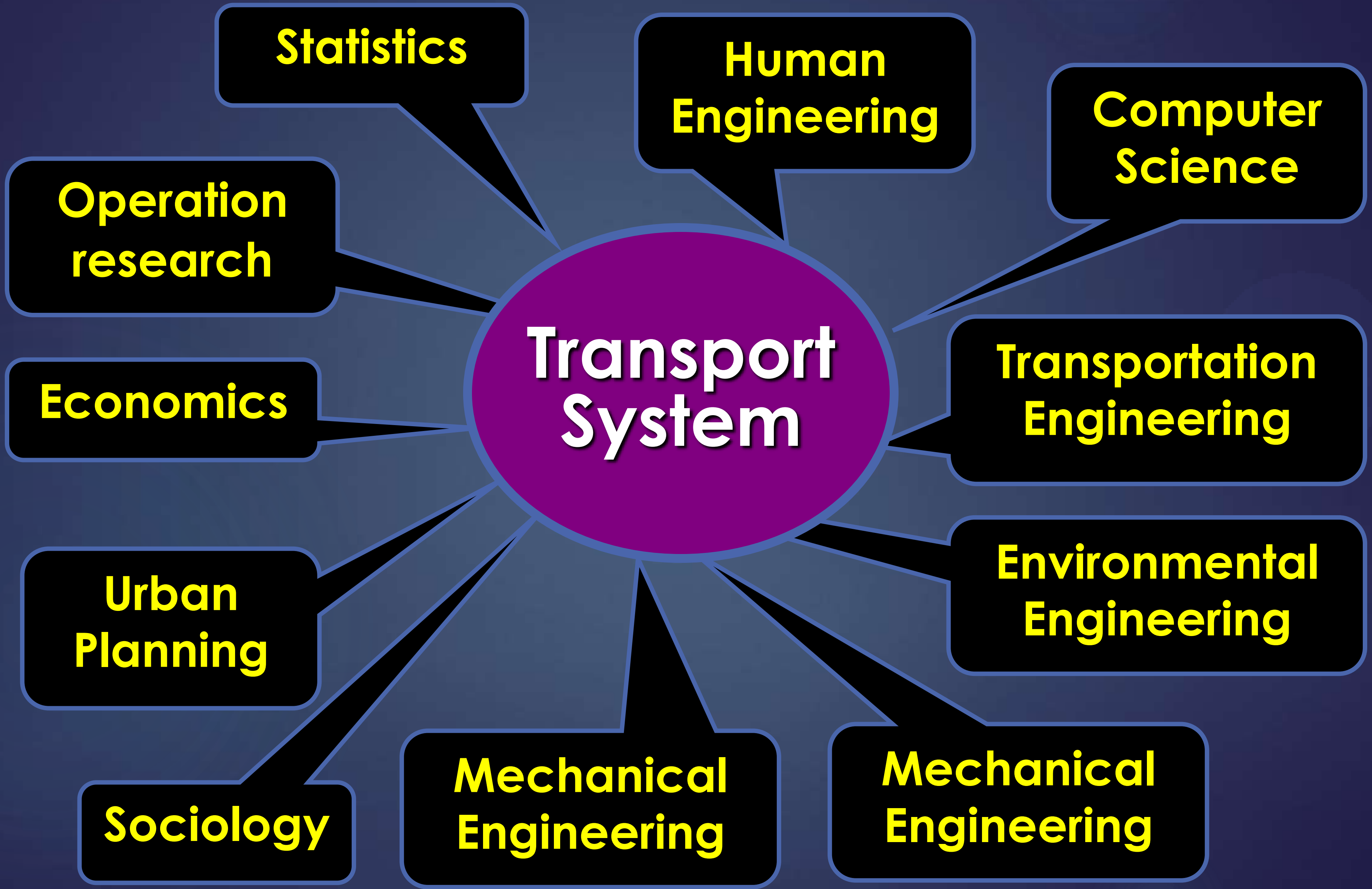
SMART TRANSPORTATION

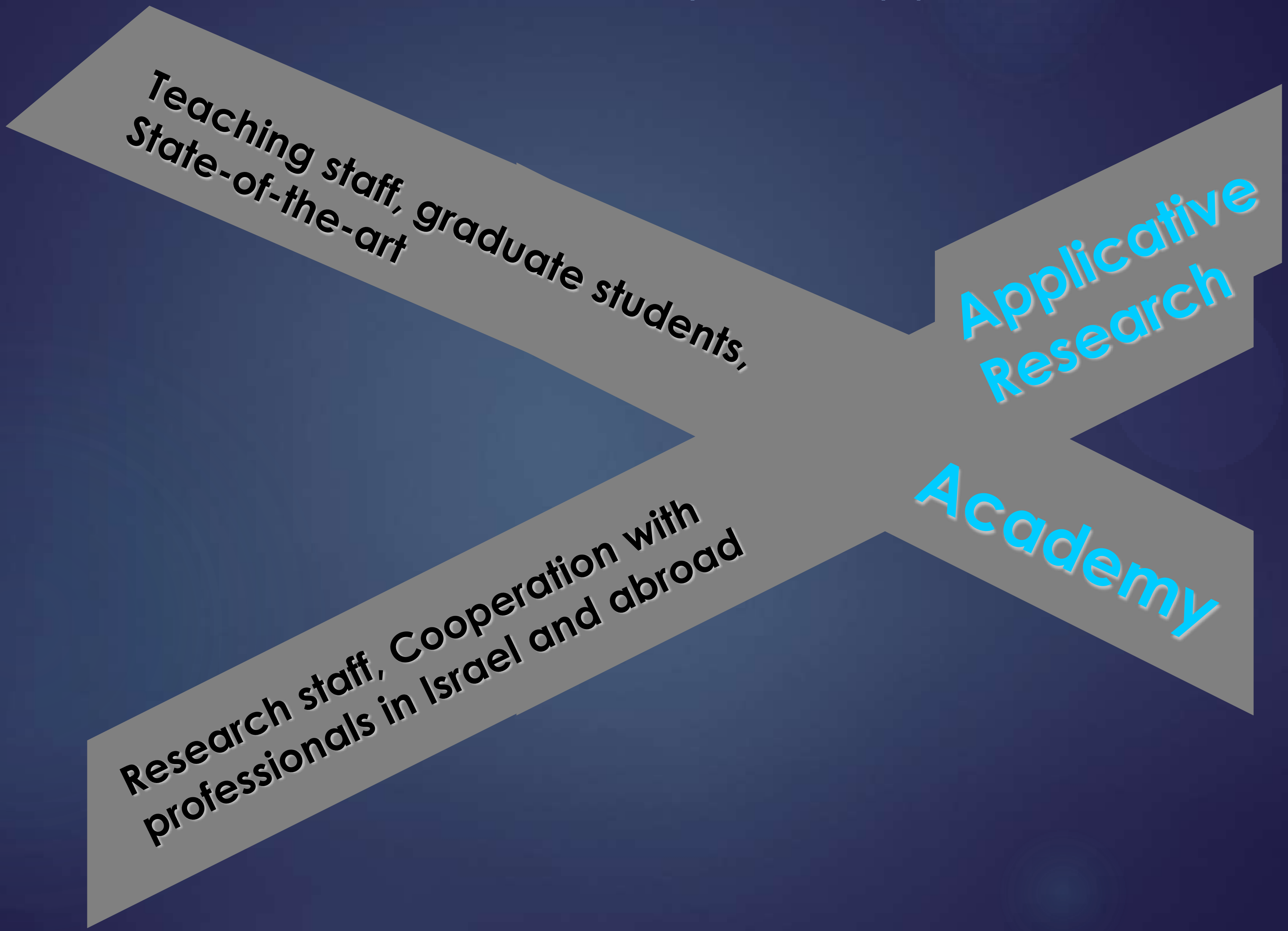
Yoram Shiftan
Transportation Research Institute (TRI)
Technion

