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AVTA Federal Fleet PEV Readiness Data Logging and Characterization Study for the National Park Service: Golden Gate National Recreation Area

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March 2014

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ABSTRACT

Battelle Energy Alliance, LLC, managing and operating contractor for the U.S. Department of Energy's Idaho National Laboratory, is the lead laboratory for U.S. Department of Energy Advanced Vehicle Testing. Battelle Energy Alliance, LLC contracted with Intertek Testing Services, North America (ITSNA) to collect data on federal fleet operations as part of the Advanced Vehicle Testing Activity's Federal Fleet Vehicle Data Logging and Characterization study. The Advanced Vehicle Testing Activity study seeks to collect data to validate the utilization of advanced electric drive vehicle transportation.

This report focuses on the Golden Gate National Recreation Area (GGNRA) fleet to identify daily operational characteristics of select vehicles and report findings on vehicle and mission characterizations to support the successful introduction of plug-in electric vehicles (PEVs) into the agencies' fleets.

Individual observations of these selected vehicles provide the basis for recommendations related to electric vehicle adoption and whether a battery electric vehicle or plug-in hybrid electric vehicle (PHEV) (collectively PEVs) can fulfill the mission requirements.

GGNRA identified 182 vehicles in its fleet, which are under the management of the U.S. General Services Administration. Fleet vehicle mission categories are defined in Section 4, and while the GGNRA vehicles conduct many different missions, only two (i.e., support and law enforcement missions) were selected by agency management to be part of this fleet evaluation. The selected vehicles included sedans, trucks, and sport-utility vehicles.

This report will show that battery electric vehicles and/or PHEVs are capable of performing the required missions and providing an alternative vehicle for support vehicles and PHEVs provide the same for law enforcement, because each has a sufficient range for individual trips and time is available each day for charging to accommodate multiple trips per day. These charging events could occur at the vehicle home base, high-use work areas, or intermediately along routes that the vehicles frequently travel. Replacement of vehicles in the current fleet would result in significant reductions in the emission of greenhouse gases and petroleum use, while also reducing fuel costs.

The San Francisco Bay Area is a leader in the adoption of PEVs in the United States. PEV charging stations, or more appropriately identified as electric vehicle supply equipment, located on the GGNRA facility would be a benefit for both GGNRA fleets and general public use. Fleet drivers and park visitors operating privately owned PEVs benefit by using the charging infrastructure. ITSNA recommends location analysis of the GGNRA site to identify the optimal placement of the electric vehicle supply equipment station.

ITSNA recognizes the support of Idaho National Laboratory and ICF International for their efforts to initiate communication with the National Parks Service and GGNRA for participation in the study.

ITSNA is pleased to provide this report and is encouraged by the high interest and support from the National Park Service and GGNRA personnel.

CONTENTS

FIGURES

TABLES

ACRONYMS

AVTA	Advanced Vehicle Testing Activity
BEA	Battelle Energy Alliance, LLC
BEV	battery electric vehicle
EPA	U.S. Environmental Protection Agency
EVSE	electric vehicle supply equipment
GGNRA	Golden Gate National Recreation Area
GHG	greenhouse gas emissions
GSA	General Services Administration
GVWR	gross vehicle weight rating
ICE	internal combustion engine
INL	Idaho National Laboratory
ITSNA	Intertek Testing Services, North America
kWh	kilowatt-hour
MPG	miles per gallon
PEV	plug-in electric vehicle (includes BEVs and PHEVs, but not hybrid electric vehicles)
PHEV	plug-in hybrid electric vehicle
SUV	sport utility vehicle
VIN	vehicle identification number
Wh	watt-hour

AVTA Federal Fleet PEV Readiness Data Logging and Characterization Study for the National Park Service: Golden Gate National Recreation Area

1. INTRODUCTION

Federal agencies are mandated by the Energy Policy Act of 1992[1], Energy Policy Act of 2005[2], Executive Order 13423 (President Bush 2007)[3], and the Energy Independence and Security Act of 2007[4] to purchase alternative-fuel vehicles, increase consumption of alternative fuels, and reduce petroleum consumption.

Battelle Energy Alliance, LLC (BEA), managing and operating contractor for Idaho National Laboratory (INL), is the lead laboratory for the U.S. Department of Energy's advanced vehicle Testing and manages the Advanced Vehicle Testing Activity (AVTA) Federal Fleet Vehicle Data Logging and Characterization study, which promotes utilization of advanced electric drive vehicle transportation technologies.

Because of their high-energy efficiencies and the ability of electric drive vehicles to reduce petroleum consumption, AVTA focuses testing activities on emerging plug-in electric vehicle (PEV) technologies. BEA selected Intertek Testing Services, North America (ITSNA) to collect data on federal fleet operations and report findings on vehicle and mission characterizations to support successful introduction of PEVs into federal fleets.

Because of the large number of vehicles in federal fleets in the United States, these fleets provide a substantial opportunity for the introduction of battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). However, to assess the scale of this opportunity, additional data are required to characterize the various missions performed by each fleet and to determine which existing vehicles may be suitable for replacement by a PEV.

Golden Gate National Recreation Area (GGNRA) contains over 117 square miles of land (Figure 1), crosses through three bay area counties (Marin County, San Francisco County, and San Mateo County), and receives more than 14.5 million visitors each year[5].

GGNRA is an excellent site for fleet evaluation, not only due to its size, diversity of terrain, and vehicle types, but also because of its accessibility by the public. While fostering the long-term vision outlined in the GGNRA long-range interpretive plan, "[To] share our national parks with an increasingly diverse America – and build a sense of ownership and civic engagement in the care of our parks, our environment, and our communities,"[6] GGNRA has an opportunity to be a leader in the adoption of BEVs and PHEVs for its fleet.

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[1] http://thomas.loc.gov/cgi-bin/query/z?c102:h.r.776.enr [accessed January 10, 2014]

[2] http://www.gpo.gov/fdsys/pkg/BILLS-109hr6enr/pdf/BILLS-109hr6enr.pdf [accessed January 10, 2014]

[3] http://www.gsa.gov/portal/content/102452 [accessed January 10, 2014]

[4] http://www.gpo.gov/fdsys/pkg/PLAW-110publ140/pdf/PLAW-110publ140.pdf [accessed January 10, 2014]

[5] www.nps.gov/goga [accessed January 9, 2014]

[6] http://www.nps.gov/goga/parkmgmt/upload/goga_final_cip_2011.pdf [accessed January 9, 2014]

Figure 1. Golden Gate National Recreation Area.

2. PROJECT OBJECTIVE

This study explores federal fleet vehicles and their usage characteristics, with a primary goal of supporting the goals of Presidential Executive Order 13514, which includes the following:

- Pursuing opportunities with vendors and contractors to address and incentivize greenhouse gas (GHG) emission reductions and petroleum use reductions
- Implementing strategies and accommodations for transit, travel, training, and conferences that actively reduce carbon emissions associated with commuting and travel by agency staff
- Meeting GHG emissions reductions associated with other federal government sustainability goals.

