
Road Vehicle Automation: Let's Get Real

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Outline

- **Diversity of automation levels**
- **The safety challenges**
- **Rates of change in vehicles and infrastructure**
- **When may some of these capabilities become available?**
- **How should we prepare?**
- ***Don't believe what you read (on this topic) in the media***

Taxonomy of Levels of Automation

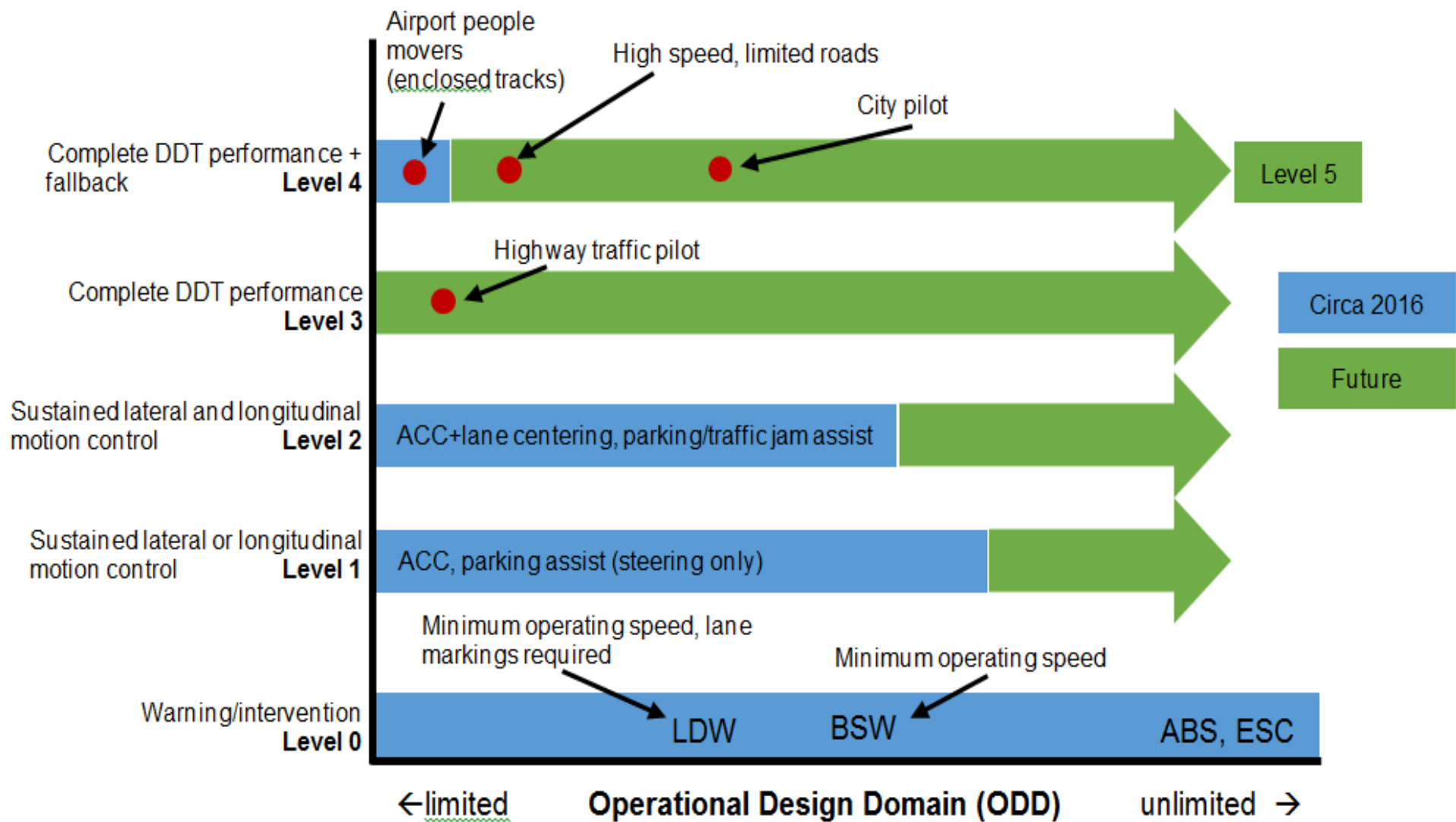
Driving automation systems are categorized into levels based on:

1. Whether the driving automation system performs *either* the longitudinal *or* the lateral vehicle motion control subtask of the dynamic driving task (DDT).
2. Whether the driving automation system performs *both* the longitudinal and the lateral vehicle motion control subtasks of the DDT simultaneously.
3. Whether the driving automation system *also* performs object and event detection and response.
4. Whether the driving automation system *also* performs DDT fallback.
5. Whether the driving automation system can drive everywhere or is limited by an operational design domain (ODD).

