UCDAVIS
PLUG-IN HYBRID & ELECTRIC VEHICLE RESEARCH CENTER
of the Institute of Transportation Studies

Understanding use patterns of partially automated electric vehicles

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Introduction

- Current studies mostly use stated preference methods to understand impacts of automation
- Partially automated vehicles are on the roads today
  - In 2018 we estimate 75% of Tesla Electric Vehicles have autopilot hardware and software
  - Around 140,000 vehicles sold in 2018

Introduction to Automated Vehicles

SAE Level	SAE Name	Description
0	No Automation	The human driver controls all aspects of driving always. The vehicle may have warning systems.
1	Driver Assistance	The vehicle may be able to control steering or acceleration/deceleration using information from the external environment. The human driver performs all driving tasks.
2	Partial Automation	The vehicle may be able to control both steering and acceleration/deceleration using information from the external environment. The human driver performs all driving tasks.
3	Conditional Automation	The vehicle can control all driving tasks (steering, acceleration/deceleration) and monitors the environment. A human driver may need to respond to a request to take over the vehicle and acts as the back-up system.
4	High Automation	The vehicle can control all driving tasks (steering, acceleration/deceleration) and monitors the environment. The vehicle may request a human to intervene though intervention is not necessary.
5	Full Automation	The vehicle can control all driving tasks (steering, acceleration/deceleration) and monitors the environment. The human could choose the manage the vehicle if they desire.

Adapted form SAE (2016)

Tesla Autopilot

- Match speed to traffic
- Keep within a lane
- Automatically change lanes
- Transition from one freeway to another
- Exit the freeway
- Self-park and be summoned to and from your garage

(Tesla, 2019)

"Every driver is responsible for remaining alert and active when using Autopilot, and must be prepared to take action at any time" (Tesla, 2019)

Method

- Online questionnaire survey of 36 States, 3002 respondents
  - 424 Tesla with Autopilot

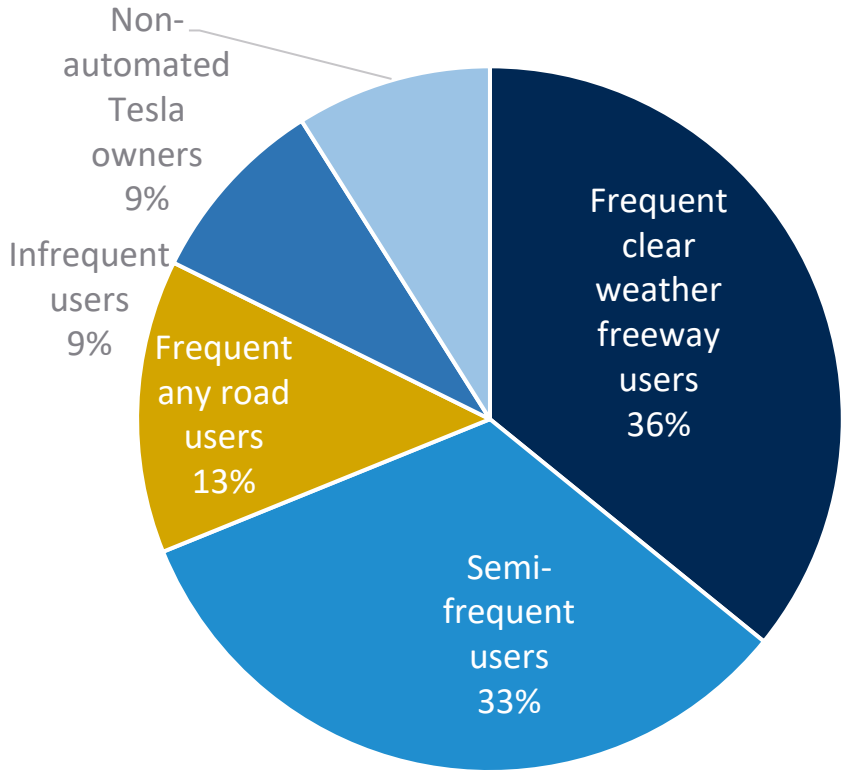
- Latent class analysis to classify automated vehicle users based on self reported use of automation (18 variables).
- Latent class analysis gives a probability for each class membership, which we assign as the class for the rest of the analysis.
- Multinomial logistic regression model to understand socio-demographic and attitudinal differences between clusters.

Results

Four classes of Tesla autopilot users

- Frequent clear weather freeway users
- Semi-frequent users
- Frequent any road users
- Infrequent users

