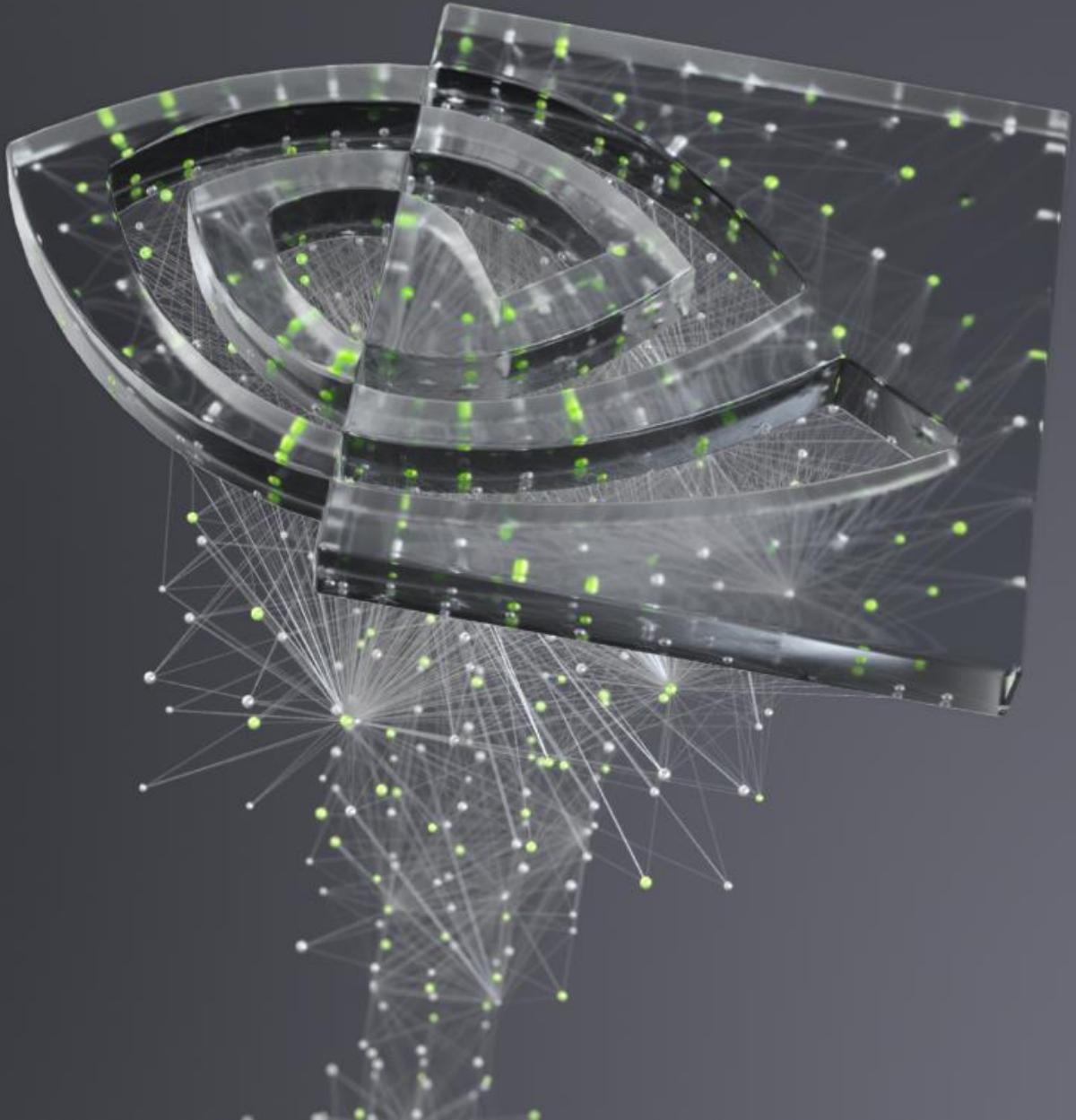




NVIDIA DRIVE

December 2019



DRIVE PLATFORM

Mass production

INDUSTRY / MARKET

SAFETY

TECHNOLOGY

REGULATIONS

THE DRIVE INITIATIVE

End-to-End, Open Platform for Building Autonomous Vehicles

DGX Saturn V



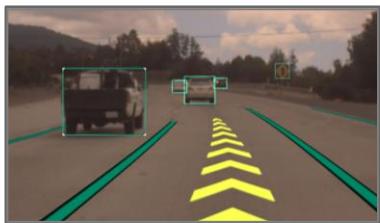
Constellation



Xavier



DRIVE AV



DRIVE IX



Re-SIM



The NVIDIA DRIVE™ Platform provides all major AI technologies for Driving, Development and Validation - from driving & cockpit computers & software to data collection & DNN training, to simulation tools. The system is an open platform with multiple programming points. Car makers are free to use or develop as much as they like and take advantage of an ecosystem of hundreds of partners.

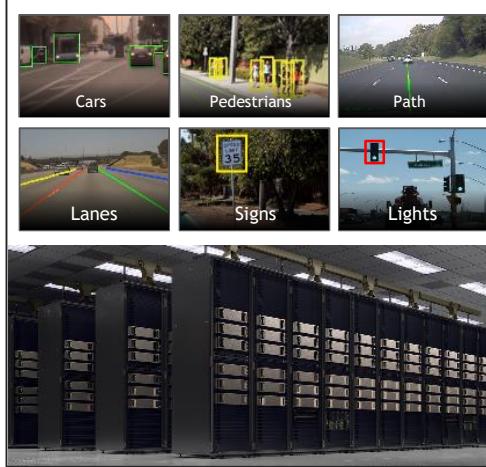
NVIDIA DRIVE

END-TO-END PLATFORM

COLLECT DATA



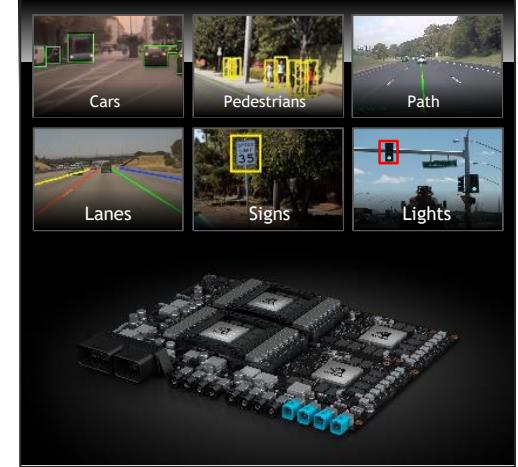
TRAIN MODELS



SIMULATE



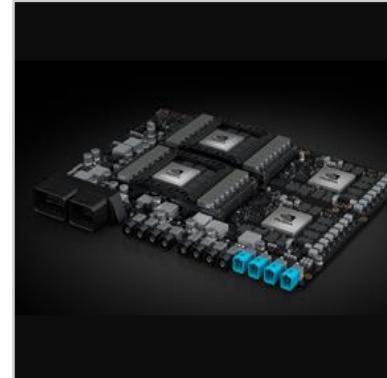
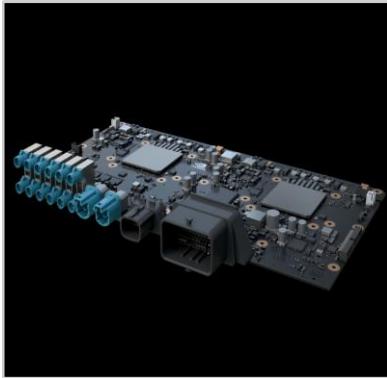
DRIVE





DRIVE COMPUTER / ARCHITECTURE
SCALABLE NOW & INTO THE FUTURE
NCAP TO ROBOTAXI

DRIVE ROADMAP



ORIN

DRIVE Parker

1x Perf
1x Efficiency
Samples - Q4'2015
Production - Q1'2017

DRIVE PX2

20x Perf
1x Efficiency
Samples - Q2'2016
Production - Q3'2016

DRIVE Xavier

23x Perf
8x Efficiency
Samples - Q1'2018
Production - Q1'2019

DRIVE Pegasus

~230x Perf
5x Efficiency
Samples - Q3'2018
Production - Q3'2019

DRIVE Orin-X

>100x Perf
~20x Efficiency
Samples - Mid 2021
Production - Q3'2022

Auto-Grade
Super Energy-Efficient

ORIN - HIGHEST PERF SOC EVER

What is driving the need for increasing performance in AV?

Sensor Complexity - More higher resolution cameras

20+ DNN Models required for most demanding ODD

New DNN Models- CNN, RCNN, RNN

DNN GOPs/Frame increasing

OTA new features / SW Patch

DNN Precision / Accuracy

Integration of functions
Centralized Computer

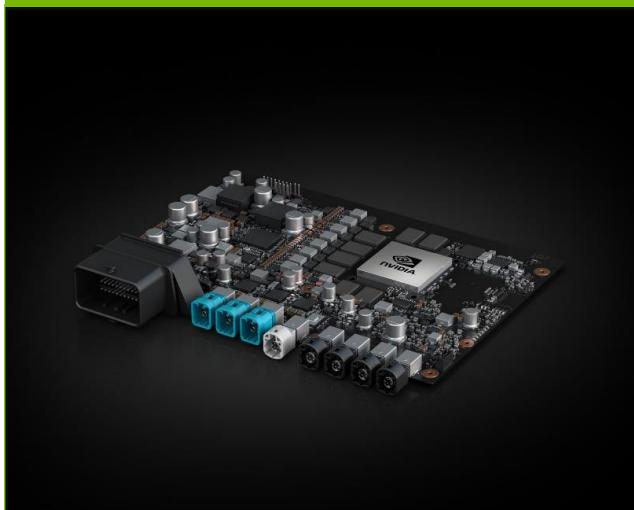
Future Proof EUNCAP With 360° Perception

More perf equates to faster time to market

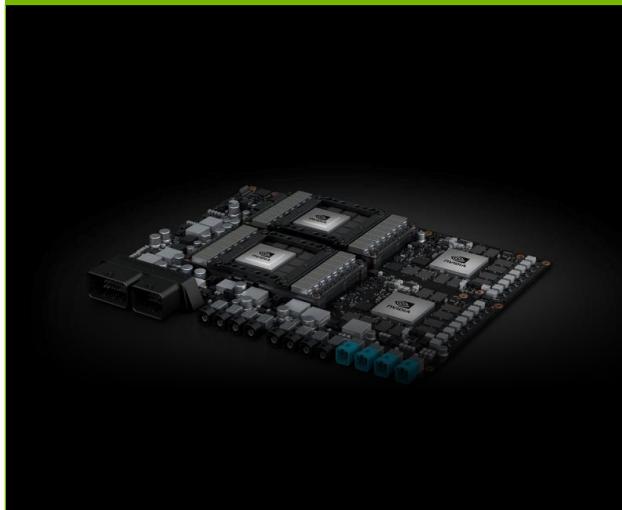
NVIDIA DRIVE

One Architecture

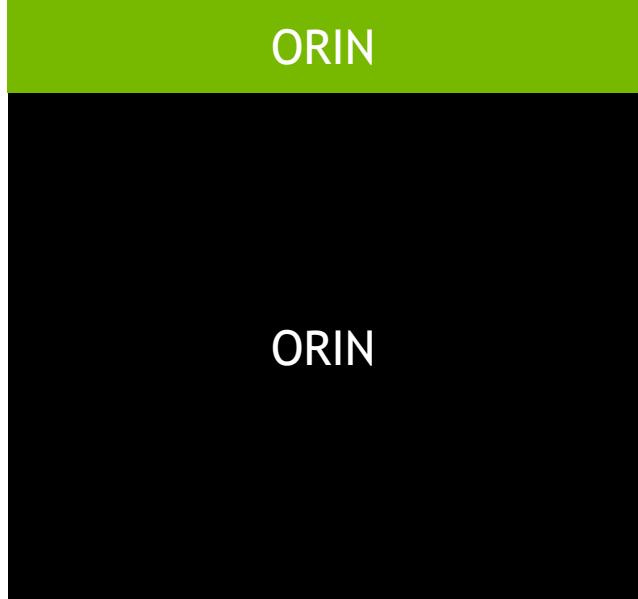
XAVIER (NCAP, L2+/L3)



PEGASUS (L4/RoboTaxis)



ORIN

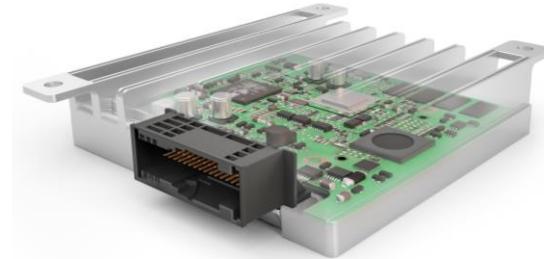
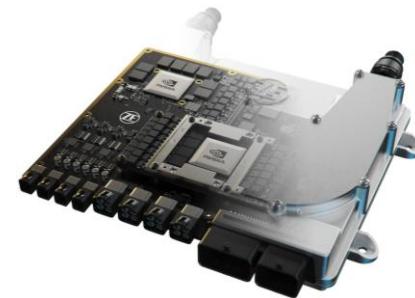


One AV Architecture for L2 -> Robo Taxi

NVIDIA DRIVE AGX platform is an open platform; allows partners to do their own innovation