Transportation Research Institute

TRI - Multi-disciplinary approach to transport problems

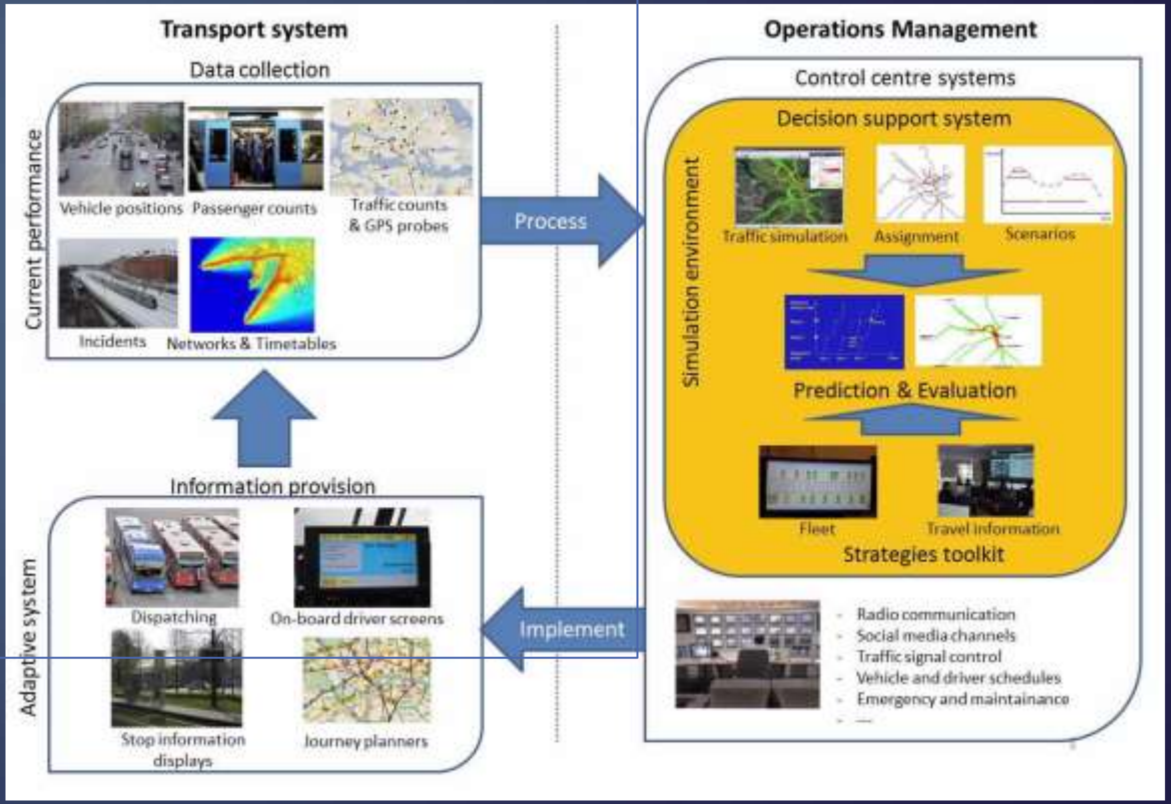


TRI - The crossroads of academy and applicative research



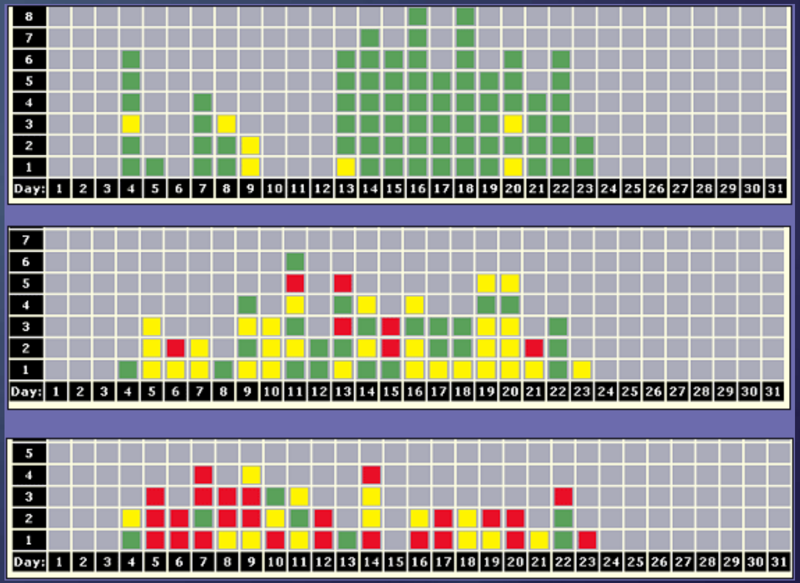
ADAPT-IT project

- Real-time public transportation operations
  - Simulation-based predictions
  - Handle multiple interacting lines
  - Strategies
    - Holding
    - Speed change
    - Skip-stop



Green boxes for novice drivers

- In-vehicle monitoring and feedback technology
  - Study driving patterns
    - Graduated driver licensing
  - Influence behavior
    - Parental involvement
    - Social incentives
    - Insurance companies