- Non-automated vehicle owners



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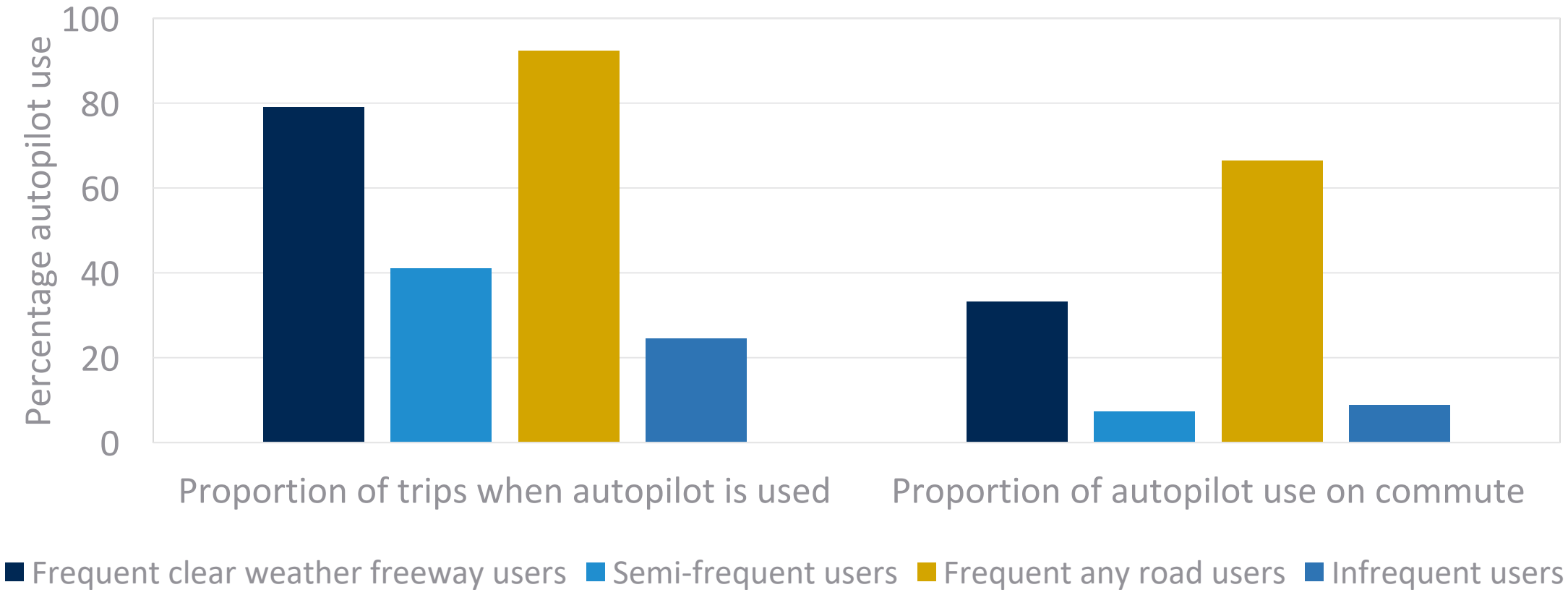
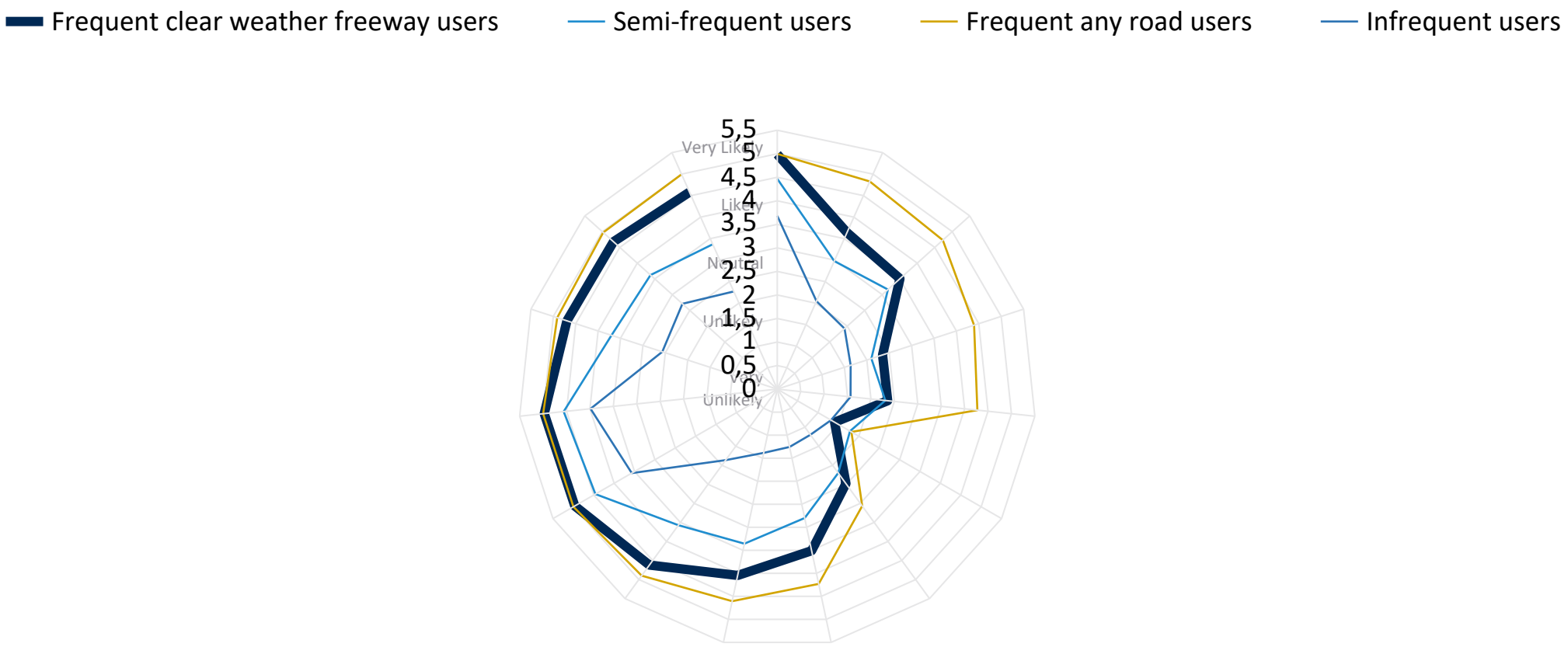
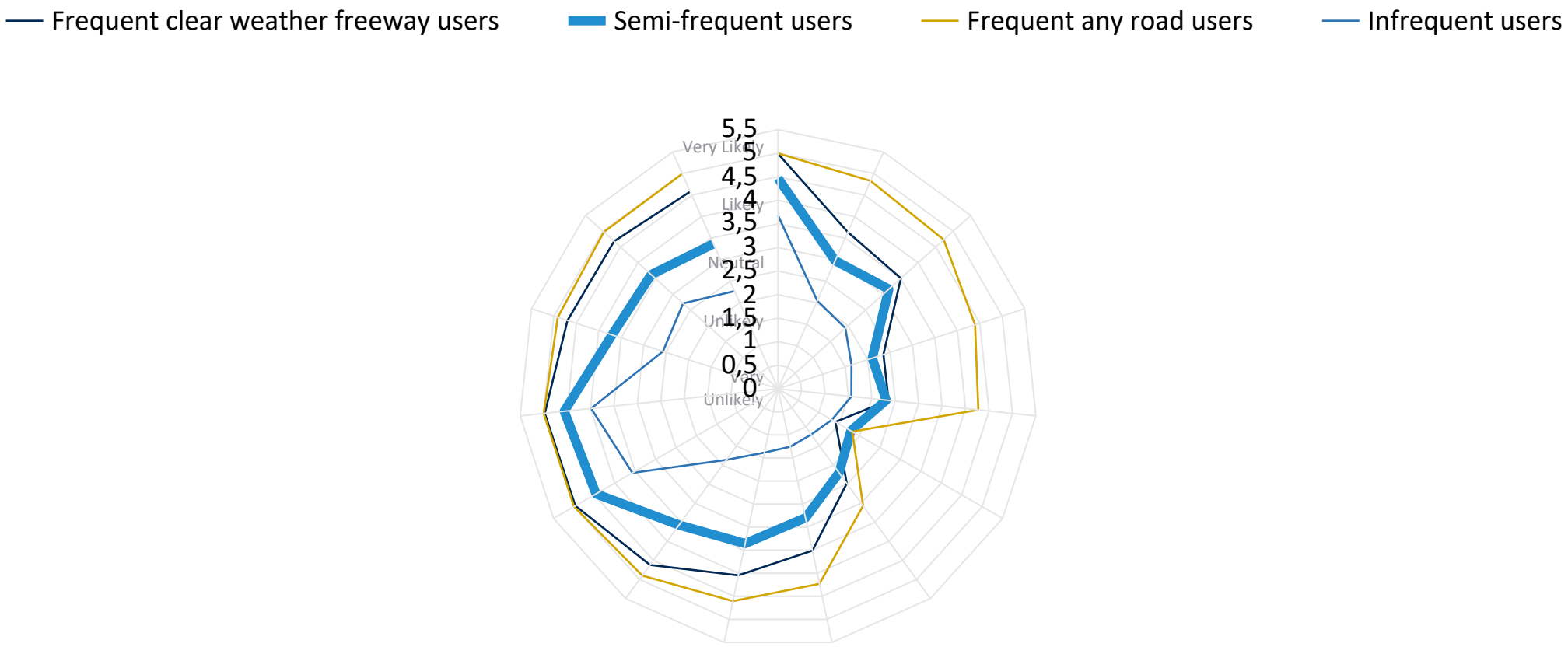


