



AUTONOMOUS FLEET DEPLOYMENT

No more guessing about
risk and safety

The **Robot Vehicles**
are coming.

It is time for
all of us to **Prepare.**

Burning Questions

- What are robot vehicles / autonomous vehicles?
- Are they really coming? If so, when?
- When and how do we prepare?

My AV Journey



ARIBO, Fort Bragg, NC
1st plans and piloting AVs on military bases. 1st commercial AV in US



AV Demo @ CES 2014
1st Level-4 AV Demo @ CES
Automated Truck Working Group
Industry, DOT, DOD collaboration
LM AV Development
Led Olli creation, testing, deployment strategies



Averified - Trucking Safety/Performance Verification
1st 3rd Party AV Safety & Performance Verification

dRISK - AV Training & Risk Assessment
NASA tech applied to AV risk identification and mitigation

US Ignite / US Army AV Pilots
Scalable AV strategies on military bases (ERDC & Fort Carson)

UGVs/UAVs Swarms
Applying swarm artificial intelligence to AVs (DARPA spinoffs)



Munich Reinsurance
1st AV insurance product (One of the world's largest reinsurance groups)

PME AV Product Innovation
AV development roadmap & 1st A-Pod in US

CES 2019 Aurigo AV Demo
1st automated pod demo in US

Michigan Mobility Challenge
1st public pilot with accessible A-Pod
Dubai World Challenge for Self-Driving Transport
1st automated shuttle pilot in UAE (1 of 6 judges)



AAA AV Strategist
1st Public Access AV Shuttle Pilot: Las Vegas

GATEWAY London
1st AV pilots in UK

North American Auto Show
1st Level-4 AV @ NAIAS

ITS World Congress
1st Level-4 automated Shuttle @ ITS WC



SMART AMERICA  AL CITY IS CHALLENGE



BUSINESS CASE ANALYSIS

Highest ROI R&D



People Moving / Transit



Goods Movement / Logistics



**What does the
project look like
in practice?**





COLLABORATIVE INNOVATION: FORT BRAGG...A Global Model



*The robot vehicles are coming.
It's time for all of us to prepare.*

Question 1:

What are robot vehicles / autonomous vehicles?

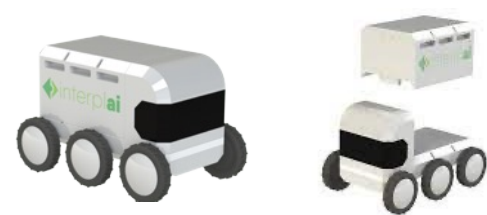
What do most Americans think of as AVs?



NO



Not yet



Question 2:

Are they really coming to the world?

GM seeks US approval to deploy self-driving car without a steering wheel

NHTSA to review safety of driverless Cruise Origin before possible 2023 deployment.

