



# Appendix-15

## Pilot Technical Lessons Learned



**Technical Lessons Learned**

# California Road Charge Pilot Program Technical Lessons Learned

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## Technical Lessons Learned

### 1. Introduction

This report presents the technical lessons that the pilot delivery team learned while executing the Road Charge Pilot Program (RCPP). Technical lessons learned include issues related to technology and organizational interfaces with entities executing technical aspects of the program, such as the Account Managers. These lessons have been used to improve the pilot design documents (Concept of Operations, System Requirements Specification, and Interface Control Document, or ConOps, SRS, and ICD, respectively), and should also be accounted for when creating contracts for any potential future road charge pilot or program.

This report contains lessons learned in five areas as follows:

- ▶ Account Managers
- ▶ Manual odometer readings and refunds
- ▶ Mileage reporting technologies
- ▶ Compliance
- ▶ Technology issues with policy implications



## Technical Lessons Learned

## 2. Lessons Learned on Account Managers

This section presents several lessons learned on Commercial Account Managers (CAMs) and the California State Account Manager (CalSAM). These lessons are grouped into three areas:

- ▶ Customer interface guidelines
- ▶ Special account holders
- ▶ Value-added services

### 2.1. Customer Interface Guidelines

One major lesson learned during the pilot was that Account Managers should be provided customer interface guidelines for all of their interactions with participants. During the pilot, all material shared with participants by Account Managers was subject to review and approval by the California Department of Transportation (Caltrans) and California State Transportation Agency (CalSTA). By providing customer interface guidelines, Account Managers will know how to structure their interactions with participants before they start creating them.

Providing such guidelines will ensure that Account Managers interact with participants in a way that the State deems appropriate, and that Account Managers always describe aspects of road charge in a consistent, correct way. These guidelines should cover all potential participant interfaces, including:

- ▶ Websites
- ▶ Mobile applications
- ▶ Invoices
- ▶ Emails
- ▶ Press releases
- ▶ Phone-based customer support

In the case of emails and phone-based customer support, the guidelines should not restrict or prevent one-on-one customer support. But, they should provide guidance that will impact the scripts used by and training given to customer service representatives when dealing with customers for road charge-related questions and issues. By doing so, the guidelines will support enhanced one-on-one customer interactions.

The customer interface guidelines should include, at a minimum, the following:

- ▶ Basic program terminology: A list of all terms related to road charge, and how they are to be used (e.g., the generic term for all ways of reporting mileage is a “mileage reporting method”).
- ▶ Guidance on how to characterize basic facts about road charging program: A description of how the basic facts of the road charging program are to be explained to participants, such as why a road charge is needed, how the funding is used, etc.
- ▶ Guidance on describing actions required of the participants: As simple a description as possible to explain to participants their requirements for compliance. Do not assume participants will understand complex words or acronyms like OEM (which means Original Equipment Manufacturer, and refers to carmakers). During the end-to-end test, several participants complained that the language used was too complex. The Account Managers corrected this, and this complaint did not come up during the pilot program.



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- ▶ A list of topics that should be referred to the State. The State should create a list of topics that Account Managers may not discuss with participants so that such calls or emails can be directed to the State.
- ▶ Guidelines on use of logos: This includes both how the State's road charging logo and any Account Manager logos should be used for road charge-related interactions and materials.
- ▶ Guidelines on document appearance: This covers topics such as acceptable fonts, font sizes, color schemes, etc. for all documents that will be shared with the public such as websites, email templates, and road charge invoices. Such guidelines should not restrict Account Manager creativity, but serve to provide the State reassurance that the communications will meet its standards.
- ▶ The ability to evolve: The State will likely want to update the customer interface guidelines, especially in the early days of the road charge program, as it observes how the guidelines are implemented. Account Managers should be made aware of this. However, Account Managers should be given a time window in which to comply with them; for example, Account Managers should have several days to update websites, and several weeks to update mobile apps to comply with updated guidelines.

### Customer Interface Guidelines Lessons Learned

1. Customer interface guidelines for Account Managers are needed to cover participant interfaces including:

- ▶ Websites
- ▶ Mobile applications
- ▶ Invoices
- ▶ Emails
- ▶ Press releases
- ▶ Phone-based customer support

2. Customer interface guidelines should include:

- ▶ Basic program terminology
- ▶ How to characterize basic facts about the program
- ▶ How to describe participant actions simply
- ▶ Topics that should be referred to the State
- ▶ Use of logos
- ▶ Document appearance
- ▶ The ability to evolve

## 2.2. Standardization and Certification

Standardization (building systems based on common design documents) and certification (verifying that systems comply with the standard documents) are the keys to executing the open system model.

Standardization and certification provide the State assurance of proper functionality of any products, services, system development, etc. They also provide the State assurance that private companies provide services that support stewardship of public funds.

The pilot demonstrated standardization as the Account Manager systems were based on 3 standardized design documents: the Concept of Operations (ConOps), the System Requirements Specifications (SRS), and the Interface Control Document (ICD). Certification was demonstrated during the pilot through the testing process, including unit, integration, and end-to-end testing.

One lesson learned was that design documents will evolve. In particular, at the start of program, various requirements may need to be updated. In this case, Account Managers or other vendors may need to update their systems. Account Managers should be given sufficient time to do so, and potentially, in cases of



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extensive updates, be compensated for doing so. After the updates are complete, vendor compliance with updated standards will need to be re-certified. For some minor changes, it may be feasible to allow existing Account Managers to be grandfathered in under old requirements.

Another lesson learned is that Account Manager customer interfaces should also be certified based on customer interface guidelines described in the section above. A final lesson learned is that certification programs will need to be formalized—made into a well-defined process—so that newly entering Account Managers have a clear, straightforward process to enter the program.

### Standardization and Certification Lessons Learned

1. Design documents will evolve.
2. Account Manager customer interfaces should be certified based on customer interface guidelines.
3. Certification programs will need to be formalized to allow new account managers to enter the program with a clear, straightforward process.

### 2.3. Audits

Account Managers were audited during the Road Charge Pilot Program. As a result of those audits, the following lessons were learned.

The steps in an Account Manager audit should be as follows:

1. Road charging information request. The auditor should request both detailed system documentation and raw data from the Account Manager.
2. Numerical analysis of data. Data for the selected VINs should be analyzed to see that they correspond to all expected values that the Account Management Oversight has received.
3. Interview with Account Manager. The auditor should ask questions about the system documentation provided and the Account Manager's overall implementation of the system, such as how requirements were interpreted, and what day-to-day operations are like.

A further lesson learned is that Account Managers should be instructed to design their systems with audit documentation in mind. As part of a business rule, the Account Managers should be required to maintain and provide documentation on their systems' raw data format and how it relates to the data transmitted in the ICD.

A final lesson learned is that in a potential future mandatory road charge system, financial record requirements will be needed. Because real money payments were not part of the Road Charge Pilot Program, Account Managers did not need to keep financial-grade records of monetary transactions. Real money payments will be part of any potential future mandatory system, so maintaining financial grade records will be vital.

### Account Manager Audit Lessons Learned

1. The steps in an account manager audit should be as follows:
  1. Road charge information request
  2. Numerical analysis of data
  3. Interview with Account Manager
2. Account Managers should be instructed to design their systems with audit documentation in mind.
3. Financial record requirements will be needed in any potential future mandatory road charge program.



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### 2.4. Special Account Holders

Most participants in the road charge pilot program were private citizens using the web as their primary interface with an Account Manager. The Account Managers in the RCPP seemed most prepared for this type of customer. However, there were also two special types of account holders – vehicle fleets and offline participants – whose needs differed from those of private citizens.

#### 2.4.1. Vehicle Fleets

EROAD handled heavy vehicle fleets. EROAD's website is designed for heavy vehicle fleets, and their interactions with those fleets beyond the website were mostly through one-on-one phone calls with the fleet managers. By all accounts, those interactions went smoothly. The lesson learned is that heavy vehicle fleets have unique needs, and need to be supported by Account Managers who have experience or specialty working with heavy vehicle fleets.

#### **Vehicle Fleets Lessons Learned**

1. Heavy vehicles require Account Managers with experience working with heavy vehicle fleets.
2. All vehicle fleets require single invoice/payment options for the entire fleet.
3. CalSAM services (manual methods) should be developed for fleets as well.
4. There should be no mandatory pairing of Vehicle Identification Numbers (VINs) to devices.

Light vehicle fleets were supported by the same Account Managers who supported private vehicles: Azuga, the CalSAM, and IMS. In total, there were 12 fleets in the pilot, ranging in size from 2 to 200 vehicles. Azuga and IMS allowed a single invoice option for all vehicles in a fleet: all vehicles appeared on a single invoice, and all charges could be paid in one payment. They also provided the same value-added services to the fleets that they provided to private participants; however, value-added services were not optimized for fleets. In general, only the fleet managers had access to the value-added services.

