



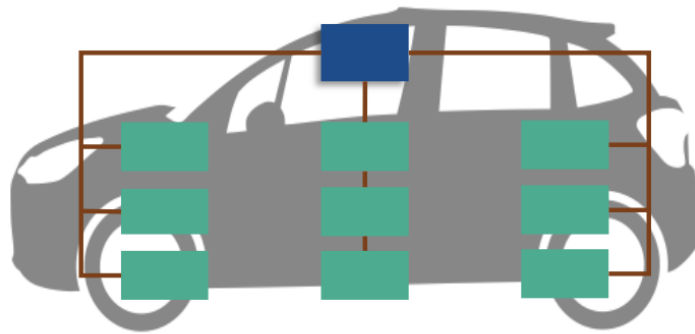
# The Software Defined Vehicle

## Does it need a Mobile Edge and Cloud?

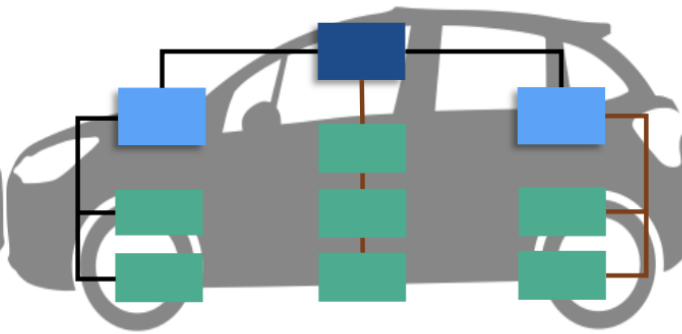
Maarten Sierhuis, Ph.D.  
Nissan Advanced Technology Center Silicon Valley  
Mobility Forum @ Lisbon, Portugal | May 9, 2023

# EVOLUTION OF VEHICLE ELECTRICAL AND/OR ELECTRONIC ARCHITECTURE

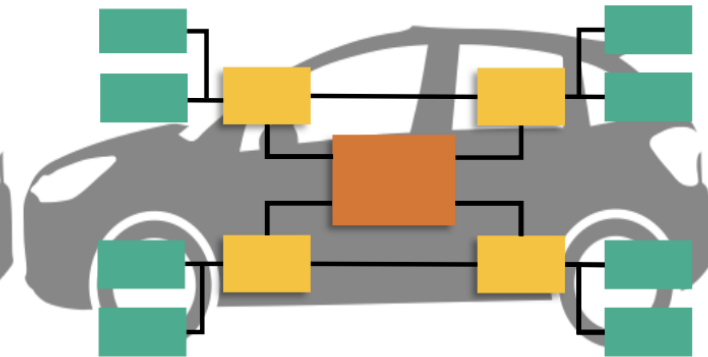
Distributed E/E Architecture



Domain Centralized E/E Architecture



Zonal E/E Architecture with High-Performance Computing Unit



Optional ECUs e.g., central gateway



Automotive ECUs (function-specific)