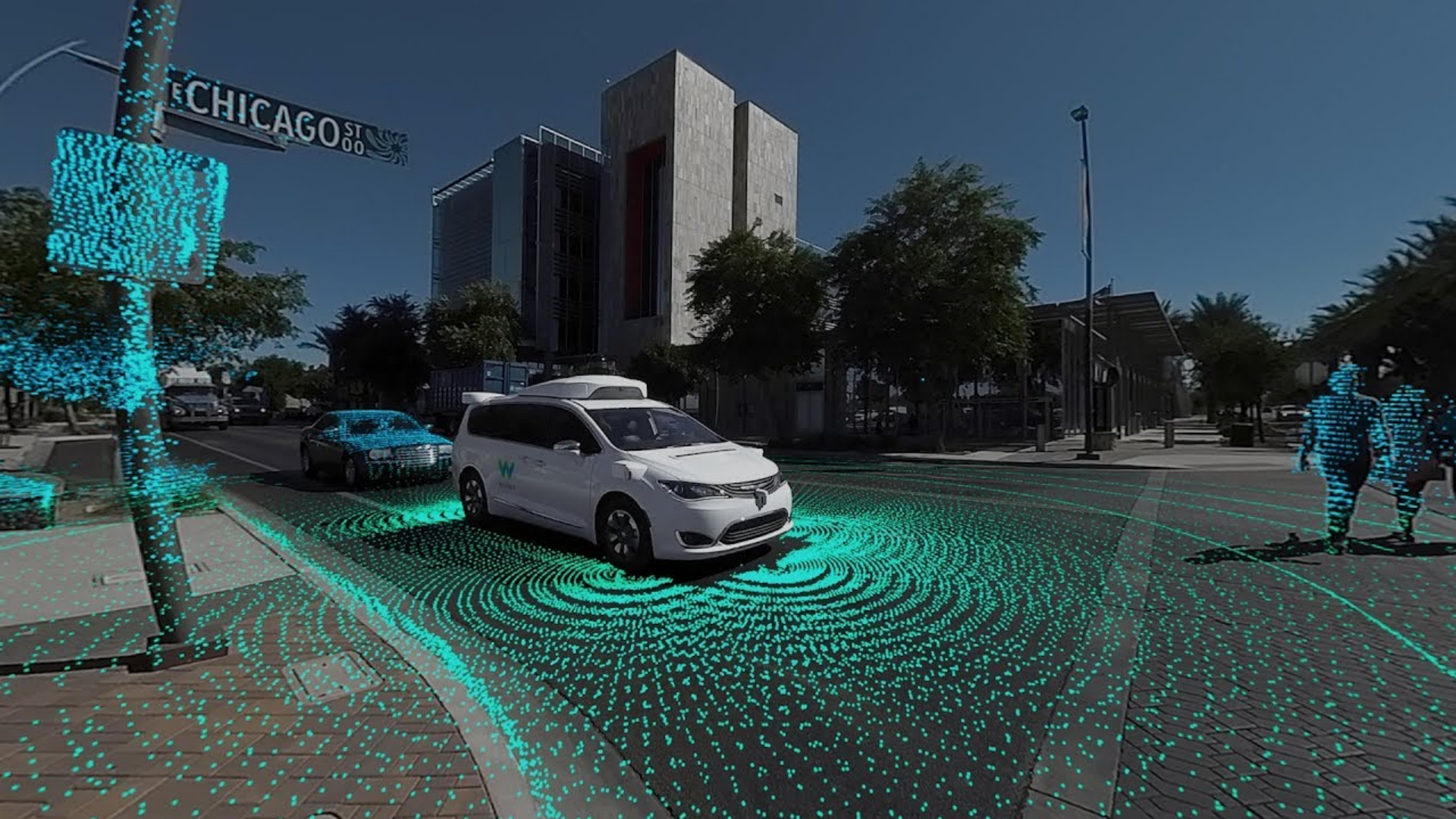
JON BRODKIN - 2/21/2022, 1:21 PM





cruise
JOIN THE **DRIVERLESS** REVOLUTION

WHICH SIDE DOES
CALCULUS
QUESTION

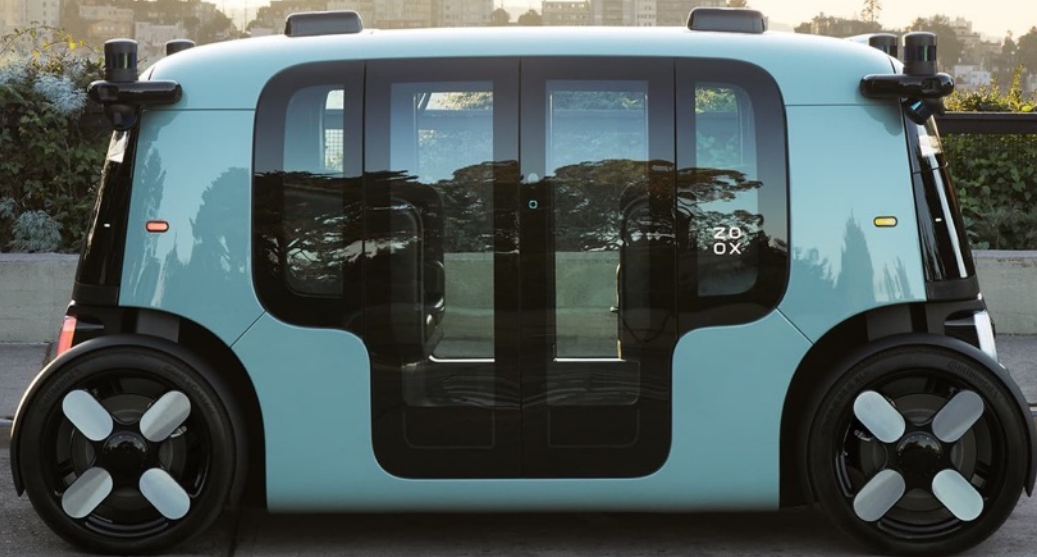


Walmart



ARGO^{AI}

self-driving system



Scout by Amazon



CANAL STATION

CANAL STREET

42
km/h

73%

MOBILE OBJECT
NOT MOVING

PASSENGER CAR
PARKING

TRANSPORTER
NOT MOVING

TRANSPORTER
NOT MOVING

PERSON
WALKING

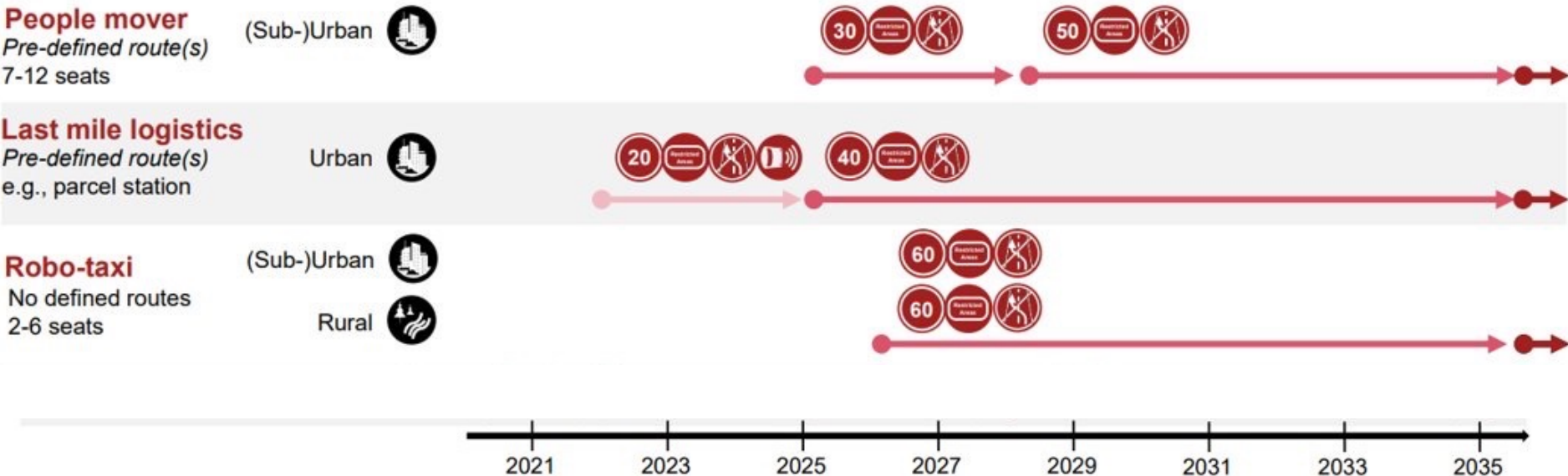


TOYOTA





Automated driving timeline of commercial road availability

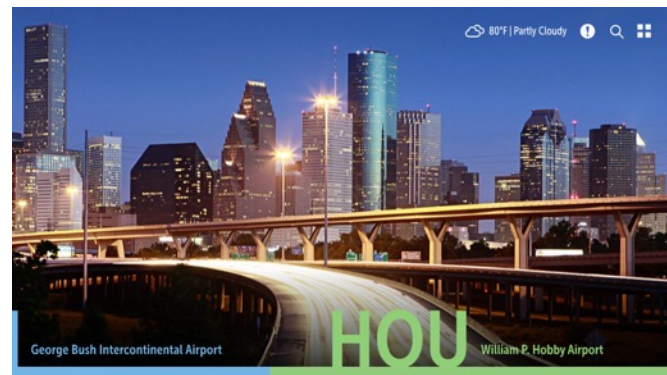


Commercial availability (beyond pilot projects)²⁾

Urban: Traffic situations with many traffic interactions and low speeds
