California
Road Charge

Public Private Roads Project

APPENDIX
D

Pilot Operations Plan and Closeout

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California Road Charge

Public/Private Roads Project

Pilot Operations Plan and Closeout

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Acronyms & Terms

Acronym / Term	Definition
API	Application Programming Interface
AWS	Amazon Web Services
CA	California
Caltrans	California Department of Transportation
CNG	Compressed Natural Gas
EV	Electric Vehicle
GB	Gigabyte
GPS	Global Positioning System
MPG	Miles Per Gallon
MPGe	Miles Per Gallon Gasoline Equivalent
OBD-II	On-board Diagnostics, Version Two
PRIME	Platform for Road Charge Innovation and Mobility Evolution
RUC	Road Use Charge
TCA	Transportation Corridor Agencies

1. Introduction

The California Road Charge Public/Private Roads Project (the Project) represents California's most recent initiative in its series of ongoing efforts to study the viability of a Road Charge program in the state. To date, the California Department of Transportation (Caltrans) has led two successful pilots, and to build upon the findings from those previous pilots, Caltrans focused the present Public/Private Roads Project upon the perspectives of two distinct populations of the state: rural and tribal communities. Accordingly, the primary objective of the Project was to engage participants from rural and tribal communities in a 6-month live demonstration, to gather information from the targeted communities regarding their use of public and private roadways, as well as to investigate the impact that a future Road Charge program might have upon these specific communities.

A secondary objective of the Project was undertaken in coordination with the Transportation Corridor Agencies (TCA), branded as "The Toll Roads", to evaluate the feasibility of a tolling entity serving as an account manager within a Road Charge program. This sub-pilot targeted the participation of 50 existing TCA customers in the live demonstration, such that participant-facing interaction with the Project would be facilitated via TCA's existing infrastructure and functionality.

The Task 5.a.1 Pilot Operations Plan deliverable (hereafter "Operations Plan") outlined a plan for the various processes and tasks that were to be utilized to conduct the Project. The purpose of the present document is to report the results of the Project's execution against that plan, as well as to shed light on the extent to which the objectives of the Project were achieved.

1.1 PROJECT DOCUMENT REFERENCES

Table 1 lists the deliverables that are referenced within this document, and that can be referred to for further details:

Table 1: Referenced Documents

Formal Title	Referential Title	Deliverable Task #	Final Report Appendix
Pilot Operations Plan	Operations Plan	5.a.1	(n/a)
Pilot Recruitment Plan with Results	Recruitment Results	2.a.3	Appendix C
Pilot System Report	System Report	3.b.1 / 3.b.2	Appendix E
Customer Support Plan and Closeout	Customer Support Results	6.c.3	Appendix F
Incentive Plan with Payout Results	Incentive Results	2.a.5	Appendix G
Plug-In Device and Geolocation Report	Device Report	6.b.1	Appendix H

2. Pilot Participants & Vehicles

As outlined in the Task 2.a.3 Pilot Recruitment Plan with Results deliverable (Final Report Appendix C, hereafter "Recruitment Results"), three distinct pools, or cohorts, of participants were targeted for participation in the Project's 6-month live demonstration: members of California's rural communities (Rural Cohort), members of the state's tribal communities (Tribal Cohort), and existing TCA accountholders (TCA Cohort). All participants were required to be a California resident at least 18 years of age, to be a licensed driver in the state, and to have access to the internet. Additionally, each of the respective cohorts specifically targeted participants exhibiting the characteristics outlined in Table 2.

Table 2: Targeted Participant Characteristics by Cohort

Cohort	Targeted Characteristics
Rural	Live in US Census tract designated as a rural community AND Anticipate driving on private roads an average of at least once per week during the pilot
Tribal	Self-identify as a member of a federally recognized tribe AND Anticipate driving on tribal land an average of at least once per month during the pilot
TCA	Active TCA "The Toll Roads" accountholder

2.1 PARTICIPANT ACTIVATION

The Recruitment Results deliverable summarizes the various recruitment tactics and the intake portal that were utilized to identify candidates for participation in each of the 3 cohorts. Candidates who had expressed an interest in participating were subsequently vetted against the pre-established requirements and targeted characteristics for each cohort, and selected candidates were then invited to enroll into the pilot on behalf of each of the three cohorts. Once an invitee had successfully completed enrollment, the project team then shipped an OBD-II plug-in device, accompanied by installation instructions, to the new enrollee, to facilitate the capture of travel information from their vehicle over the course of the 6-month live demonstration. Upon successful installation of the device into their vehicle's OBD-II port, the pilot system began collecting travel information from the enrollee's vehicle, thereby making them an active participant in the pilot.

Table 3 depicts the number of participants who successful enrolled in each of the 3 cohorts, versus the number of enrollees who then followed through and successfully installed their plug-in device. Unfortunately, there were 6 individuals who successfully enrolled into the pilot, who never actually took the next step of becoming active participants; more specifically, 4 of the Rural enrollees, 1 of the Tribal enrollees, and 1 of the TCA enrollees failed to install their devices and become active pilot participants.

The subsequent analyses presented in this document will focus upon the active participants that successfully installed their plug-in device, and thereby facilitated the collection of travel data from their vehicles.

Table 3: Participant Enrollment vs. Activation

Cohort	Successfully Enrolled	Activated Device & Participated
Rural	238	234
Tribal	16	15
TCA	35	34
TOTAL	**289**	**283**

2.2 PARTICIPANT RESIDENCE

A breakdown of the active pilot participants by geographic region of residence, shown in Table 4, indicates that all regions of California were generally well represented in the geographic makeup of the pilot's participants. Over half of both the Rural and Tribal Cohorts was made up of participants who reside in northern California. In contrast, almost three-quarters of the TCA Cohort was made up of participants who reside in southern California, a finding that makes sense in light of the fact that the toll roads administered by TCA are all located in that region of the state. It should also be noted that one of the participants in the Rural Cohort provided a home address in the state of Idaho. However, over 98% of the pilot miles captured for that vehicle did in fact take place on California roads, and therefore this participant's results were included in the closeout analysis for the pilot.

Table 4: Segmentation of Participants by Region of Residence

Macro-Region of Residence	Active Participants				Region of Residence	Active Participants			
	Rural	*Tribal*	*TCA*	**TOTAL**		*Rural*	*Tribal*	*TCA*	**TOTAL**
Northern CA	122	9	7	138	Bay Area	12		1	13
					Lost Coast	23	4		27
					Northern California	54	5		59
					Sacramento Valley	33		6	39
Central CA	87	3		90	Central Coast	14	1		15
					San Joaquin Valley	49	1		50
					Sierra	24	1		25
Southern CA	24	3	27	54	Southern California	24	3	27	54
Out-of-State	1			1	Idaho	1			1
TOTAL	**234**	**15**	**34**	**283**		**234**	**15**	**34**	**283**

To gain insight into the extent to which the cohorts were distributed across urban vs. rural communities, Table 5 breaks down participant counts by cohort, across the following U.S. Census Tract Urban/Rural Classifications:

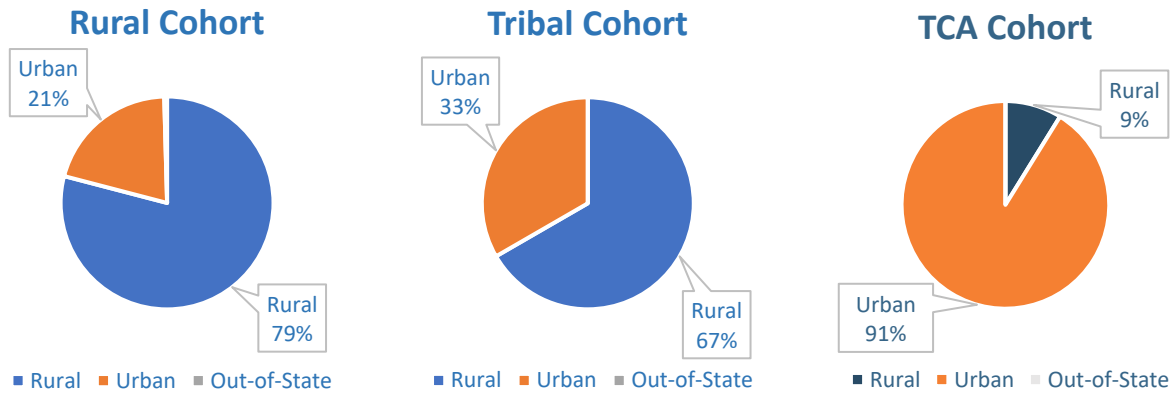
- **Large Urban Dense:** metro population greater than 250,000 (among the densest 40% of U.S. census tracts) and primary commute flow within urban areas
- **Large Urban Moderate:** metro population greater than 250,000 (not among the densest 40% of U.S. census tracts) and primary commute flow within urban areas
- **Small Urban:** metro population less than 250,000 and primary commute flow within urban areas
- **Rural Connected:** outside urban area with population greater than 10,000 and primary commute flow is >=50% into urban areas
- **Rural Independent:** all other tracts

Table 5: Segmentation of Participants by U.S. Census Tract Urban/Rural Classifications

Urban / Rural Categorization of Residence	Active Participants			
	Rural	*Tribal*	*TCA*	**TOTAL**
Large Urban Dense	11	3	27	41
Large Urban Moderate			4	4
Small Urban	37	2		39
Rural Commuters	102	3		105
Rural Independent	83	7	3	93
Out-of-State	1			1
TOTAL	**234**	**15**	**34**	**283**

If we were to aggregate the first 3 urban-related rows of Table 5 into a broader "Urban" meta-category, and similarly group the 2 rural-related rows into a "Rural" meta-category, the urban/rural composition of the 3 cohorts can be more broadly grasped via Figure 1.

Figure 1: Relative Urban/Rural Characterization of Participant Residence, by Cohort



This perspective reveals that 4 out of 5 of the participants in the Rural Cohort, as well as 2 out of 3 in the Tribal Cohort, reside within rural communities. In light of the fact that a target characteristic for the Rural Cohort was for the participants to reside in a rural community, it was somewhat surprising to find that 1 out of 5 of the participants in this cohort actually resided in an urban area. In contrast to the first two cohorts, 9 out of 10 participants in the TCA Cohort were found to reside within urban communities.

2.3 PARTICIPANT DEMOGRAPHICS

As outlined in the Recruitment Results deliverable, the recruitment objectives for the Project did not establish demographic stratification goals for the participants. Nonetheless, understanding the demographic makeup of the California citizens who chose to actively participate can only serve to paint a more complete picture, with respect to the insights to be gleaned from the pilot. Towards

that end, the following figures provide breakdowns of the active pilot participants by gender, age, education, and income, respectively, whereas a segmentation by ethnicity is shown in Table 6.