Example Systems at Each Automation Level

(based on SAE J3016 - http://standards.sae.org/j3016_201609/)

Level	Example Systems	Driver Roles
1	Adaptive Cruise Control OR Lane Keeping Assistance	Must drive <u>other</u> function and monitor driving environment
2	Adaptive Cruise Control AND Lane Keeping Assistance Traffic Jam Assist (Mercedes, Tesla, Infiniti, Volvo...) Parking with external supervision	Must monitor driving environment (system nags driver to try to ensure it)
3	Traffic Jam Pilot	May read a book, text, or web surf, but be prepared to intervene when needed
4	Highway driving pilot Closed campus “driverless” shuttle “Driverless” valet parking in garage	May sleep, and system can revert to minimum risk condition if needed
5	Ubiquitous automated taxi Ubiquitous car-share repositioning	Can operate anywhere with no drivers needed

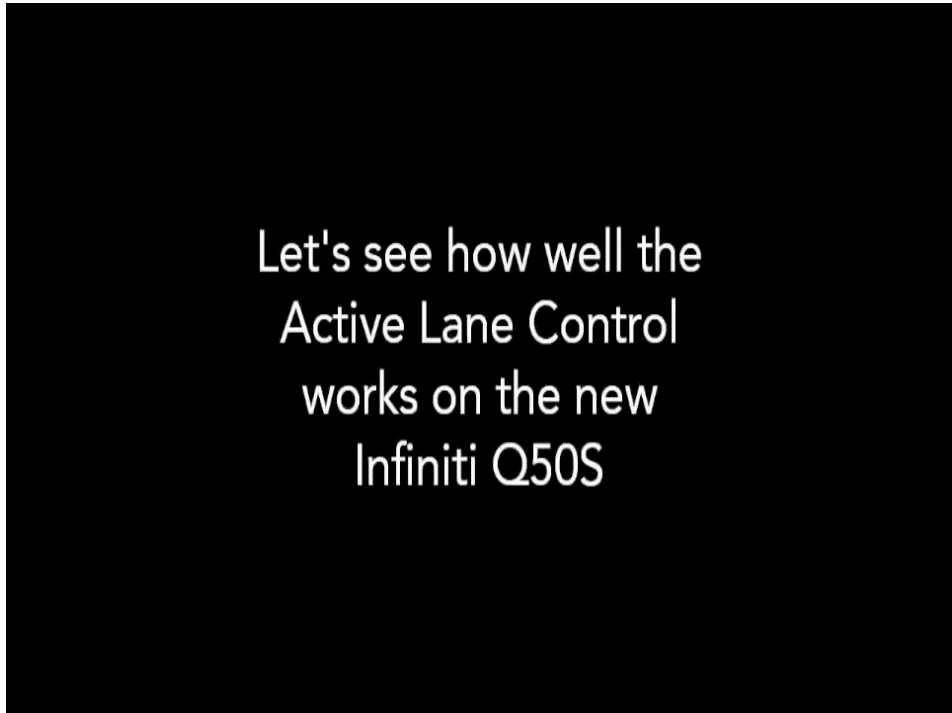


Intentional Mis-Uses of Level 2 Systems by ordinary drivers

Mercedes S-Class



Infiniti Q50

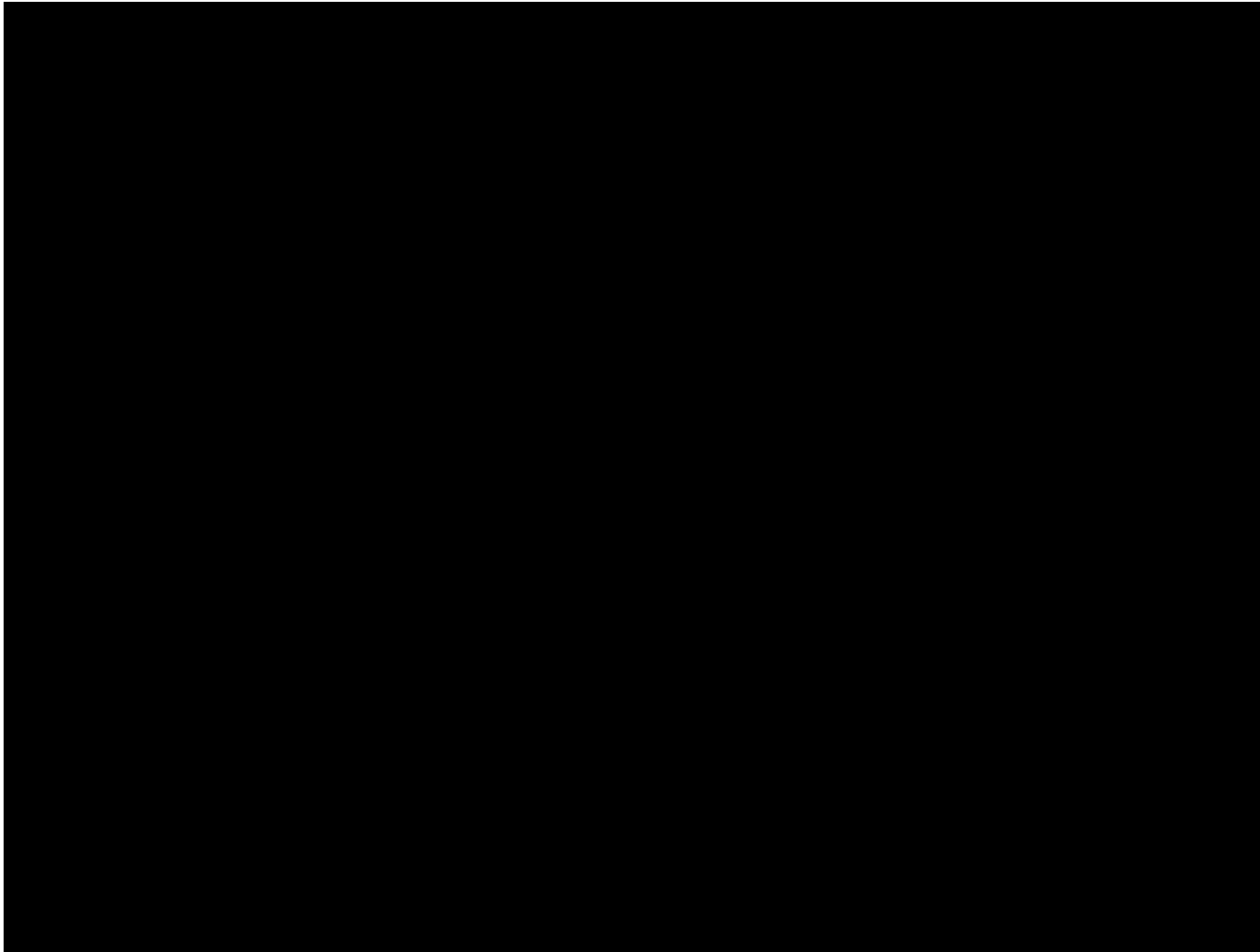


PATH Automated Platoon – 1997 Demo (Level 4 automation in protected lane)



CityMobil2 La Rochelle Demo 2015

Level 4 Urban Shuttle, Infrastructure Protection



Limited Pace of Change in Transportation

- **Consider useful lifetimes of investments in:**
 - **Roadway infrastructure – decades**
 - **Vehicles – years**
 - **Personal electronics – months**

- **Essential differences:**
 - **Capital intensity**
 - **Safety criticality**
 - **Cost of making (and fixing) a mistake**

The Safety Challenge

- **Current U.S. traffic safety sets a very high bar:**
 - **3.4 M vehicle hours between fatal crashes (390 years of non-stop 24/7 driving)**
 - **61,400 vehicle hours between injury crashes (7 years of non-stop 24/7 driving)**
- **How does that compare with your laptop, tablet or “smart” phone?**
- **How much testing do you have to do to show that an automated system is equally safe?**
 - **RAND study – multiple factors longer times**
- **How many times safer does it need to be?**