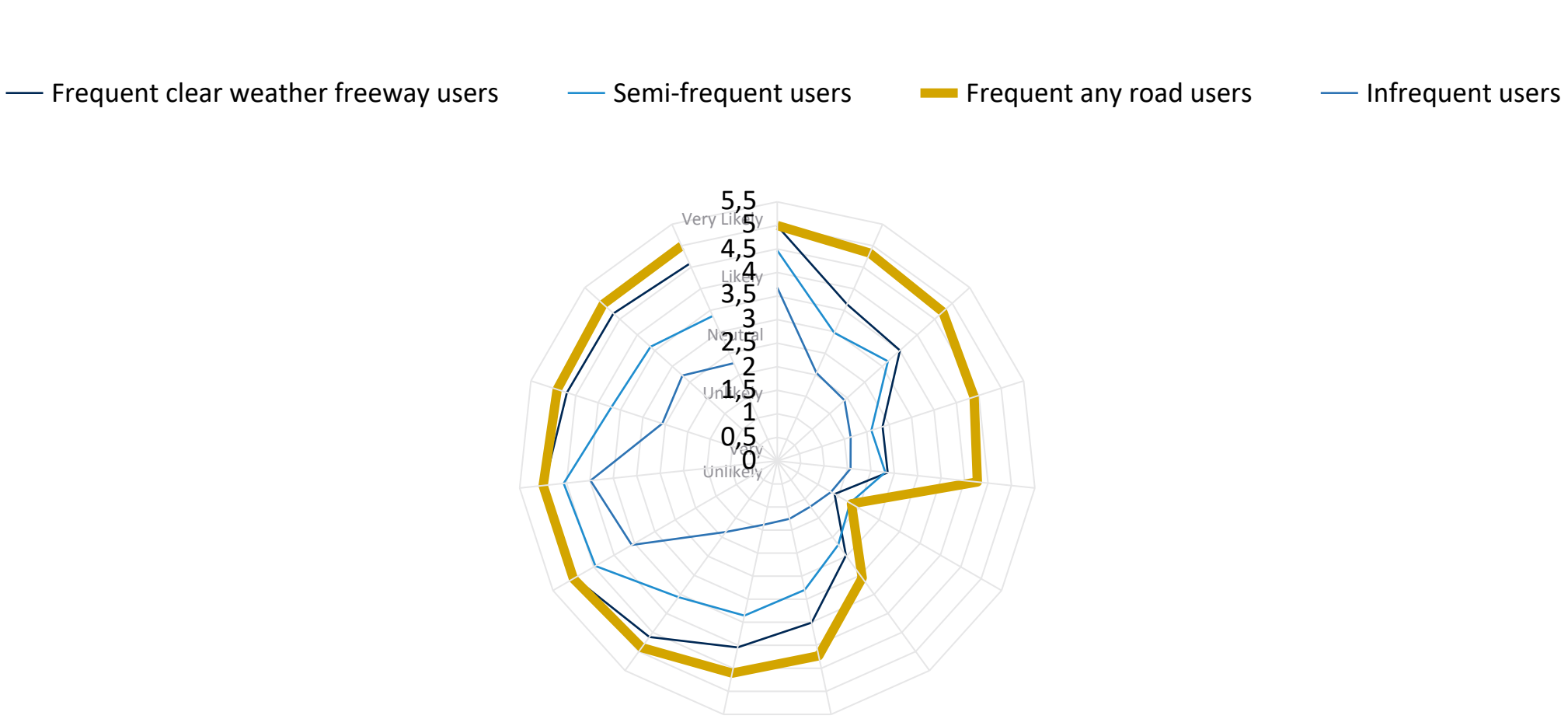
Frequent clear weather freeway users (36%)