- Implementing innovative policies and practices that address agency-specific Scope 3 GHG emissions.[7]

Because of the large number of vehicles in the federal fleets, there is a substantial opportunity for PHEV and BEV adoption. Federal fleets offer an opportunity as a first market replacement for alternative fuels due to their scale, refueling patterns, and high vehicle turnover.[8]

This project has the following four defined tasks:

1. Data collection: Coordinate with the fleet manager to collect data on agency fleet vehicles. This includes collecting fleet vehicle characteristics and installing and monitoring data loggers on select fleet vehicles to characterize their missions.
2. Data analysis and review: Examine the data collected by the loggers and fleet vehicle characteristics to describe typical fleet activity and incorporate fleet manager input on introducing PEVs to the agency's fleet.
3. PEV implementation feedback: Provide feedback to fleet personnel and BEA on the selection criteria and use of PEVs in their specific fleet vehicle missions.
4. Observations and recommendations: Provide actionable information to implement PEVs into agency fleet operations and assess related impacts for the facility.

Data collected from vehicles include trip distance, idle time, time between uses, and stop locations. Data collection continues for 30 to 60 days using a non-intrusive data logger, which gathers and transmits information using global positioning satellites and cellular service. The loggers transmit data to the data center at 5-second intervals when an active signal is present.

Extrapolating the results of this analysis to the larger fleet provides estimates of potential savings in gasoline consumption and GHG emissions. This report also provides recommendations relating to fleet management of BEVs and PHEVs for additional consideration.

Fleet managers may use the information supplied in this report to identify which types of vehicles are suitable for BEV or PHEV replacement. BEVs are preferred because of the greater potential reduction of GHG emissions and petroleum usage, but they may not be suitable for all vehicle missions.

The information in this report supports a final report to BEA/INL and the U.S. Department of Energy (DOE). The aggregated results for all agencies' fleets will provide an overview of federal fleets, vehicle missions, vehicle use, and agencies needs to plan and establish a more systematic method for the adoption of BEVs and PHEVs.

3. METHODS

3.1 Fleet Vehicle Survey

Agency fleet managers selected fleet vehicles for this study and provided basic information for each vehicle, including its managing agency, home base for the vehicle, contact information, primary vehicle mission, vehicle ownership, fuel type, and annual mileage driven. This information was collected using vehicle information forms (Appendix A).

GGNRA (operating agency) identified 182 fleet vehicles owned by the U.S. General Services Administration (GSA; owning agency). Because of the high turnover and shifting of vehicle assignments to and from GGNRA, fleet managers provided ranges of values for two mission categories (i.e., pool and

[7] http://energy.gov/sites/prod/files/2013/10/f3/eo13514.pdf [accessed February 5, 2014]

[8] *Fleet Purchase Behavior: Decision Processes and Implications for New Vehicle Technologies and Fuel*, Nesbitt, Sperling, University of California, Davis 2001

support vehicles). For consistency in measurement and reporting, ITSNA has used the mid-range value for pool vehicles, support vehicles, and total fleet vehicles, as shown in Table 1. (Note that Section 4 provides descriptions of the vehicle mission types.)

Table 1. Fleet evaluation.

Fleet Evaluation				
Vehicle Mission	Study Vehicles	Total Fleet Reported	Mid-Range (Rounded)	Percentage Studied
Pool Vehicles	—	48 to 75	62	—
Enforcement Vehicles	8	30	30	27
Support Vehicles	6	50 to 99	75	8
Transport Vehicles	—	1	1	—
Specialty Vehicles	—	0	0	—
Shuttle/Bus	—	5	5	—
Low Speed Vehicles	—	0	0	—
Total Fleet Vehicles	14	134 to 210	172	9

ITSNA coordinated with the GGNRA fleet manager to identify specific vehicles for data collection for inclusion in the study. The fleet manager assessed their wide range of light-duty vehicles and made selections of high-interest vehicles based on vehicle missions and vehicle type/class. Selection also favored vehicles used at least twice a week. Because data loggers rely on the vehicle's battery power, non-use of the vehicle can result in the vehicle having a depleted battery. ITSNA received no reports of depleted batteries during the study at GGNRA.

3.2 Data Collection

Individual privacy concerns exist when monitoring vehicle movement with data loggers. Data collection occurs by vehicle identification (ITSNA-assigned vehicle ID), data logger number, and vehicle identification number (VIN). ITSNA receives no information related to the vehicle operator and provides no raw data to the fleet managers. In this manner, ITSNA does not collect, analyze, or report on individual driving habits.

3.2.1 Data Logger

Non-intrusive data loggers, produced by InTouchMVC[9] and depicted in Figure 2, placed into the vehicle's on-board diagnostic port, collect and transmit the relevant data. The data logger installation and manual recording of vehicle information typically takes less than 5 minutes. Once installed and activated (during vehicle use), the data loggers transmit vehicle information every 5 seconds by cellular communication to the data center.

ITSNA maintains the data logger's connectivity and verifies data transmission weekly. If a data logger is not reporting, ITSNA works with the fleet manager to evaluate connectivity and data reporting issues. Missing data (reported as "null" values) are frequently the result of lost global positioning system reception because the vehicle is in a cellular "dead" zone at the time of use or the vehicle driver removed the data logger. ITSNA eliminates the vehicle and data logger information if these null values present a significant impact on the data collected and no resolution is possible. This report identifies the statistics on this validation process as well.

[9] www.intouchmvc.com [accessed January 10, 2014]

Figure 2. InTouchMVC data logger.

The agency removes and ships the data loggers to ITSNA at the conclusion of the data collection period.

GGNRA requested 20 data loggers and installed loggers into 16 vehicles (i.e., eight law enforcement vehicles and eight support vehicles). Two support vehicles (Vehicles 92 and 100) provided no data for reasons unknown.

3.2.2 Data Captured

Data consist of key-on events, key-off events, and position updates logged every minute while the vehicle is keyed on. InTouchMVC fleet reporting converts these data points into records of trip events, stop events, and idle events.

From these data points, the following information is available for evaluation:

- Trip start and stop time and location
- Trip distance and duration
- Idle start time, location, and duration
- Stop start time, location, and duration.

3.3 Data Analysis

3.3.1 Definitions

Figure 3 illustrates a vehicle outing, which is comprised of trips, stops, and idle events, that may occur over 1 day or several days. The following list provides a definition of these terms:

1. *Outing*: An outing is the combination of trips and stops that start at the home base and includes all travel until the vehicle returns to home.
2. *Trip*: A trip starts with a key-on event and ends with the next key-off event.
3. *Vehicle stop*: A stop begins with a key-off event and ends with the next key-on event.
4. *Idle time*: The amount of time a vehicle spends stationary after a key-on event when the vehicle is not moving for a period of 3 minutes or longer.
5. *Trip travel time*: This is the amount of time required to complete a trip, excluding stops.

Definitions of additional analysis and survey terms are as follows:

1. *Operating shift*: Fleet manager-defined period worked
2. *Study days*: Days during which the data loggers are connected

3. *Vehicle days*: Study days during which a vehicle is used
4. *Null values*: A null value is a data record unusable for analysis for various reasons.