In a mandatory road charging program, it will be necessary for Account Managers to support participants with single invoices and single payments. Ideally, Account Managers will offer fleet-specific services as well, that include services that might be offered using on-board diagnostic (OBD-II) devices from existing light vehicle fleet providers. In addition, fleets need dedicated customer service representatives trained on their specific needs and characteristics.

The CalSAM was not optimized for fleets. Each vehicle required individual selection of and payment for a mileage reporting method. However, three fleets nonetheless chose to be on the CalSAM. For all three fleets, all vehicles were registered to use the odometer charge. A lesson learned is that in case of a mandatory road charge program, the manual methods may be desirable for some small vehicle fleets who do not wish to have a device, so the CalSAM services should be developed for fleets as well, with a single invoice and single payment.

A final lesson learned for vehicle fleets is that there should be no mandatory pairing of Vehicle Identification Numbers (VINs) to devices. During the pilot, both IMS and Azuga required that a given device be plugged in to a specific vehicle (VIN) in a fleet, instead of allowing any device to be plugged into any vehicle. It would be more convenient for fleets to be able to plug any device into any vehicle.



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### 2.4.2. Offline Participants

Another group of participants who required special attention by Account Managers were offline participants. Offline participants completed all pilot activities by mail or phone, including the following:

- ▶ Selecting a mileage reporting method
- ▶ Paying for road charges
- ▶ Responding to surveys
- ▶ Receiving newsletters

The RCPP did not advertise for offline participants, in part because recruiting required participants to sign up online. However, three participants requested to participate offline, meaning without internet or email access. The CalSAM was designed to be able to handle offline participants, so CalSAM supported all three offline participants.

They received printed documentation of the CalSAM's web pages, which provided them the same guidance to make a selection among the mileage reporting methods available. They were also able to speak with CalSAM customer service representatives about their choice of mileage reporting method. All three offline participants chose the time permit. All three remained involved in the pilot until the end, and all three closed out their participation successfully.

#### Offline Participants Lessons Learned

1. Communications channels to accommodate offline participants are needed.
2. A robust communications process should be in place to keep offline participants involved.

One lesson learned about offline participants is to provide communications channels that accommodate them, especially under a mandatory road charge policy. Another lesson learned is that a robust communications process needs to be put in place to keep the offline participants involved. Such a process should include mailings and, in cases in which a participant may be noncompliant, phone calls.

### 2.5. Value-added Services

The third area of lessons learned about Account Managers is value-added services, the services provided by CAMs in areas beyond road charging. D'Artagnan prepared a separate policy paper on CAMs that identified a range of current and potential future value-added services that CAMs may offer. This information will not be repeated here. Because value-added services have potential for providing greater customer service and thus helping to make the public appreciate the benefits of road charging program (to like it more or dislike it less), they are worthy of mention again in this lessons learned report.

#### Value-added Services Lessons Learned

1. Value-added services may be a major component to success of the CAM open system model.
2. Value-added services were generally popular with participants.
3. Value-added services were not perfect.
4. CAMs should receive high-level guidance on content of value-added services.

Provision of value-added services may be a major component of the success of the CAM model. Because CAMs may be compensated for value-added services—either by the customer directly, or by another business partner (such as an insurance company), they have a major impact on state compensation of CAMs for road charge. If CAMs earn enough money from value-added services, they may require less funding to provide road



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charge services. This is the case for Oregon's heavy vehicle weight-mile tax<sup>1</sup>: the State of Oregon pays nothing to EROAD for account management services; rather, the heavy vehicle fleets pay EROAD for the services, and EROAD handles payments to the Oregon Department of Transportation for weight mile taxes at no charge to the State.<sup>2</sup>

In the RCPP, value-added services were, based on participant comments, generally popular. In fact, some participants even requested to keep their value-added service even as the pilot ended. Despite their general popularity, value-added services were not perfect. In particular, Azuga experienced issues with some of their value-added services which caused them not to function exactly as intended. Azuga fixed the issues that were leading to this unintended behavior, and the problems did not recur after that.

A final lesson learned on value-added services is that CAMs should be provided high-level guidelines on the content of these services. Regulation of any commercial services between CAMs and motorists requires a careful balance. For example, it may not be appropriate for the State to require advance approval for every new functionality. However, the State should specify minimum acceptable behavior. One requirement could be that the services should not function if there is suspicion a driver is using them when a vehicle is moving. Another requirement would be to repeat the general customer interface guidelines. A final requirement would be that the value-added services should be accurate—they should do what they say that they do.

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<sup>1</sup> Oregon's Heavy Vehicle Weight Mile Tax is described in Oregon's Motor Carrier Education Manual section on the Weight Mile tax, available here: <https://www.oregon.gov/ODOT/MCT/docs/Section%203%20Weight-Mile%20Tax.pdf>

<sup>2</sup> EROAD's role in collection of the Heavy Vehicle Weight Mile Tax is described in the Oregon Secretary of State's Audit Report, ODOT: Automating Weight-Mile Tax Collections Can Benefit the State and Commercial Motor Carriers, available here: <http://sos.oregon.gov/audits/Documents/2013-32.pdf>



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### 3. Lessons Learned on Manual Odometer Readings and Refunds

This section describes lessons learned on two areas of manual activities included in the RCPP: manual odometer readings and manual refunds.

#### 3.1. Manual Odometer Readings

The RCPP, is, to the knowledge of everyone involved, the first road charging pilot in the U.S. to feature manual readings performed by a state official reading the odometer and entering the value into a computer system designed to accept such information. Manual odometer readings were required for all participants on the mileage permit and the odometer charge that chose not to use smartphone mileage reporting for their official odometer readings.

Manual odometer readings were offered at 15 Smog Check Referee locations across California. At the start of the pilot, participants could reserve a 15-minute appointment on two dates: Saturday, July 9, 2016 and Saturday, July 16, 2016 between 8 AM – 12 PM and 1 PM - 5 PM. All participants who could not attend an official odometer reading on one of those dates was required to switch to smartphone-based official odometer readings or to choose another mileage reporting method. In total, 82 participants got official manual odometer readings in July 2016.

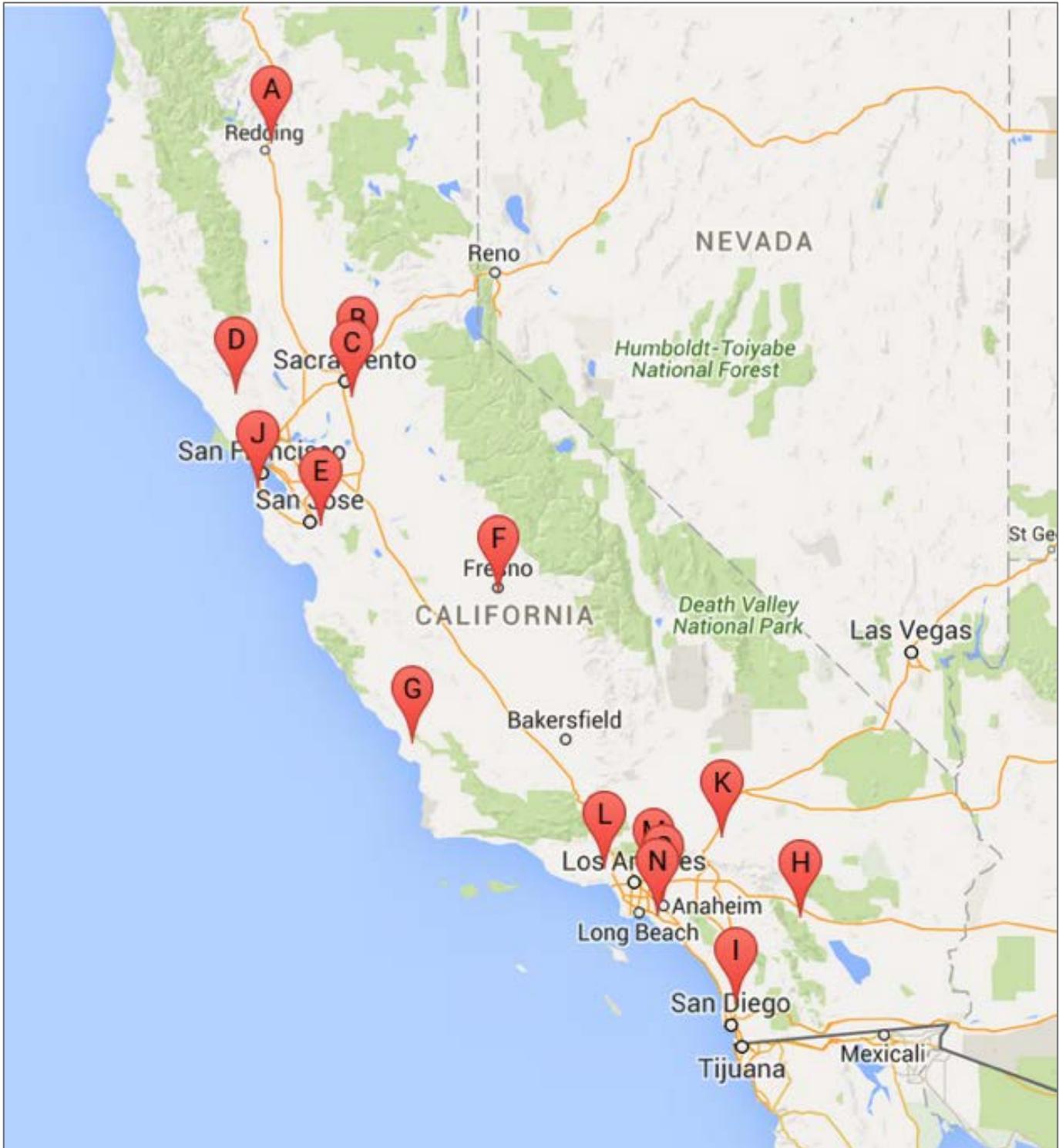
The 15 locations available included the following, illustrated on the map in Figure 3-1 on the next page:

- A. Redding—Shasta College
- B. East Sacramento—American River College
- C. Sacramento—Cosumnes River College
- D. Santa Rosa—Santa Rosa Junior College
- E. San Jose—Evergreen Valley College
- F. Fresno—Fresno Career and Technology Center
- G. San Luis Obispo—Cuesta College
- H. Palm Desert—College of the Desert
- I. San Diego—Miramar College
- J. San Bruno—Skyline College
- K. Victorville—Victor Valley College
- L. Woodland Hills—L.A. Pierce College
- M. Whittier—Rio Hondo College
- N. Huntington Beach—Golden West College
- O. Fullerton—Fullerton Junior College



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**Figure 3-1 15 Smog Check Referee Locations Available for Manual Odometer Readings**



At the end of the pilot, on March 18 and 25, 2017, official odometer readings were again required of the participants who had gotten manual odometer readings at the start of the program, and who had not switched



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to another mileage reporting method or to smartphone-based mileage reporting. In March, there were 52 readings.

Below is information about the 30 participants who got official odometer readings in July 2016 but not in March 2017:

- ▶ Six had switched away from mileage permit and odometer charge, so did not need a final official odometer reading.
- ▶ One switched to mobile phone reporting and provided an official odometer reading via the Odocheck app.
- ▶ Four called the CalSAM to say that they could not find time to make an official odometer reading appointment at a Smog Check Referee due to their schedules.
- ▶ 19 did not provide a final official odometer reading.

### Manual Odometer Reading Lessons Learned

1. In a potential future mandatory program, there should be a large number of locations available for manual odometer readings statewide.
2. Manual odometer readings should not be required too frequently, perhaps once a year.
3. A small but important number of participants will prefer manual odometer readings.

One lesson learned is that for a fully operational system, there need to be significantly more locations available statewide so that participants do not have to drive far to get an official odometer reading. One possibility would be to offer manual odometer readings at all Smog Check locations, not just referees. A further possibility would be to offer manual odometer readings at all auto services businesses—repair shops, oil change shops, etc. Another lesson learned is that manual odometer readings cannot be required at highly-frequent intervals. In many cases, the time commitment of the participants for the manual reading, including drive time to and from the Smog Check referee, ranged from 30 minutes to over an hour. Based on the behavior in the RCPP, it seems feasible to require official odometer readings once per year.

A final lesson learned is that a small but important number of participants will prefer having manual odometer readings to other mileage reporting methods and other means by which official odometer readings can be obtained, such as a smartphone app. Thus, the State should consider offering manual odometer readings, acknowledging that the frequency of official readings will be lower than with other methods.

### 3.2. Manual Refunds

All participants who chose a non-location-based mileage reporting method were charged for miles driven in states other than California and off of public roads in California. However, these miles would not normally be subject to state road charges. Thus, these participants were offered the opportunity to claim a simulated refund for these miles by submitting a refund request.

To submit a refund request, participants recorded their dates of travel, start and end locations for each day, and major changes in travel direction on a single day. They did so for travel in other states, off-road, and on private roads. When the total value of all non-chargeable travel exceeded \$18 (1,000 miles at 1.8 cents per mile), the participants could complete and submit a web form to claim a simulated refund for the miles driven. On that web form, the participants entered the start and end points for each day of travel, and number of miles driven on each day.



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The pilot delivery team reviewed each refund request. If it was filled out correctly, the team sent a simulated refund statement to the participant. If it was not filled out correctly, the team replied to the motorist with clarification questions and suggestions. The participant then had to reply to the mail and/or re-submit the web form before the simulated refund was granted.

Table 3-1 below summarizes the 13 non-chargeable miles refund requests sent over the course of the live pilot:

**Table 3-1 Non-chargeable Miles Refund Requests**

Request #	Date Processed	Account Manager	Out of State Miles		Total Refund (\$)
			Requested	Confirmed	
1	8-Sep	CalSAM	1,326	1,326	\$23.87
2	18-Sep	Azuga	1,327	983	\$17.69
3	18-Sep	CalSAM	1,008	1,008	\$18.14
4	23-Oct	CalSAM	1,015	1,015	\$18.27
5	23-Oct	CalSAM	1,147	1,147	\$20.65
6	24-Oct	Azuga	4,984	4,984	\$89.71
7	24-Oct	Azuga	2,870	2,870	\$51.66
8	21-Nov	CalSAM	1,765	1,765	\$31.77
9	30-Dec	CalSAM	1,754	1,754	\$31.57
10	30-Dec	CalSAM	1,002	1,002	\$18.04
11	17-Jan	CalSAM	6,546	6,546	\$117.83
12	9-Feb	CalSAM	1,313	1,313	\$23.63
13	28-Mar	CalSAM	1,928	1,928	\$34.70
<b>Total</b>			<b>27,985</b>	<b>27,641</b>	<b>\$497.53</b>

When the pilot delivery team was processing the non-chargeable mileage refund requests, several participants required guidance on how to properly enter their data into the web form. Guidance that had to be provided on more than one occasion included the following:

- ▶ Be sure to enter travel for each day, and not an entire multi-day trip mileage total on a single date.
- ▶ Ensure that travel on a given date was less than 1000 miles, or provide an explanation of why it was more than 1000 miles.
- ▶ Do not count any miles driven inside California—mileage for out-of-state trips had to start from the California border.

A lesson learned is that instructions on how to fill out the form correctly need to be extremely clear, and even then, many participants may not complete it correctly or may make suspicious claims which require feedback from the reviewer. For example, in some cases, having just start and end points for a given day of travel is not enough documentation – when mileage exceeds a certain threshold greater than the mileage from start to end for a given day, midpoints may be required.



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As a further lesson learned, the pilot delivery team observed that allowing manual refund requests without requiring any proof that the travel occurred may enable fraud. A motorist could simply enter one or more trips into the web form that did not actually occur. A simple form of proof would be to require a copy of a receipt from a restaurant, gas station, or other venue along the route traveled. One such receipt could be required for every day of out-of-state travel.

### Manual Refunds Lessons Learned

1. Instructions for filling out the refund form should be extremely clear.
2. Allowing manual refunds without requiring any proof may enable fraud.
3. Processing manual refund requests takes time and could be operationally expensive.

Another lesson learned is that supporting manual refund requests takes time, and could thus be expensive. Providing manual refunds requires skilled employees to review all refund requests and to respond to customer questions, which could be operationally expensive. If proof of travel is required, it will need to be reviewed. Some parts of non-chargeable mileage request reviews may be able to be automated with software. However, such automation will require software development and testing, with associated costs. Some manual reviews, in particular of items offered for proof, may still be necessary. Instead of providing a method for claiming refunds for non-chargeable miles, an alternative would be to require that participants who wish to not be charged for such miles have devices with location-determining technology.