Sub-Urban: Traffic situations with moderate traffic interactions and moderate speeds
Rural: Traffic situations with few traffic interactions and higher speeds







Question 2:

Are they really coming to bases and installations?



TEDDY
The Durable Shuttle
Demonstrations in Yellowstone

Yellowstone National Park

CANYON
VISITOR
EDUCATION
CENTER





Question 3:

When and how do we prepare?

Thinking about AVs?

Here are a few tips that can help.

Its time to start planning & prepping now.

- Collaborative Systems Engineering
- Data driven deployment
- Don't do an RFI – work with experts



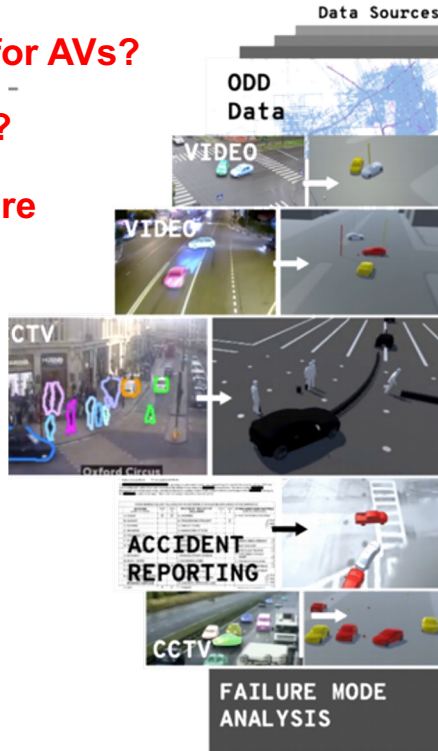
GenerationAV ODD Risk Assessment

powered by $\mathcal{D}(\text{risk})$

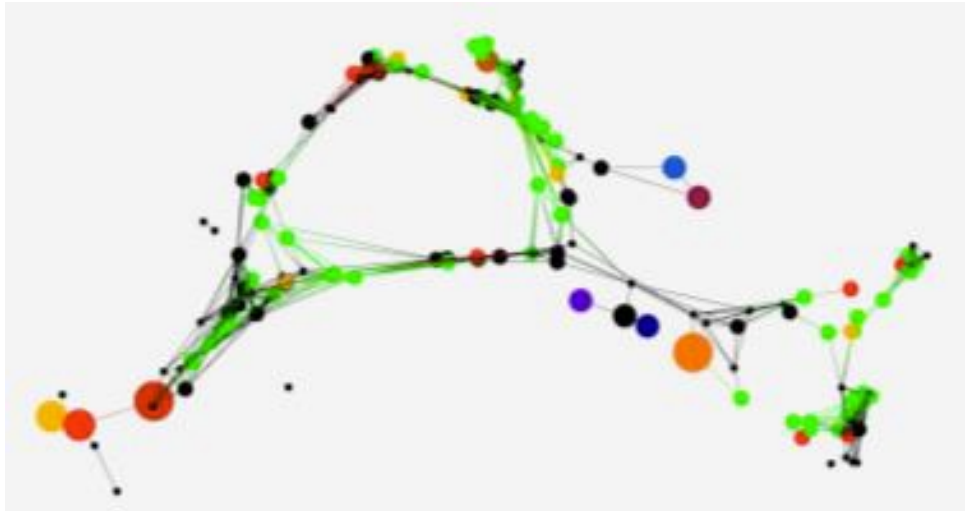
Is your route safe for AVs?