Traffic Safety Challenges for High and Full Automation Systems

- **Extreme external conditions arising without advance warning (failure of another vehicle, dropped load, lightning,...)**
- **NEW CRASHES caused by automation:**
 - **Strange circumstances the system designer could not anticipate**
 - **Software bugs not exercised in testing**
 - **Undiagnosed faults in the vehicle**
 - **Catastrophic failures of vital vehicle systems (loss of electrical power...)**
- **Driver not available to act as the fall-back**

Needed Breakthroughs

- **Software safety design, verification and validation methods to overcome limitations of:**
 - **Formal methods**
 - **Brute-force testing**
 - **Non-deterministic learning systems**
- **Robust threat assessment sensing and signal processing to reach zero false negatives and near-zero false positives**
- **Robust control system fault detection, identification and accommodation, within 0.1 s response**
- **Ethical decision making for robotics**
- **Cyber-security protection**

Personal Estimates of Market Introductions

**** based on technological feasibility ****

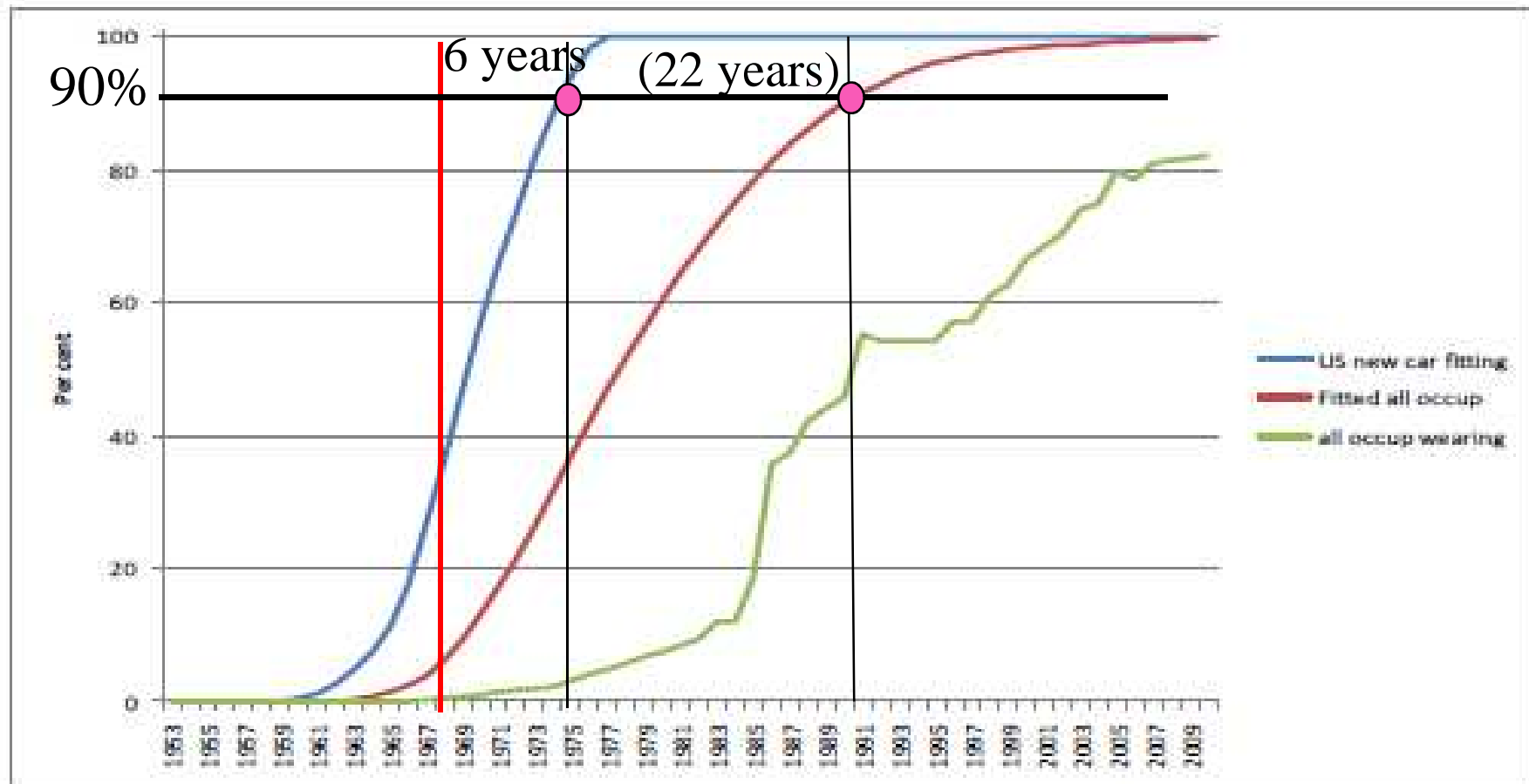
Everywhere	Yellow	Orange	White	White	Red
General urban streets, some cities	Green	Orange	Brown	Brown	White
Campus or pedestrian zone	Green	Yellow	Yellow	Yellow	White
Limited-access highway	Green	Green	Yellow	Orange	White
Fully Segregated Guideway	Green	Green	Green	Green	White
	Level 1 (ACC)	Level 2 (ACC+ LKA)	Level 3 Conditional Automation	Level 4 High Automation	Level 5 Full Automation
Color Key:	Now	~2020s	~2025s	~2030s	~~2075