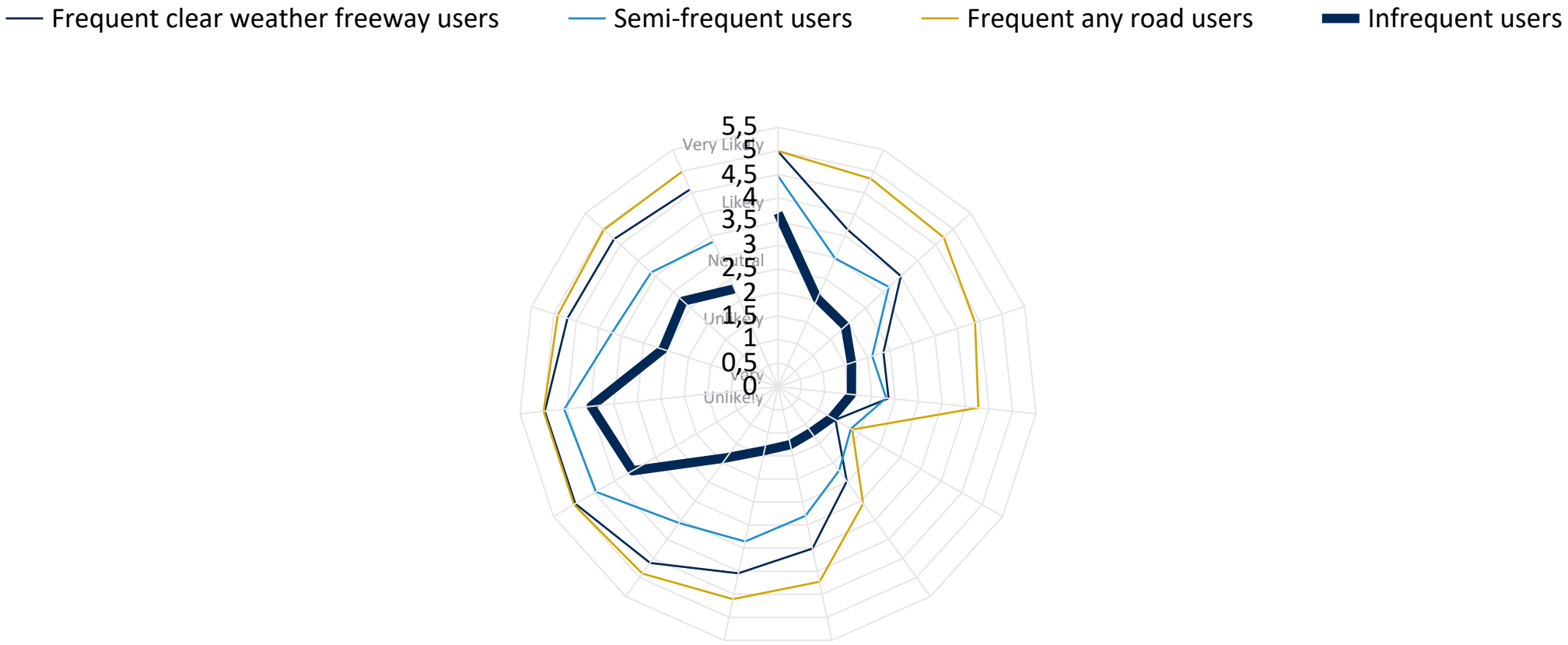
Semi-frequent users (33%)



Frequent any road users (13%)



Infrequent users (9%)