What are the risks?

What edge cases are expected?



It is important to assess the ODD to align to the capabilities of the AV ensuring its ability to operate safely and effectively



Traffic Hazard Assessment: Fixed

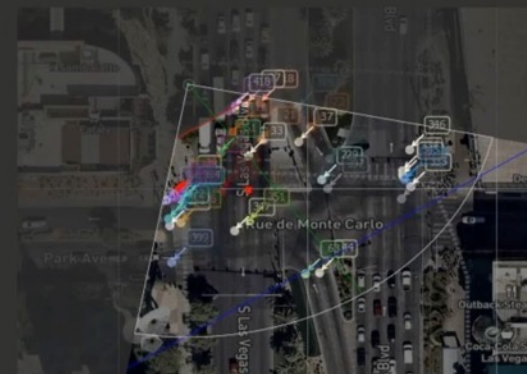
Las Vegas Intersection



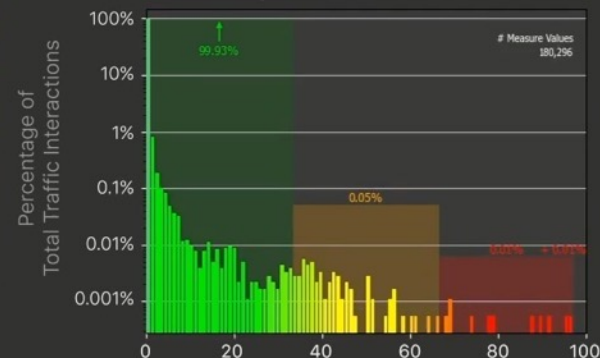
nFrames: 1024
Duration: 496.796 [seconds]
Distance: 0.000 [miles]
Display Units: English

Frame: 000360, Time: 0:12.011

Collision Hazard Measure: m6
• Saturation Level: 100.00
• Line Persistence: 60 frames
• Car PRT: 750 [msec]



Streetscope Collision Hazard Measure



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RRAI Accelerating Autonomy in the Military

October 2022

RRAI

RRAI
22601 Gateway Center Drive Clarksburg, MD 20871
www.roboticresearch.com



Founded in 2002, RRAI is led by industry pioneers who helped develop the very concepts and definitions of modern autonomy.

RRAI is a true dual use company with both defense and commercial customers.

In 2014, RRAI deployed its first autonomous shuttle for commercial use. By 2018, the RRAI commercial autonomy stack, AutoDrive, was deployed globally on electric transit shuttles. To date, AutoDrive has been deployed on four continents and over 10 countries.

20



Years in
Business

40



Unique Platforms
Automated

90+



Unmanned
Trucks
Delivered

>35



Cities
Deployed
Globally

History/Facts Experience

Founded in 2002, RRAI is led by industry pioneers who helped develop the very concepts and definitions of modern autonomy.

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In 2014, RRAI deployed its first autonomous shuttle for commercial use. By 2018, the RRAI commercial autonomy stack, AutoDrive, was deployed globally on low-speed electric shuttles. To date, AutoDrive has been deployed on four continents and over 10 countries including combat zones such as Afghanistan.

RRAI has developed autonomous solutions for several commercial OEMs including New Flyer, GILLIG, Mack, and Gaussin. In 2023, AutoDrive will be deployed on CTFastrak as the first automated bus operating in revenue service in North America

RR boasts a collection of some of the brightest minds in the field of robotics and vehicle automation, with personnel located across four company offices, and across the country stationed at bases and customer sites.

Our SME experience for Mission Engineering is critical to success—over 20 years of maneuver experience on armored combat vehicles.

RRAI

AutoDrive has been deployed in >20 cities and mixed traffic environments for both buses and shuttles. AutoDrive leverages AI/ML to fuse sensor modalities at the edge and enable secure communication. AutoDrive is sensor and system agnostic and has multiple configurable ODDs to support the US Government and commercial clients.

RRAI's core technology was originally derived from off-road autonomy in unstructured environments for the US Army. As a result, our hardware and software architecture is designed from end-to-end to account for the challenges with autonomous operation in areas of heavy foliage, poor visibility, unpaved surfaces, and unstructured terrain.

