The implications of autonomous vehicles on Transport Investment and Policy

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ITS Israel, Tel Aviv, Nov 2015

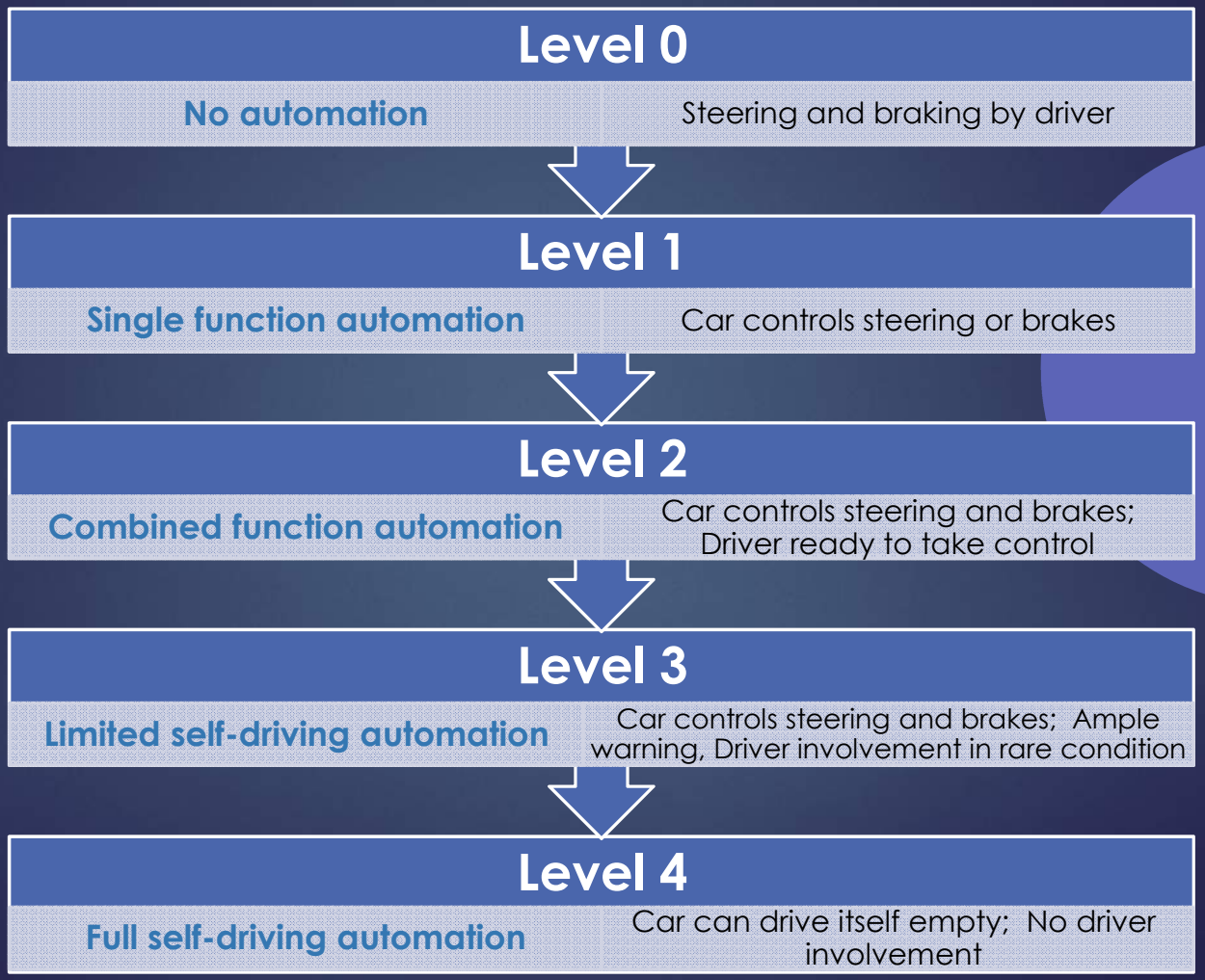
Background

- Automated driving technology is expected to enter the market in the years to come.
- This will have far-reaching implications on travel behavior, activity participation and land use.
- Only 2 of the 25 largest MPO in the US mention automated vehicles in official long-range regional transportation plans (Guerra, 2015)
- We need to prepare for the arrival of this technology by thinking on the investment and policy implications TODAY.