תזמון ותדירות

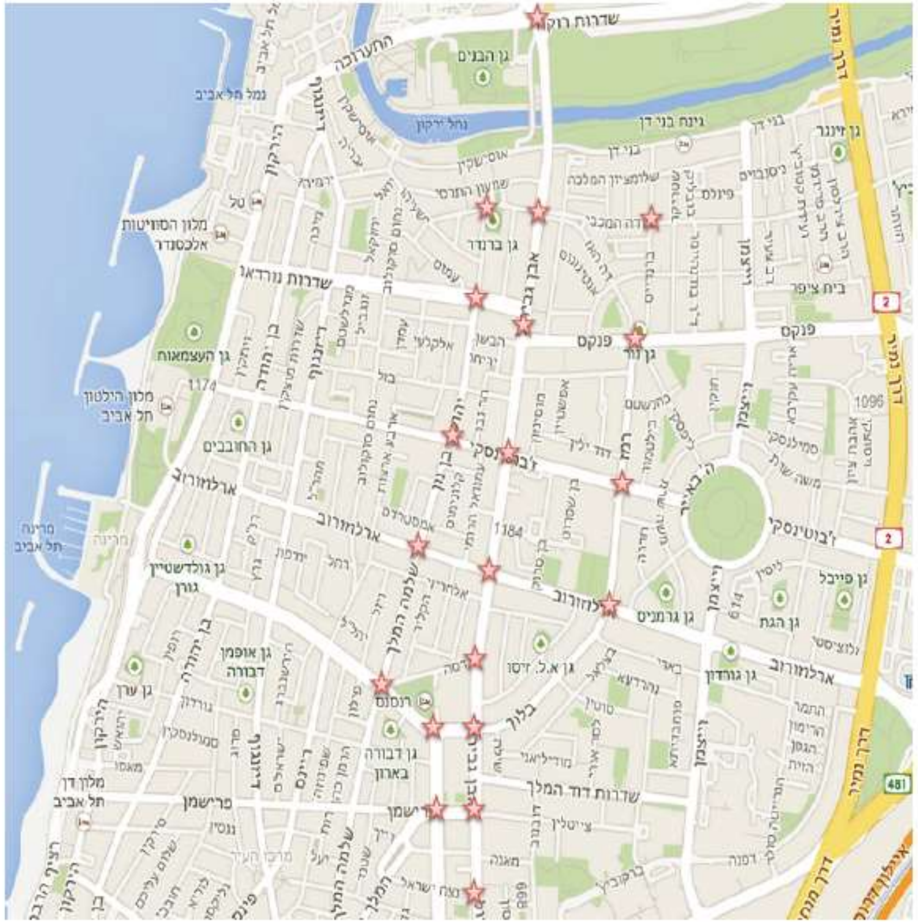
אכיפה עצמית בעזרת IVDR

אכיפה ידידותית

קנסות קטנים

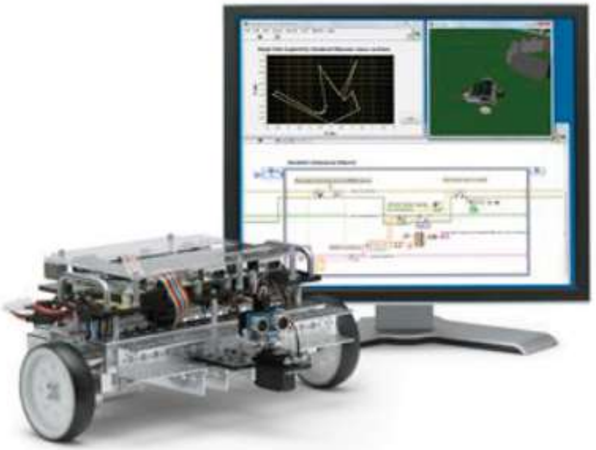
T-SMART Lab - A Real Sensory Netwok (Tel-Aviv)

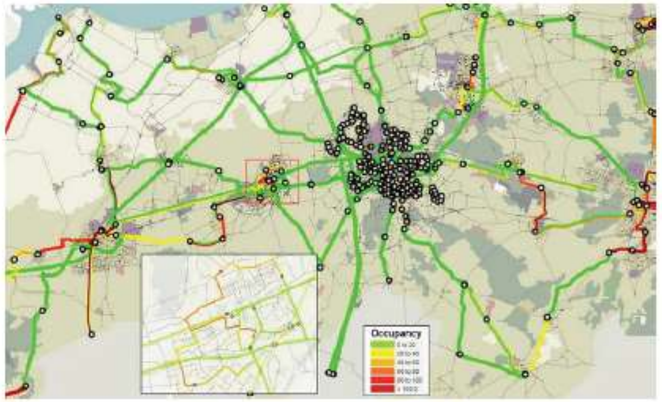
- 39 Bluetooth sensors.



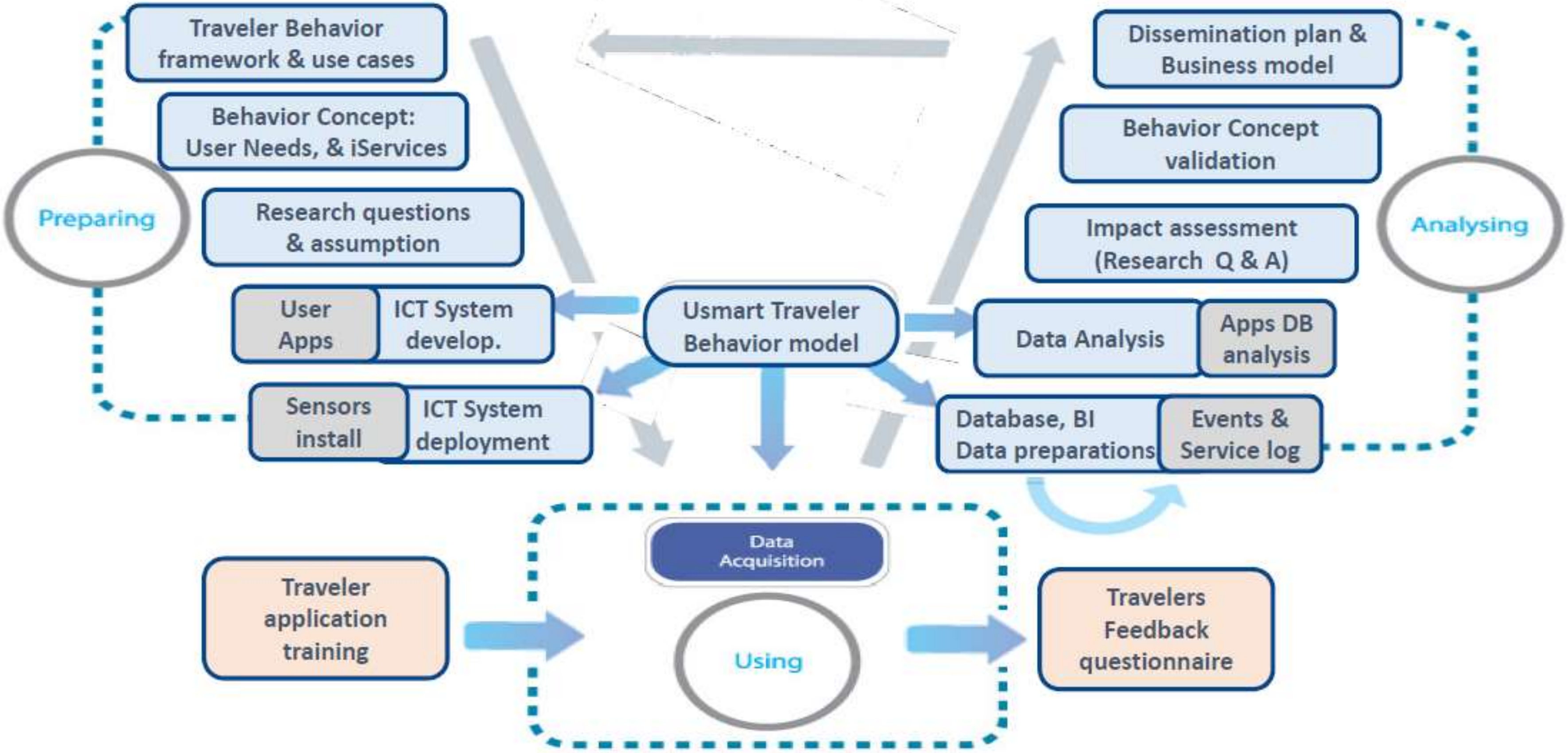
T-SMART Lab - further equipments and software

- 3 robots and 8 cameras.
- Aimsun microsimulation software.

