Autonomous Driving
Internet of Vehicles
Applications

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Mobility scenarios

- Urban
- Suburban
- Rural
- Remote areas

Today consumers use their vehicles for all purposes; in the future, they will choose an optimal mobility solution for each specific purpose.

Today:
One vehicle for every trip purpose

Avg. share of annual driving time

2030:
A solution for each specific purpose

1 Only showing automobile based mobility, alternative options like walking, biking, and public transportation are also included in optimal mobility solutions.

SOURCE: McKinsey
Infrastructure needs

Many Ways To Connect

Traffic Lights
Many transportation infrastructure devices will communicate to optimize travel.

Satellite
Will provide accurate Global Positioning System data.

Cell Tower
Cars will connect to the Internet and cloud services over 3G and 4G.

Gas Pump
Fuel retailers will deliver promotional marketing and simplify transactions.

Toll Booth
Automated payment will enable freer traffic flow.

Other Cars
We will gather additional valuable insight from what the vehicles around us have sensed.

GPS Satellite

Cellular

WIFI

Bluetooth

Charging Station
Stations will provide automated, flexible payment (subscription, one-time, etc.).

Parking Meters
Meters will report their availability, restrictions and costs to help us identify where to park.

Mobile Devices
The car will also provide connectivity for driver and passenger devices within the car.

Source: Intel
Autonomous Vehicle View

Autonomous systems

Intelligent computing platform

CAMERAS
- Image Data
- Object Data

LIDAR
- LIDAR Data
- Object Data

RADAR
- Raw Data

ULTRASOUND
- V2X

MAPS
- Perception
- Planning
- Policy
- Decision making
- Data/Knowledge Fusion
- Environment Modelling/Representation
- AI Methods
- Machine Learning

Intelligent and sharp eyes - Vision
Intelligent and low power brain
Perception and fusion
Modeling and planning
Decision making
Machine learning
Connectivity
Autonomous Vehicle - Services
Autonomous Vehicles Vision

Source: Google

Source: Volvo

Source: Ford
Autonomous Vehicle View

- Sensors, actuators, vision, maps
- Connectivity
- Vehicle architecture
- High-performance vehicle computing platform, flexible, and programmable
- Infrastructure platform
- AI design and implementation platform
- Edge computing platform and solution
- Data Center solution for fleet simulation and testing
- Pervasive security, safety trust program
Autonomous Vehicle View

**Sensing**
- GPS/IMU
- LIDAR/Radar
- Camera

**Perception**
- Localization
- Object Recognition
- Object Tracking

**Decision**
- Path Planning
- Action Prediction
- Obstacle Avoidance

**Connectivity**
- V2X
- IoT
- Intra-V

**Operating System**

**Hardware Platform**

**Communication**

**Cognition and Intelligence**

**Actuation**

**HD Map**

**Data Center**

**Cloud Computing**

**Edge Computing**

**Simulation**

**Data Storage**

**Model Training**

**Simulation Processing and communication Platform**
Communication infrastructure
Communication Domains

### Communication Domains

- **Satellite Navigation System**
- **V2G**
- **Charging station**
- **V2D**
- **V2I**
- **V2P**
- **V2V**

#### Communication Domains

- **TSP**
  - Telematics service provider
- **ATMS**
  - Advanced traffic management system
- **UTGS**
  - Urban traffic guidance system
- **ACR**
  - Automatic crash response
- **EMS**
  - Emergency management system
- **IBS**
  - Intelligent bus system
- **VDS**
  - Vehicle diagnostic
- **TFM**
  - Traffic flow monitoring

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<th>Category</th>
<th>Application</th>
<th>Feature</th>
<th>Technology</th>
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<tr>
<td><strong>V2D</strong></td>
<td>Internal transmission</td>
<td>Real-time, higher reliability</td>
<td>CAN, LIN, MOST, FlexRay</td>
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<td><strong>V2I</strong></td>
<td>Short range communication</td>
<td>Short distance</td>
<td>Bluetooth</td>
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<tr>
<td><strong>V2I</strong></td>
<td>Vehicle and external communication</td>
<td>Long distance, high speed movement</td>
<td>GSM, GPRS, 3G, GPS</td>
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<tr>
<td><strong>V2I</strong></td>
<td>Vehicle and external traffic facilities</td>
<td>Short distance, high speed movement</td>
<td>Microwave, Infrared, DSRC</td>
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<tr>
<td><strong>V2V</strong></td>
<td>Transmission mobile vehicles</td>
<td>Security and real time</td>
<td>Microwave, Infrared, DSRC</td>
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**Source:** AUTOPilot
V2X Communication Technology

• V2V and V2I Wireless Networking for Vehicle Safety and C-ITS
• US WAVE (Wireless Access in Vehicular Environment) and EU ITS G5
• Less than 100 msec Latency and 1 km radio coverage
• Frequency Band : 5.855 ~ 5.925GHz
LTE V2X Technology

- Coexistence study between WAVE and LTE V2X – C-V2X in 3GPP
- LTE V2X/C-V2X interworking standard in ISO CALM architecture
- LTE V2X/C-V2X interworking standard in Communication platform
Fleets of vehicles coordinate their activity and optimize services.

