Connected Future Transport Systems

Realities of the Changing Mobility Landscape

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Scott has degrees in Mathematics, Mechanical and Aerospace Engineering, a Master's in Business Administration, and Doctoral Research in Artificial Intelligence. Prior to CVTA, Scott was the first President of the VII Consortium and before that the Executive Director of the Automotive Multimedia Interface Collaboration, a nonprofit research organization of the world's largest automakers.

In March 2012, 2014, 2016 and 2018 Scott was appointed by Congress to the ITS Program Advisory Committee to advise the Secretary of Transportation and Congress on matters relating to the study, development, and implementation of Intelligent Transportation Systems.

On June 7th, 2016 Scott was inducted into the Automotive Hall of Fame in Detroit, Michigan.

Who We Are: Connected Vehicle Trade Association

CVTA is an international, non-profit trade association formed at the request of the 12 largest automakers in 2005 to advance the interests of industries and organizations involved in vehicle communications.

Membership is open to companies, universities, standards bodies and public agencies globally.

The Board of Directors was established with one representative from each industry involved.

What is an Autonomous and Connected Vehicle?

Autonomous Vehicles (AV)

- Vehicles that can perform all driving functions with or without human drivers, also called self-driving or driverless vehicles.

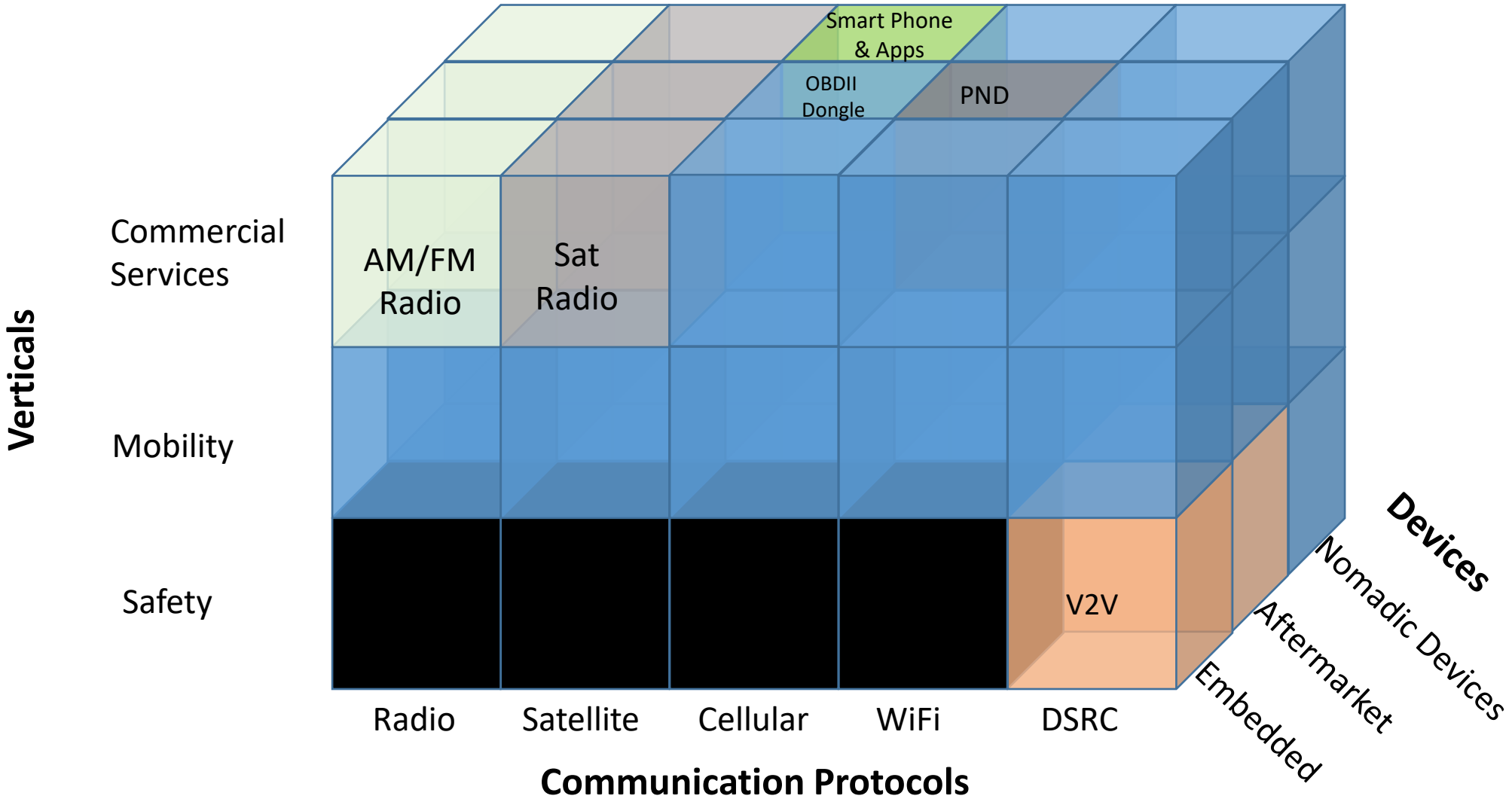
Connected Vehicles (CV)

