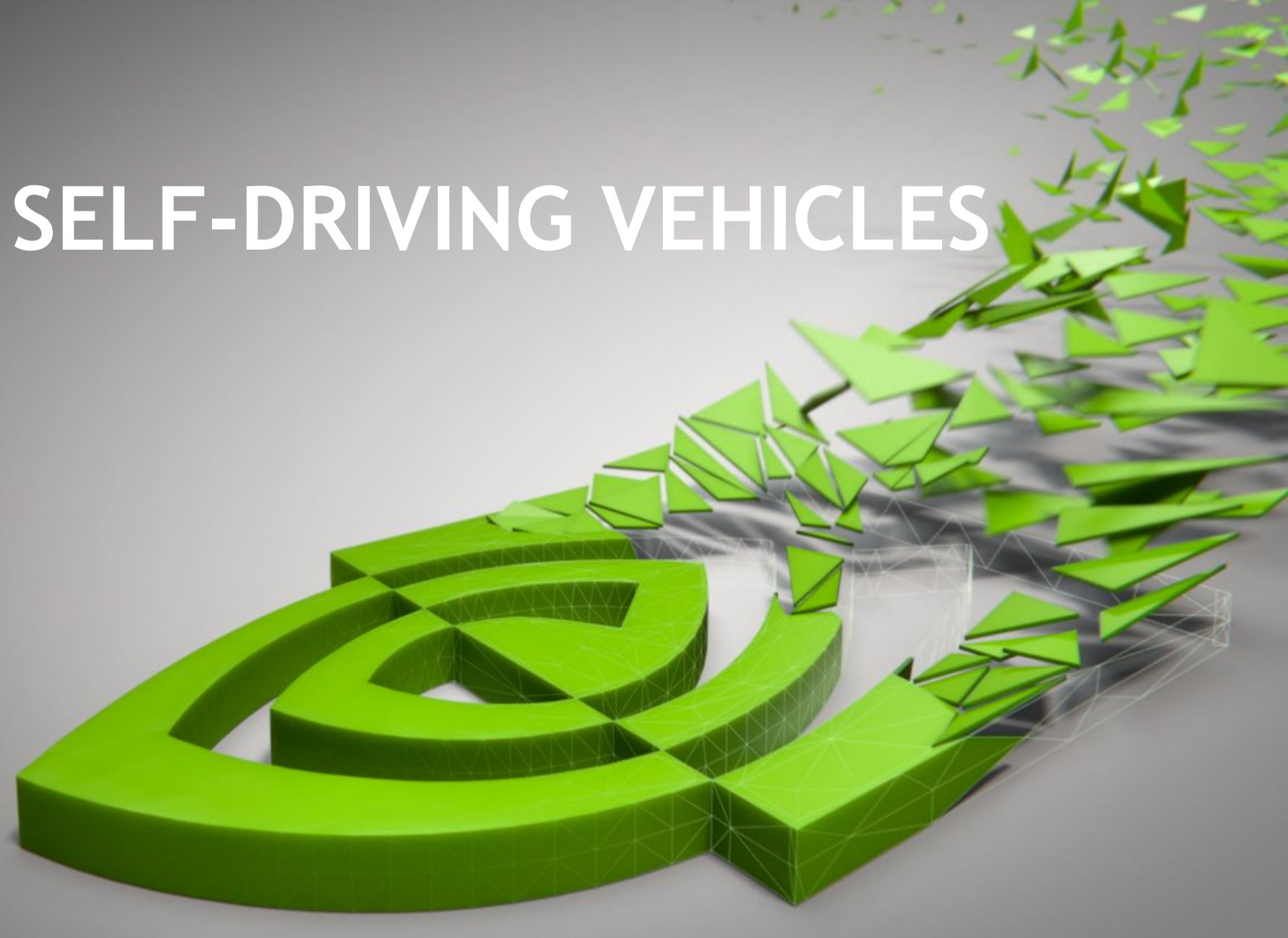
AI FOR SELF-DRIVING VEHICLES

Romuald Josien

Nov, 2018

NVIDIA.



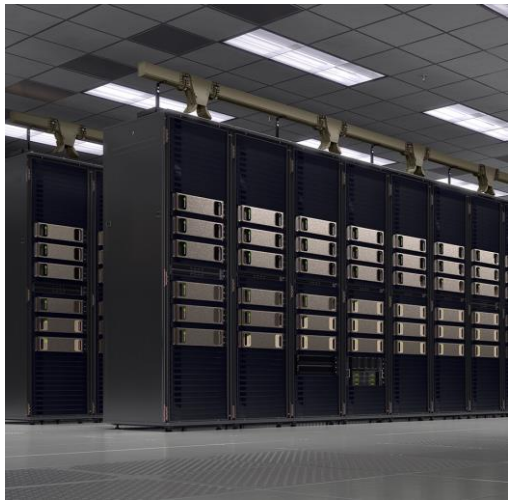
NVIDIA FACTS

- Founded in 1993
- HQ in Santa Clara (CA – USA)
- > Jensen Huang, Founder & CEO
- > 12,000 employees WW
- $9.7B revenue in FY18 (+41%)
- >1B GPUs shipped to date
- 6,000 patents WW

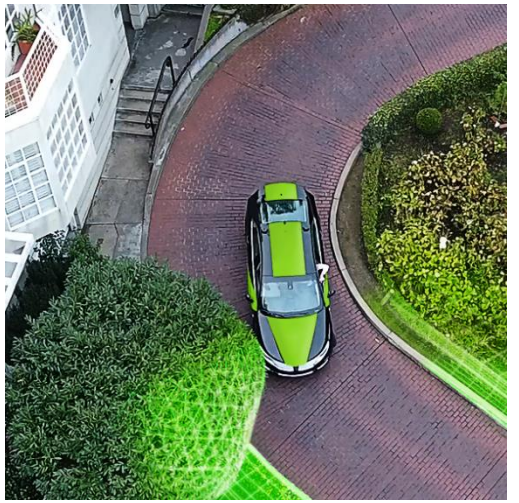
NVIDIA - GPU COMPUTING

Gaming

VR

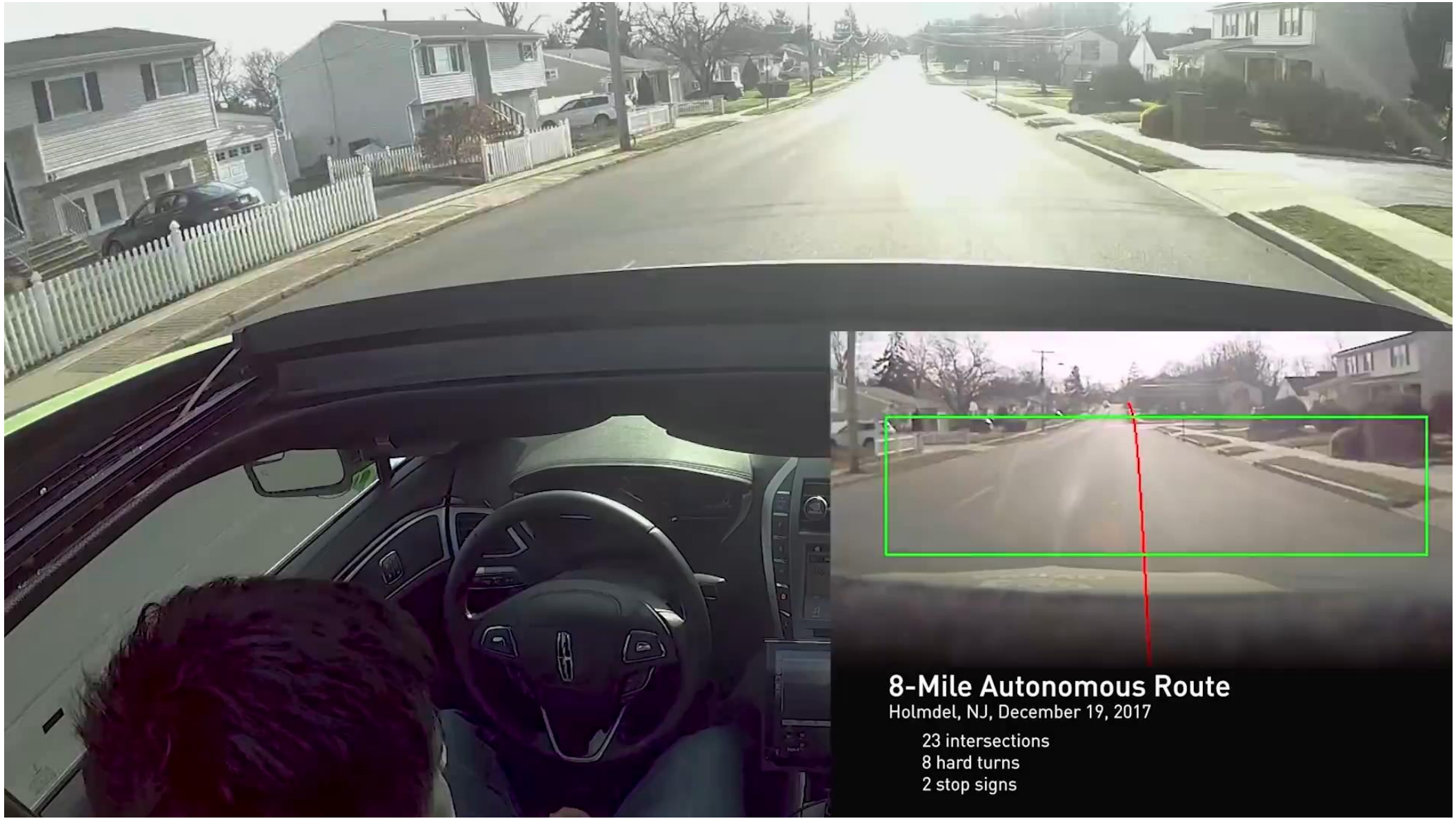


AI & HPC



Self-Driving Cars
& Autonomous Machines

ONE ARCHITECTURE — CUDA


8-Mile Autonomous Route
Holmdel, NJ, December 19, 2017
23 intersections
8 hard turns
2 stop signs

