Nothing Compares
NORTH CAROLINA

2016 Highway Safety Symposium

Autonomous Vehicles

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Nomenclature – Connected Vehicles

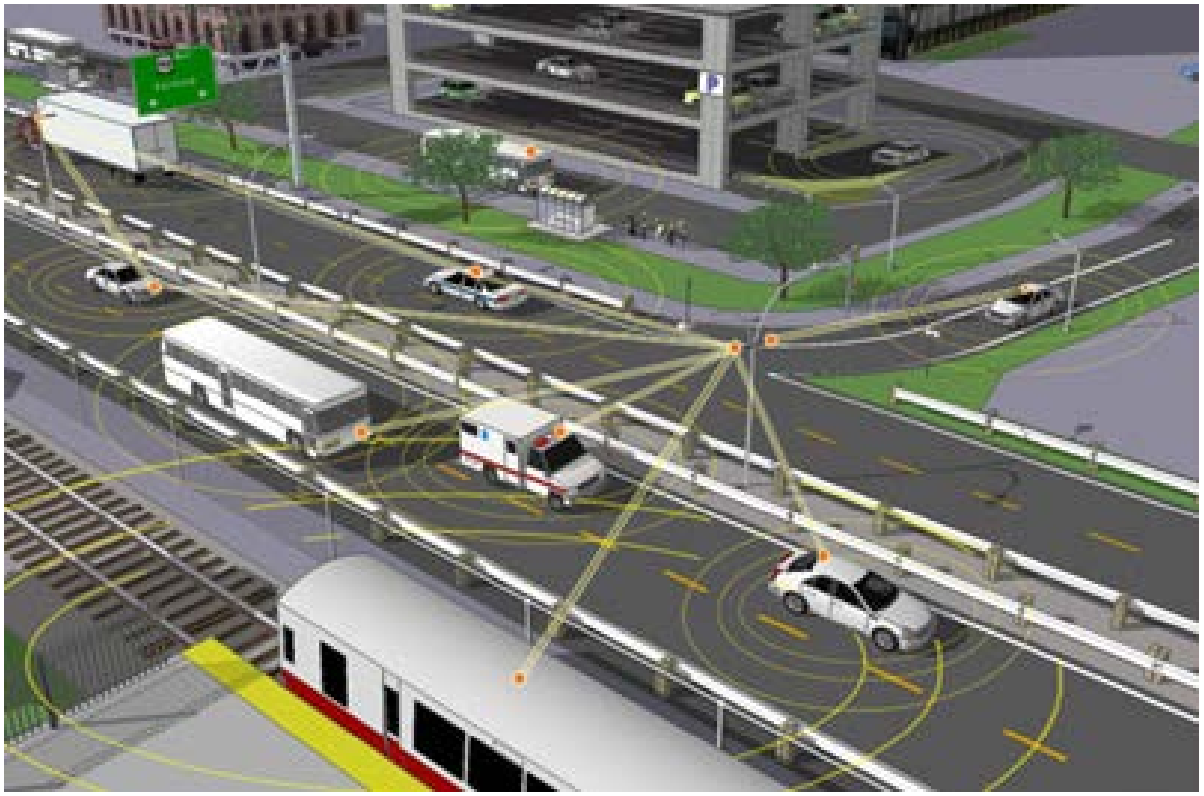


Image from www.networkworld.com

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

NHTSA working on proposed rules to new vehicles to have communication equipment. The rule is expected in 2016, we should expect some time lag in the requirement to allow automakers sufficient time to react.