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### 4. Lessons Learned on Mileage Reporting Technologies

This section described lessons learned on the various mileage reporting technologies as follows:

- ▶ Plug-in mileage meters
- ▶ Smartphone with no location
- ▶ Smartphone with general location
- ▶ In-vehicle telematics
- ▶ Heavy vehicle mileage meters
- ▶ Manual methods (odometer charge, time permit, and mileage permit)

#### 4.1. Plug-in Mileage Meters

Plug-in (OBD-II) mileage meters were, by far, the most popular mileage reporting method in the pilot: at pilot close, 60% (3,073 of 5,129) compliant vehicles used plug-in mileage meters. The popularity of this method may be attributed to a number of factors:

- ▶ Foremost, plug-in mileage meters were fully automated. They required no manual purchasing of permits or taking of odometer images, and after plugging the device into the vehicle, no further activity was required of the participant to report miles.
- ▶ Secondly, unlike in-vehicle telematics, plug-in mileage meters worked with the majority of vehicle makes and models.
- ▶ Finally, plug-in mileage meters offered the possibility to use a range of value-added services that were not offered with the other mileage reporting methods.

Plug-in mileage meters worked well for the purpose of collecting miles, but they were not perfect. Their main imperfection was that they were sometimes left unplugged, and could not record miles when they were not unplugged (see Section 5 for a discussion of plug-in mileage meter compliance). One lesson learned is that users of plug-in mileage meters must be reminded promptly to plug in their devices, if there is a suspicion that they are unplugged. Because plug-in mileage meters generally do not transmit data on days that a vehicle is not turned on, there is never a clear remote signal that a device is unplugged. However, it would be possible for Account Managers to send a message to participants asking them to check whether their device was unplugged after a certain number of days if no signal is heard from the device.

A further imperfection is that they do not work with all electric vehicles because electric vehicles are not required to comply with the OBD-II standard (and, in general, they do not). However, Azuga's location-based plug-in mileage meters could compute miles traveled using the location signal to measure distance traveled for many electric vehicles. However, when electric vehicles were charging, such devices often recorded very short (0.1-0.2 mile) phantom trips. In future developments, it should be possible for Account Managers to filter out such phantom trips using software: for example, if a vehicle type is recorded as an electric or plug-in hybrid, any individual trips taken by the vehicle less than 0.3 miles could be deleted from the trip records. Thus, a lesson learned is that plug-in mileage meters support many, though not all, electric vehicle models, but special attention must be given to their behavior when used in electric vehicles.

As documented in the report on 5G and OBD-II updates, starting with 30% of new vehicles in model year 2019, and completing with 100% of new vehicles in model year 2021, the vehicle's odometer will be required to be



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included in OBD-II data. Thus, for non-electric vehicles that have been updated to comply with the new OBD-II requirements, miles traveled when the device is not plugged in will no longer be lost. However, for vehicles that use a location-based mileage meter, location information will not be recorded for miles driven with the device is not in the vehicle.

Another lesson learned is that location-based devices were significantly preferred by pilot participants to non-location-based devices. Of plug-in mileage meter users, 85% (2,608 of 3,073) chose a GPS-equipped device. This may be because GPS devices allow non-chargeable mileage not to be charged (no refund process necessary), and that participants wanted the possibility of using value-added-services that require location information.

### Plug-in Mileage Meter Lessons Learned

1. Plug-in mileage meters work well but do not collect data when they are not plugged in.
2. Users of plug-in mileage meters must be reminded to plug in their devices.
3. Only location-based plug-in mileage meters work for electric vehicles.
4. With the next OBD-II update completing in 2021, plug-in mileage meters will be able to capture miles driven when they were not plugged in.
5. Location-based devices were preferred by the pilot participants.

## 4.2. Smartphone with no Location

The smartphone with no location option was provided by Vehcon in the form of their MVerity app. Participants were asked to submit photos of their odometer and VIN number at the start of the pilot, and then each month.

Early in the pilot, Caltrans and the pilot delivery team determined that participants on the smartphone methods required more than one reminder in order to maximize the number of participants who reported their mileage each month. Together, it was decided that there would be three reminders: on the 25<sup>th</sup>, 27<sup>th</sup>, and 29<sup>th</sup> of each month. All participants received the reminder on the 25<sup>th</sup>. Only those who had not reported by the 27<sup>th</sup> received the reminder on that day. Similarly, only those who had not reported by the 29<sup>th</sup> received the reminder on that day.

For Vehcon MVerity, reminders were sent by text message, e-mail, and in-app notification. Participants could choose by which of those three channels they received reminders—and participants could choose to receive reminders by two or all three channels.

One lesson learned is that having three reminder dates helped achieve monthly reporting (compliance) rates in the 55-90% range (see Section 5 for details). However, it will be important to determine the best frequency of notifications, since some participants may find three reminders per month to be too frequent. It should be pointed out that no mileage is lost from smartphone participants unless they never send another

odometer image. So long the participant does send another image, all of the mileage for the months in which no image is sent is included in the next month for which an image is sent.

### Smartphone with no Location Lessons Learned

1. Having 3 reminders per month achieved reporting compliance in the 55-90% range.
2. Account Managers should allow up to 24 hours for image processing.
3. Each Account Manager should have a single brand for all mileage reporting methods, including smartphone no location.



## Technical Lessons Learned

A further lesson learned is that Account Managers should allow time (up to 24 hours) for image processing by Vehcon. While many images are processed immediately, some images require manual review in which a specialist looks at the image and verify that the software had made the correct odometer reading. Such a manual review usually is quick (at most 30 seconds to review the image and type in the correct reading). However, due to staff availability, Vehcon often required up to 24 hours when manual reviews were needed.

A final lesson learned is that each Account Manager should have its own single brand for all mileage reporting methods. Having both the Azuga brand and the Vehcon MVerity brand was confusing for some participants.

### 4.3. Smartphone with General Location

All lessons learned and considerations about smartphone with no Location also apply to smartphone with general location, which was provided by Driveway. The Driveway app used the phone's GPS signal and other signals to determine when a phone was in the driver's primary vehicle, and computed miles traveled in that primary vehicle when the phone was in the vehicle. Driveway stated that after an initial learning period, the app could compute distance traveled with 99% accuracy. However, to ensure that distance traveled was measured with acceptable accuracy for the RCPP, the Driveway app also included a feature to support the capture of odometer images. Driveway sent these images to Vehcon for processing, and actual miles traveled were taken from the odometer values.

When participants drove out-of-state in their primary vehicles, and had the Driveway app enabled, the app would record the number of miles traveled out-of-state. Thus, these miles were recorded as non-chargeable miles. These miles were then deducted from the total miles driven for the month as computed from the odometer images, and the remaining miles were reported as chargeable.

Some participants reported that the Driveway app used excessive battery life and/or data on their smartphones. Driveway stated that their app did not use more battery or data than other similar apps. However, more participants (28) left the Driveway app during open enrollment than any other mileage reporting method, although 10 changed into Driveway, resulting in a net loss of 18 vehicles for Driveway. 516 participants finished the Pilot using Driveway, thus the net loss of 18 vehicles represented about 3.5% of the number of vehicles on Driveway.

#### **Smartphone with General Location Lessons Learned**

*All lessons from "smartphone with no location" apply.*

1. Odometer images needed to ensure accurate mileage.
2. Some participants reported the app used excessive data and/or battery.

### 4.4. In-vehicle Telematics

The RCPP was the first pilot of a road charge to feature native automaker in-vehicle telematics systems, called "in-vehicle telematics" in the pilot, as a means of recording and reporting miles driven. To do this, Account Managers accessed the automaker telematics system for a given vehicle and read the odometer value of the vehicle at least once per month.



## Technical Lessons Learned

One lesson learned early on was that only limited makes and models of vehicles are supported. Even among vehicles that have native automaker telematics systems built in, only a limited number of makes and models are currently supported. Another lesson learned is that Account Managers should verify vehicle compatibility based on the VIN at the time the participant signs up for the system, in order to ensure that only those vehicles that can support In-vehicle telematics are ever signed up for it.

Another lesson learned is that even if a vehicle includes a supported telematics system, the vehicle owner must subscribe to the telematics package in order for in-vehicle telematics to be supported. For many new vehicles with a

telematics system, the first 3-5 years subscription is often included with the price of the vehicle, but after that, the participant must subscribe in order for use of in-vehicle telematics mileage reporting to be possible. In addition, vehicle odometer data is not always included in the base telematics package. For most vehicle makes and models, odometer data is included, but in Acura vehicles, at least, it is not.

Another lesson learned is that vehicle owners must provide an up to date userid and password for their automaker telematics system to their Account Manager. Without the updated log-in credentials, the Account Managers were not able to access the telematics system and read the odometer. Failure to provide the updated password to the Account Manager was the only issue that would cause participants using in-vehicle telematics not to report miles for a given month.