Figure 2: Participant Segmentation by Gender

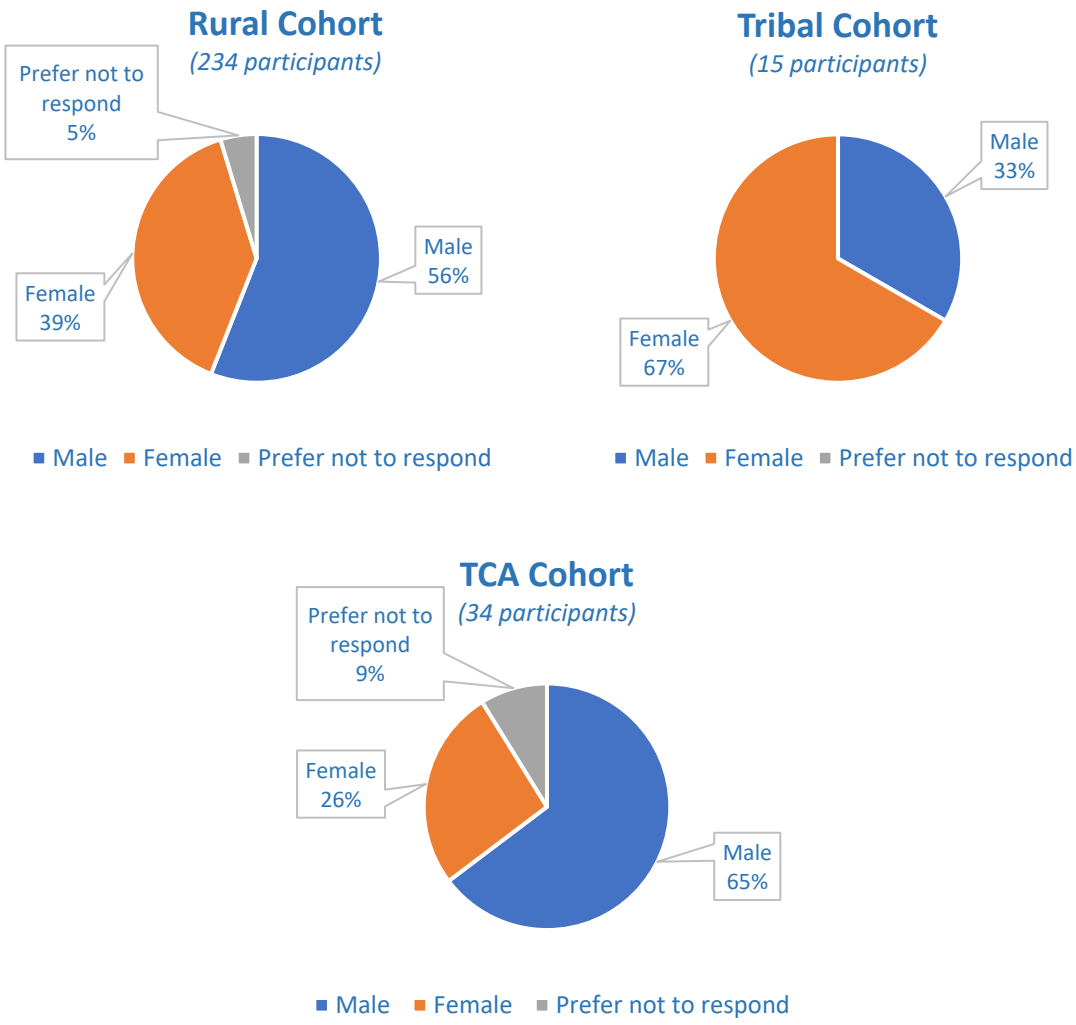


Figure 3: Participant Segmentation by Age

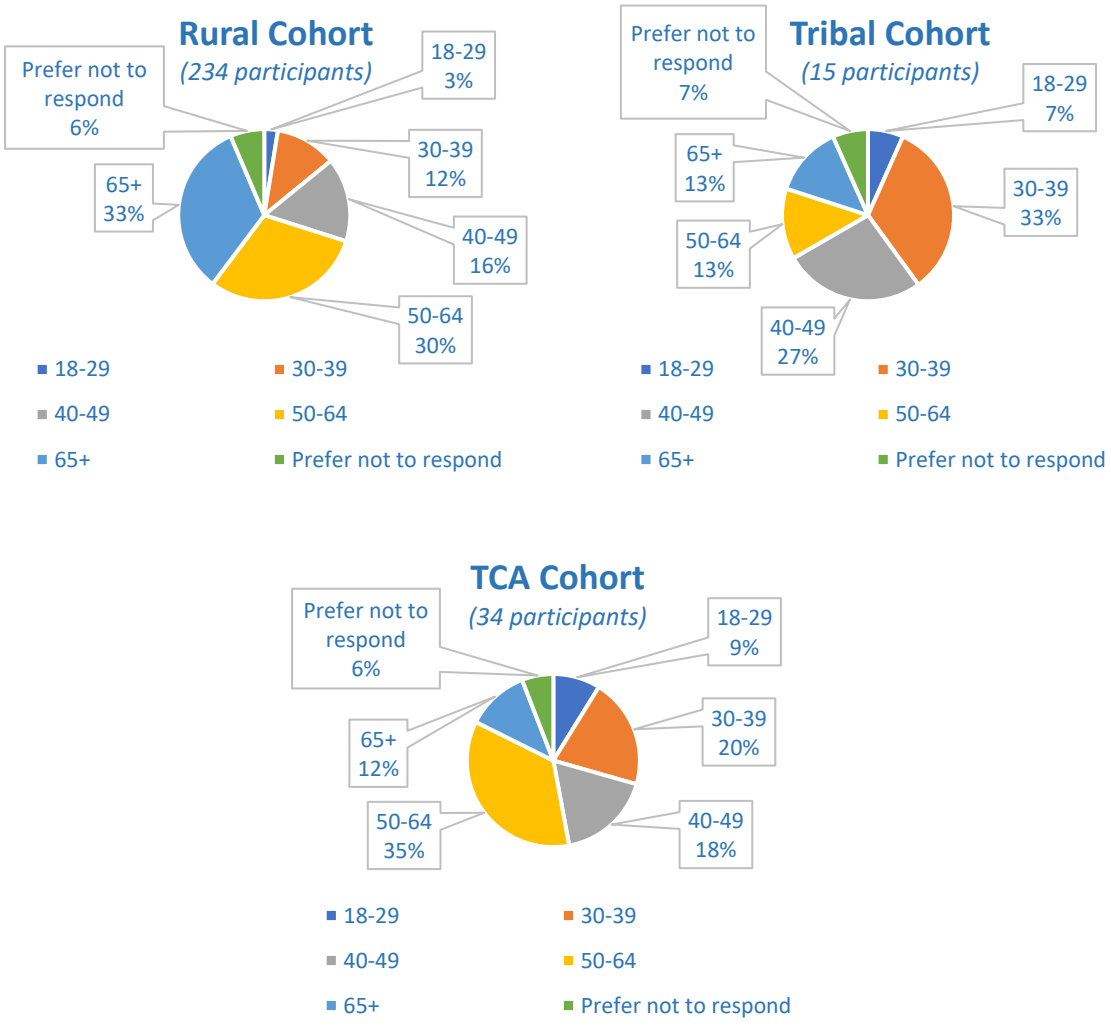


Figure 4: Participant Segmentation by Education

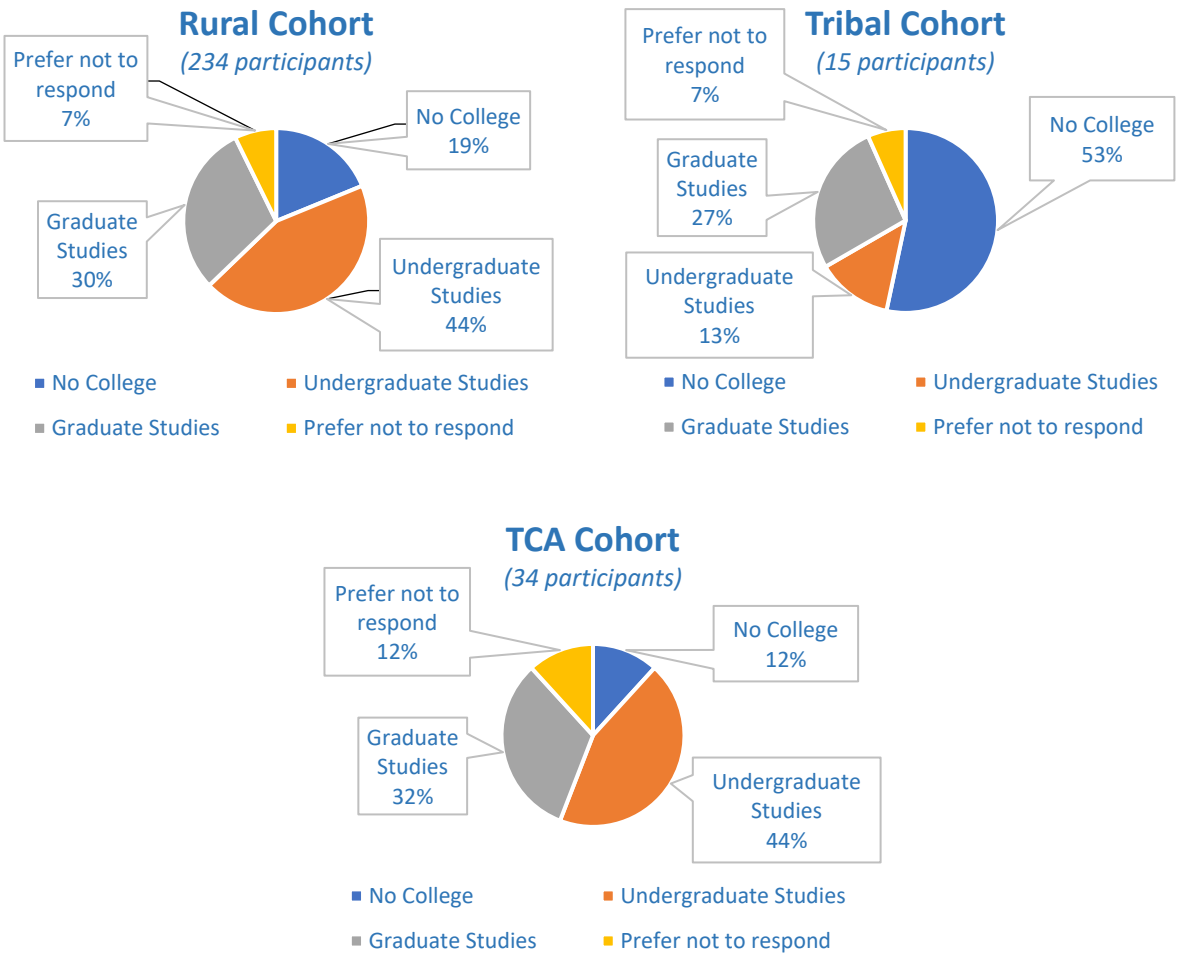


Figure 5: Participant Segmentation by Income

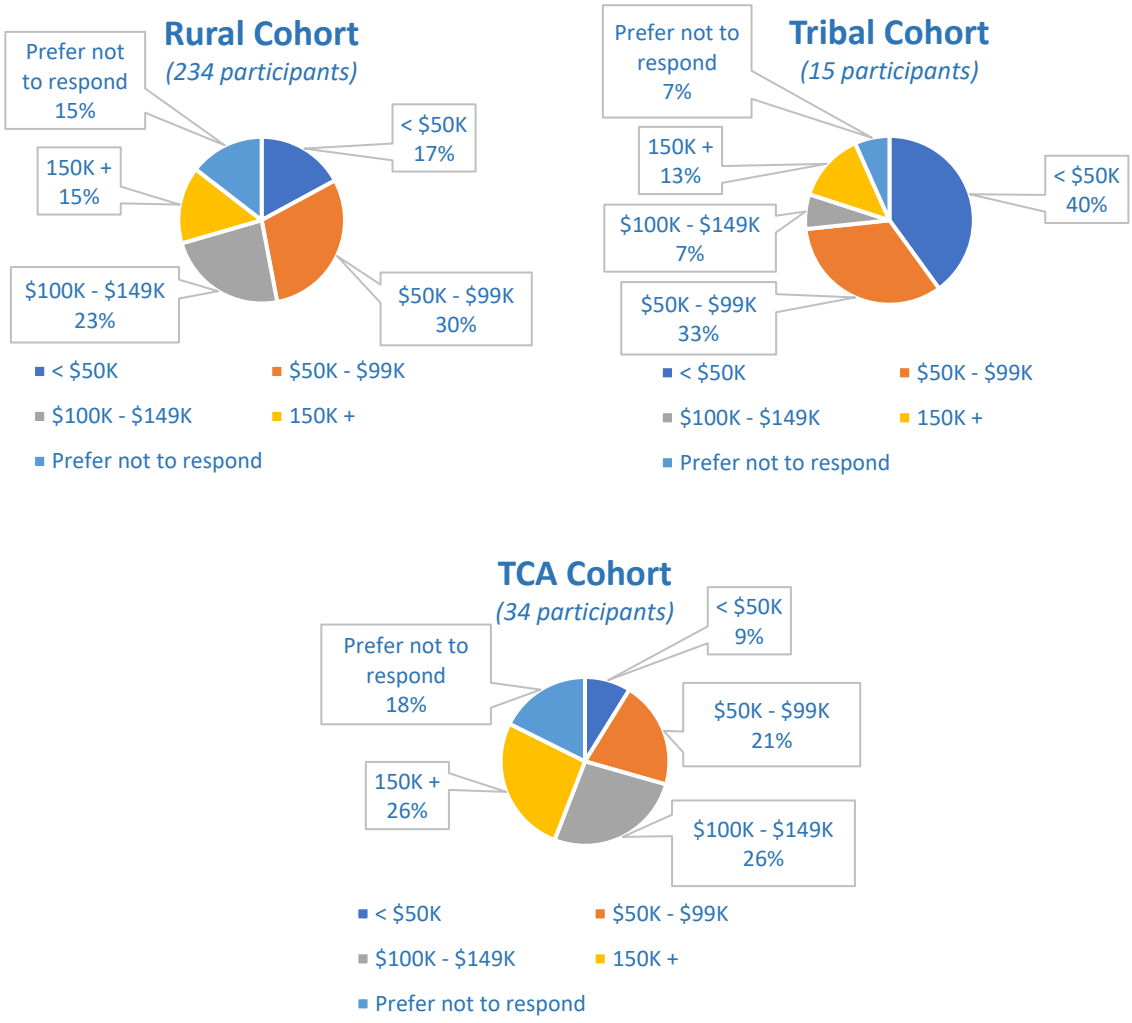


Table 6: Participant Segmentation by Ethnicity

Ethnicity	Active Participants			
	Rural	*Tribal*	*TCA*	**TOTAL**
White	176		17	193
Latino	14		5	19
American Indian	6	15	1	22
Black	5		1	6
Asian	9		7	16
Native Hawaiian	1			1
Other / Prefer not to respond	23		3	26
TOTAL	**234**	**15**	**34**	**283**

2.4 PILOT VEHICLES

At the time of enrollment, every participant was allowed to identify a single vehicle that they would be using for their participation in the pilot. Upon successful installation of the OBD-II into their vehicle, the vehicle was thereafter deemed to be "active" with respect to the pilot. The vehicle information that follows pertains to all vehicles that were active in the pilot.

As depicted within Table 7, there were a total of 283 vehicles for which travel information was collected for the pilot (one for each of the 283 active participants):

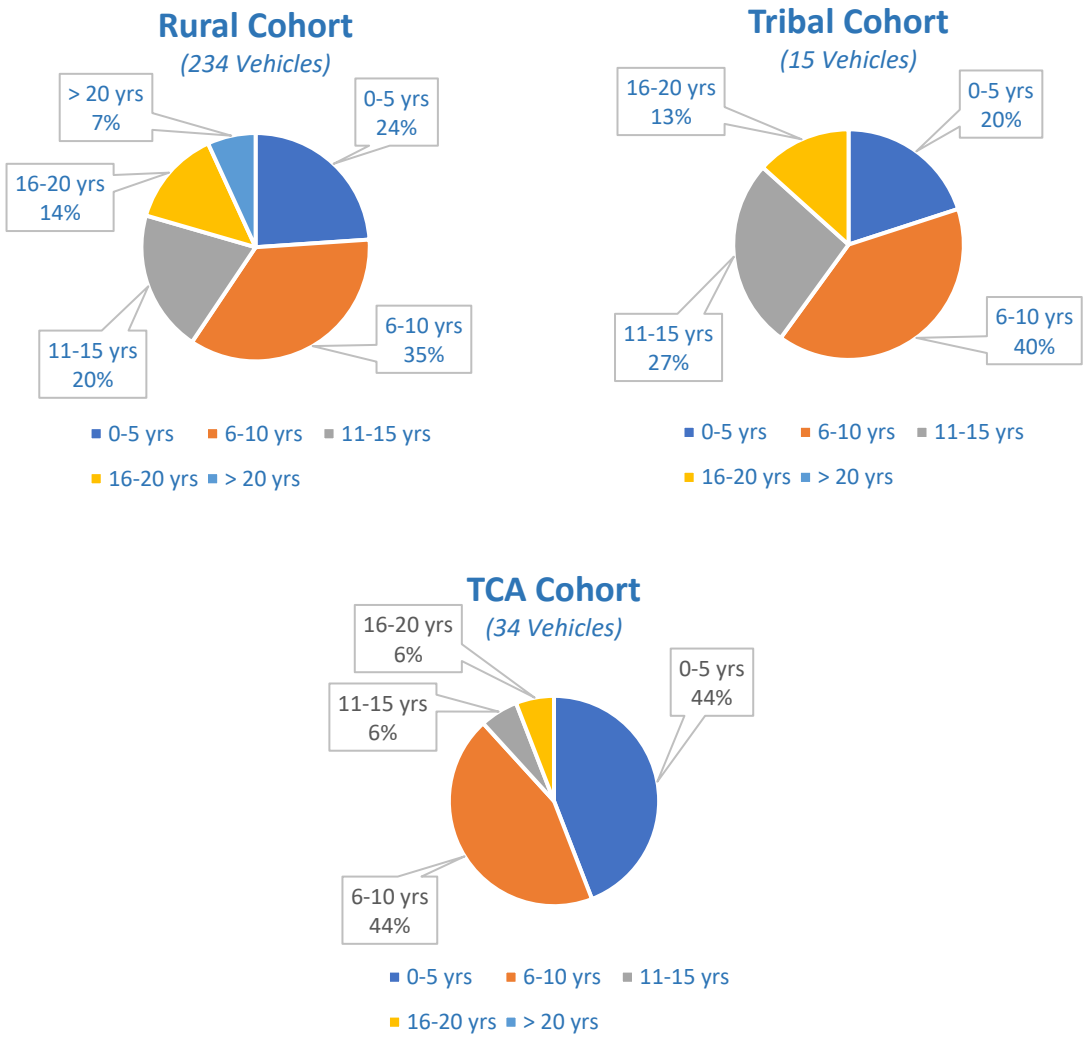
- A total of 14 EVs participated, with 13 in the Rural Cohort and 1 in the TCA Cohort.
- The Rural Cohort included 1 alternative fuel vehicle, which utilized E85 flex fuel.
- The TCA Cohort also included 1 alternative fuel vehicle, which utilized Compressed Natural Gas (CNG).
- The balance of the vehicles was made up of gasoline and diesel vehicles.

Table 7: Pilot Vehicles by Fuel Type & MPG/MPGe

Fuel Type	# Vehicles				MPG /MPGe	# Vehicles			
	Rural	*Tribal*	*TCA*	**TOTAL**		*Rural*	*Tribal*	*TCA*	**TOTAL**