Nomenclature – Autonomous

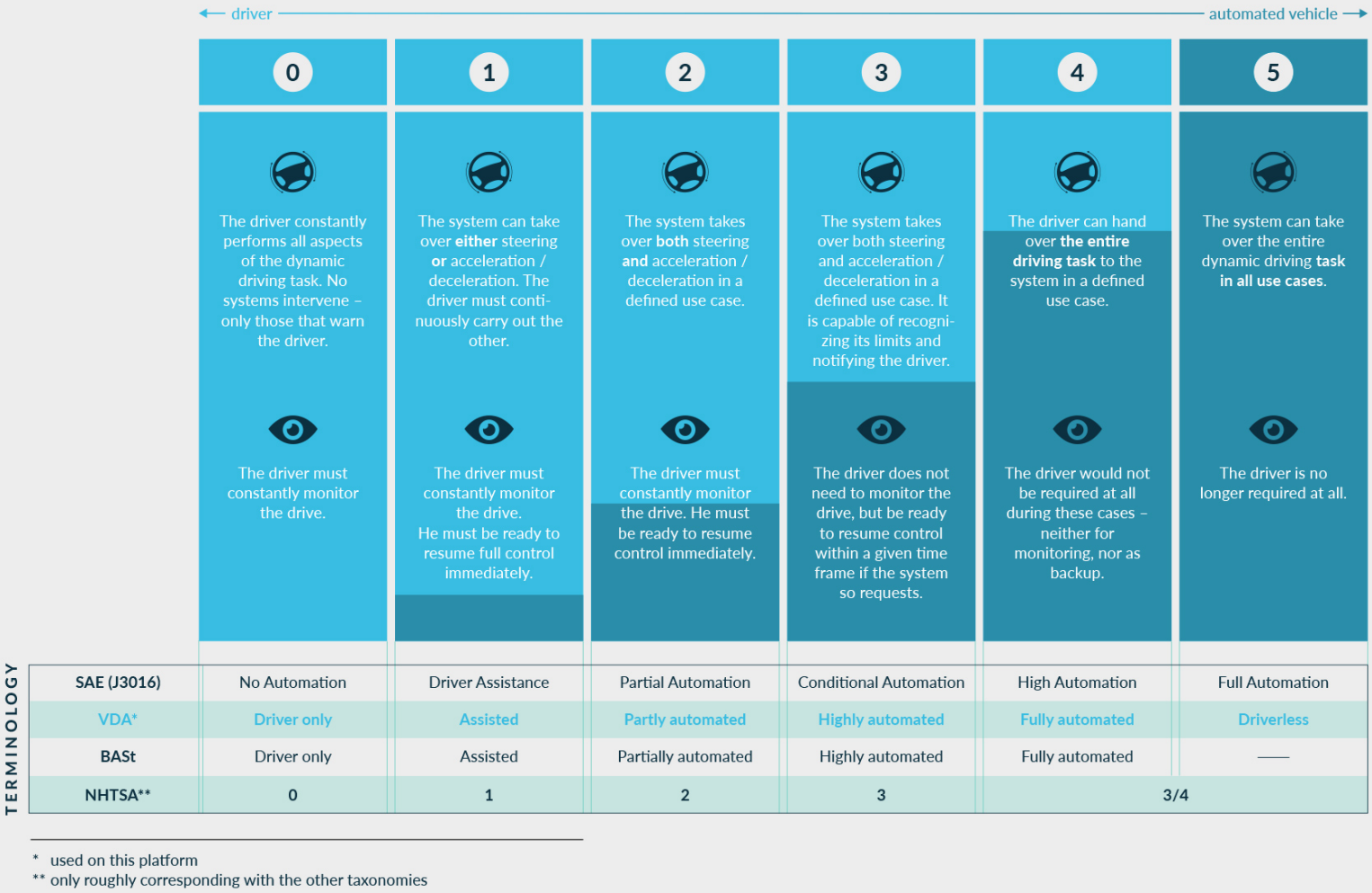
https://www.ll.mit.edu/publications/imagespublications/urbanchallenge1.jpg

