Speakers:

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With more than 15 years in opto-mechatronics Engineering, Lingxuan has held management positions at Lucid Motors and Valeo. He earned his Master's degree in Mechanical Engineering from UTC France and is currently pursuing an EMBA at ESCP Business School.

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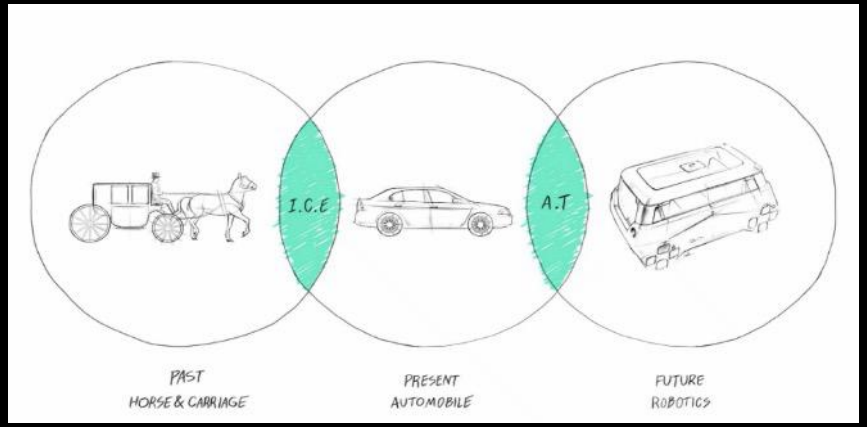
The Crucial Role of Lighting in Sensing, Perception, and Communication for Autonomous Vehicles

DVN Workshop 2023, SF USA

Agenda:

- Transportation's Evolution and the Role of Lighting in this Evolution
- Zoox's Commitment: Launch, Sustain, Grow
- Redefining Vehicle Lighting for the Modern Era
  - Headlights Adapted for Sensing & Cameras
  - The Imperative for ADB and HD Lighting in Autonomous Vehicles
- Beyond the Basics: The Potential of AV Lighting
- The Evolution of AV Lighting: From Human Eyes to Machine Perception
- AV Communications:
  - Road projection and Display
  - The Spectrum Beyond Light
- Defining Modern Mobility: Software-Driven AVs
- Zoox's Promise: Delivering Superior Riding Experiences
- Closing Remarks: The Road Ahead

Transportation's Evolution and the Role of Lighting in this Evolution



Over the course of more than a century, transportation has evolved from horse carriages to robotic vehicles. Similarly, automotive lighting has transitioned from simple petroleum lamps to advanced HD lighting.

Zoox's Commitment: Launch, Sustain, Grow

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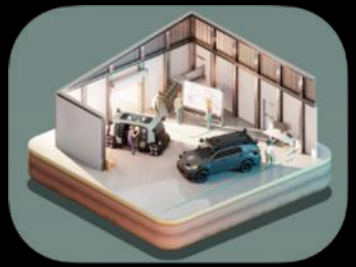
Roadmap to Road Ready



CREATE THE VEHICLE

We are designing and engineering an integrated system while developing hardware manufacturing, supply chains, firmware, and software.

UNDERSTAND THE CITY

To understand a new city, we develop our infrastructure, map the area, and begin AI driving.

TEST SAFETY & GAIN PERFORMANCE

With the roads mapped and infrastructure in place, it's time to make sure Zoox is ready to drive, driver free.

SET UP THE SERVICE

Now we focus on bringing up all the aspects of our service that'll bring Zoox to real customers.

LAUNCH, SUSTAIN, & GROW

We're live! Now, we start this city's day-to-day operations, always with an eye towards growth.

Redefining Vehicle Lighting for the Modern Era

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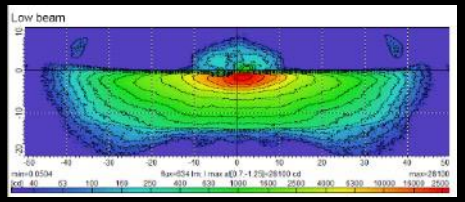
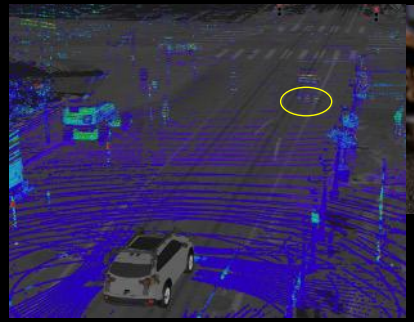
Headlights Adapted for Sensing & Cameras

For a century, lighting development and innovation have been centered on optimizing human vision.