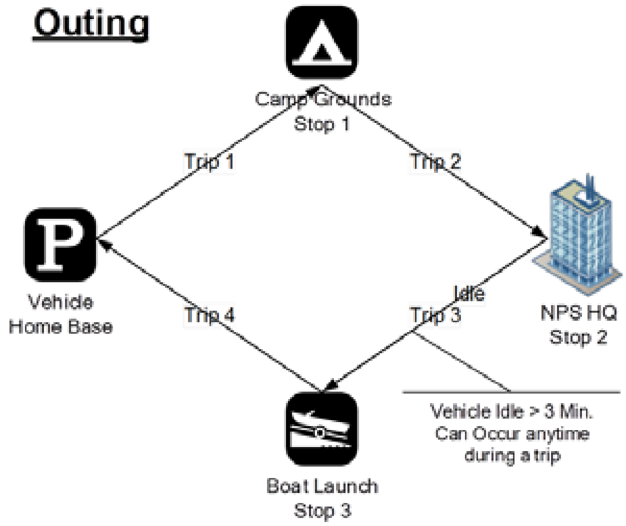

Figure 3. Vehicle outing.

3.3.2 Data Evaluation

Processing the data involves removal of null values and aggregation by different spatial and temporal scales. Aggregation is by day, by trip and by outing to produce figures showing the patterns of use. Appendix D provides the detailed evaluation for each vehicle monitored. Aggregation by vehicle mission follows to characterize use for the agency fleet. Section 5 presents these results. Finally, data extrapolation occurs to provide the overall fleet usage and benefit analysis. Section 6 presents these benefits. ITSNA observations are included in Section 7.

Statistical data analysis uses Python 2.7 with the Matlab Plotting Library graphics environment (Matplotlib) and spatial display with ESRI ArcGIS.[10] Frequency distributions summarize travel behavior of each vehicle and vehicle mission during the study period. Rounding of the tables and figures are to three significant digits.

4. VEHICLES

4.1 Vehicle Missions

The vehicle mission is an important characteristic in the fleet study. Information used to define the vehicle mission includes the vehicle's configuration (i.e., combination of basic engine, engine code, inertia weight class, transmission configuration, and axle ratio), vehicle use, classification per 40 CFR Part 600.315-82, the participating agency use, and general vehicle use. ITSNA has found that fleet vehicles generally fall into seven mission/vehicle categories that are listed as follows and are depicted in Figure 4.

1. **Pool vehicles**: A pool vehicle is any automobile (other than the low-speed vehicles identified below) manufactured primarily for use in passenger transportation, with not more than 10 passengers.

[10] www.esri.com [accessed January 10, 2014]

2. **Enforcement vehicles**: Light-duty motor vehicles that specifically are approved in an agency's appropriation act for use in apprehension, surveillance, police, or other law enforcement work. This category also includes site security vehicles, parking enforcement, and general use, but the vehicles are capable of requirements to support enforcement activities. Appendix C provides further definition.
3. **Support vehicles**: Vehicles assigned to a specific work function or group to support the mission of that group. Vehicles are generally passenger vehicles or light-duty pickup trucks and may contain after-market modifications to support the mission.
4. **Transport vehicles**: Light, medium, or heavy-duty trucks used to transport an operator and tools or equipment of a non-specific design or nature. The vehicle's uses include repair, maintenance, or delivery.
5. **Specialty vehicles**: Vehicles designed to accommodate a specific purpose or mission (such as ambulances, mobile cranes, and handicap controls).
6. **Shuttles/buses**: Vehicles designed to carry more than 12 passengers and further outlined in 49 CFR 532.2.
7. **Low speed vehicle:** Vehicles that are legally limited to roads with posted speed limits up to 45 mph and that have a limited load-carrying capability.

Figure 4. Vehicle missions.

4.2 Alternative Fuel Vehicles

As the operating agency, GGNRA has a unique opportunity to plan for the adoption of BEVs and PHEVs, along with planning for the supporting infrastructure. The adoption of PHEVs and BEVs is a primary goal of GSA and supports the directives previously referenced.

As GSA increases its certification of PHEVs and BEVs, agencies can plan for vehicle replacement through GSA for passenger vehicles and trucks. Table 2 presents the replacement requirements for fleet vehicles.

4.3 BEV and PHEV Benefits/Challenges

BEVs are powered 100% by the battery energy storage system available onboard the vehicle. The Nissan LEAF is an example of a BEV. Because the BEV has no other significant energy source, the range, power requirements, and mission of the needed vehicle factor greatly in purchasing decisions. Maximizing BEV capabilities typically requires batteries an order of magnitude larger than the batteries in hybrid electric vehicles.

Table 2. General Services Administration vehicle replacement requirements.

GSA Vehicle Replacement Requirements[11]			
	Fuel Type	Years	Miles
Passenger vehicles	Gasoline or Alternative Fuel Vehicle	3 and	36,000
		4 and	24,000
		5 and	Any miles
		Any year and	75,000
	Hybrid	5 and	Any miles
	Low Speed BEV	6 and	Any miles
Light trucks 4 x 2	Non-diesel	7 or	65,000
	Diesel	8 or	150,000
	Hybrid	7 and	Any miles
Light trucks 4 x 4	Non-diesel	7 or	60,000
	Diesel	8 or	150,000
	Hybrid	7 and	Any miles

PHEVs obtain their power from two energy sources. The typical PHEV configuration uses a battery and an internal combustion engine (ICE), powered by either gasoline or diesel. PHEV designs differ between manufacturers, although all have a charge-depleting mode, in which the off-board energy supplied to the battery discharges to propel the vehicle, and a charge-sustaining mode, in which the battery assists the ICE but the latter provides the majority of the propulsion power. Some PHEVs exhibit completely all-electric charge-depleting modes, while others have a blended charge-depleting mode in which both the battery and the ICE provide propulsion power while the battery depletes.

4.3.1 Battery Electric Vehicle/Electric Vehicle Benefits/Challenges[12]

The U.S. Environmental Protection Agency (EPA) identifies the following benefits and challenges of BEVs:

- **Energy efficient:** Electric vehicles convert about 59 to 62% of the electrical energy from the grid to power at the wheels, whereas conventional gasoline vehicles only convert about 17 to 21% of the energy stored in gasoline to power at the wheels.
- **Environmentally friendly:** PEVs emit no tailpipe pollutants, although the power plant producing the electricity may emit them. Electricity from nuclear, hydro, solar, or wind-powered plants causes no air pollutants.
- **Performance benefits:** Electric motors provide quiet, smooth operation and exhibit maximum torque at zero and low speeds, while also requiring less maintenance than ICEs.
- **Reduce energy dependence:** Electricity is a domestic energy source.

The EPA also identifies challenges associated with BEVs, including the following:

[11] http://www.gsa.gov/graphics/fas/VehicleReplacementStandardsJune2011Redux.pdf [accessed January 10, 2014]
[12] http://www.fueleconomy.gov/feg/evtech.shtml [accessed December 27, 2013]

- **Driving range:** Most BEVs can only travel about 100 to 200 miles (or less) before recharging, whereas gasoline vehicles can often travel over 300 miles before refueling and some much further.
- **Recharge time:** Fully recharging the battery pack can take 4 to 8 hours. Even a " charge" to 80% capacity can take 30 minutes.
- **Battery cost:** The large battery packs are expensive and may need to be replaced one or more times.
- **Bulk and weight**: Battery packs are heavy and take up considerable vehicle space.