- Vehicles with advanced technology to communicate with external systems.

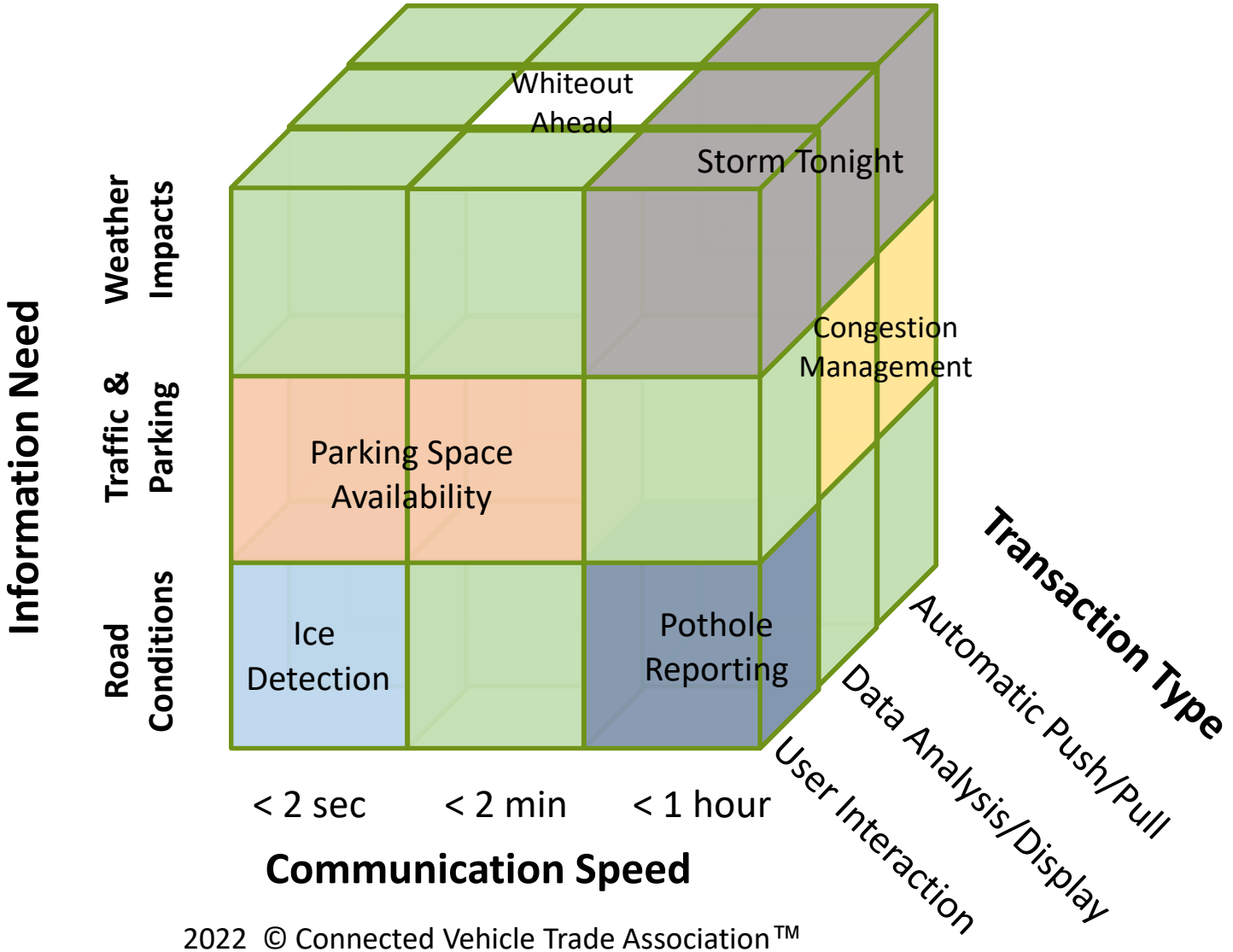
Doing either requires comprehensive integration of:

- Global Positioning System (GPS).
- Inertial Navigation System.
- Laser Illuminated Detection And Ranging (LIDAR).

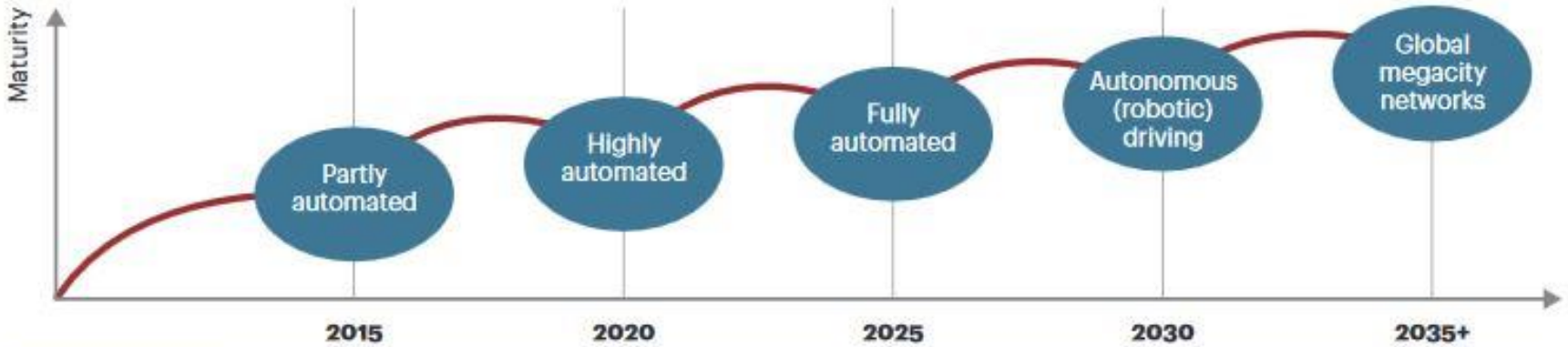
Connected Vehicle Ecosystem



Technology Decision Cube



Autonomous driving technology will advance in waves



	2015	2020	2025	2030	2035+
Legal protection	Scoring system for preventive driving	Daily legal protection for car rental and car-to-go	Legal protection based on mobile devices	Legal protection for all kinds of devices	Legal protection for all kinds of devices
Technology	First-generation automation and control	Second-generation automation, pooling	Third-generation fixed-distance automation	Fourth-generation automated traffic junctions	Fully automated traffic flow management
Infra-structure	Highway networks	Regional or national network	Selected megacities	Micro-/mobile city metropolises	Globally interconnected megacities
Standards	Internet standards for mobility apps	Camera and image processing and interfaces	Radio frequency and interface standards	Control and automation standards	Fully automated networks/ telematics

Sources: Rinspeed; A.T. Kearney analysis

LEVELS OF DRIVING AUTOMATION

0	1	2	3	4	5
NO AUTOMATION	DRIVER ASSISTANCE	PARTIAL AUTOMATION	CONDITIONAL AUTOMATION	HIGH AUTOMATION	FULL AUTOMATION
Manual control. The human performs all driving tasks (steering, acceleration, braking, etc.).	The vehicle features a single automated system (e.g. it monitors speed through cruise control).	ADAS. The vehicle can perform steering and acceleration. The human still monitors all tasks and can take control at any time.	Environmental detection capabilities. The vehicle can perform most driving tasks, but human override is still required.	The vehicle performs all driving tasks under specific circumstances. Geofencing is required. Human override is still an option.	The vehicle performs all driving tasks under all conditions. Zero human attention or interaction is required.