Domain-specific ECUs



Central high-performance computing unit



Zonal ECUs



CAN BUS connection

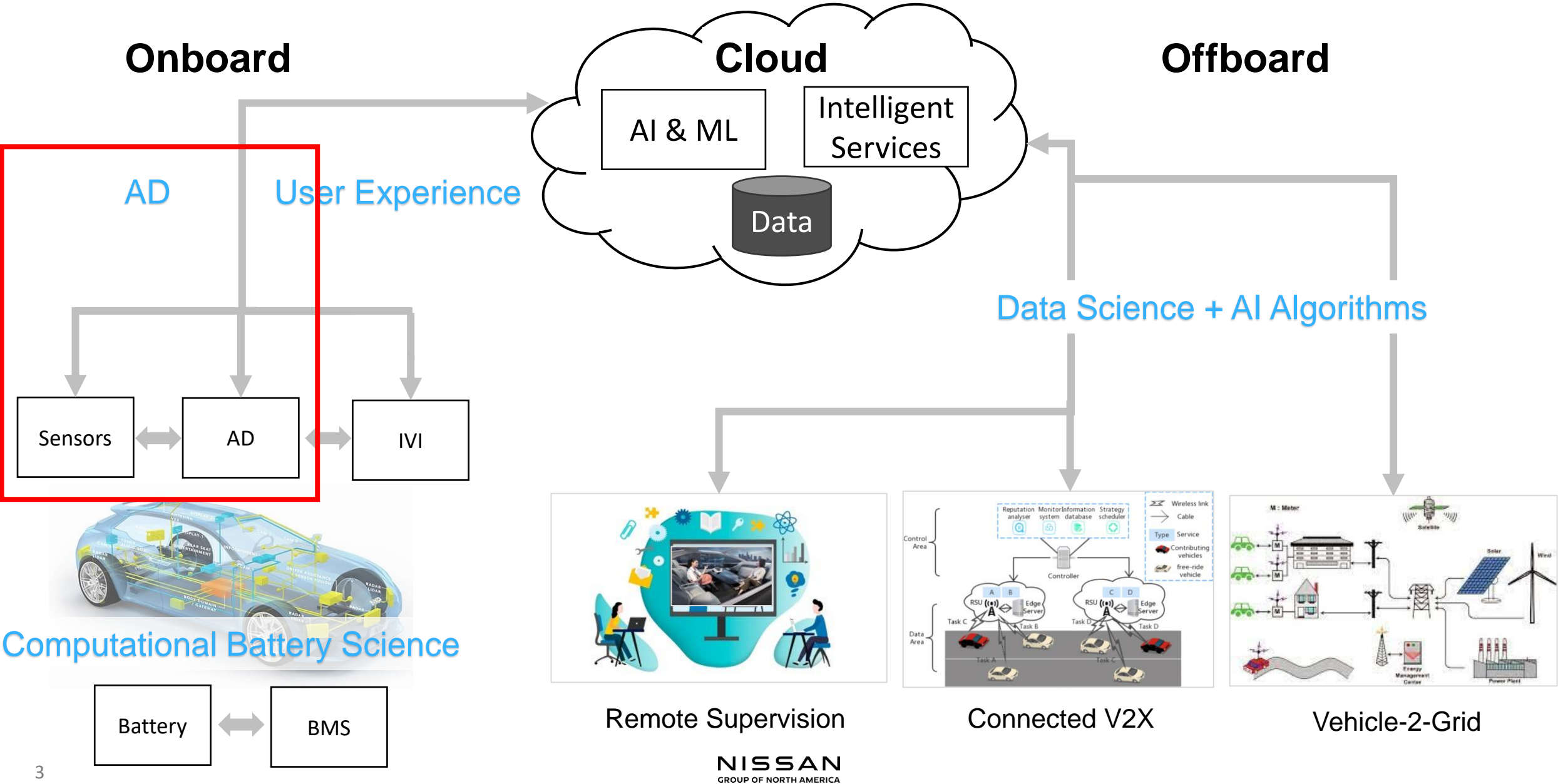


Automotive Ethernet connection



[1] Askaripoor, Hadi & Farzaneh, Morteza & Knoll, Alois. (2022). **E/E Architecture Synthesis: Challenges and Technologies**. Electronics. 11. 518. 10.3390/electronics11040518.