Fastest changes in vehicle capabilities: Regulatory mandate to force progress

Figure 1: US seat belt adoption curves

Source: Gargett, Cregan and Cosgrove,
Australian Transport Research Forum 2011



Historical Market Growth Curves for Popular Automotive Features (New cars)

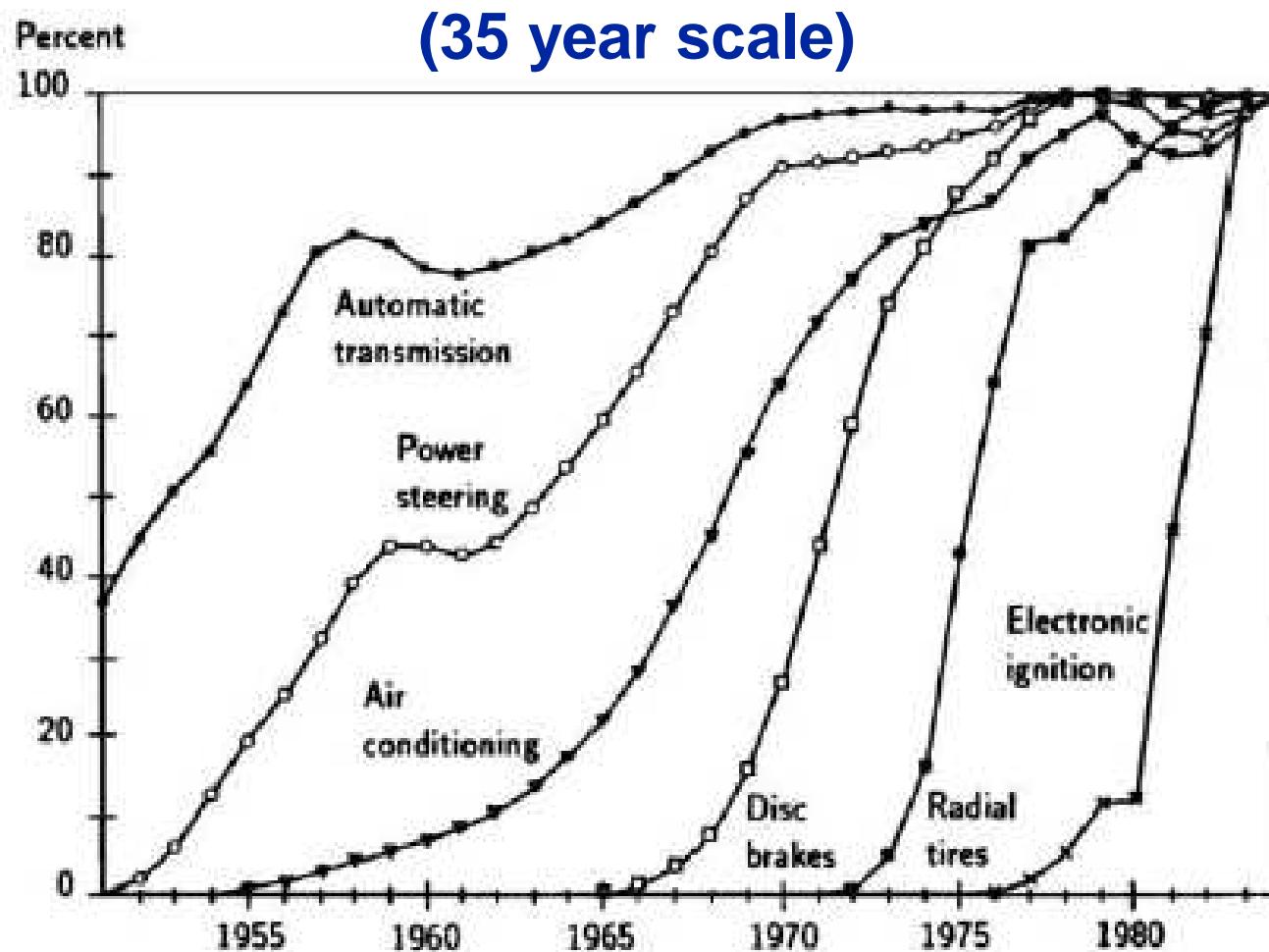


Figure 3.3.10. Diffusion of new technologies in the US car industry (in percent of car output). (Source: Jutila and Jutila, 1986.)

Big Unresolved Questions (1/2)

- **How safe is “safe enough”?**
- **How can an AV be reliably determined to meet any specific target safety level?**
- **What roles should national and regional/state governments play in determining whether a specific AV is “safe enough” for public use?**
- **Should AVs be required to inhibit abuse and misuse by drivers?**
- **How long will it take to achieve the fundamental technological breakthroughs needed for higher levels of automation?**

Big Unresolved Questions (2/2)

- How much support and cooperation do AVs need from roadway infrastructure and other vehicles?
- What should the public sector role be in providing infrastructure support?
- Are new public-private business models needed for higher levels of automation?
- How will AVs change public transport services, and to what extent will societal goals for mobility be enhanced or degraded?
- What will be the net impacts of AVs on vehicle miles traveled, energy and environment?

How should we prepare?

- **Install cooperative infrastructure for I2V communication (5.9 GHz DSRC) at traffic signals**
- **Support regulations that balance public safety and encouraging innovation**
- **Seek early deployment opportunities for first generation systems (e.g., automated shuttles in well protected environments)**