THE HUMAN MONITORS THE DRIVING ENVIRONMENT

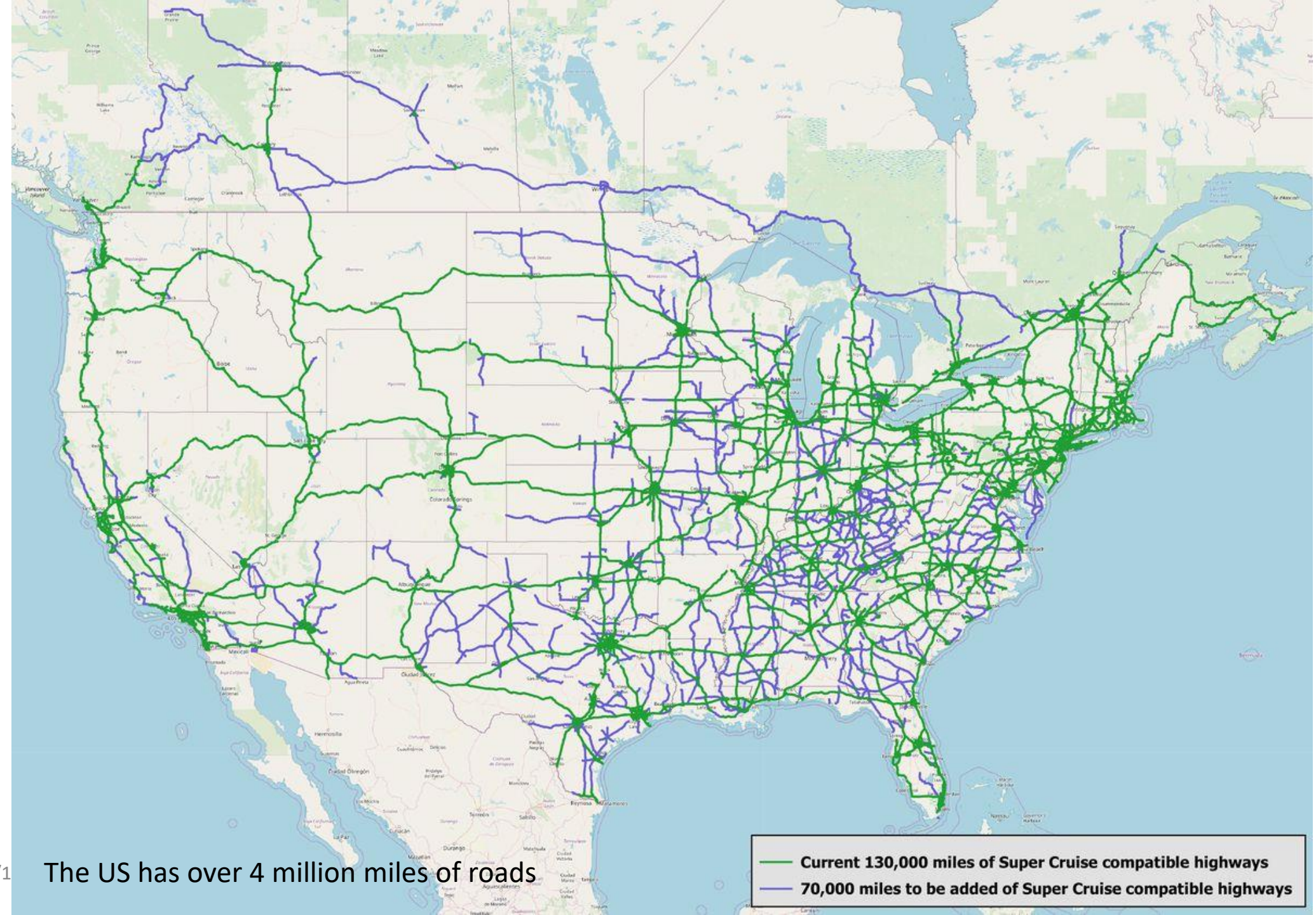
THE AUTOMATED SYSTEM MONITORS THE DRIVING ENVIRONMENT

Autonomous Car Timeline

- 2019: Driver-assistance features got more sophisticated, and could sync up with GPS and navigation. Commercial trucks were the first vehicles to hit the road autonomously.
- 2020: Cars equipped with semi-autonomous features are able to navigate through traffic lights and intersections and stop-and-go traffic, but still require a human to take over.
- 2021 – 2024: Semi-autonomous features should work in more conditions, like in rain and at night. But automakers working on tech are unlikely to spend time bringing it to city streets. They'll be more focused on enhancing long commutes.
- 2025 – 2030: Most cars are fully automated, sales will decline: More consumers will rely on ride-sharing, or may share a car with multiple owners.
- 2045 – All cars are automated, and none are likely to be owned personally, as everyone uses ride sharing services.