LB beam pattern and cut off optimization for camera



Edge cases: lighting optimized for weather conditions especially, rain during night and snow.



Ex. ghost reflection reduction

City light, dimming the headlight to minimum photometry required by regulations, ex. In LV, SF etc.

A strong collaboration between the Sensing, Perception, and Lighting teams is essential for effective adaptation and optimization.

Redefining Vehicle Lighting for the Modern Era

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The Imperative for ADB and HD Lighting in Autonomous Vehicles

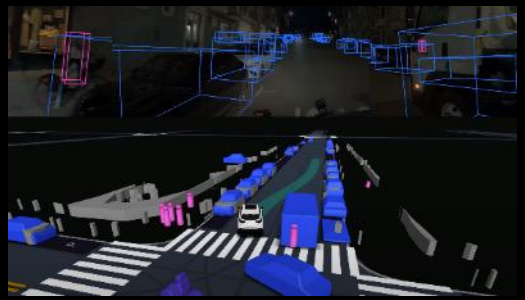
Do we need ADB or HD for an AV?

ADB for not glaring other drivers
And better pedestrian detection

ADB need be wider for earlier
pedestrian animal identification

Best contrast optimization
Camera can be glared too

HD Headlight projection of
Trajectory



Beyond the Basics: The Potential of AV Lighting

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Edge case: low Sun position impact traffic light detection

Back-light compensation on targeting object, using like a flashlight

Lighting helping objects identification Redundancy is Key

In low light or adverse weather conditions, where rain can create significant interference for LiDAR or Radar, the precise resolution of an ADB/HD system can assist in identifying objects.

IR lighting for cameras operating in low-light condition

Active IR system as LIDAR redundancy, IR beam integrated into Headlamp

The Evolution of AV Lighting: From Human Eyes to Machine Perception

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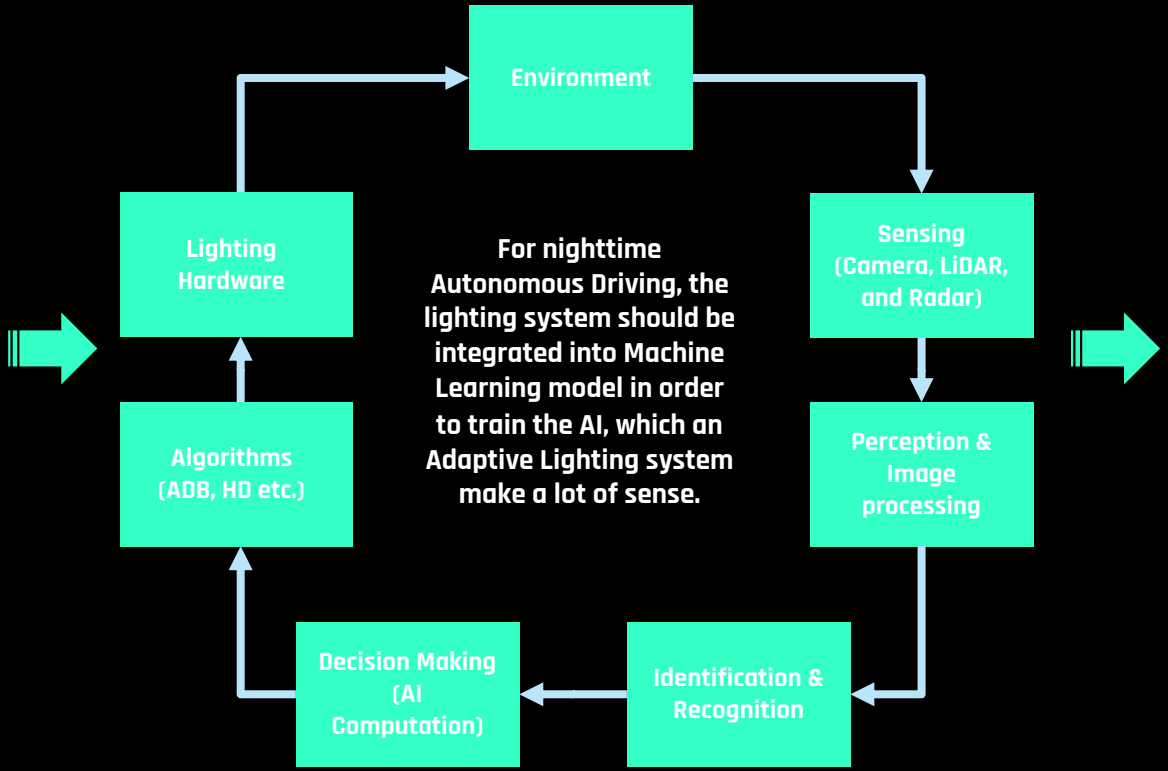
Human Eyes focused Lighting