4.3.2 Plug-in Hybrid Electric Vehicle Benefits/Challenges[13]

The U.S. Environmental Protection Agency (EPA) identifies the following benefits and challenges of PHEVs:

- **Less petroleum use:** PHEVs are expected to use about 40 to 60% less petroleum than conventional vehicles. Because electricity is produced primarily from domestic resources, PHEVs reduce dependence on oil.
- **Fewer GHG emissions:** PHEVs are expected to emit fewer GHG emissions than conventional vehicles, but as with BEVs, the difference depends largely on the type of power plant supplying the electricity.
- **Higher vehicle costs, lower fuel costs:** PHEVs will likely cost $1,000 to $7,000 more than comparable non-PHEVs. Fuel will cost less because electricity is much cheaper than gasoline, but the fuel savings depends on how much of the driving is done on the off-board electrical energy.
- **Recharging takes time:** Recharging the battery typically takes several hours. However, PHEVs do not have to be plugged in to be driven. They can be fueled solely with gasoline, but will not achieve maximum range, fuel economy, or fuel savings without charging.
- **Measuring fuel economy:** Because a PHEV can operate on electricity alone, gasoline alone, or a mixture of the two, EPA provides a fuel economy estimate for gasoline-only operation (charge-sustaining mode), electric-only operation (all-electric charge-depleting mode), or combined gasoline and electric operation (blended charge-depleting mode).

In many cases, the PEV retail cost is higher than a non-PEV model. This incremental cost also may be a challenge; however, many original equipment manufacturers have offered incentives to encourage the use and adoption of BEVs and PHEVs. Some original equipment manufacturers have recently reduced the vehicle cost, while also increasing vehicle range. A common assumption is that increasing PEV sales will result in a decrease in this incremental cost.

4.4 Plug-In Electric Vehicle Availability

GSA provides a summary of light and medium-duty passenger vehicles available for lease or purchase through GSA[14], although not all BEVs and PHEVs currently on the market are 'certified' to be GSA replacements. Vehicles not on the GSA list of 'certified' vehicles require an agency to self-certify a functional need or alternative measures for exemptions. Table 3 summarizes the vehicles that may be suitable replacements and are certified replacements through GSA.

Replacement is dependent on vehicle configuration characteristics and the vehicle mission. Further evaluation related to vehicle purpose, mission, and need should be completed.

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[13] http://www.fueleconomy.gov/feg/phevtech.shtml [accessed July 19, 2013]

[14] http://gsa.gov/portal/mediaId/163395/fileName/FY2013AlternativeFuelLeasingGuide (February_2013) [accessed July 19, 2013]

Tables 4 through 7 provide summaries of PHEVs and BEVs either currently available or near commercialization in both passenger cars and pickup trucks, but do not appear on the GSA 'certified' vehicle list. These vehicles may qualify for use by the agency through demonstrating a functional need.

Table 3. General Services Administration-certified battery electric vehicles/plug-in electric vehicles.

Make/Model	GSA Class	Type	City/Highway	GSA Incremental Price
Chevrolet Volt	Sedan, Subcompact	PHEV	101/93 MPGe	$21,601.88
Ford CMAX PHEV	Sedan, Subcompact	PHEV	Not available	$14,806.60
Ford Focus BEV	Sedan, Subcompact	BEV	110/99 MPGe	$20,234.34
Ford Fusion Energi	Sedan, Compact	PHEV	108/92 MPGe 44/41 MPG	$19,051.63
Mitsubishi iMiEV	Sedan, Subcompact	BEV	126/99 MPGe	$15,642.88

Table 4. Original equipment manufacturer plug-in hybrid electric vehicle cars and availability.

Make	Model	Model Year/Estimated Date for Commercialization
Audi	A3 eTron PHEV	2015
BMW	i8	2015
Cadillac	ELR	2014
Chevrolet	Volt	2011
Ford	C-Max Energi	2012
Ford	Fusion Energi	2013
Honda	Accord PHEV	2013
Mercedes	S-Class Plug-in Hybrid	2015
Toyota	Prius PHEV	2012
Volvo	V60 Plug-in	2016

Table 5. Original equipment manufacturer battery electric vehicle cars and availability.

Make	Model	Model Year/Estimated Date for Commercialization
BMW	i3 (Megacity)	2014
BMW	I3	2014
Chevrolet	Spark	2015
Fiat	500e	2014
Ford	Focus electric	2012
Honda	Fit EV	2013
Kia	Soul EV	2015
Mercedes	B-Class E-Cell	2015
Nissan	LEAF	2011
Scion	IQ EV	2016
smart	ED	2014
Tesla	Model S	2012
Tesla	Model X	2015

Make	Model	Model Year/Estimated Date for Commercialization
Volkswagen	Golf Blue-e-Motion	2014
Volvo	C30 Electric	2015

Table 6. Original equipment manufacturer plug-in hybrid electric vehicle trucks and vans and availability.

Make	Model	Model Year/Estimated Date for Commercialization
Ford	Escape Plug-in Hybrid	2012
Land Rover	Range Rover Sport	2016
Mitsubishi	Outlander PHEV	2015
Via	VR300	2013

Table 7. Original equipment manufacturer battery electric vehicle trucks and vans and availability.

Make	Model	Model Year/Estimated Date for Commercialization
Nissan	eNV200	2015
Toyota	RAV4 EV	2014

4.5 Plug-In Electric Vehicle Charging

Refueling electric vehicles presents some challenges not encountered when refueling petroleum-fueled vehicles. Recharging the battery of a PHEV follows the same methodology as that for BEVs. This section provides basic information on recharging PEVs.

4.5.1 Electric Vehicle Supply Equipment Design

4.5.1.1 Charging Components. Figure 5 illustrates the primary components of a typical battery charging station. A station, more correctly identified as electric vehicle supply equipment (EVSE), delivers the electric power from the utility to the applicable charge port on the vehicle.