Gas	212	14	32	258	0-15	16		1	17
					16-25	122	7	16	145
					26-35	58	5	10	73
					36-45	5	1		6
					> 45	11	1	5	17
Diesel	8	1		9	0-15	3	1		4
					16-25	3			3
					26-35	2			2
Electric	13		1	14	36-45	1			1
					> 45	12		1	13
Other	1		1	2	16-25	1		1	2
TOTAL	**234**	**15**	**34**	**283**		**234**	**15**	**34**	**283**

The breakdown by vehicle age of each cohort's pool of vehicles is depicted in Figure 6. The distribution of vehicles across age ranges was fairly similar for the Rural and Tribal Cohorts, as 6 out 10 of the newer vehicles in each group were no more than 10 years old. In contrast, the vehicles in the TCA Cohort were relatively newer, with 9 out of 10 vehicles in that group being no more than ten years old.

Figure 6: Pilot Vehicles by Vehicle Age Range



3. Mileage Capture

An OBD-II plug-in device with geolocation capabilities was installed in each vehicle taking part in the pilot. As outlined within the Operations Plan, travel information from each vehicle was then collected as follows:

- For each trip undertaken by a vehicle, the device transmitted to the pilot platform, independent messages associated with ignition on, ignition off, and the geolocational waypoints traversed between those two events.
- Device messages were cached by the platform as they were received, and subsequently aggregated into "trip" records.
- Each trip record captured the start time and end time for the trip, the overall distance travelled during the trip, and served as an aggregator for all of the geolocational waypoints collected by the system on behalf of the trip.

The Task 3.b.1/3.b.2 Pilot System Report (Final Report Appendix E, hereafter "System Report") deliverable provides a detailed overview of the platform architecture that was implemented and deployed to execute the pilot.

