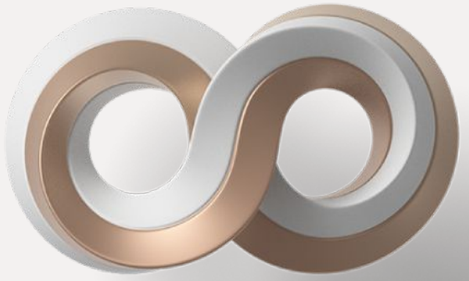

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The future of roads.

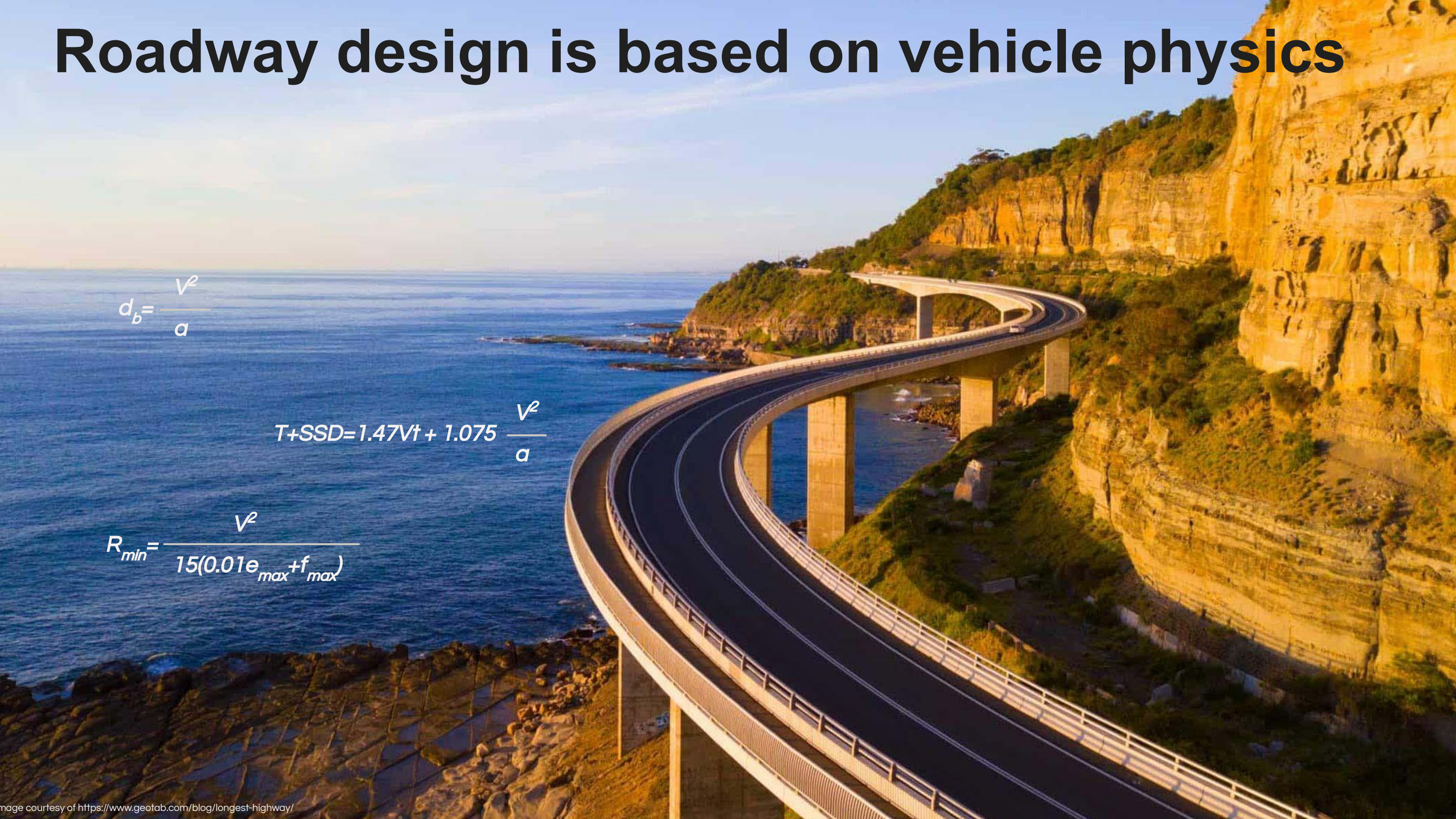
UNECE Meeting
March 22, 2022
Dino Nardicchio