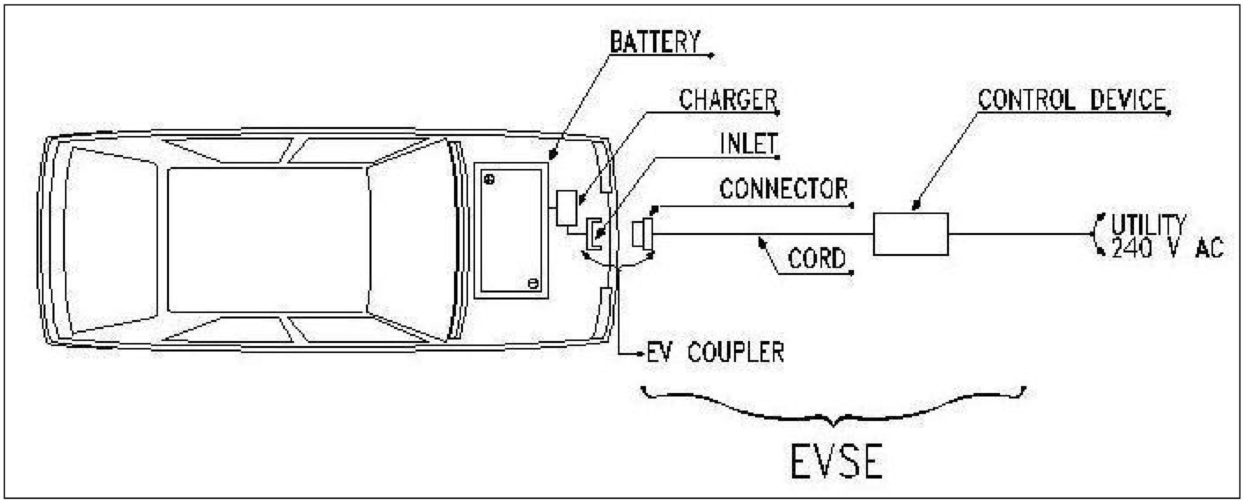


Figure 5. Alternating current Level 2 charging diagram.[15]

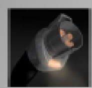
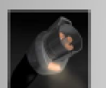
The EVSE delivers power to the PEV from either an alternating current (AC) or direct current (DC) source as further explored in Section 4.5.1.2. For the AC source, current flows to the PEV's battery through the PEV *inlet* to the onboard *charger*. The charger converts AC to the DC current required to charge the battery. A *connector* attached to the EVSE inserts into a PEV inlet to establish an electrical connection to the PEV for charging and information/data exchange. DC charging proceeds in a similar manner, except that the AC to DC conversion occurs in a charger that is off-board the vehicle and, thus, bypasses any onboard charger. The PEV's battery management system on board the vehicle controls the battery rate of charge among other functions.

4.5.1.2 Charging Configurations and Ratings

The Society of Automotive Engineers standardized the requirements, configurations, and equipment followed by most PEV suppliers in the United States in the J1772 Standard. Figure 6 summarizes these attributes and the estimated recharge times. Actual recharge times depend on the onboard equipment, including the charger, battery, and battery management system.

[15] http://avt.inel.gov/pdf/EVProj/EVChrgInfraDeployGuidelinesPhoenixVer3.2.pdf [accessed January 15, 2014]

SAE Charging Configurations and Ratings Terminology

AC level 1 (SAE J1772™)	PEV includes on-board charger	*DC Level 1	EVSE includes an off-board charger
	120V, 1.4 kW @ 12 amp 120V, 1.9 kW @ 16 amp		200-450 V DC, up to 36 kW (80 A)
	Est. charge time:		Est. charge time (20 kW off-board charger):
	PHEV: 7hrs (SOC* - 0% to full)		PHEV: 22 min. (SOC* - 0% to 80%)
	BEV: 17hrs (SOC – 20% to full)		BEV: 1.2 hrs. (SOC – 20% to 100%)
AC level 2 (SAE J1772™)	PEV includes on-board charger (see below for different types)	*DC Level 2	EVSE includes an off-board charger
	240 V, up to 19.2 kW (80 A)		200-450 V DC, up to 90 kW (200 A)
	Est. charge time for 3.3 kW on-board charger		Est. charge time (45 kW off-board charger):
	PEV: 3 hrs (SOC* - 0% to full)		PHEV: 10 min. (SOC* - 0% to 80%)
	BEV: 7 hrs (SOC – 20% to full)		BEV: 20 min. (SOC – 20% to 80%)
	Est. charge time for 7 kW on-board charger		
	PEV: 1.5 hrs (SOC* - 0% to full)	*DC Level 3 (TBD)	EVSE includes an off-board charger
	BEV: 3.5 hrs (SOC – 20% to full)		200-600V DC (proposed) up to 240 kW (400 A)
	Est. charge time for 20 kW on-board charger		Est. charge time (45 kW off-board charger):
	PEV: 22 min. (SOC* - 0% to full)		BEV (only): <10 min. (SOC* - 0% to 80%)
	BEV: 1.2 hrs (SOC – 20% to full)		
*AC Level 3 (TBD)	> 20 kW, single phase and 3 phase		

*Not finalized
Voltages are nominal configuration voltages, not coupler ratings
Rated Power is at nominal configuration operating voltage and coupler rated current
Ideal charge times assume 90% efficient chargers, 150W to 12V loads and no balancing of Traction Battery Pack

Notes:
1) BEV (25 kWh usable pack size) charging always starts at 20% SOC, faster than a 1C rate (total capacity charged in one hour) will also stop at 80% SOC instead of 100%
2) PHEV can start from 0% SOC since the hybrid mode is available. Developed by the SAE Hybrid Committee ver. 031611

Figure 6. Society of Automotive Engineers charging configurations and ratings terminology.[16]

Most PEV manufacturers supply an AC Level 1 cordset with the vehicle, which provides sufficient capabilities for some drivers, but more typically provides an emergency backup capability because of the long recharge times. AC recharging capabilities found in the public arena more typically are AC Level 2. Figure 7 identifies a typical J1772-compliant inlet and connector for both AC Levels 1 and 2.

[16] http://www.sae.org/smartgrid/chargingspeeds.pdf [accessed January 15, 2014]

Figure 7. J1772 connector and inlet.[17]

The J1772 standard also identifies requirements for DC charging. For PEVs that accept both AC and DC inputs, the Society of Automotive Engineers approved a single connector and inlet design. Figure 8 shows this connector, which is called the J1772 combo connector.

Figure 8. J1772-compliant combo connector.[18]

Some PEVs delivered in the United States prior to the approval of the J1772 standard for DC charging employed the CHAdeMO standard for connector and inlet design. Figure 9 shows this connector.

The presence of the two separate standards for DC charging presents challenges for vehicle owners to ensure that the EVSE accessed provides the appropriate connector for their vehicle inlet. Not all PEV suppliers include DC charging options. BEV suppliers more typically provide DC inlets than PHEV suppliers, because the rapid recharging provides opportunities for expanded vehicle range with minimal operator wait times. PHEV operators can rely on the gasoline drive in the event they deplete the vehicle's battery; at present, no PHEV on the market or near commercialization has DC charging capability.

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[17] http://carstations.com/types/j09 [accessed January 15, 2014]

[18] http://www.zemotoring.com/news/2012/10/sae-standardizes-j1772-fast-dc-charging-up-to-100-kw [accessed January 15, 2014]

Figure 9. CHAdeMO-compliant connector.[19]

Because the battery of the BEV is typically much larger than that of a PHEV, recharge times are longer (see Figure 6). BEVs that see daily mileage near the limits of the advertised range do better when recharged using AC Level 2 EVSE because AC Level 1recharge time is limiting. On the other hand, PHEVs more generally use AC Level 1 EVSE for overnight charging to ensure a fully charged battery at the start of daily use. If intermediate or opportunity charging is used during the day, AC Level 2 EVSE units provide the greatest value in providing the greatest range in the shortest amount of time. DC fast charging provides the fastest recharge capability for those vehicles equipped with DC fast charge inlets.