3.1 OVERVIEW OF TRIPS / MILEAGE

The overall summary of the trips taken and the mileage captured for each cohort are shown in Table 8. The average daily trips taken by each participant, as well as the average miles driven during each trip, are generally in line with the "rule of thumb" values observed within various other Road Charge pilots, both in the state of California as well as within other states (i.e., 3 trips per day, and 10 miles per trip). The slightly higher average daily trips that were observed for the Tribal Cohort is likely more attributable to the relatively very small participant count for that particular pool of participants (i.e., 15 participants), than to any general driving trend for the tribal community, as the driving frequency of a single participant within such a small sample size could significantly skew the results for the entire cohort.

Table 8: Summary of Trips / Miles by Cohort

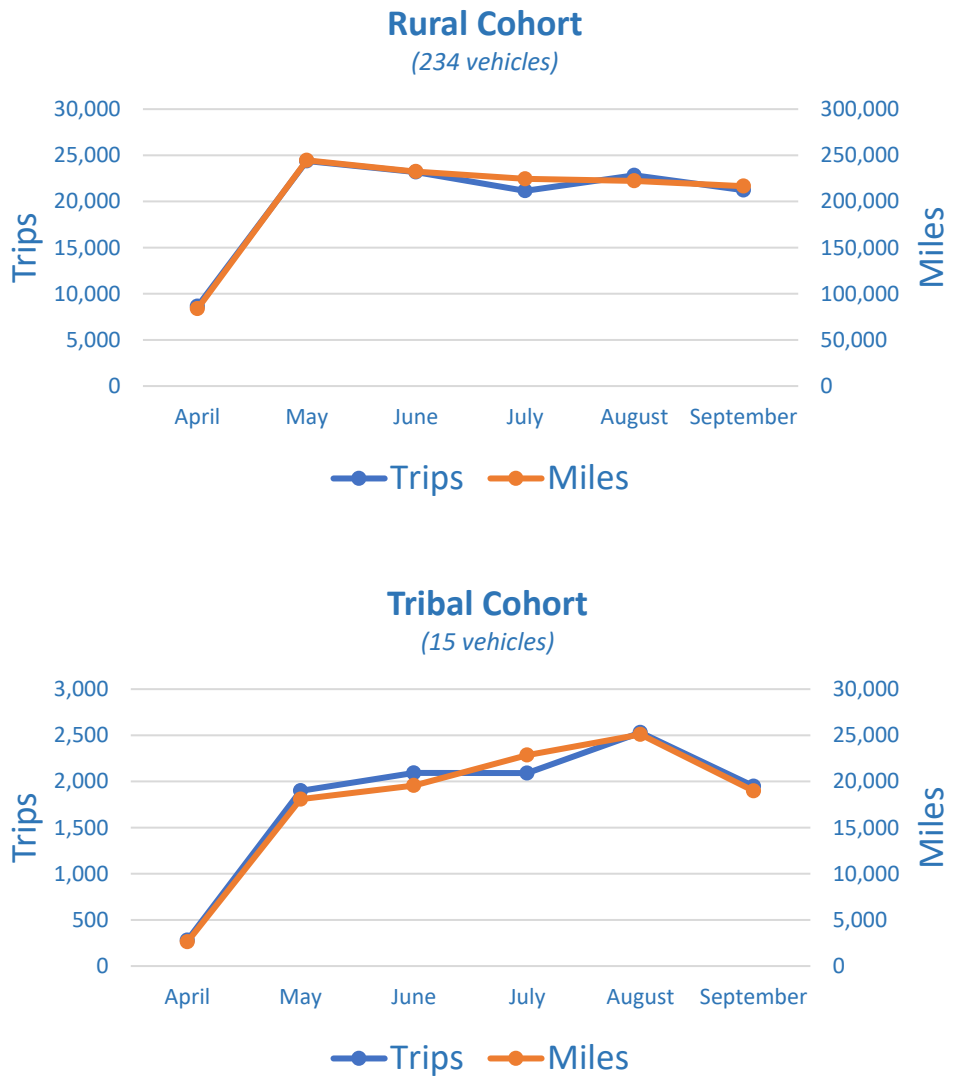
Metric	Cohort		
	Rural	*Tribal*	*TCA*
Active Participants	234	15	34
Total Trips *	121,456	10,889	20,138
Avg Total Trips / Participant	519	726	592
Avg Daily Trips / Participant	2.8	4.0	3.2
Total Miles Driven	1,238,453	107,740	176,803
Avg Miles / Trip	10.2	9.9	8.8

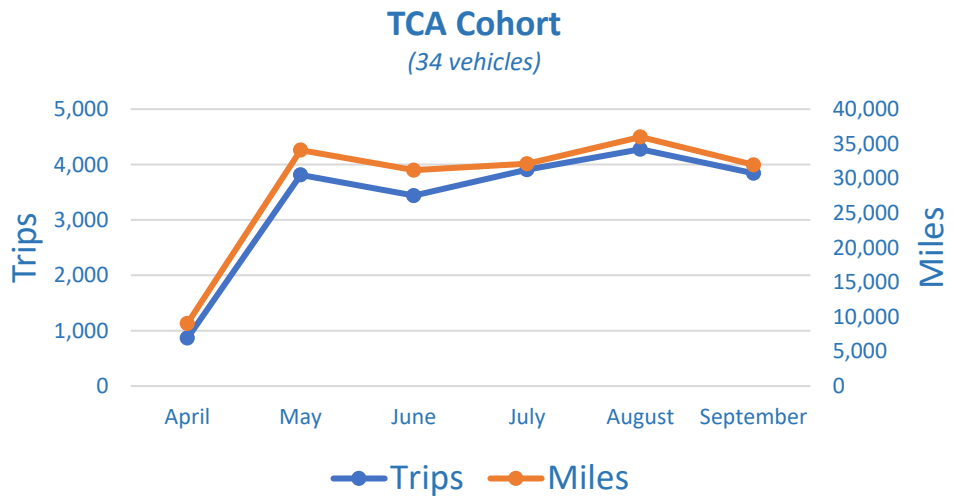
* Excludes zero-distance trips

3.2 TIMING OF TRIPS / MILEAGE

A segmentation by pilot month of both trip counts and mileage driven is shown in Figure 7, for all 3 cohorts. After an initial ramp-up period in the first month of the pilot, during which the participants were undertaking the installation of the plug-in device into their vehicle, a fairly consistent number of trips and mileage were captured for all 3 cohorts over the subsequent 5 months of the pilot. Note that for each cohort, the Trip and the Mileage plots generally mimic one another in shape, indicating that the miles driven per trip also remained fairly consistent across all 6 months of the pilot. A slight exception to this trend can be observed for the Rural and Tribal Cohorts, as for each group the miles driven per trip exhibited a slight uptick in the month of July, indicating that more "outlier" trips were being taken during that timeframe, as might be the case for more leisure-oriented trips typically taken during the height of summer.

Figure 7: Pilot Trips & Mileage by Month



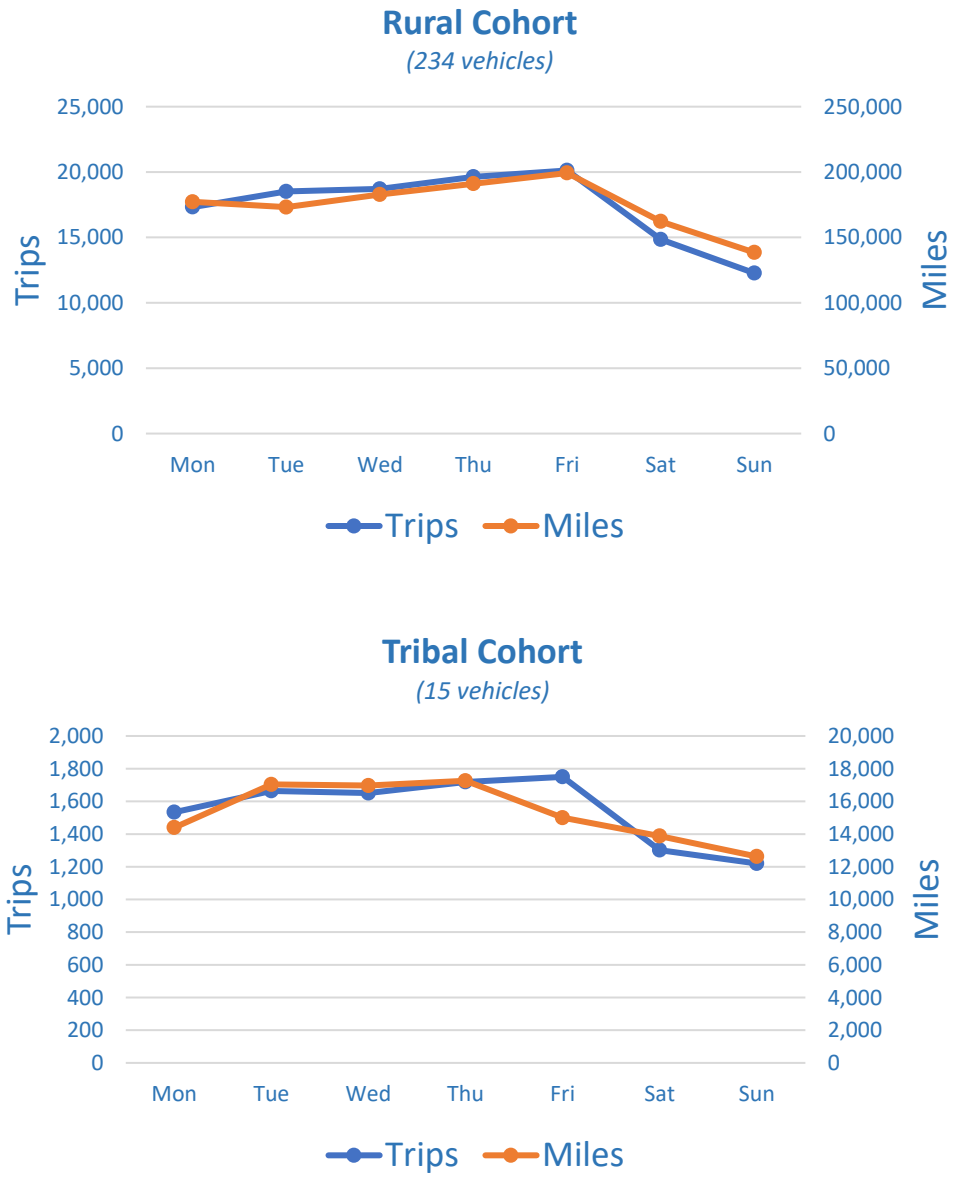


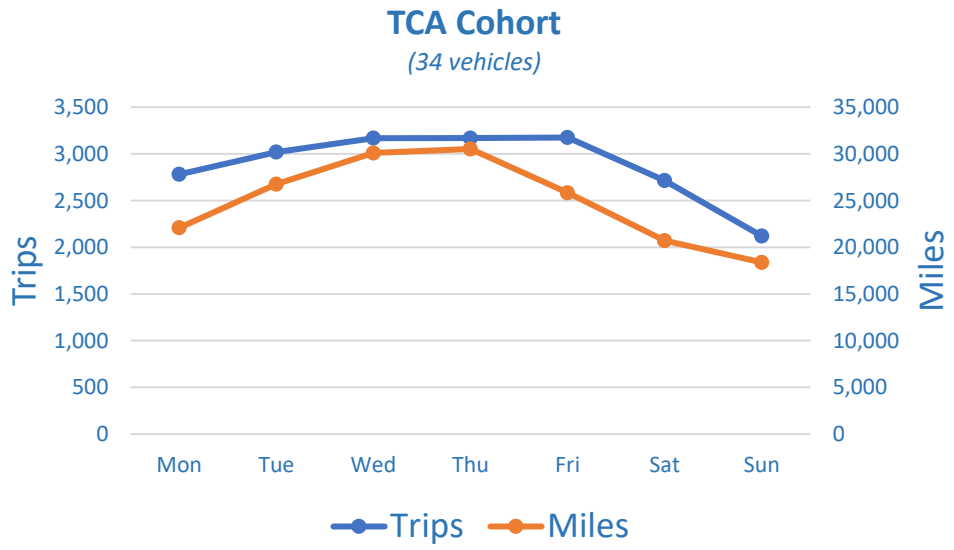
A breakdown by day of the week of both trip counts and mileage driven is depicted in Figure 8, for all 3 cohorts across all 6 months of the pilot. For all 3 cohorts the highest number of trips occurred at the end of the workweek on Fridays, and the lowest number of trips was taken on Sundays.