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

Nomenclature – Levels of Autonomy



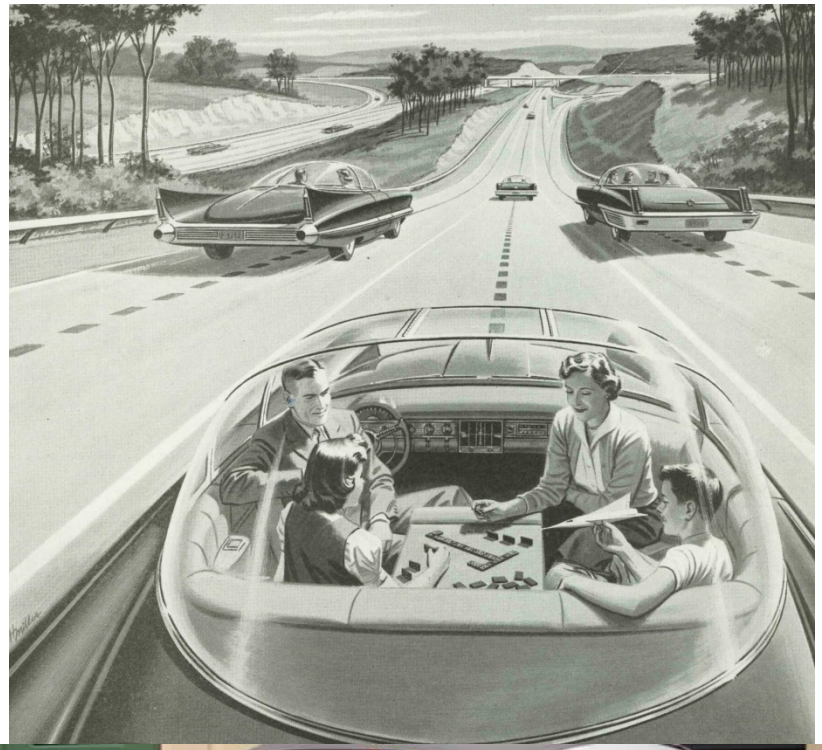
TERMINOLOGY

SAE (J3016)	No Automation	Driver Assistance	Partial Automation	Conditional Automation	High Automation	Full Automation
VDA*	Driver only	Assisted	Partly automated	Highly automated	Fully automated	Driverless
BASt	Driver only	Assisted	Partially automated	Highly automated	Fully automated	——
NHTSA**	0	1	2	3	3/4	

* used on this platform
** only roughly corresponding with the other taxonomies

https://www.2025ad.com/fileadmin/user_upload/Evergreen/Technology/Levels_of_Automation/Levels_Grafik_Lightbox.jpg

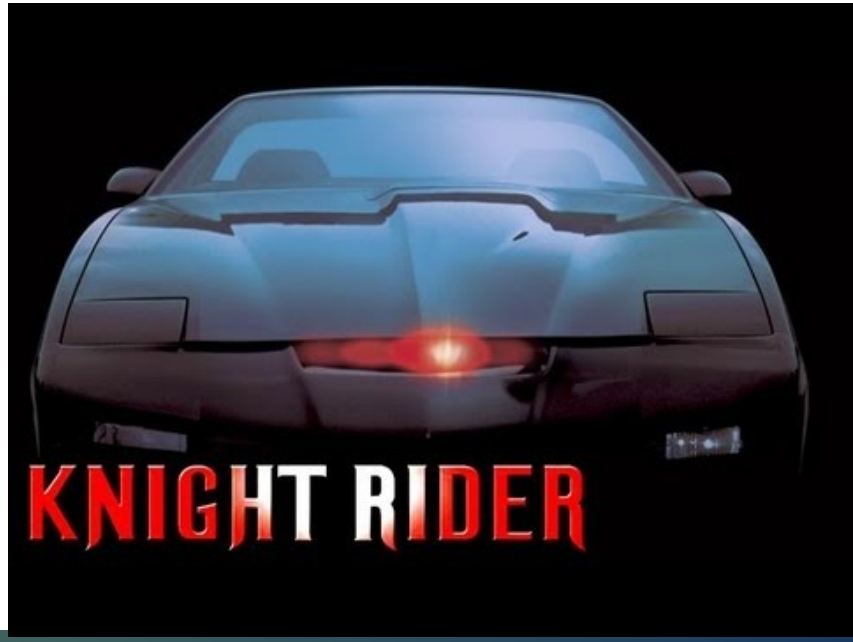
Autonomous Vehicles Not a New Concept



1957 Advertisement about electricity and electronics.

Herbie the Love Bug from the 1968 Disney Shows.

