NORTH CAROLINA
Department of Transportation

Autonomous Vehicles Update

Kevin Lacy, PE, State Traffic Engineer

March 2022

Nomenclature -Connected

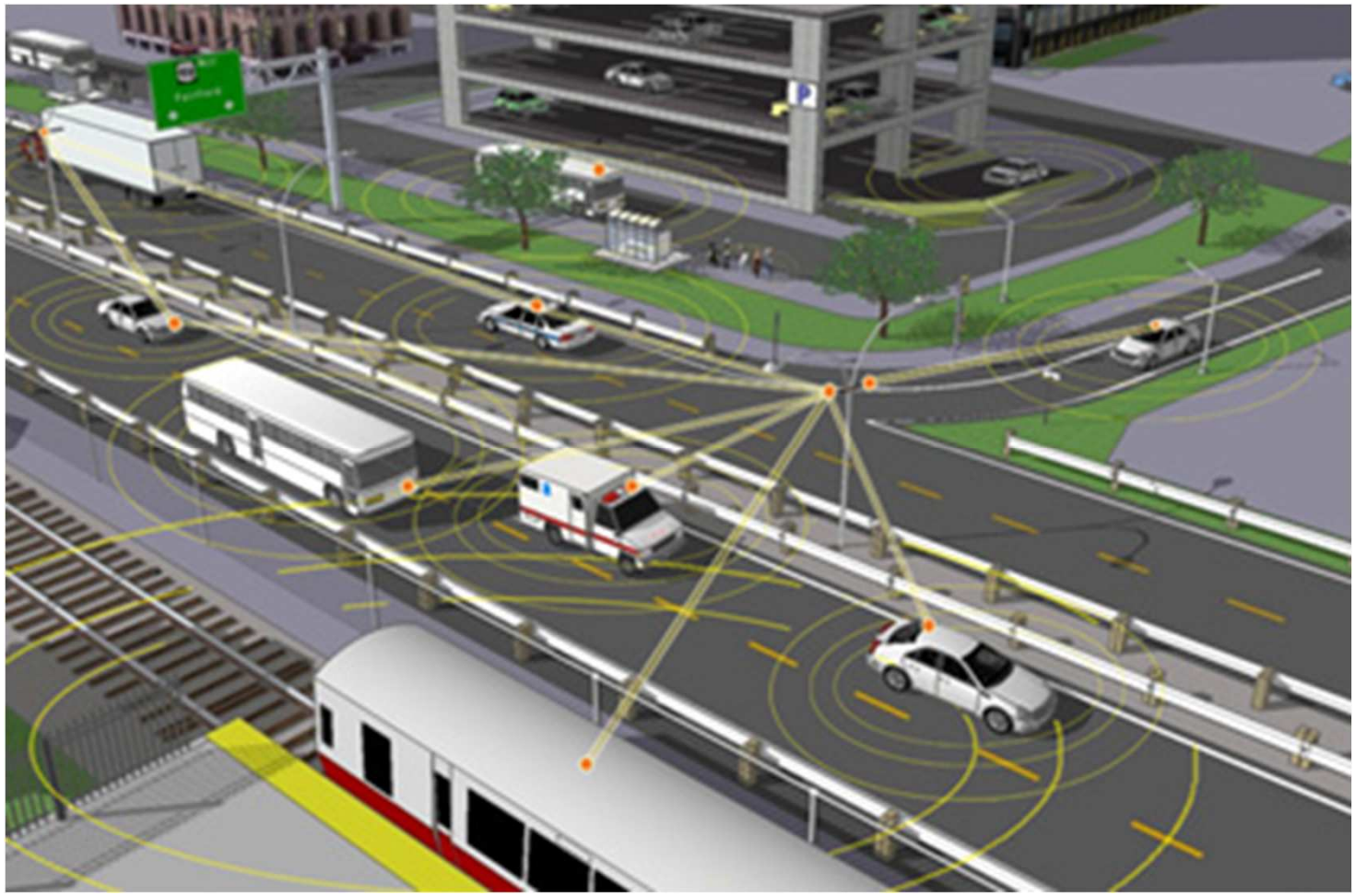


Image from www.networkworld.com

Vehicles Connected to:

Each other sending information to each other about speed, braking, other information needed to make decisions

To the Infrastructure to determine roadway conditions, signal condition, levels of congestion on various routes, much more