Roadway design is based on vehicle physics

$$d_b = \frac{V^2}{a}$$

$$T+SSD = 1.47Vt + 1.075\,\frac{V^2}{a}$$

$$R_{min} = \frac{V^2}{15(0.01e_{max}+f_{max})}$$



mage courtesy of https://www.geotab.com/blog/longest-highway/

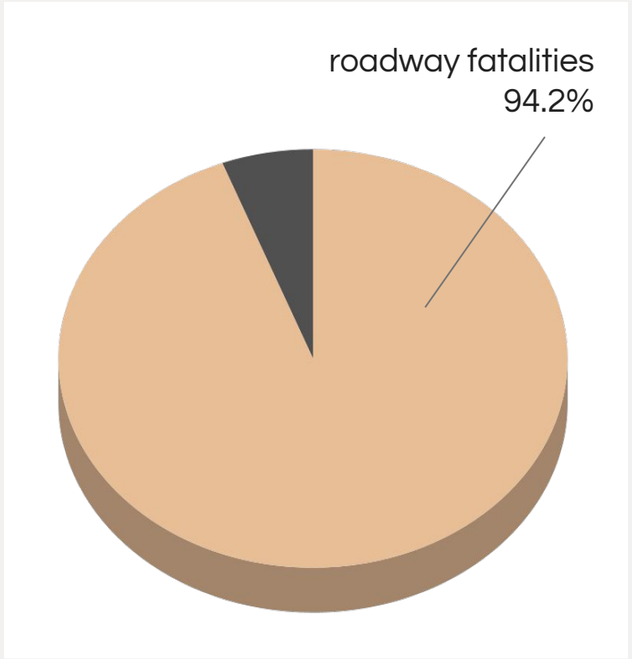
Roadway Design is based on a human driving the vehicle to deal with other issues

+Unpredictable road actors

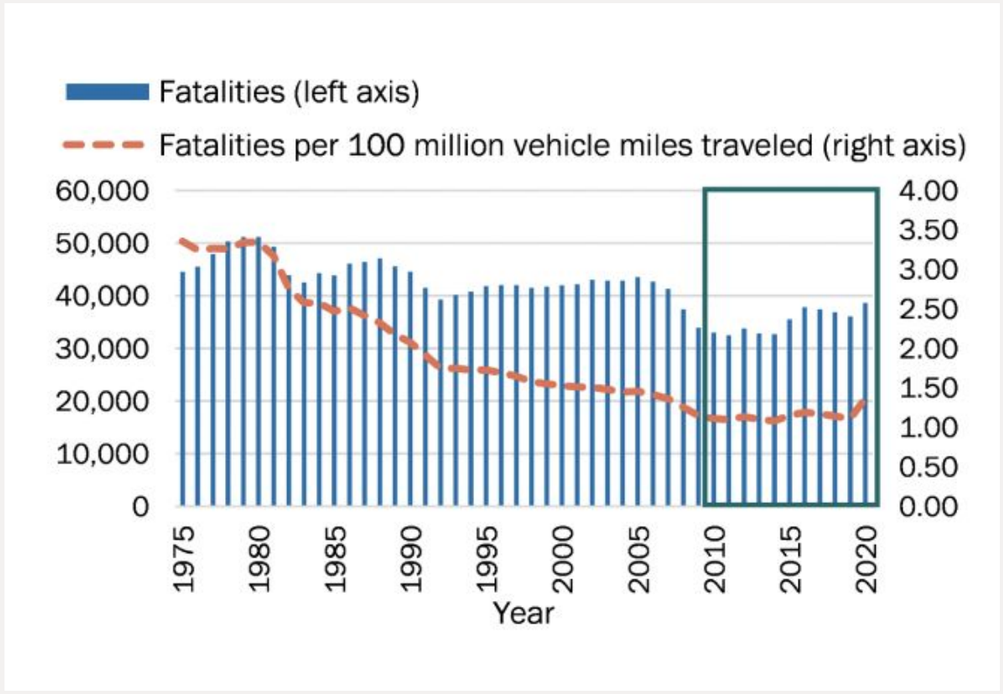
+Unpredictable infrastructure

+Unpredictable environment

The results are not pretty



In the last decade, more than 370k people died in transportation incidents in the U.S. More than 350k of them died on our roads.