Knight Rider series in the 80's



Some forms of "Automation" and "Connectivity" have been around

Cruise Control invented in the late 40's became available as an option on many cars in 70's

Windshield Wipers

- Intermittent wiper invented in 60's (a form of automation for comfort and convenience)
- Automatic Wipers in 80's because of the inconveniences of turning on the wipers and judging the best speed of the wipers.

Automatic headlights 60's more common in the 80's

Lane Departure Warning and Lane Keep Assist (LKA) – beginning development in 1992 on the market in 2001 in Japan, 2004 in the US

Parking Assist developed in the late 90's, on the market in Japan early 2000's, USA and Europe 2009

Some forms of "Automation" and "Connectivity" have been around

Adaptive Cruise Control – Development as early as 1992 warning only; 1997 Controlling throttle; 2006 speed and distance control available.

Others Blind Spot Information Systems – 2007 with the first counter steering controls in 2010

Connectivity

- Cell phones
- Navigation
- Traffic Conditions via phone, internet and mapping Apps
- Phone Apps for intravehicular communication WAVES, Gas Buddies
- ** No routinely available communications that cause an action of the vehicle without driver intervention … yet.
- Auto pilot Road Trains – demonstrated
- Other vehicle to infrastructure communications testing in various sites; smart city grant opportunities to promote

Autonomous feature available today

BMW, Lexus, and Mercedes-- Safety and convenience features like automatic cruise control, automatic parking, lane keeping and automatic braking using radar, cameras and other sensors.