DRIVE ARCHITECTURE

AUTOMOTIVE GRADE - INDUSTRIALIZED ECU'S



德赛西威
DESAY SV AUTOMOTIVE

Quanta Computer

ZF

veoneer continental



NVIDIA DRIVE
SENSOR ECOSYSTEM

SENSOR ECOSYSTEM

IMAGING SENSOR / CAMERA

ON Semiconductor®



SONY



AR0820, AR0144, AR0231, IMX390, IMX490, IMX424

LIDAR

CEPTON



Velodyne LiDAR™

RADAR



ARS430

GNSS/IMU



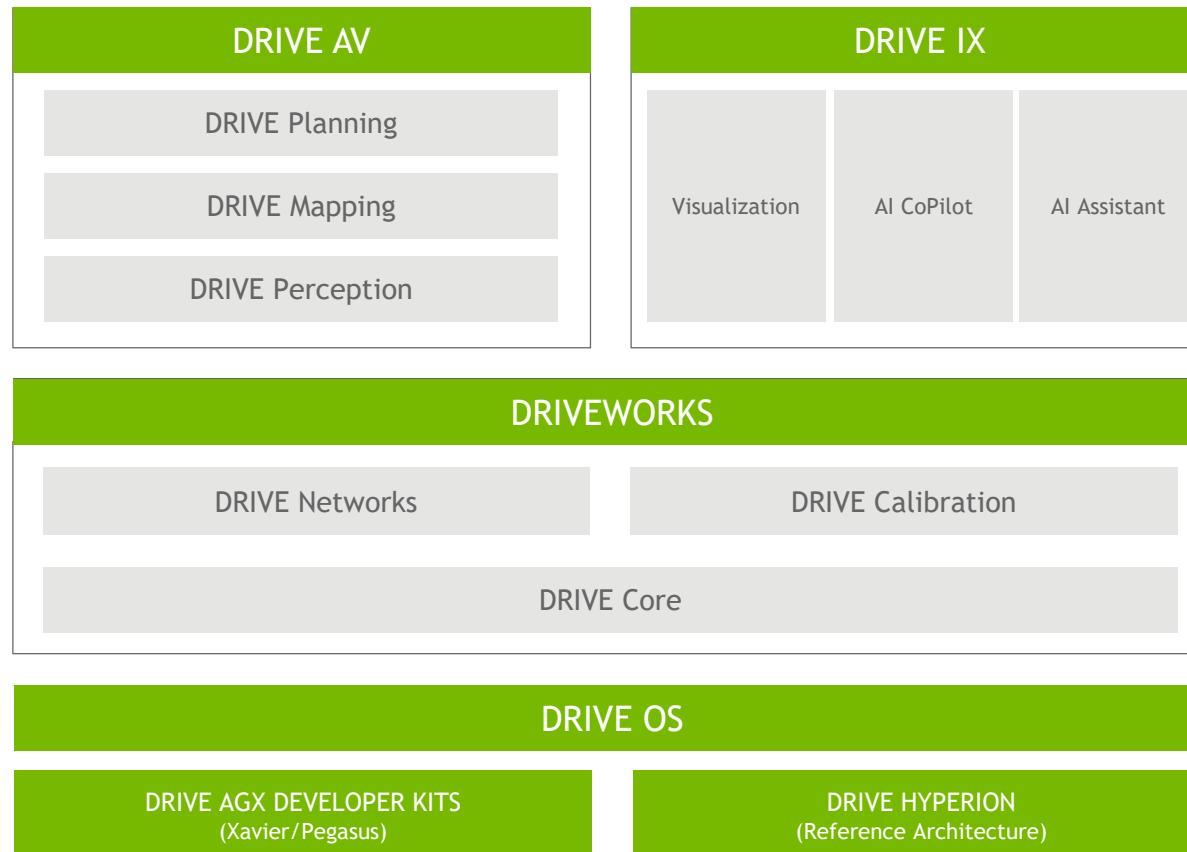
SC13S, MTi-G-710,
SPAN-IGM A1



NVIDIA DRIVE DRIVE SOFTWARE

NVIDIA DRIVE SOFTWARE ARCHITECTURE

Open and modular software for AV development

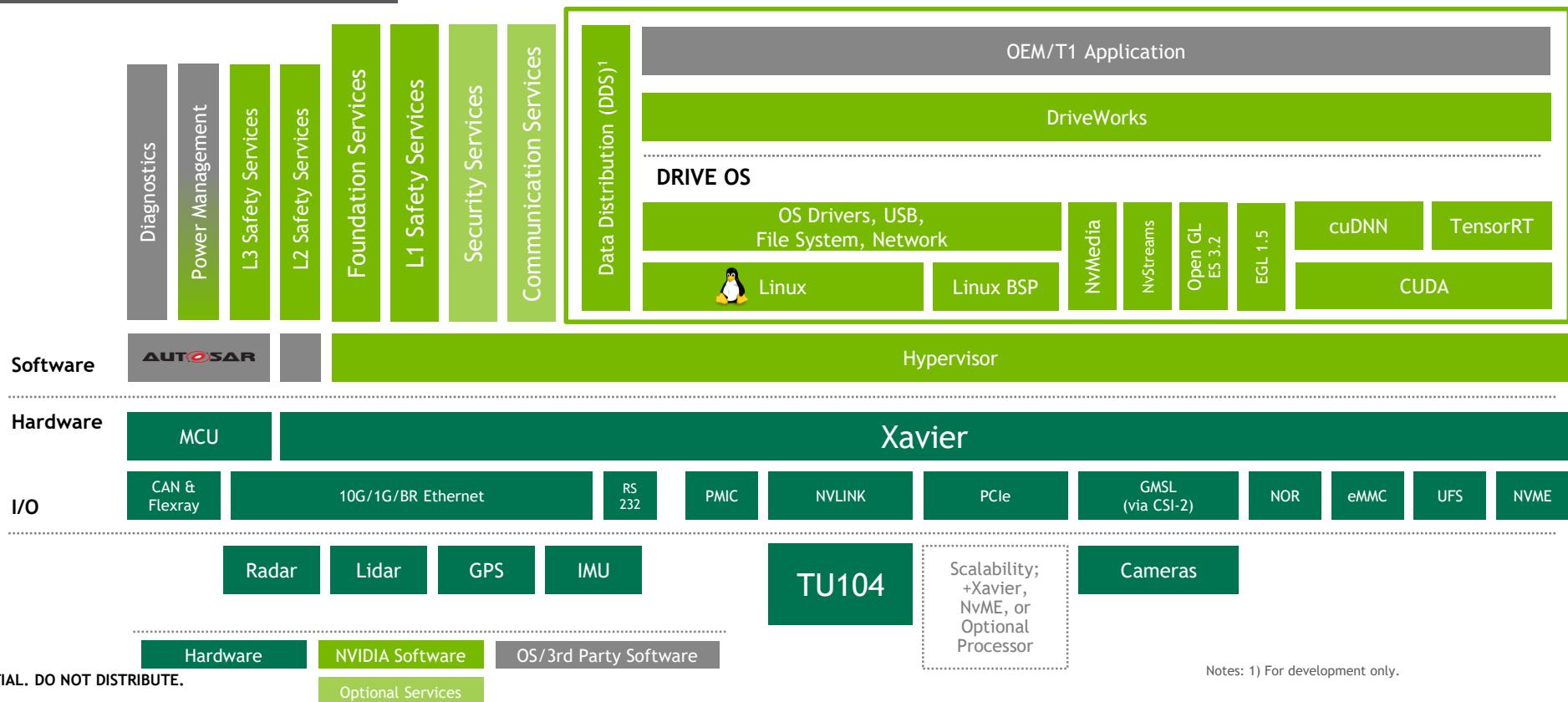




NVIDIA DRIVE
DRIVE OS

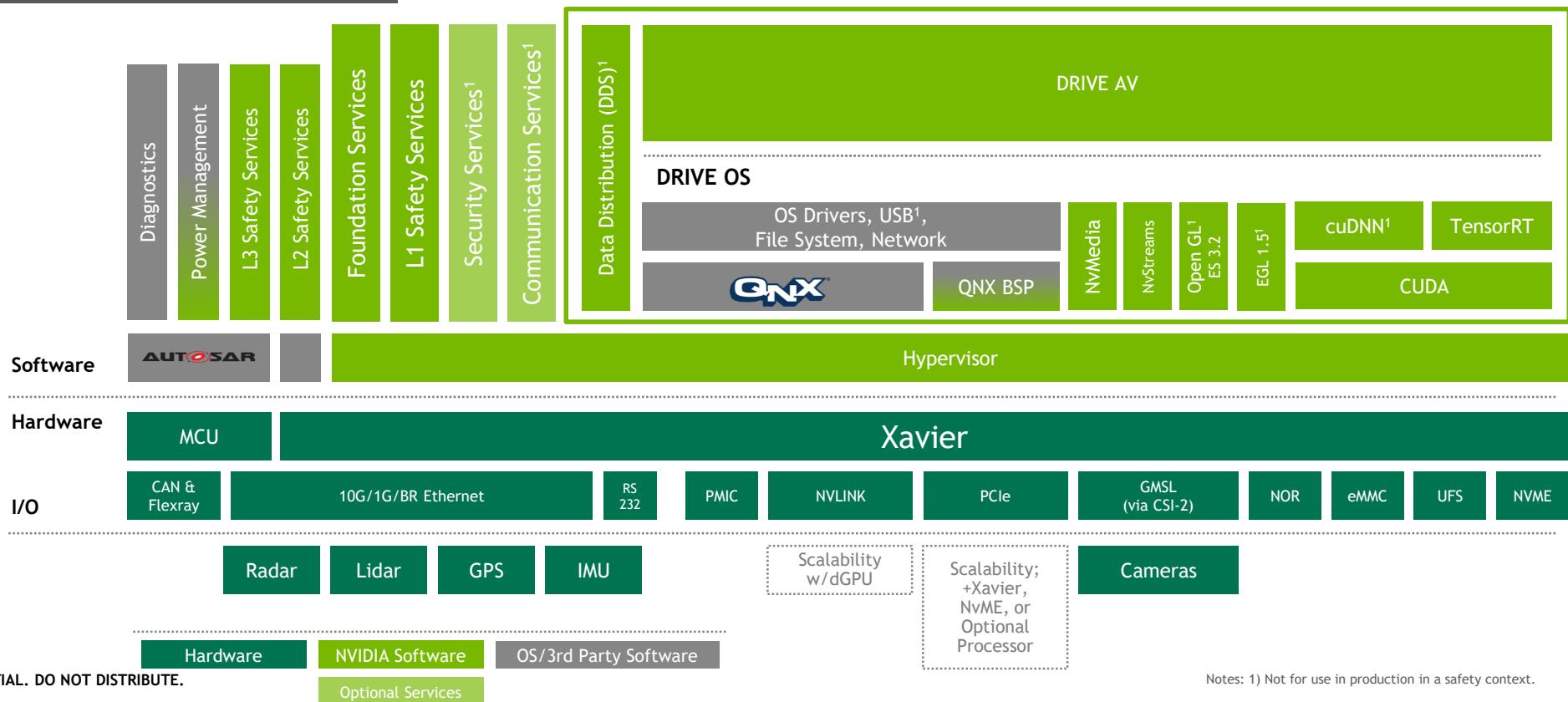
DRIVE AGX

AV Software Platform



DRIVE AGX

AV Software Platform

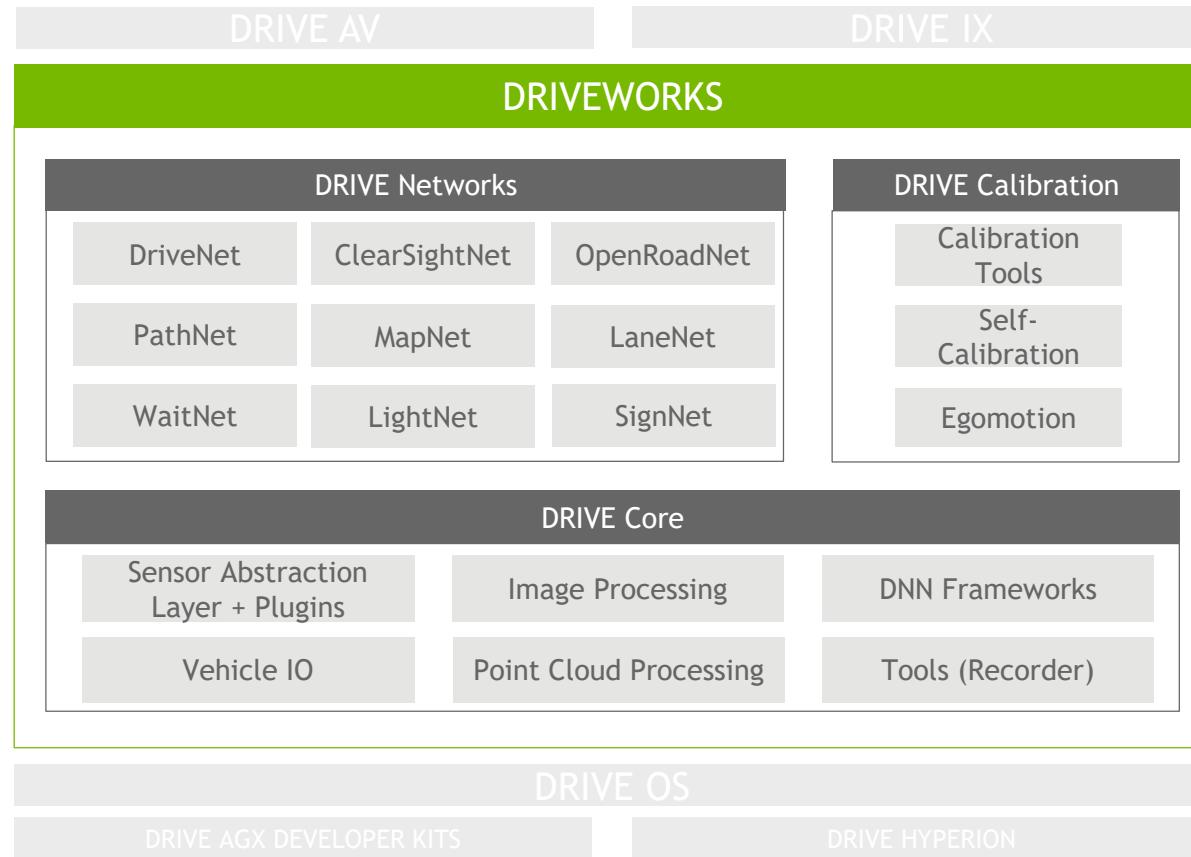




NVIDIA DRIVE AUTONOMOUS DRIVING APPLICATION

NVIDIA DRIVEWORKS SDK

Data Abstraction | Calibration | Compute Modules



NVIDIA DRIVEWORKS SDK

Foundation for AV SW Development on NVIDIA DRIVE



SOFTWARE MODULES

- Open, modularized library of functions
- Optimized for DRIVE AGX
- Easy to integrate and build upon



TOOLS

- Software dev tools ranging from sensor data capture to calibration and visualization



DEVELOPER SUPPORT

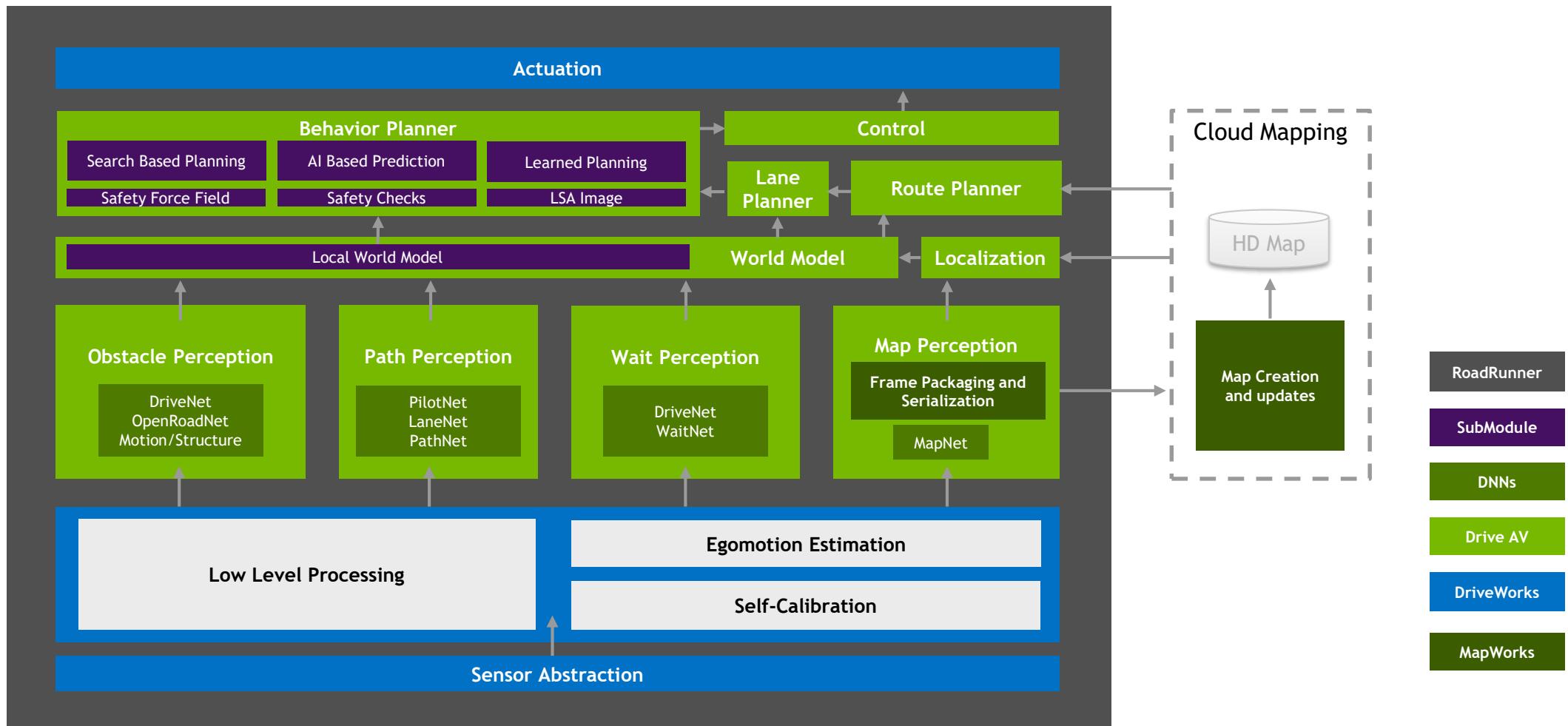
- Sample apps
- Documentation, tutorials
- Active developer forum and community



PRODUCTION GRADE

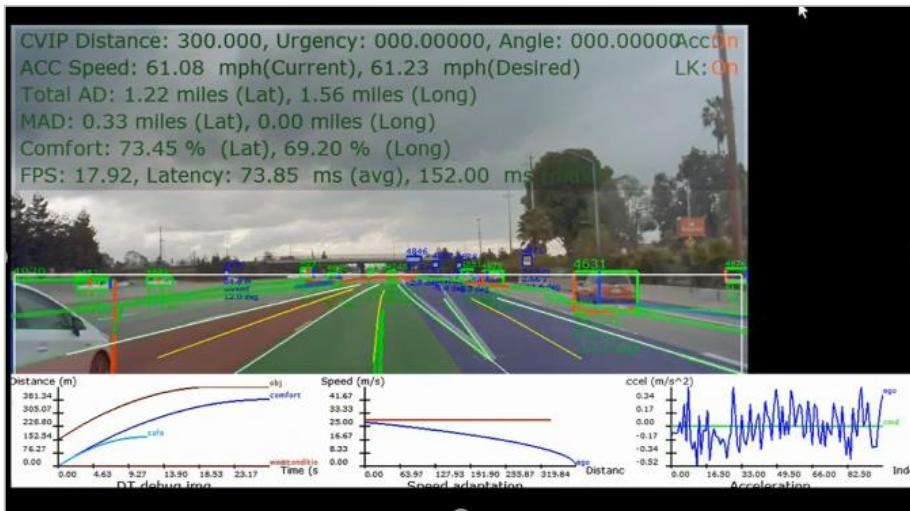
- Architected for automotive safety
- Compliant with industry standards, (ISO 26262/21448, MISRA)

DRIVE AV

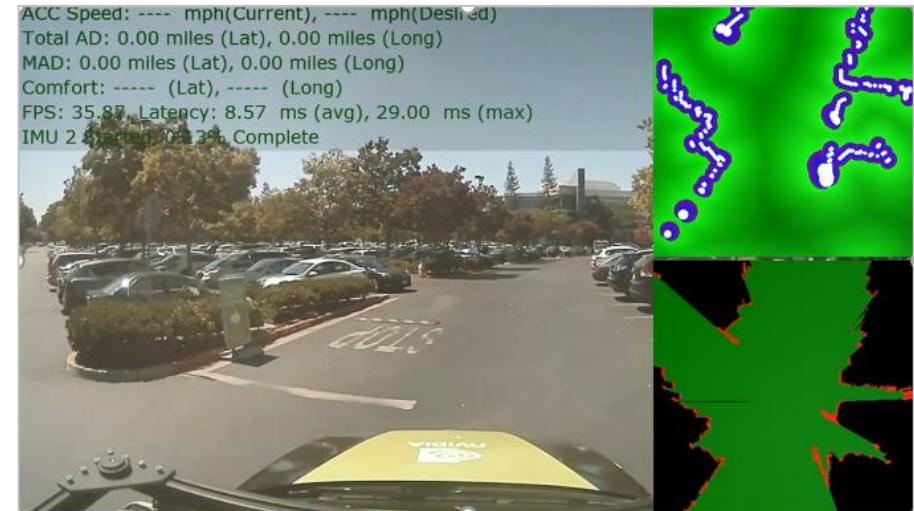


SCALABLE PLATFORM

One architecture - Highway and Urban AV Driving



ON RAMP TO OFF RAMP



URBAN: ADDRESS TO ADDRESS

ADVANCED FUNCTIONS

Auto High Beam



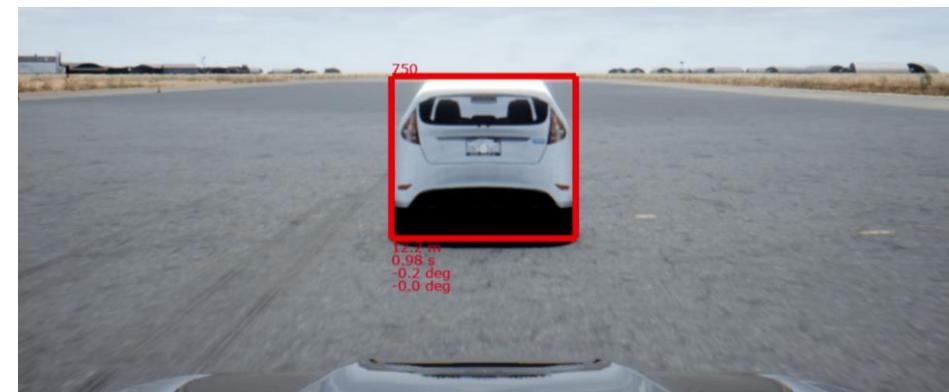
Clear Sight



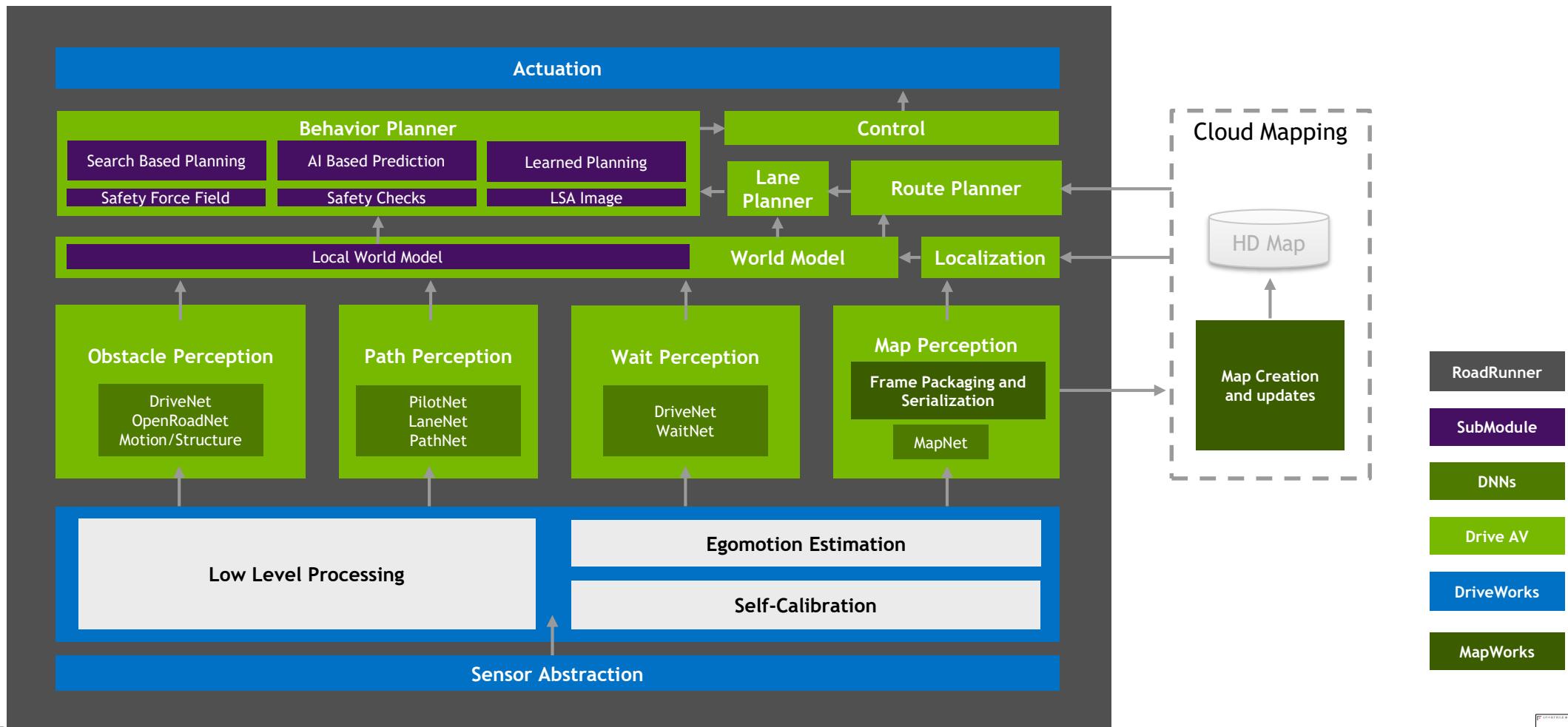
Parking



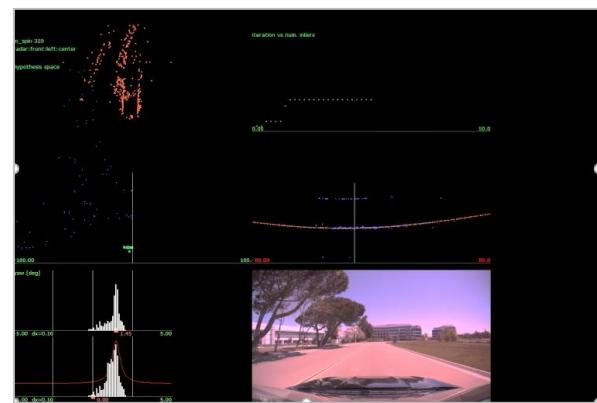
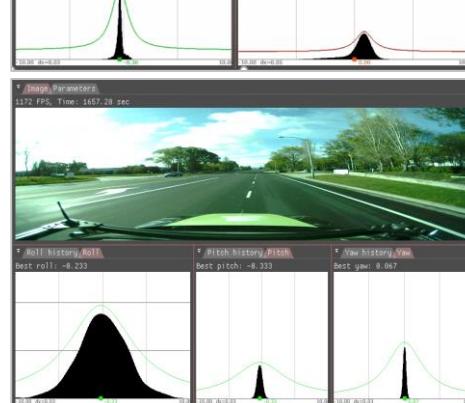
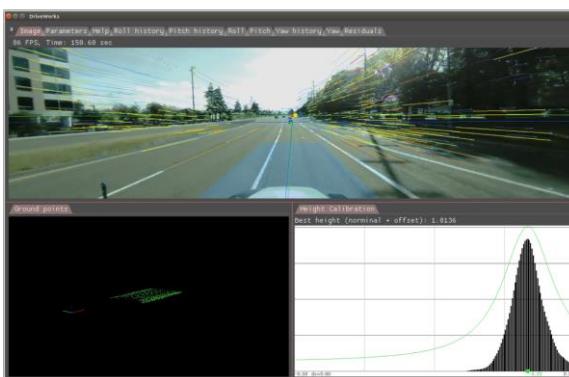
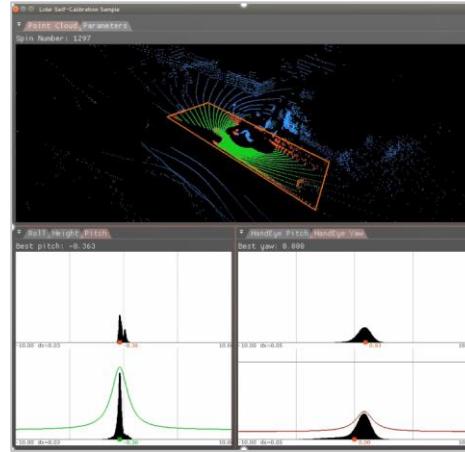
NCAP