AutoDrive has been integrated into over 40 vehicle types and counting. RRAI has delivered 90+ military systems globally: US Army PLS, LVSR, MTVR, JLTV, JLTV ROGUE Fires Carrier, and the German Army HX2 tactical truck. Preferred autonomy vendor for Oshkosh and Mack Defense (CTT). AutoDrive has been deployed to combat zones and large-scale exercises such as Combined Resolve and Saber Junction.

AutoDrive has operated on many different vehicles, including 40-ft electric buses, 12-passenger electric shuttles, yard trucks, and Class 8 Trucks. These vehicles have operated in mixed-traffic public roads. Starting in Q4 2022, operations of commercial vehicles will commence in off-road conditions in West Texas. AutoDrive is the preferred autonomy stack for New Flyer, Gillig, Mack, Oshkosh, Gaussin, ITS ConGlobal, and others.



History/Facts Deployments

UNITED STATES

Akron, Oh. – Transit
Corporate Campus

Concord, Calif. – Transit
Corporate Campus

Chicago, Il. – Transit
Corporate Campus

Sacramento, Calif. – Transit
Corporate Campus

Fresno, CA – Yard Truck
Distro Center

Rancho Cordova, CA –
Transit Shuttle Public Road

Miramar, Calif. – Transit
Military Base

Chandler, Az. – Transit
R&D Campus

Kansas City, Mo. – GILLIG
Bus Precision Docking

Clarksburg, Md. – Transit
Demo and Testing by RR

Fort Myer, Va. – Transit
Military site

Greenville, Sc. – Transit
Public Roads

Lake Nona, Fl. – Transit
Public Roads

Port St. Lucie, FL – Transit
Shuttle Public Road

Buffalo, Ny. – Public Roads
University Campus /
Inclement Weather Testing

Hartford, Ct. – New Flyer Bus
CTFastrak BRT corridor

Baltimore, Md. – Transit
Sports Stadium

National Harbor, MD - Transit
Public Roads Testing

Yellowstone Park, WY Transit
Shuttle Public Roads

Clearwater, FL – Transit
Shuttle Public Road

Tampa, FL – Transit Shuttle
Public Roads

Peachtree Corners, Ga. –
Transit - Public roads

Phoenix, Az. – Public Roads
R&D Campus

Knoxville, Tn. – Transit
R&D Campus

Port St. Lucie, FL – Transit
Shuttle Public Road

Jacksonville, Fl. – Transit
Public Roads Testing

COMBAT ZONES

Afghanistan. – Route
clearance and logistics

CANADA

Quebec, Canada – Off-
Road Trucking
Canadian Bush, Forest
Roads

Whitby, Canada - Transit
Shuttle Public Roads

EUROPE

Copenhagen, Denmark. –
Transit - Corporate
Campus

Ghent, Belgium. – Transit
Hospital

London, UK - Yard Truck
Distro Center

Zalaegerszeg, Hungary -
Transit Shuttle Test Site

Chateauroux, France –
Transit Shuttle Corporate
Campus

Paris, France. – Transit
Corporate Campus

Turin, Italy. – Transit
University Campus

Hambach, Germany. –
Transit - Public Roads

AUSTRALIA

Adelaide, Australia. –
Transit-Public Boardwalk



Applications

Current commercial applications that can be used today for installations:

- ❑ **Moving People:** Automated bus applications on and around base
- ❑ **Moving Goods:** Automated truck applications to move material
- ❑ **Infrastructure Support:** Automated electric vehicles to offset charging demands



RRAI



- Won highly competitive evaluation process to deliver 120 autonomous Class 8 Trucks for a large-scale logistics company that operates in a large geographic area on private and public roads
- Operational environments include off-road/off-highway, on-road with traffic, minimal to no comms in remote areas, and heavy weight hauling using multiple trailers
- Designed to operate in heavy dust, rain, and complex on and off road at normal vehicle speeds
- Beat out several other large US based truck autonomy companies
- Delivery begins in Q4 2022 and revenue service beginning in Jan 2023, with all 120 vehicles in operation by the end of 2023
- Plans to grow initial autonomous fleet by 2.5x by 2025
- Created partnership with OEM to integrate autonomy stack and will deliver brand new L3/L4 capable vehicles



- Selected by a large distribution and logistics company that operates over 1,100 DCs
- Fully automated yard operations and completed 1,400 autonomous moves at a 94% success rate – outperforming every other company that was evaluated
- Demonstrated success in navigating complex mixed-use yards while maintaining throughput equivalent to that of a human operator
- Scaling to several more DCs and intermodal terminals in 2023
- In contracting with several other yard operations centers and expect >100 deployed in 2023 (in revenue operations)
- Providing autonomy kits for multiple OEMs that hold over 90% of the international market share



- Competitively selected as the autonomy provider for Connecticut DOT for the Automated BRT project
- Automation of driving, platooning, and docking
- First Automated BRT
- First Revenue Bus in Service
- First Automated Precision Docking
- First Automated Platooning Buses



- Competitively down selected by Canada's FPInnovations for automating logging trucks
- Automation of trucks in arctic and taiga climates
- Automated operations on-road but without lane markers and signage

The background of the slide is a dark gray with a complex, light gray circuit board pattern. The RRAI logo is positioned on the left side of the slide.