Some terms

- Automated/autonomous/driverless
- Connected/unconnected automated vehicles

NHTSA Levels of Automation

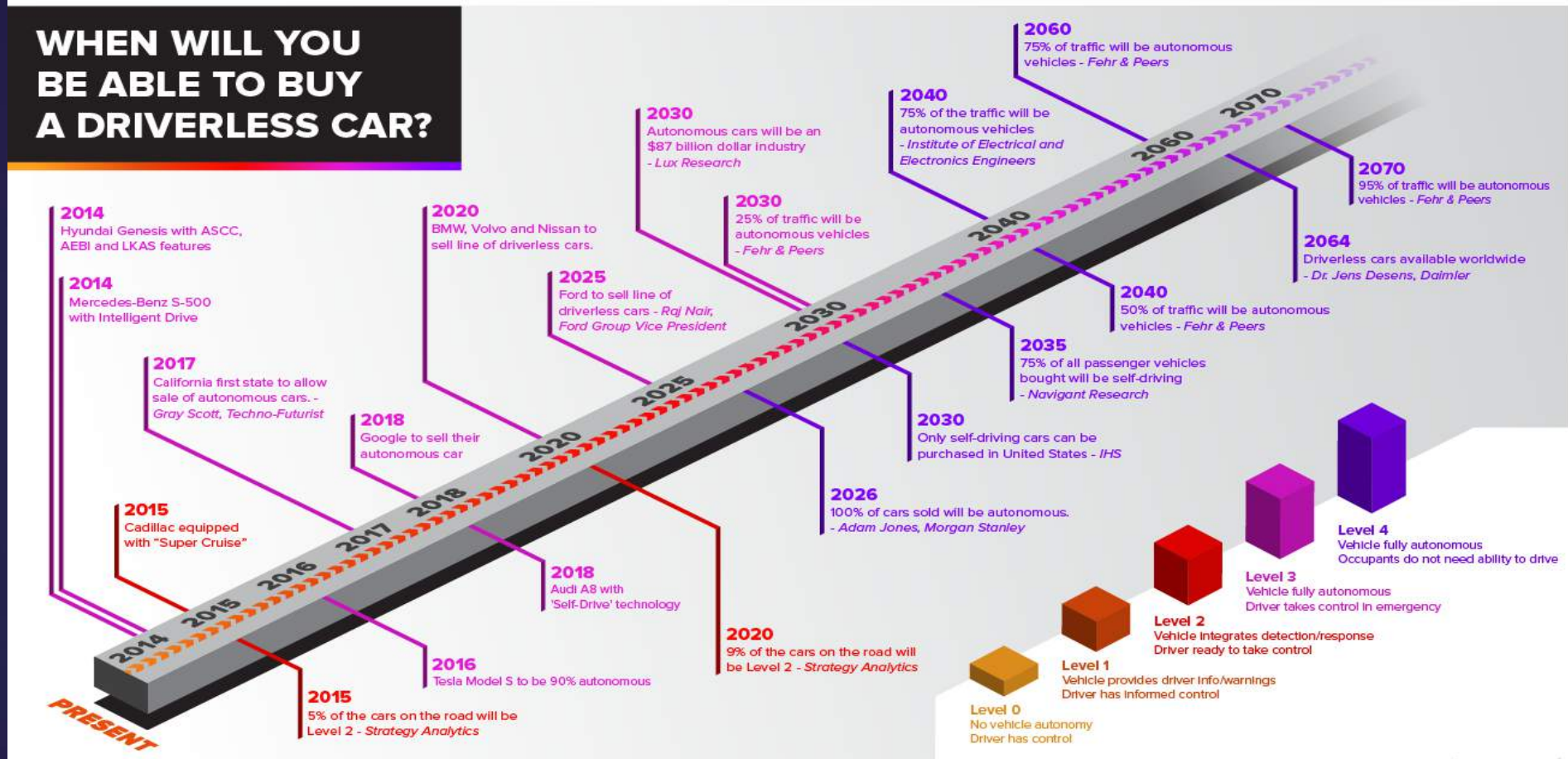


Current status of vehicle automation

When will we will see large-scale deployment of driverless vehicles on the road?

- Tesla Motors – by 2023 (Kaufman, 2014)
- Ford – by 2020 (Su, 2015)
- Volvo – by 2017
- BenHaim, BenHaim & Shiftan (forthcoming) - by 2030 40% of all vehicles will be connected to vehicle-infrastructure communication systems and by 2050 all vehicles will be driverless.