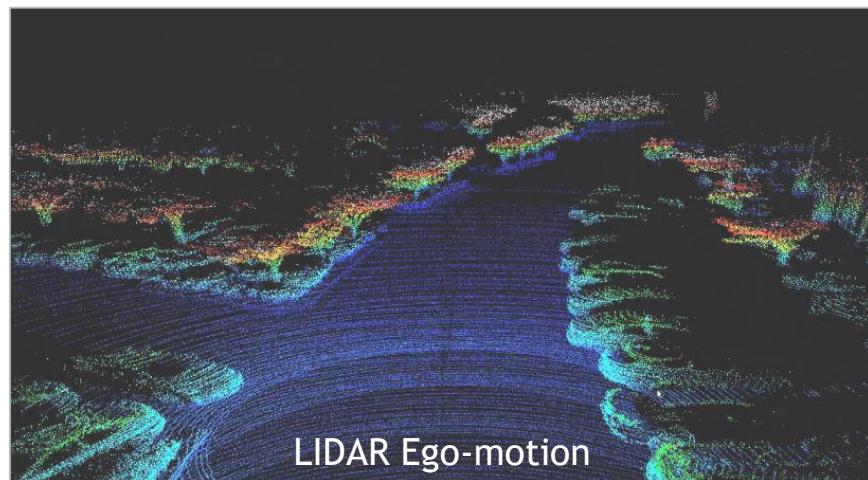
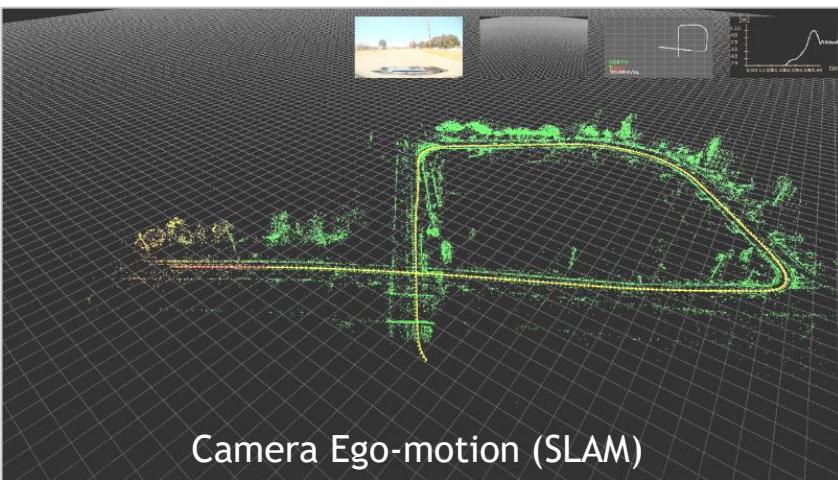
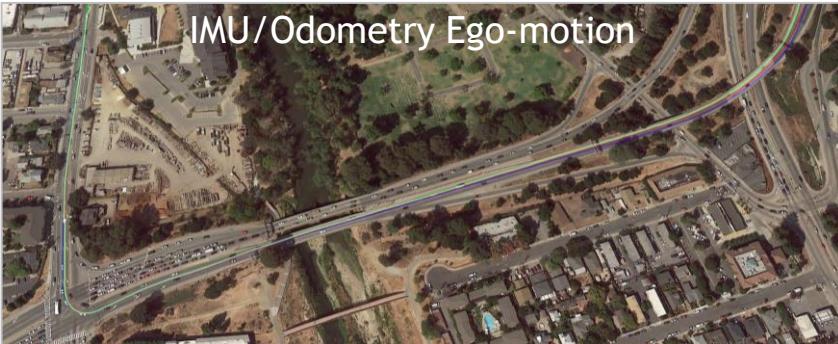
DRIVE AV



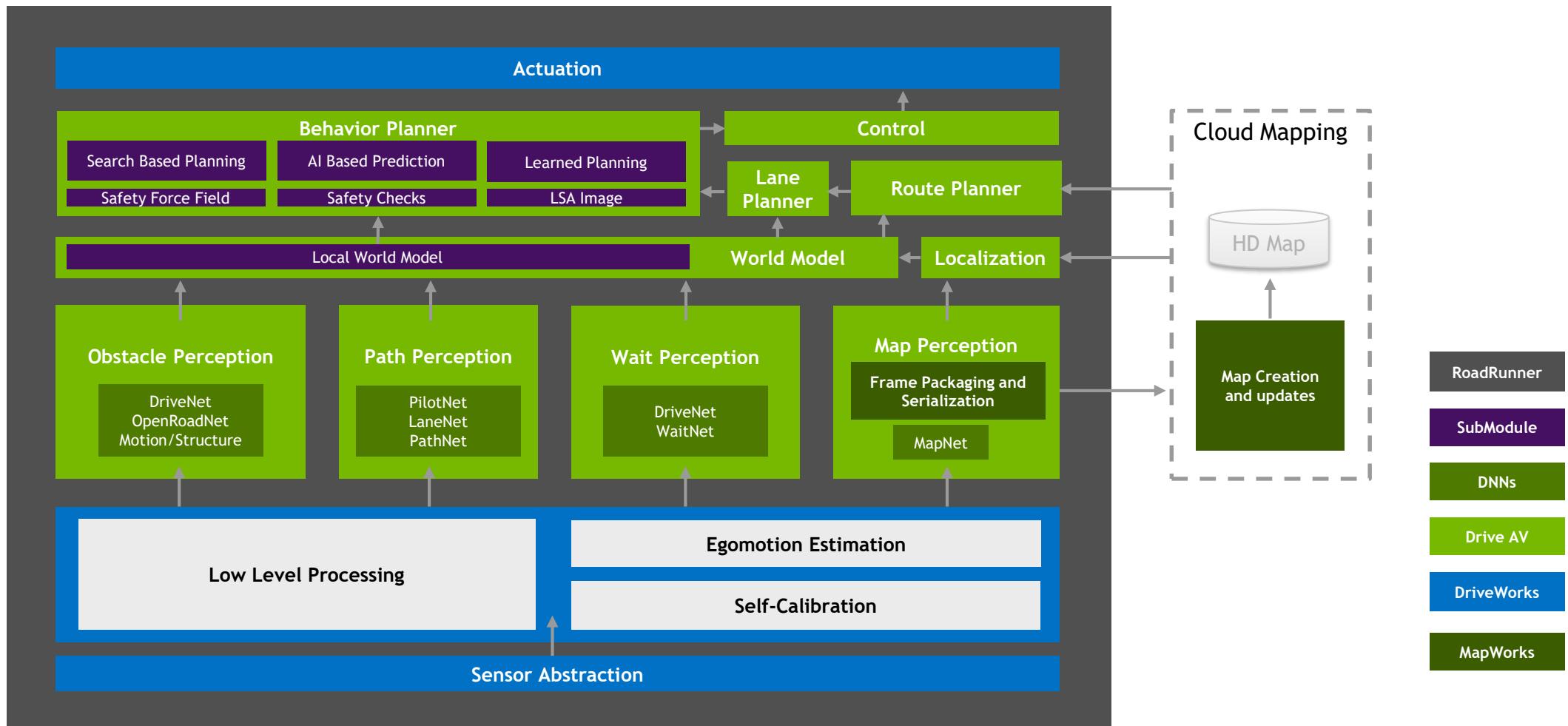
SENSOR SELF-CALIBRATION



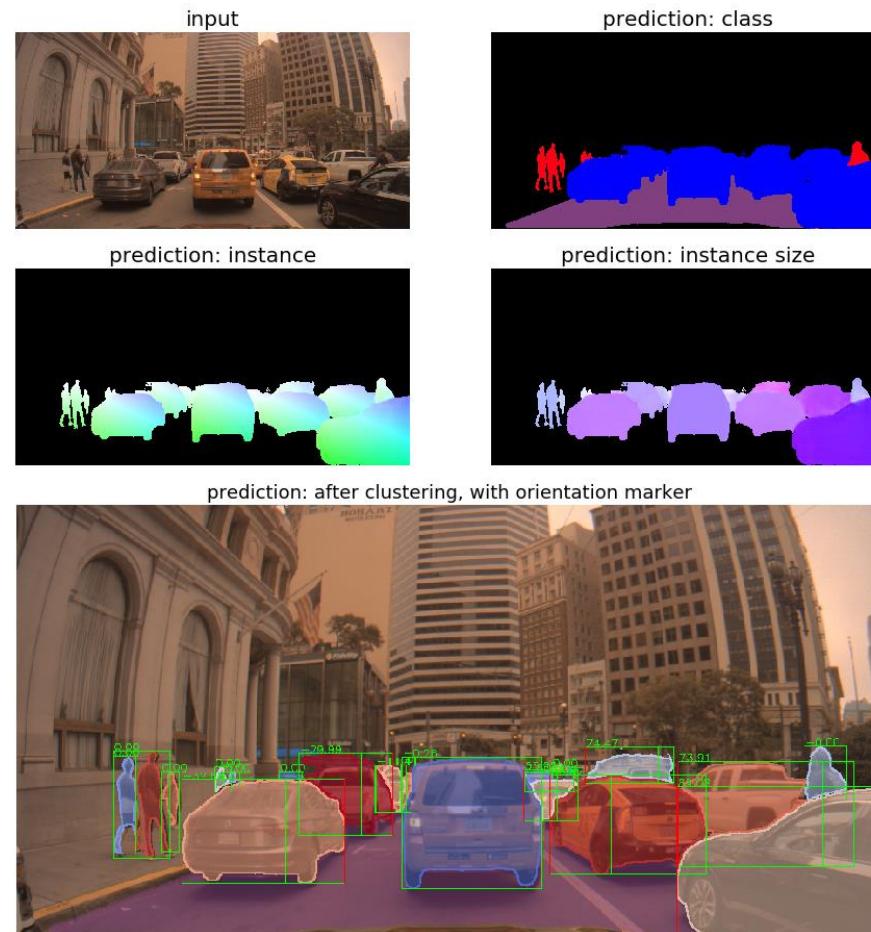
EGOMOTION



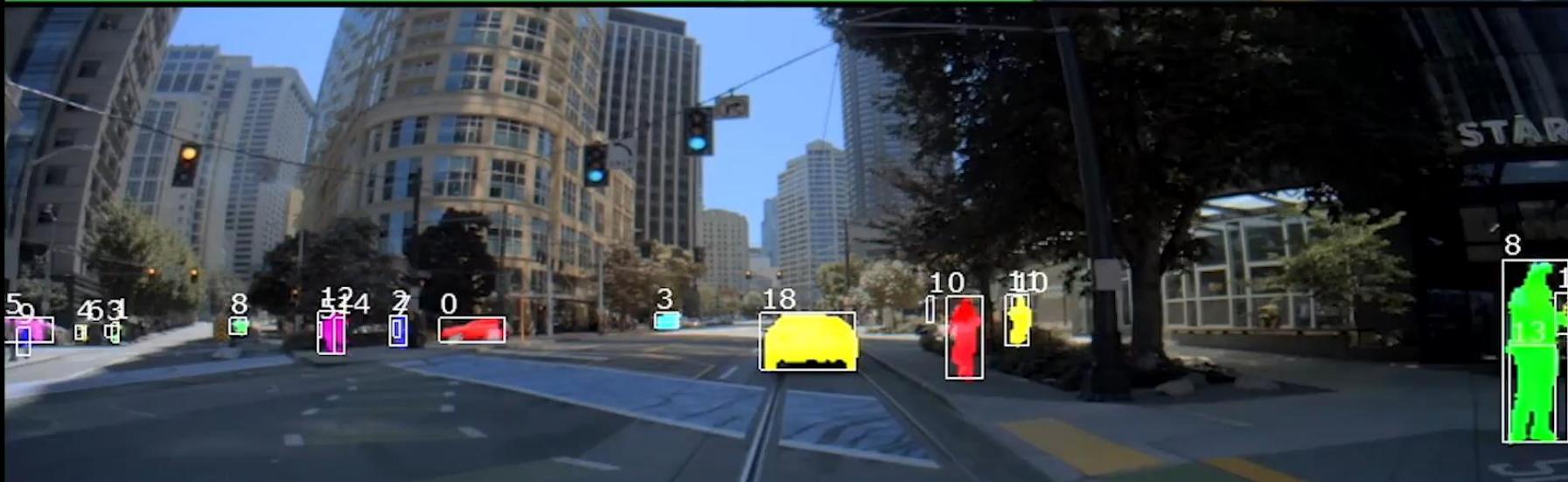
DRIVE AV



CAMERA OBSTACLE PERCEPTION

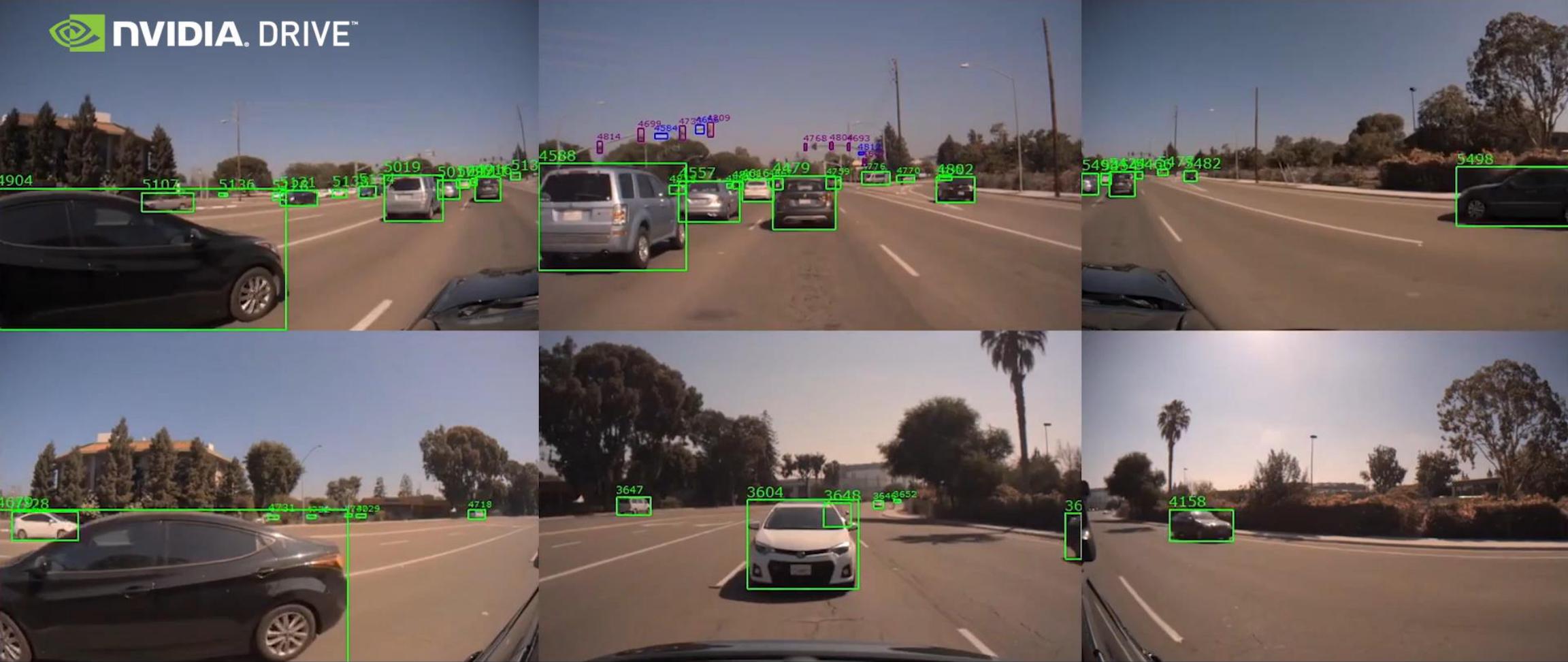


OBJECT DETECTION

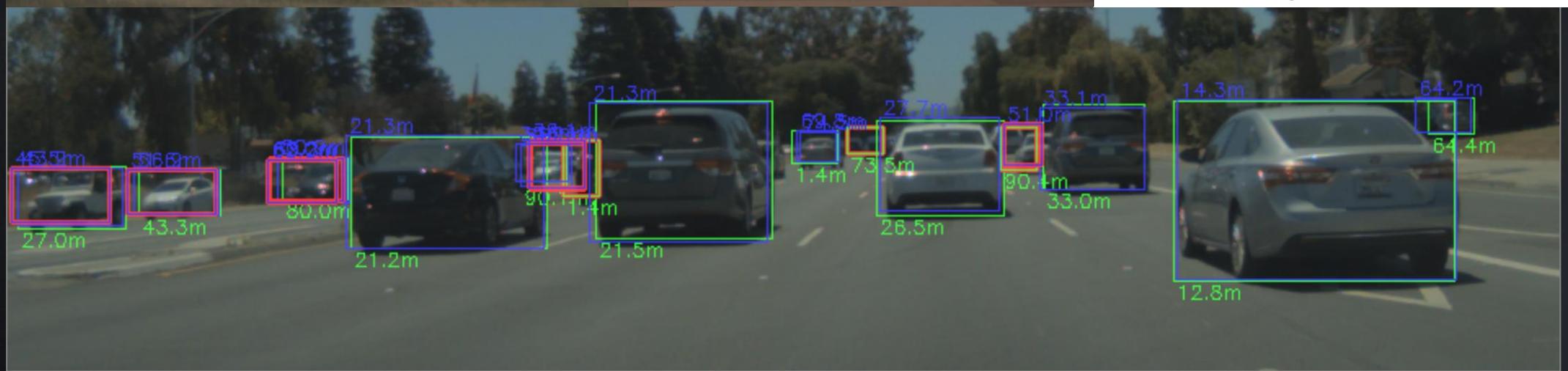
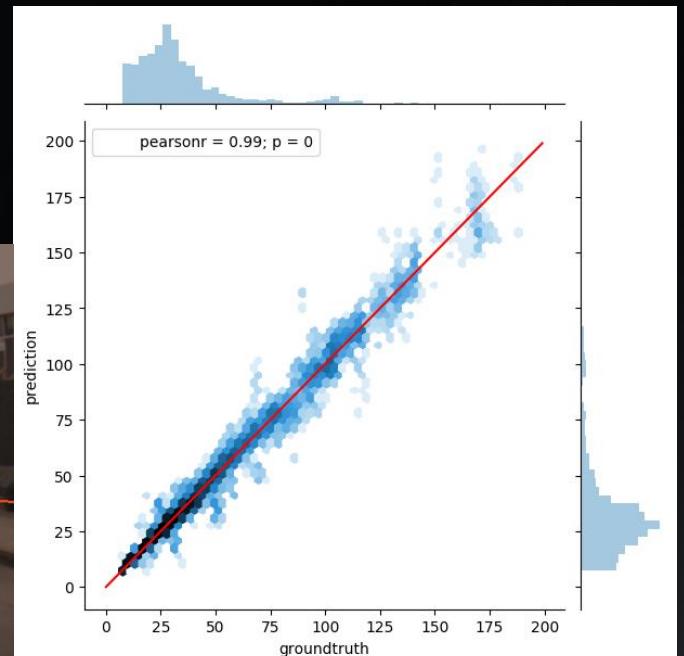
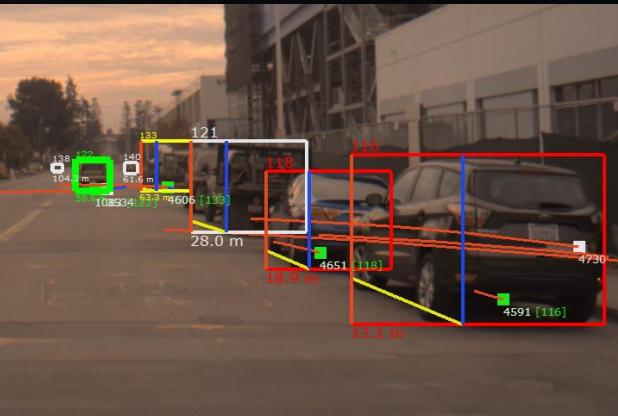
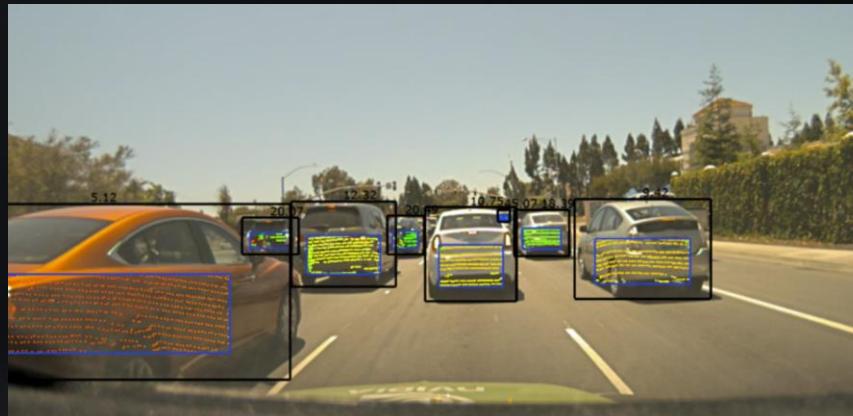