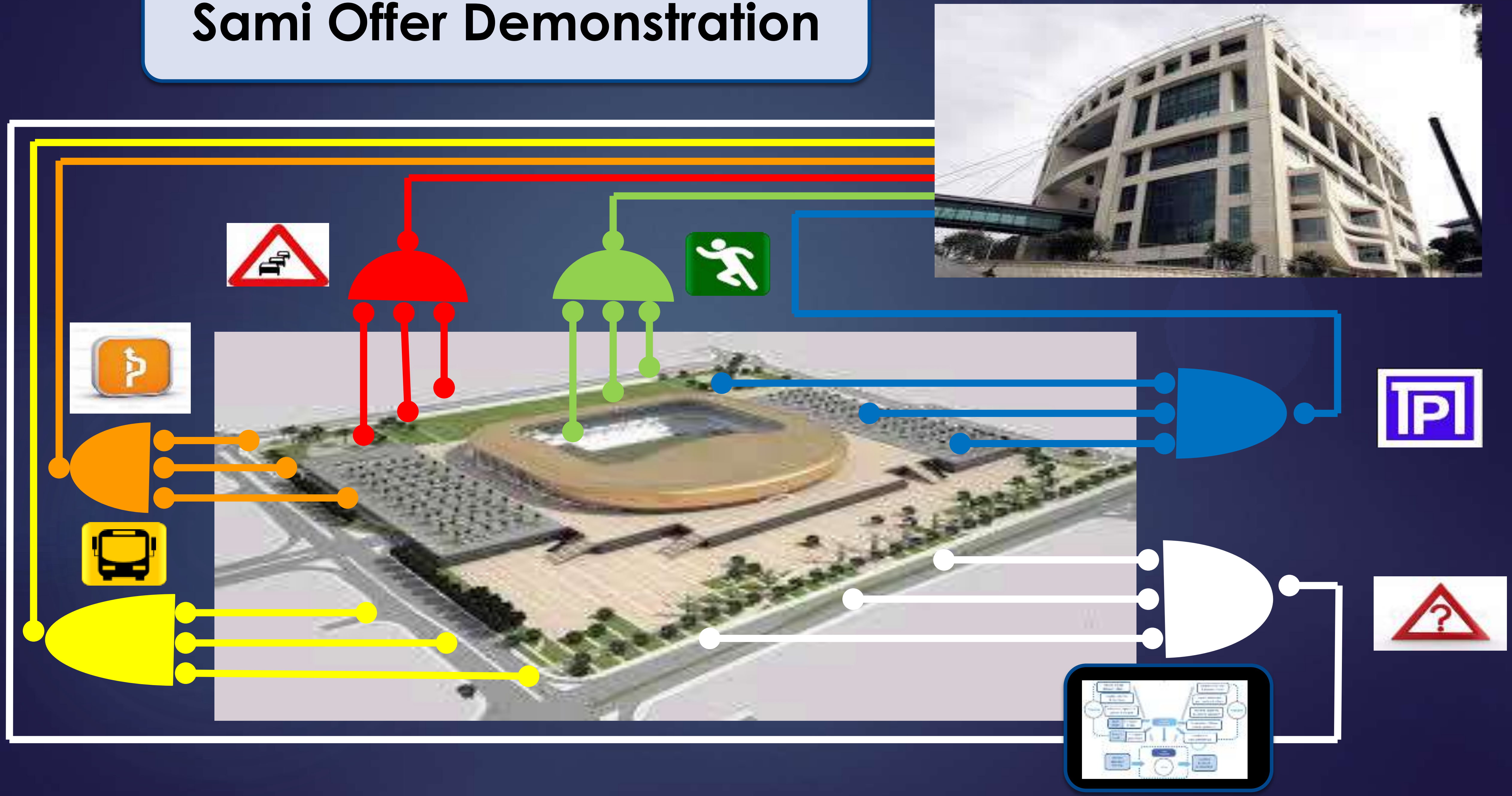




Usmart V diagram



Sami Offer Demonstration




Road user behaviour
Services
Communities
Data & info
Ecosystems
Infrastructure


Services

TRAVEL BEHAVIOR IMPLICATION/MODELING OF AUTOMATED VEHICLES/SHARED MOBILITY

Yoram Shiftan
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Technion

Motivation

- *Impact on Behavior!!!*
- *AV/SM will change the way we: travel, make activity, lifestyle…..*
- *Land use/residential*
- *Impact on congestion/people livability*
- *Impact the industry*
- *Policy implications*

Behavior is a key to Impact

- Can be a silver bullet – all will share…..
- Can result in hell – all will travel more…..

- Need to understand what policies/scenarios will move people from SOV

My Research Questions – Shared Mobility

- The factors affecting shared mobility
- The role of technology/app based services
- The role of information and incentives
- Policies to encourage shared mobility
- The potential of shared mobility to replace other modes
- The impact on the transportation system
- Research methods

My Research Questions - AV

- How to design reliable choice experiments?
- How to deal with the lack of experience?
- What creative virtual realities/games/simulators can better reflect the AV world?
- What type of revealed preference data can be used today to research behavior (travel, activity participation and locations) in a world of driverless vehicles?
- How to design field experiments? Other new methods and creative techniques?

Issues in (Modeling) Adoption and Use of Driverless Cars

The Driverless Car Debate: How Safe Are Autonomous Vehicles?

By Lauren Keating, Tech Times | July 28, 9:00 AM

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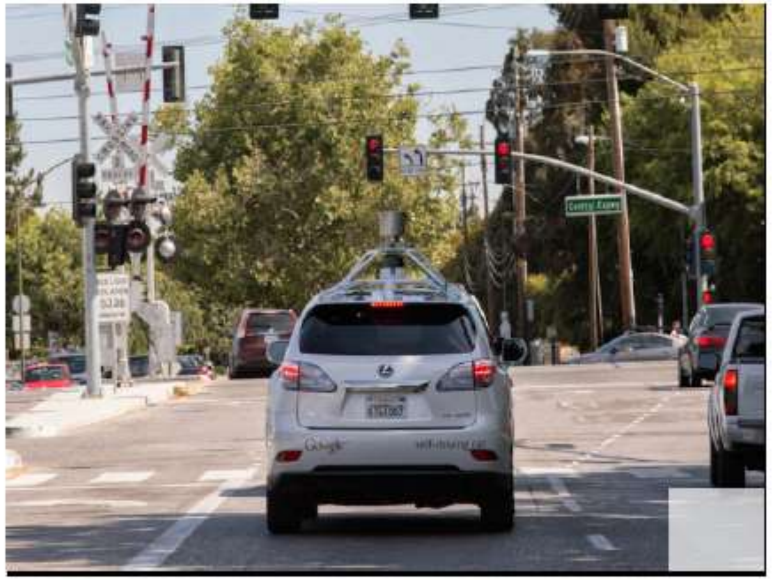


As companies like Google and Delphi Automobile continue to test autonomous vehicles on the road, issues concerning the safety in regard to accidents and vulnerability in the software continue to rise. How safe are autonomous cars? (Photo : Google)

When it comes to the future of transportation, the first thing that comes to mind is the possibility of flying cars. It's easy to imagine an urban utopia with vehicles that float through the air, swerving around buildings, reaching toward the heavens.