The software architecture that allowed Account Managers to access data from in-vehicle telematics required that the Account Managers access or “pull” data from the vehicles over the automaker’s telematics system. Software could not reside on the vehicle (which, if it were possible, would allow the vehicle to “push” the data to the Account Manager’s system) because carmakers forbid all third-party software from being loaded on to any part of their systems that is connected to vital driving components. As a lesson learned, this architecture in turn prevents the use of location data with in-vehicle telematics systems, because the Account Manager’s system can only know the location of the vehicle at the time that it pulls data from the system—it cannot know where the vehicle was when, for example, miles were travelled.

In order to support location-based mileage reporting, two different techniques may be able to be employed. One, a simple smartphone app could be developed that will notify the Account Manager’s system whenever the vehicle crosses a state border, allowing accurate recording of miles by state. Two, the Account Manager’s system can pull data more frequently when a vehicle is near a state border. This latter solution, however, is not ideal for participants residing close to a state border, as their Account Managers would need to pull data from their vehicles very frequently, and every data pull activity has an associated cost. In the future, carmakers may change the architecture of in-vehicle telematics to allow a different, potentially better way of supporting use of location data on a road charging system.

### In-vehicle Telematics Lessons Learned

1. Only limited makes/models of vehicles supported.
2. Account Managers should verify vehicle compatibility based on VIN at participant sign-up.
3. Vehicle must have an active telematics subscription.
4. Vehicle odometer data not always included in base telematics package.
5. Vehicle owners must keep telematics username/password updated with Account Manager.
6. Current telematics architecture prevents use of location data. Location could be supported by a smartphone app or frequent data pulls.



## Technical Lessons Learned

### 4.5. Heavy Vehicle Mileage Meters

The RCPP was the first pilot of a road charge to feature light vehicles and heavy commercial vehicles in the same program. Based on the anecdotal evidence of statements made by managers from among the eight heavy vehicle fleets that provided the 55 heavy vehicles in the pilot, the system worked well, as the fleet managers were generally satisfied. Moreover, at least two fleets decided to keep EROAD service for other value-added services after the pilot ended. Thus, one lesson learned is that heavy vehicle fleets like and take advantage of the fleet services available through heavy vehicle mileage meters—enough to pay for their service.

#### Heavy Vehicle Mileage Meter Lessons Learned

1. Heavy vehicle fleets like and take advantage of fleet services available via the mileage meters.
2. Heavy commercial vehicles drive substantially more miles per vehicle than light vehicles.

A further lesson learned is that heavy commercial vehicles drive a lot—much more than light vehicles. The 55 heavy vehicles represented about 1% of the total 5,129 vehicles that finished the pilot. Yet this 1% of vehicles drove about 2.9 million out of the total 37 million miles driven in the pilot, or about 8% of all pilot miles driven.

A further lesson learned is that heavy commercial vehicles drive a lot—much more than light vehicles. The 55 heavy vehicles represented about 1% of the total 5,129 vehicles that finished the pilot. Yet this 1% of vehicles drove about 2.9 million out of the total 37 million miles driven in the pilot, or about 8% of all pilot miles driven.

### 4.6. Manual Methods

Manual methods were provided by the CalSAM in the pilot. At pilot close, the CalSAM supported 1,035 participants across all three manual methods (time permit, mileage permit, and odometer charge) comprising 20% (1,035 out of 5,129 vehicles). A major lesson learned, indicated by the fact that 20% of participants chose a manual method, is that there is a significant number of motorists interested in using a manual method. There were also two other lessons learned about manual methods in general.

At the start of the live pilot, the CalSAM website allowed participants to register for the site without adding a vehicle to their account. However, this led to a significant number of participants signing up for the account who never added a vehicle. These participants received several reminder emails asking them to add a vehicle, and those who did not after two reminders and a final warning were dropped from the pilot. The CalSAM changed their website to require vehicle registration at the same time as account registration, and doing so prevented this phenomenon from recurring. Thus, one major lesson learned is that enrollment should only be possible with a vehicle included, even for manual methods.

Another general lesson learned is that it should be possible for all manual methods to be purchased retroactively, in cases of non-compliance.

Specifically, it should be possible to purchase a time permit for a day in the past, purchase a mileage permit for an odometer value less than the current odometer reading, and pay an odometer charge based on a past odometer value. As implemented in the CalSAM, this was not possible, so in cases in which a participant became noncompliant, they were unable to pay for the miles or time since their last point of compliance. Similarly, it should be possible for participants on the time permit and mileage permit to purchase additional time or miles prior to their current permit expiring.

#### Manual Methods General Lessons Learned

1. Registration should only be possible if a vehicle is included.
2. All manual methods should be able to be purchased retroactively.

Further lessons learned were specific to each manual reporting method.

Further lessons learned were specific to each manual reporting method.



## Technical Lessons Learned

### 4.6.1. Time Permit

Although the time permit requires the least amount of participant interaction—participants purchased it, and that was all—it proved to be the least popular mileage reporting method, with 88 participants (about 2% of 5,129 vehicles) using the

time permit at the time of the pilot close. It may be that the time permit's lack of popularity was due to the fact that there was so little interaction required. The typical pilot participant may have wanted interaction. Thus, this fact should not be interpreted as being negative for the time permit. Indeed, the time permit allowed participants to choose a manual method that didn't require them to either drive to a Smog Check Referee or to use a mobile phone for mileage reporting, and this feature was very convenient for some participants. Thus, a lesson learned from the time permit is that there are some participants who will want to choose this option.

#### Time Permit Lessons Learned

1. Some participants will choose a time permit.
2. Longer permits are more popular.

Also, long permits (90-day) were most popular, by far (generating over \$12,000 in simulated revenue compared with the shorter permits generating under \$1,000 each). The lesson learned is that longer permits are more popular, and the State should consider time permit of 90-days or even a full year for state residents (perhaps coinciding with registration renewal). Shorter permits, of course, would be well-suited to out-of-state drivers, if such drivers were subject to the road charge.

### 4.6.2. Mileage Permit

The mileage permit had 190 participants at the time of the end of the pilot, about 4% of 5,129 vehicles. The major lesson learned about the mileage permit is that it is hard to provide reminders for participants on mileage permits that coincide with the permits expiring. That is because the Account Manager has no way of knowing the expiration point of the permits, except when participants self-report their mileage.

To overcome this challenge, mileage permit participants received reminders at a self-identified and at a fixed interval:

- ▶ Mileage permit participants were asked to specify a date on which to receive a reminder to purchase a new mileage permit. However, participants may not have known how long it would take them to drive the specified amount.
- ▶ Mileage permit participants also received reminders every three months. However, for some participants, such as those who purchased 10,000-mile permits, these 3-monthly reminders may have come much too early; for other participants, such as those who purchased a 1000-mile permit, these reminders may have come too late.

Thus, the lesson learned is that in any potential future mandatory road charge program including mileage permits, reminders to purchase mileage permits should come at both a fixed interval and at a self-identified date.

#### Mileage Permit Lessons Learned

1. Reminders to purchase a new permit should come at a fixed interval and a self-identified date.
2. A variety of mileage permit sizes should be offered.

Although 1,000-mile permits were the most popular, all three of permit sizes were grouped closely together in popularity (generating \$4,800, \$4,400, and \$3,600 in simulated revenue). Thus, another lesson learned is that a variety of mileage permits should be offered.



## Technical Lessons Learned

### 4.6.3. Odometer Charge

The odometer charge was the most popular manual method, with 753 participants at the end of the pilot (about 15% of the 5,129 vehicles that finished the pilot).

One lesson learned about the odometer charge is that odometer charges should be automatically renewed when a participant pays for mileage. In other words, the default expectation should be that the participant remains on the odometer charge. This was not the case during the pilot. Participants had to click on a choice to remain on the odometer charge, which resulted in some participants having no permit, and thus being noncompliant for a period of time.

Another lesson learned is that the official odometer readings should be integrated with the odometer charge mileage reporting, to the extent possible. In other words, when a participant submits an official odometer reading through the Odocheck (mileage reporting) app, it should become the basis for the charges for the given reporting period. This was not the case during the pilot. Participants had to self-report their odometer reading in addition to submitting the odometer image, and this caused some confusion and extra work for participants.

#### **Odometer Charge Lessons Learned**

1. The odometer charge should be automatically renewed when the participant pays for mileage.
2. Official odometer readings should be integrated with odometer charge mileage reporting.