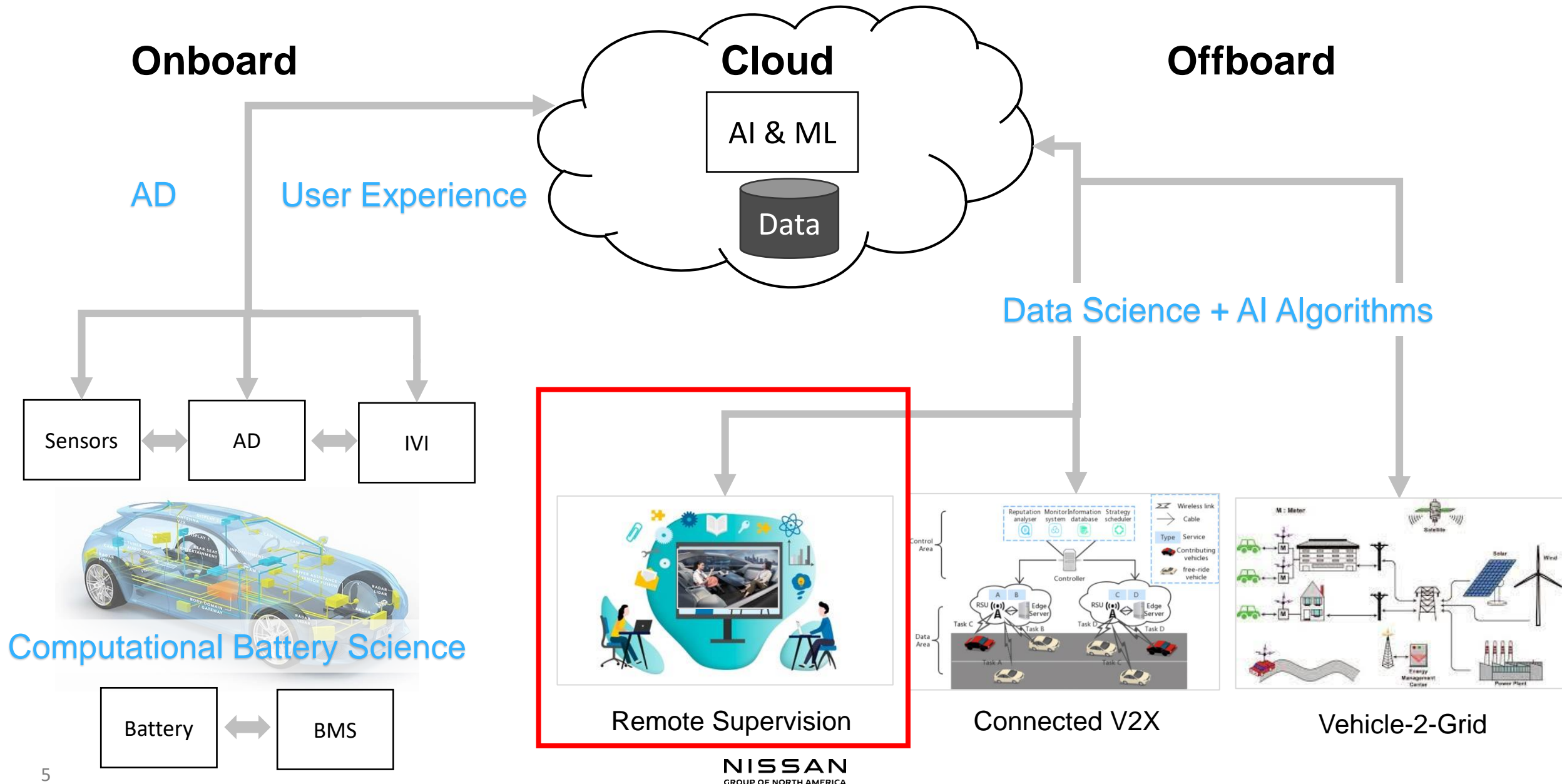
# EXAMPLES





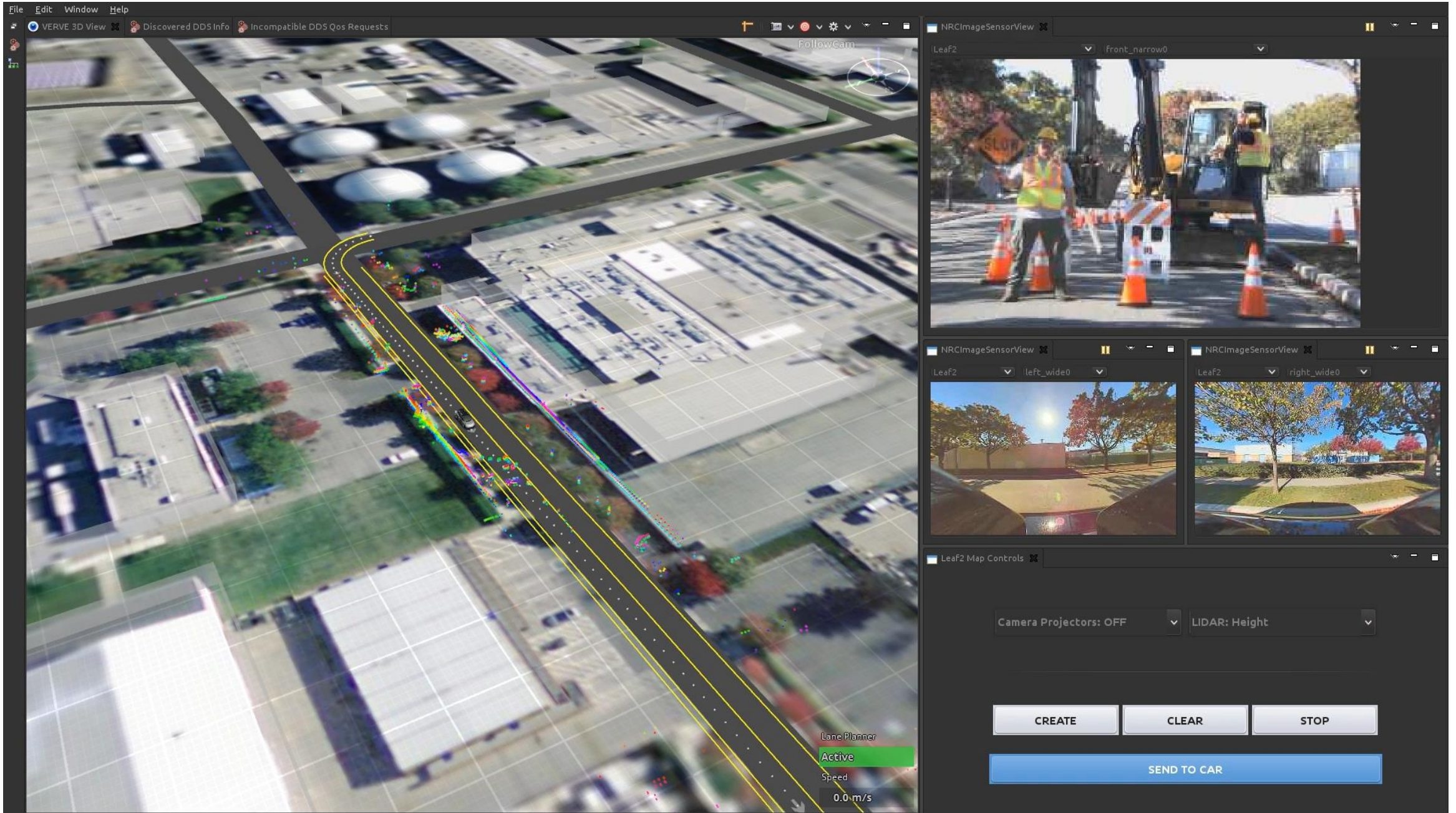


# EXAMPLES





# TELEOPERATION: WAYPOINT DRIVING (2016)





# TELEOPERATION: GUIDED DRIVING (2023)



14:00:29.756