Evolved for driving safety, aiding human vision during nighttime and dark conditions.



For nighttime Autonomous Driving, the lighting system should be integrated into Machine Learning model in order to train the AI, which an Adaptive Lighting system make a lot of sense.

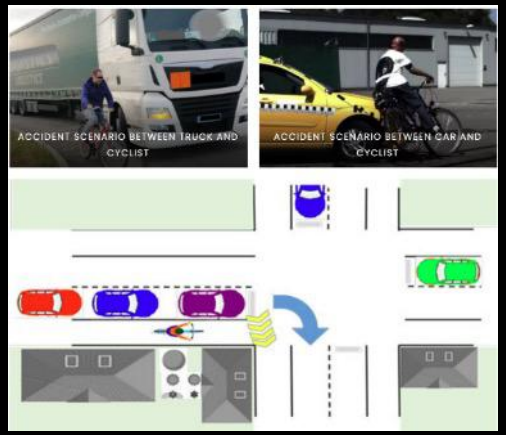
AV Lighting

An adaptive tool for machine eyes to recognize the real world. Providing light and enhancing contrast where needed. Synchronize with sensing through AI for machine-optimized illumination.

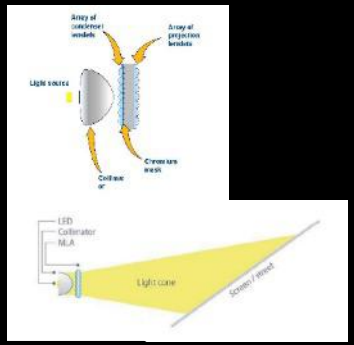
AV Communications:

Road projection

Ground projection make a lot of sense for an autonomous vehicle to communicate with pedestrians or cyclists, it could be integrated into a headlamp, but also could be on a higher position, for example, sensor pod.



MLA is the one of the most convinced solution so far for this application.



Source: DVN report

AV Communications:

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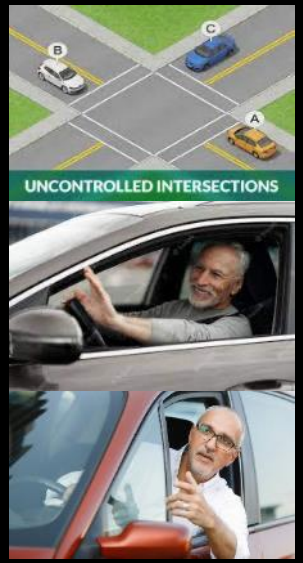
Display

While road projection is beneficial, ensuring visibility during daytime and optimal sun conditions requires enhanced brightness and contrast.