While *Back to the Future: Part II* wrongly predicted that we would have this technology in 2015, autonomous vehicles—which are currently being tested—may just be the stepping stone to making this a reality. Who would've thought robot cars would be our present?

No matter what side you stand on in the safety debate, even those who have concerns still agree that this innovative technology is the way of the future.

Companies like Google, Delphi Automotive, Bosche, Tesla, Nissan Mercedes-Benz, Uber and Audi have already begun testing self-

Self-Driving Cars and Insurance

FEBRUARY 2015

THE TOPIC

Each new generation of cars is equipped with more automated features and crash avoidance technology. Indeed, many of today's high-end cars and some mid-priced ones already have options, such as blind-spot monitoring, forward-collision warnings and lane-departure warnings. These will be the components of tomorrow's fully automated vehicles. At least one car manufacturer has promised to have fully automated cars available by the end of the decade.

Except that the number of crashes will be greatly reduced, the insurance aspects of this gradual transformation are at present unclear. However, as crash avoidance technology gradually becomes standard equipment, insurers will be able to better determine the extent to which these various components reduce the frequency and cost of accidents. They will also be able to determine whether the accidents that do occur lead to a higher percentage of product liability claims, as claimants blame the manufacturer or suppliers for what went wrong rather than their own behavior. Liability laws might evolve to ensure autonomous vehicle technology advances are not brought to a halt.

RECENT DEVELOPMENTS

- A study by the Insurance Institute for Highway Safety (IIHS) has found that improvements in design and safety technology have led to a lower fatality rate in accidents involving late model cars. The likelihood of a driver dying in a crash of a late model vehicle fell by more than a third over three years, and nine car models had zero fatalities per million registered vehicles. Part of the reason for the lower fatality rate might also stem from the weak economy, which led to reduced driving, the IIHS said.
- The study, which looked at fatalities involving 2011 model year cars over a year of operation, found that there were an average of 28 driver deaths per million vehicle car years through 2012, down from 48 deaths for 2008 model cars through

Why You Shouldn't Worry About Liability for Self-Driving Car Accidents

By Mark Harris
Posted 12 Oct 2015 | 20:00 GMT

Photo: Volvo

Håkan Samuelsson—President & CEO, Volvo Car Group

Volvo president Håkan Samuelsson caused a stir earlier this week when he said that Volvo would accept full liability whenever its cars are in autonomous mode (https://www.media.volvocars.com/global/en-gb/media/pressreleases/167975/us-urged-to-establish-nationwide-federal-guidelines-for-autonomous-driving). Samuelsson went further, urging lawmakers to solve what he called "controversial outstanding issues" over legal liability in the event that a self-driving car is involved in a crash.

"If we made a mistake in designing the brakes or writing the software, it is not reasonable to put the liability on the customer," says Erik Coelingh, senior technical leader for safety and driver support technologies at Volvo. "We say to the customer, you can spend time on something else, we take responsibility."

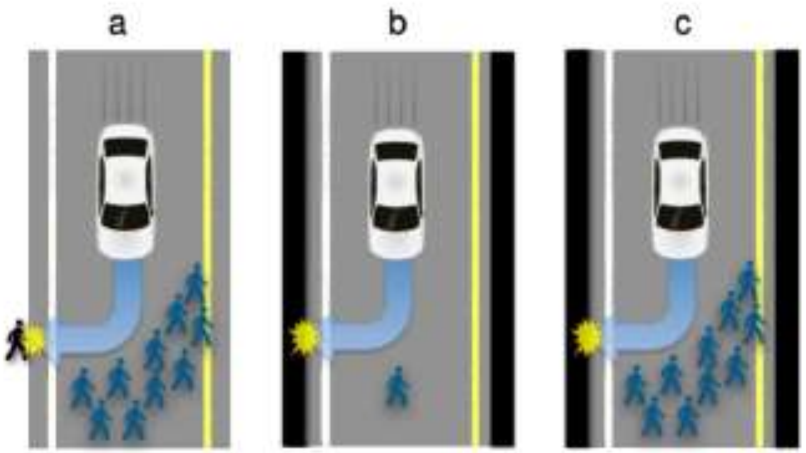
A View from **Emerging Technology from the arXiv**

Why Self-Driving Cars Must Be Programmed to Kill

Self-driving cars are already cruising the streets. But before they can become widespread, carmakers must solve an impossible ethical dilemma of algorithmic morality.

October 22, 2015

When it comes to automotive technology, self-driving cars are all the rage. Standard features on many ordinary cars include intelligent cruise control, parallel parking programs, and even automatic overtaking—features that allow you to sit back, albeit a little uneasily, and let a computer do the driving.



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Security Nightmare of Driverless Cars

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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.
- Decrease time cost
- 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)
- Feldman and Avineri estimated this figure for Israel from 1.1 billion NIS today to 4.5 billion NIS in the future (ITS Israel, 2016)

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

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/)

Typology of Research Objectives

- Ownership/Use
- Travel behavior/Mode
- Activity/Lifestyle
- Land use

Typology of Approaches

1. Perform simulation based/scenario analysis studies
2. Stated Preference Surveys
3. Virtual reality/Games/Simulators
4. Revealed Preference/Analog modes/naturalistic experiments
5. Qualitative?

Stated Preference Studies

Willingness to go driverless and preferred degree of automation

Studies reveal a wide range of opinions among users:

- Megens (2014) found that users prefer partial automation over full automation (Van der Waerden, 2015 obtained similar findings).
- Schoettle & Sivak (2014) surveyed travelers in China, India, Japan, U.S., U.K. and Australia and obtained high levels of concern about riding automated vehicles.
- Alessandrini et al. (2014) showed that users did not perceive automation as valuable when there weren't savings in travel time and fare.
- Howard and Dai (2013) showed that people are most attracted to the safety benefits, parking convenience, and en route multitasking.