Nomenclature – Autonomous

https://www.ll.mit.edu/publications/imagespublications/urbanchallenge1.jpg

http://www.govtech.com/fs/Autonomous-Cars-Could-Increase-Drivership-11-Percent-Researchers-Estimate.html

http://si.wsj.net/public/resources/images/BN-MC635_0114dr_P_20160114143938.jpg

http://www.insurancejournal.com/news/national/2015/04/24/365573.htm

CAVE

Connected

Autonomous

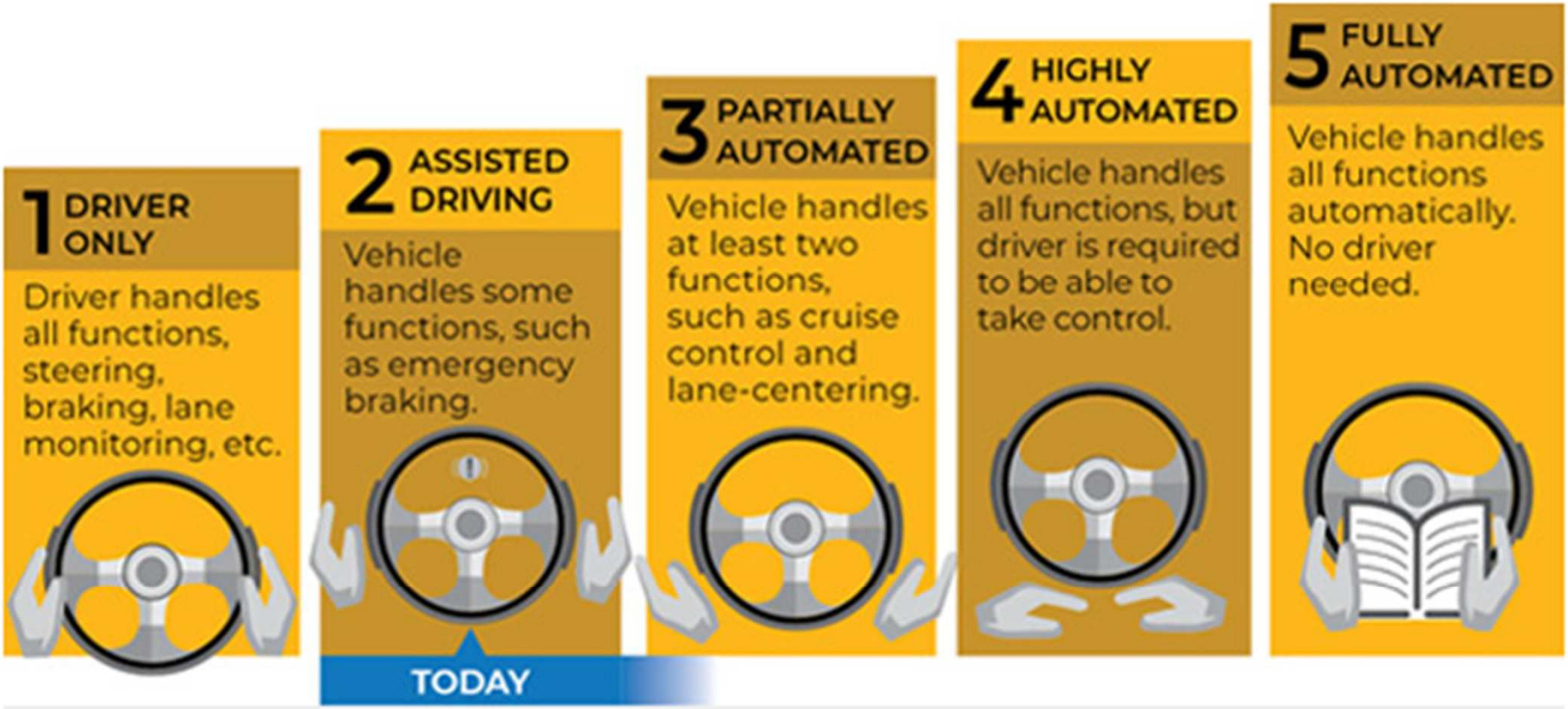
Vehicle

Electric

WAYMO vehicle

While Connected, Autonomous, and Electric are three different technologies; they can/are developing independently. HOWEVER, there is a lot of synergy with the three.