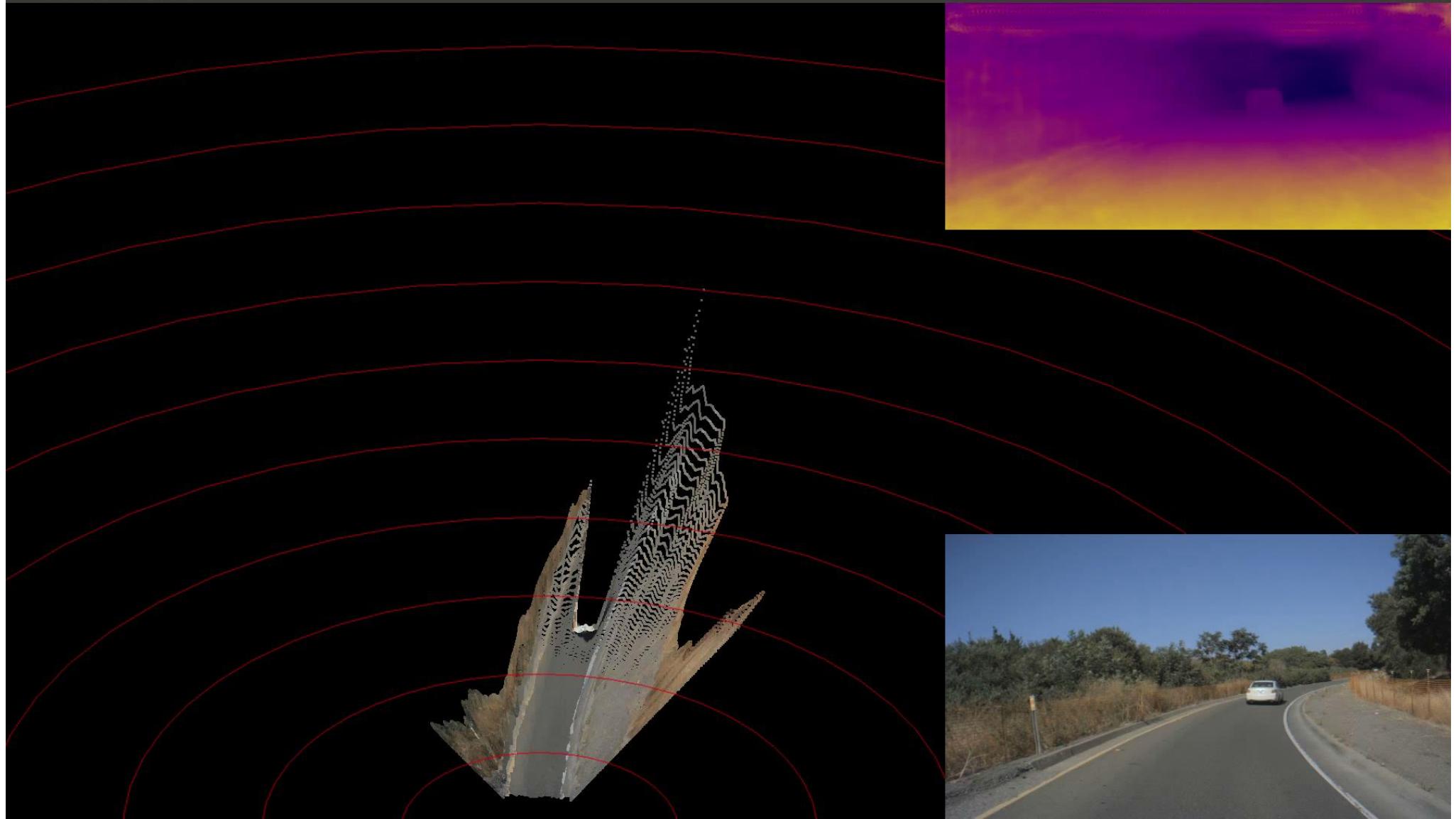
SURROUND OBJECT TRACKING

NVIDIA DRIVE™



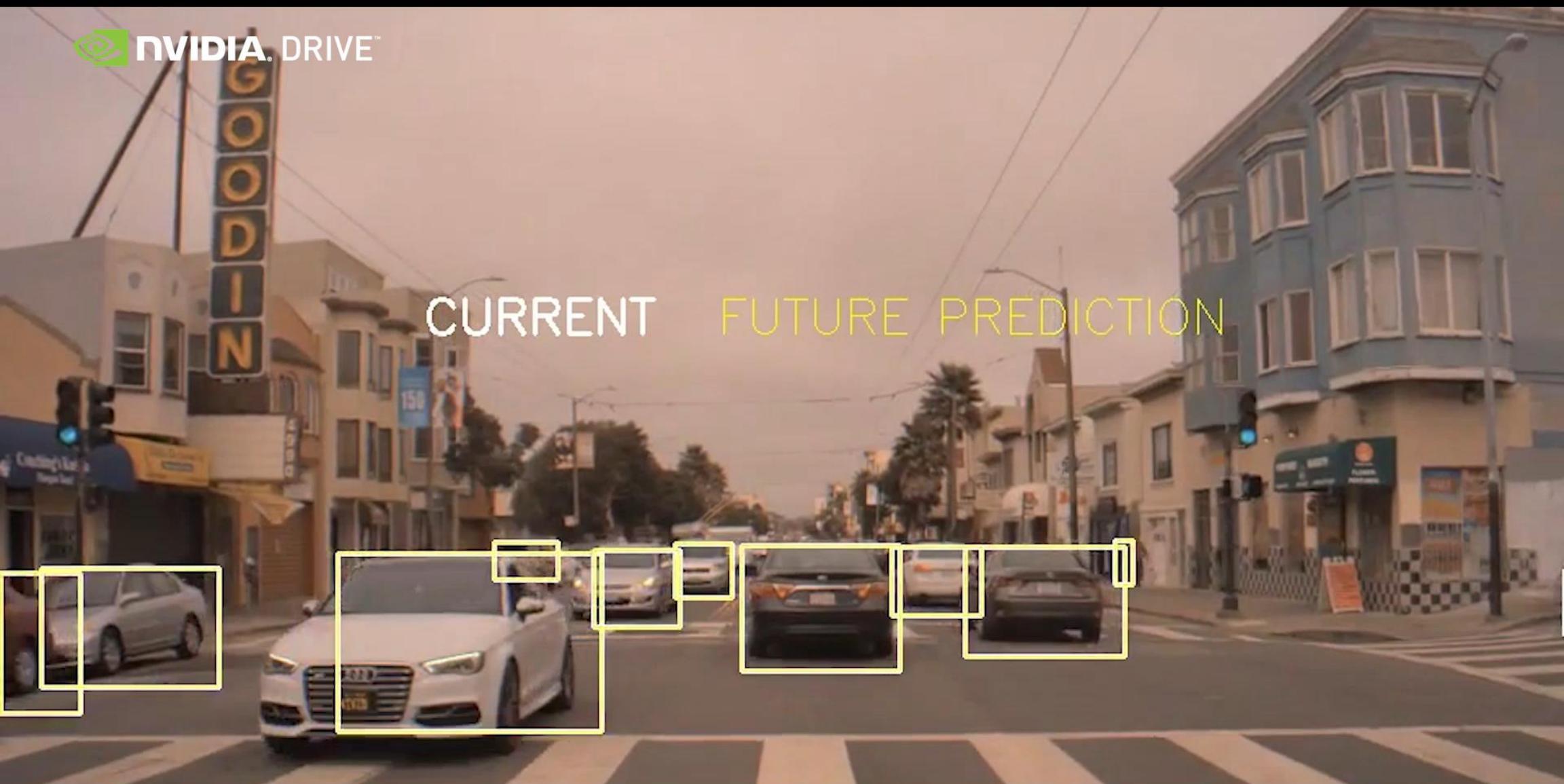
DNN DISTANCE



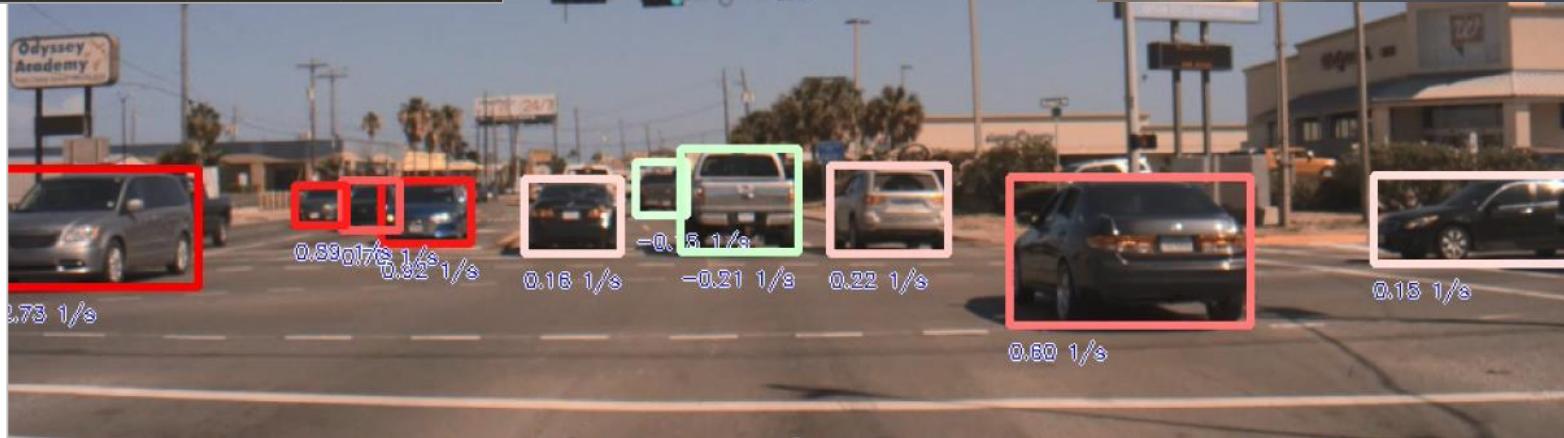
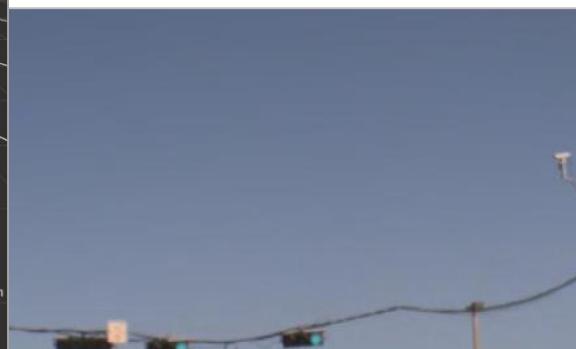
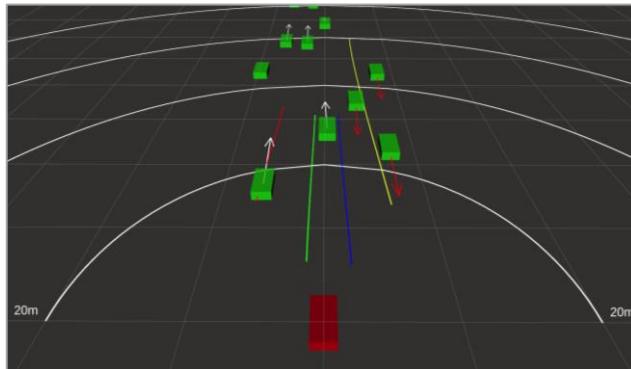


FUTURE MOTION PREDICTION (RNN)

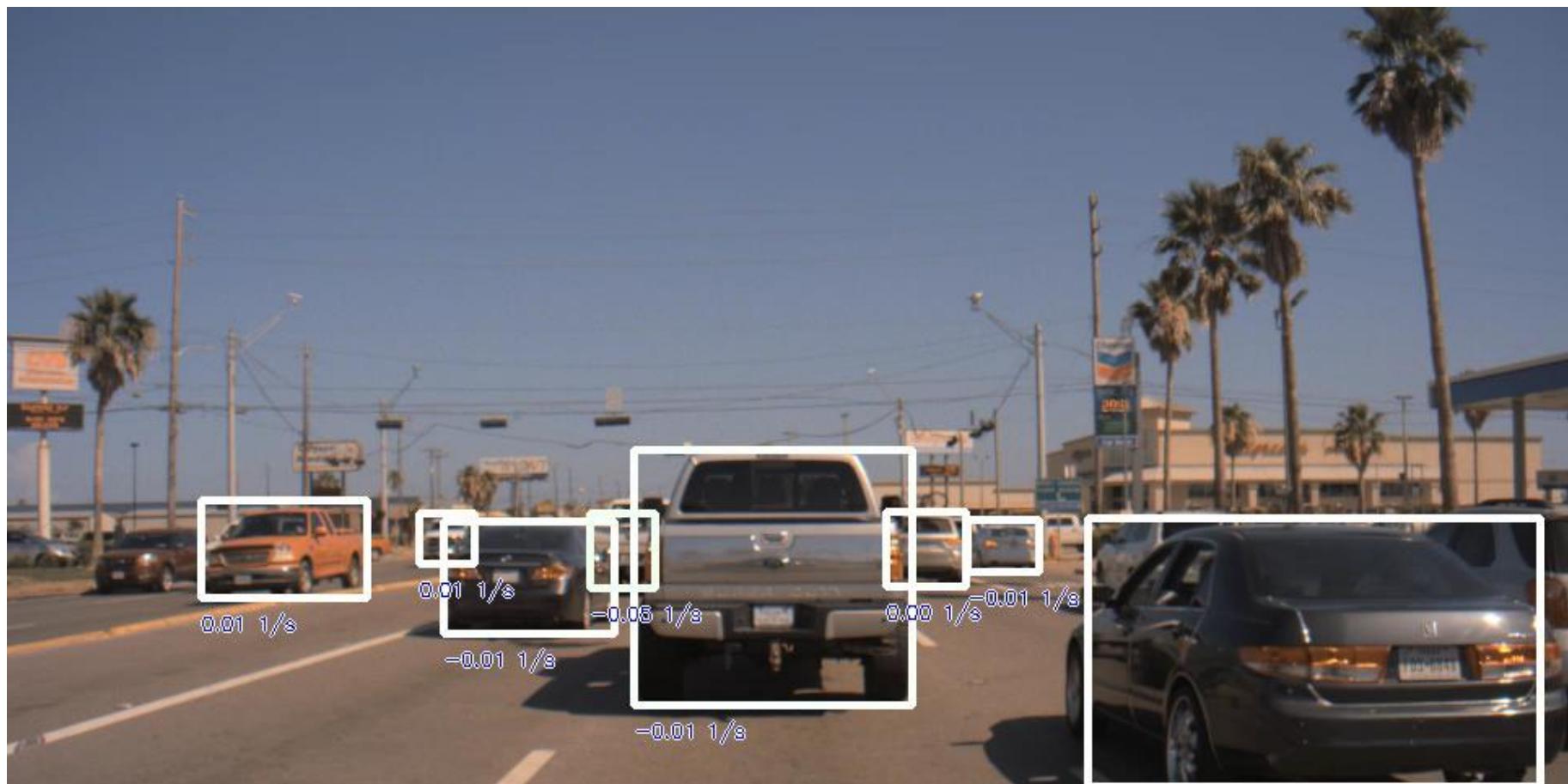
NVIDIA DRIVE™



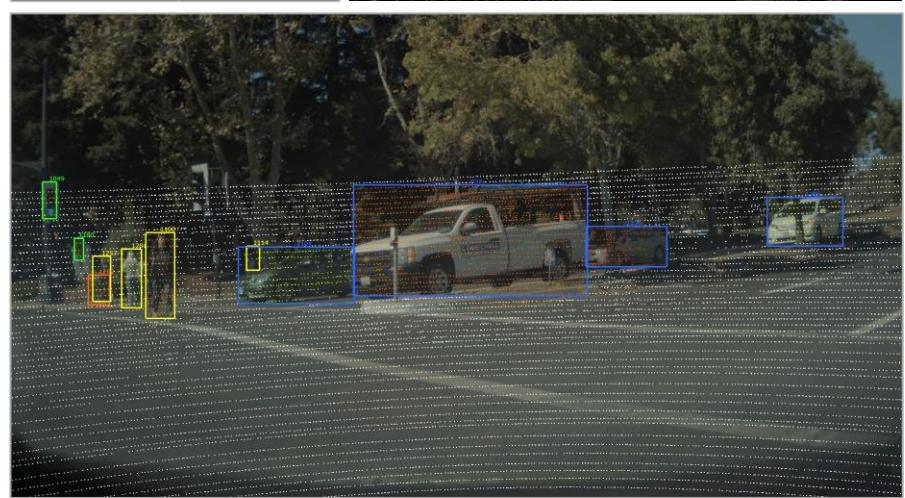
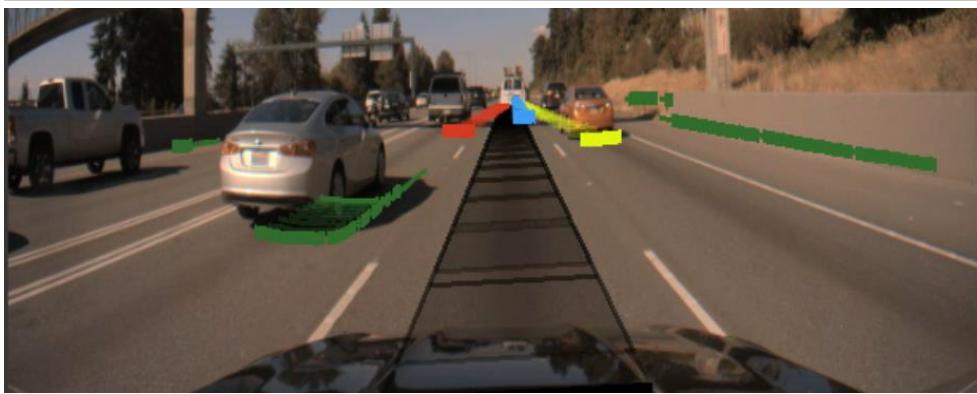
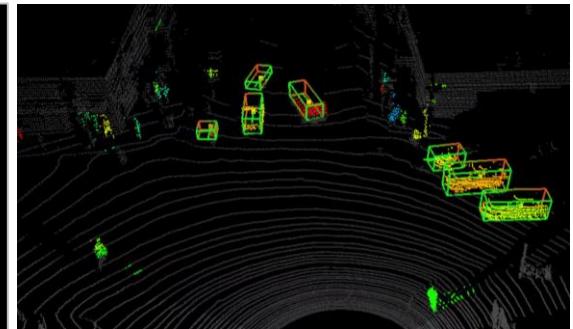
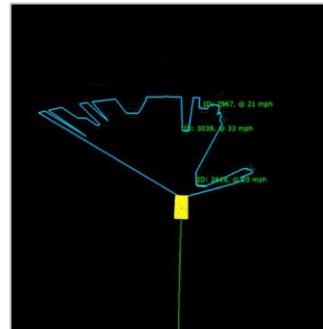
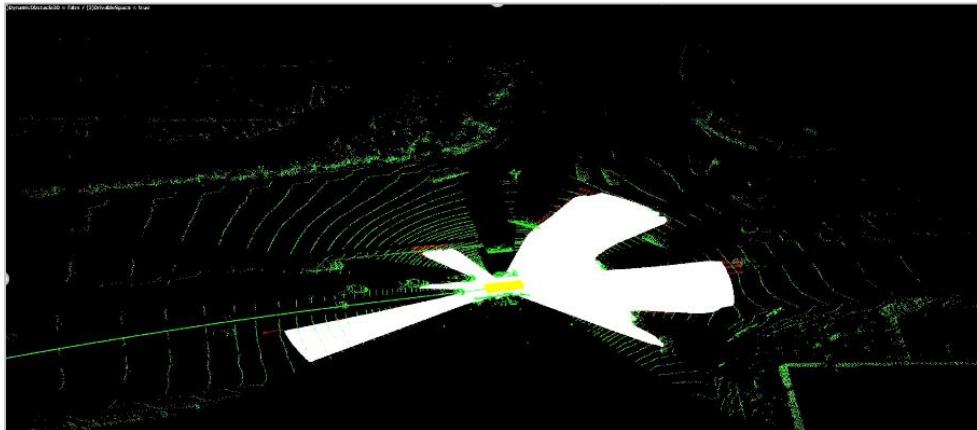
VELOCITY ESTIMATION