AUTONOMOUS VEHICULE

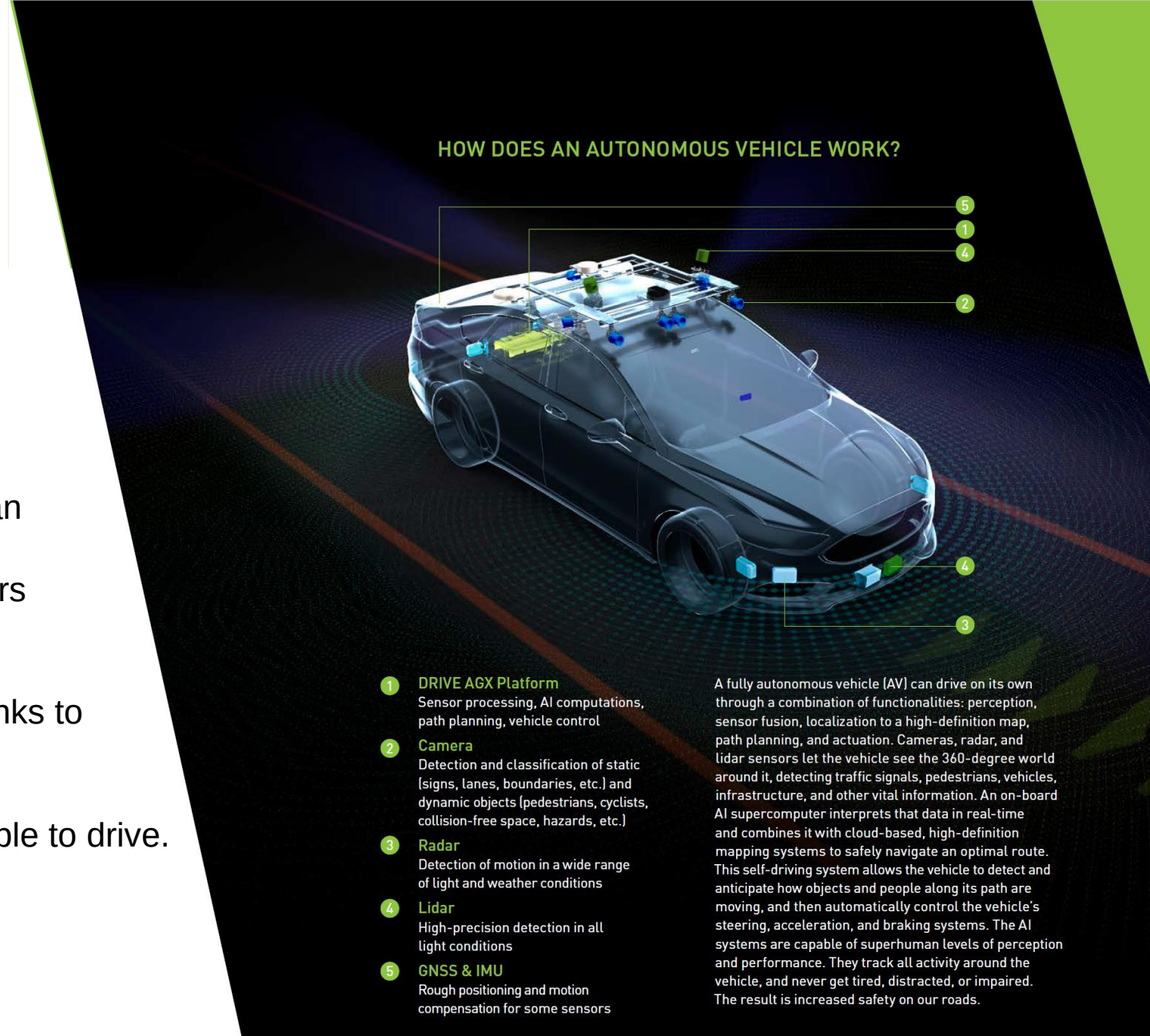
To increase productivity,

To reduce the accidents caused by human

To reduce the number of hours commuters waste in traffic

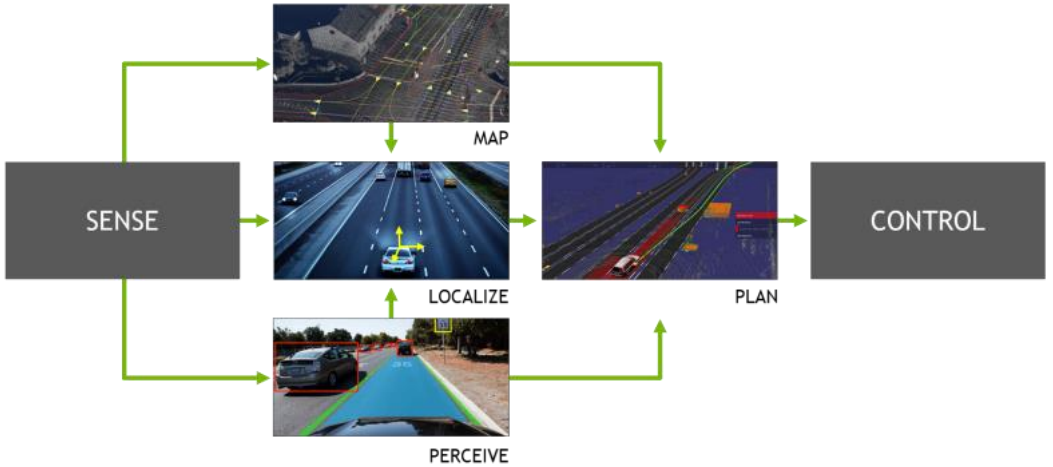
To reduce the amount of air pollution thanks to more efficient traffic patterns

To provide mobility to those who are unable to drive.

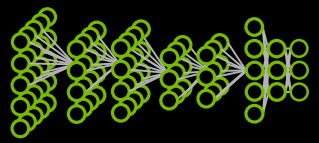


SELF-DRIVING AND AI SUPERCOMPUTING

THE BASIC SELF-DRIVING LOOP



SELF-DRIVING IS HARD



DEEP LEARNING TO THE RESCUE

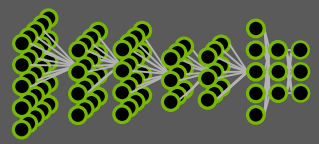
DEEP LEARNING — A NEW COMPUTING MODEL

"Big Bang in AI"

BIG DATA

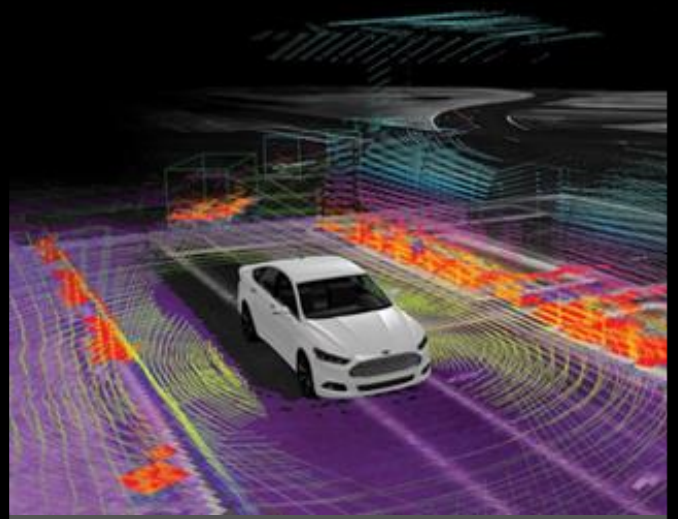
LEARNING ALGORITHM

"millions of trillions of FLOPS"



"A car stops at the STOP sign"

THE CHALLENGE AUTOMAKERS FACE



PROCESSING REQS

The ODDs scale from Lane Keeping to robo-taxis

Up to 100s of TOPs, 10s of TFLOPs, 1000s of KDMIPs

POWER, COST

Up to …

1000s of Watts,

10000s of $

Cost of Software

TESTING, VALIDATION

Up to …

100s of billions of driving miles,

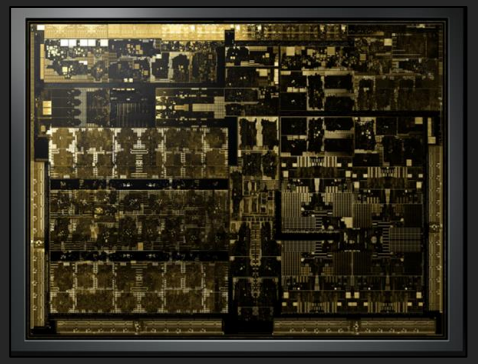
100s of years

NVIDIA KEY STRATEGY

Game Changers

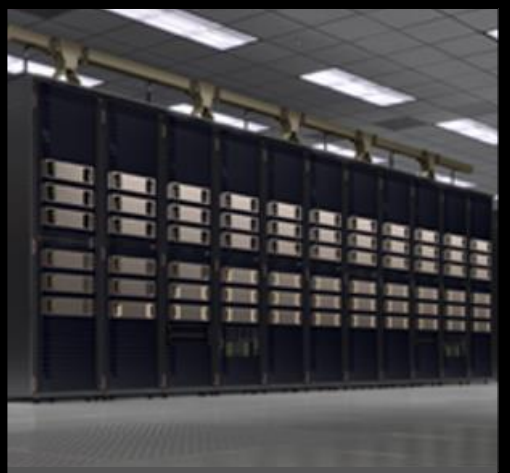
AI

The Computing Model
for AV



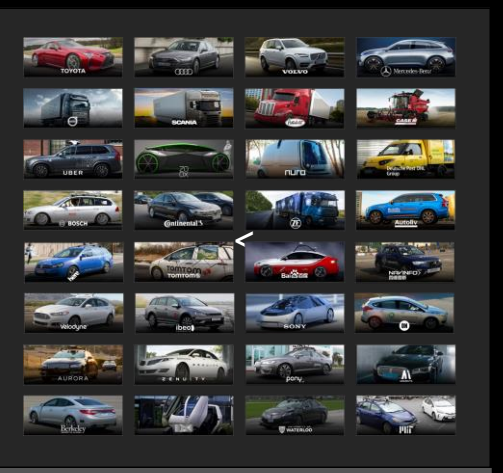
One-Architecture

Xavier – Pegasus
From L2 to L5



DRIVE
END-TO-END SYSTEM

Collect Data
Train Models
Simulate
Drive



OPEN PLATFORM

370+ Partner
Ecosystem

NVIDIA DRIVE

Spans the entire range of autonomous driving

L1 NO AUTOMATION

Zero autonomy

Driver performs all driving tasks

L2 DRIVER ASSISTANCE

Vehicle has some function-specific assist automation

Driver performs all driving tasks

L3 CONDITIONAL AUTOMATION

Vehicle can monitor and respond to its environment

Driver must be ready to take control when alerted

L4 HIGH AUTOMATION

Vehicle can perform all driving functions under certain conditions

Driver has the option to control the vehicle

L5 FULL AUTOMATION

Vehicle can perform all driving functions under all conditions

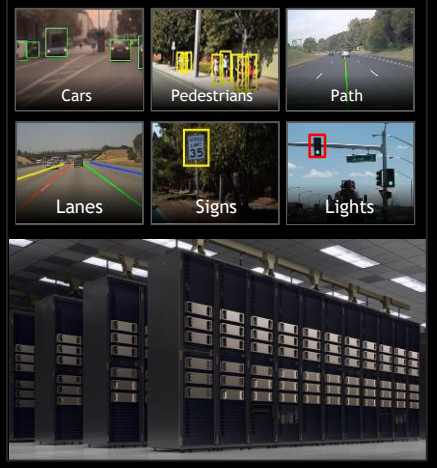
Driver may have the option to control the vehicle