Nomenclature – Levels of Autonomy

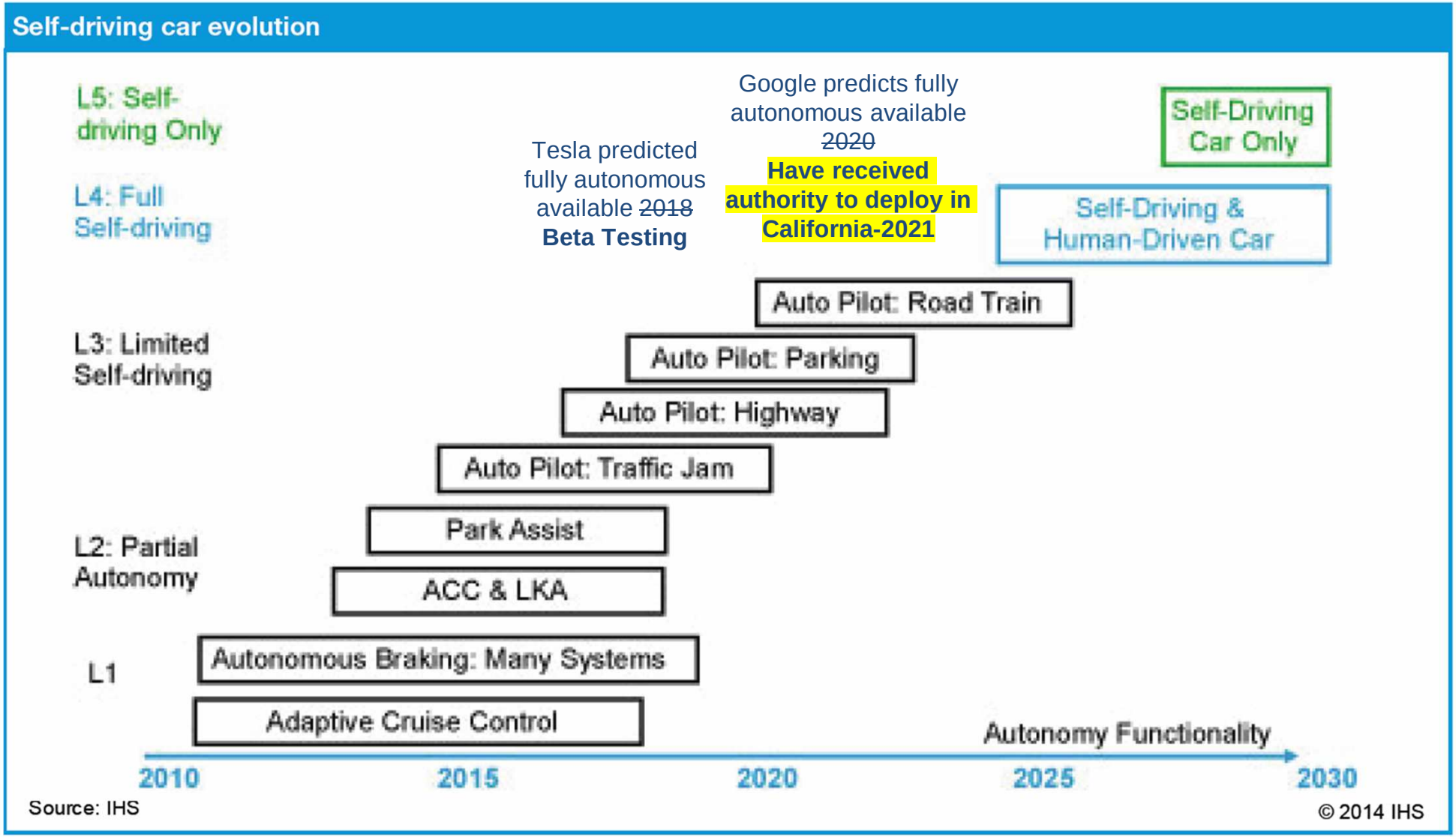


Levels of autonomy based on the Society of Automotive Engineers' (SAE International) guidelines.

https://www.ansys.com/blog/perception-algorithms-autonomous-vehicles

Levels of Automation-2022

When Will it Get Here?