Who is the Closest to Automated Driving?

- The closest production car to that reality was to be the new Audi A8, equipped with the new Traffic Jam Pilot feature capable of navigating highway gridlock while you watched the morning news on the dashboard touchscreen. But regulatory hurdles forced Audi to sideline the system for U.S. shoppers, at least for now.
- Cadillac's Super Cruise hands-free adaptive cruise control system has been available since 2018 on CT6 models. Unlike other autonomous systems, the car only functions on certain mapped roads with lane markings in clear weather.
- Autopilot, Tesla's wide-reaching semi-autonomous driving system. Although Tesla bills it as a hands-on-the-wheel system, early versions allowed you to drive hands-free for extended periods of time. The automaker has since updated Autopilot's software on existing and new cars to deactivate itself if it senses drivers' hands are repeatedly off the wheel.
- All automakers who sell vehicles in the US have committed to having Automated Braking on all vehicles sold in 2022.



The US has over 4 million miles of roads

Primary Available Systems

- **Adaptive cruise control down to a stop:** This feature builds on basic adaptive cruise control, a decades-old feature that maintains a selectable distance between you and the car ahead. Adaptive cruise that works at *higher* speeds is widely available, but systems that function down to a full standstill are an important next step to manage bumper-to-bumper traffic.
- **Lane-centering steering:** This goes beyond lane-departure steering assist, which intervenes only as you approach or cross the lane markings — and often pinballs you back toward the *opposite* markings — to actively center the vehicle in its lane by tracking lane markings, the vehicle ahead or some combination of the two. Such systems can often negotiate mild curves, as well, but nearly all of them require you to keep your hands on the wheel, issuing warnings and eventually deactivating if they sense a lack of steering force after a short time.
- **Hands-free steering:** This centers the car *without* your hands on the wheel. For 2019, only two systems — Cadillac's Super Cruise and BMW's Extended Traffic Jam Assistant — do this. Both require you to pay attention, intuited via driver-facing cameras.

Carmakers with Level 2 Capability

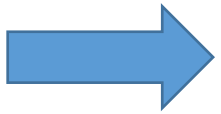
Capability	Acura	Audi	BMW	Buick	Cadillac	Chevrolet	Chrysler/Dodge	Ford	Honda	Hyundai	Infiniti	Jaguar	Jeep	Kia	Land Rover	Lexus	Lincoln	Maserati	Mazda	Mercedes	Mini	Mitsubishi	Nissan	Porsche	Subaru	Tesla	Toyota	Volkswagen	Volvo	Total
ACC to a stop	5	1	4	5	7	7	5	5	6	8	4	4	4	6	2	3	4		5	4	3	3	5	8	7		7	9		131
ACC and HF Steering	3	9	11		1			1	12	1	4	2		2	4	11	1	3		12			4	2		3	3		8	97