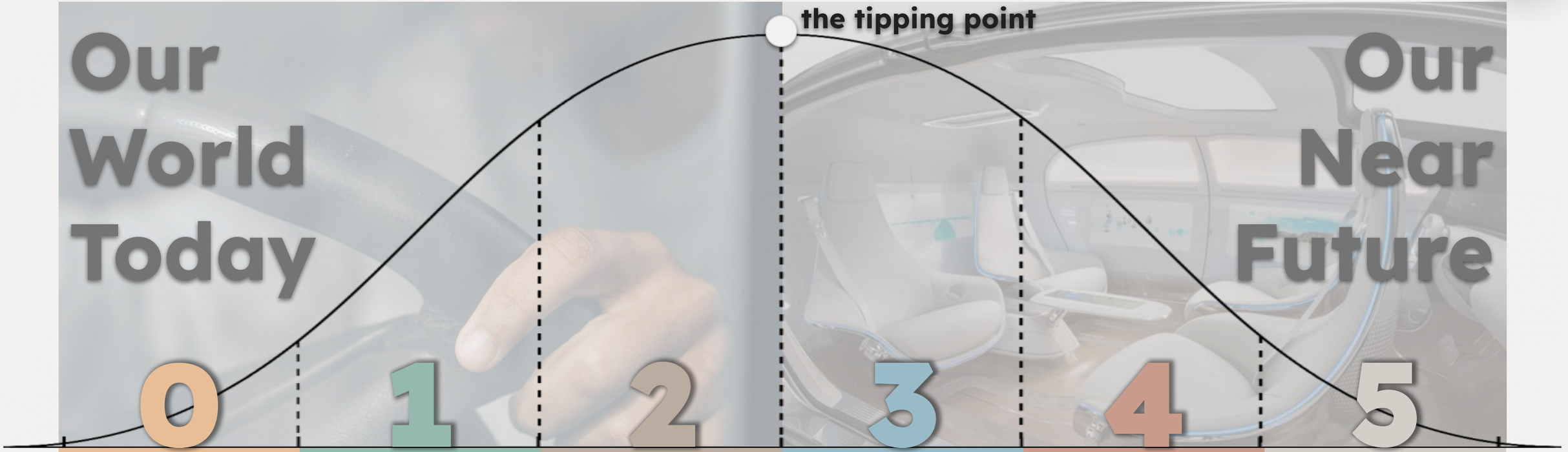
Roadway fatalities and the fatality rate declined consistently for 30 years, but progress has stalled over the last decade and went in the wrong direction in 2020.

Compared to 2019, fatalities increased:

- 7.2% overall
- 23% per mile driven
- 23% among Black people
- 20% involving persons ejected from a vehicle
- 18% among ages 25-34
- 15% among passenger vehicle occupants not wearing seatbelts
- 15% among ages 16-24
- 14% among ages 35-44
- 11% in speeding-related crashes
- 9% in crashes with police-reported alcohol involvement
- 9% among motorcyclists

National Roadway Safety Strategy; United States Department of Transportation | January 2022

The Future of Vehicles



HUMAN ONLY	MODERN VEHICLE	MODERN PLUS	PARTIAL AUTONOMY	FULL AUTONOMY + HUMAN	FULL AUTONOMY WITHOUT HUMAN
The driver controls everything (steering, braking, throttle, power, etc.)	Most functions are still controlled by a driver but some–like braking–can be done automatically by the vehicle.	At least two operational functions are automated (cruise control, lane centering, etc.) but the driver must be ready to take control of the vehicle at any time.	Human drivers are still necessary, however they are not required to monitor the situation.	Vehicle perform all safety-critical driving functions and monitor roadway conditions for an entire trip. Includes option for human driving.	Same as Level 4, without an option for human driver as there is no steering wheel or controls.