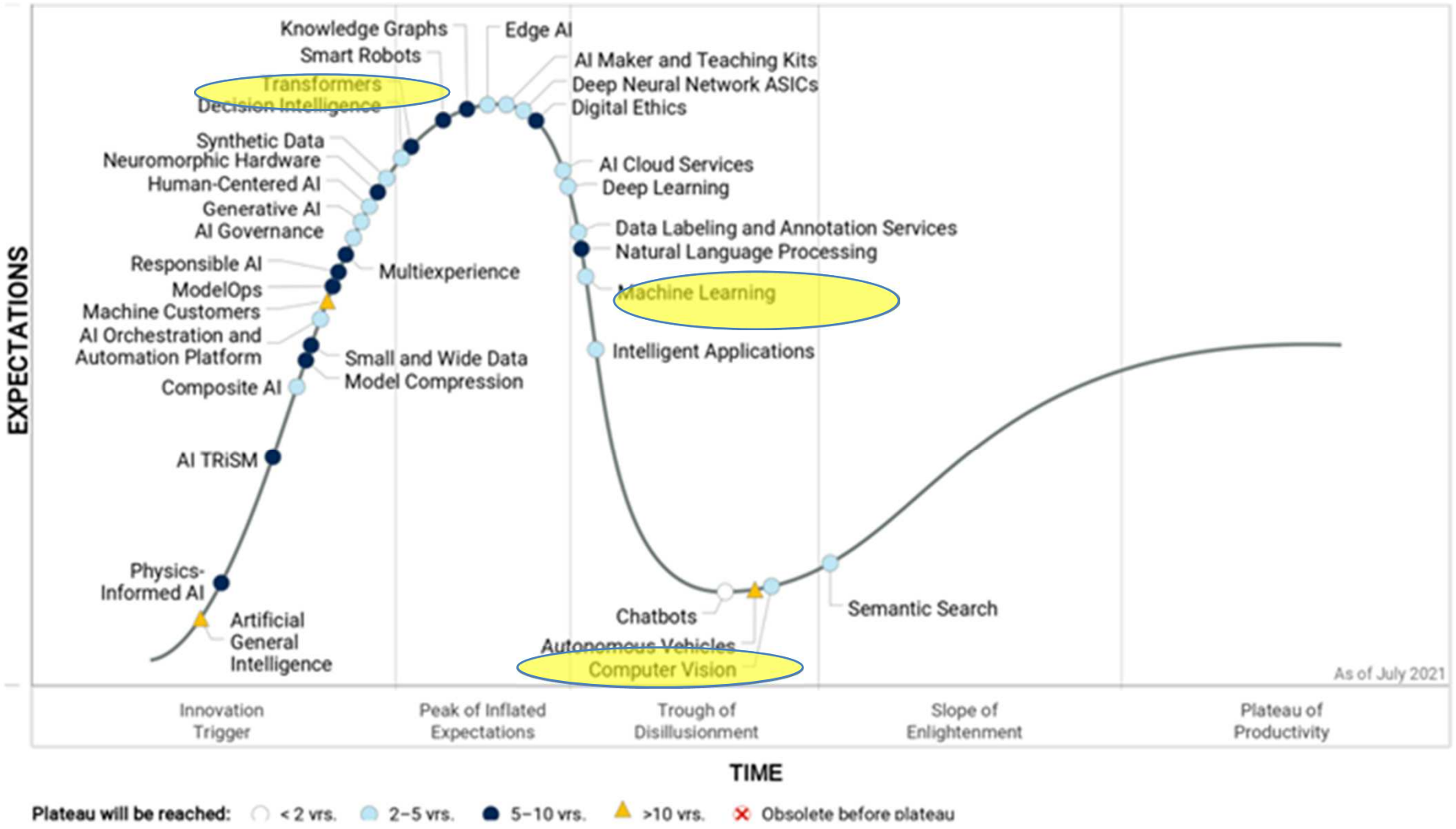


http://1.bp.blogspot.com/-68WQ4LKWiTg/VltzSFdmibI/AAAAAAABEwI/jvUXiYz1dyY/s1600/levelsofautonomy.png

Gartner Hype Cycle for Emerging Technologies, 2019

gartner.com/SmarterWithGartner

Gartner.