Tendency toward AV

- Megens, 2014; Missel, 2014; Yvkoff, 2012; Kyriakidis et al., 2015; Payre et al., 2014: male, educated, young

Effect of Safety/Trust on Driverless Vehicles Acceptance

- People don't feel comfortable using a new technology which's safety hasn't been proven yet. Issues of trust are expected to be a major issue of AV acceptance (Howard & Dai, 2014; Choi & Ji, 2015)
- Automation can cause over trust that will lead to reduced situation awareness and increased reaction time (Endsley, 1996; Parasuraman & Riley, 1997; Young & Stanton, 2007)
- Operator's trust might exceeds the actual capabilities and cause over trust (Cunningham & Regan, 2015)
- Long periods of no manual driving may result in degradation of both the cognitive and psychomotor skills required to execute driving safely (Cunningham & Regan, 2015)
- The vehicle control algorithm affect trust (Price et. al., 2016)

Stated Preference Studies

The Impact of Multi-Tasking

- Malokin et al. (2015) showed that engaging in productive activities such as using a laptop significantly increased utility
- Berliner et al. (2015) found that users with longer commutes who traveled via commuter rail and ridesharing had the highest propensity to engage in various activities
- Additional multi-tasking related factors: age, gender, income, distance, education level, attitudes and preferences towards the adoption of technology, familial obligations, and time use expectations

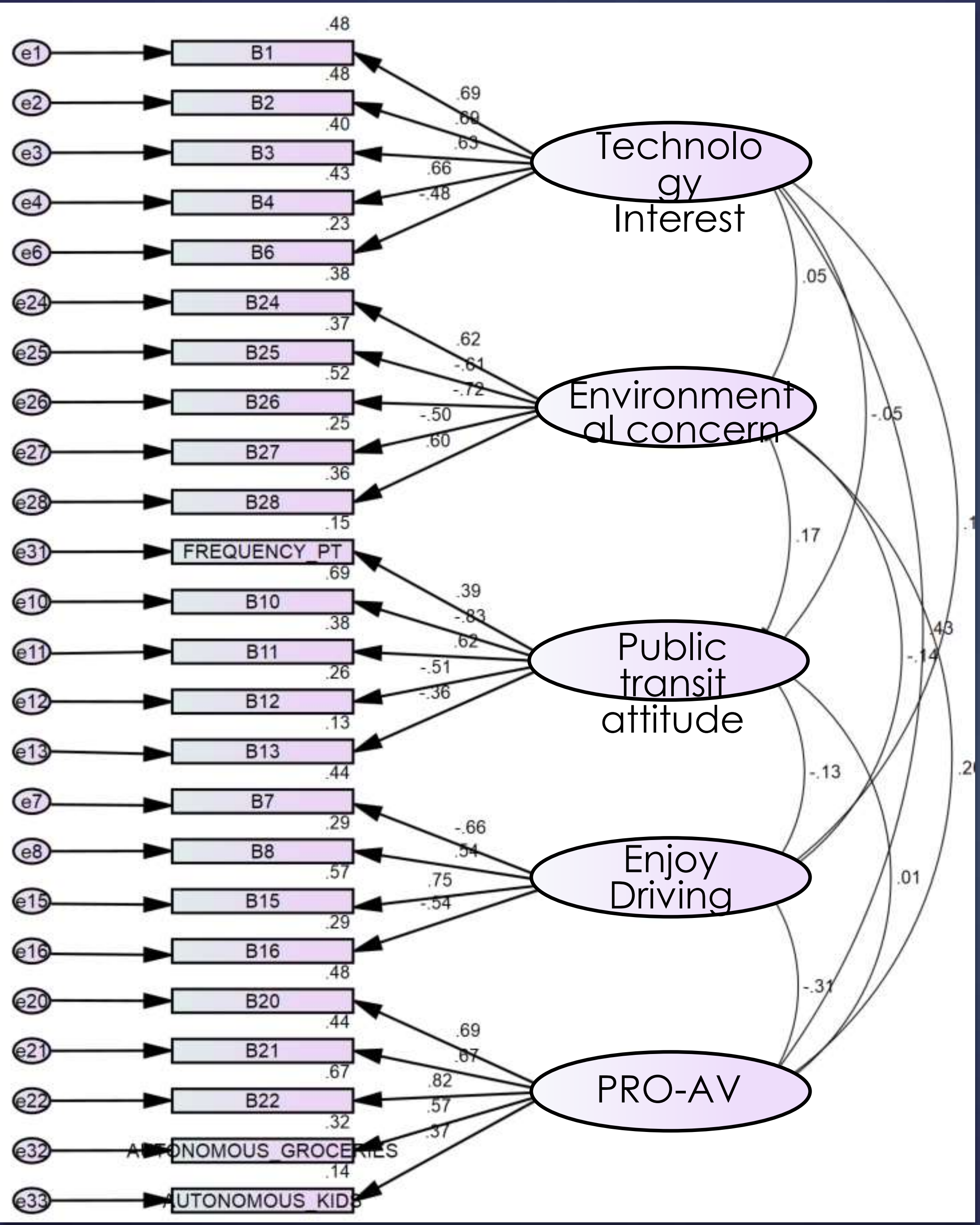
SP Design

Given the following characteristics, which option would you choose for your commute?

	Current car	Private autonomous vehicle	Shared autonomous vehicle
Purchase cost	30000$	34500$	--
Yearly membership cost	--	--	0$ /year
Trip cost (per direction of commute)	1.50$	1.27$	2.50$
Parking cost	4$	1.20$	--

Which option would you choose to use for this trip?

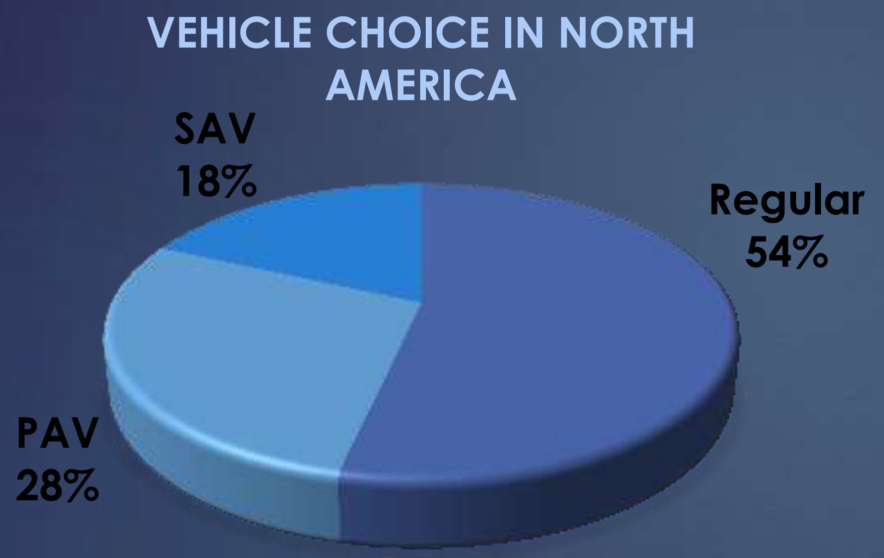
Current vehicle ○ Private autonomous vehicle ○ Shared autonomous vehicle ○