Vehicles in the same geographic domain form virtual ecosystem to collaborate in some activity.
Complex simulation environment

Diagram showing components and interfaces:
- RSU
- Cellular tower
- Traffic simulator (TS)
- Network simulator (NS)
- Display - Visualise
- Vehicle dynamics module
- Human interface device
- Driving simulator (DS)
- TS interface
- Vehicle driving models
- Offline driver modelling
- Physical channel modelling
- ACV interface
- CE interface
- Monitoring control module
- Automated and Connected Vehicles (ACV)
- Connected environment (CE)
- Multiple driving simulators
- TSV: Traffic simulator vehicle (Vehicle driving model)
- FACV: Fully AC vehicle
- DSV: Driving simulator vehicle
- 1. Traffic and infrastructure
- 2. DS vehicle manoeuvres
- 3. V2X messages for TS vehicle
- 4. V2X messages for DS vehicle

Managing DS, TS, NS, ACV and CE
Running experiments and archiving experimental data

Server System

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NVIDIA Case

• Suite of hardware and software needed to develop and run AI in the vehicle
  • Using an array of algorithms known as deep neural networks (DNNs).
  • DNNs enable vehicles to learn how to navigate the environments autonomously using sensors data

Pathfinders

DNNs that help the car determine where it can drive and safely plan the path ahead:
  o OpenRoadNet identifies all of the drivable space around the vehicle, regardless of whether it’s in the car’s lane or in neighbouring lanes.
  o PathNet highlights the driveable path ahead of the vehicle, even if there are no lane markers.
  o LaneNet detects lane lines and other markers that define the car’s path.
  o MapNet also identifies lanes as well as landmarks that can be used to create and update high-definition maps.
Path-finding DNNs work together to identify a safe driving route for an autonomous vehicle.

Object Detection and Classification

DNNs that detect potential obstacles, as well as traffic lights and signs:
  o DriveNet perceives other cars on the road, pedestrians, traffic lights and signs, but doesn’t read the colour of the light or type of sign.
  o LightNet classifies the state of a traffic light — red, yellow or green.
  o SignNet discerns the type of sign — stop, yield, one way, etc.
  o WaitNet detects conditions where the vehicle must stop and wait, such as intersections.

DNNs that can detect the status of the parts of the vehicle and cockpit, as well as facilitate manoeuvres like parking:
  o ClearSightNet monitors how well the vehicle’s cameras can see, detecting conditions that limit sight such as rain, fog and direct sunlight.
  o ParkNet identifies spots available for parking
NVIDIA Case

- **NVIDIA DRIVE AGX Platforms**
- **DRIVE AGX Xavier** targeting Level 2+ to Level 4
- **DRIVE AGX Pegasus** for Level 5 - robo taxis and driverless shuttles.
  - Xavier - SoC with sensor fusion and processing, vehicle location, path planning, integrated into a 30-watt package that delivers 30 Trillion Operations Per Second (TOPS).
  - NVIDIA includes an additional 2 next-generation TensorCore GPUs in the Pegasus version, which delivers 320 TOPS.
  - Development kits for both the Xavier and the Pegasus platforms, sensor cabling and DRIVE Software.
NVIDIA Case

- **NVIDIA DRIVE Constellation**
- **Driving simulation software.**
  - Cloud-computing platform that uses two different GPU-equipped servers and software to simulate the operations of an autonomous vehicle.
  - The platform can simulate an autonomous vehicle driving down millions of miles of roads to reduce the time and expenses of developing and testing safer smart vehicles.

Test a (real) smart vehicle’s behavior to handle several driving conditions (sun, rain, snow, twilight, night, backlit, etc.).

Factor in the thousands of possible impediments the vehicle could encounter (bikes, motorcycles, trikes, trains, pedestrians, stop signs, potholes, black ice, traffic circles, etc.), on billions of miles of roads.
NVIDIA Case

• **NVIDIA MagLev**

  • End-to-end auto model development platform, provides the on-ramp for auto customers and partners.

  • Over 370 partners developing on NVIDIA DRIVE provide scalable AI training models with traceability to code and data, petabyte-scale AI testing, pre-curated data for model development, and workflow automation to speed development.
NVIDIA Case

- NVIDIA MagLev

- NVIDIA fleet of 30 vehicles. Each vehicle equipped with 12 sensors (cameras, RADAR and LIDAR), that actively collect 1 Petabyte of road data every week.

- The 30 vehicles have, created in 2018 a 15-petabyte (PB) dataset—for training neural networks to run on the DRIVE AGX system, and to enable the DRIVE Constellation virtual testing platform.

- NVIDIA employs 1,500 people to label the objects in the database, at the rate of 20 million objects every month resulting in 20 deep learning models. These are simulated on a 4,000 GPU cluster, which are fed the output controls from 100 DRIVE AGX Pegasus systems (DRIVE Constellations).
NVIDIA Case

MAGLEV
"Collect ⇒ Select ⇒ Label ⇒ Train ⇒ Test" as programmatic workflows

- Data Lake
  - 15PB Today
- Selected Datasets
  - 1,500 Labelers
  - 20M objects labeled per month
- Labeled Datasets
- Metrics & Logs
- Trained Models
- ML/Metrics UI
- Large AI Dev team

Cloud

- Ingest
  - 1PB per week
- Run Multi-Step Workflow
  - (workflow = sequence of map jobs)

Kubernetes over 4000 GPU Cluster (= 480 PFLOPs)
Platform Integration
V2X
Sensing/Actuating

Enjoy life

Connectivity
Map

Auto Drive

Safe
Secure
Reliable

Technology for a better society!