## Technical Lessons Learned

### 5. Lessons Learned on Compliance

Compliance means that participants report mileage accurately and on time for their vehicles. The activities required for compliance vary by mileage reporting method and are described individually in the sections below:

- ▶ Plug-in mileage meter
- ▶ Smartphone
- ▶ In-vehicle telematics
- ▶ Manual methods

During the pilot, Account Managers encouraged non-compliant participants to comply through a range of reminders. However, participants did not experience any means of enforcement (real or simulated). In a mandatory program, the threat of financial penalties and possibly of enforcement activities would change—hopefully improve—participant compliance. However, the voluntary nature of the pilot means that pilot participants might be more predisposed to compliance than the public as a whole.

The compliance rates varied by mileage reporting method, but the consequences of noncompliance also varied. Plug-in mileage meters experienced the highest compliance rates; however, when a mileage meter was not plugged in, it is not recorded at all. By contrast, for smartphone and in-vehicle telematics mileage meters, all mileage that is driven during a time when a vehicle is not compliant is captured when the odometer reading is again reported for the vehicle.

#### 5.1. Plug-in Mileage Meter

Plug-in mileage meter (OBD-II) devices experienced the highest levels of compliance. However, compliance was not perfect with plug-in mileage meters, because sometimes participants unplugged their devices for various reasons. Unlike other mileage reporting methods, mileage driven when the mileage meter is not plugged in to the vehicle is not recaptured later—it is simply not recorded or reported. This behavior will change with the recent OBD-II updates that will become active in new vehicles between 2019 and 2021.

The main causes for unplugging/noncompliance with plug-in mileage meters are the following:

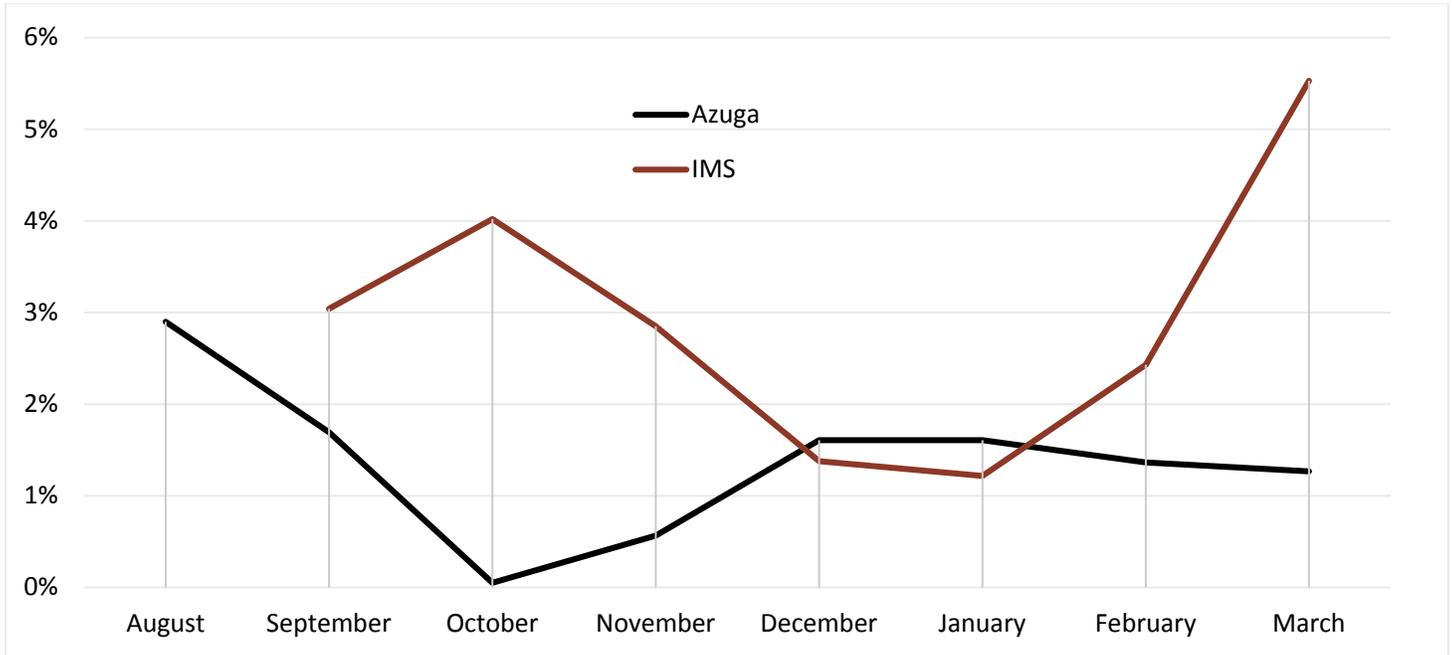
- ▶ Participant removed mileage from vehicle (e.g., for repair, to show friends) and forgot to put it back.
- ▶ Participant changed vehicles in the pilot, but did not plug mileage meter into the new vehicle immediately.
- ▶ The mileage meter had to be replaced.

As a measure of overall compliance for plug-in mileage meters, Figure 1 presents the percent of devices for IMS and Azuga participants that were unplugged for seven or more days in a month.



**Technical Lessons Learned**

**Figure 5-1: Percentage of Plug-in Mileage Meters Unplugged 7+ Days in Each Month<sup>3</sup>**



Lessons learned about compliance with plug-in mileage meters include the following:

- ▶ Plug-in mileage meters do not have perfect compliance—although compliance levels are good, sometimes participants leave their mileage meters unplugged.
- ▶ Account Managers should send reminder messages to their participants who are suspected of having unplugged devices. Note that mileage meters may not report on days that the vehicle is not driven, so Account Managers do not receive definite, positive notifications that devices are unplugged. However, it would be possible for Account managers to send notifications to all participants whose devices do not report for a certain period of time—say, one week—to check
- ▶ In a mandatory system, it may be useful to encourage participants to submit odometer images in addition to using a plug-in mileage meter. In cases in which a mileage meter is left out of a vehicle for an extended period of time, motorists could be subject to a penalty. However, if the motorist has provided an odometer image, the motorist could then provide another odometer image, and by

**Plug-in Mileage Meter Compliance Lessons Learned**

1. Plug-in mileage meters have the highest compliance of all methods, but it is not perfect.
2. Account Managers should send reminder messages to participants who are suspected of having unplugged devices.
3. In a mandatory system, it may be useful for plug-in mileage meter participants to submit odometer images as well.

<sup>3</sup> Source: Monthly RCPP Compliance Reports, July 2016-March 2017. IMS did not provide data for August, and the relatively high value for March may indicate some participants taking their devices out of vehicles early, before the formal end of the live pilot.



**Technical Lessons Learned**

doing so account for miles driven while the device was unplugged. If the motorist does this, the motorist may no longer be required to pay a penalty, but rather only pay for the missing miles.