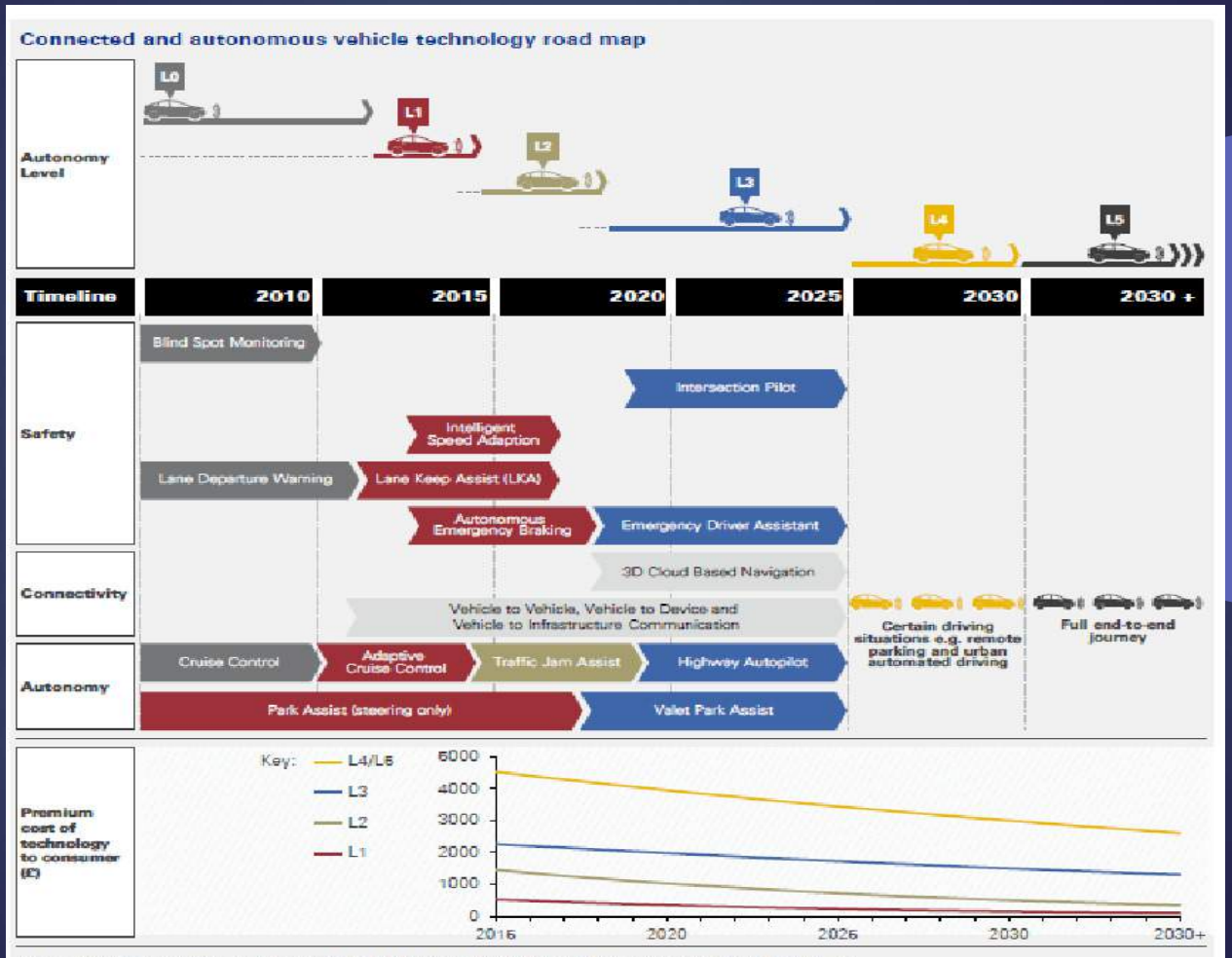
- As of April 2014, Google's self-driving cars have driven over 700,000 miles on California public roads.



Source: Mercedes-Benz, GM News, Strategy Analytics, Automotive News, Nissan News, Navigant Research, Volvo News, Fehr & Peers, Lux Research, IHS

mojomotors

Into the future: Technology roadmap



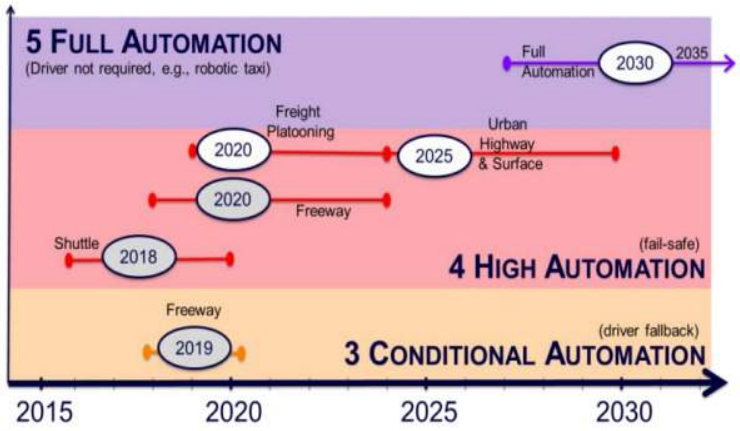
Source: KPMG analysis based on publically available industry information and interviews with key participants in the automotive industry