SAM Teleop

14:00:29.749



14:00:29.752



mapbox

Mapbox © OpenStreetMap Improve this map © Maxar

Tele-Operation Support

Create PATHSpecify DIRECTION



Request

Operating

Recover

FACTOR

Obstruction

STOPPED TIME

10 sec

Car ID: NRC\_Leaf\_Bravo



Google

Keyboard shortcuts | Map data ©2023 Google | Terms of Use | Report a map error

DESTINATION

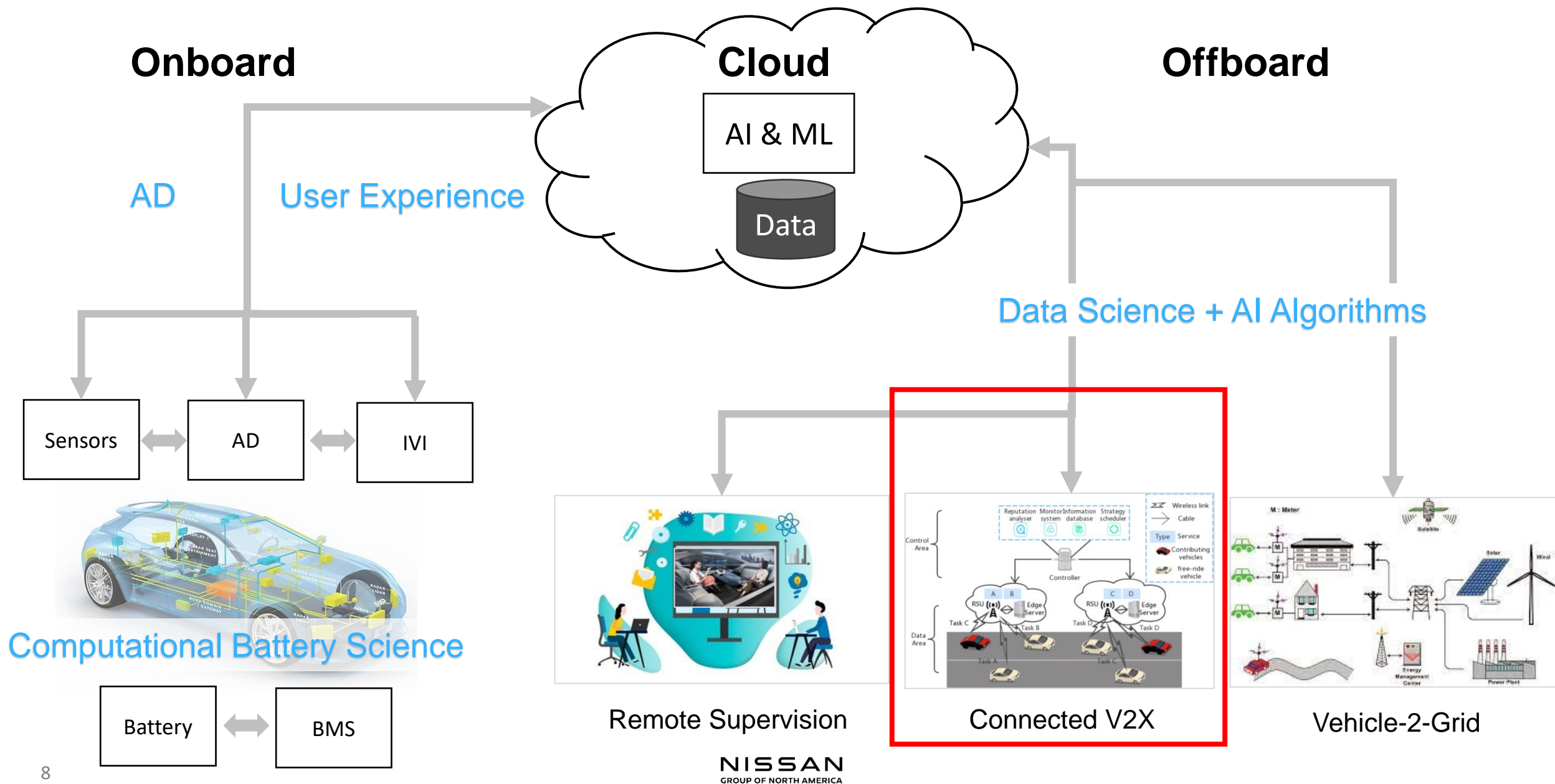
AIL-SV

CURRENT STREET

7