4.5.2 Electric Vehicle Support Equipment Stations

AC Level 2 charging is the predominant rating of publicly accessible EVSE because of its wide acceptance by auto manufacturers and faster than AC Level 1recharge times. Installation costs are more manageable than DC fast chargers and less space is required. There are several manufacturers of AC Level 2 equipment and the agency should review brands for comparison purposes. Figure 10 provides an example of a public AC Level 2 EVSE[20].

Figure 10. Alternating current Level 2 electric vehicle support equipment.

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[19] https://radio.azpm.org/p/azspot/2012/5/10/1632-electric-cars/ [accessed January 15, 2014]

[20] www.eaton.com/ [accessed January 29, 2014]

DC fast chargers also are available from several manufacturers. Figure 11 illustrates one such charger.[21] This particular charger uses the CHAdeMO connector standard.

Figure 11. Direct current fast charger.

In general, installation costs are higher for the DC fast charger because of the higher voltage requirements and the inclusion of the AC to DC charger and other safety and design features. Costs for both types are highly dependent on site characteristics such as distance to the nearest power source, asphalt or concrete cutting and repair, conduit requirements, and payment systems, if any.

Payment and equipment control systems included by some suppliers provide the potential for use by privately owned vehicles for a fee, but allow agency fleet vehicle use without direct payment. These systems allow for accurate record keeping of vehicle charging requirements.

5. GOLDEN GATE NATIONAL RECREATION AREA ANALYSIS

5.1 Survey Results

Sixteen vehicles were included in the study at GGNRA. Eight vehicles are law enforcement (i.e., six sport utility vehicles [SUVs] and 2 sedans) and eight are support vehicles (1 SUV and 7 trucks). Two support vehicles failed to provide data. Table 8 presents a summary of these vehicles.

Table 8. Vehicle survey summary.

Mission	SUV	Truck	Sedans	Total
Law Enforcement Vehicle	6	—	2	8
Support Vehicle	1	7	—	8
Other Vehicles	—	—	—	—
Total	7	7	2	16

[21] https://www.blinknetwork.com [accessed January 29, 2014]

Appendix D provides the analysis of each individual vehicle included in this study. Grouping the vehicles by mission creates an aggregated view of mission requirements to provide observations related to PEV replacement. The missions of these two categories vary considerably; therefore, a combined analysis provides little usable information.

5.2 Data Validity

GGNRA data collection took place from February 15, 2013, through April 19, 2013 (63 calendar days), although some vehicles had data loggers removed during the study. Vehicle data sheets (presented in Appendix D) detail the collected data for each vehicle.

Of the data collected, validation occurred for 96.6% of the data, while null values exist for the balance. Table 9 shows this information by mission type. As noted previously, two support vehicles provided no data.

Table 9. Vehicle data logger reporting summary.

Vehicle Data Logger Reporting Summary			
Mission	% Collected	% Null Values	Total
Law Enforcement Vehicles	95.4	4.63	100
Support Vehicles	98.2	1.83	100
All Vehicles	96.6	3.43	100

5.3 Law Enforcement Vehicles Evaluation

5.3.1 Survey and Site Information

Law enforcement vehicles are typically light-duty motor vehicles specifically approved in an agency's appropriation act for use in apprehension, surveillance, police, or other law enforcement work. This category includes site security vehicles.[22]

Law enforcement missions can vary by agency, location, and jurisdiction. The U.S. Park police, a division within the National Park Service, manage law enforcement at GGNRA. The San Francisco Field Office personnel, headquartered at the Presidio of San Francisco, provide a wide range of law enforcement services to the GGNRA. These U.S. Park police officers undergo training in various types of patrol that include horse, motorcycle, bicycle, and ATV beach patrols. Some of the areas covered include the Presidio, Marin Headlands, Aquatic Park, and Ocean Beach[23].

Incorporation of BEVs and/or PHEVs into the law enforcement mission is a definite possibility. Law enforcement vehicles used to patrol small areas and for parking enforcement activities qualify for BEV or PHEV replacement, while other law enforcement vehicle activities that are associated with longer trips may require PHEV capabilities.

5.3.2 Summary for Law Enforcement Vehicles

Appendix D provides the vehicle data sheets for each of the eight law enforcement vehicles monitored. This section aggregates data for all law enforcement vehicles. Table 10 summarizes law enforcement travel during the study period. Vehicle use occurred primarily between 0900 and 1900 hours daily. They traveled 9,581 miles, logged 694 hours, and idled for 211 hours during the 63-day study period.

[22] 41 CFR Part 102-34.35 2012

[23] http://www.nps.gov/uspp/sffo.htm [accessed January 10, 2014]

Table 10. Law enforcement vehicles travel summary.

Law Enforcement Vehicles Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	42.5/198.3	19.0/248.4	5.6/52.6	9,581
Travel Time (Minutes)	184/533	81/577	23.7/313	41,640
Idle Time (Minutes)	55.5/NA	24.8/NA	7.0/NA	12,639

Figures 12 and 13 show the travel summary for law enforcement vehicles: by vehicle, by daily mileage, and daily usage time. Data loggers removed from some vehicles in late March contributed to a decline in values toward the end of the evaluation period. Figure 14 shows the composite for all law enforcement vehicles.

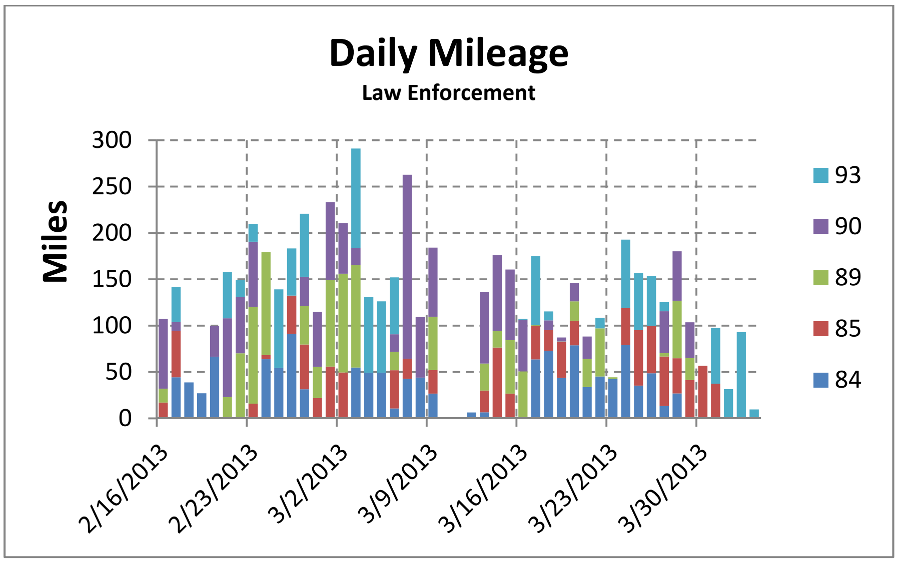

Figure 12. Law enforcement vehicle daily travel miles.