Multinomial logistic regression

	Frequent clear weather freeway users			Semi-frequent users			Frequent any road users			Infrequent users			Non-automated Tesla owners				
Covariates	Estimate	z-value		Estimate	z-value		Estimate	z-value		Estimate	z-value		Estimate	z-value		Wald	p-value
Age	-0.02	-1.99	**	0.00	0.00		0.02	1.52		0.00	-0.25		0.00	0.17		5.22	0.27
Male_1	0.61	2.15	**	-0.03	-0.13		0.45	1.17		-0.51	-1.43		-0.52	-1.68	*	8.20	0.09
HHsize	-0.16	-1.65	*	0.00	0.02		-0.20	-1.33		0.13	0.75		0.23	1.68	*	6.45	0.17
Postgrad	-0.41	-2.03	**	-0.33	-1.61		-0.14	-0.49		0.17	0.53		0.70	2.23	**	8.57	0.07
Income	0.00	0.12		0.00	1.24		0.00	-0.18		0.00	1.48		0.00	-2.31	**	6.90	0.14
CmtDist	0.01	0.99		-0.03	-1.73	*	0.01	1.06		0.01	0.87		0.00	0.18		3.31	0.51
VMT	0.00	3.72	***	0.00	-0.35		0.00	3.38	***	0.00	-1.99	**	0.00	-1.79	*	18.40	0.00
Detached_1	0.52	1.22		-0.43	-1.24		-0.23	-0.55		-0.27	-0.40		0.41	0.69		3.58	0.47
FrustCmters	-0.11	-1.24		0.03	0.28		0.11	0.81		-0.17	-1.03		0.14	1.10		4.08	0.40
TechnoPhobes	-0.19	-1.87	*	0.15	1.67	*	-0.39	-2.26	**	0.23	1.67	*	0.19	1.39		11.20	0.02
DrivEnthuiasts	-0.01	-0.13		0.13	1.77	*	0.15	1.43		-0.15	-1.48		-0.13	-1.09		7.03	0.13
*<0.10, **<0.05, ***<0.01																	

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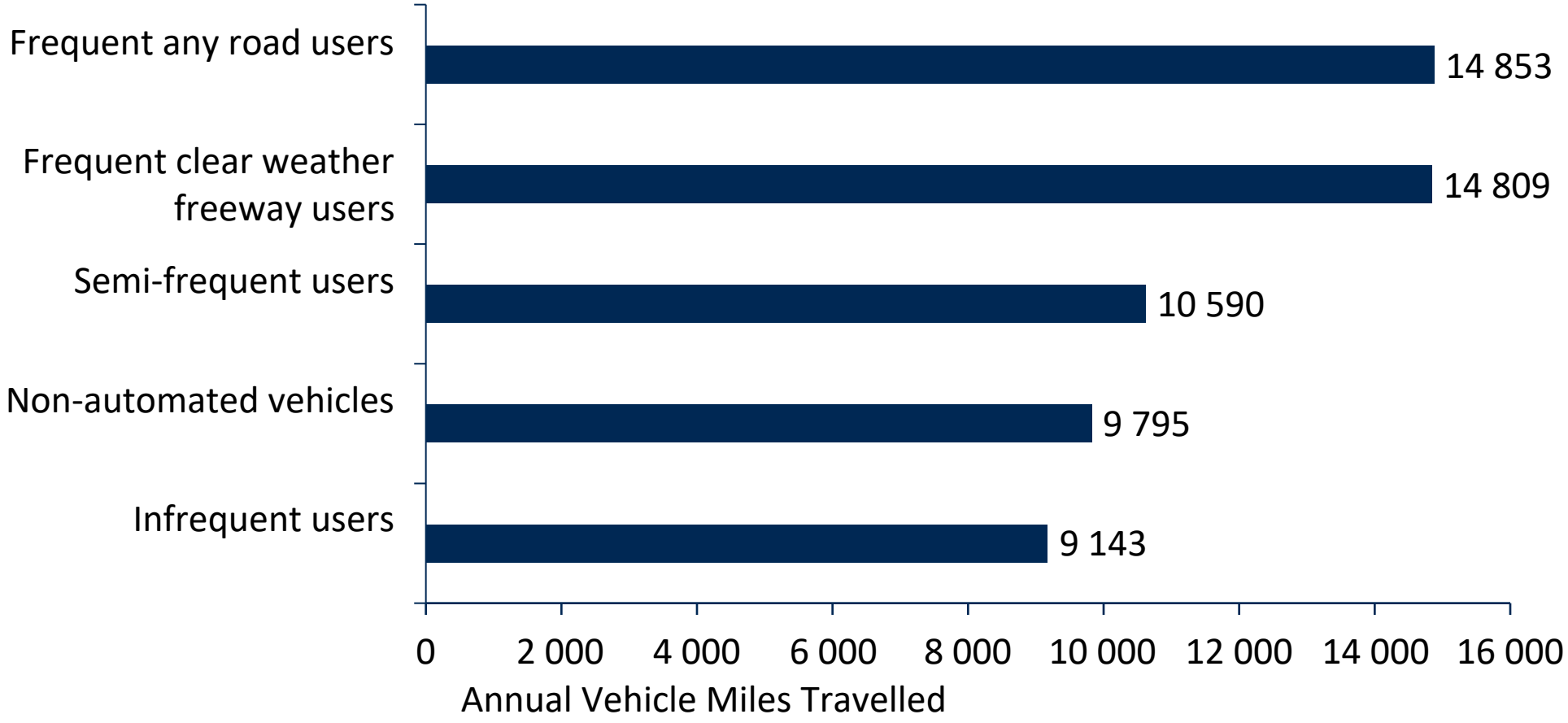
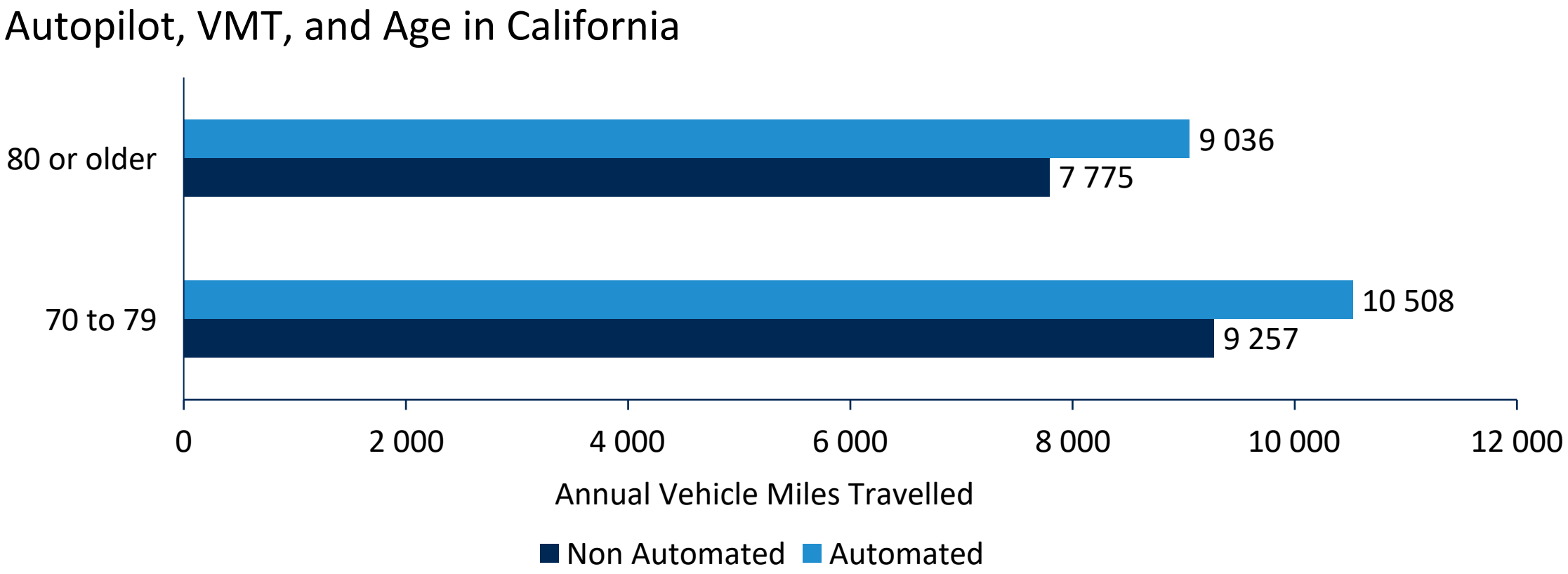
Annual VMT of Autopilot Classes