Knowledge Graphs
Smart Robots
Transformers
Decision Intelligence
Edge AI
AI Maker and Teaching Kits
Deep Neural Network ASICs
Digital Ethics
Synthetic Data
Neuromorphic Hardware
Human-Centered AI
Generative AI
AI Governance
AI Cloud Services
Deep Learning
Data Labeling and Annotation Services
Natural Language Processing
Machine Learning
Responsible AI
ModelOps
Machine Customers
AI Orchestration and Automation Platform
Multiexperience
Small and Wide Data
Model Compression
Intelligent Applications
Composite AI
AI TRiSM
Physics-Informed AI
Artificial General Intelligence
Chatbots
Autonomous Vehicles
Computer Vision
Semantic Search
As of July 2021
EXPECTATIONS
Innovation Trigger
Peak of Inflated Expectations
Trough of Disillusionment
Slope of Enlightenment
Plateau of Productivity
TIME
Plateau will be reached:
< 2 yrs.
2–5 yrs.
5–10 yrs.
>10 yrs.
Obsolete before plateau

Gartner

Some Big Questions

When will self driving vehicles (SDV) be reality?

When Will They Be Here?

Depends on meaning of “here”.

- If “Here” means you can purchase Lev 4 or 5 probably 10 years +/-
- If “Here” means you can use a Lev 4 or 5 in many major metro areas – say 5 years
- If “Here” means the proof of capability and technology, then “Here” has already arrived. This is no longer a technologic capability issue.

2020

Driverless Shuttle a Smart Move for Centennial Campus

https://news.ncsu.edu/2020/02/driverless-shuttle-a-smart-move-for-centennial-campus/

2021

cassi
Connected Autonomous Shuttle Supporting Innovation

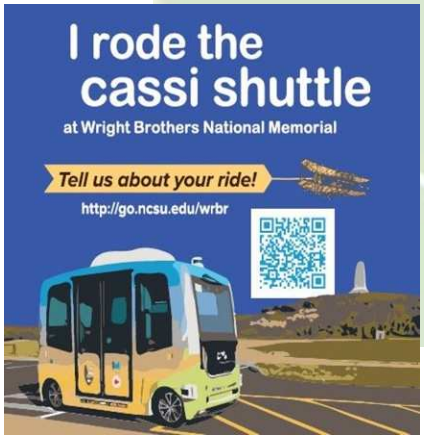
Dates: April 20-July 16, 2021, 13 weeks

Ridership: 3335 (with COVID capacity restrictions)

Length: 1.2 mi

Speed: 10-12 mph

Open to public



Survey responses: 364

Lessons Learned

Grass

Pedestrians and Machine Interaction

Geo Referencing

State Laws, Federal Laws,

Waymo's Experience

- 20+ million self-driven miles
- 15+ billion Simulated Miles
- 5 Generations of Self-Driving Vehicles
- Has operated in 9 States and DC (WA, CA, AZ, NV, NM, TX, GA, FL, MI
- Permitted for driverless deployment in California

Over 100,000 paid self driving rides in Las Vegas

Over 1.5 million miles traveled in highly congested, highly distracting, and mixed vehicle environment. This is more "real-world" experience than most drivers will achieve in a lifetime.

Tipping the Scale with Beta?

Elon Musk and Tesla have MOXIE

Tesla is putting 'self-driving' in the hands of drivers amid criticism the tech is not ready

https://www.washingtonpost.com/technology/2020/10/21/tesla-self-driving/

Tesla also has lawyers:

"As we have stated consistently, no vehicle available for purchase today is capable of driving itself. The most advanced vehicle technologies available for purchase today provide driver assistance and require a fully attentive human driver at all times performing the driving task and monitoring the surrounding environment. Abusing these technologies is, at a minimum, distracted driving. Every State in the Nation holds the driver responsible for the safe operation of the vehicle."

What about trucks?

https://www.youtube.com/watch?v=ffNHS96LdCI

Trucking is a very Active Mode

TuSimple https://www.youtube.com/watch?v=dGglN4J9zZ0

Aurora https://www.youtube.com/watch?v=TxrVgKqqm6A

Volvo https://www.youtube.com/watch?v=2Gc1zz5bl8I

Gatik and Walmart https://youtu.be/Br1vU2Xcr-o

There are others

Barriers

Technology is not a barrier to this technology. The industry has demonstrated **it will produce a machine that will drive**

…

IF…

Legislative and Regulation Barriers

In Feb 2022 a congressional hearing was held on autonomy in the transportation industry.

My impression of the 45 minutes I watched was not encouraging. Labor Unions are not supportive – they say they support driver assist technology that will help good union jobs. But are very weary of the technology without a person, or union person.

Congress can and the federal government can be a major impediment to this technology in the United States. It will only mean other countries will reap the benefits before the US.