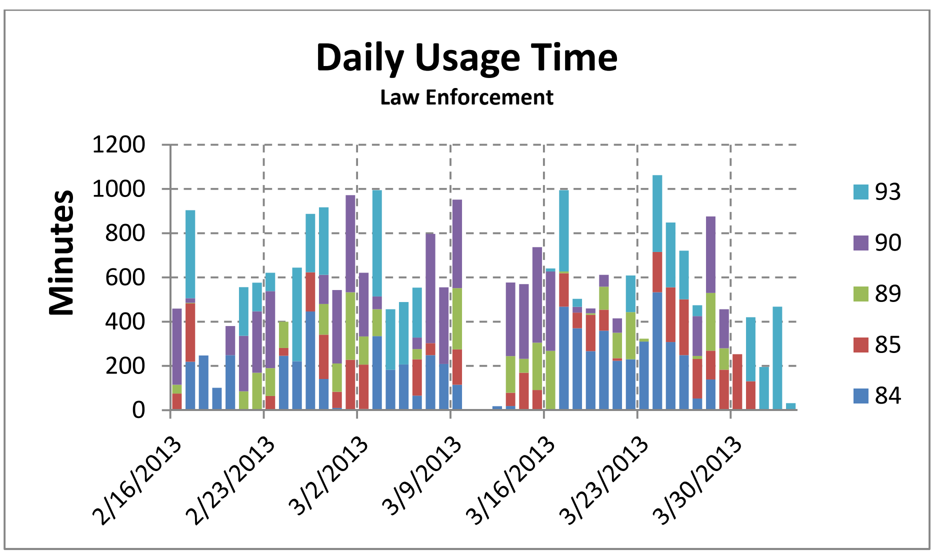

Figure 13. Law enforcement vehicle daily usage time.

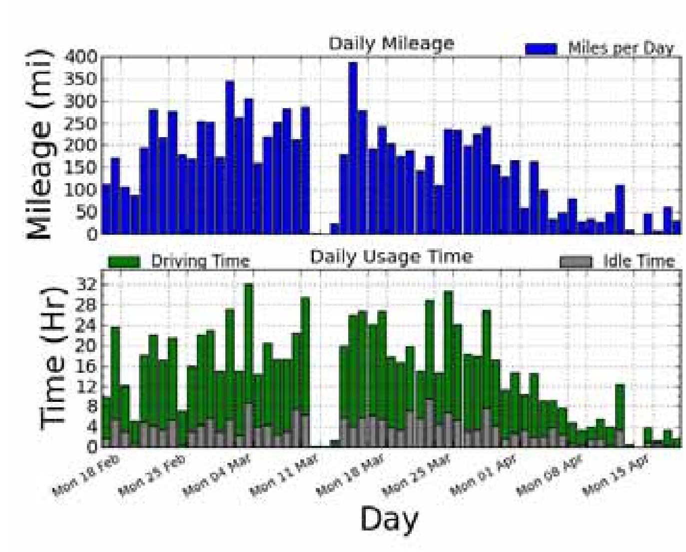

Figure 14. Law enforcement vehicles travel summary (all vehicles).

5.3.3 Law Enforcement Vehicles Daily Summary

The average travel distance per day for law enforcement vehicles is 42.5 miles. On 84% of vehicle days, the daily travel is less than the 70 miles considered to be within the BEV safe range. That is, while BEV range can vary based on several factors, most BEVs provide at least 70 miles of vehicle range on a single battery charge. Sixteen percent of law enforcement daily travel is greater than 70 miles. Figure 15 displays law enforcement summary data, including time of day, travel distance, and travel time.

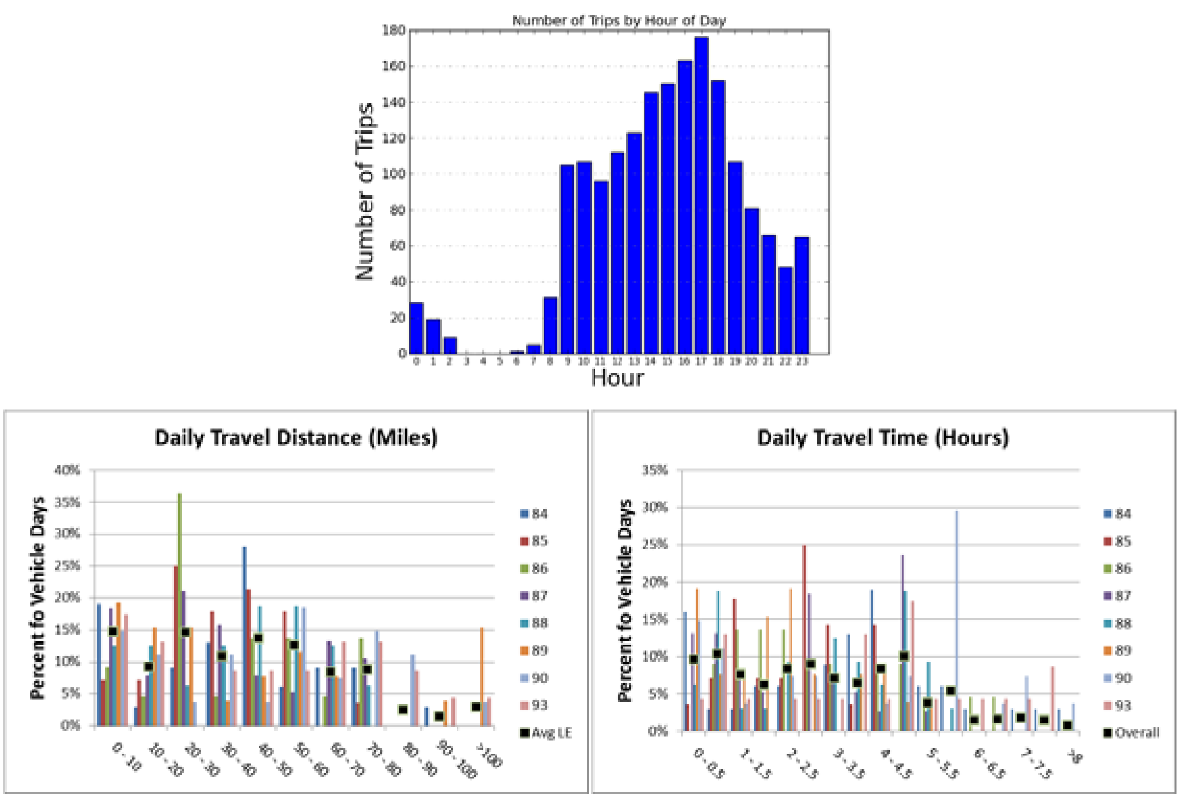

Figure 15. Law enforcement vehicles daily travel graphs.

Appendix D provides the details of each of the law enforcement vehicle's daily travel. At some point during the evaluation period, every law enforcement vehicle exceeded 70 miles of daily travel, although all vehicles experienced this on less than 30% of all travel days. Appendix D also shows that several vehicles had outings that were greater than the daily travel (Figure 16), meaning, several vehicles did not return to their home base within the same day.