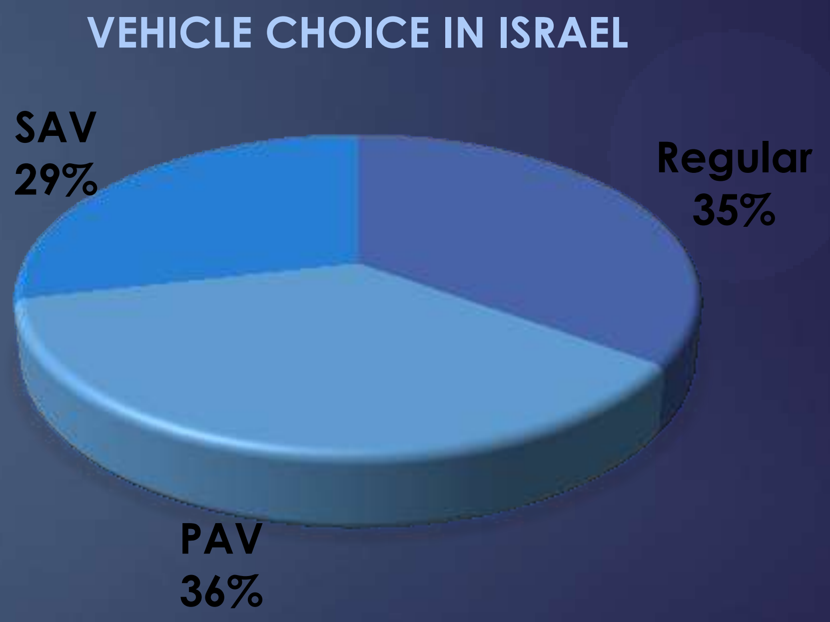


CONFIRMATORY FACTOR ANALYSIS

Generated using SPSS AMOS

Differences by Location

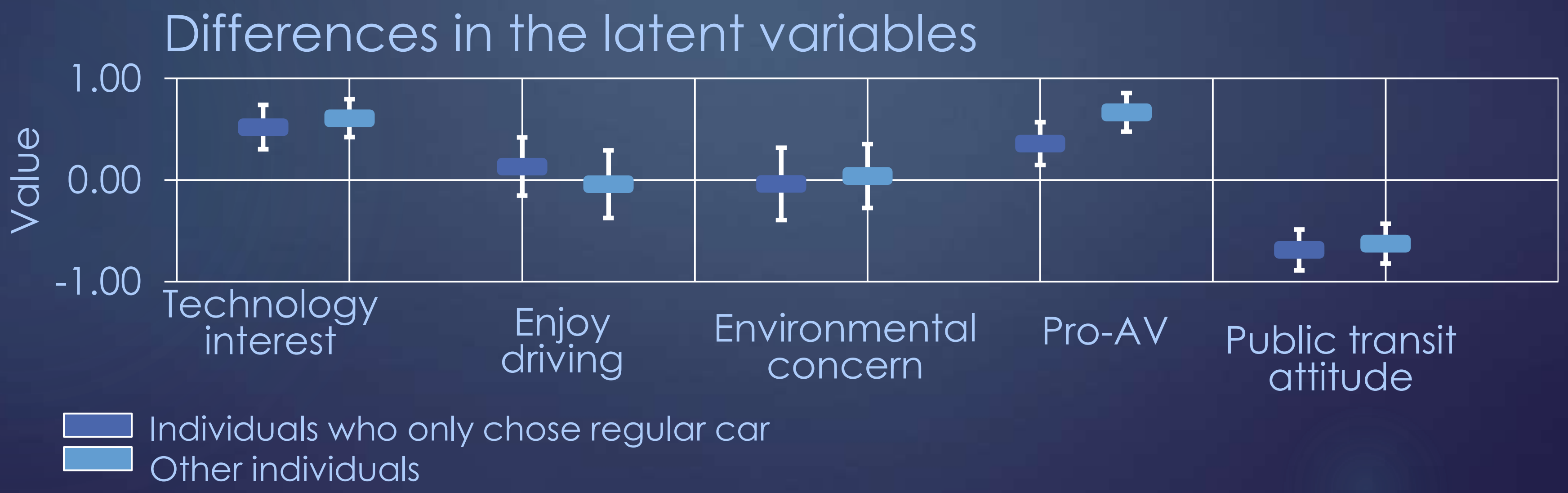




Consistent Individuals

An examination of the 166 individuals who always chose regular cars

- **Older, less likely to have young children**
- **More likely to be female**
- **Less educated**
- **Lower income**
- **Willing to spend less on a new car**
- **Less willing to let others drive their cars**
- **Answered the survey faster**



Multinomial Logit (MNL) Model

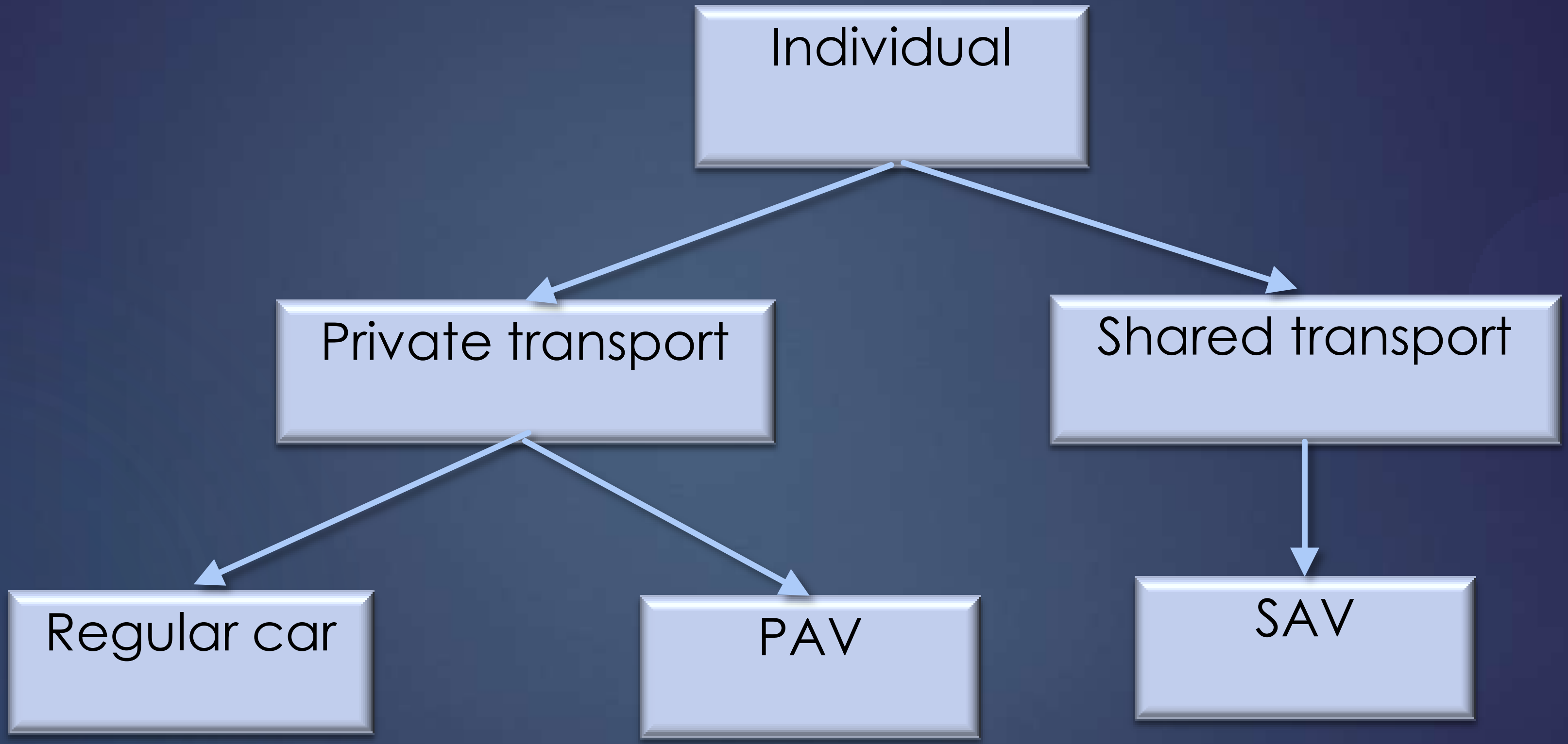
	Regular	PAV	SAV
Number of observations		4260	
Number of estimated parameters		30	
Null Log-likelihood		-4680	
Final Log-likelihood		-3508	
Constant		-4.88	-4.88
Travel time		0.00761	0.00761
Control of the AV		0.259	0.259
Education		0.279	0.279
Frequency of errands	0.148		
Store items in car [-0.82, -0.2,]			-0.821
Student (dummy variable)		0.239	0.239
Never uses PT (dummy variable)			-0.257
Number of days they commute			-0.170
Number of young children			0.172
Enjoy driving (ED) [-1, 0.5]	0.761		
Environmental concern (EC) [-1, 0.7]			0.661
PRO-AV attitude [0, 1]		5.36	5.36
Technology Interest (TI) [0, 1]		0.550	0.550