NVIDIA

END-TO-END SYSTEM FOR AV

COLLECT DATA

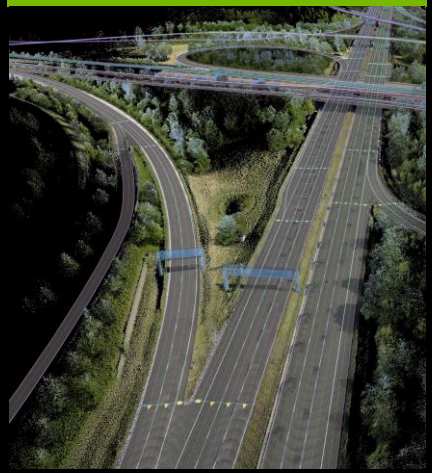
TRAIN MODELS



SIMULATE

RE-SIMULATE

MAPPING



Sources: NVIDIA, RAND Corporation

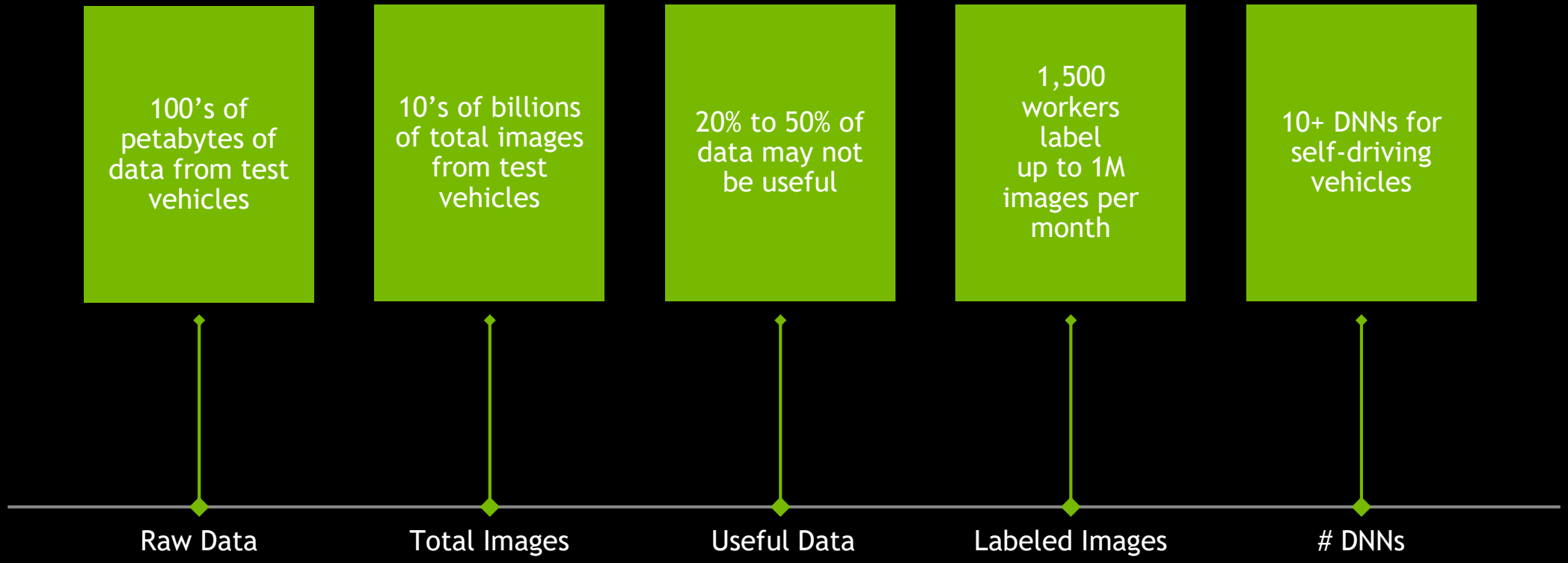
NVIDIA

DATA GENERATION FROM ONE SURVEY CAR

DATA COLLECTED	TOTAL IMAGES	LABELED IMAGES
2 petabytes per car / year	1 billion images / year	3 million images / year

Source: NVIDIA's Self-Driving Cars - BB8

DATA COLLECTION AND LABELING FOR AI



Source: Data from test fleets of 50-100 cars

NVIDIA

NVIDIA PERCEPTION INFRASTRUCTURE

LARGE-SCALE DEEP LEARNING MODEL DEVELOPMENT

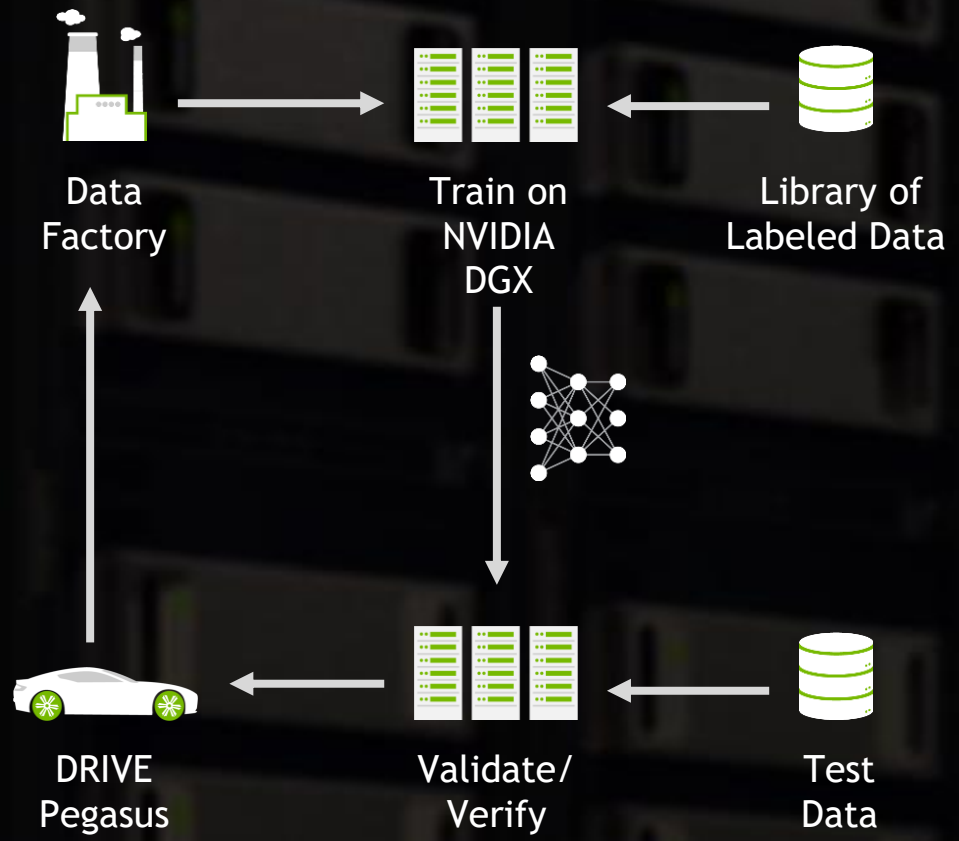
Workflow, Tools, Supercomputing Infrastructure

Data Ingest, Labeling, Training, Validation, Adaptation

Automation, Best Model Discovery, Traceability, Reproducibility

Purpose-built for Safety Standards of Automotive

"Data is the new source code"