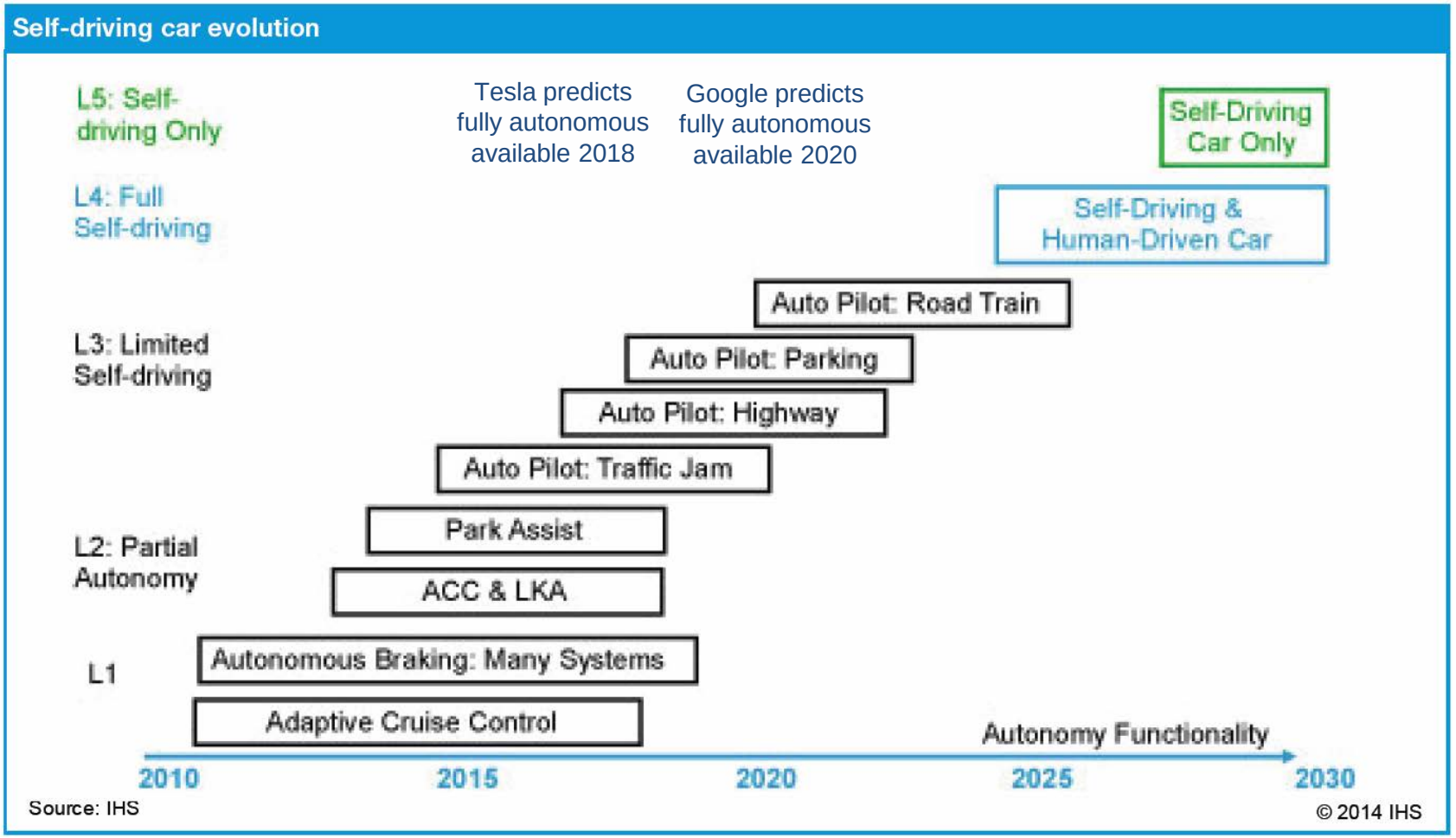
Tesla – Autopilot feature include lane keeping, automatic breaking, automatic cruise control, blind spot detection, using forward facing sonar and camera, with ultrasonic sensor monitoring the space 360 degrees around the car.

General Motors – “Super cruise” available 2017

Audi – “Traffic Jam Assist “ that can self drive in stop and go traffic up to 40 mph.