* All parameters are significant at the 95% level

MNL Model

		Regular	PAV	SAV
Purchase price (ratio)	If Purchase price PAV > REG		-0.806	
	If Purchase price PAV < REG		0.263	
Subscription cost (not-ratio)	Israel			-0.123
	North America			-0.575
Trip cost (ratio)	If trip cost PAV > REG		-0.249	
	If trip cost PAV < REG		0.364	
Trip cost (not-ratio)	Israel			-0.0106
	North America			-0.0165
	0 trip cost			0.762
Increase in parking price	Israel	-0.0946		
	North America	-0.111		
Age	Young			0.490
	Old		-0.293	-0.293
	Very old		-0.586	-0.586
Female		0.291	0.291	
Income			-0.205	
Km driven per year			0.0680	0.0680

Nested Logit Model



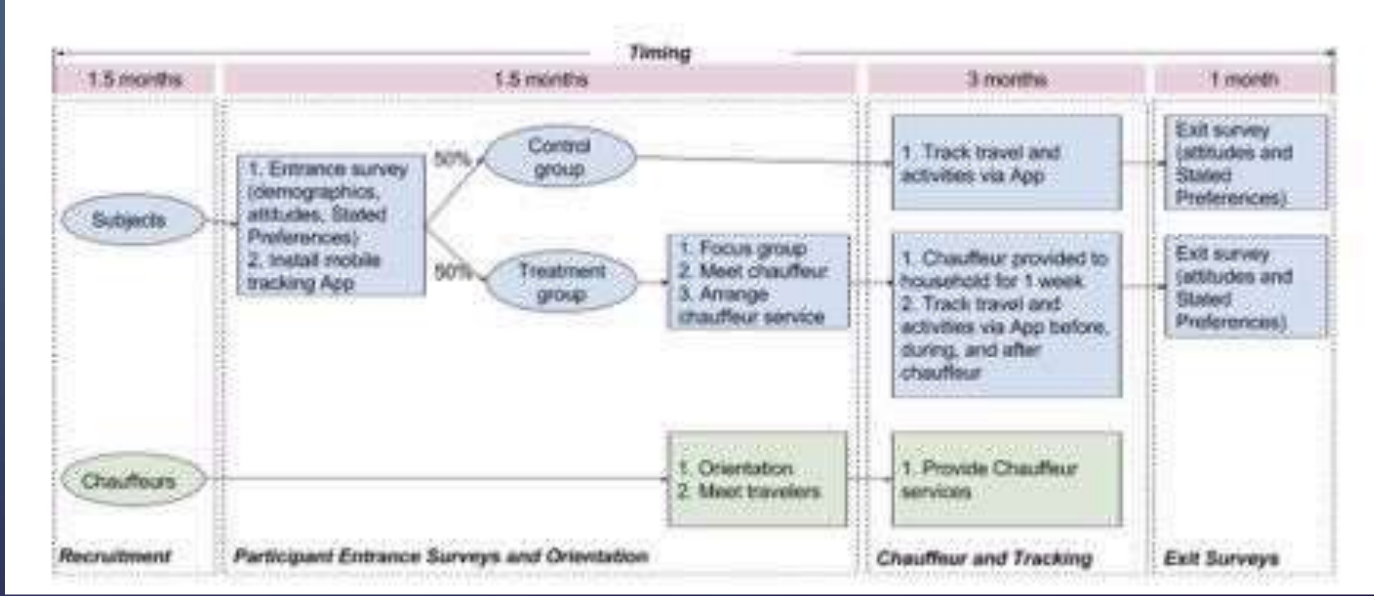
Unobserved shared attributes exist between the regular car and PAV

Revealed Preference: Analog Modes
Initial Evidence From Previous Studies of Emerging Services

Shaheen and Cohen, 2013	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.
Martin et al., 2010	Car sharing 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.
Firnkorn & Müller, 2015	Having driven an electric-car2go increased car2go-users' willingness to forgo a private car purchase.
Becker et al., 2015	Free-Floating Car Sharing (FFCS) - the car can be returned in any legal parking space.
Kopp et al., 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.

Naturalistic Experiment with Chauffeurs
Joan Walker et al., UC Berkeley

- **Question:** How would people use their cars differently if they were fully autonomous?
- **Method:** Naturalistic experiment - provide auto-owning households 40 hours of chauffeur service. Track travel via mobile phone with and without chauffeur.
- **Status:** Through human subjects (!); beta testing with 5 households
- **Findings:** Coming…
- **Graphic:**



BREAKOUT SESSION 15:

BEHAVIORAL EXPERIMENTS FOR MODELING ADOPTION AND USE OF AUTOMATED VEHICLES

Yoram Shiftan, Joan Walker, Dimitris Milakias, Srinivasan Sivaramakrishnan

AUTOMATED VEHICLES SYMPOSIUM 2016®

USERS. VEHICLES. INFRASTRUCTURE.

Key Action Items

- Integrated approach of methods
- Better ways to provide experience and knowledge to respondent
- Preferences, knowledge, awareness will change over time, must collect consistent data over time and across geographies.
- Coordination and collaboration with rest of AVS (HMI).
  - Leverage field tests for behavioral research. ALL field tests should also consider travel, activity, attitude, behavioral angles.
- Standards: generate set of standard questions (brief) to ask consistently across experiments. Ask before and after.

AVS 2017: Proposed Breakout Session

- Two-part session under one title
- Objectives:
  - How to better study behavior in the AV era (acceptance, adoption, usage)
  - How to design behavioral experiments and also other methodological approaches to do so
- First day: focus on a more general modeling framework, define variables, typology, dimensions of choices, etc.
  - Work on this framework before the symposium in order to present it for feedback and expansion.
- Second day: address behavioral experiments/ other methods in both small and large groups
  - Small group breakout to focus on creative solutions to a methodological challenge posed

Collaborations:

- Industry
  - Technology developers
  - Service provider
- Government and local authorities
  - Field studies
  - Policies
- Academia
  - Technology, big data, information systems and computer science, psychology, economy, political science, law, ethics,
- LIVE LAB – Integrate it all……

Thank You !!!