There is a real need for Avs
Not only AVs on the Road



OLED application for excellent contrast

RGB Light Bar

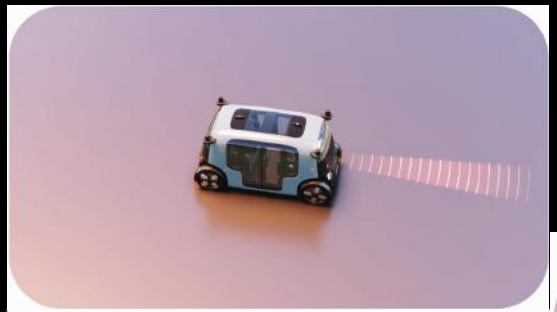
Display with traditional LED

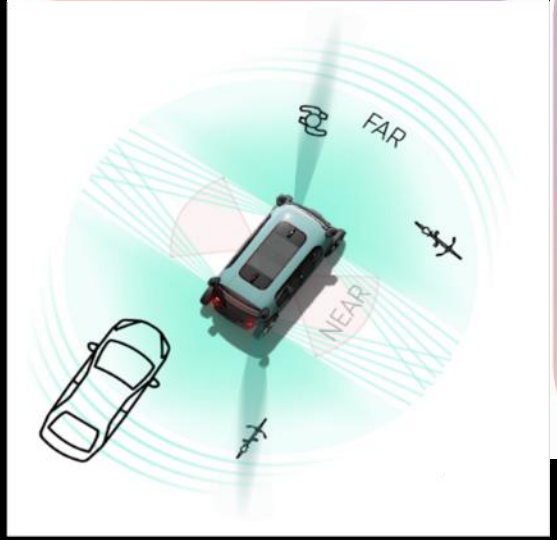
With Integral display

MiniLED

A lot of possibility and technologies associated, but regulatory changes may be needed to accommodate at least some of these technologies. The challenge is that the rulemaking process in the U.S. is often slower than in EU or China.

AV Communications: The Spectrum Beyond Light





A speaker array will generate directional sound wave communication with both near field and far field.

AV Communications: The Spectrum Beyond Light

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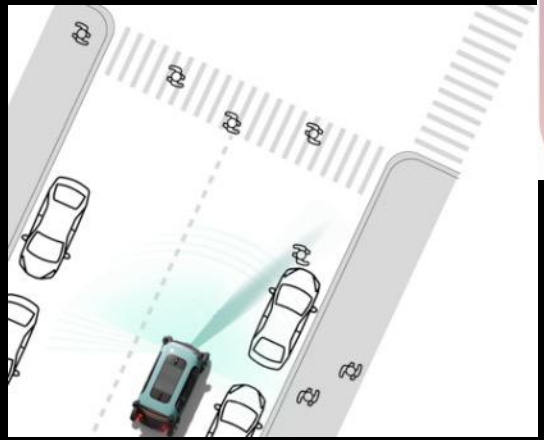
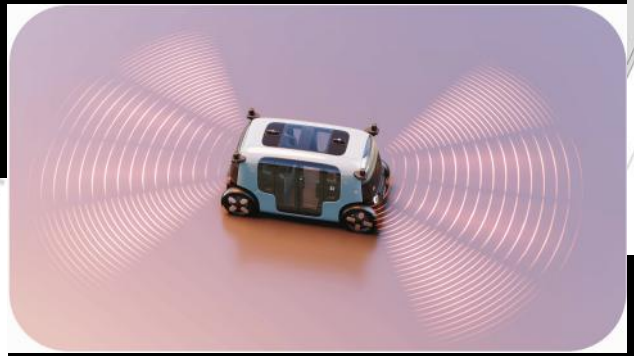
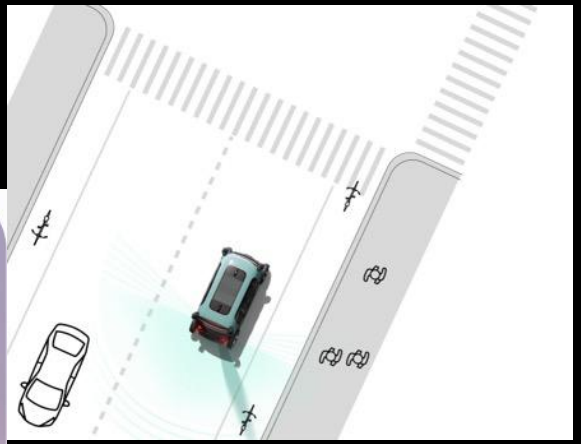
Pedestrian can also talk to the robot directly.







Scenario of merging into a bike lane, communicating intent to yield to pedestrians or bicyclists.