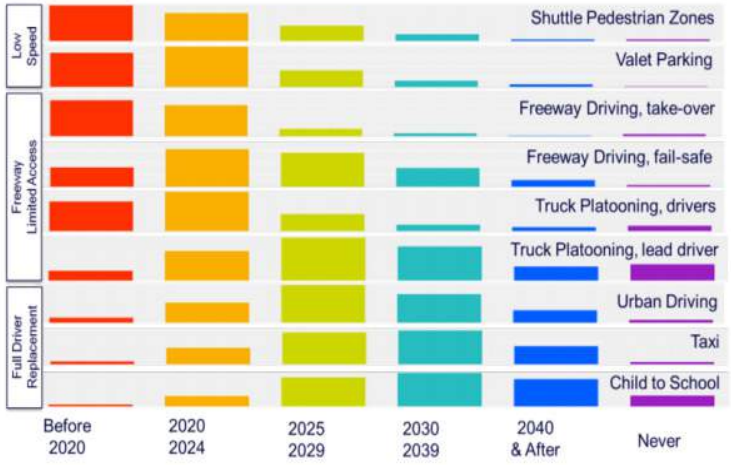
Underwood (2014) survey of 220 registrants of the AVS 2014 Symposium.

Respondents predicted a mean date of 2030 for the deployment of fully automated taxis.

25% indicated that they would only let their children/grandchildren ride alone by 2040 or later.

The timeline at right represents survey respondents' opinions of likely deployment years for vehicle automation systems falling within SAE levels 3, 4, and 5.





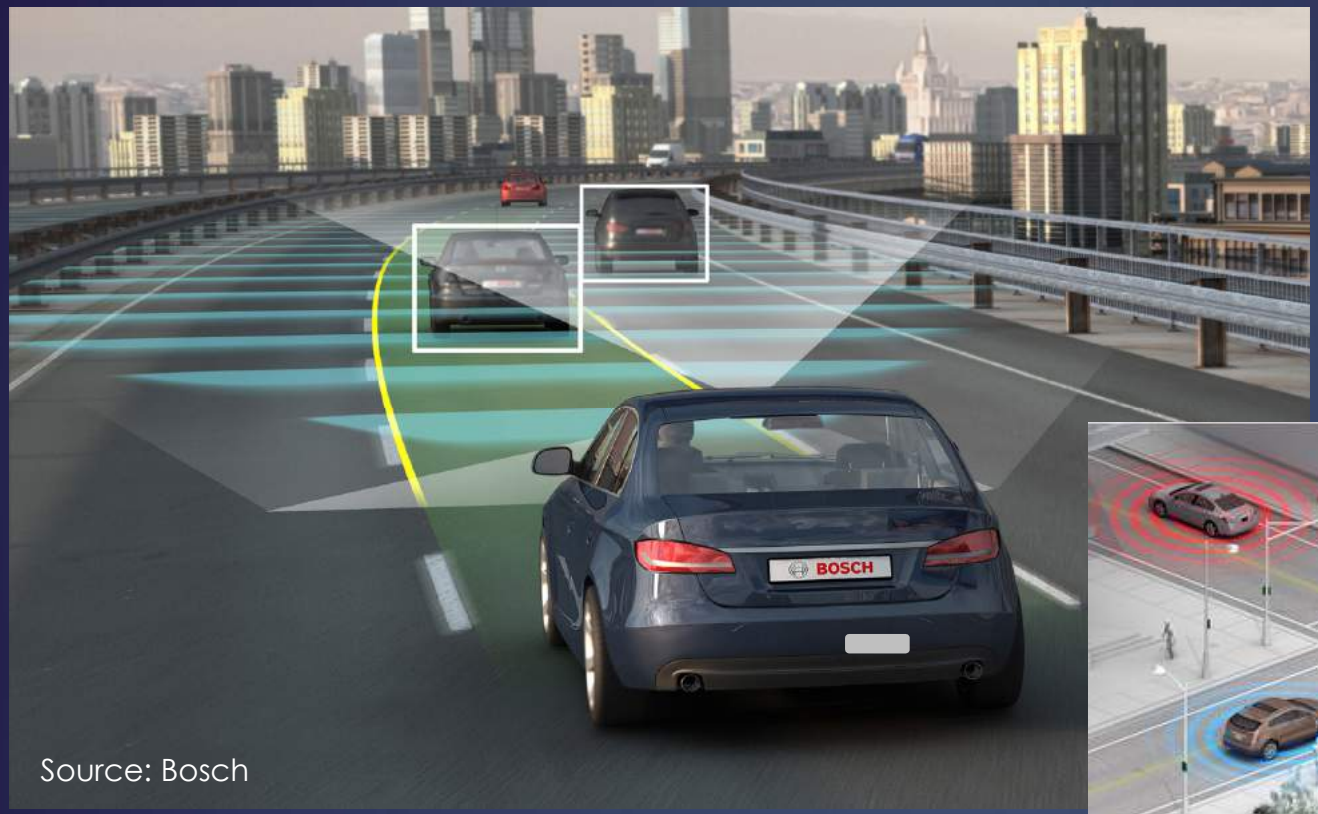
Distributions of responses among AVS 2014 attendees regarding the likely deployment years for vehicle automation systems falling within SAE levels 3, 4, and 5.