Legislative and Regulation Barriers

I suspect that we will hear conversations about limited the use of the technology due to safety concerns.

Even if the machine can outperform the human driver.

This may create a Roles and Responsibility conflict between Federal and State Government. Historically the Federal Government regulated the vehicle and the States regulated the drivers. What happens when the operator is not a human but a machine that is not necessarily specific to that vehicle?

US Regs Apply Here

Companies' competitiveness in self-driving patents

Ranking Jan. 2021 (July 2018)	Company (Country)	Competitiveness score	Number of patents in force
1 (4)	Ford Motor (U.S.)	6,054	1,195
2 (2)	Toyota Motor (Japan)	5,349	1,705
3 (1)	Waymo (U.S.)	4,895	582
4 (3)	General Motors (U.S.)	3,193	678
5 (16)	State Farm Mutual Automobile Insurance (U.S.)	1,958	231
6 (6)	Bosch (Germany)	1,952	512
7 (8)	Denso (Japan)	1,872	509
8 (9)	Honda Motor (Japan)	1,791	1,006
9 (5)	Nissan Motor (Japan)	1,704	351
10 (19)	Mobileye (Israel)	1,587	155

Source: Compiled by Nikkei based on a survey by Patent Result

These are global companies working on this technology. Based on this table of patents, the US and our companies are leading. But Japan and Germany close.

If Will Happen

Overall rank	Country	Total score	Policy and legislation		Technology & innovation		Infrastructure		Consumer acceptance	
			Rank	Score	Rank	Score	Rank	Score	Rank	Score
1	The Netherlands	27.73	3	7.89	4	5.46	1	7.89	2	6.49
2	Singapore	26.08	1	8.49	8	4.26	2	6.72	1	6.63
3	United States	24.75	10	6.38	1	6.97	7	5.84	4	5.56
4	Sweden	24.73	8	6.83	2	6.44	6	6.04	6	5.41
5	United Kingdom	23.99	4	7.55	5	5.28	10	5.31	3	5.84
6	Germany	22.74	5	7.33	3	6.15	12	5.17	12	4.09
7	Canada	22.61	7	7.12	6	4.97	11	5.22	7	5.30
8	United Arab Emirates	20.89	6	7.26	14	2.71	5	6.12	8	4.79
9	New Zealand	20.75	2	7.92	12	3.26	16	4.14	5	5.43
10	South Korea	20.71	14	5.78	9	4.24	4	6.32	11	4.38
11	Japan	20.28	12	5.93	7	4.79	3	6.55	16	3.01
12	Austria	20.00	9	6.73	11	3.69	8	5.66	13	3.91
13	France	19.44	13	5.92	10	4.03	13	4.94	10	4.55
14	Australia	19.40	11	6.01	13	3.18	9	5.43	9	4.78
15	Spain	14.58	15	4.95	16	2.21	14	4.69	17	2.72
16	China	13.94	16	4.38	15	2.25	15	4.18	15	3.13
17	Brazil	7.17	20	0.93	18	0.86	19	1.89	14	3.49
18	Russia	7.09	17	2.58	20	0.52	20	1.64	18	2.35
19	Mexico	6.51	19	1.16	17	1.01	17	2.34	19	2.00
20	India	6.14	18	1.41	19	0.54	18	2.28	20	1.91

This chart shows the other Countries working in this space. If our government decides to slow it down, or create barriers, it will just move the $$ and focus else where.

Public Acceptance

This is still a very large unknown.