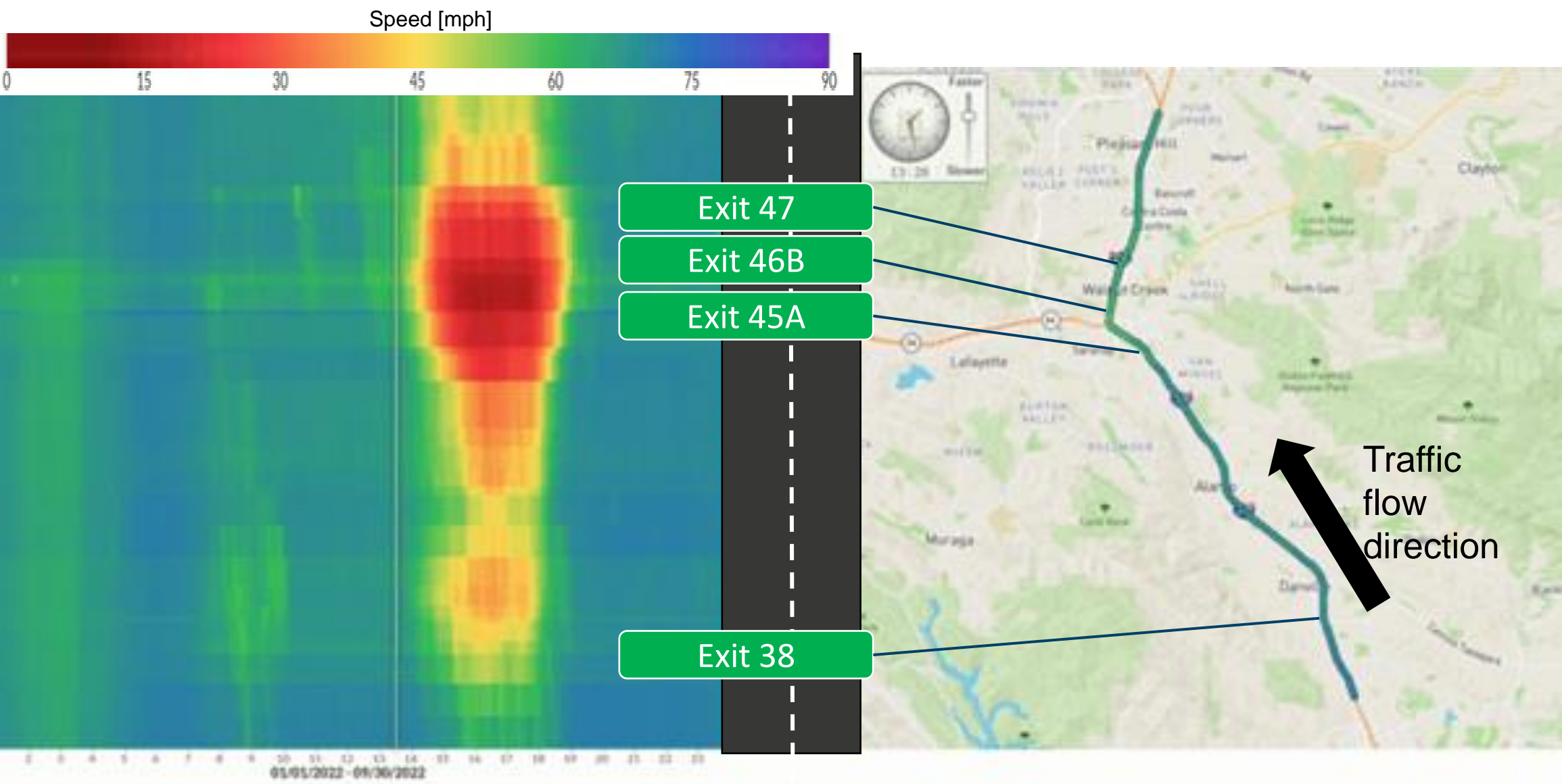
NISSAN  
GROUP OF NORTH AMERICA

# EXAMPLES





# CHALLENGE: CONGESTION NEAR THE CA-24/I-680 JUNCTION

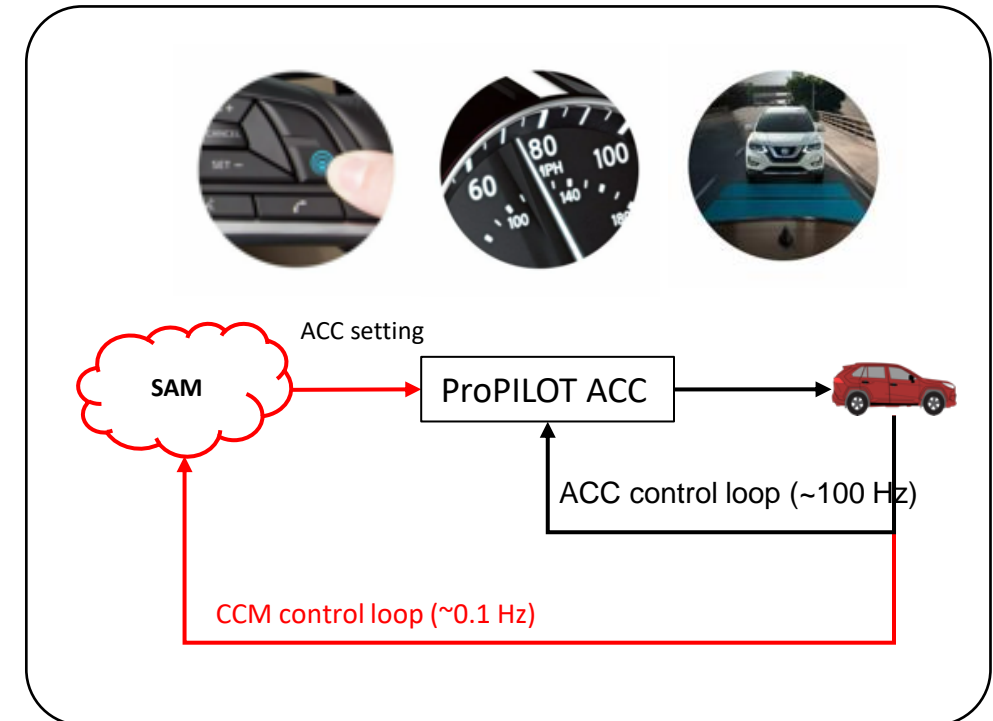
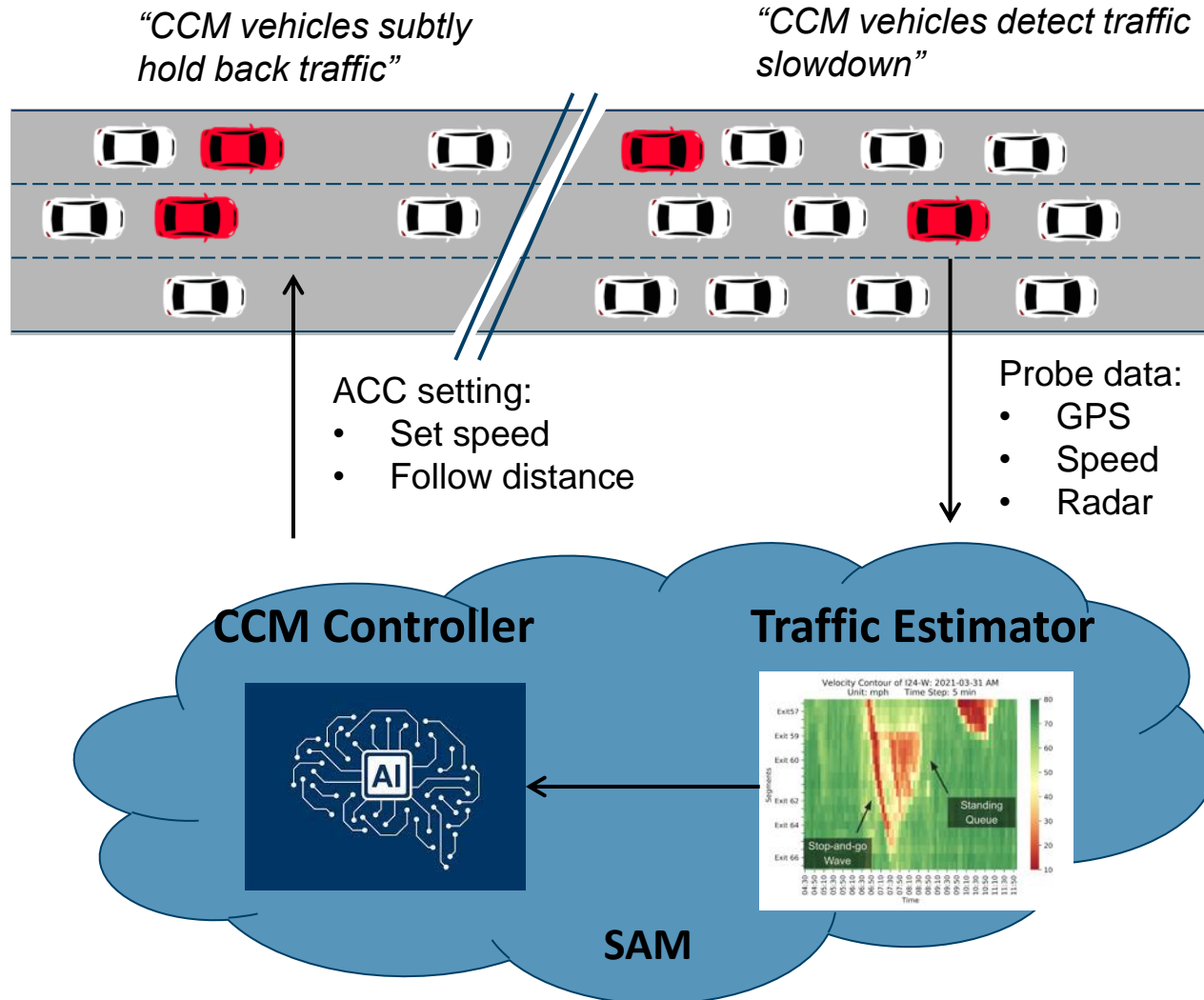