Complex remaining questions

- Cost (current added cost is estimated at 100,000 USD (Dellenback, 2013)
- Legal
- Licensing/Certification (NV and CA have already allowed AV certification, FL, MI, and DC allowed AV testing
- Insurance and Liability
- Perception
- Privacy
- Security

Potential impacts of driverless vehicles

Safety



Source: Bosch

Capacity

Automated vehicles:

- require less headway, narrower lane widths

- drive at higher speeds → travel time reduction
- reduce the need to park → more land use for other purposes
  → direct access, minimum walking distance

FHWA estimates that 25% of congestion is attributable to traffic incidents, around half of which are crashes (FHWA, 2005)

Estimations of increased capacity

- A full deployment of connected vehicle technology: **20%-50%** (Ni et al., 2012).
- Cooperative adaptive cruise control deployed at 90% market penetration will increase capacity by 80% (Shaldover et. al., 2012)
- Fully automated vehicles **43%;** (Tientrakool, 2011)
- Connected fully automated vehicles: **273%** (Tientrakool, 2011)
- Capacity can increase to 4,000 vehicles per lane per hour or more (Bierstedt et. al., 2014)

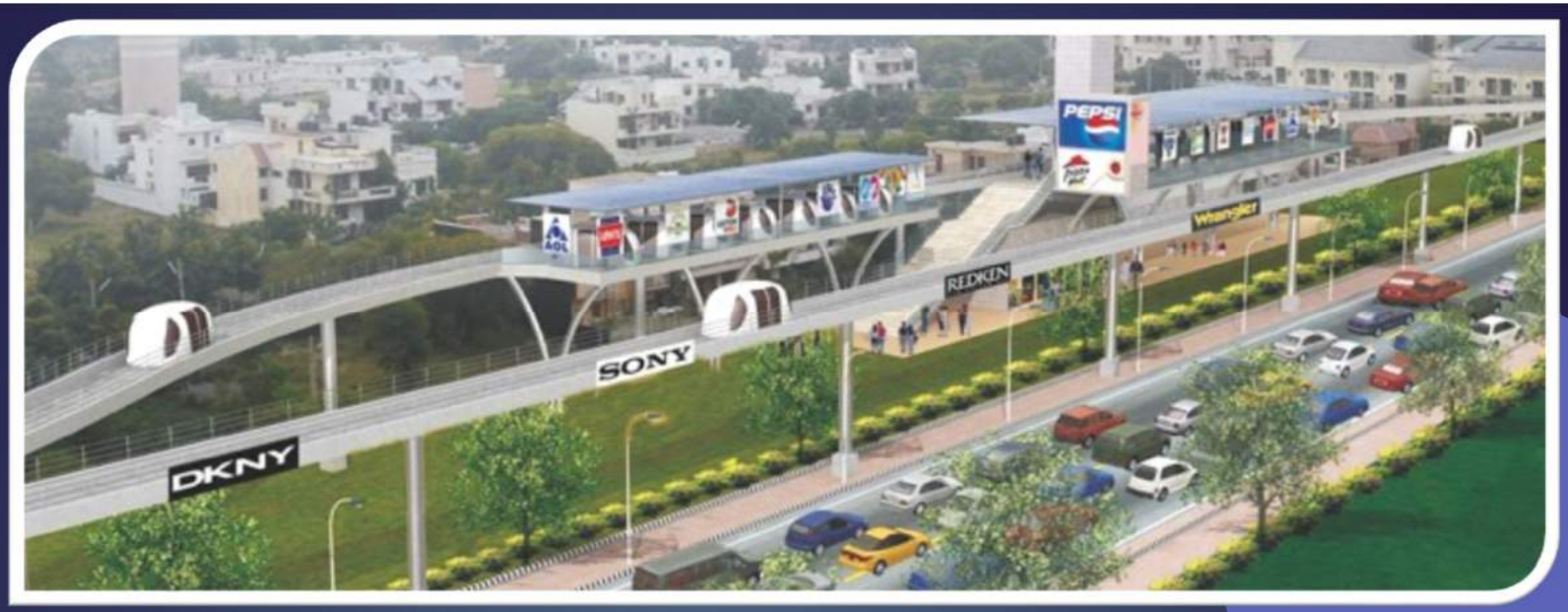
Cost

- High technology cost (but decreasing over time).
- Decreased cost of crashes and insurance policies due to increased safety.
- Decreased operating costs, including parking cost and car-sharing vehicles.
- Savings in parking space where land is scarce.
- Fuel and emission reduction

- Annual economic benefits for the US are estimated at $27 billion for 10% penetration and $450 billion for high penetration (Fagmant and Kockelman, 2015)

Emerging Services

- Reducing service operating costs by eliminating the need to pay drivers
- Increase flexibility by positioning vehicles to better respond to demand.
- Encouragement of widespread use of vehicle and ride-sharing programs.
- Engendering new modes that will be a cross between public and private modes available today.