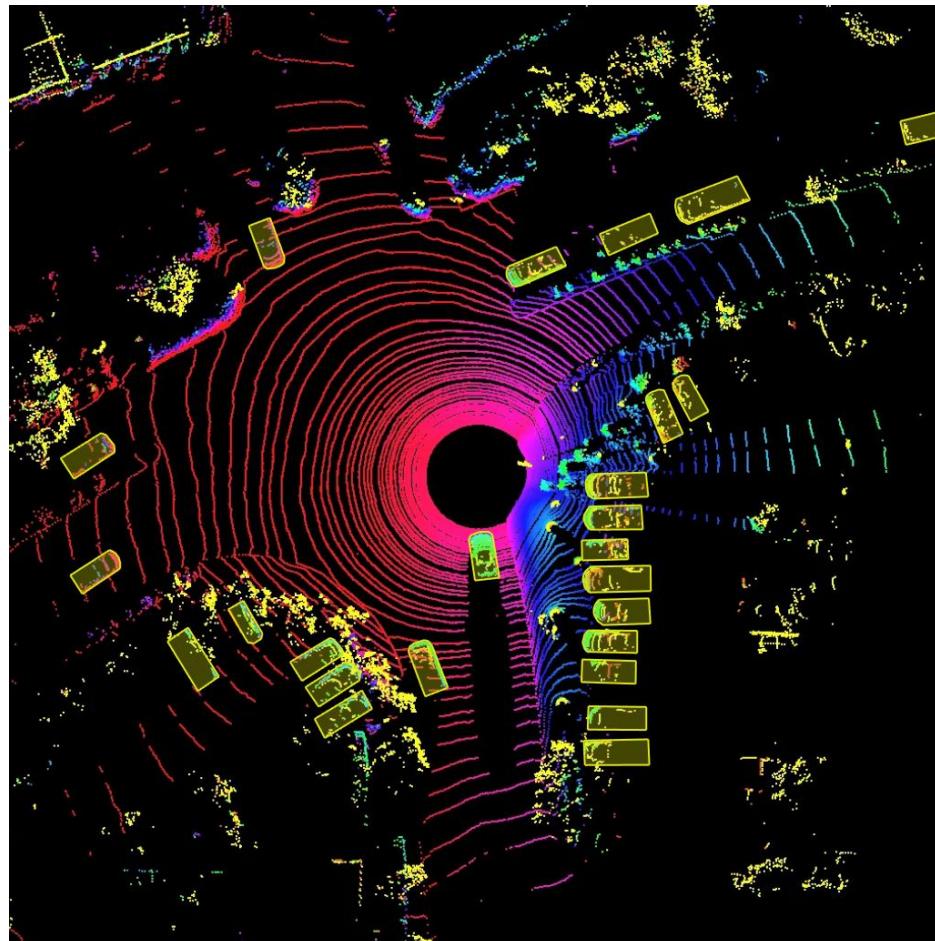
VELOCITY ESTIMATION



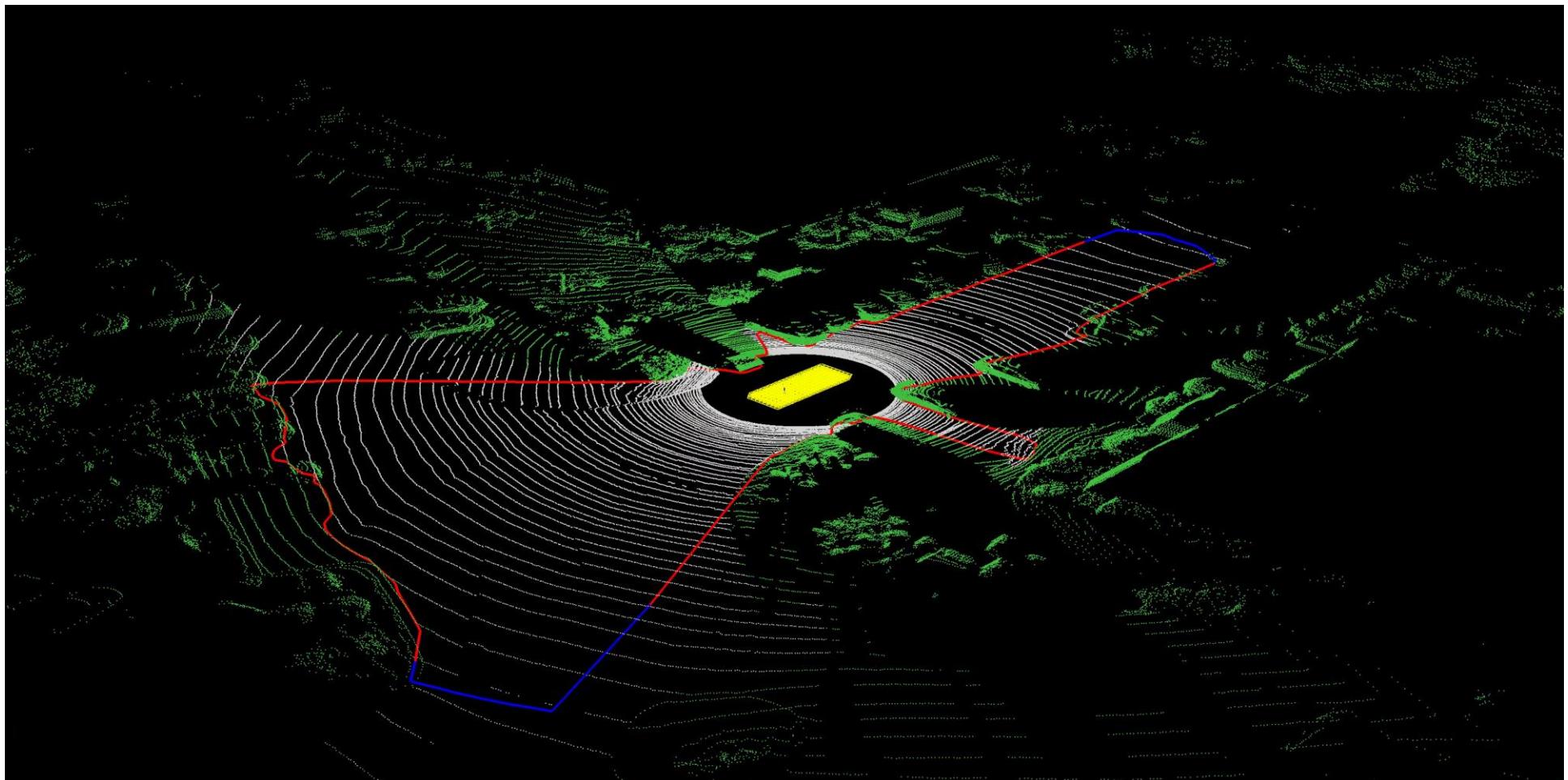
LIDAR - OBSTACLE PERCEPTION



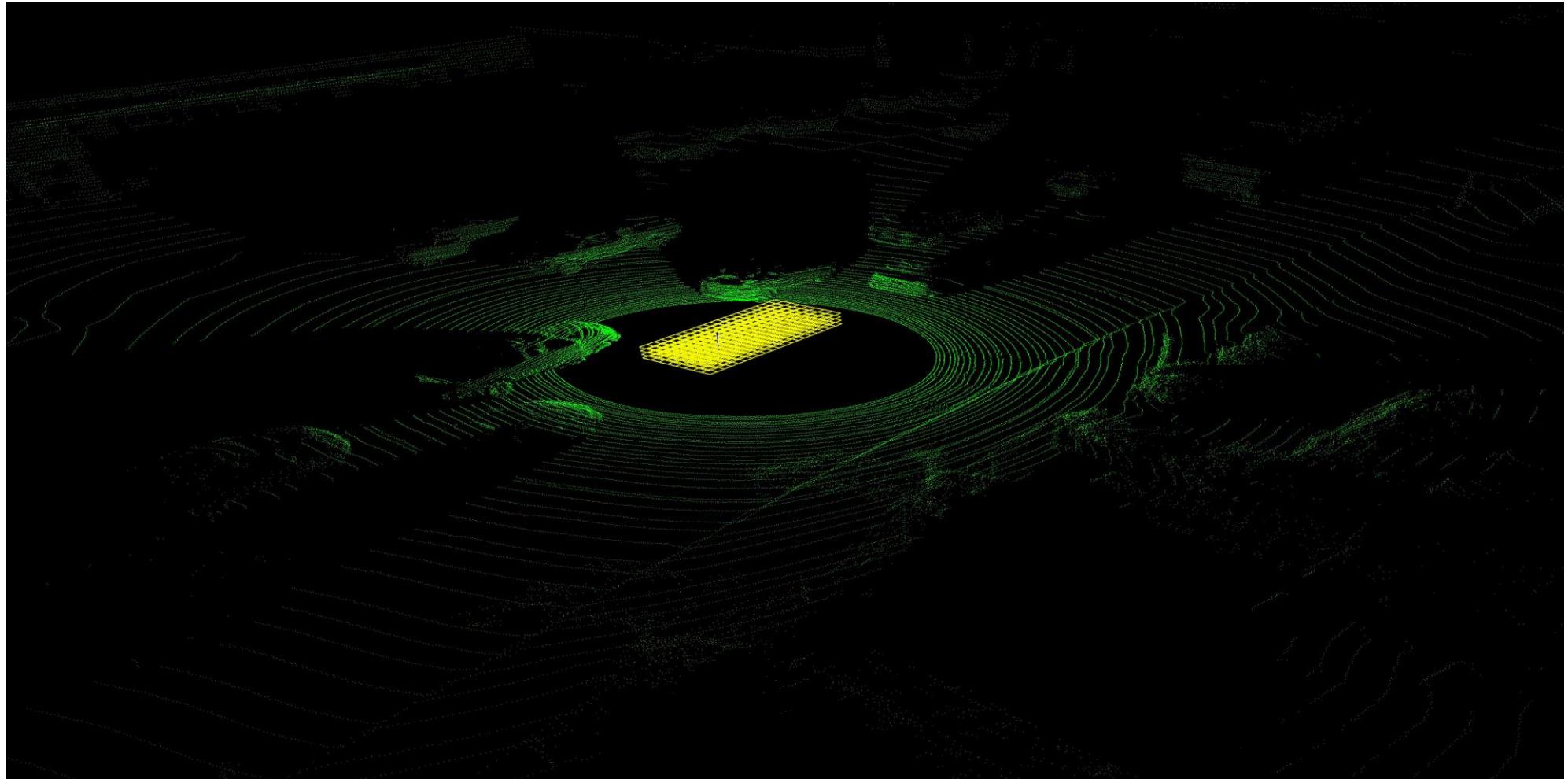
LIDAR - OBSTACLE PERCEPTION



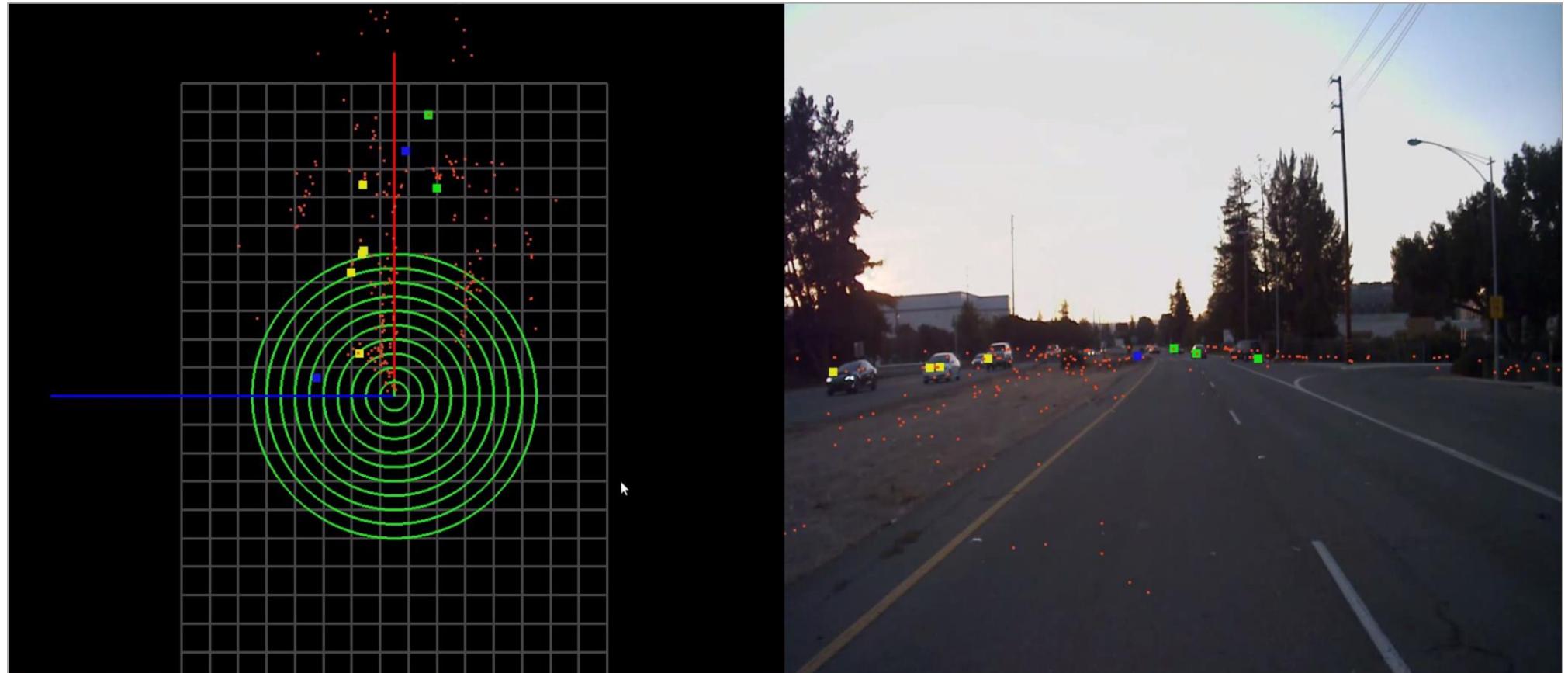
LIDAR FREESPACE



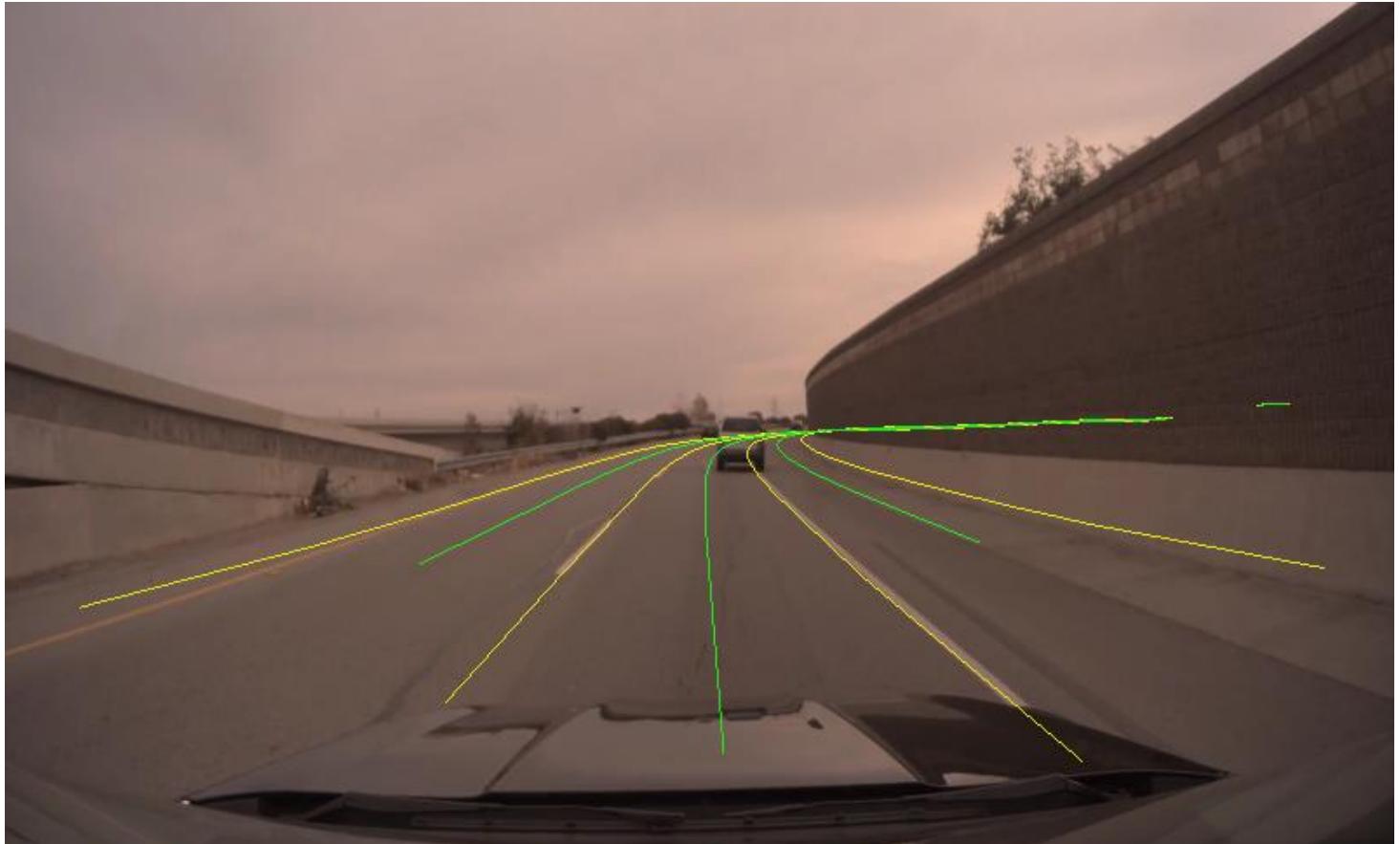
LIDAR MOTION DETECTION



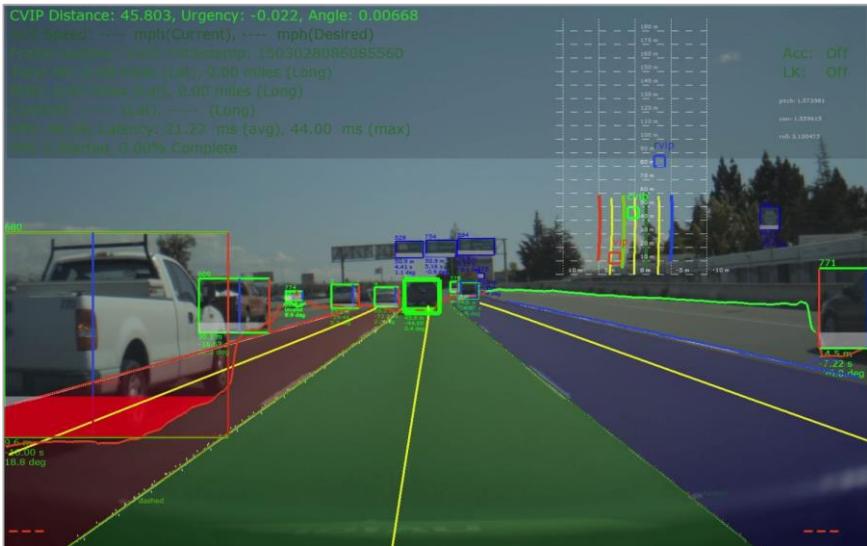
RADAR TRACKING



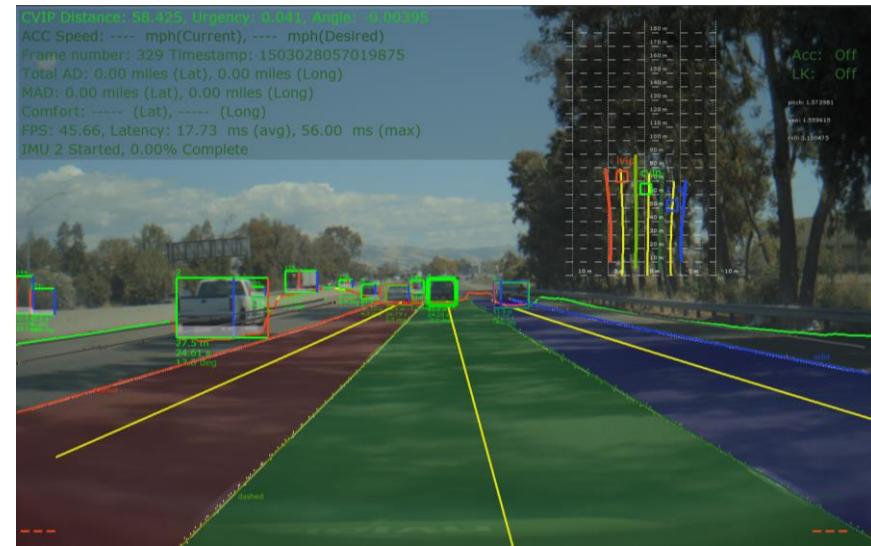
PATH REPRESENTATION (THE LANE GRAPH)