State of L4

In 2016

> “By 2017, a vehicle will be able to drive from LA to Times Square without a single touch of the steering wheel”
>
> **Automobile CEO**

> “We will have a Level 4 vehicle in 2021 – no gas pedal, no steering wheel, and the passenger will not need to take control”
>
> **Automobile CEO**

In 2022

Trucking

- Improves redundancy for L2+ systems
- Improves quality of driver experience
- Reduces shipping costs
- Additional savings via battery electric fleet integration

Transit

- Improves safety, which reduces operating costs
- Enhances fleet management and planning
- Improves reliability
- Provides equitable access to autonomy

Passenger Vehicles

- Improves safety
- Increases throughput and time savings
- Provides value of autonomy to passengers
- Creates opportunity for future integration with EV charging

Level-4 autonomy has not arrived, but Level-2 features are reaching market scale

OEM	Intro year	Models[1], #	Examples	Est. sales volume, K 2020	Est. sales volume, K 2023
General Motors *Super Cruise*	2020	22	• Cadillac Lyriq • Buick Encore	37.6	177.3
Ford *BlueCruise*	2020	11	• Mustang Mach-E • F-150 SuperCrew	3.7	52.7
Tesla *Autopilot*	2020	5	• Model X • Model 3	153.5	302
Volvo *Pilot Assist*	2023	2	• Volvo XC90 • Volvo XC100	0	7.6
Volkswagen *Traffic Jam Assist*	2020	12	• Volkswagen Atlas • Audi A4	27.4	52.1
Nissan *ProPilot Assist 2.0*	2021	2	• Infiniti QX50 • Infiniti QX55	0	5.5
Toyota *SafetySense 2.5*	2021	46	• Toyota Camry • Lexus LX	0	421.6

Headlines

"GM's Super Cruise Self-Driving Tech Will Be on 22 Vehicles by 2023" — CAR AND DRIVER — Feb 2021

"Tesla Full Self-Driving subscription model coming in Q2 2021" — ROAD & SHOW — Mar 2021

"2021 Toyota Camry is first to get Safety Sense 2.5 Plus" — ROAD & SHOW — Jul 2020

[1] Estimated based on public announcements

What can be accomplished if roadways were also designed for vehicle technology?

The Future of Roads

CARS ARE GETTING SMARTER

Vehicles with increasing ADAS[1] capability are reaching scale

ROADS HAVE NOT KEPT UP

Road infrastructure is woefully inadequate to achieve these vehicles' full potential

SMART CARS NEED SMART ROADS

The future of roads will be safer and more efficient

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[1] Advanced Driver Assistance Systems.

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Simplifying the driving environment and providing digital insights to vehicles about the road ahead will accelerate the benefits of connected and automated driving.


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1. Simplify
2. Observe
3. Inform
Provide reliability that the road will be the same today, tomorrow and the next day - roadway surface, lane lines, lighting, objects, etc.
Enhance elements that are required for vehicle perception
Minimize cut-ins/cut-outs with the use of physical separation
70
Dry
Clear
1
1
1

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1. Simplify

2. Observe

3. Inform

Deploy sensors every 200 meters to provide a full view of the roadway

Develop insights that detect what is happening on the road

System Architecture

Key Stakeholder
Data interface
Physical interface

ROAD USERS

L2+ vehicles receive information from the infrastructure to enhance perception and path planning.

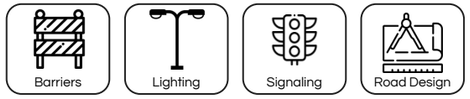
ACTUATION

Information that can guide toward the "ideal state" is transmitted to L2+ vehicles.

SENSING

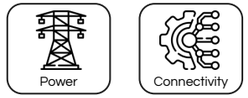
Vehicles and road state are detected.

PHYSICAL ODD SIMPLIFICATION & ENHANCEMENT



Interventions are made to the physical infrastructure to mitigate or eliminate disengagement scenarios.

UTILITIES

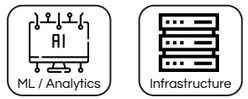


Provision of energy and communications to power the technology and transmit data to and from the roadside to the cloud.

DIGITAL TWIN

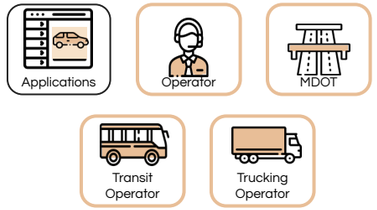
Sensed data is aggregated and interpreted and the "ideal state" is calculated to provide feedback to L2+ vehicles.

DATA INFRA & LEARNING



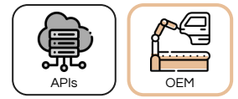
Trained analytics models, compute & data infrastructure that provide the foundation for the digital twin

APPLICATIONS & USERS



Display of insights to operators and policy-makers to facilitate decision-making and enable control and optimization of road and fleet O&M.

INTEGRATIONS



Information sent to OEMs to help with tech ops & development.