[2] The Congestion Impacts Reduction via CAV-in-the-loop Lagrangian Energy Smoothing (CIRCLES) Project



# COOPERATIVE CONGESTION MANAGEMENT SERVICE



# I-680 Initial Value Estimates with CCM

1



**"Tim"**  
Municipality (CCTA)

## A. TRAFFIC

**\$6.8M** ➤ Saved congestion costs  
**326K** ➤ Fewer Vehicle Hours of Delay (VHD)  
**15.7%** ➤ Increase in throughput

*10% adoption, per year*

## B. FUEL

**33,500** ➤ Fewer kg of CO2  
**1,521** ➤ Trees' worth of CO2

*10% adoption, per year*

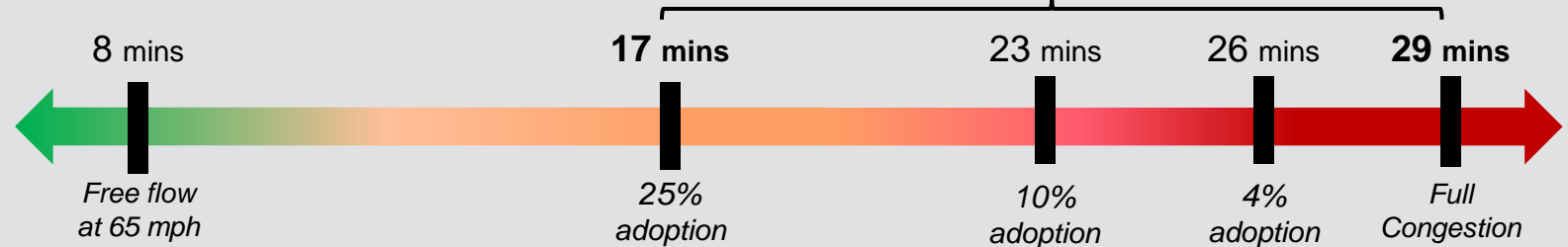
2



**"Liam"**  
I-680 Commuter

## A. TRAFFIC

Reduced time spent in traffic ➤ Up to 12 mins saved



**52%** ➤ Increased average speed at bottlenecks from 0% to 25% adoption

**~39 hours per year saved**

of the average 97 hours per year that Americans spend in congestion

## B. FUEL

**6.3%** ➤ Increase in average gasoline mpg

*10% adoption*

3



**"Alice"**  
Truck Fleet Operator

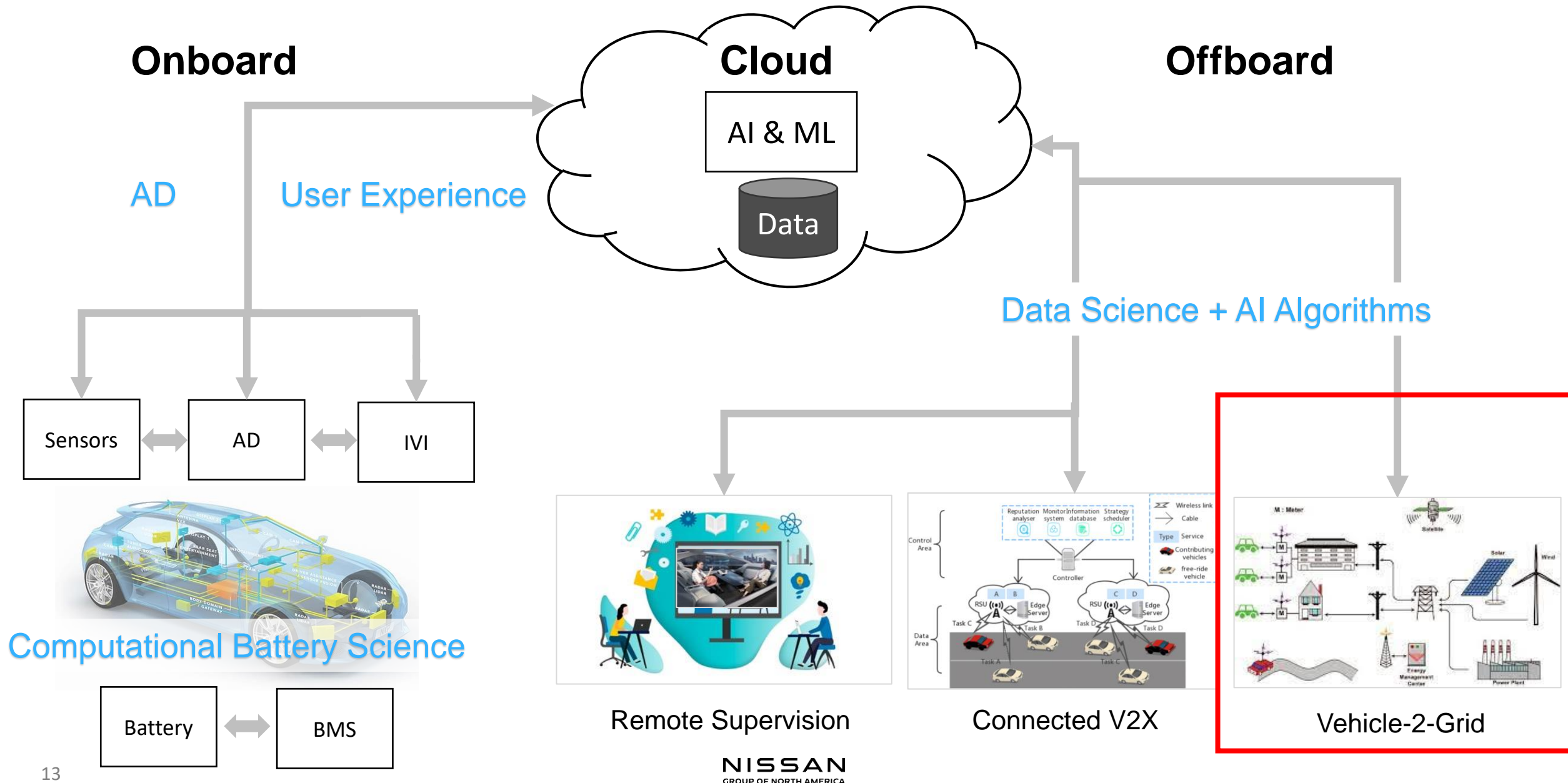
## B. FUEL

**20.1%** ➤ Increase in average diesel mpg

*10% adoption*

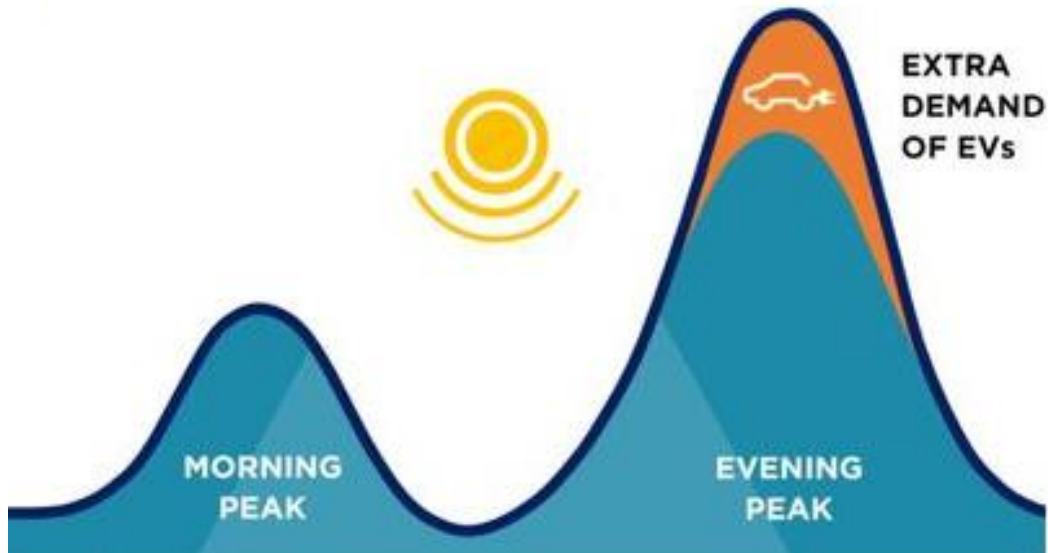


# EXAMPLES



# VGI: VEHICLE GRID INTEGRATION

## Uncontrolled charging



Results in extra pressure on the grid - blackouts

Costs the customer more

Source: Amsterdam Vehicle2Grid

## Controlled Charge/Discharge



Charging is managed for the customer, so they pay less without having to manage it themselves