For the Rural Cohort, miles driven per trip exhibited a slight uptick over the weekends (i.e., the Trips plot decreased faster than the Miles plot over the weekends). In contrast, the opposite was observed for the TCA Cohort, as miles driven per trip experienced a decrease over the weekends (i.e., the Miles plot decreased faster than the Trips plot over the weekends), a result that would likely be consistent with the more commuter-oriented nature of the TCA Cohort during the workweek.

Lastly, Friday was the sole day upon which the driving behavior of the Tribal Cohort differed from the other days of the week, with miles per trip exhibiting a notable decrease on that day. Again, this result may very likely be more attributable to the relatively very small participant count for the Tribal Cohort, than to any general driving trend for the tribal community.

Figure 8: Pilot Trips & Mileage by Day of the Week

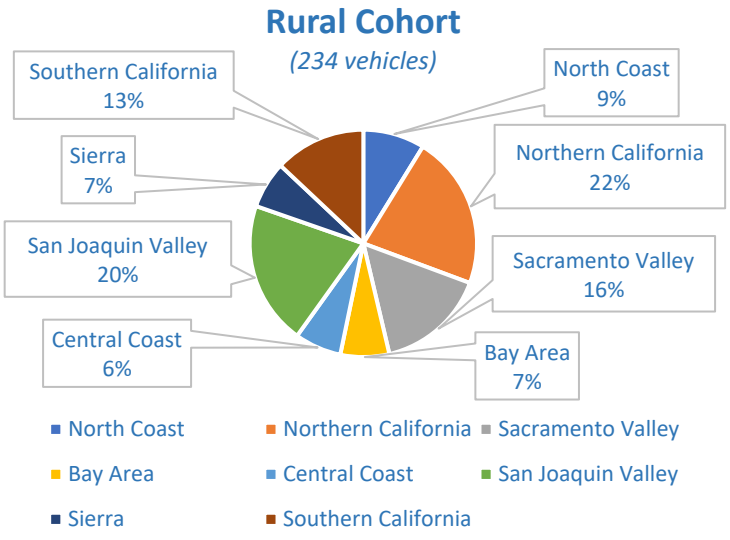


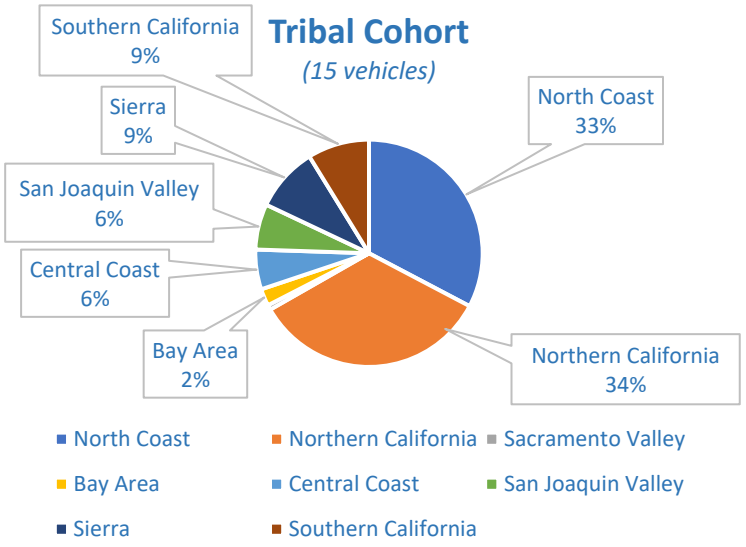


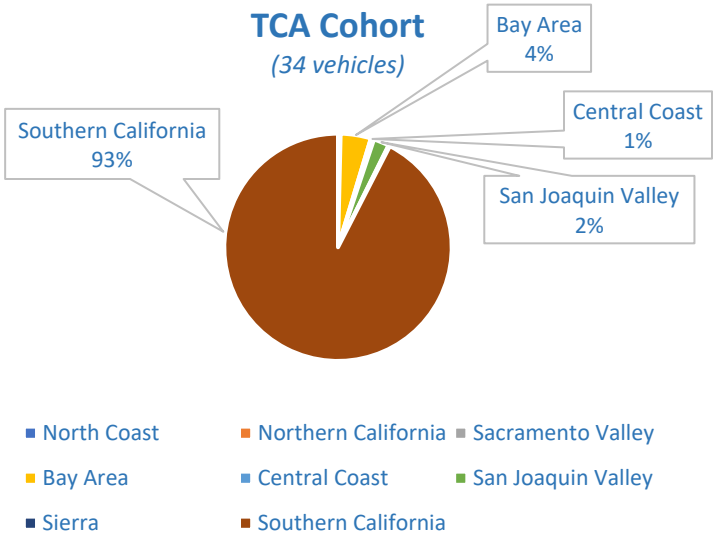
3.3 MILEAGE BY REGIONS TRAVERSED

A breakdown of the captured in-state mileage by the California regions traversed is shown for each cohort in Figure 9. All regions of California are generally well-represented by the miles captured for the Rural Cohort, while two-thirds of the miles captured for the Tribal Cohort were in the northernmost portion of the state. With regard to the TCA Cohort, since the toll roads administered by TCA are all located in Southern California, it makes sense that over 9 out of 10 miles captured for TCA account-holder participants were driven in that portion of the state.

Figure 9: Segmentation of In-State Mileage by Regions Traversed




Tribal Cohort
(15 vehicles)
Southern California 9%
Sierra 9%
San Joaquin Valley 6%
Central Coast 6%
Bay Area 2%
North Coast 33%
Northern California 34%
North Coast
Northern California
Sacramento Valley
Bay Area
Central Coast
San Joaquin Valley
Sierra
Southern California


TCA Cohort
(34 vehicles)
Bay Area 4%
Central Coast 1%
San Joaquin Valley 2%
Southern California 93%
North Coast
Northern California
Sacramento Valley
Bay Area
Central Coast
San Joaquin Valley
Sierra
Southern California

4. Differentiation by Road Type

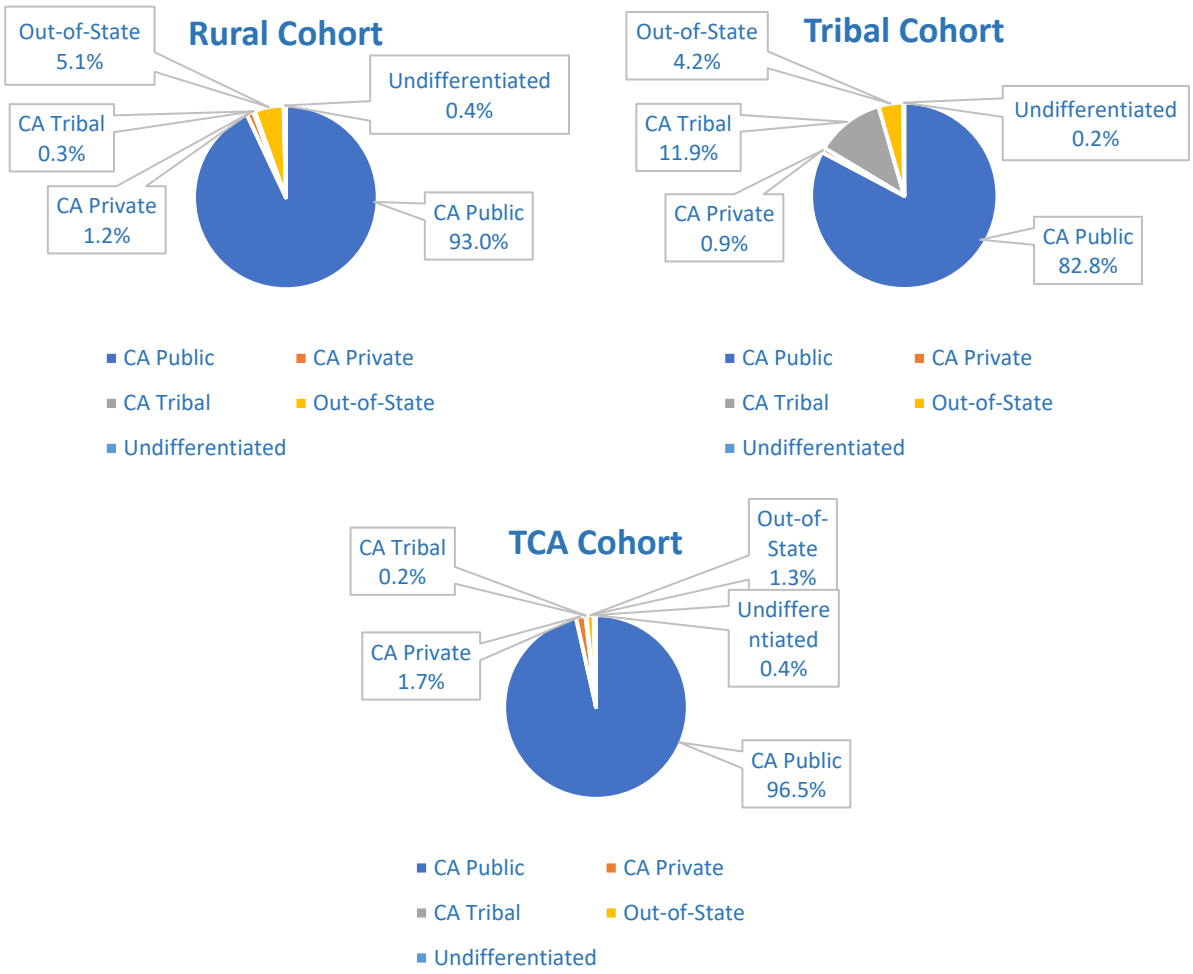
As outlined within the Operations Plan, subsequent to capture by the pilot system each trip record underwent a mileage differentiation process:

- Each GPS waypoint traversed by the trip was computationally assessed against a Caltrans-approved map-set, to determine whether the waypoint was located inside or outside the state of California … and for those waypoints found to be in-state, to subsequently also determine if it was located on a public road, a private road, or a road that was located on tribal land.
- The distance between consecutive trip waypoints was then calculated, with the resulting inter-waypoint distances being summed-up and allocated accordingly to the public road, private road, tribal road, and out-of-state road distance sub-totals for that trip.
- For each trip, multiple "trip segment" records were then persisted, to separately model the portions of that trip's miles that were driven on roads outside the state of CA, on public roads in CA, on private roads in CA, and on tribal land in CA, respectively.