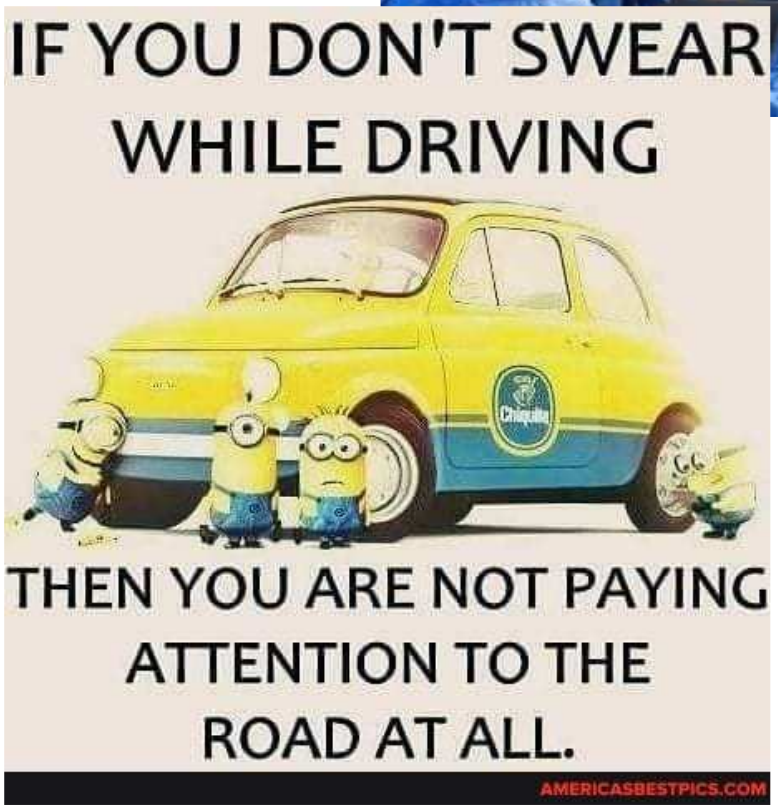
The last chart showed we had a high consumer acceptance.

This is one of the key values of pilot projects such a CASSI and other limited deployment.

Just watch other drivers, recognize the thousands of crashes that occur weekly.

Drivers are clearly telling us that they wish to do something else other than drive the car.

Distracted, Inattentive Drivers



What Else is Happening

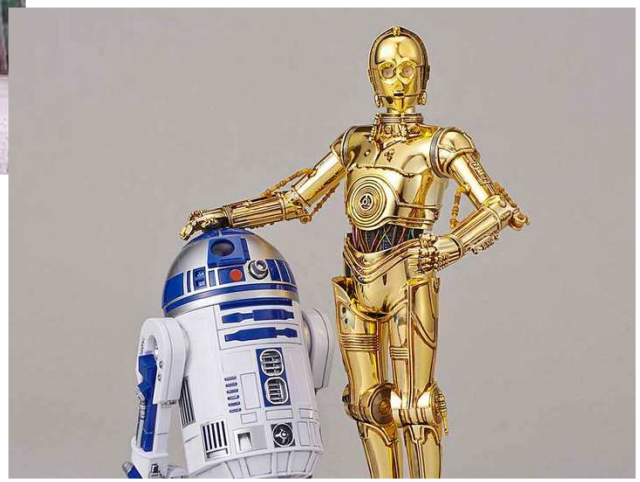
Port and Wearhouse Automation

Personal Delivery Devices

Neighborhood Occupantless Vehicles

What else is happening in this Space land-based automation?

Personal Delivery Devices –It is a self driving device that can deliver items without a person operating the device.



PDD

State Law 20-175.15

- Always Monitored
- Allowed on side walks must operate less than 10 mph
- Cannot operate on a highway unless there is not a sidewalk. Then must stay to the extreme right, yield ROW to all other vehicles, limited to 35 mph roadways with a Op Speed no greater than 20 mph.
- Must always yield to all human pedestrians
- Cannot unreasonably interfere with vehicles or pedestrians
- Unlit 12/1/22 a local government cannot prohibit their use – they can limit time and place but not outright prohibit. After 12/1/22 they can outright prohibit.

Zero Occupant Vehicle

Neighborhood Occupantless Vehicle – a small vehicle designed for no passengers and designed to be operated exclusively by an automated driving system

Zero Occupant Vehicle

Allows operation on certain roads and conditions:

- only on streets and highways where the posted speed limit is 45 miles per hour or less.
- must be operated in the right-hand travel lane or as close as practicable to the right-hand curb or edge of the street or highway, except when preparing for a left turn.
- On a highway with two travel lanes, the operator of the neighborhood occupantless vehicle must turn off the roadway to a controlled stop as soon as practicable and when it is safe to do so to allow faster moving vehicles to pass when passing is unsafe because of traffic in the opposite direction or other conditions and there are five or more vehicles immediately behind the neighborhood occupantless vehicle.

Operator Defined. – For the purposes of this section, an "operator" is a person that enables or controls, or is responsible for enabling or controlling, with or without remote support, the operation of a neighborhood occupantless vehicle.

Many other Activities

Numerous Research Projects

More Pilots

More Clarity

More Uncertainty

Updating the Roadmap – Strategic Plan

For More Information Contact:

Kevin Lacy, PE

jklacy1@ncdot.gov

http://www.ncav.org/