LANENET + TRACKING + FUSION

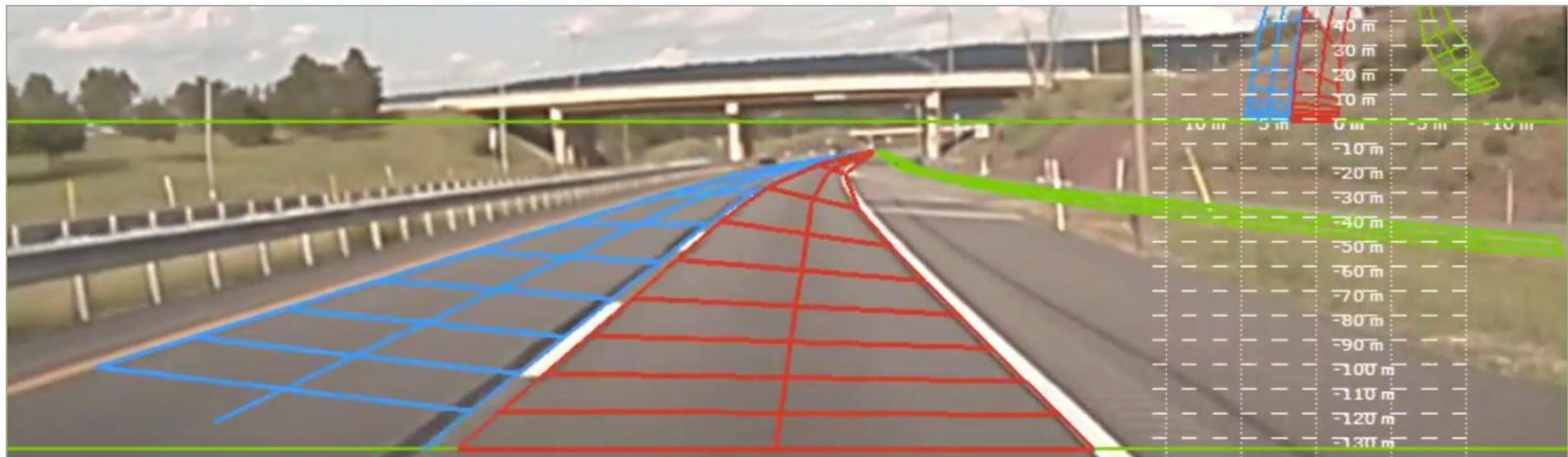


Tracking and Fusion

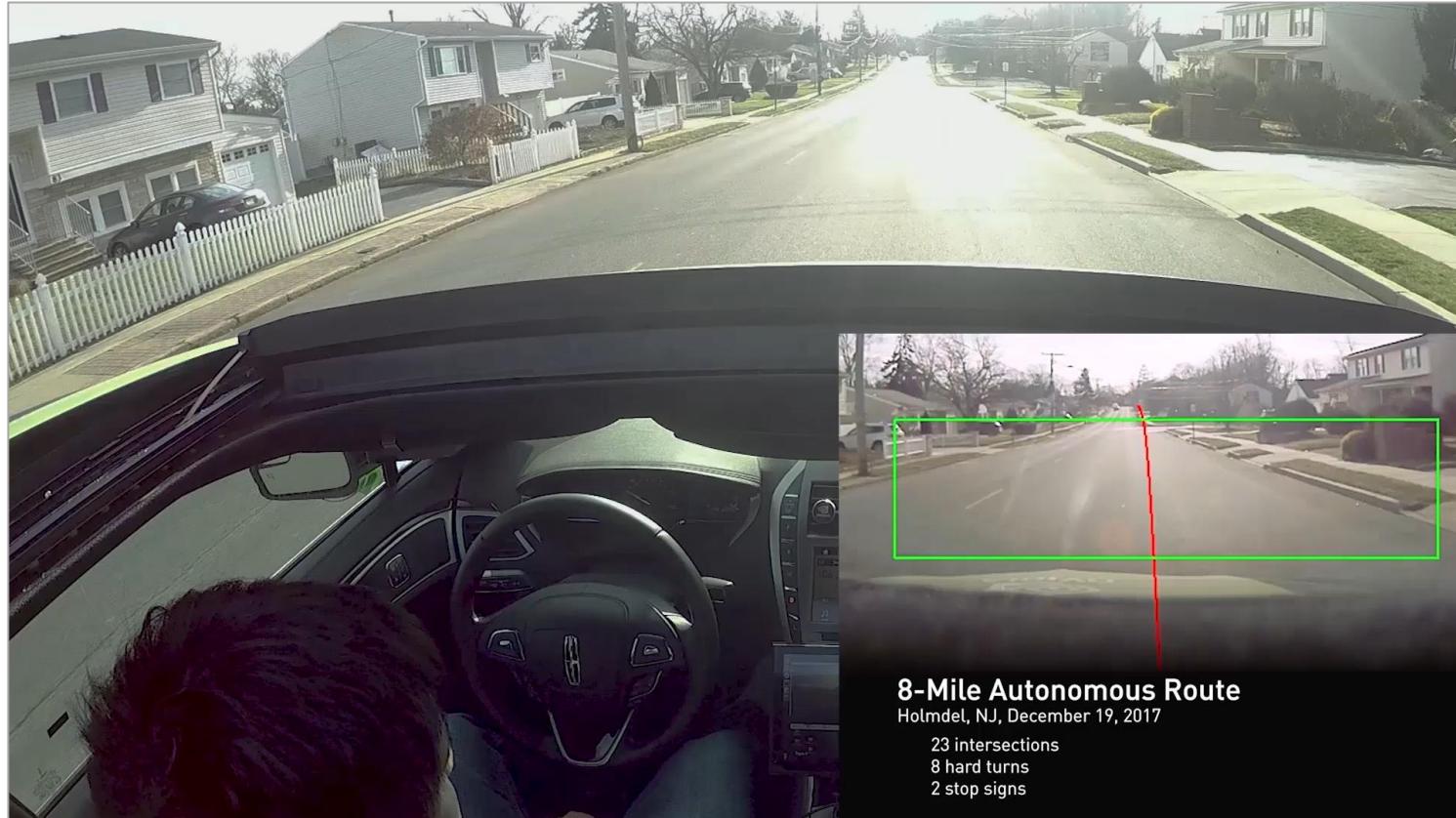


Lane Assignment (OIPA)

PATHNET



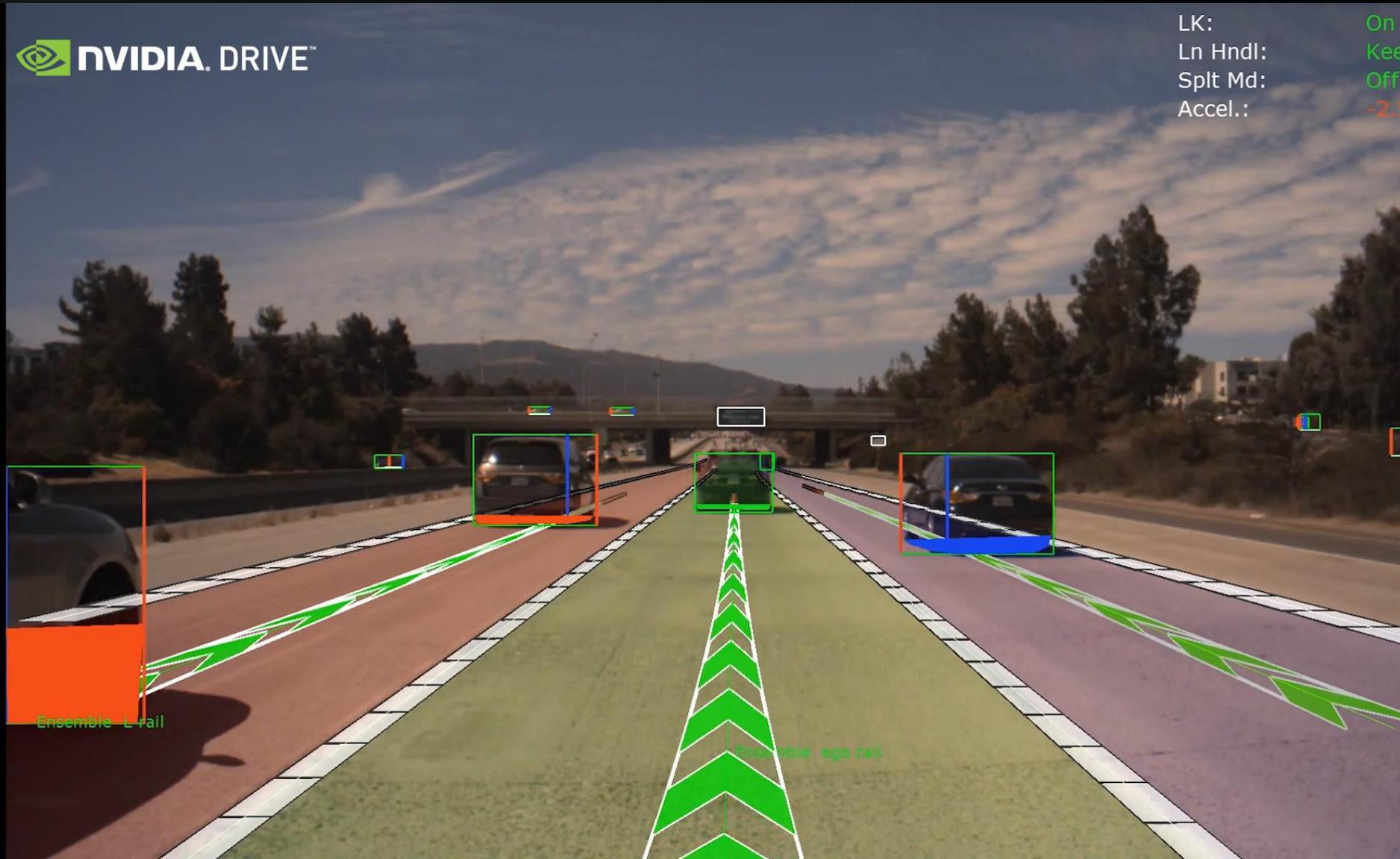
FACTORED PILOTNET TURNS



PATH PERCEPTION ENSEMBLE

NVIDIA. DRIVE™

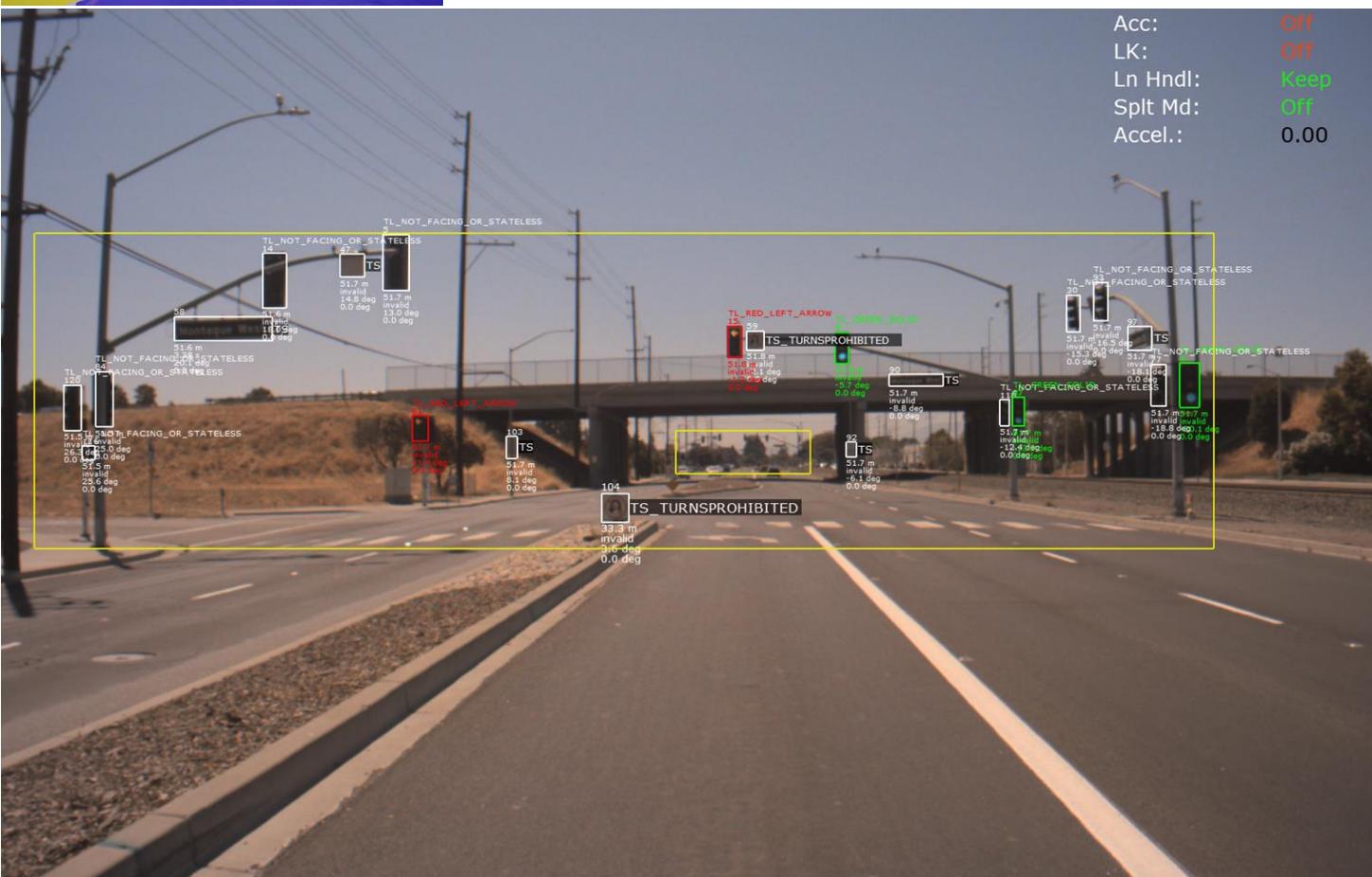
LK: On
Ln Hndl: Keep
Splt Md: Off
Accel.: -2.50



NVIDIA



WAIT CONDITIONS



INTERSECTION DETECTION

 NVIDIA. DRIVE™



SIGN AND TRAFFIC LIGHT CLASSIFICATION



CAMERA BLINDNESS DETECTION

NVIDIA. DRIVE™



PARKING SPACE DETECTION



LIGHT SOURCE PERCEPTION



DRIVE NETWORKS

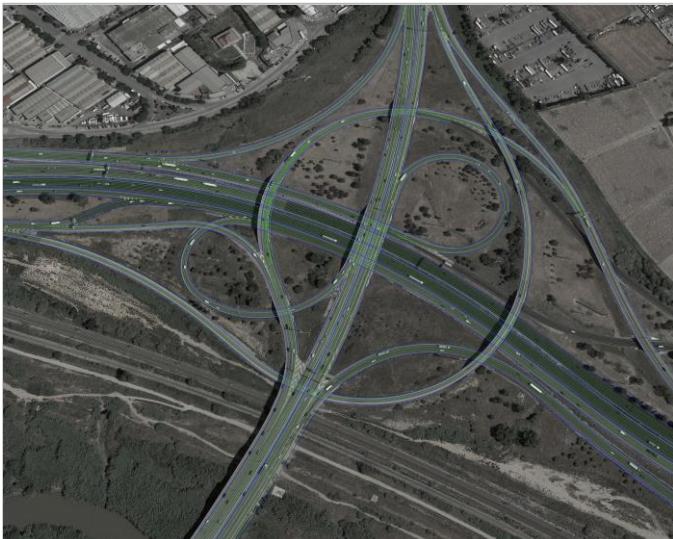
Fully trained DNN solutions for advanced situational awareness



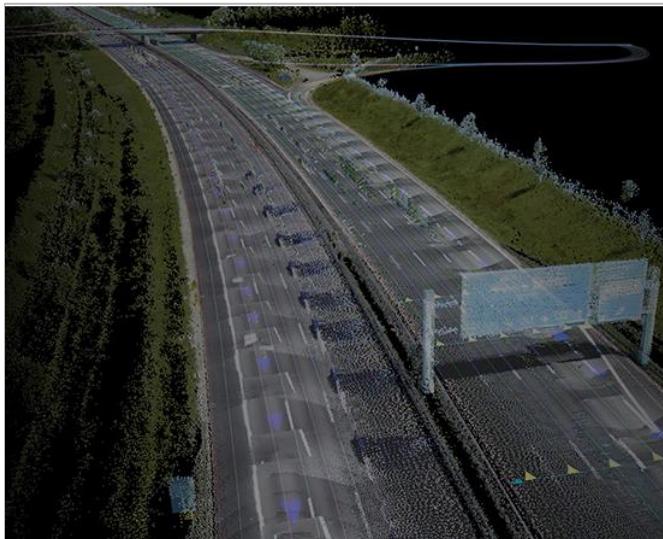
Obstacle Perception	DriveNet	Detects objects including vehicles, pedestrians, bicycles, traffic lights & signs
	DepthNet	Dense depth inference at pixel level
	OpenRoadNet	Detects drivable freespace around the vehicle
	PredictionNet	RNN to predict dynamic objects
	LidarNet	Lidar point cloud classification
Path Perception	LaneNet	Detects and classifies lanes
	MapNet	Detects visual landmarks such as lanes & crosswalks
	PilotNet	Learn trajectories from human driver
	PathNet	Predicts full geometry of drivable paths
Wait Condition Perception	SignNet	Classifies traffic signs detected by DriveNet, for US and EU
	LightNet	Classifies traffic lights (color, solid, and arrows) detected by DriveNet
	WaitNet	Detects intersections
Assistance Functions	ClearSightNet	Determines if the camera view is blocked
	AhbNet	Auto high beam detection

NVIDIA DRIVE MAPPING

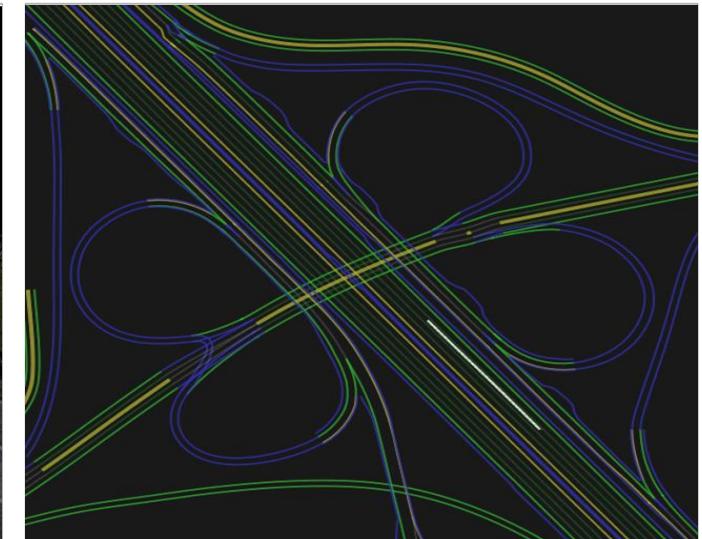
Drive, Update and Create HD Maps



Map Localization
Using DRIVE Localization API



Map Update
Using DRIVE MapStream API



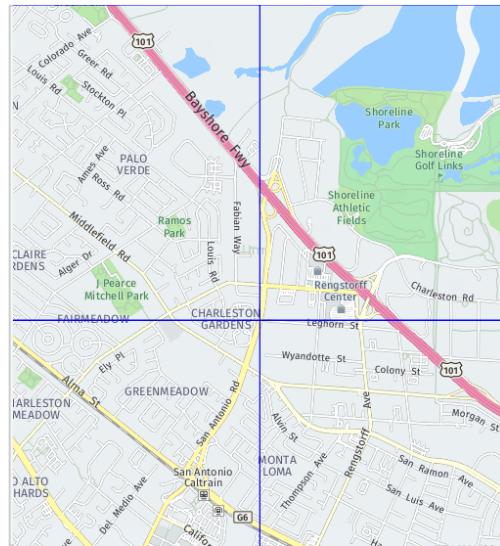
Map Creation
Using DRIVE MapStream/MapServices API