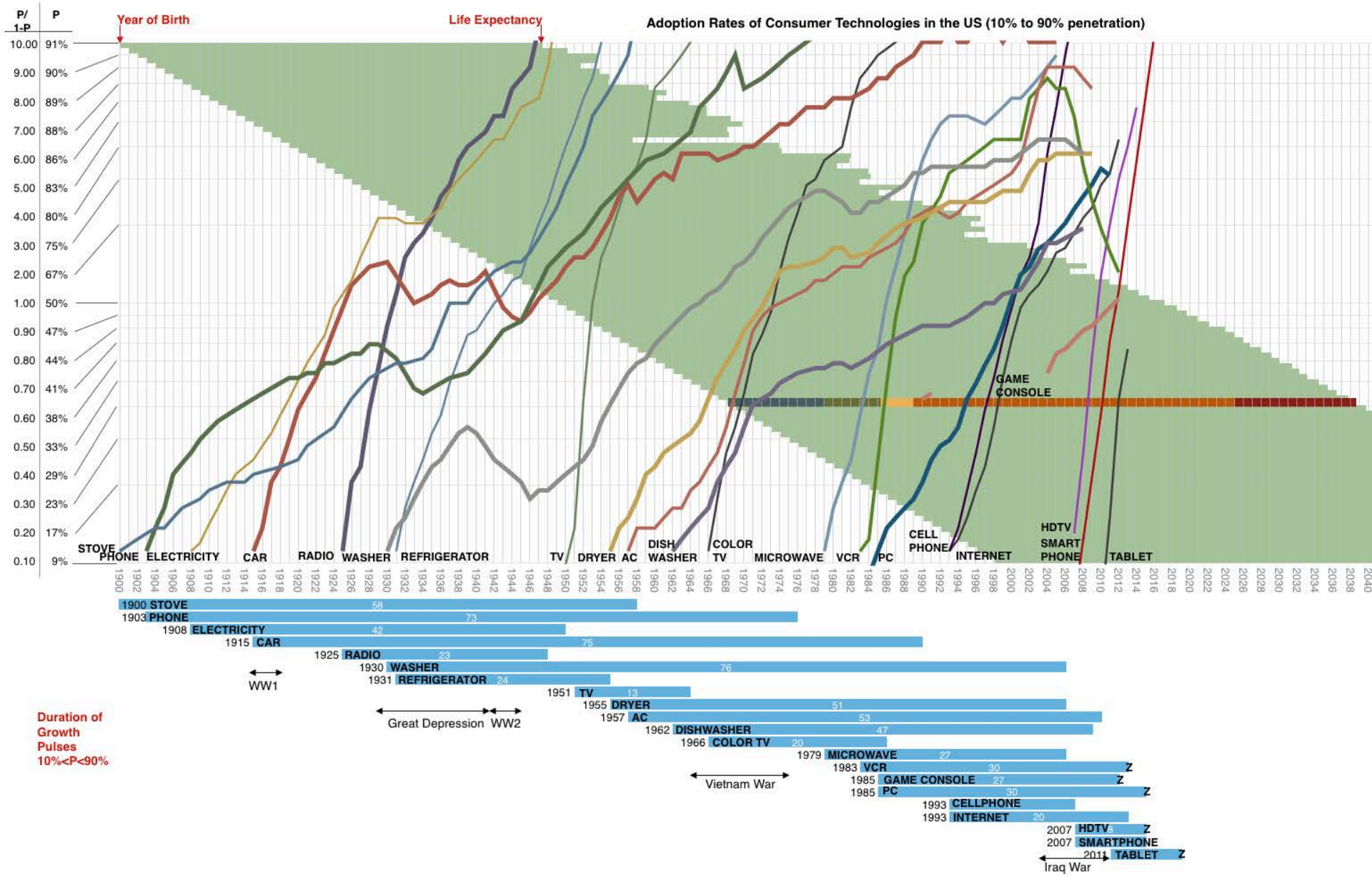
Google – proposing to remove all driver interfaces not steering wheel, brake or accelerator.

Nomenclature – Levels of Autonomy



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

Rate of Adoption of Technology



Rate of Adoption of Technology

Technology	Years to 90% Adoption in US	Percent Adoption per year	Barriers to Adoption Rate	Benefited Rate of Adoption
Automobiles	75	1.2	Infrastructure, Manufacturing, cost	Tax Dollars/Fees Funded infrastructure expansion
Electricity	42	2.1	Infrastructure, Production	Tax Dollars/Fees Funded infrastructure expansion
Telephone	73	1.2	Infrastructure	Tax Dollars/Fees Funded infrastructure expansion
Radio	23	3.9		Widespread Distribution from single place
Television	13	6.9		Widespread Distribution from single place
Cable/Pay TV	Introduced in the early 1960's never achieved 90%, grew at a rate of 1.8 per year		Infrastructure, cost, competition	
Cell phone	14	6.4	Infrastructure, cost	Widespread Distribution from single place
Internet	20	4.5		Initial Infrastructure in place (Telephone & Cable)
Smartphone	3	30.0		infrastructure in place, cell phones
Clothes Washer	76	1.2	Cost	
Air Conditioning	53	1.7	Cost	
Stove	58	1.6	Cost	
Microwave	27	3.3		
Connected Vehicle	?	Maybe Never	The "connected" part of the infrastructure	
Autonomous Vehicle	?	likely quicker than we expect		Infrastructure in place, manufacturing in place, computer technologies mature at a much faster pace

This chart was primarily ownership or equipped, when we talk about autonomous vehicles, there is a chance we will never see 90% ownership. Considering how the transportation on demand concept (Uber, Lyft, etc.) is growing at a very rapid pace, we may be looking at a 90 % utilization as the measure of adoption.