For the vast majority of the pilot mileage that was captured, this differentiation process was found to effectively identify the road types that were traversed during any given trip, and to accurately suballocate trip mileage accordingly. However, as outlined within the Task 6.b.1 Plug-In Device and Geolocation Report (Final Report Appendix H, hereafter "Device Report"), there were several scenarios encountered during the pilot which interfered with the system's ability to accurately differentiate the miles collected for a given trip, and which therefore resulted in the miles for such a trip having to be allocated to an "undifferentiated" category (versus a category such as public road, private road, etc.). It should be noted, however, that less than 4 out every 1000 miles collected on behalf of the pilot, actually fell into this undifferentiated category.

The results of the road type differentiation process for each cohort are shown within Figure 10 below.

Figure 10: Differentiation of Pilot Mileage by Road Type



Roughly 19 out of every 20 miles were driven in-state by the Rural and Tribal Cohorts, while only 1 out of every 100 miles driven by the commuter-focused TCA Cohort was done so out-of-state.

The fact that almost 12% of the miles driven by the Tribal Cohort was driven on tribal land was in line with the participation criteria for that group (i.e., driving on tribal land an average of at least once per month). In contrast, in light of the request that participants in the Rural Cohort drive on private roads at least once per week, it was initially somewhat surprising to learn that only 1 out of every 100 miles driven by the Rural cohort was done so on private roads.

Further analysis revealed that for those pilot trips involving travel on private roads, the average portion of the trip over private roadways was only 0.15 miles, and for such trips the travel over private roads constituted an average of only 12% of the overall trip distance. By way of comparison, for those trips involving travel on tribal land, the average portion of the trip over tribal roadways was 1.9 miles (an order of magnitude higher than the same figure for private roads), and the average share of the overall trip distance made up of travel over tribal roads was a much higher 50%. So when participants did take a trip involving travel over a private road, that portion of their overall trip typically represented a much smaller share of the overall trip distance, relative to trips involving the traversal of tribal land; and it then makes sense that even if the majority of the Rural

Cohort participants actually fulfilled their target of driving on private roads at least once per week, it's to be expected that the overall share of their driving miles represented by travel over private roads would be relatively small (e.g., the above-referenced 1% that was observed for the cohort during this pilot).

5. Assessment of Simulated Fees

The Operations Plan deliverable details the manner in which the simulated road charge fees and fuel tax credits were calculated against the differentiated pilot mileage:

- As CA public roads are maintained by Caltrans, mileage determined to have taken place on such roads was assessed a $0.024 cents per-mile road charge. In contrast, a per-mile road charge was not applied to mileage determined to have taken place on private roads, roads traversing tribal lands, and roads not located in CA, as such roads are not maintained by Caltrans.
- For all mileage captured on behalf of a given vehicle, the fuel used by the vehicle to achieve that distance was approximated by leveraging the vehicle's EPA MPG rating. More specifically, the amount of fuel (in gallons) required for a vehicle to travel a given distance (in miles), was calculated as follows:

  Estimated Gallons Used = Miles Travelled / EPA MPG Rating

- To avoid double taxation on mileage for a given vehicle (i.e., road charge plus state tax on the fuel used for that mileage), the pilot then credited the state tax that would be required to purchase the fuel to drive that distance, back against the road charges assessed for that same mileage. The amount of fuel tax credited for gasoline, diesel, and alternative-fuel vehicles was $0.539, $0.740, and $0.539 per gallon, respectively. The fuel tax credit was calculated as follows:

  Fuel Tax Credit = Estimated Gallons Used x Fuel Tax Paid per Gallon

- Note that fuel tax credit was applied on behalf of all differentiable mileage, regardless of where the mileage was determined to have taken place (on public, private, tribal, or out-of-state roads).

The resulting simulated road charges, fuel tax credits, and net balances are outlined for the three cohorts in Table 9, Table 10, and Table 11 below.

Table 9: Differentiation Results & Fee Assessments for Rural Cohort

Rural Cohort								
Total Cohort Miles			In-State Miles			Fee Assessment		
In-State vs. Out-of-State	Mileage	Share of Total Cohort Miles	Road Type	In-State Mileage	Share of In-State Miles	Road Charges	Fuel Tax Credit	Net Balance
In-State	1,170,272	94.5%	Public	1,151,672	98.4%	$27,691.60	-$25,252.06	$2,439.54
			Private	14,840	1.3%	$0.00	-$251.71	-$251.71
			Tribal	3,760	0.3%	$0.00	-$90.51	-$90.51
Out-of-State	63,437	5.1%				$0.00	-$1,583.85	-$1,583.85
Undifferentiated	4,744	0.4%				$0.00	$0.00	$0.00
TOTAL	1,238,453	100.0%	-	1,170,272	100.0%	$27,691.60	-$27,178.13	$513.47

Table 10: Differentiation Results & Fee Assessments for Tribal Cohort

Tribal Cohort								
Total Cohort Miles			In-State Miles			Fee Assessment		
In-State vs. Out-of-State	Mileage	Share of Total Cohort Miles	Road Type	In-State Mileage	Share of In-State Miles	Road Charges	Fuel Tax Credit	Net Balance
In-State	102,937	95.5%	Public	89,157	86.6%	$2,144.36	-$2,030.80	$113.56
			Private	935	0.9%	$0.00	-$16.47	-$16.47
			Tribal	12,845	12.5%	$0.00	-$316.42	-$316.42
Out-of-State	4,563	4.2%				$0.00	-$141.26	-$141.26
Undifferentiated	240	0.2%				$0.00	$0.00	$0.00
TOTAL	107,740	100.0%	-	102,937	100.0%	$2,144.36	-$2,504.95	-$360.59

Table 11: Differentiation Results & Fee Assessments for TCA Cohort

TCA Cohort								
Total Cohort Miles			In-State Miles			Fee Assessment		
In-State vs. Out-of-State	Mileage	Share of Total Cohort Miles	Road Type	In-State Mileage	Share of In-State Miles	Road Charges	Fuel Tax Credit	Net Balance
In-State	173,844	98.3%	Public	170,586	98.1%	$4,103.60	-$3,449.61	$653.99
			Private	2,960	1.7%	$0.00	-$50.96	-$50.96
			Tribal	298	0.2%	$0.00	-$8.21	-$8.21
Out-of-State	2,269	1.3%				$0.00	-$65.38	-$65.38
Undifferentiated	691	0.4%				$0.00	$0.00	$0.00
TOTAL	176,803	100.0%	-	173,844	100.0%	$4,103.60	-$3,574.16	$529.44

Table 12 summarizes these results from the perspective of the individual cohort participant.

Table 12: Per-Person Pilot Fees by Cohort

Cohort	# Active Participants	Total Cohort Net Balance over 6-Month Pilot	Net Balance per Participant, per Month	Net Balance per Participant, Annualized
Rural Cohort	234	$513.47	$0.37	$4.39
Tribal Cohort	15	-$360.59	-$4.01	-$48.08
TCA Cohort	34	$529.44	$2.60	$31.14

Of the 3 cohorts, the participants in the TCA Cohort incurred the highest average net fees per-person. This was most likely primarily attributable to the relatively very small share of the TCA Cohort's total mileage that was driven out-of-state, for which there was no road charge but for which gas tax was still credited (i.e., 1.3% of the TCA miles were out-of-state, versus 5.1% and 4.2% for the other 2 cohorts). In other words, the net balances of the other two cohorts derived more financial gain from the share of their respective total miles that were driven on out-of-state roads, where fuel tax was refunded against zero road charge.

The participants in the Tribal Cohort on average actually received a net credit of about $4 per month, or $48 when projected to a full year. This was due to road charge being applied to only 83% of the cohort's overall mileage (i.e., 95.5% of the miles were driven in-state, with only 86.6% of those in-state miles being driven on public roads), while fuel tax was refunded against almost 100% of the cohort's miles (i.e., all but the 0.2% that were determined to be undifferentiable).

Lastly, the participants in the largest of the 3 cohorts, the Rural Cohort, essentially broke even on a per-person basis, with the average cohort participant paying only $0.37 a month, or less than $5.00 per year. While a relatively healthy 5% share of the cohort's total miles were driven out-of-state, only 1.6% of the remaining in-state miles were driven on non-chargeable roads (1.3% private and 0.3% tribal).

6. Incentives

The Project monetarily incentivized participants for their efforts and engagement throughout the 6-month pilot. The plan that was established for that purpose, the extent to which the Project was successful in executing against that plan, and the associated learnings are detailed within the Task 2.a.5 Incentive Plan with Payout Results deliverable (Final Report Appendix G, hereafter "Incentive Results") and summarized in the sections that follow.

6.1 INCENTIVE PLAN

Caltrans, through the project team, paid a total of up to $250 to each participant, for achievement of milestones such as fully completing all enrollment and onboarding activities, driving a minimum of 20 miles per month, reviewing their monthly road charge statement and simulating payment of the associated fees, completing the pre- and post-pilot surveys, and returning their OBD-II plug-in device upon completion of the pilot.

More specifically, the detailed milestone activities, their relative timing, and the associated payouts are outlined in Table 13 below.