AI FOR SELF-DRIVING WORKFLOW

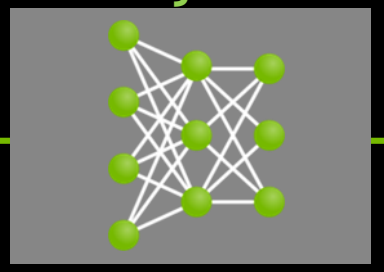
Get Data

Labeled Data

Train & Test

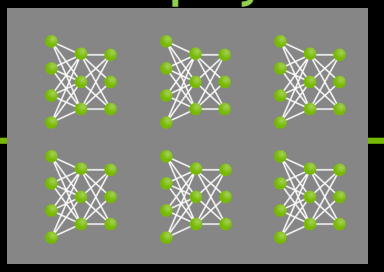
Trained Model

Adjust



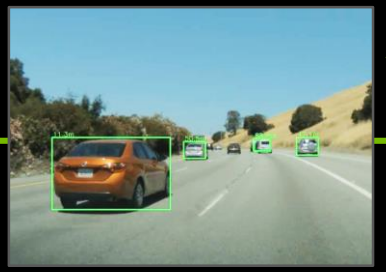
Fine Tune Model

Deploy



Export Model

Test & Validate



Inference at Edge

DNN Development
Exploration
Development
Model Selection

Simulate

Re-Simulate

NVIDIA

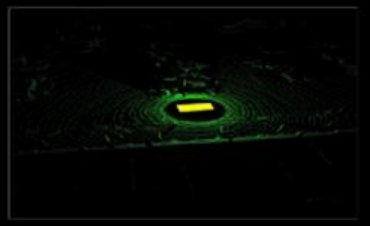
AI FOR SELF-DRIVING

Perception

Free Space Perception

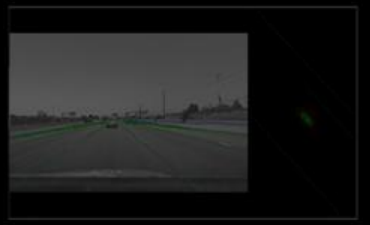
Distance Perception

Weather



LIDAR Perception

Camera-based Mapping



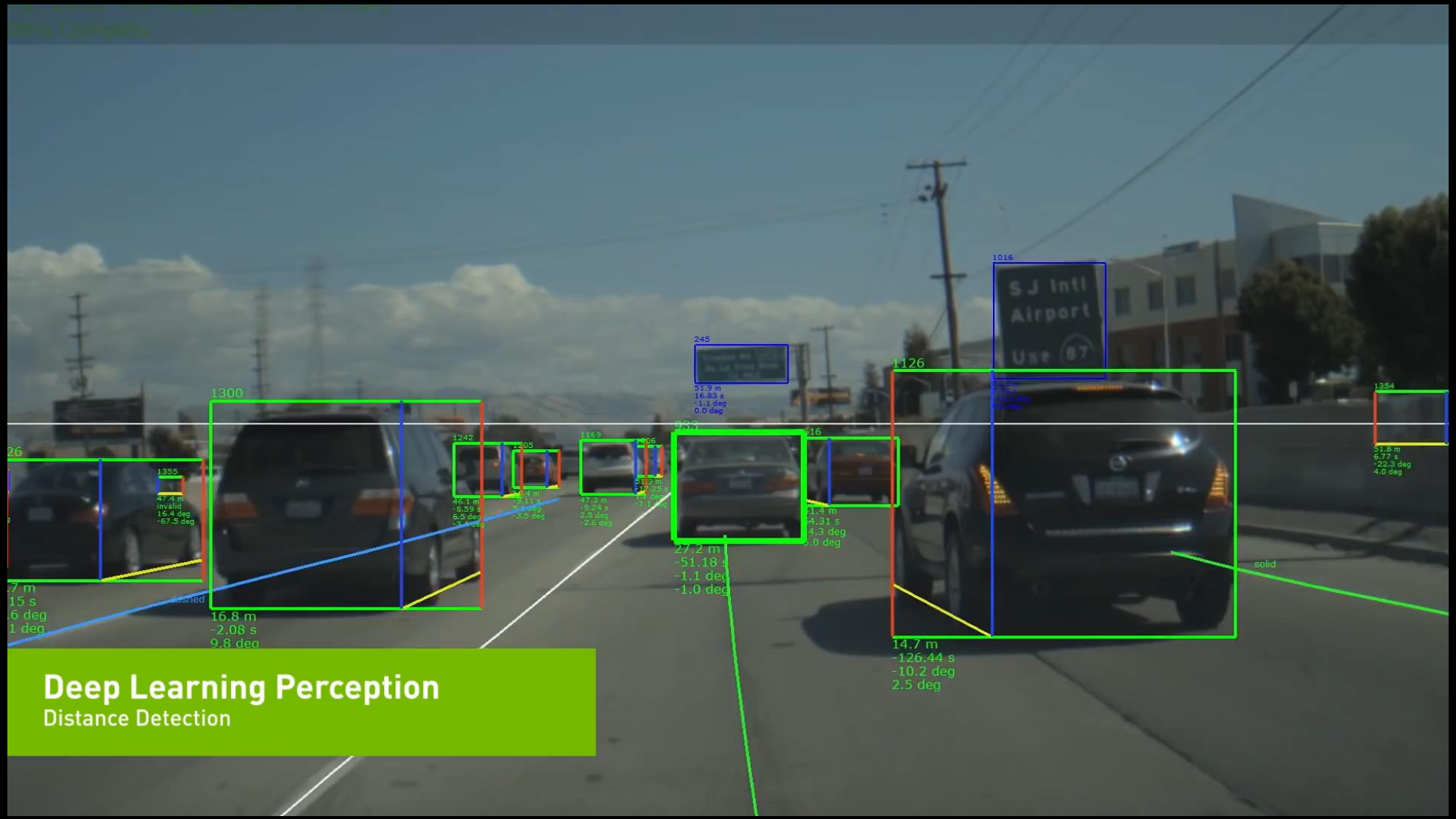
Camera Localization to HD Map

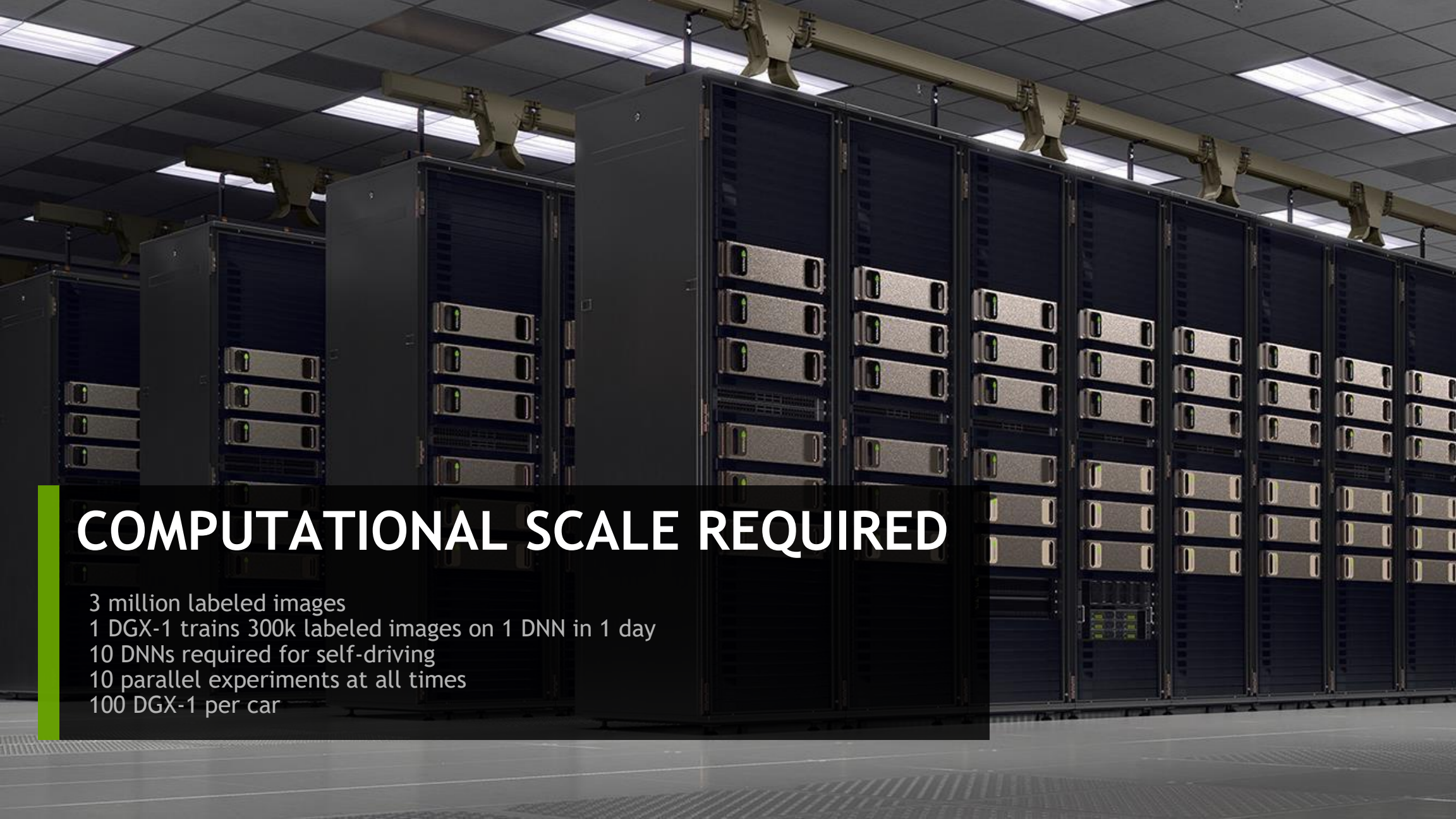
LIDAR Localization to HD Map

Path Perception

Scene Perception

NVIDIA


SJ Intl
Airport
Use 87
1016
245
1126
1300
1354
1355
1242
1205
1169
1206
solid
16.8 m
-2.08 s
9.8 deg
14.7 m
-126.44 s
-10.2 deg
2.5 deg
Deep Learning Perception
Distance Detection



COMPUTATIONAL SCALE REQUIRED

3 million labeled images
1 DGX-1 trains 300k labeled images on 1 DNN in 1 day
10 DNNs required for self-driving
10 parallel experiments at all times
100 DGX-1 per car