- **Support infrastructure investments to segregate automated vehicles from other road users**
- **Local governments identify their point person for vehicle automation (cutting across traditional agency stove-pipes)**

Media Hype is Rampant...

Chron

<http://www.chron.com/business/technology/article/Government-will-consider-Google-computer-to-be-6820375.php>

Computer as driver? 'Yes' from feds boosts self-driving cars

Tom Krisher and Justin Pritchard, Associated Press Updated 1:41 pm, Wednesday, February 10, 2016

U.S. Officials: Artificial Intelligence Now Qualifies as a Car's Driver

By **Frederick Cook** · Feb 10, 2016, 5:08 PM ET [Share with Facebook](#) [Share with Twitter](#)

TECH | AUTOS

Self-Driving Cars Clear a Hurdle, With Computer Called Driver

NHTSA responds to a query from Google's autonomous-car program

BUSINESS / AUTOS

Who's the driver of that Google car? Feds ready to say it's the computer

Technology | Wed Feb 10, 2016 1:14pm EST

Exclusive: In boost to self-driving cars, U.S. tells Google computers can qualify as drivers

WASHINGTON/DETROIT | BY DAVID SHEPARDSON AND PAUL LIENERT

TECHNOLOGY

A car's 'driver' can be a computer, federal government tells Google

Related: TECH, AEROSPACE & DEFENSE

by Administration ruled this week that a car's ling conflicts with state requirements that all cars In case a person needs to take over control of a

BloombergBusiness

Google's Self-Driving Car Software Considered a Driver by U.S. Agency

Craig Trudell Jack Clark
ctrud mappingbabel
February 9, 2016 — 6:29 PM PST

What did U.S. DOT really say?

‘NHTSA *will consider initiating rulemaking* to address whether the definition of “driver” in Section 571.3 should be updated in response to changing circumstances.’