Table 13: Incentive Plan Outline

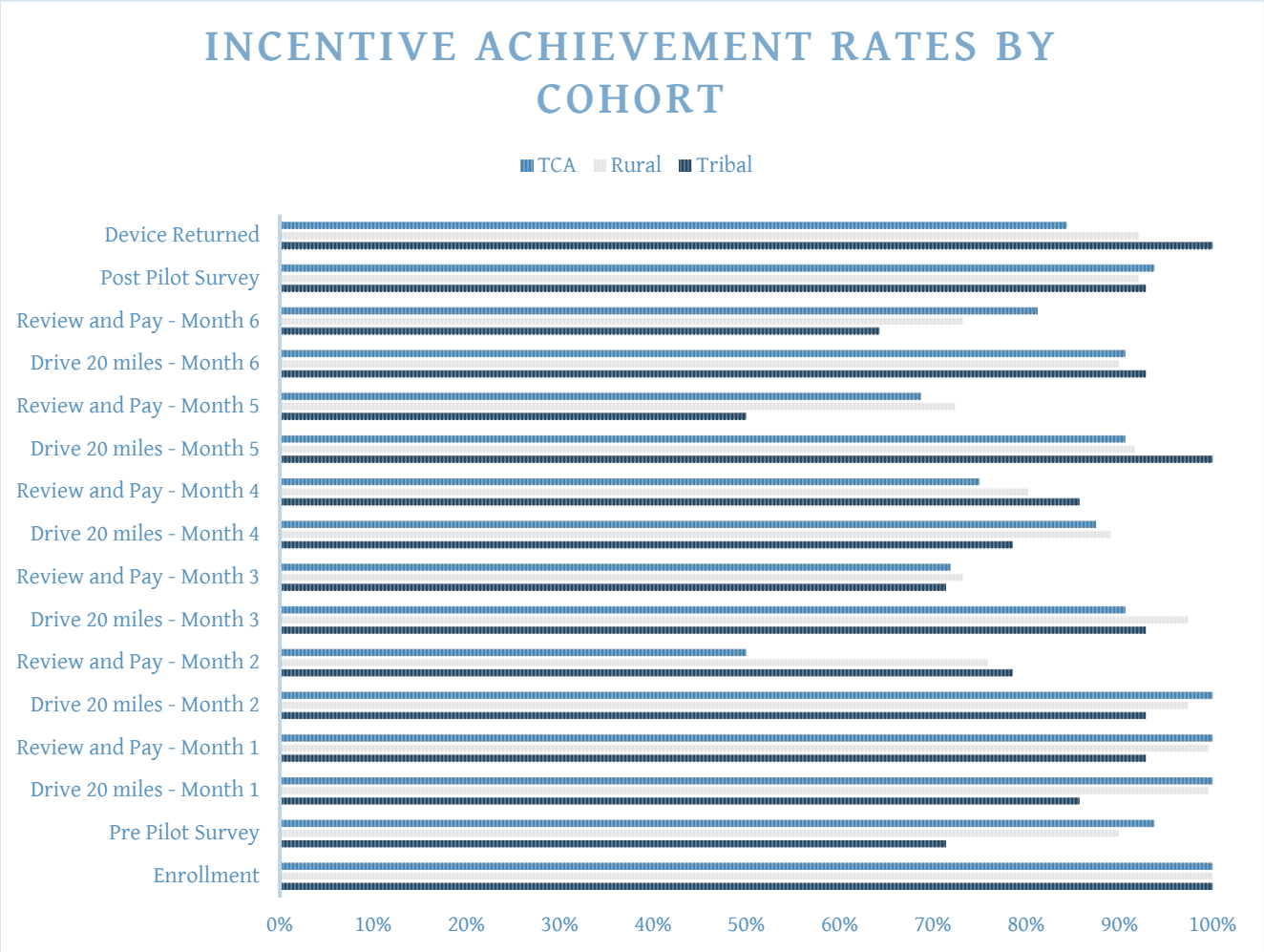
Pilot Activities	Onboarding	Pilot Months						Closeout
		1	2	3	4	5	6	
Complete all enrollment activities which may include online account establishment, plug-in device installation, mobile app download, and accessing the participant portal	$55							
Drive at least twenty (20) miles over the course of each month as reported through the installed plug-in device		$5	$5	$5	$5	$5	$5	
Review monthly road charge statements; simulate road charge payments through the Road Charge Account Management Platform no later than the fifteenth (15th) calendar day of the following month		$10	$10	$10	$10	$10	$10	
Complete the Pre-Pilot Survey	$25							
Complete the Post-Pilot Survey								$25
Close out Road Charge Account; Return Mileage Reporting Device								$55
Total Available	**$80**	**$15**	**$15**	**$15**	**$15**	**$15**	**$15**	**$80**

6.2 INCENTIVE RESULTS

Overall, only 90 of the pilot participants across the 3 cohorts completed all 16 incentive-eligible activities. However, all participants received incentive payouts for completing at least some activities. As might be anticipated, it was observed that the incentive participation rate was highest during the early months of the pilot, with the fall-off in participation rate over the course of the Project being generally attributable to "pilot fatigue". Additionally, there was very little material difference between the participation rates observed for the 3 distinct participant cohorts.

Figure 11 breaks out by cohort, the completion rates for each of the incentive milestones.

Figure 11: Incentive Achievement Rates by Cohort



6.3 INCENTIVE FINDINGS & RECOMMENDATIONS

The following sub-sections summarize the findings and recommendations that are detailed within the Incentive Results deliverable.

Incentives Are Highly Regarded

In light of the considerable number of participant inquiries received with questions related to incentives, it was clear that the various incentives served as a viable motivator and that participants were very interested in receiving the rewards that were promised them to participate in this Project.

Monthly Payout is Administratively Burdensome

The payout of incentives on a monthly basis greatly increased the hours that were expended to support the incentive program, in terms of facilitating the incentive payouts, answering questions

on how to redeem the incentives, and tracking and managing the association of activities to the incentives. It is highly recommended that future initiatives adopt the practice of paying all incentives at the end of the project.

Visa Gift Cards Are Problematic

In spite of the near-universal acceptance of Visa gift cards at retail, their overly restrictive usage allowances and the fact that they cannot be used to pay a portion of any given purchase price proved to be highly frustrating to recipients, particularly for gift cards with relatively small denominations (e.g., $5). This resulted in many of the participants having balances remaining on their cards that they could not readily redeem. Additionally, once a card was sent to a participant, there were no means for the project team to monitor its successful receipt and subsequent redemption, nor was it possible to re-send the card in the event it was never received.

Moving forward, it is recommended that consideration be given to using a vendor that offers a catalog of various gift cards, from which participants can self-select.

Physical Gift Cards Are Strongly Preferred

Although electronic gift cards were the sole incentive payout option at the outset of the pilot, a sufficient number of people complained about the difficulty they encountered in redeeming the digital version that an alternative option to receive a physical card was additionally offered. A relatively large number of participants (107) to whom electronic gift cards had previously been sent, subsequently requested to be switched to the physical Visa gift card option. It should be noted that the addition of the physical card option was accompanied by an incremental expenditure of $5200 over the last four months of the pilot, in costs associated with shipping, handing, and the preparation of collateral.

Payout Delivery Will Never Reach 100%

Initially the monthly incentive payouts were sent via email. Due to delivery issues related to spam/junk filters and uncommunicated changes in email address during the first two months of the pilot, a secondary option to send the payouts via US Mail was added in the 3rd month. However, issues with delivery via physical mailings were still encountered throughout the remainder of the pilot, due to incorrect mailing addresses being entered at enrollment, as well as uncommunicated changes in participant residences. As a consequence, consistent and ongoing oversight by the project team was required to ensure that participants successfully received the incentive payouts they were anticipating.

Although these issues with both electronic and physical payout delivery can never be fully eliminated, the adoption of an end-of-pilot, one-time payout policy (versus payouts on a monthly basis) would surely help to mitigate their impact.

7. Participant Inquiries

The Task 6.c.3 Customer Support Plan and Closeout deliverable (Final Report Appendix F, hereafter "Customer Support Results") overviews the customer service framework that was deployed on behalf of the Project, and provides a detailed categorization and analyses of all participant inquiries that were fielded during the execution of the Project.

The content that follows will focus upon the scope and nature of the participants' inquiries throughout the Project, as well as the overall findings and recommendations relative to the provisioning of customer support on behalf future road charge pilots/programs. For a detailed description of the Tier 1 vs. Tier 2 resources that were assembled for the Project, the various communication channels that were made available for the submission of inquiries, the timing of inquiry submissions (e.g., by pilot month, or by submission during the Project's live pilot demonstration versus submission after the demonstration had been completed), and the customer support team's service levels in responding and resolving inquiries, please refer to the Customer Support Results.

7.1 SUMMARY OF INQUIRY TOPICS

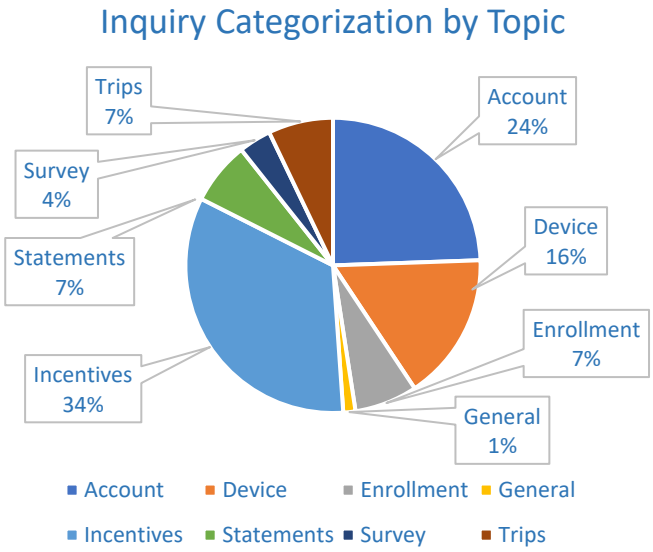
The Project team grouped participant inquiries into eight topical categories:

- **Enrollment**: Questions on account setup, locating the Vehicle Identification Number (VIN), shipment of the plug-in device, and enrollment steps.
- **Account**: Questions about account information and access, issues accessing or using participant portal (e.g., forgot password), etc.
- **Device**: Questions about device installation/activation, how device reports travel data to pilot system, device not reporting, etc.
- **Trips**: Questions about travel data, mileage calculations, mileage or fuel discrepancies, road type differentiation, etc.
- **Statements**: Questions about simulated monthly road charge statements.
- **Incentives**: Questions about incentive-eligible activities, how to earn incentives, and incentive payments.
- **Survey**: Questions related to initial or post-pilot survey, including issues accessing or completing survey.
- **General**: General participant inquiries and questions related to pilot and California Road Charge Program as a whole.

Over the course of the Project's 6-month live demonstration period, in addition to the 2 months immediately following the demonstration, the project team fielded a total of 450 inquiry submissions (Tier 1 and Tier 2) from the pilot participants. A categorical breakdown of these inquiries by the topical groupings outlined above is shown in Figure 12. This breakdown reveals

that 3 out of every 4 inquiries were focused upon on either the pilot incentive program, the participant's account, or the OBD-II plug-in device.