…but it might not all be bad



Summary

- Partial automation **may** increase:
  - VMT
  - Weekend travel*
  - Driving during congested times*
- This could lead to an increase in travel & energy consumption
  - Which goes US Department of Transportation VMT reduction goals and California goals

*results from California Survey of 1800 Tesla drivers, analysis forthcoming

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Thanks

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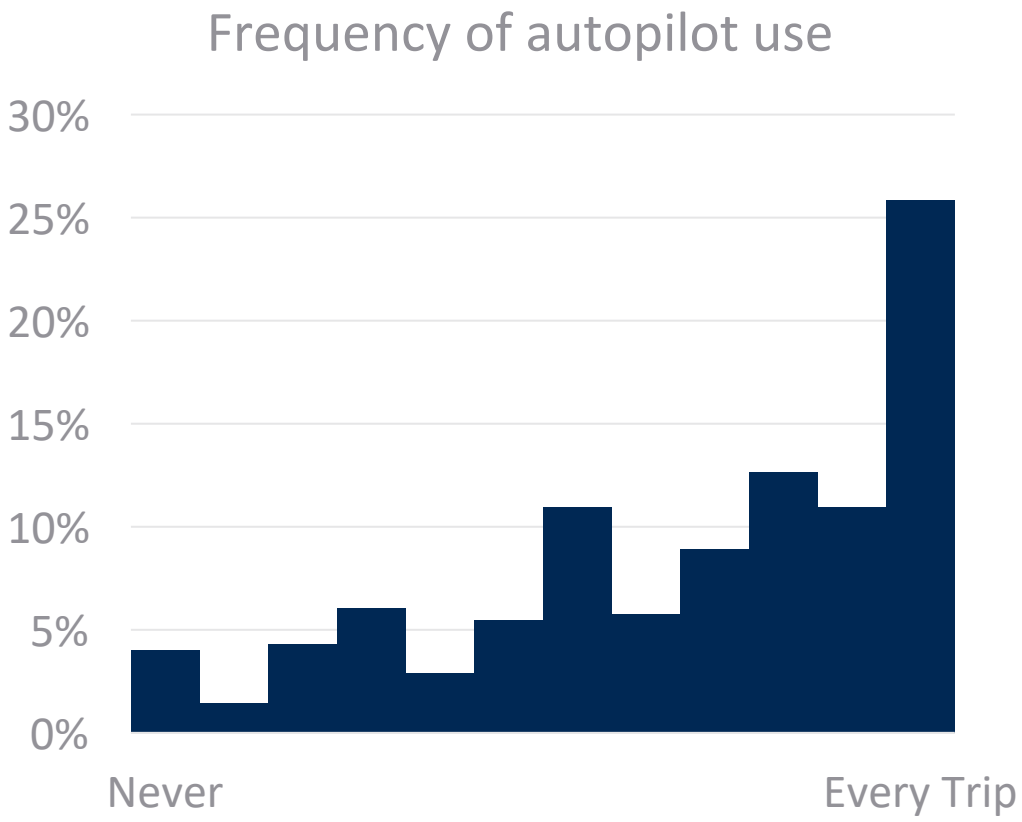
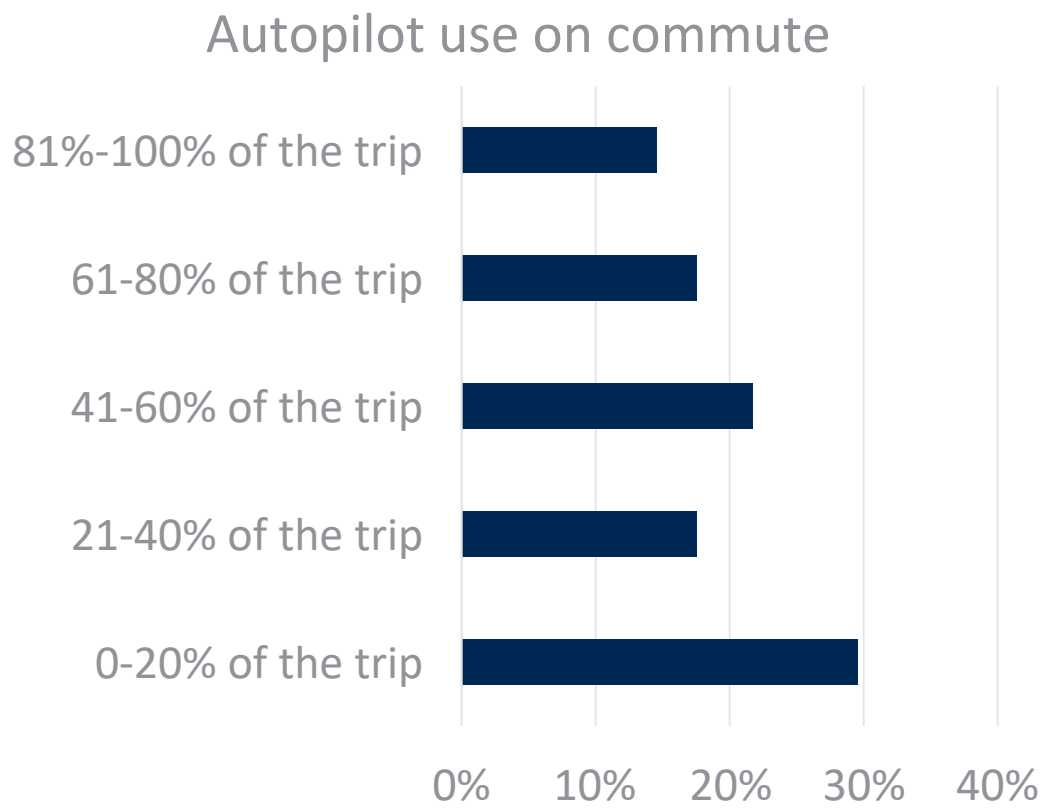
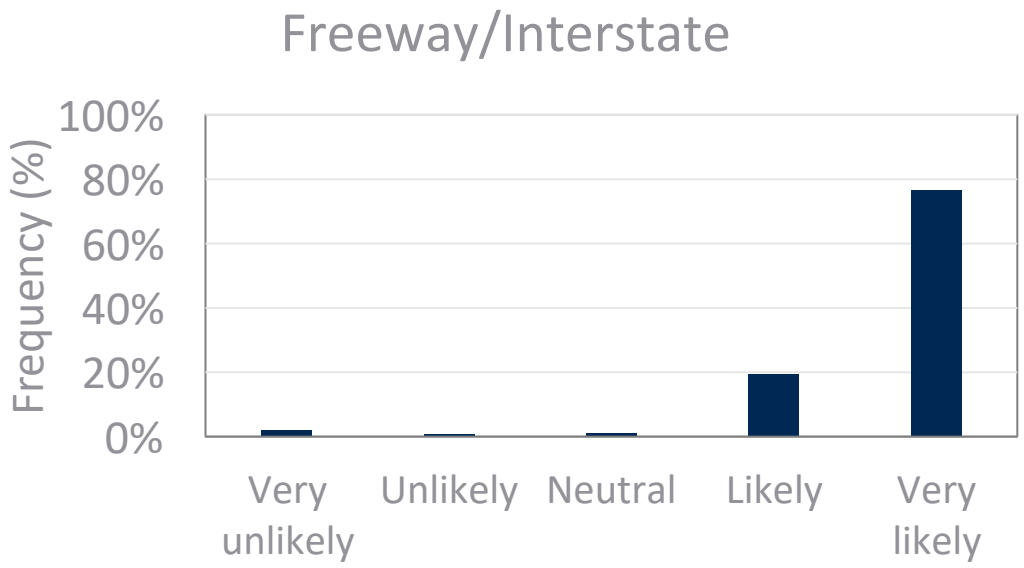
Plug-in Hybrid & Electric Vehicle Research Center
Institute of Transportation Studies
University of California Davis