RRAI | Thank You

Please do not hesitate to reach out with any questions.

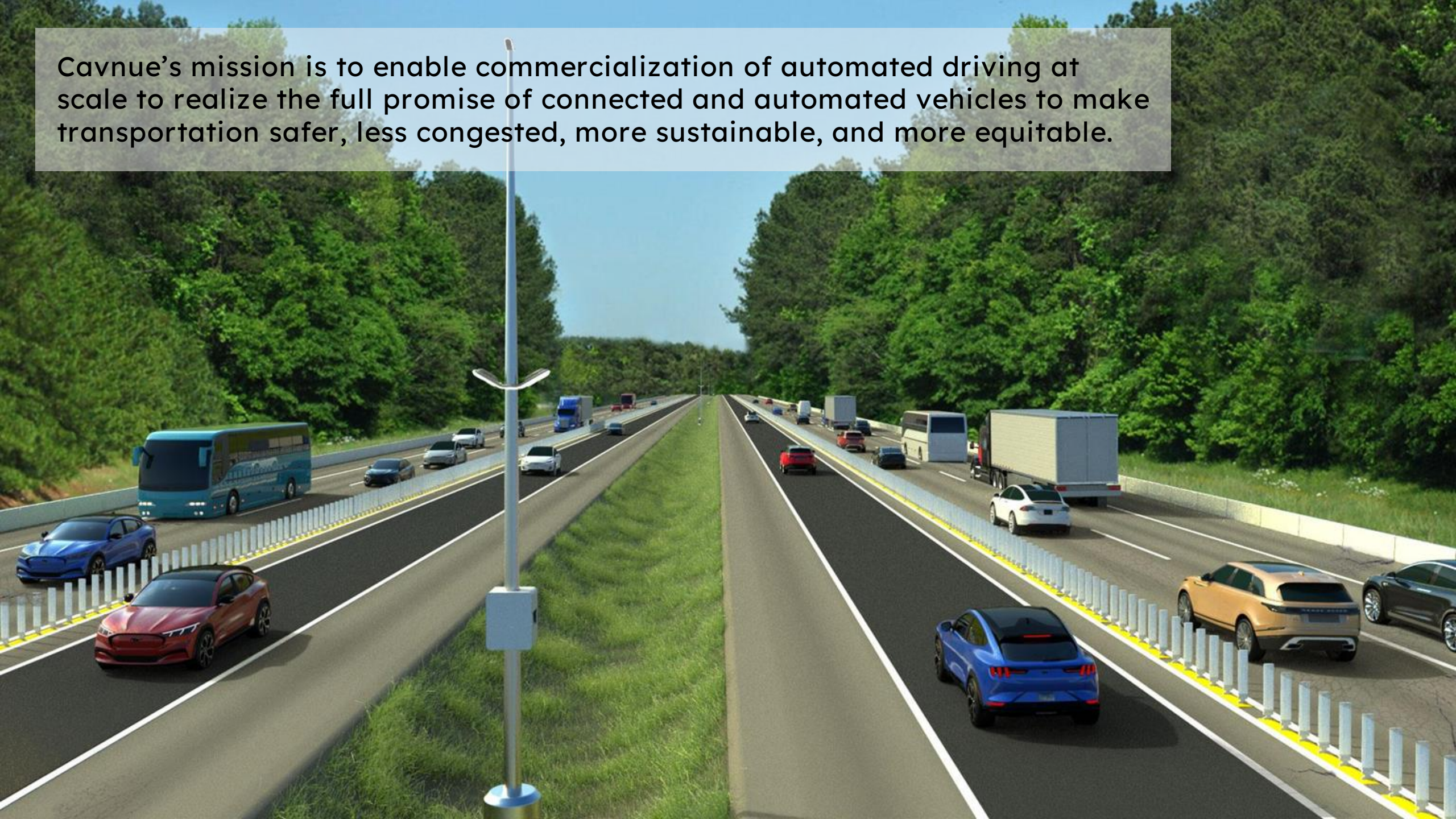
Bryan Brillhart – VP of Strategic Partnerships
Bryan@RR.AI

RRAI

About Cavnue



Cavnue's mission is to enable commercialization of automated driving at scale to realize the full promise of connected and automated vehicles to make transportation safer, less congested, more sustainable, and more equitable.



Cavnue builds smarter roads for smarter vehicles

Enabling and accelerating the safe adoption and deployment of automated transportation technologies

Road Design

We design roads to benefit automated vehicle performance, including favorable lane geometry and physical lane attributes.

Road Insights

We leverage data from multiple sources - including ground truth in near-real-time from proprietary data feeds - to generate actionable insights for road users and road operators alike.

Road Operations

We manage roads to a premium, highly reliable standard that favor automated driving performance - including asset management / maintenance, incident response, and traffic management.