Some Potential Barriers

Government – For now, government seems to be encouraging. However, there is a heavy investment in connected vehicles with the hope this may help autonomous. Are we pouring money in the betamax of future vehicles?

Cost – The technology is very expensive and to take full control of a vehicle it will even be more costly. The cost to retrofit the infrastructure for the "connected" portion is tremendous. The cost to install will be trivial when compared to the cost to maintain and keep up with the change in technology.

Public Acceptance – Will the public be willing to give up the control? Driving is a favorite pastime, think road trips, and racing.

Public Acceptance – Will the public be willing to TRUST the machines? Will the public trust the security? We all know some one who had something hacked. An Example from the past, the elevator was around before 200 B.C., not trusted for passengers until 1850's, automatic elevators invented in the 1920's, became more common in the 1930's there are still manual elevator operators.

What does this mean for NCDOT?

We have more questions than answers.

Road Maintenance – More emphasis on markings and we may need to mark roads we currently do not mark. More emphasis on technology especially if the infrastructure to vehicle connectivity concepts matures and becomes a requirement. May require new services to be provided an example is pavement “finger print”, or providing navigational aides for work areas.

Transportation Facilities – What impact will AV have on traffic volumes? Some say it will reduce volumes by simplifying car pooling and making car pooling more convenient. Others say it will increase traffic volumes because there will be empty trips, the AV traveling empty to pick up the next trip or traveling to a staging. How do we consider this in the transportation planning realm?

What does this mean for NCDOT?

Driver Licenses – Will there be a need to have licensed drivers? Maybe the autonomous vehicle and / or the software is “licensed”. If so, who provides that USDOT, or each state?

Vehicle Registration – Will it increase or decrease?

Public Transportation – It too will likely be transformed but how? Will there be smaller vehicles that provide door to door services? Will there be a demand for the large buses? What about intra city public transit? Will large mass transit system become more or less cost competitive? increase or decrease?

Freight Movement – Will we allow trucks to move without drivers? Will companies want trucks to move without someone providing security? What about Hazardous material?

What are we doing to prepare for Autonomous Vehicles?

NCDOT has started a comprehensive study to look at this issue holistically from the State perspective.

Commissioner Thomas, Hope Mozingo and Kevin Lacy are leading the study with steering committee representation from other state agencies, and stakeholders.

The primary purpose is to review our state laws, policies, etc. to determine what do we need to start working on to prepare for this change. We want to encourage the development and research to occur in our state.

Some of the areas discussed in addition to DOT items are:

Insurance, Tort, Law Enforcement, Privacy Concerns, Vehicle Regulations

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Two Key Project Objectives and Deliverables Include:

1) Assess the Department and the State's current conditions with regard to autonomous vehicle (AV) testing and operations for the immediate term, medium term, and long term. These conditions include:

- Vehicle Code
- Liability/Tort
- Road owners (NCDOT and municipality) operations and maintenance
- Surface transportation planning (metropolitan planning organizations, municipalities, and NCDOT)
- University Research and Development
- Industrial research, development, and collaboration
- Regional (e.g., multi-state) coalitions and efforts

2) Provide road map of near-term action items for NCDOT and other key State agencies. Provide guidance recommendations for other stakeholders. Provide forecast of key exogenous milestones and issues that may impact North Carolina autonomous vehicle readiness and deployment.

What are we doing to prepare for Autonomous Vehicles?

Stakeholders include:

Department of Transportation including DMV, GHSP, DOH, Others

Department of Insurance,

Attorney General's Office

Universities – NCSU-ITRE; UNC-HSRC

Trucking Association

Manufacture Reps,

Data Management Reps,

NC Division of Blind,

Law Enforcement (Local and State)