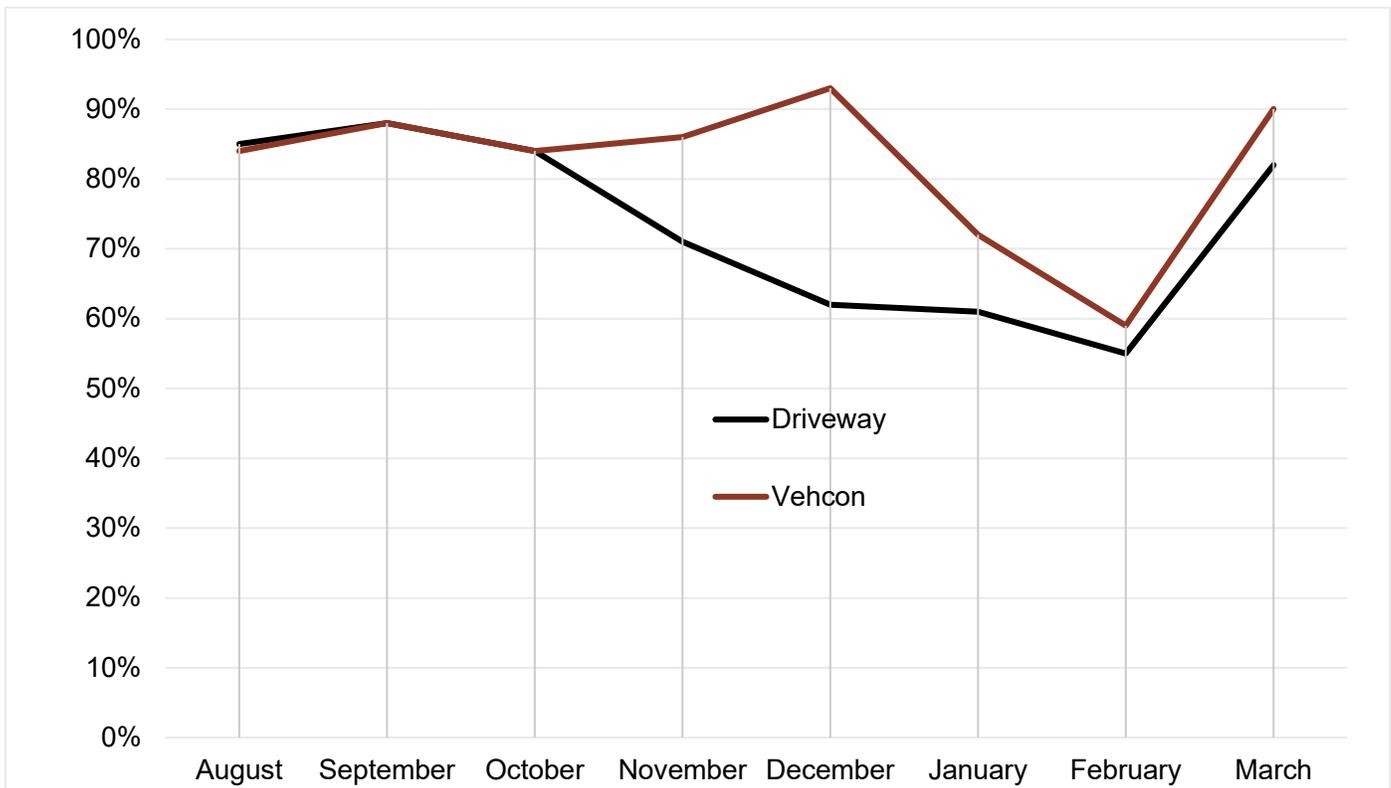
**5.2. Smartphone**

The cause of noncompliance for the two smartphone methods—Vehcon MVerity and Driveway—was failure to submit a monthly odometer image. Shortly after start of pilot, Caltrans and the pilot delivery team realized that it would be necessary to send smartphone participants more than one reporting reminder per month. Starting in August 2016, smartphone participants were sent three reminders per month: on the 25<sup>th</sup>, 27<sup>th</sup>, and 29<sup>th</sup> (participants were only sent reminders on the 27<sup>th</sup> and 29<sup>th</sup> if they had not already reported for the month).

With the smartphone mileage reporting methods, the mileage is not lost when a participant fails to report for the given month, unless no further report is ever received from that participant. Rather, the mileage from the month(s) of non-reporting is captured in the next month in which a report is received.

As a measure of overall compliance for users of the smartphone mileage reporting methods, Figure 2 presents the percent of Vehcon MVerity and Driveway participants who sent in official odometer readings each month.

**Figure 5-2: Percentage of Smartphone Vehicles Reporting Mileage Each Month<sup>4</sup>**



<sup>4</sup> Source: Compliance and Cross-reference, and Monthly RCPP Compliance Reports, July 2016-March 2017.



## Technical Lessons Learned

Vehcon participants outperformed Driveway in the timeframe November through February, perhaps because they sent email reminders to their participants in addition to text reminders and an in-app reminder. Both Vehcon and Driveway experienced a low in reporting in February, possibly due to the fact that February has fewer days than other months.<sup>5</sup> In addition, both Vehcon and

Driveway experienced a sharp increase in compliance during March for pilot closeout reporting, most likely due to participants wanting to close out their accounts and become eligible for their reward check.

### Smartphone Compliance Lessons Learned

1. Multiple reporting reminders are necessary, ideally by text message, in-app reminder, and e-mail reminder.
2. With reminders, compliance generally fell in the 60%-90% range.

Lessons learned about compliance with smartphone mileage meters include the following:

- ▶ Multiple reporting reminders are necessary, ideally by three channels: text message, in-app reminder, and email reminder—though participants should ideally be able to select which of those reminders they receive.
- ▶ With reminders, compliance fell mostly in the 60%-90% range, and a mandatory road charge may experience similar compliance levels. Sometimes, participants were unable to report for a given month because they were travelling when the reminders were sent. In a mandatory road charge, the State may not wish to assess penalties when participants fail to report for only one or two months. Similarly, the State may prefer to require odometer images only quarterly, semi-annually or annually rather than annually, or at least give motorists a choice.

### 5.3. In-vehicle Telematics

For in-vehicle telematics, the cause of noncompliance was participants not providing updated username/password for their telematics account to their Account Managers.

As with the smartphone mileage reporting methods, the mileage is not lost when an in-vehicle telematics participant's odometer is not read for a given month, unless no further report is ever received from that participant. Rather, the mileage from the month(s) of non-reporting is captured in the next month in which a report is received.

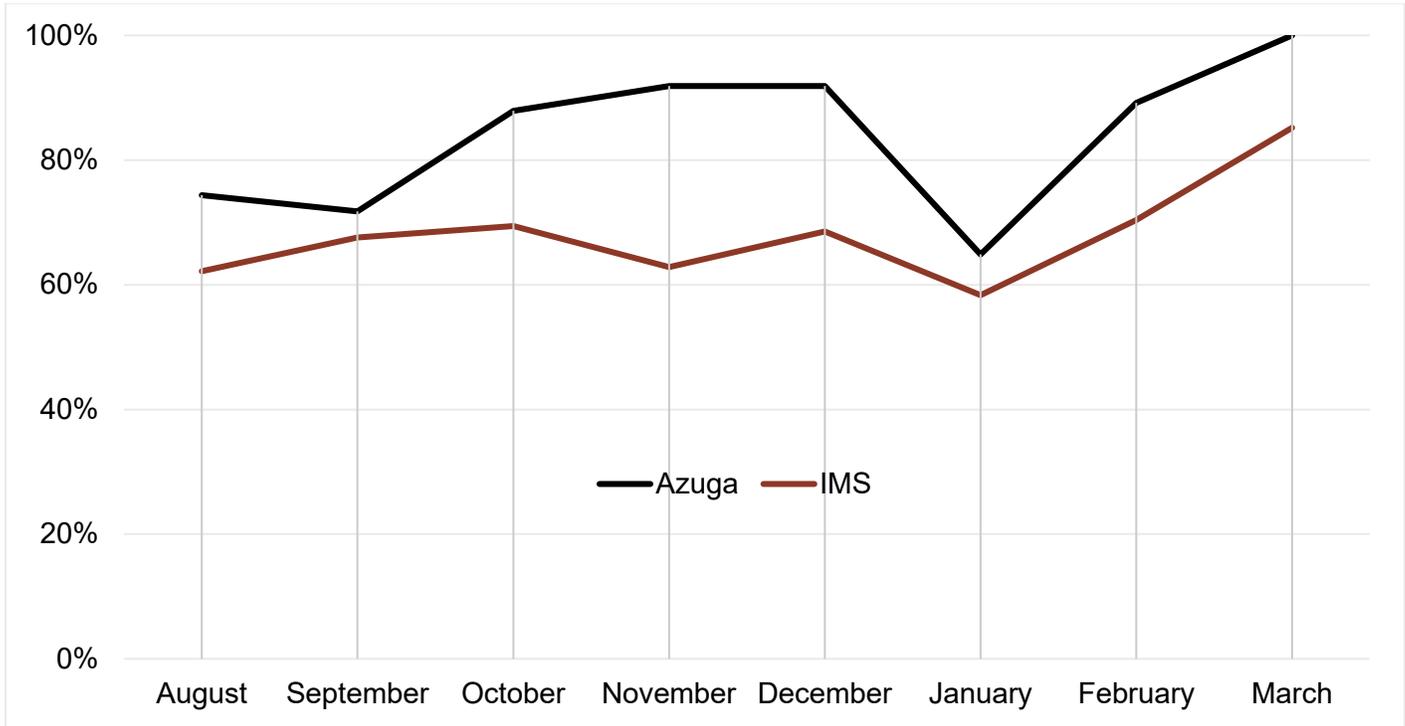
As a measure of overall compliance for users of the In-vehicle telematics reporting, Figure 3 presents the percent of Azuga and IMS participants for whom mileage was read each month.

<sup>5</sup> Both Vehcon and Driveway switched their reminder schedule in February to remind participants on the 24<sup>th</sup>, 26<sup>th</sup>, and 28<sup>th</sup> of the month. However, it may be that participants used to receiving the third reminder and then reporting in the following two days did not change their behavior in February—such participants would have ended up submitting their images on March 1 or 2, too late to be included in February numbers.



**Technical Lessons Learned**

**Figure 5-3: In-vehicle Telematics Reporting by Month**



The main lesson learned from in-vehicle telematics compliance is that Account Managers must remind participants to update their username/password often. In particular, after any failure to read an odometer of in-vehicle telematics participants, Account Managers should contact the participants to remind them to update their login credentials.

**In-vehicle Telematics Compliance Lessons Learned**

1. Account Managers must remind participants to update their username/passwords often, in particular after any failure to read the odometer of a participant.