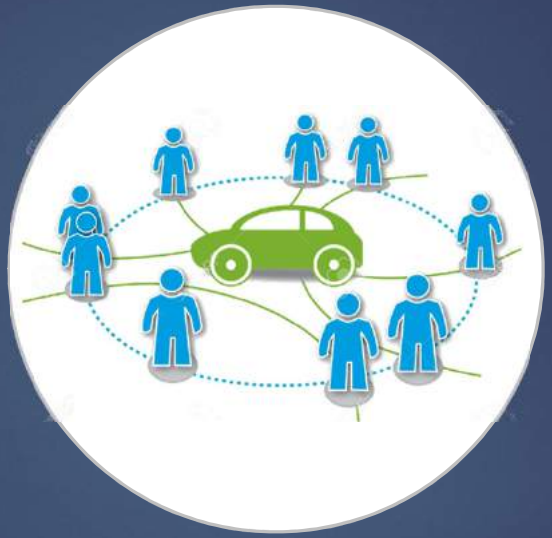

PEPSI
Wrangler
REDKEN
SONY
DKNY

The driver's private "**Capsule**"

The alternate "**Chassis**" that is infrastructure-dependent

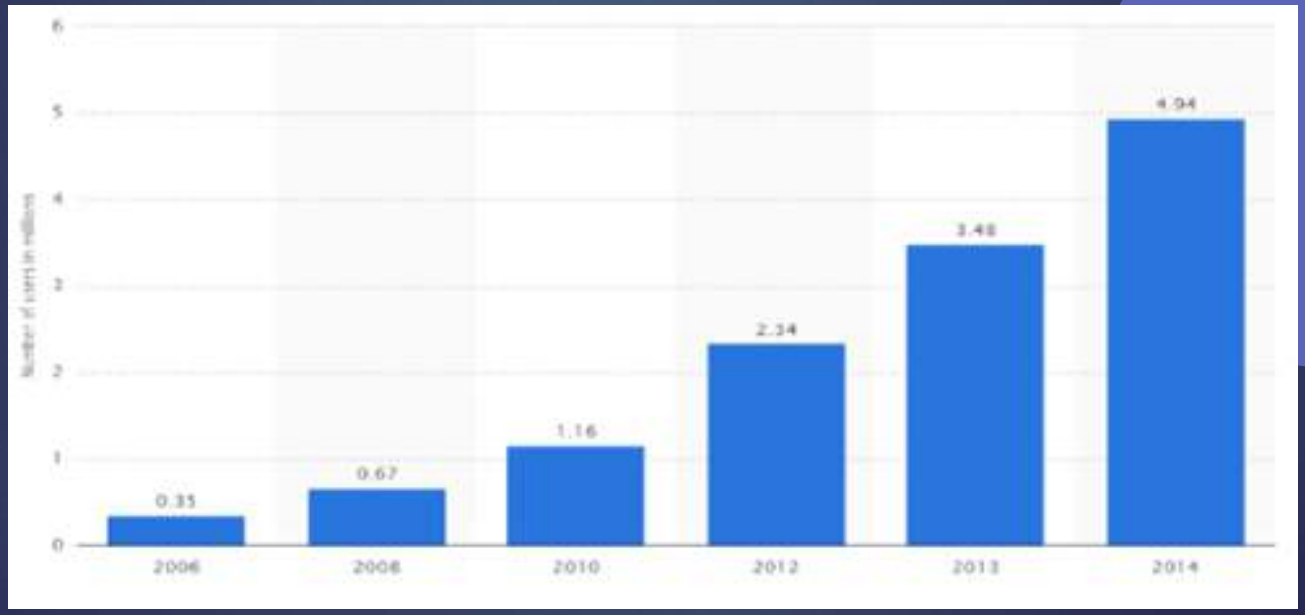
Road Chassis

Rail Chassis




Flinkster

Number of vehicle sharing users worldwide from 2006 to 2014 (in millions)



Source: http://www.statista.com/statistics/415636/car-sharing-number-of-users-worldwide/

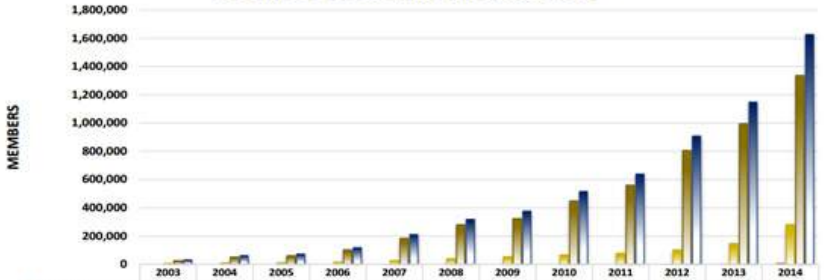
State	Car sharing membership (July 2013 – July 2014)	Car sharing fleets (July 2013 – July 2014)
US	↑ 34%	↑ 14%
Canada	↑ 91%	↑ 28%
Mexico	↑ 33%	↑ 18%
Brazil	↓ 0.9%	↑ 22%