Eases pressure on the grid

Produces energy for the grid



# VEHICLE-2-BUILDING SERVICE

## LOWERING BUILDING ENERGY COSTS WITH CHARGE / DISCHARGE MANAGEMENT



### PREDICTIONS

*How many cars are expected,  
How long plugged-in,  
How much energy needed*



### OPTIMIZATION

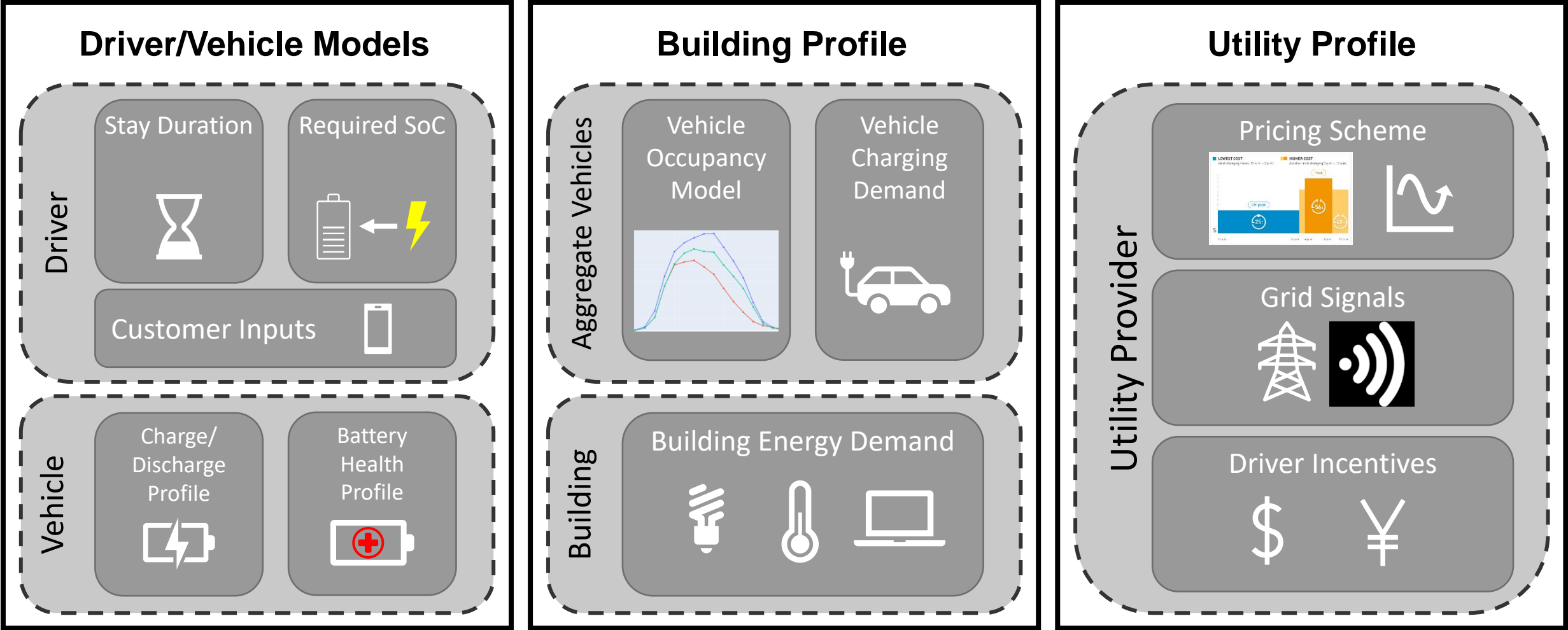
*Schedule charge and discharge  
depending on (1) driver patterns,  
(2) site, (3) grid*



### CONTROL

*Execute schedule with  
plugged-in vehicles*

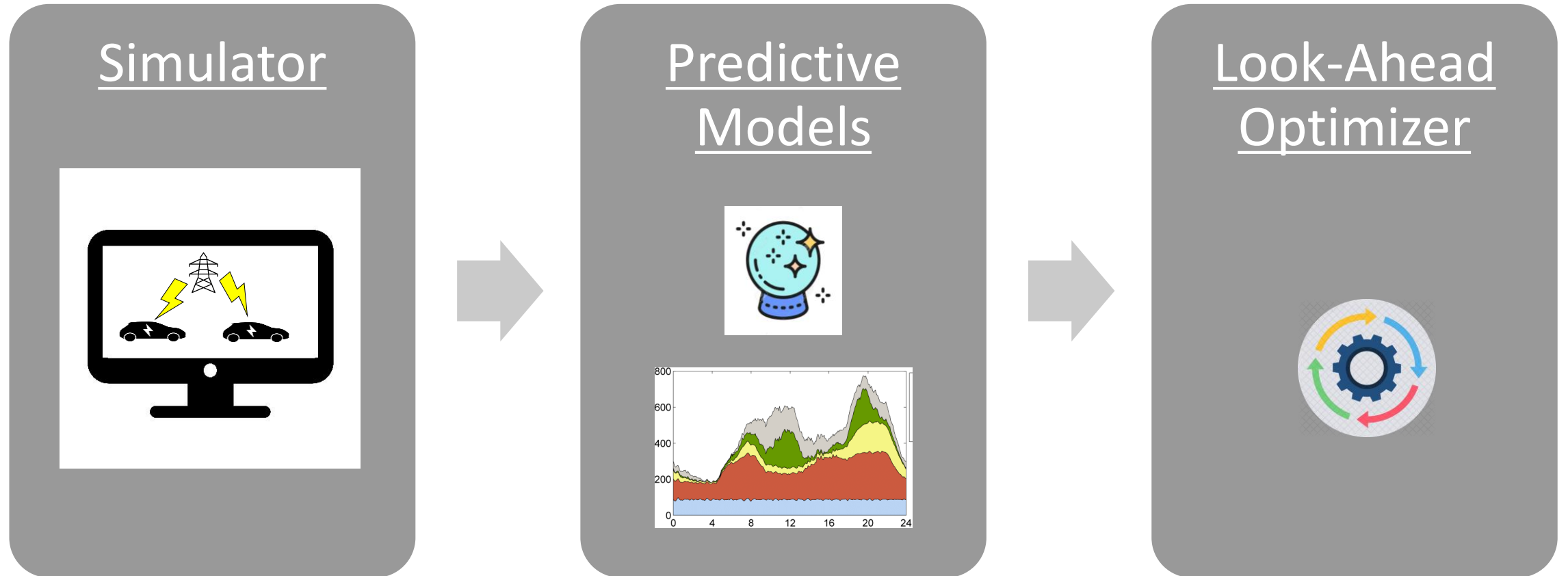
# OPTIMIZATION INPUT MODELS





# OVERALL APPROACH

On Nissan Cloud



# CONCLUSION

## The Software Defined Vehicle Does it Need a Mobile Edge and Cloud?

### 1. A vehicle will be a Smart Edge

- Central Compute Stack
  - Flexible, software defined architecture
  - Superior perception software
- Infotainment System with Android/iOS
- Fiber ethernet between ICU, PCU and
- Continuous 4G or 5G connection to the OEM's cloud
- Autonomous Driving Service on Vehicle Edge

*Is an Edge  
Needs additional Mobile Edges  
Needs a Central Cloud Connection*

### 2. Mobile Edges to connect to local smart services

- Intelligent Intersection Service
- Intelligent Vehicle-2-Grid Service
- Congestion Management Service

### 3. Smart Subscribed Services provided by the OEM will live in the OEM's Cloud

- AD Continuous Development
- AD Continuous ML
- Over-The-Air Updates (OTA)
- Predictive Maintenance Service
- Intelligent UBI Service
- Entertainment Service