NVIDIA GPU PLATFORM SAVES MONEY

Enable Deep Learning Training at Scale

$1.25M in servers

=

10x TCO

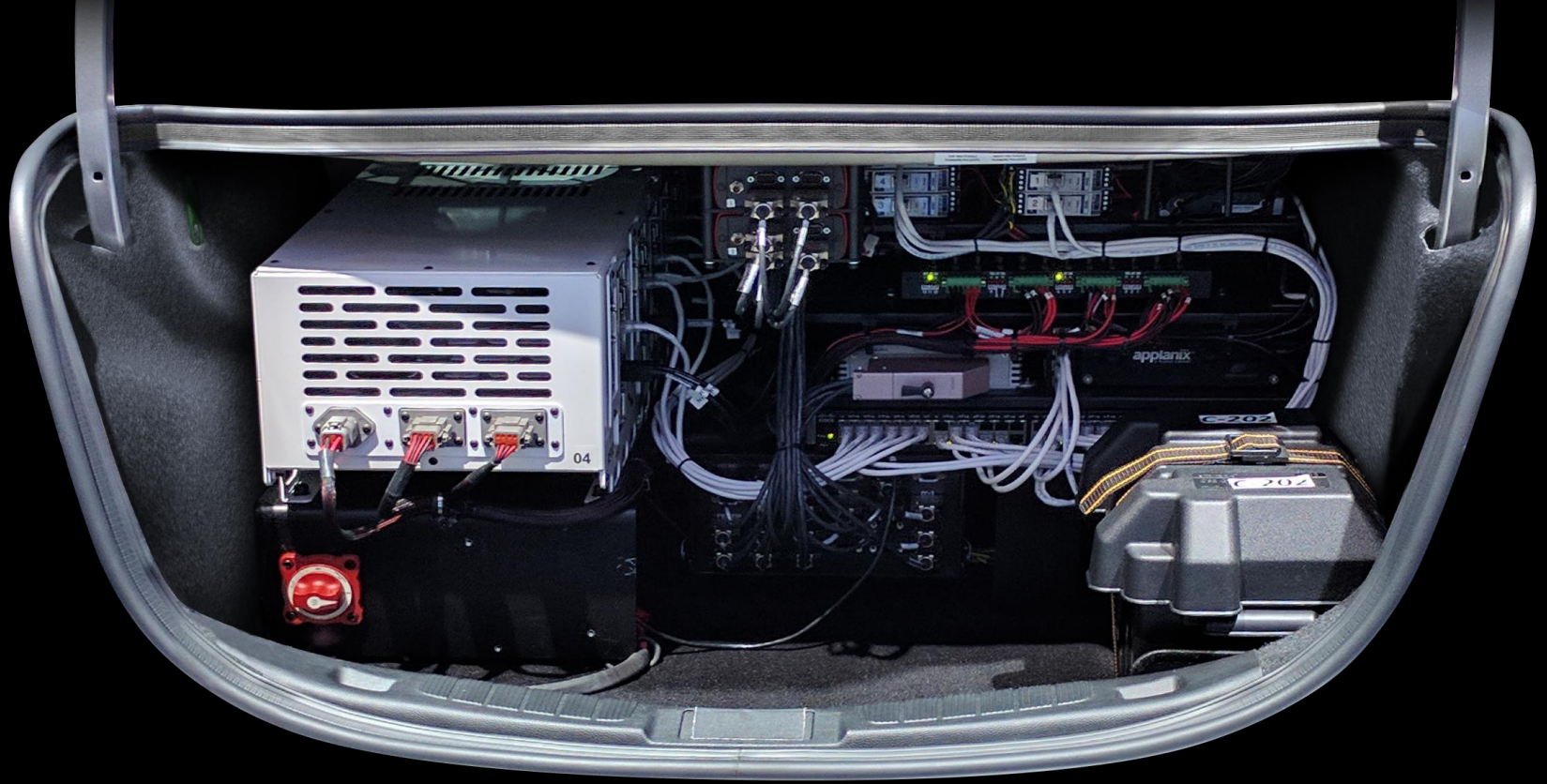
1/8 THE COST

10X LESS SPACE

20X LESS POWER

140 Skylake Gold CPU Servers

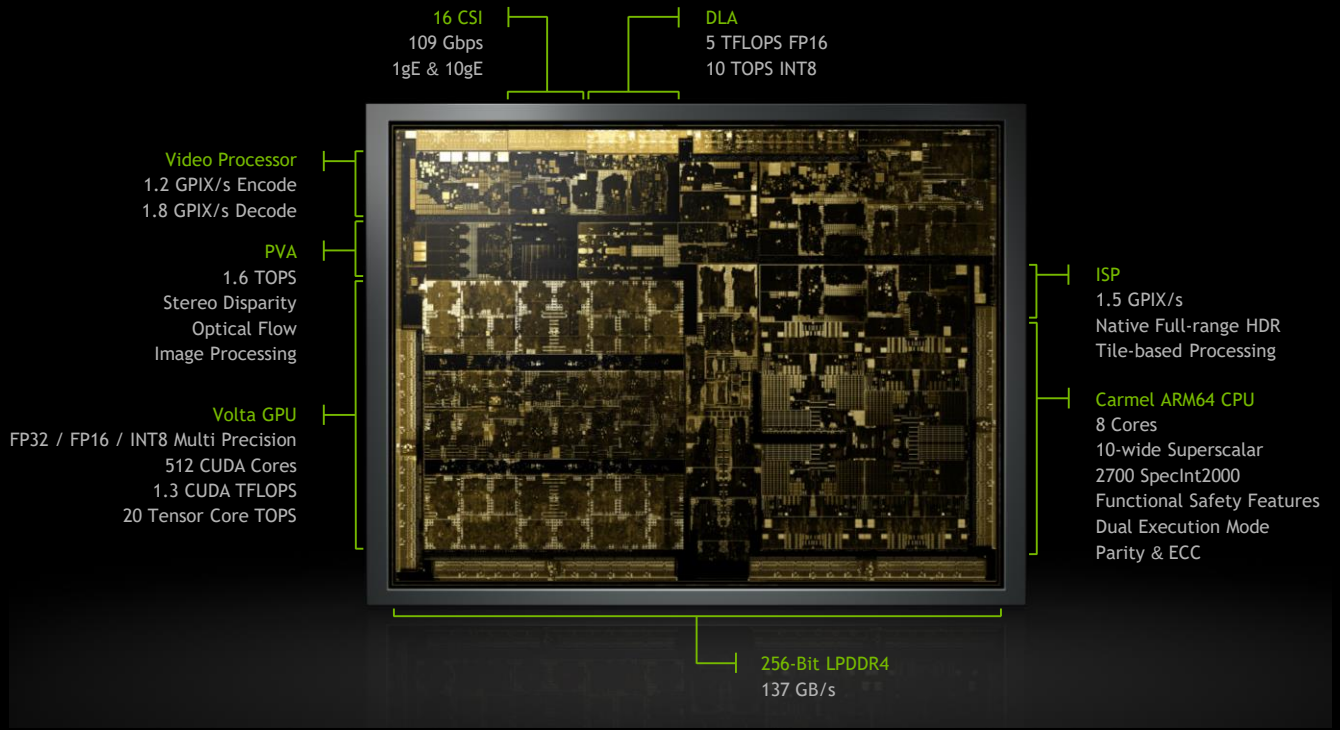
One DGX-1

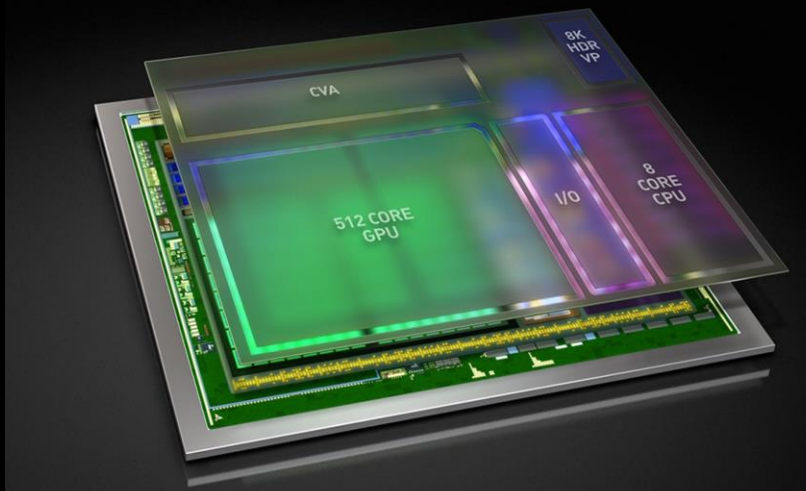


STATE-OF-THE-ART DRIVERLESS VEHICLES

NVDIA DRIVE XAVIER

The World's first autonomous Machine Processor





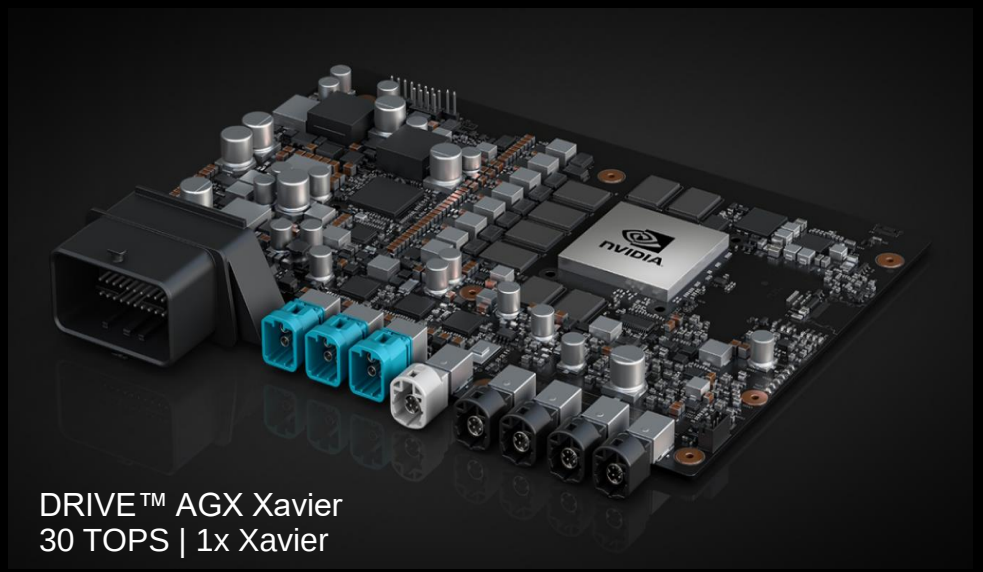
Most Complex SOC Ever Made | 9 Billion Transistors, 350mm^2, 12nFFN | ~8,000 Engineering Years
Diversity of Engines Accelerate Entire AV Pipeline | Designed for ASIL-D AV