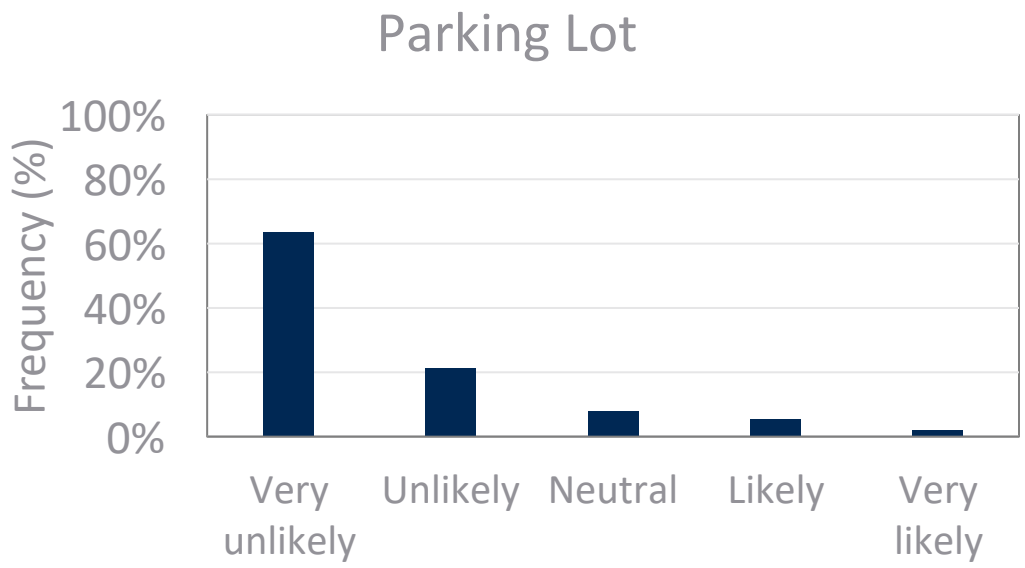
Autopilot use



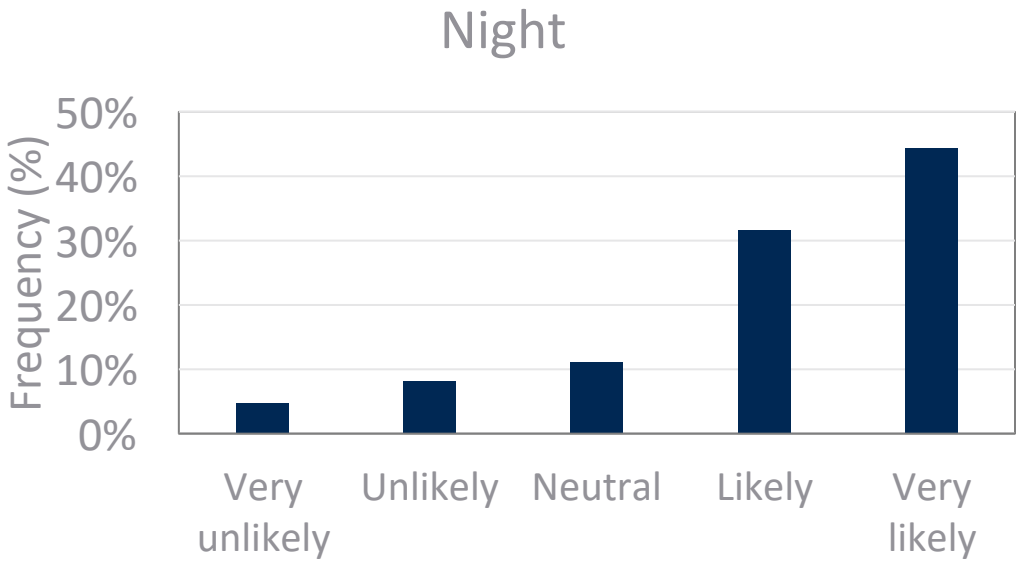


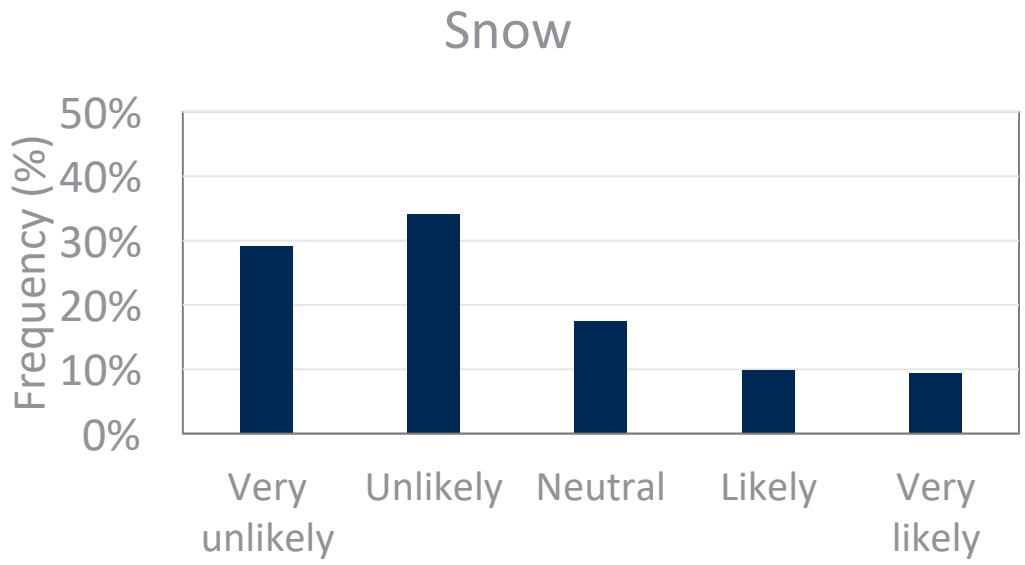
Autopilot use by road type





Autopilot use by weather





Autopilot use by traffic conditions