State	Member-vehicle ratio (July 2014)
US	70:1 (↑ 19% from 2013)
Canada	56:1 (↑ 47% from 2013)
Mexico	131:1 (↑ 98% from 2013)
Brazil	51:1 (↓19% from 2013)
The Americas	67:1 (↑ 22% from 2013)

Source: Shaheen & Cohen (2014)

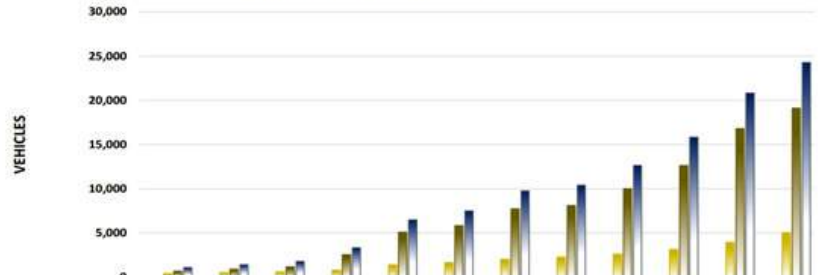
CARSHARING MARKET TRENDS IN THE AMERICAS

Member Growth in the Americas*



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Brazil (n=1)								98	347	910	2,884	2,857
Mexico (n=1)										750	2,654	6,174
Canada (n=20)	7,007	10,001	11,932	15,663	26,878	39,664	53,916	67,526	78,856	101,502	147,794	281,675
United States (n=23)	25,640	52,347	61,658	102,993	184,292	279,234	323,681	448,574	560,572	806,332	995,926	1,337,803
The Americas (n=45)	32,647	62,348	73,590	118,656	211,170	318,898	377,597	516,198	639,775	909,494	1,149,258	1,628,509

Vehicle Growth in the Americas*



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Brazil (n=1)								12	18	58	46	56
Mexico (n=1)											40	47
Canada (n=20)	397	521	599	779	1,388	1,667	2,046	2,285	2,605	3,143	3,933	5,048
United States (n=23)	696	907	1,192	2,561	5,104	5,840	7,722	8,120	10,019	12,634	16,811	19,115
The Americas (n=45)	1,093	1,428	1,791	3,340	6,492	7,507	9,768	10,417	12,642	15,835	20,830	24,266

*Data depicted July of each year. "N" reflects number of operators as of July 2014. Numbers include round-trip and one-way carsharing. Numbers do not include peer-to-peer carsharing. Costa Rica excluded due to ceased operations in April 2014. SigoCar had operated in Costa Rica since 2010.

Source: http://web.stanford.edu/class/me302/PreviousTerms/2014-06Car-SharingServiceUsingAutonomousAutomobiles(paper).pdf; http://zackkanter.com/2015/01/23/how-ubers-autonomous-cars-will-destroy-10-million-jobs-by-2025/

Car Sharing Impacts

- North American car-sharing members reduced their driver distance by 27% | approximately 25% of members sold a vehicle and another 25% forgone a vehicle purchase (Shaheen and Cohen, 2013)
- Carsharing facilitates a substantial reduction in household vehicle holdings in North America. Car sharing has taken between 90,000 and 130,000 cars off the road (Martin et al., 2010)
- Having driven an electric-car2go increased car2go-users' willingness to forgo a private car purchase (Firnkorn & Müller, 2015)
- Using GPS tracking smartphone application, higher trip frequency was found for FFCS compared to non-car-sharers. FFCS users are more prone to intermodal and multimodal travel (Kopp et al., 2015)

Ford will rent out your ride in new car-sharing pilot

Alisa Priddle, Detroit Free Press *11:21 a.m. EDT June 24, 2015*

SAN FRANCISCO — Instead of fighting public transportation, bicycles and car-sharing services, Ford is looking to join them -- and still make money even if fewer people are buying cars.

Ford is trying to reinvent itself as a mobility company and address the trend in urban areas of cities growing and becoming more congested, CEO Mark Fields said in an interview. "People value access more than ownership. We need to understand customers' concerns and make their lives easier."

(Photo: Ford)

USA TODAY

Ford diving into autonomous-car horse race

(http://www.usatoday.com/story/tech/2015/06/23/ford-diving-into-autonomous-car-horse-race/29187375/)

CarSharing: State of the Market and Growth Potential

By Chris Brown, March/April 2015 - Also by this author

Though aspects of carsharing have existed since 1948 in Switzerland, it was only in the last 15 years that the concept has evolved into a mobility solution in the United States.

In that time, the carsharing market has grown from a largely subsidized, university research-driven experiment into a full-fledged for-profit enterprise, owned primarily by traditional car rental companies and auto manufacturers. Today, Zipcar (owned by Avis Budget Group), car2go (owned by Daimler), Enterprise CarShare and Hertz 24/7 control about 95% of the carsharing market in the U.S.