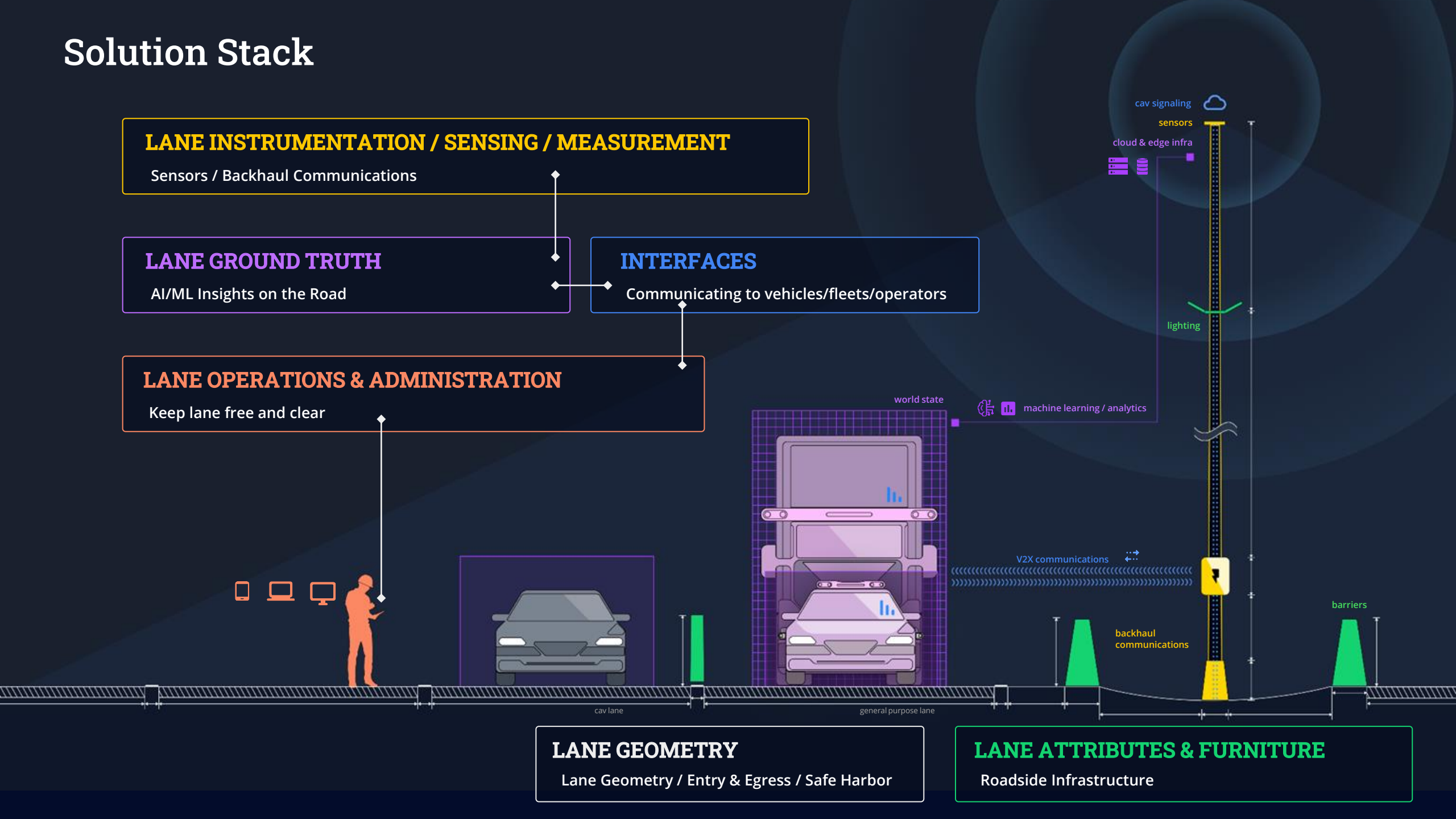
Solution Stack

LANE INSTRUMENTATION / SENSING / MEASUREMENT
Sensors / Backhaul Communications

LANE GROUND TRUTH
AI/ML Insights on the Road

INTERFACES
Communicating to vehicles/fleets/operators

LANE OPERATIONS & ADMINISTRATION
Keep lane free and clear

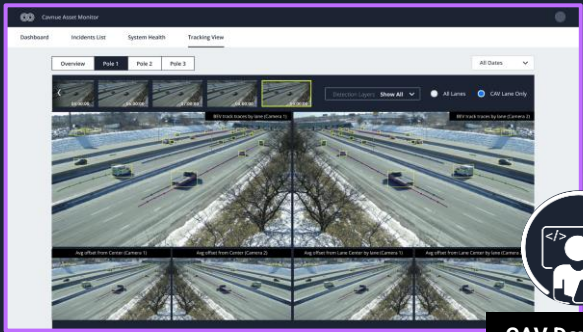


LANE GEOMETRY
Lane Geometry / Entry & Egress / Safe Harbor

LANE ATTRIBUTES & FURNITURE
Roadside Infrastructure

Ecosystem Interactions

- LANE GEOMETRY
- LANE ATTRIBUTES & FURNITURE
- LANE INSTRUMENTATION / SENSING / MEASUREMENT
- LANE GROUND TRUTH



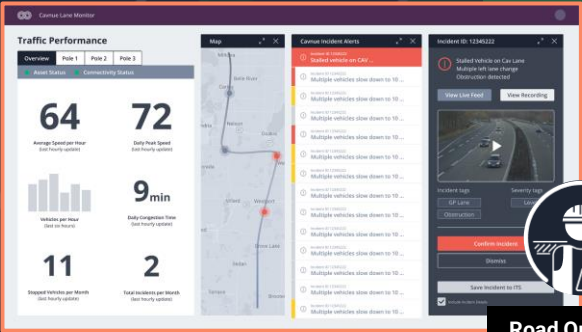
CAV Developer

INTERFACES

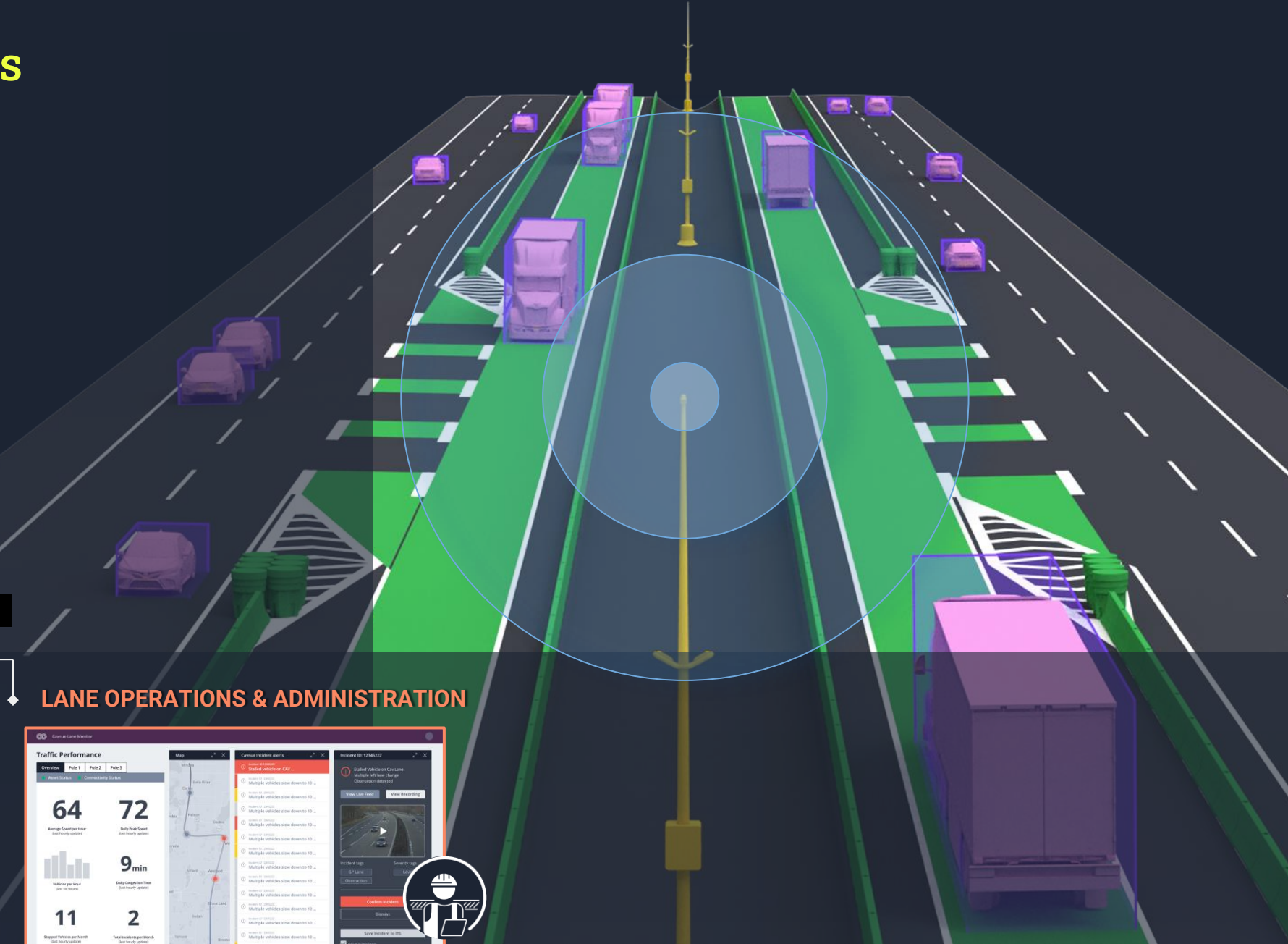


CAV Admin

LANE OPERATIONS & ADMINISTRATION



Road Operator



Use Cases



Passenger Vehicles

Cavnue is working with Passenger Car OEMs, including Ford Motor Company, to enable superior performance of automated driving systems and create value for their customers, including **time** back and superior **safety**.



Drayage & Intermodal

Drayage and supply chain logistics are challenging and critical to **economic prosperity**. We are developing solutions to automate short-haul drayage operations on public right-of-way.



Long-Haul Freight

We are developing solutions to address challenges posed by the dramatic increase in commercial vehicle volumes to improve **throughput of goods** and to improve **safety** for all drivers on the interstate.