Defining Modern Mobility: Software-Driven AVs

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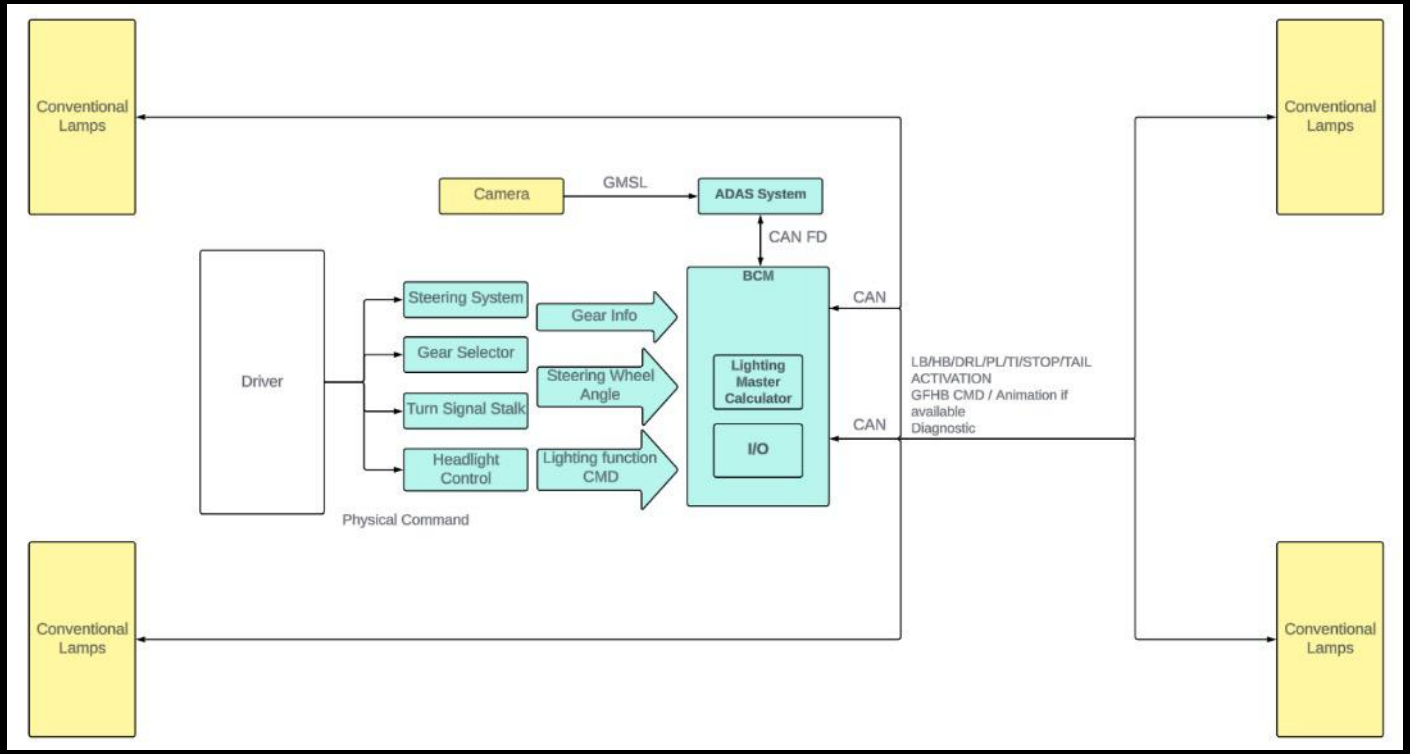
Supplier Owned

OEM Owned

Conventional Vehicle high level lighting architecture example:



Defining Modern Mobility: Software-Driven AVs

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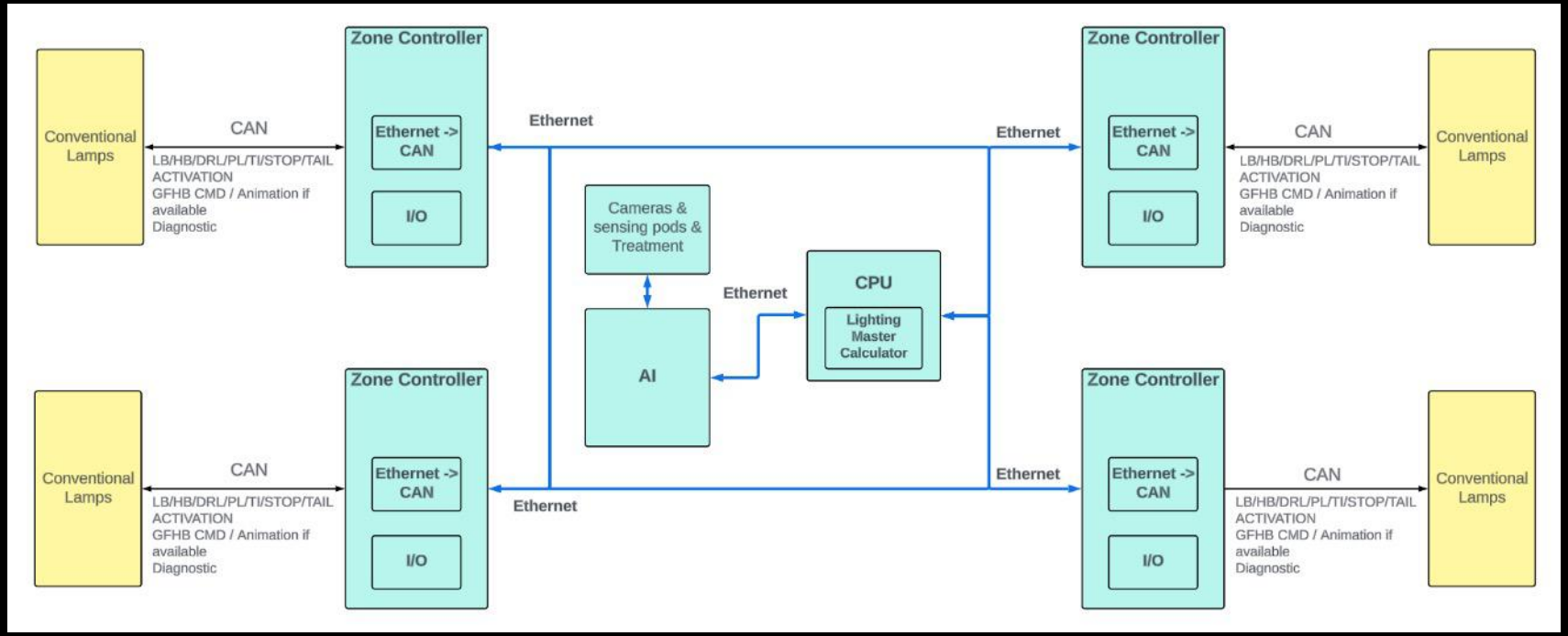
Supplier Owned

OEM Owned

Autonomous Vehicle high level lighting architecture:



Defining Modern Mobility: Software-Driven AVs

Supplier Owned
OEM Owned
Potential implementation

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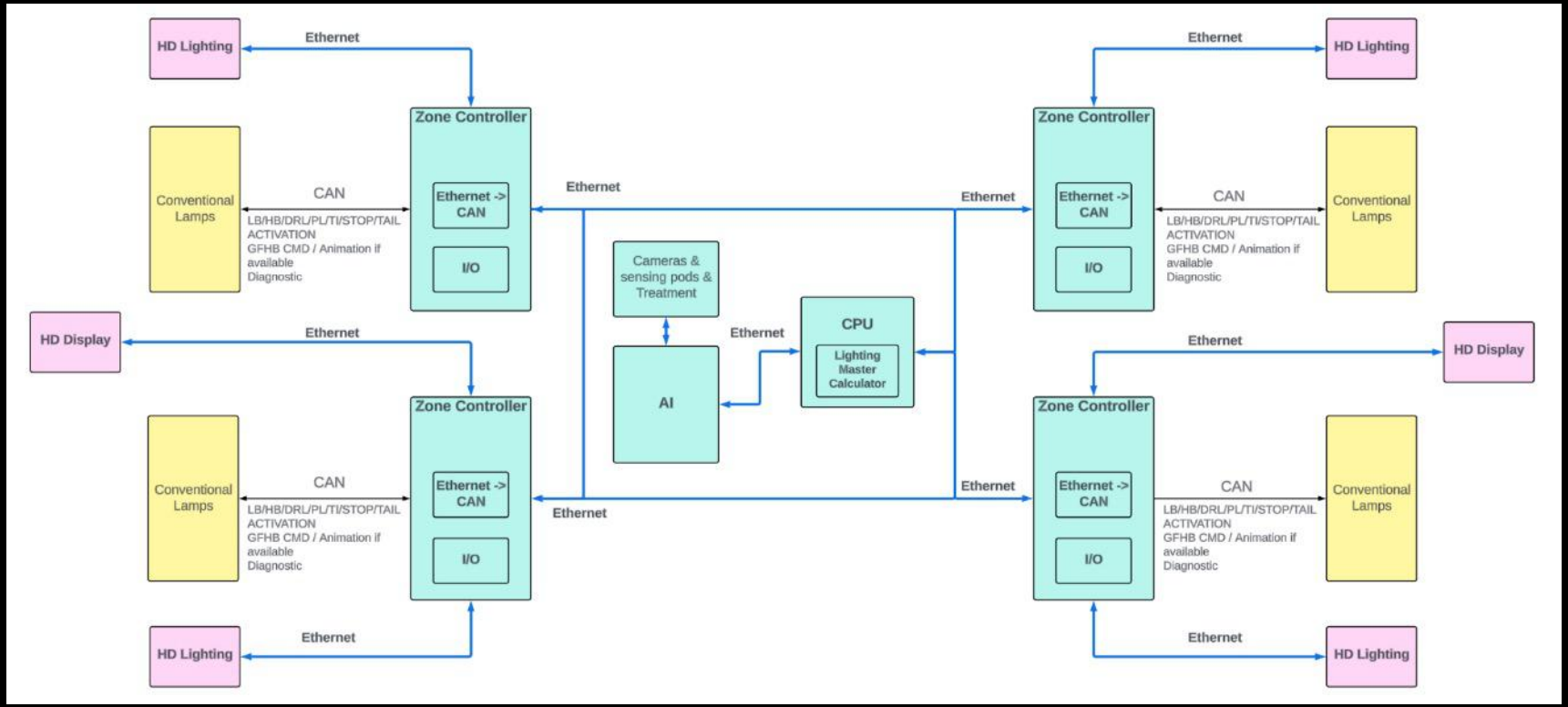
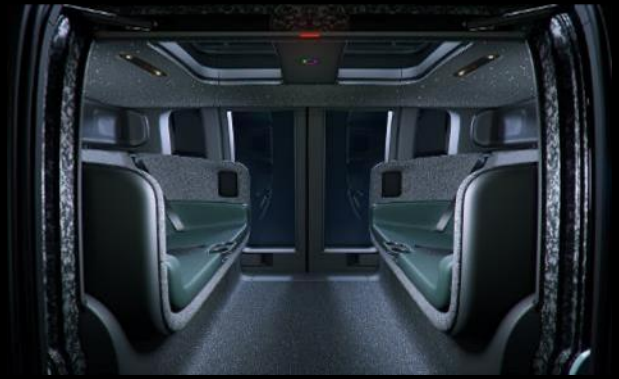
More flexible to add new features:



Zoox's Promise: Delivering Superior Riding Experiences



The riding experience is a top priority for Zoox, communication with vehicle is not only outside of vehicle but also inside.

Closing Remarks: The Road Ahead

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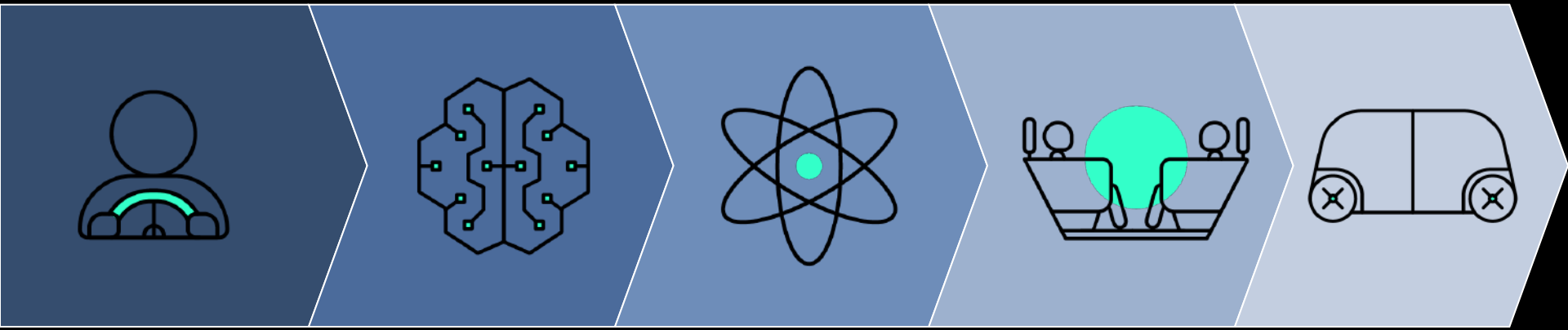
Evolutionary Journey | **Technological Diversity** | **Lighting's Expanding Horizon** | **Future of Interaction** | **A Vision for Tomorrow**



END / THANK YOU