NVIDIA

DRIVE AGX — A SCALABLE AV PLATFORM

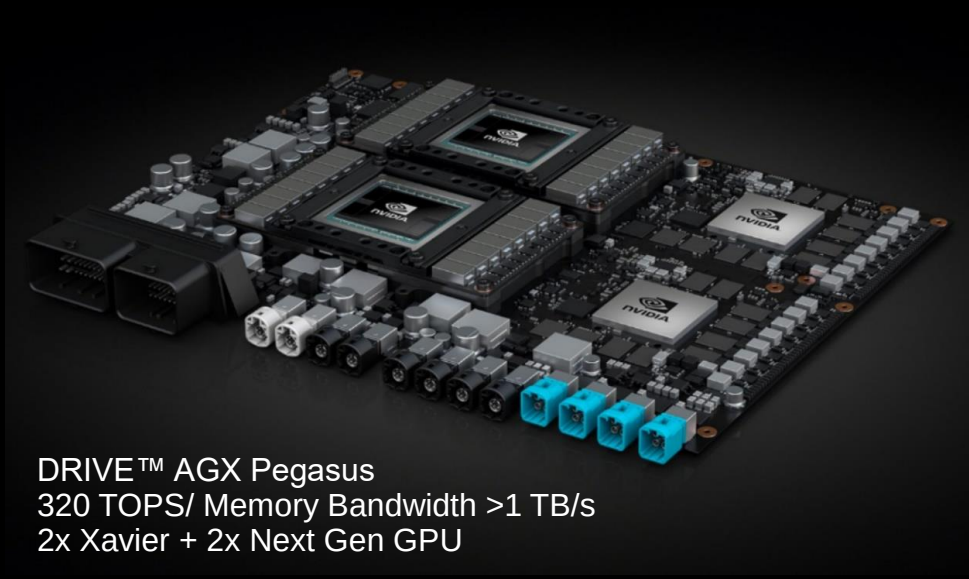
One AV Architecture for L2+ up to L5

DRIVE AGX XAVIER



DRIVE™ AGX Xavier
30 TOPS | 1x Xavier

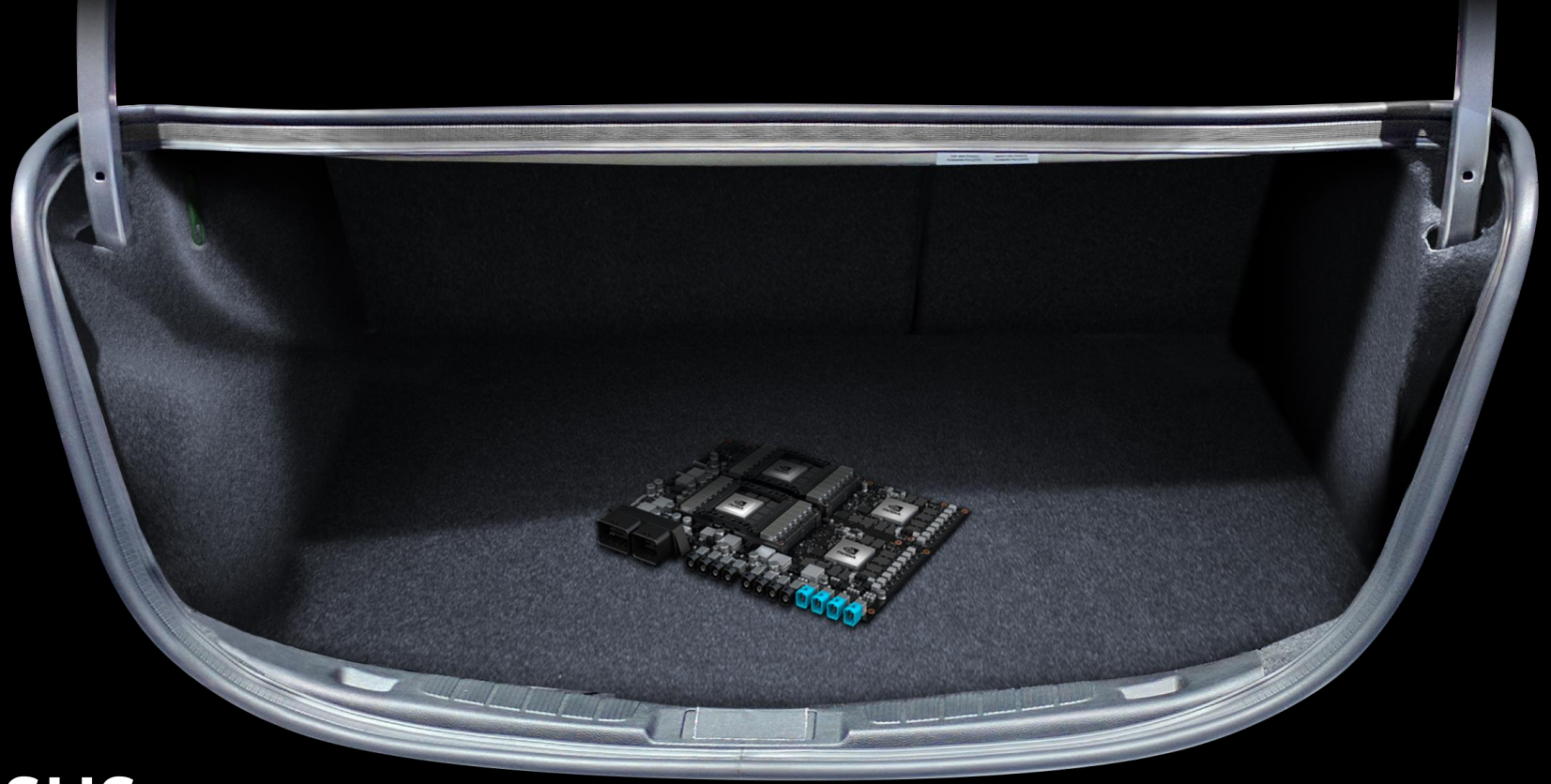
DRIVE AGX PEGASUS



DRIVE™ AGX Pegasus
320 TOPS/ Memory Bandwidth >1 TB/s
2x Xavier + 2x Next Gen GPU

ROBOTAXI AI COMPUTER
Data Center in the Trunk

NVIDIA.



DRIVE PEGASUS

ROBOTAXI DRIVE PX

320 TOPS CUDA TensorCore | 16x GMSL | 4x 10G | 8x 1G | 16x 100M | Auto-grade | ASIL D

500W | Late Q1 Early Access Partners

Supercomputing Data Center in your Trunk

SAFETY REQUIRES HIGH-PERFORMANCE COMPUTING

For self-driving cars, processing performance translates to safety. The more compute, the more sophisticated the algorithm, the more layers in a deep neural network and the greater number of simultaneous DNNs that can be run. NVIDIA offers an unprecedented 320 trillion operations per second of deep learning compute on DRIVE AGX Pegasus.

SCALING UP AV PERCEPTION IS HARD

Operation Driving Domains (ODDs) ∩ Driving Modes (DMS) == 1000s of Conditions


Vehicles


Pedestrians


Bicycles


Animals


Hazards


Day


Twilight


Night


Lamps


Backlit

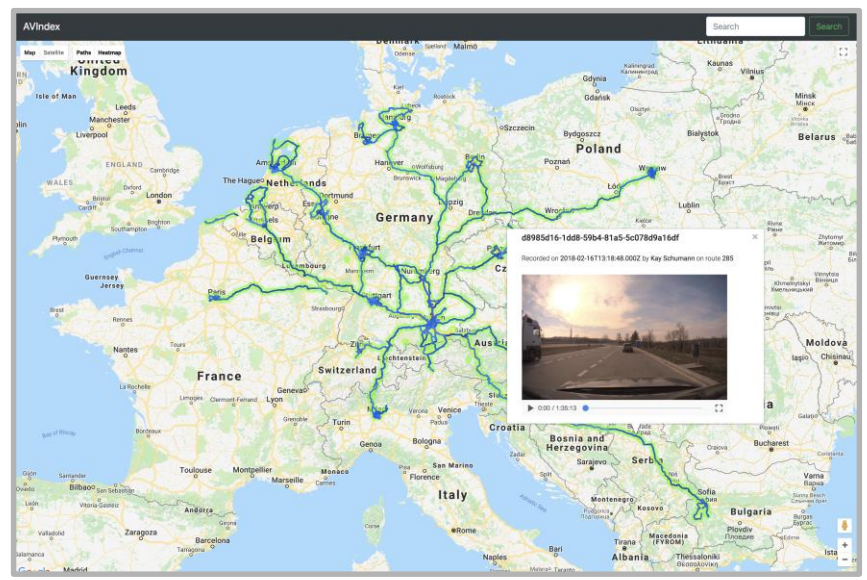

Clear


Cloudy


Rain


Fog


Snow



SIMULATION
THE PATH TO BILLIONS OF MILES

World drives trillions of miles each year.

U.S. has 770 accidents per billion miles.

A fleet of 20 test cars cover 1 million miles per year.

NVIDIA DRIVE SIM AND CONSTELLATION

AV VALIDATION SYSTEM

- Virtual Reality AV Simulator
- Same Architecture as DRIVE Computer
- Simulate Rare and Difficult Conditions, Recreate Scenarios, Run Regression Tests, Drive Billions of Virtual Miles
- 10,000 Constellations Drive 3B Miles per Year

NVIDIA DRIVE SIM AND CONSTELLATION

AV VALIDATION SYSTEM

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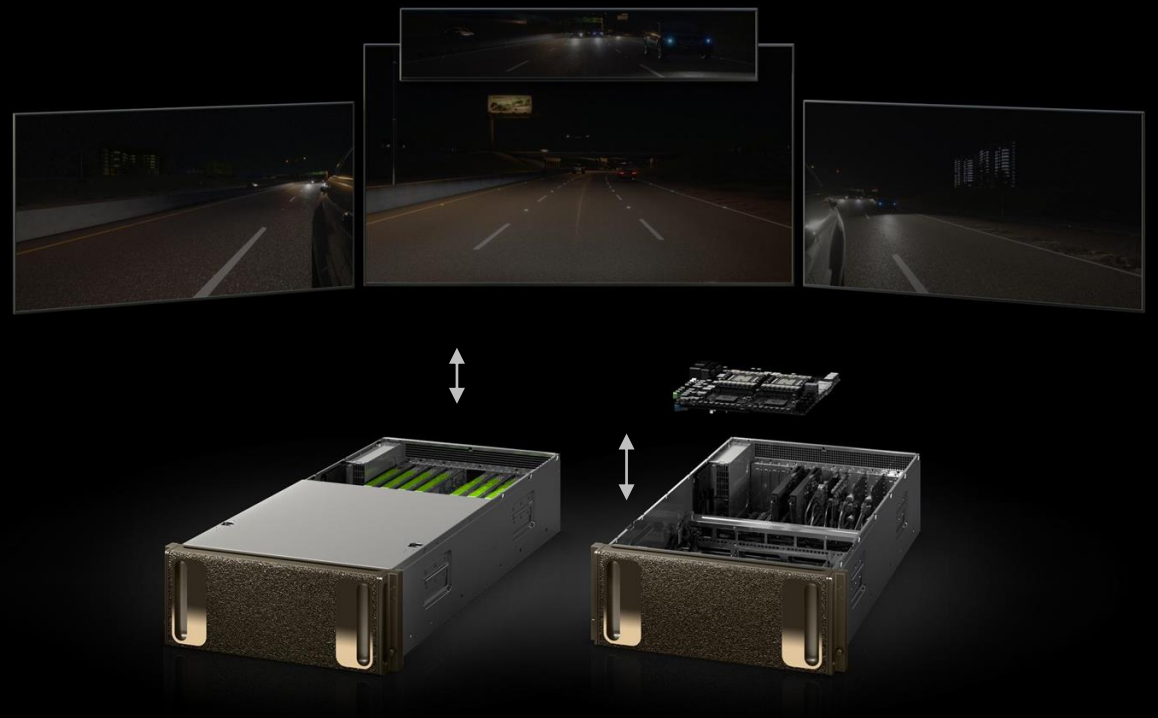
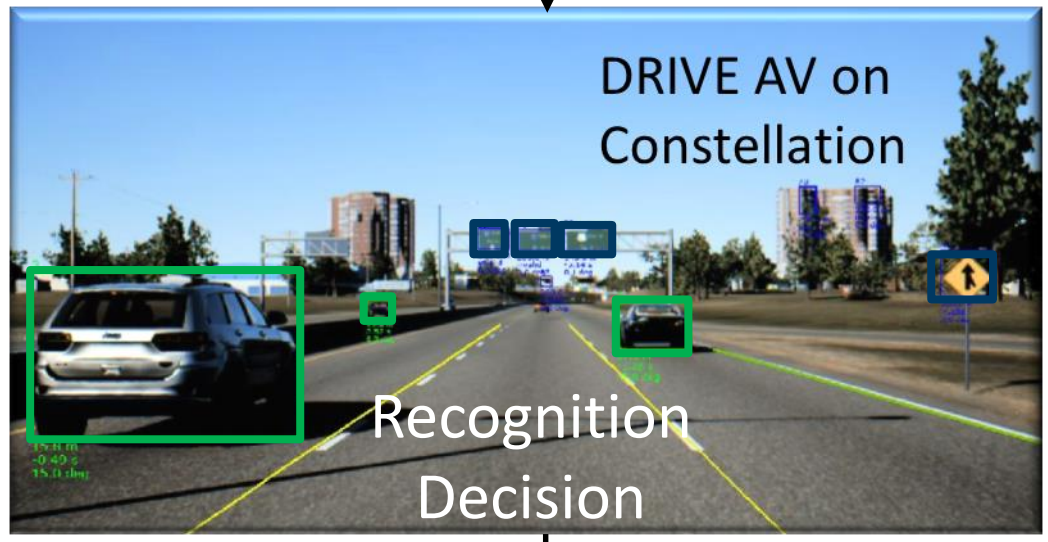