**5.4. Manual Methods**

**5.4.1. Time Permit**

One metric for time permit compliance is the number of participants who held permits that went through March 25, the day required in order to be compliant for the purpose of pilot closeout. The value for this metric in the RCPP was 41% (37 of 90 participants on the time permit).

One lesson learned is that the time permit had the worst compliance of all mileage reporting methods. This, in turn, may mean that more reminders are needed. So, another lesson learned is that more reminders are needed than the reminder sent a week before the time permit was to expire.

In cases that participants ran out their time permits without purchasing a new permit, participants were

**Time Permit Compliance Lessons Learned**

1. Time permit had the worst compliance of all mileage reporting methods
2. More reminders are needed for time permits.
3. Time permits should be able to be purchased retroactively.



## Technical Lessons Learned

not able to purchase permits for past, non-compliant days. Thus, a further lesson learned is that time permits should be able to be purchased for past days. Similarly, participants should be able to add new permit days immediately after the end of their current permit—in other words, that they should be able to purchase permits ahead of time.

### 5.4.2. Mileage Permit

Meaningful compliance metrics about the mileage permit can only be made for participants who made an odometer reporting (either official or self-reported values). Of those participants who provided a final odometer reading, 39% had overrun their permit (39 participants of 101 who had made final reports had overrun their permit).

The main lesson learned is that mileage permit holders should get more reminders, although providing reminders to mileage permit holders is challenging, as described above in the section on mileage reporting methods. Another lesson learned is that, in a similar manner to the time permit, it should be possible for participants to add mileage permits for past odometer readings, and participants should be able to add additional permit miles onto the end of their current permit.

#### **Mileage Permit Compliance Lessons Learned**

1. Mileage permit holders should get more reminders.
2. It should be possible to add mileage permits for past odometer readings.

### 5.4.3. Odometer Charge

As with the mileage permit, meaningful compliance metrics about the odometer charge can only be made for participants who made an odometer reporting (either official or self-reported values). Of the 753 participants on the odometer charge, 73% (549 of 753) provided an odometer reading. Of those, 81% (445 of 549) performed simulated payment for their miles.

One main lesson learned from the odometer charge, and indeed, from the other manual methods, is that without enforcement or significant financial penalties, compliance will be imperfect. Another lesson learned, because some participants provided official but not self-reported odometer readings, is that odometer readings made on the Odocheck app should automatically populate the CalSAM website (in other words, self-reported readings should not be required of app users). Also, as with the time permit and mileage permit, the odometer charge should be able to be calculated from a past odometer reading. Finally, based on the fact that a significant number of participants did not pay for all of their miles, automatic payment should be possible. That is, once a participant has provided their (simulated) payment information, they should not have to do so again. This would have increased the percentage of participants who made a report and paid for miles driven.

#### **Odometer Charge Compliance Lessons Learned**

1. Without enforcement, compliance will be imperfect.
2. Odometer readings made with any app should automatically populate the CalSAM website.
3. Automatic payment should be possible.



## Technical Lessons Learned

# 6. Lessons Learned on Technology Issues with Policy Implications

This section describes technical lessons learned on three important technology issues with significant policy implications:

- ▶ Private roads
- ▶ Fuel tax credits
- ▶ Electric vehicles

## 6.1. Private Roads

Miles driven on private roads do not constitute chargeable miles, because they are not publicly funded roadways. Although miles driven out-of-state and off-road can be distinguished using any digital map, miles driven on private roads can only be distinguished using a digital map that identifies which roads are private and which roads are public.

One lesson learned in the RCPP was that many digital maps do not distinguish private roads from public roads, and of those that do, the information may not be complete or accurate enough to use as a basis for road charging. In the pilot, IMS identified private roads using the map service 'HERE'.<sup>6</sup> Although not perfect, here provided reasonably good private road information. When the HERE system's information on public/private status was found not to be correct by participants, IMS updated the roads to their correct status in IMS's own proprietary map data layer.

By contrast, Azuga used Google Maps during the RCPP. Google Maps does not distinguish private roads from public roads, and Google has not announced plans to add this feature. Thus, it may not be possible to use Google Maps—an otherwise excellent digital map database—for road charging, if private road miles are not to be charged.

One pilot participant was very interested in ensuring that travel on private roads was not charged. That participant was directed to use IMS. This illustrates that there is a potentially small but vocal group of potential road charge payers who are very interested in ensuring that miles driven on private roads are not charged.

### Private Roads Lessons Learned

1. Providing private road exemptions requires that the Account Manager use a digital map database with accurate public and private road data.

## 6.2. Fuel Tax Credits

In the pilot, participants using methods based on metered mileage (all methods except the time permit and mileage permit) were provided credits for their fuel taxes paid. The amount of fuel used by each vehicle was computed in one of two ways:

- ▶ It was calculated from data made available through the OBD-II port to plug-in mileage meters, or

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<sup>6</sup> [www.here.com](http://www.here.com)



## Technical Lessons Learned

- It was estimated based on miles driven using the U.S. Environmental Protection Agency (EPA) combined city-highway fuel economy rating for the vehicle in question.

Currently, about 70% of vehicles on the road provide data over the OBD-II port that allows the vehicle to calculate fuel used. This number is growing, but slowly. Starting in 2019, new OBD-II requirements will mean that 30% of new vehicles will have to report the amount of fuel used directly, and by 2021, 100% of new vehicles will have to report this data. Thus, an increasing number of vehicles are providing data to compute fuel used with an OBD-II device. However, this is not available to other mileage reporting methods.

### Fuel Tax Credit Lessons Learned

1. For vehicles that did not provide sufficient data to calculate fuel consumption over the OBD-II port, and for non-plug-in mileage meter methods, fuel tax credits must be based on estimated fuel consumption.
2. Estimated fuel consumption can be imprecise, and varies based on driving style and whether vehicles are plug-in hybrids.

Other mileage reporting methods estimate fuel consumption based on the number of miles driven—Account Managers simply divided the number of miles driven by the EPA combined city-highway fuel economy rating. However, estimated fuel economy could be very imprecise, because the actual fuel consumption varies based on the driving style of the vehicle operator and the location including weather, elevation, terrain, and traffic conditions. Slow, stop-and-go city driving consumes more fuel than faster, even speed highway driving. EPA's combined city-highway fuel economy is intended to represent a balance of city and highway driving that reflects the average driver, but for motorists who drive mostly in the city, the estimated fuel consumption will be low, while for motorists who drive mostly on the highway, the estimated fuel consumption will be high. Moreover, motorists with aggressive driving styles (hard acceleration and hard braking) will cause a vehicle to consume more fuel than motorists with a gentler driving style. For plug-in hybrids, the quality of this estimate for fuel economy is especially poor, because the estimate does not account for how many miles were driven using electricity, and how many were driven using liquid fuel.

### 6.3. Electric Vehicles

Electric vehicles constituted 2.9% (151 of 5,129) of the total vehicle population that finished the pilot. The main lesson learned on electric vehicles is that automated mileage collection is more challenging for electric vehicles than for standard internal combustion engine vehicles. That is primarily because OBD-II support is not mandated for electric vehicles. In spite of this, plug-in mileage meters with general location information work on many, but not all, models of electric vehicle. Unfortunately, plug-in mileage meters with general location often record short (0.1-0.2 mile) phantom trips when a vehicle is charging. Future software developments may allow such phantom trips to be eliminated. Plug-in mileage meters without general location do not work on electric vehicles. In-vehicle telematics works for some electric vehicles, and is expected work for more makes and models in the future. Of course, smartphone and manual methods work for electric vehicles as they do for all vehicles.

### Electric Vehicle Lessons Learned

1. Automated mileage collection is more challenging than with other methods. It can be supported by plug-in mileage meter with general location, although such vehicles recorded short phantom trips when they were charging. It can also be supported by vehicle telematics for those makes and models which are supported.



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## Technical Lessons Learned

### 7. Summary

The pilot provided a fertile learning ground not only for participant experiences and opinions and organizational perspectives but also for technology and technical issues. This report summarizes the top lessons learned by Caltrans and the pilot delivery team during the RCPP preparations and live pilot operations. Experiences during system testing, feedback from participants directly to Caltrans, calls and emails to the various help desks, and information communicated directly from Account Managers to the pilot delivery team served as the basis for this compilation of technical learnings.

There are endless technology and system improvements that can be made for future road charge pilots and programs. The RCPP provided opportunities to learn about more mileage reporting methods across a larger group of “test drivers” than any pilot of its kind, and it featured a large team of professionals scouring the landscape for feedback. Thus the lessons learned reported here can be viewed as a starting point for technical enhancements and improvements in the future.