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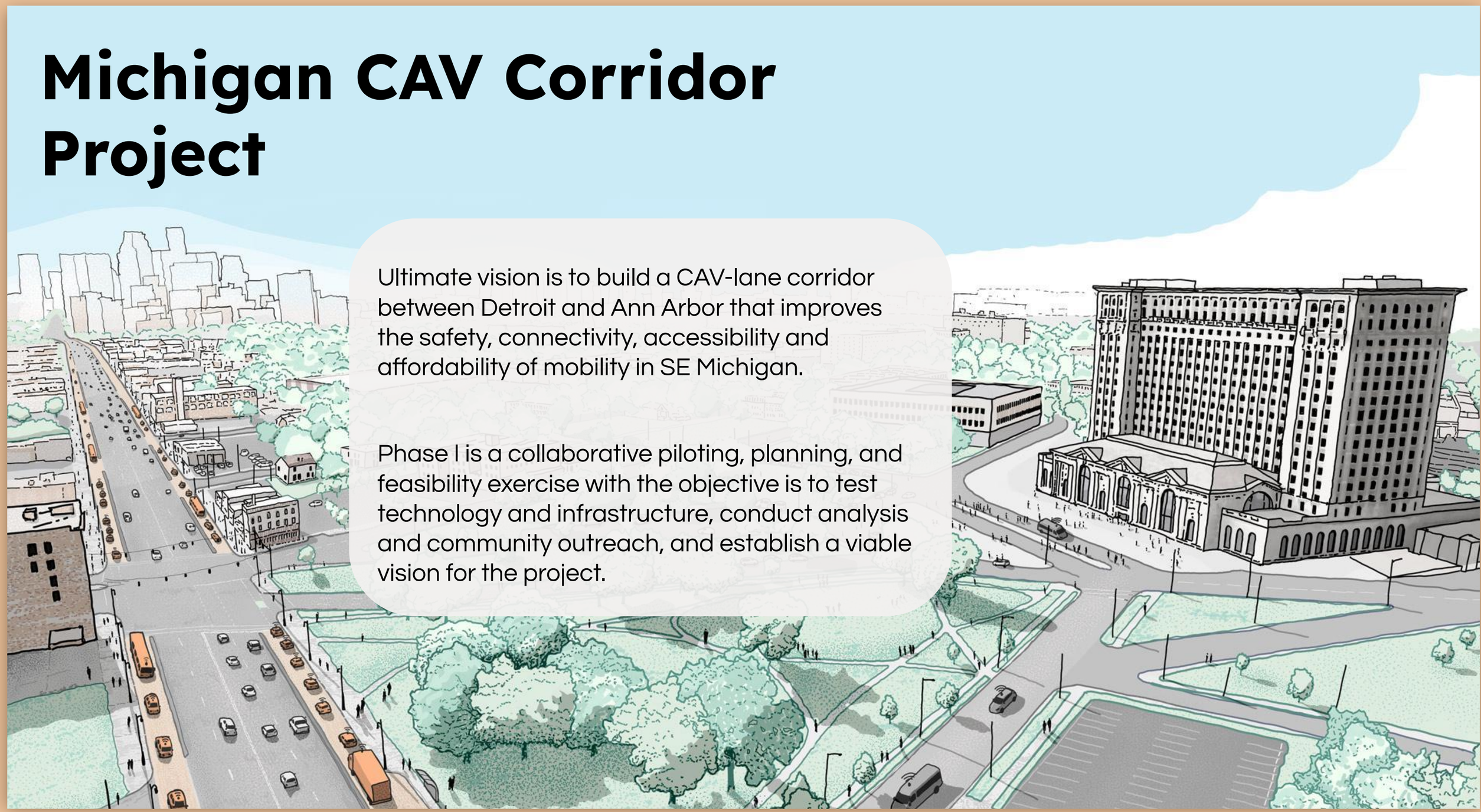
3. Inform

Provide information directly to the vehicle about the road ahead

Michigan CAV Corridor Project



Ultimate vision is to build a CAV-lane corridor between Detroit and Ann Arbor that improves the safety, connectivity, accessibility and affordability of mobility in SE Michigan.

Phase I is a collaborative piloting, planning, and feasibility exercise with the objective is to test technology and infrastructure, conduct analysis and community outreach, and establish a viable vision for the project.

Join us on the road to the future

dino@cavnue.com