HARDWARE IN THE LOOP (HIL)

Perception

Cameras | Radar | Lidar | IMU

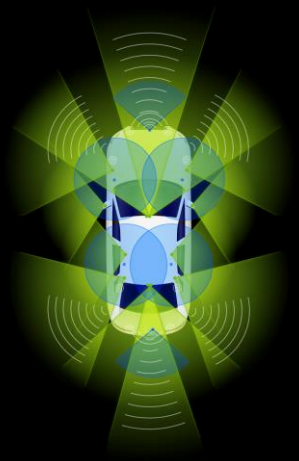


Control

Steering | Throttle | Brake

NVIDIA DRIVE SIM™

AI OUTSIDE AND INSIDE THE VEHICLE



Exterior Driver Recognition

Automatic Personalization

Device usage detection

Cyclist Alert

Distracted Driver Alert

Driver/Passenger Recognition

Customer Application

DRIVE AV
Object, Freespace, Path / Lane, Path Planning, Wait, Map, Sign, Lights, Road Markings, Surround

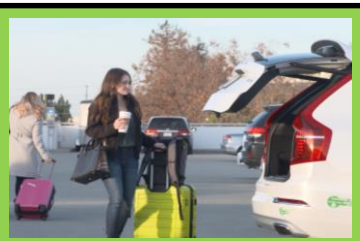
DRIVE IX
Gaze, Eye Openness, Head Pose, Gestures, Emotions
Facial Recognition, Voice Recognition & Lip Reading

DRIVE OS

NVIDIA

USE CASES

Functional Domains



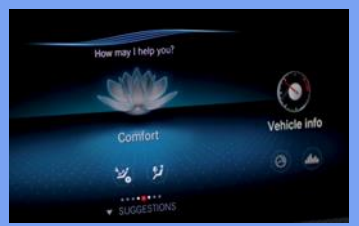
User Ext ID /Trunk opening

User Ext ID/Car start

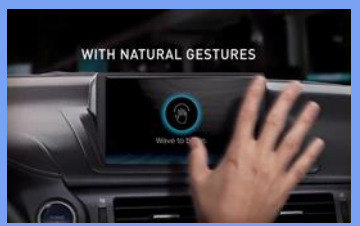
Driver Int ID/ Greeting / Settings

Passenger Int ID/ Settings

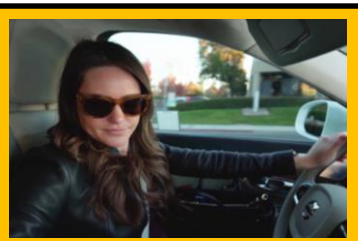
Driving modes selection



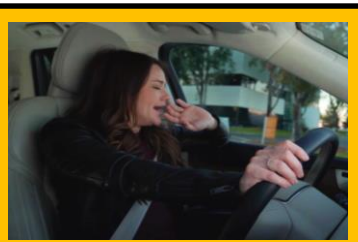
Voice assistant



Gestures



Distraction detect



Drowsiness detect

Side traffic detect

Front cross traffic detect

Rear traffic detect

Convenience

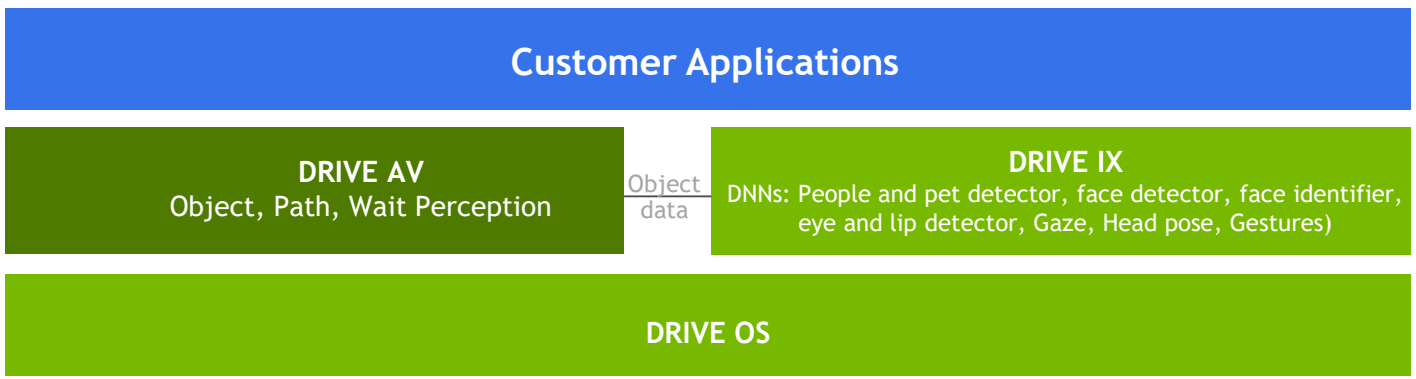
Man-machine interface

Guardian Angel

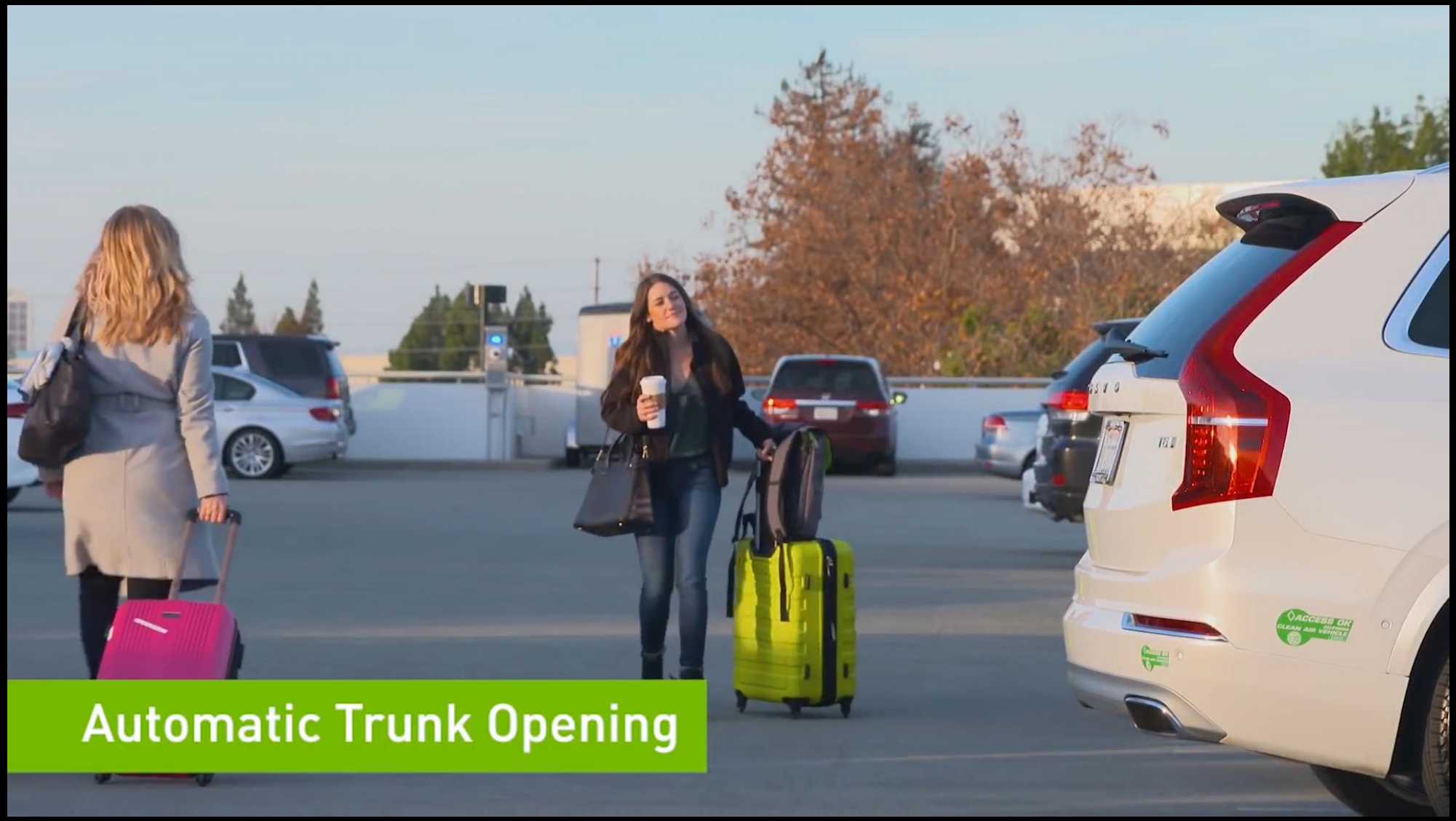
Use case support schedule to be confirmed by NVIDIA

NVIDIA DRIVE IX

AI Enabled Intelligent Experiences From a Dual Computer Architecture



Safety Applications | Convenience applications I Man-machine interface



NVIDIA DRIVE AR

Augmented Reality Navigation System
Surround Perception
Environment Mapping & Tracking
Graphics & Registration