Photo by Chris Brown.

Compared to car rental, total fleet size and revenues for carsharing remain relatively small. The "Fall 2014 Carsharing Outlook," produced by the Transportation Sustainability Research Center at the University of California, Berkeley, reports 19,115 carsharing cars in the U.S., shared by about 996,000 members. Total annual revenue for carsharing in the U.S. is about $400 million, compared to the $24 billion in revenue for the traditional car rental market.

Those carshare numbers have roughly doubled in five or six years, demonstrating steady growth but not an explosion. Yet technology, new transportation models, shifting demographics and changing attitudes on mobility present new opportunities. Is carsharing poised to take advantage?

Demand

- Reduce driver burden (stress, fatigue, productive time
- No need to park

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Reduced cost (operators)

Reduced cost (traveler)

- Travel time budget, VOT
- Travel money budget

New services and modes

Increased flexibility

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- Longer commute
- Travel distance to other purposes
- Changes in activity patterns
- More travel

- New opportunities
  - To all
  - To pop. who can't drive
- More options to accomplish tasks

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- Changes in activity patterns
- More travel

- Residential location
- Land use
- City expansion
- Value of aggloremation

- New opportunities
  - To all
  - To pop. who can't drive
- More options to accomplish tasks

Type of car purchased

Less walking – heath effect

Implication for Infrastructure Investments

- Impact on future infrastructure planning and current infrastructure utilization, reducing the need to build new roads/rail systems?

- More and longer trips
- Higher capacity
- The cheap and convenient emerging services

Mitigation

- Research suggests that induced traffic can be mitigated by the AV advantages
- Other negative impacts, such as sprawl, emissions, and health concerns, may not be read mitigated
- "Highway may carry significantly more vehicles, but average delay during the peak period may not decrease appreciably" (Smith, 2013)
- Can they replace mass transit? rail systems?
- Will need appropriate aggressive car constraint measures!

Policy Implications

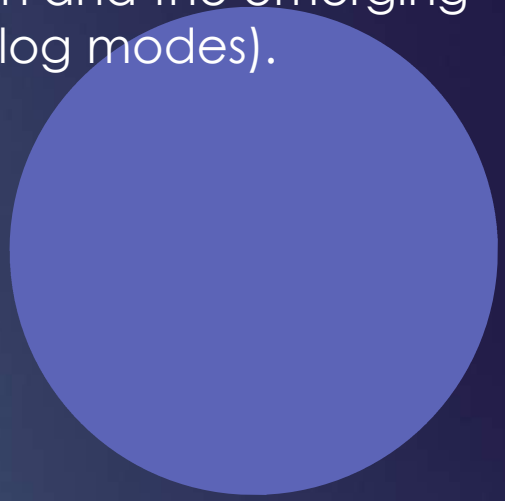
- Rethinking the current parking paradigm
- Policies to encourage sharing
- More intensive use of pricing policies
- Policies for limiting unnecessary travel by zero occupancy vehicles.
- Planners must consider taking actions today to prepare cities for driverless vehicles and sharing economy.

What Should We do:

- Evaluate the current investments in roads and rail systems in light of a scenario of SAV
- Encourage policies to support implementation of SAV
- Encourage policies to better sharing economy from tomorrow

Four main approaches to gaining insights of potential impacts

1. Study the impact of previous new technology innovation and the emerging services that have already penetrated the market (analog modes).
2. Perform stated preference studies
3. Perform experiments with a simulator
4. Perform simulation based/scenario analysis studies



Scenario Analysis using existing Activity Based Modeling

	Assumptions	Scenarios	Range of Impacts
Atlanta **Kim et al. (2015)**	• 71% reduction in vehicle operation cost • 50% increase in road capacity • 50% reduction of the IVT coefficient • No parking cost at primary destinations	• 100% market penetration of level 4 in 2014	• Average trip length increases from 10 to 12 miles • Number of daily trips increase from 2.5% • Average delay reduce by 14% • Transit share reduce by 42%
Puget Sound **Childress et al. (2015)**	• 30% increase in road capacity • 35% reduction in VOT (all HH or only high income HH) • $1.65 per mile for SAV	• SAV replaces private care	• 4-20% increase in VMT • 17% increase in VHT • 30% reduction in VMT • 45% reduction in VHT • 140% increase in transit • 50% increase in walking
MTC **Gucwa (2014)**	• 50% reduction in VOT • No parking cost • 50% reduction in parking cost		• 8-24% increase in VMT

Conclusion

1. AV can significantly change the way we travel/conduct activity/live
2. Regulation and policy are key issue – need to manage the process
    1. Pricing, parking, priority, incentives
3. Net impact of increased travel and capacity are not clear

Missing Research

4. Market penetration studies
5. Modify our travel demand models
6. Automated transit and shared mobility
7. Regional planning and modeling
8. Implications for transport investment and policy making

Thanks for your attention!