LOCALIZATION STEPS

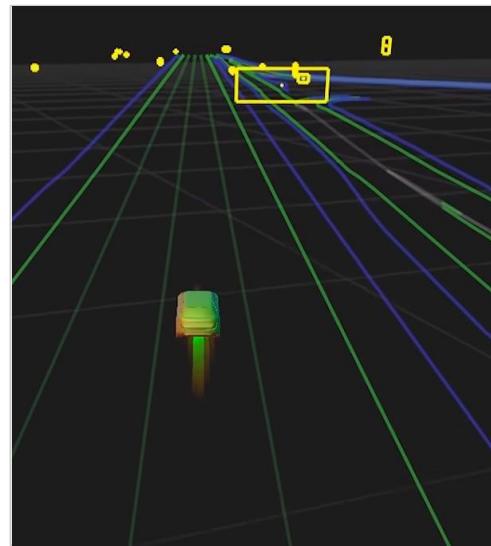
HERE example



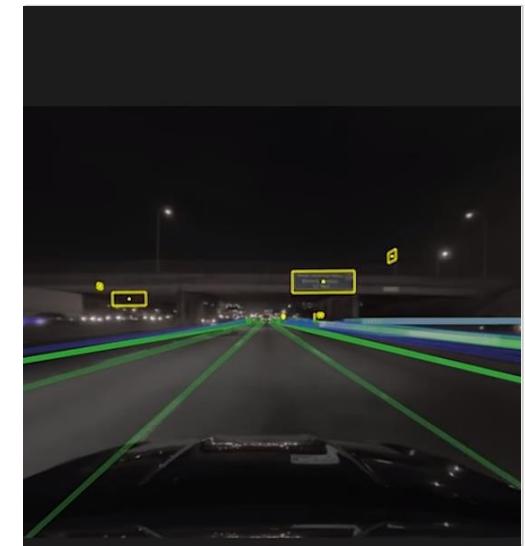
Detect
MapNet



Project
HERE HD Live Map

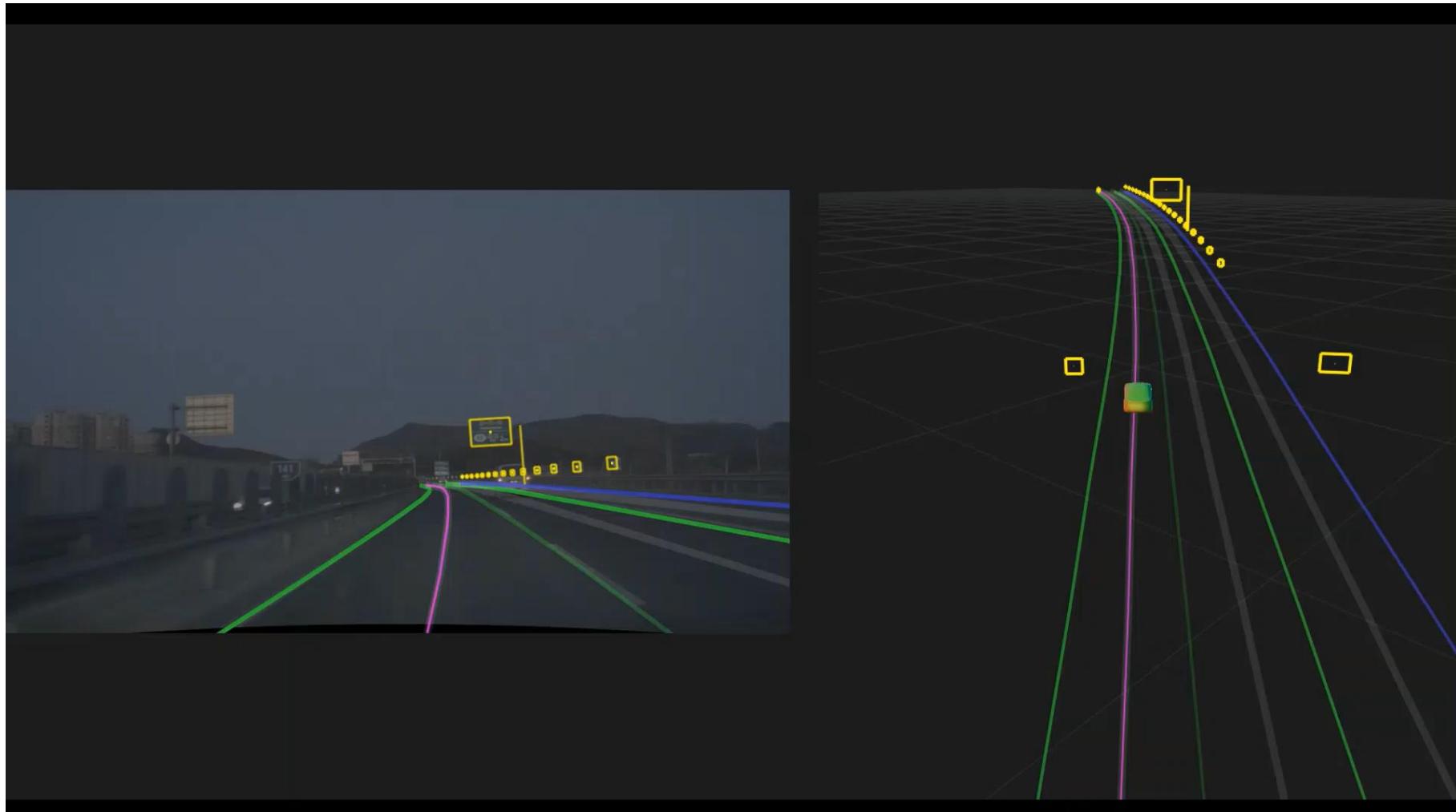


Match
DLA and CUDA



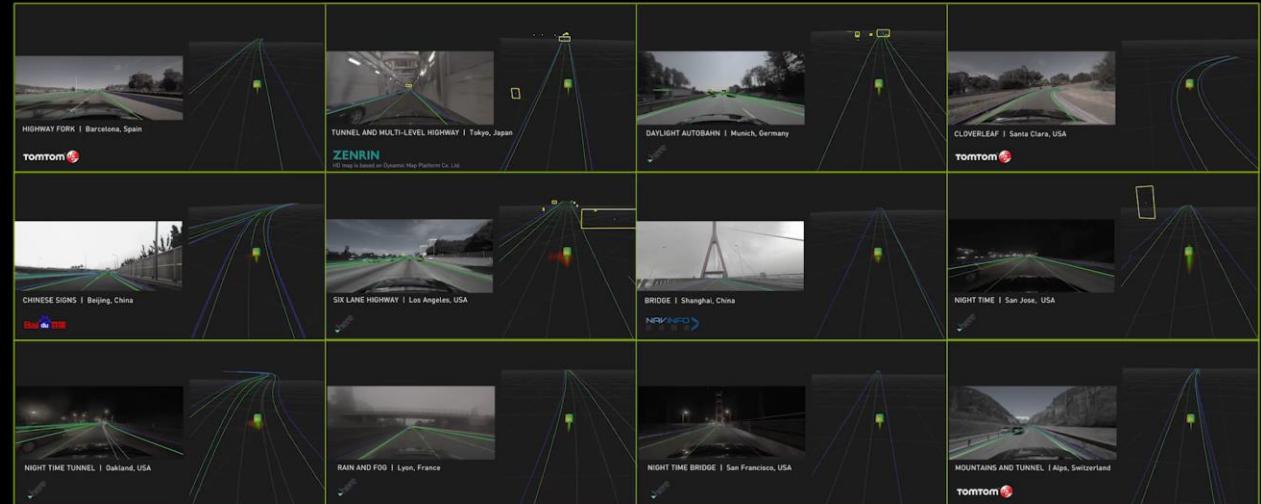
Drive
DRIVE Software

CAMERA LOCALIZATION

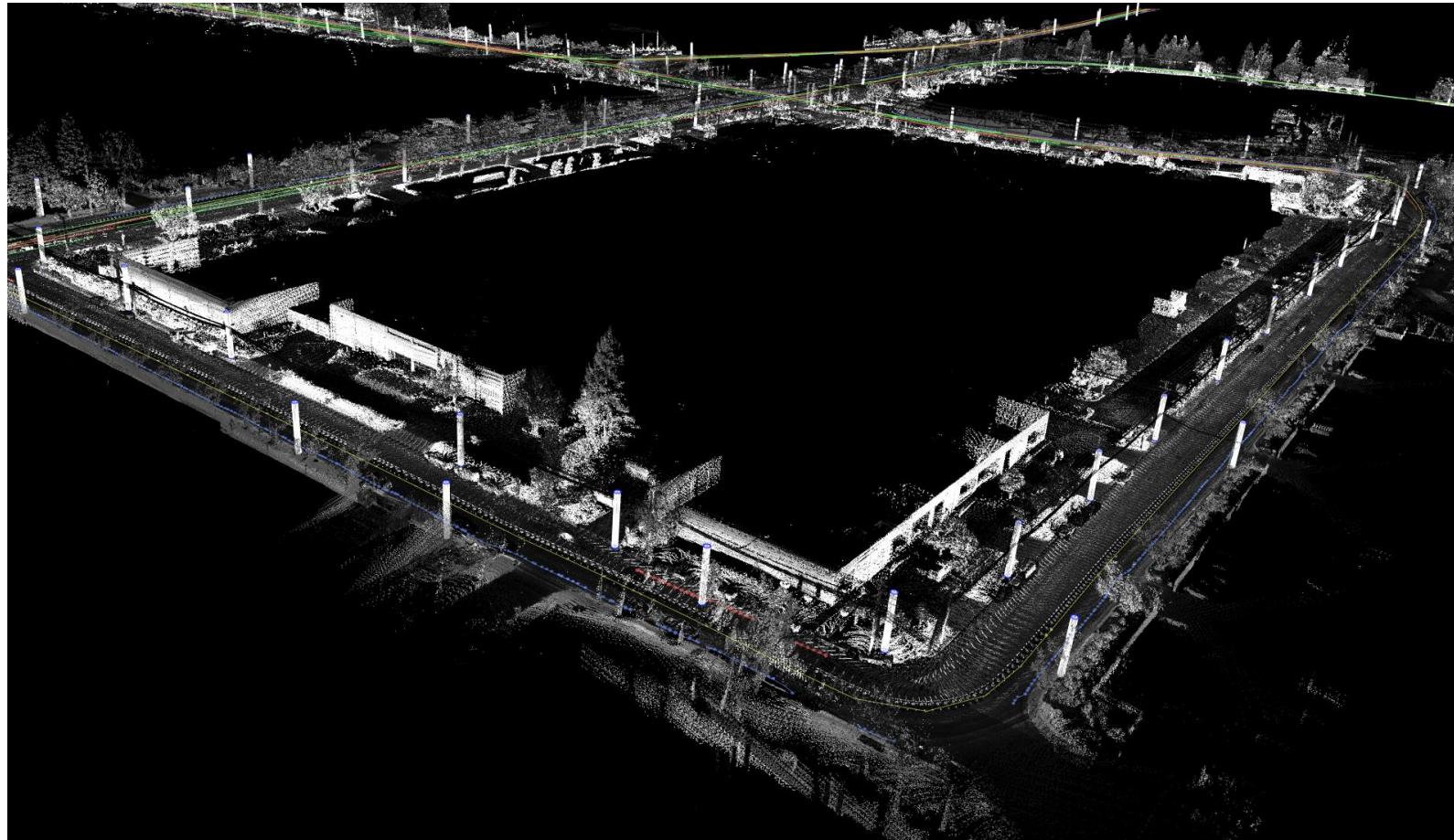
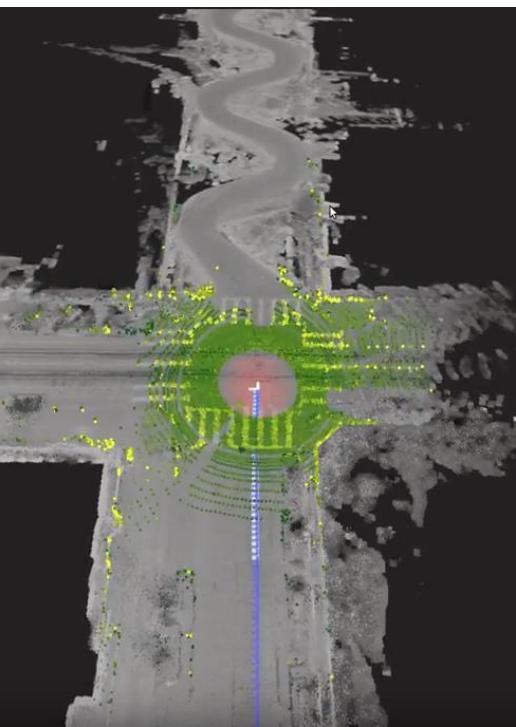