Figure 12: Breakdown of Pilot Inquiries by Topic



7.2 INQUIRY FINDINGS & RECOMMENDATIONS

The findings and recommendations related to participant inquiries that are detailed in the Customer Support Results can be summarized as follows:

- Inquiry service levels declined fairly significantly over the latter half of the 8-month period during which inquiries were fielded (6 months for live pilot, followed by 2 months post-pilot). This was attributable to the increasing complexity of participant inquiries, primarily related to incentive payments and the use of Visa cards. Given the way that the Visa gift cards worked, there was a certain level of difficulty built into the method required to redeem the gift cards, which led to quite a few frustrated participants.
- Paying out incentives on a monthly basis rather than at the end of the pilot significantly increased the number of customer support hours required to support inquiries about the incentive program. These extra hours were spent facilitating the incentive payouts, answering questions on how to redeem the incentives, and tracking and managing the association of participant activities to the incentives.
- Turnaround time for support from the Giftogram service vendor also presented challenges for the Customer Support team, as did a lack of timely communication from some participants.
- 24% of all inquiries fielded were submitted during the 2-month post-pilot period, after the live demonstration had been completed. It is therefore highly recommended that a

customer support team be kept active for a period following the conclusion of any future road charge pilots to address participants' questions.

8. System Management

As used within this section, "system" includes all subsystems and components that make up pilot operations, including all business partners, technology providers, and the pilot data warehouse. This section describes the state of the system over the course of the 6-month pilot period, including uptime/downtime, maintenance windows, and a general status of the cloud-based data warehouse.

8.1 SYSTEM UPTIME

The uptime performance of the system over the 6 months of the pilot is captured in Table 14. In summary, system uptime consistently remained at 100% for the full duration of the pilot, with no downtime experienced on behalf of planned or unplanned events.

Table 14: System Uptime by Pilot Month

Months	Percent of System Uptime	Percent of System Uptime Less Than 99.9%	Average
April 2023	100%	0%	100%
May 2023	100%	0%	100%
June 2023	100%	0%	100%
July 2023	100%	0%	100%
August 2023	100%	0%	100%
September 2023	100%	0%	100%
TOTAL	**100%**	**0%**	**100%**

8.2 DATA WAREHOUSE SUMMARY

The pilot's central data repository was hosted on the Snowflake cloud-based data storage and analytics service. In addition to informational models representing each participant, account, and vehicle participating in the pilot, the Snowflake platform housed all the trip, mileage, and geolocational information collected from each vehicle participating in the pilot, as well as the transactional values (e.g., road charges, fuel tax credits, etc.) that were subsequently calculated by the system in association with those parameters of travel.

The costs associated with the usage of Snowflake are predicated upon the storage capacity used, the amount of compute resources expended, and the data transfer resources utilized for data egress out of the system.

A breakdown by pilot month of the storage capacity used and the amount of compute resources expended on behalf of the pilot is shown in Table 15. It should be noted that at the Pilot's outset, Caltrans requested that the plug-in devices for the Pilot be pre-configured with a GPS frequency of one second (i.e., the device should capture the vehicle's GPS location every second). Sixty days into the Pilot, however, the project team discovered that the device vendor had inadvertently set the GPS frequency for all pilot devices to five seconds. A process was therefore undertaken to

alter every deployed device's GSP frequency to the proper value of one second, but the time required to fully implement and test this reconfiguration unfortunately amounted to an additional 60 days. As a result, over the first four months of the Pilot, GPS information for trip waypoints was collected at five-second intervals, and for the last two months waypoint locations were collected at one-second intervals. The increases observed within Table 15 in storage capacity utilized during August and September are therefore largely attributable to the resulting approximately five-fold increase in the number of geolocation records being stored within Snowflake over the last two months of the pilot.

Table 15: Warehouse Storage & Compute Time

Category	APR	MAY	JUN	JUL	AUG	SEP
Data Storage	23.8 GB	118.7 GB	105.4 GB	76.1 GB	124.71GB	143.2GB
Compute Time	579.2 hrs	891.4 hrs	596.2 hrs	634 hrs	684.1 hrs	704.5 hrs

Data transfer resources were utilized to output data from Snowflake on behalf of three distinct interfaces:

- **myMiles**: The web-based platform that provided near-real time information on trip data and associated road charge transactions to the participants in the Rural and Tribal Cohorts, and also allowed them to review their monthly statements and simulate the payment of the associated road charges. (Note that the participants in the TCA Cohort accessed this same pilot information via their existing account on the TCA's tolling account management platform.)
- **TCA Daily Transaction Summary Message**: Exported on a daily basis from Snowflake to an AWS S3 bucket, to facilitate transfer to the Transportation Corridor Agencies (TCA) of all travel and transactional information related to the TCA Cohort.
- **Administrative Portal**: The web-based platform that facilitated System Administrators' management of pilot operations, as well as maintenance of the data stored on behalf of the participants, vehicles, and OBD-II devices taking part in the pilot.

8.3 COST SUMMARY

The various costs associated with using the OBD-II plug-in device to facilitate the differentiation of mileage and the assessment of road charges on behalf of this Pilot can be grouped as follows:

- **Device Costs**: The one-time purchase price for the physical device itself, together with the provisioning of a cellular data plan for the device.
- **Infrastructural Costs**: The one-time setup and recurring fees paid to Danlaw, for the use of its BitBrew gateway server to serve as the collection endpoint for device messages; the data storage costs associated with the Pilot's front-end cache of raw incoming device messages, stored in an Amazon S3 server; the storage costs for the processed data used for Pilot operations and reporting, stored in Snowflake; and the "compute time" processing costs associated with the aggregation of trip data, differentiation of mileage, and calculation of road charges within Snowflake.

- **Logistical Costs:** The costs associated with getting the device to the participant on the front-end of the Pilot, as well as retrieving the device from the participant at Pilot closeout.

The costs in the above categories for this Pilot are broken down per device within Table 16, culminating in a calculated total monthly per-device cost of $36.92 for this Pilot, or about $335 per-device annually. For a more complete exploration of all the costs associated with this Pilot, as well as those that might be anticipated for future road charge programs offering a plug-in device as a mileage reporting option, please refer to the Device Report (Final Report Appendix H).

Table 16: Summary of Pilot Costs per Device

Cost Category	Amount per device per transaction *(283 devices)*	No. of Transactions	Amount per device
Device purchase	$95.00	1x	$95.00
Wireless data plan	$0.90	6x	$5.40
Gateway (Danlaw)	$9.26	6x	$55.56
Hosting – raw data (Amazon S3)	$0.01	6x	$0.05
Hosting – processed data (Snowflake)	$0.01	6x	$0.06
Data processing compute time (Snowflake)	$8.83	6x	$52.98
Packaging for shipment	$0.24	3x	$0.71
Collateral (install instructions)	$0.25	1x	$0.25
Shipping labels	$0.03	3x	$0.10
Shipping fee	$3.80	3x	$11.40
Total per-device cost for six months ->			$221.50
Total monthly cost per device ->			**$36.92**

9. Conclusion

9.1 PARTICIPANT COUNTS

From its outset, the ultimate success of the Project was inexorably linked to active participation by the rural and tribal communities of California, which are generally acknowledged to be two relatively difficult-to-reach audiences. As outlined within the Recruitment Results deliverable, overall recruitment for the Rural Cohort performed well, generating the captured participatory interest of almost 1300 individuals. As a result, the live demonstration was able to benefit from the gathering of vehicle travel data from a respectable 234 active participants from the rural community.

On the other hand, the fact that the live demonstration was able to leverage vehicle travel on behalf of only 15 members of the tribal community, makes it challenging at best to meaningfully extrapolate the findings of the pilot to the broader tribal communities of California. A significant recruiting challenge was posed by the sheer number of distinct Native American tribes in California, as well as by the fact that engaging with tribal communities, especially on initiatives as sensitive as road charge, requires continuous engagement with timeframes well beyond the six months of this Project. Moving forward, it is therefore highly recommended that any initiatives targeting the tribal communities should plan for a sustained engagement period spanning multiple years.

Similar to the Rural Cohort, recruitment efforts on behalf of the TCA mini-pilot also performed generally well, yielding an interested party count of 369, and although at first blush it might've appeared that the active TCA participant count of 34 was relatively low, it was a sufficient number to vet the mini-pilot's objective of assessing the viability of a tolling entity serving as an account manager within a Road Charge program.

9.2 DIFFERENTIATING ROAD CHARGE BY ROAD TYPE

From a technical perspective, the Project was successful in demonstrating that geolocational technologies can most definitely be leveraged to mitigate citizens' frequently expressed concerns relative to not being taxed by the state when driving on roadways that are not maintained by the state (i.e., private roads, roads on tribal lands, and roads outside the state). Unsurprisingly, however, the effectiveness of this process is obviously highly dependent upon the reliability and accuracy of the geolocation technology being employed, over and above the limitations and tolerances inherent within the GPS ecosystem itself. More specifically, with respect to the OBD-II plug-in device that was employed for this Project, several concerning device idiosyncrasies and behaviors were observed, as detailed within the Device Report deliverable.

The concerns captured within the Device Report potentially call into question the application of OBD-II plug-in devices, at least in their current form, to the accuracy-related needs of a large-scale operational RUC program. The current generation of plug-in devices was specifically designed for the insurance industry and was subsequently updated to address the needs of emerging fleet management systems. Neither of these domains (i.e., insurance nor fleet management) require the precise assessment of miles driven, which is obviously an absolute necessity for RUC applications. It is therefore highly recommended that a prerequisite for moving forward with the

use of OBD-II plugins on behalf of RUC applications, would be for RUC practitioners to collaborate with OBD-II device vendors in order to tailor the device functionality and message set to the unique distance-critical needs of the RUC space.

The primary objective of the Project's formation of the Rural Cohort was to study the impact upon this particular community of the capability to refrain from taxing the miles driven on private roadways. As seen in Sections 4 and 5 above, the share of overall miles driven on private roadways by the average participant in the Rural Cohort came to only 1.2%, which translated into a tax reduction of a mere 18 cents per month for each taxpayer (i.e., $251.71 tax reduction across entire 234-participant cohort over 6-month period). The "optics" associated with the state being able to tell citizens that they will not have to pay a mileage tax on private roads would no doubt be beneficial. However, in light of the fact that the accuracy requirement for distance measurement within an operational RUC program is generally projected to be in the neighborhood of 3-5%, a reasonable argument could be made that the administrative costs and overhead that would be required to properly refrain from taxing just 1% of the miles driven by any given taxpayer outweigh the benefits to be derived therefrom. From that perspective, if subsequent research further confirms that the percentage of miles driven on private roads by a taxpayer living in a rural area does in fact average out to approximately 1% over time, perhaps a more cost-effective approach for a program might be to slightly reduce the per-mile road charge for individuals residing in rural areas, to account for the average distance that they'll be driving on private roads.

9.3 TCA MINI-PILOT

The TCA mini-pilot demonstrated that a tolling entity's existing account-based infrastructure and functionality can in fact be readily enhanced to support the customer-facing needs of a Road Charge program's participants. Insomuch as the Project's informational feed from the main pilot's data collection and transactional facilities to the TCA's customer-facing system was manual in nature, a recommended precursor to moving forward with a tolling entity serving as a RUC account manager would be to fully automate the API between the two systems.