Adaptive Cruise Control down to a stop: 131 models across 30 automakers = 51%

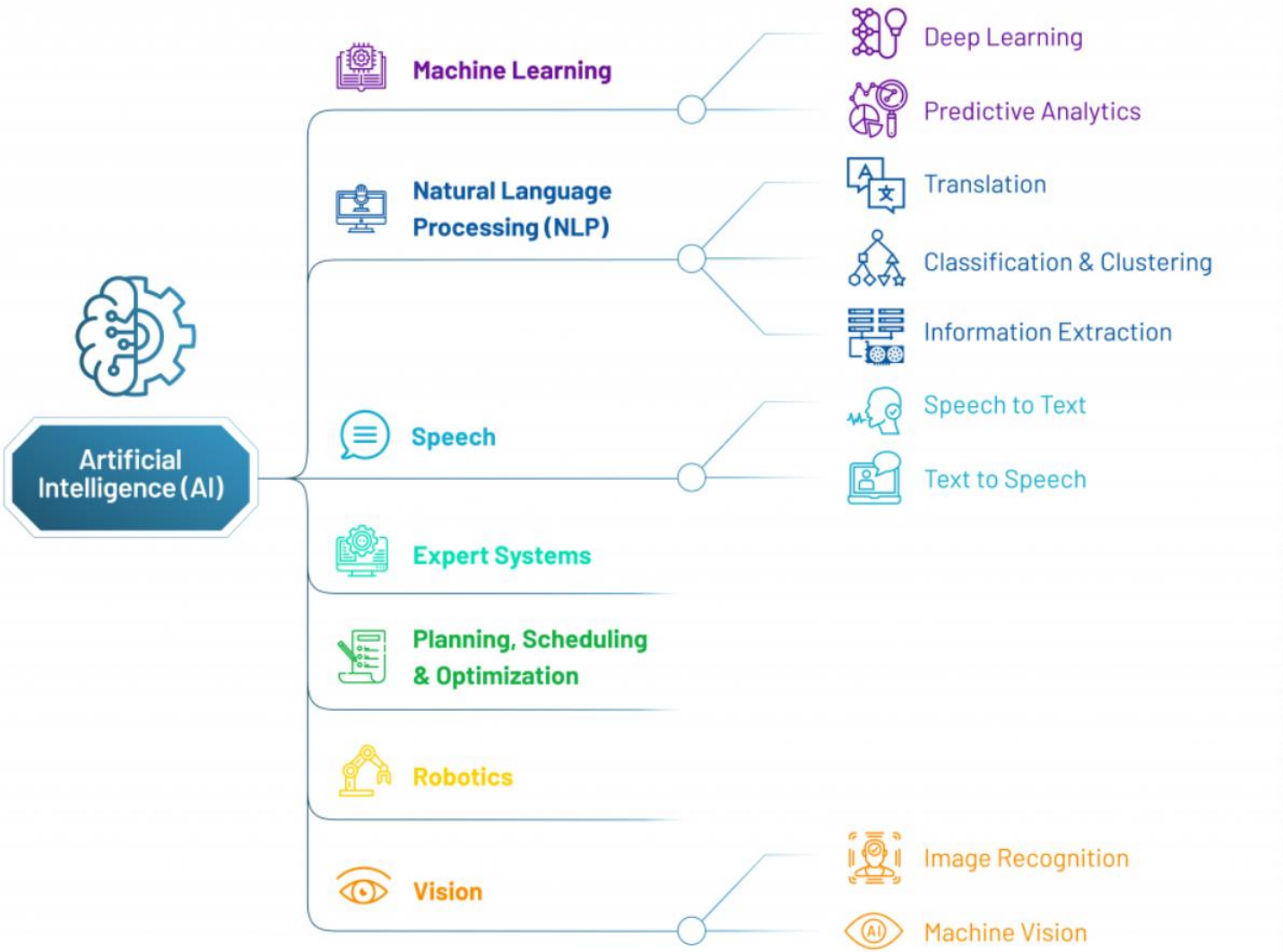
Lane-centering steering with ACC down to a stop: 97 models across 21 automakers = 38%

228 models out of the 257 models sold in the US = 89%

All automakers have committed to only producing cars with automatic braking by 2021



Vehicle Intelligence



Addressing Security

- Threats exist to identity, confidentiality, data and application integrity, intrusion for malicious intent, and disrupting continuity of service.
- In-vehicle software can have up to 100 million lines of code which executes on both the primary computer board(s) and 70-100 microprocessor-based electronic control units (ECUs) networked throughout the body of the car.
- Threats exist from both bad programming and the inability to test all possible software interactions.
- A large number of vehicles communicating to each other is essentially an ad-hoc, self-forming network of devices with no server-side security.
- As vehicle communications are new to automakers, understanding and protecting the systems are a major, ongoing priority.
- As with computers, as the vehicle ages, new threats will surface.

When will the OEMs go Electric?