NVIDIA DRIVE

Localizing to Global HD Maps



LIDAR/RADAR MAPPING+LOCALIZATION

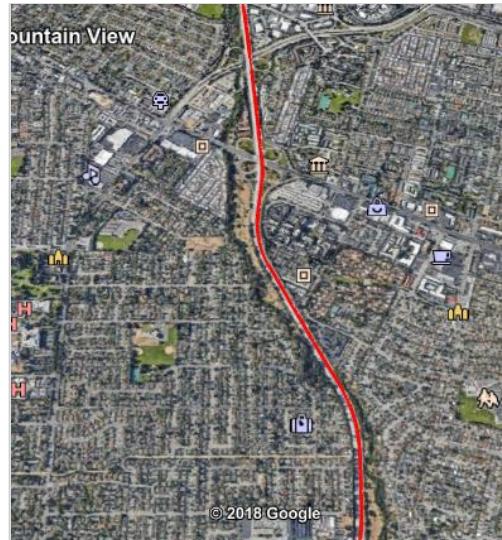


MAP UPDATE STEPS

TomTom example on I-85 in CA



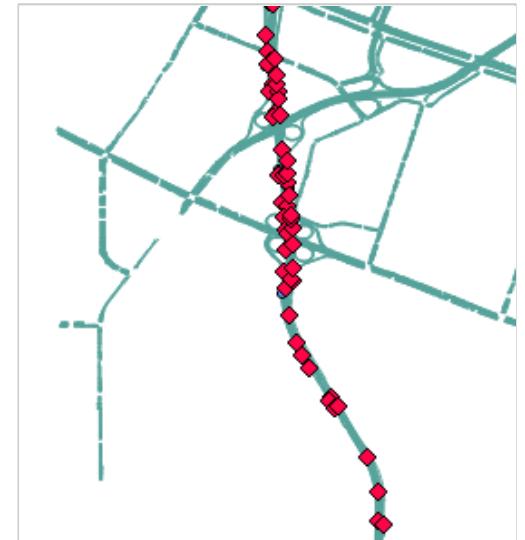
Detect
MapNet



Create MapStreams
Map update primitives

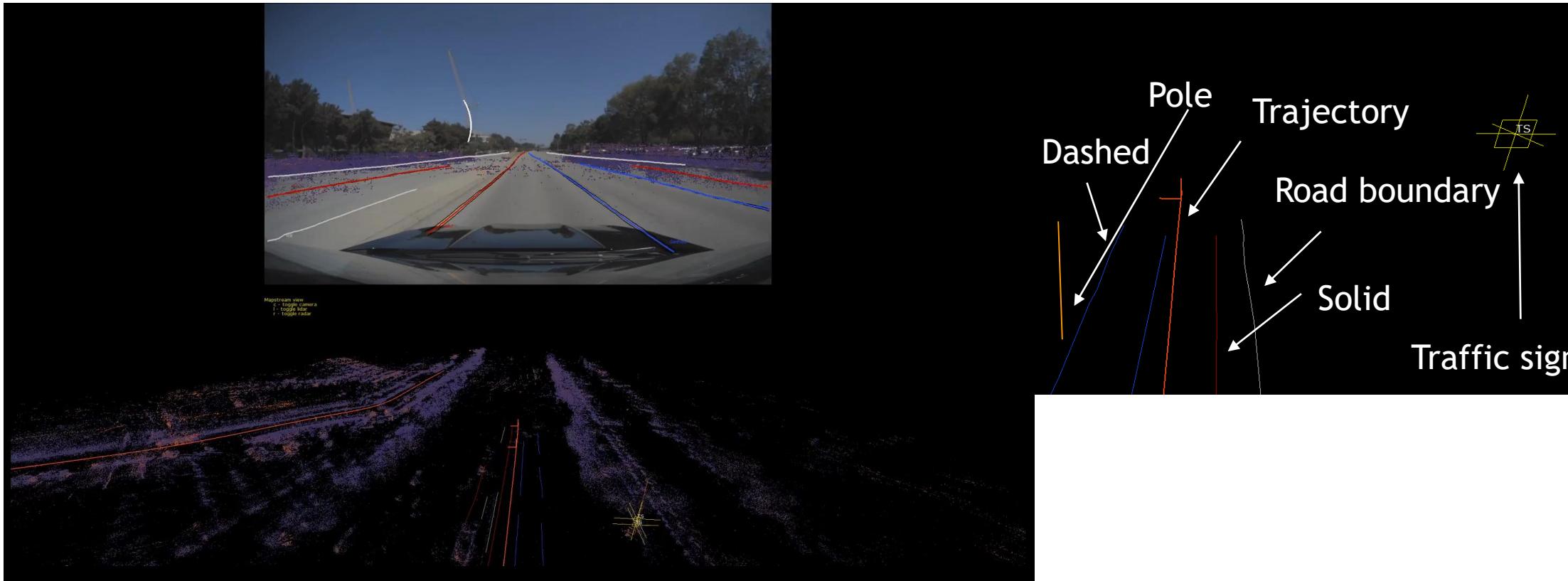


Convert
MapStreams to Roadgrams

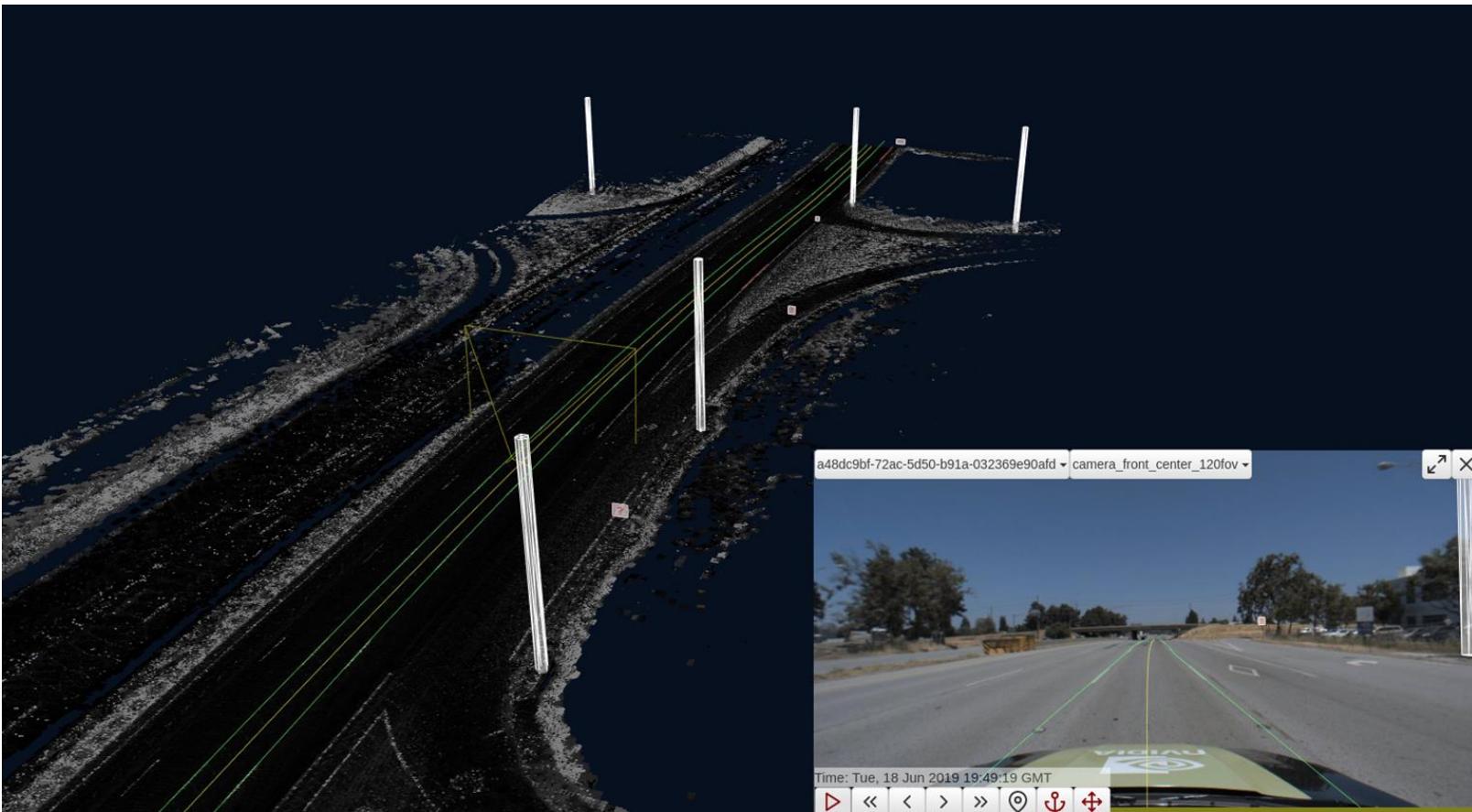


Update Map
HD map in the Cloud

MAPSTREAM CREATION IN THE CAR



VISUALIZING A CREATED MAPSTREAM



PLANNING

Advanced Behavior Planner

Basic Behavior Planner

Lane Planner

Route Planner



Route Planner

Lane Planner

Behavior Planner

Search Based Planning

Prediction

Learned Planning

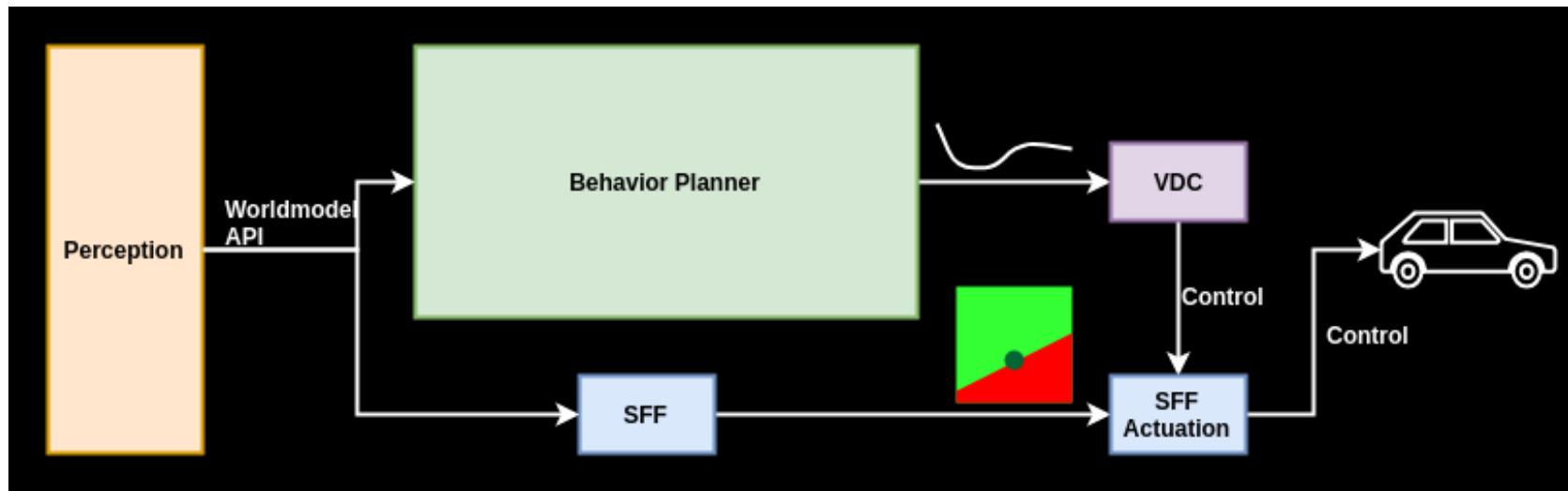
Safety Force Field

Safety Checks

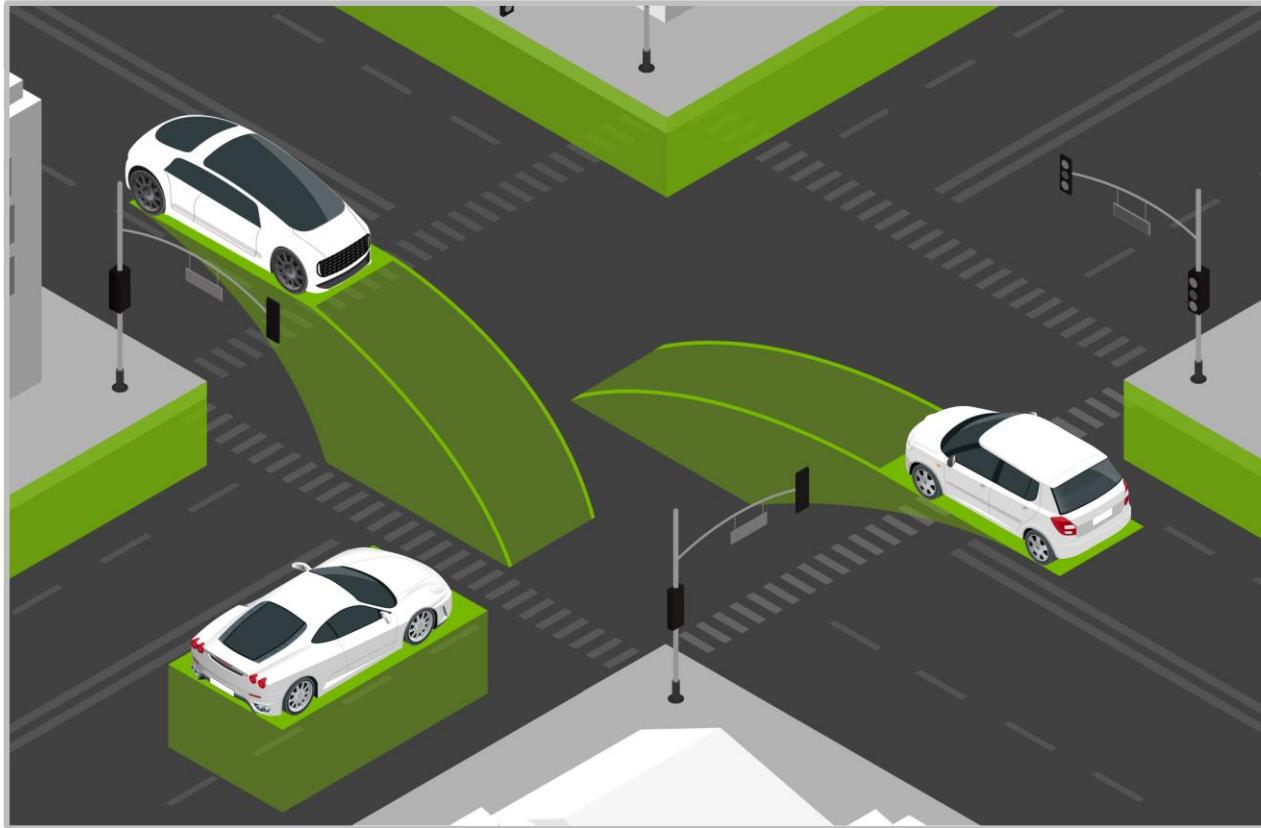
Latest Safe Arrival (LSA) Image

SAFETY FORCE FIELD

High-Level Architecture



SAFETY FORCE FIELD

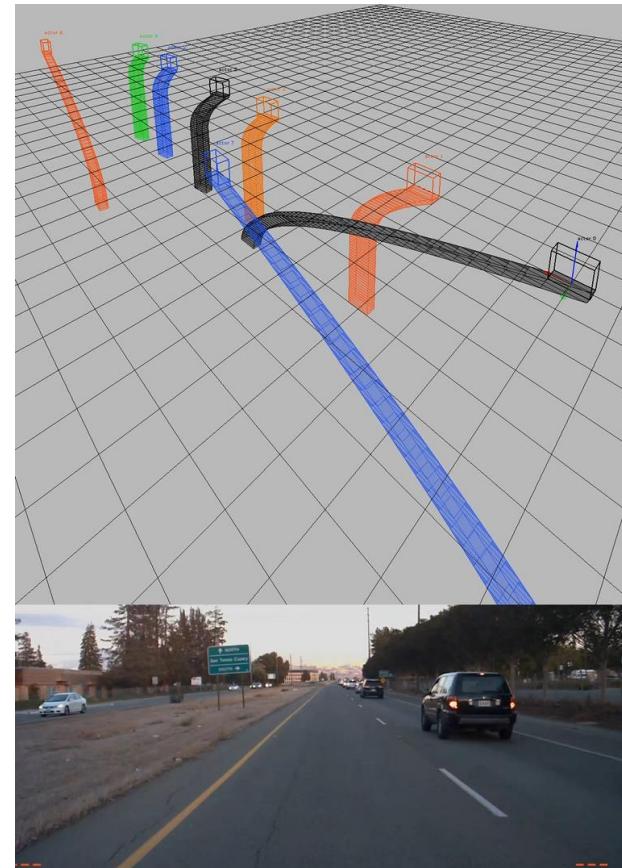
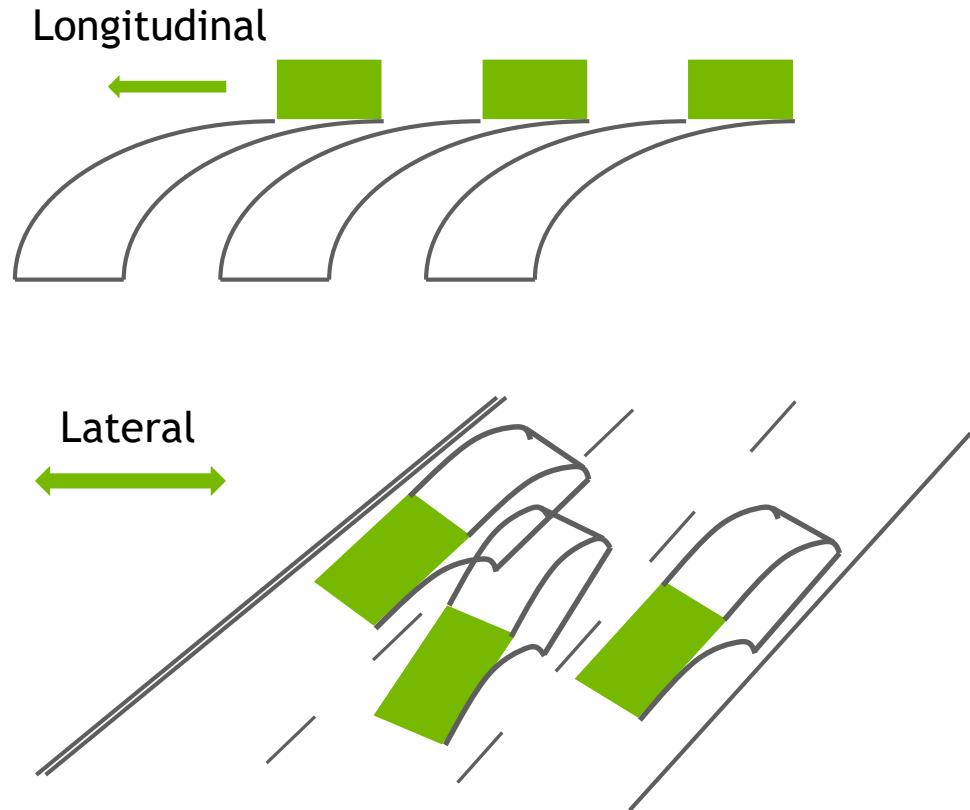


Our vehicle is always perceiving other actors and obstacles.

The Safety Force Field is a computational module that monitors for overlap between our safety procedure and that of other actors.

The Safety Force Field provides a repelling constraint that prevents us from contributing to a collision.

SAFETY FORCE FIELD





NVIDIA DRIVE
DRIVE EXPERIENCE

DRIVE IX - CONNECT TO SELF DRIVING

Using AR and VR



Confidence View



Perception view

EXAMPLE USE CASES



User Ext Face ID /
Trunk opening /
Car start



Driver/ Passenger Int face ID/
Greeting/ Settings



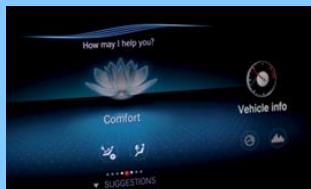
Auto adjust mirrors/seats



Emotion detect



Health/Wellness detect



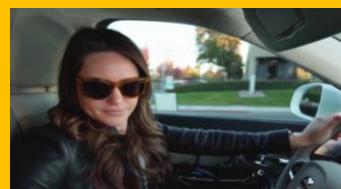
PA: Personal Assistant / NLU



PA: AV Driving modes



Hand Gestures detection



Distraction detect



Drowsiness detect



Child /Pet detect



Side traffic detect



Front cross traffic detect



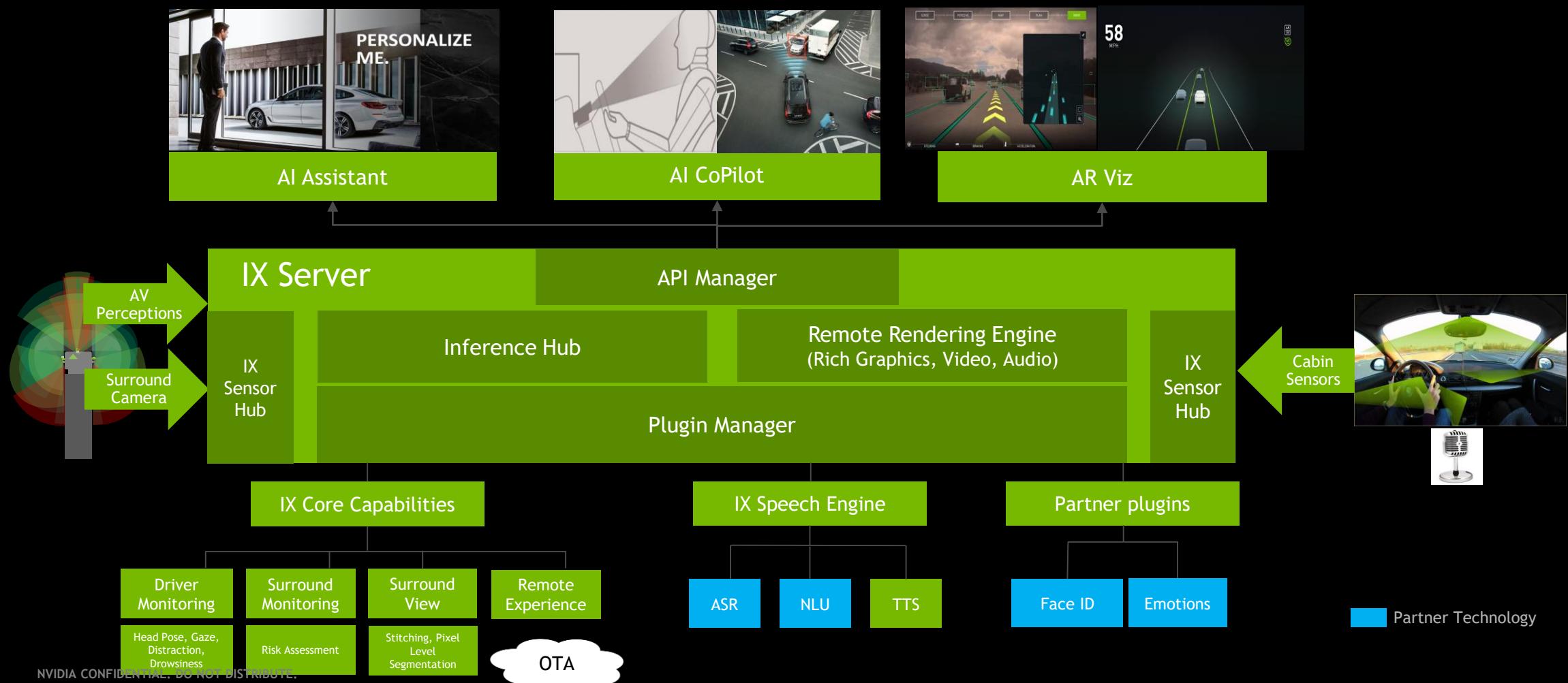
Safe back-up



Respond to sign commands

DRIVE IX

AI Toolkit for Intelligent Experience





NVIDIA DRIVE
DRIVE SIM

DRIVE CONSTELLATION

Virtual Reality AV Simulator

Hardware in the-Loop System Level Simulator

Simulate Rare and Difficult Conditions

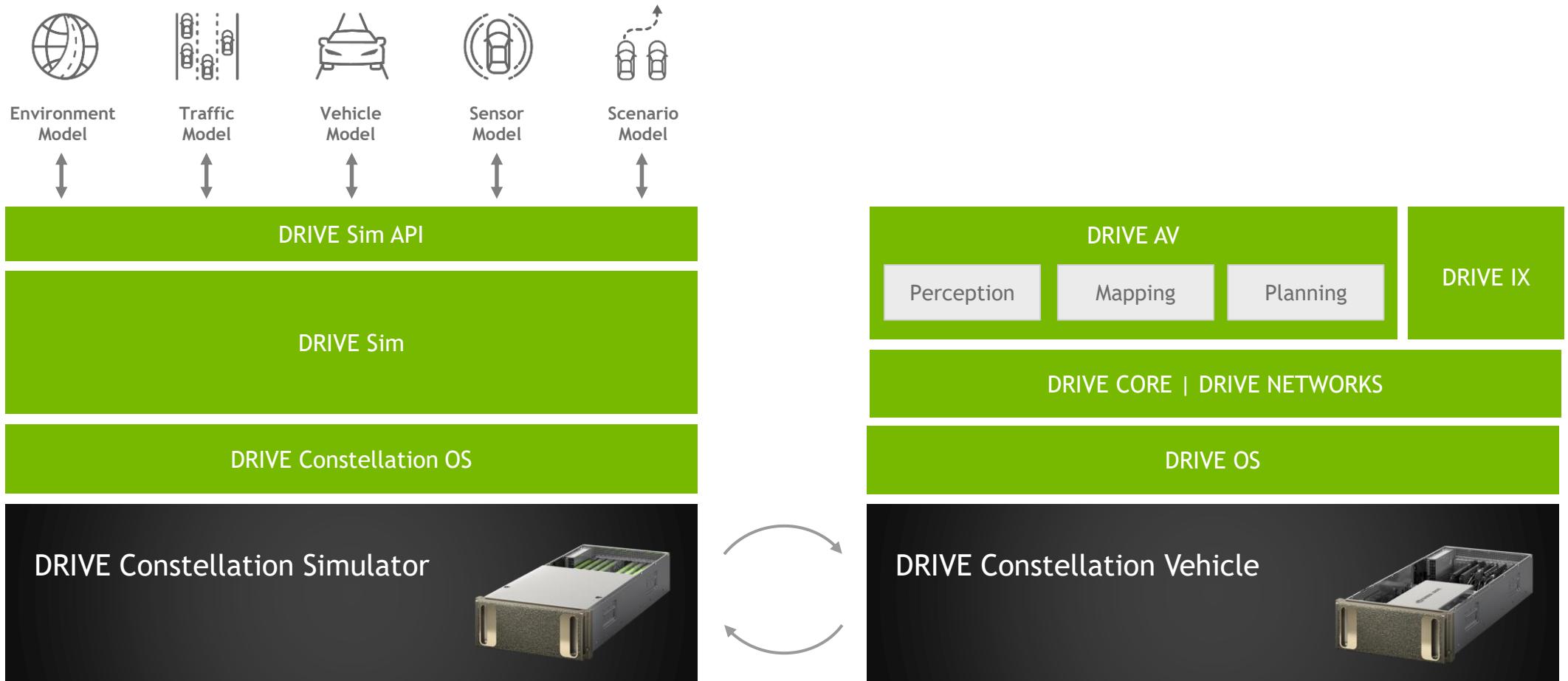
Scalable Platform | Data Center Solution

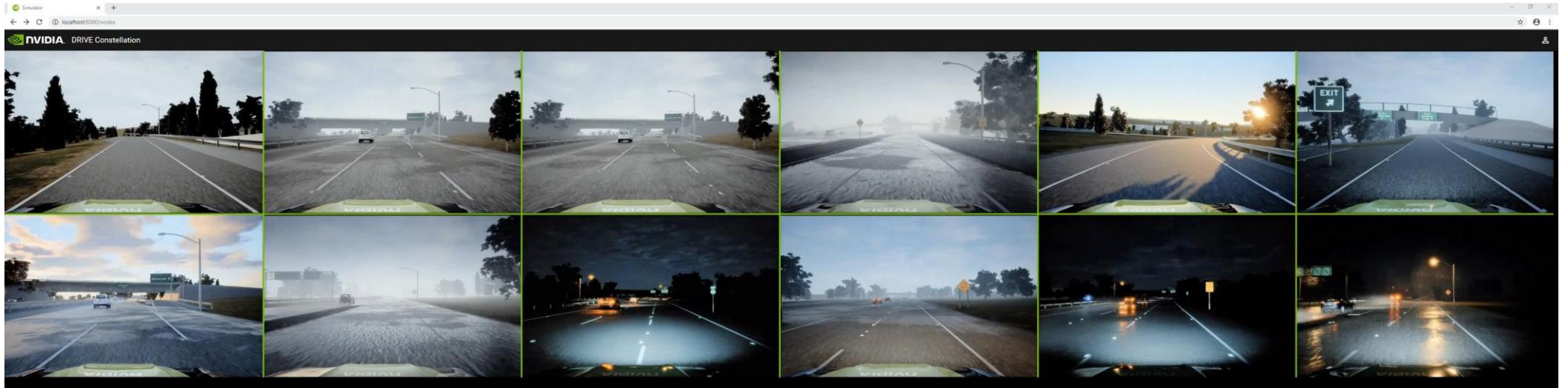
Timing Accurate and Bit Accurate

Scenario Based Coverage



DRIVE CONSTELLATION ARCHITECTURE





CONSTELLATION DATA CENTER WORKFLOW - CONT.

DRIVE PLATFORM

Mass production

INDUSTRY / MARKET

SAFETY

TECHNOLOGY

REGULATIONS