DRIVE AR

Most Important Use Cases

Establish trust between the Self-driving computer and vehicle occupants

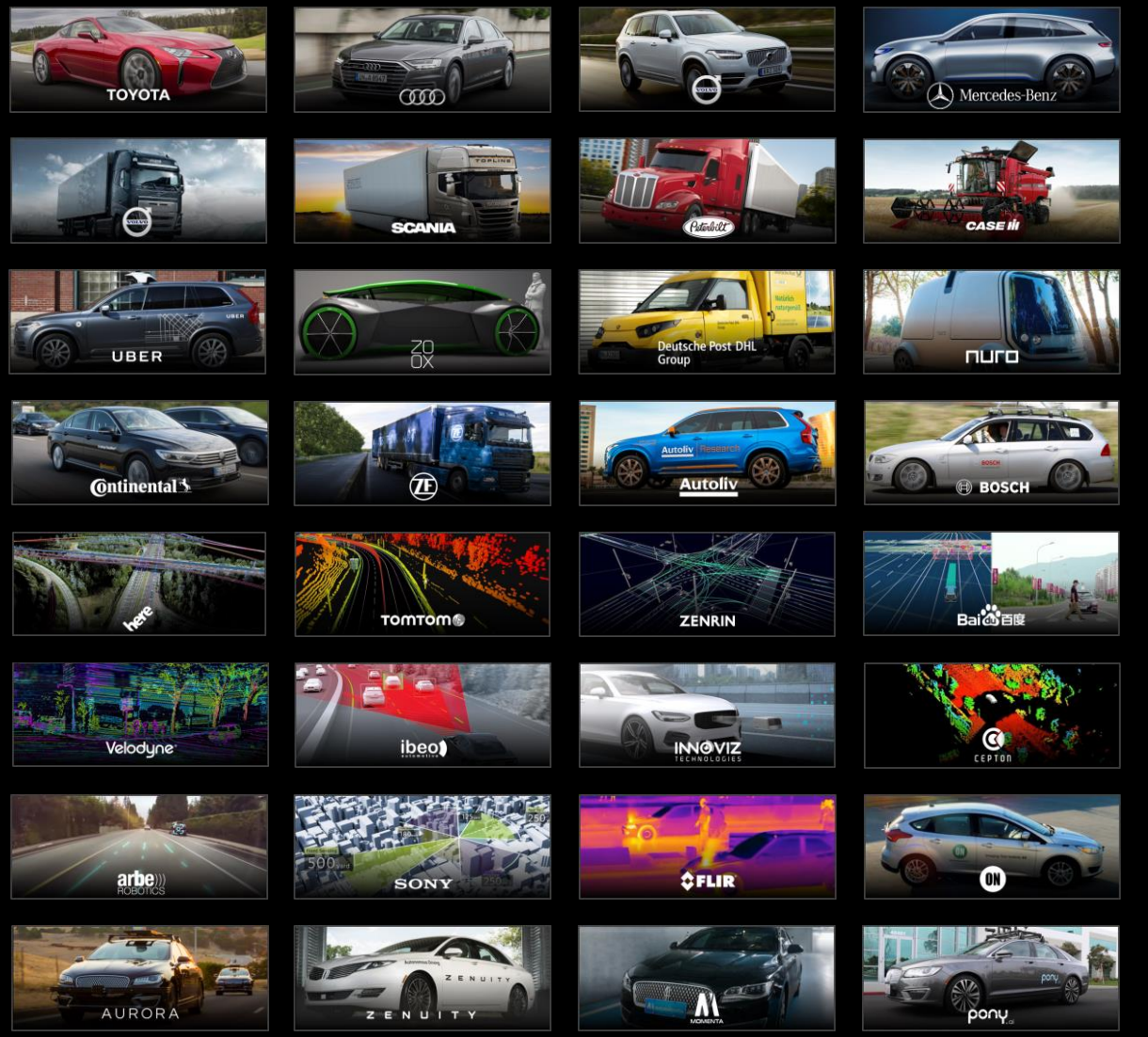
- Show surrounding detection (lanes, cars, signs, pedestrians, …)
- Show the driving path
- Show the stop events

Display POIs

Expand driver’s view when driving or parking

Enable amazing graphics in the cabin

370 PARTNERS DEVELOPING ON NVIDIA DRIVE



CARS

TRUCKS

MOBILITY SERVICES

SUPPLIERS

MAPPING

LIDAR

CAMERA / RADAR

STARTUPS

NVIDIA

ANNOUNCING VOLKSWAGEN SELECTS NVIDIA TO INFUSE AI INTO FUTURE VEHICLE LINEUP

DRIVE IX Brings VW I.D. BUZZ to Life with AI

“Mercedes-Benz’s New MBUX In-Car Assistant and Smart UI Rocks”

— TechCrunch

Mercedes-Benz unveiled a new, NVIDIA-powered infotainment system that uses AI to transform how drivers and passengers interact with their vehicles. NVIDIA graphics and deep learning technologies come together to provide beautiful 3D touch-screen displays, voice-activated controls, and a rich set of personalization features. MBUX will debut in February 2018 with the sleek new Mercedes-Benz A-class compact.

AI-POWERED DESTINATION PREDICTION AND ROUTE PLANNING

Even more than its meticulous engineering, Mercedes-Benz is defined by its continuous innovation. Since inventing the car in 1886, the company has never stopped reinventing it. And now Mercedes-Benz is using AI to enhance the user experience behind the wheel by having its cars predict where drivers want to go.

Trained on driver behavior data from 24,000 road trips, the NVIDIA GPU-accelerated destination prediction AI learns the driver's habits over time in order to make better suggestions.

REVOLUTIONIZING TRANSPORTATION WITH AI

Autonomous vehicles can reduce accidents, improve the productivity of trucks and taxis, and enable new mobility services — transforming the $10 trillion transportation industry. WEpods is piloting an autonomous shuttle that leverages GPUs to compute data and build a complete picture of the environment, enabling it to safely navigate traffic and other obstacles. It's a revolutionary new kind of transportation that offers the convenience of a personal vehicle, without the hassles of car ownership.

WEpods

ANNOUNCING BAIDU AND ZF SELECT NVIDIA DRIVE XAVIER

AV COMPUTER FOR CHINA

GTC US – APRIL 2018

ANNOUNCING AURORA AND NVIDIA TO BUILD AUTONOMOUS VEHICLE COMPUTE PLATFORM

GTC US – APRIL 2018

GTC US – APRIL 2018

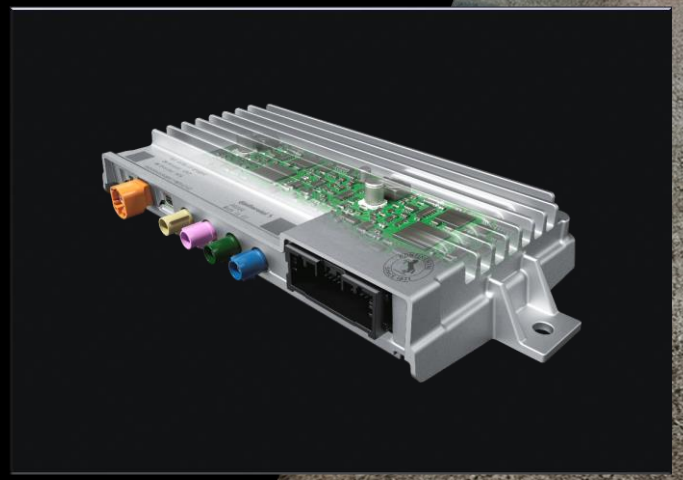
ANNOUNCING VOLVO CARS SELECTS NVIDIA DRIVE AGX

DRIVE AGX Xavier to Pilot
Next-generation Production Cars

GTC EU - OCT 2018

ANNOUNCING CONTINENTAL ADOPTS NVIDIA DRIVE AGX

Scalable Platform in Production 2021



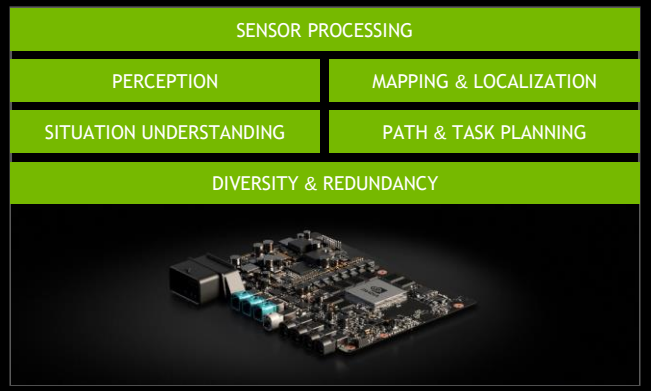
GTC EU - OCT 2018

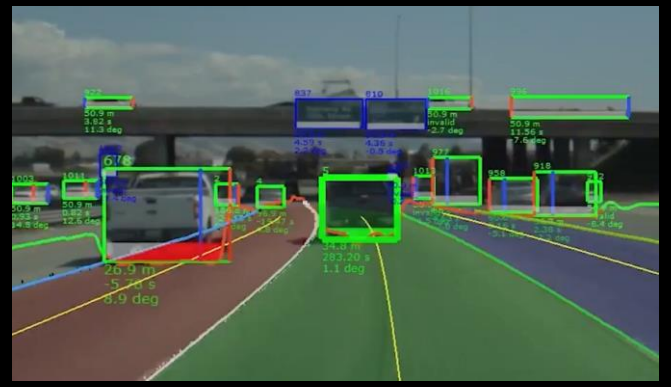
ANNOUNCING VEONEER AND ZENUITY SELECT NVIDIA DRIVE AGX

NVIDIA Xavier-based L4 System Production Ready by 2021

GTC EU - OCT 2018

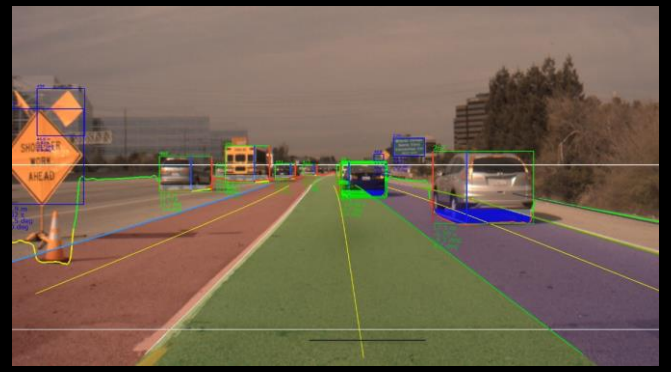
NVIDIA DRIVE
WORLD'S FIRST AUTONOMOUS VEHICLE PLATFORM





DRIVE IX
Available Now

DRIVE AGX XAVIER DEVELOPER KIT
Available Now



DRIVE AV
Available Now

NVIDIA AGX PEGASUS TEST DRIVE

OCTOBER 2, 2018

80 KILOMETERS

4 HIGHWAY INTERCHANGES

10 LANE CHANGES

0 DISENGAGEMENTS

THANK YOU

Romuald Josien

NVIDIA.