- GM plans for 20 all-electric vehicles by 2023.
- Ford with 13 new models slated for release by 2023.
- Toyota and Mazda have no forecast.
- Mercedes-Benz - offering 50 electric and hybrid models by 2022.
- The Renault, Nissan and Mitsubishi alliance plan to release 12 all-electric models by 2022.
- Jaguar Land Rover plans to electrify its entire vehicle lineup by 2022.
- Volvo will electrify its entire vehicle line by 2022, with five all-electric models slated to roll out from 2019 to 2023.
- Volkswagen, Audi, and Porsche, plan to offer electric and hybrid versions of 300 vehicles by 2030.

The Electric Dilemma

The production and use of the lithium Ion battery for a car is estimated to produce only 20% less greenhouse gases than a diesel car produces over its lifetime.

If all cars in the US were electric, it would consume 25% more energy than we produce.

If California was to go all electric, it would have to install 100 charging station each week from now through 2050, and it would consume 50% more power then they produce.

Current Infrastructure Limitations

- According to the National League of Cities' research, only six percent of the U.S.'s largest cities' transportation plans include any language on the potential effect of driverless technology on mobility.
- In many states, only 20% of the roads are paved and marked well enough for an AV to navigate.
- The maintenance levels on most of the roadway infrastructure are based on human vision, not machine vision.
- The vehicle development is way ahead of the public policy.
- Self-driving cars vastly multiplies vehicle miles traveled in all studies.

Challenges

- The state of the art in machine intelligence is nowhere near adequate to take over driving in any road, weather or traffic condition.
- Vehicle vision systems have many limitations.
  - Simply speaking, the human eye is a *subjective device*. This means that your eyes work in harmony with your brain to create the images you perceive.
  - A camera, on the other hand, is an *absolute measurement device* — It is measuring the light that hits a series of sensor, but the sensor is 'dumb', and the signals recorded need to be adjusted to suit the color temperature of the light illuminating the scene.
- Only one autonomous vehicle has audio receivers – the rest are deaf.
  - Isolating the proximity and direction of another car blowing its horn in a chaotic audible environment is extremely difficult.
  - Determining if evasive action is necessary, and taking such evasive action, even if the car could determine a threat is extremely complex .
- No AV can "feel" rumble strips

Challenges, continued

- We must move from Reactive to Preventative Safety
  - All vehicle ADAS systems react to road, weather or traffic conditions
  - All autonomous vehicle sensors capture movement, changes, intersecting threats and react to avoid.
  - With vehicle communications, and the machine intelligence to process the information, the vehicle will know in advance of a potential problem and threat and can preventatively adjust speed, course, trajectory well in advance of the specific problem location.
  - Communications provide for and awareness of upcoming problems or potential problems in advance of sensor range.
  - This gives the vehicle more time to react, ability to focus sensors to likeliest threats, and process the data quicker, with substantially less hardware and software.

What is needed?

We need substantially better automatic braking system.

- A Study by the American Automobile Association (AAA) found that in the tests, at 30 miles an hour, none of the test vehicles avoided a collision with pedestrians.
- In daylight, the car traveling at 20 miles an hour avoided a collision with the pedestrian 40% of the time.
- When encountering a child darting from between two cars, with the vehicle traveling at 20 miles per hour, a collision occurred 89% of the time.
- At night, none of the systems detected the adult pedestrian.
- In the US, nearly 6,000 pedestrians lose their lives each year, accounting for 16% of all traffic deaths.

What is needed?

The world needs technical innovation to:

- Allow AVs to hear
- Allow AVs to ‘feel’ road variations
- Embed biometrics, passenger facing cameras and dialogical AI to monitor and interact with at-risk riders
- Faster machine intelligence to react to the items above
- Machine Intelligence to know how to interact with chaotic humans
- Much better and cheaper Vision/Radar/Sonar/LIDAR
- Test and validation methods for all aspects of the AV performance

Summary

- For all cars, connectivity will be a necessity.
- All automakers have some efforts underway to add levels of automation to their vehicles over time.
- Connectivity allows us to move from reactive safety to preventative safety.
- Given that there is no clear path forward, having OEMs with different strategies and implementation paths will bring about the broadest understanding of what works.
- Moving autonomous functions from dry, flat, well marked roads to those with varying road weather and traffic conditions is a monumental task and will take years.
- Charging infrastructure will not happen as fast as the OEMs plans, making ICE power plants dominant for years.

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