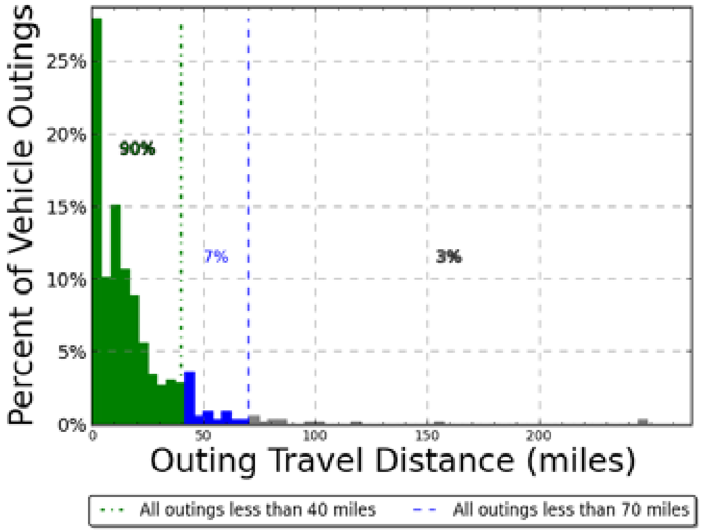

Figure 16. All law enforcement vehicle outing distance.

5.3.4 Law Enforcement Vehicle Observations/Summary

As a group, the law enforcement vehicles have a low percentage (16%) of days when daily travel distances exceed 70 miles. Among the vehicles in this study, Vehicles 90 and 93 had the highest percentage of daily travel exceeding 70 miles at 30% each.

There appears to be three choices for GGNRA in implementing PEVs into the law enforcement fleet. Keep in mind that the optimum goal would be to incorporate as many BEVs as possible to realize the advantages of reduced petroleum usage and reduced emissions of GHG.

1. All BEV fleet: While some BEV manufacturers report vehicle range exceeding 70 miles, ITSNA recommends careful evaluation of experienced range to ensure vehicle missions are accomplished. Nevertheless, assuming the 70-mile safe range for a BEV, an all BEV fleet is possible if charging stations are provided at frequent stop locations for all law enforcement vehicles.
2. Mixed BEV/PHEV fleet: Certainly, PHEVs can accomplish the same mission as the current fleet when only considering travel times and distances because the PEV's gasoline engine can provide motive power when the battery has been depleted. The data reveal that on 50% of all vehicle travel days, the total travel is less than 40 miles, which typically is the maximum distance a PHEV will travel on battery power only. This scenario requires fleet manager attention to assign vehicles appropriately for the anticipated use on that day.
3. All PHEV fleet: As noted above, PHEVs can accomplish the same mission as the current fleet when only considering travel times and distances. Replacing all current vehicles with PHEVs only requires an evaluation of the individual vehicle capabilities of currently available PHEVs to meet current law enforcement requirements. Data show that for a significant number of days, the PHEV will operate in a pure-electric mode. Intermediate charging opportunities provide additional benefit, enhancing the pure-electric mode. Data show significant charging opportunities throughout the day during stop times.

While it would appear that PEVs are suitable replacements for some law enforcement vehicles, additional mission analysis and management input is required. The missions of these vehicles likely include considerations other than mileage, such as power demands placed on the vehicle. Parking enforcement missions are excellent missions for BEVs, while other missions likely require heavy use and emergency demands that may not allow for limited range and intermediate charging.

The vehicle summary shows sufficient time for charging at the base location during the course of the day and additional opportunities at intermediate charging stations. These stations also provide charging opportunities for the visiting public, whose fees may assist in offsetting operating costs.

ITSNA suggests further mission evaluation be given to law enforcement vehicles when considering the adoption of BEVs and PHEVs. The fleet of law enforcement vehicles in this study included six SUVs and two sedans. Section 4.4 provides information on PEV SUVs and sedans currently or soon to be available in the automotive market. However, based on this travel information and providing a conservative approach to the law enforcement fleet, ITSNA suggests that of these eight law enforcement vehicles, two BEVs and six PHEVs meet current mission requirements. Additional BEVs may be possible with further management or fleet software attention.

Considering a full complement of 30 enforcement vehicles in the total fleet, this same ratio suggests eight BEVs and twenty-two PHEVs carry out the same mission as the existing fleet. Further, with approximately 90% of the outings of travel less than 40 miles, up to 90% of the PHEV travel could be electric drive only, provided that recharging the PHEV occurs between outings. Using intermediate charging along the outing route adds to electric drive only mode.

5.3.5 Law Enforcement Vehicle Charging Needs

ITSNA suggests replacement of the law enforcement fleet with about 25% BEV and 75% PHEV. No available PHEVs at this writing provide for DC fast charging nor do the data suggest that this would be a significant benefit for PHEVs in the law enforcement fleet. Assuming that the mission of 25% of the fleet is appropriate for BEVs, additional charging of these vehicles during the day is not a requirement nor would DC fast chargers be required.

As noted above, AC Level 2 overnight charging of BEVs is typical, whereas overnight charging of PHEVs uses the AC Level 1 outlet. Opportunity charging at intermediate stops obtains greater benefits from AC Level 2 EVSE.

Analysis of the stop locations for the law enforcement fleet that had durations greater than 2 hours shows the following locations were the most frequented (the percentage of all stops also are shown):

1. Fort Funston Road (34%)
2. McReynolds Road (25%)
3. Bunker Road (5%)
4. Lamoraux Drive (5%)
5. Ralston Avenue (5%).

GGNRA identified Fort Funston, McReynolds Road, Muir Beach and Lamoraux Drive as the home bases for the law enforcement vehicles. Figure 17 illustrates the identified EVSE locations.

ITSNA’s experience suggests that each vehicle have an assigned charging location at their home base. Assigned stations require less management attention to ensure completion of overnight charging. BEVs and PHEVs not assigned to these locations also benefit during visits to the location as part of their normal operation. For the entire fleet of law enforcement vehicles, eight BEVs require eight AC Level 2 EVSE units for overnight charging and 22 PHEVs require 22 AC Level 1 outlets for home base and six AC Level 2 EVSE for intermediate charging. Table 11 provides these identified locations. (ITSNA recommends a minimum of two EVSE at each location to maximize charge capability without a significant increase in installation costs.)

Figure 17. Frequent stop electric vehicle support equipment locations.

Table 11. Potential electric vehicle support equipment locations for law enforcement vehicles.

Location	AC Level 1 Outlet	AC Level 2 EVSE without Mgmt Attn	AC Level 2 EVSE with Mgmt Attn
Fort Funston	7	5	4
McReynolds Road	5	3	2
Bunker Road	4	2	2
Lamoraux Drive	3	2	2
Ralston Avenue	3	2	2
Muir Beach	2	2	2
Total	**24**	**16**	**14**

Greater management attention provides the possibility of reducing the overall number of AC Level 2 EVSE. EVSE used for overnight charging of some vehicles function as the intermediate charging location for others. A ratio of two AC Level 2 charging stations to three vehicles typically sustains a normal fleet operation. This analysis does assume a fully recharged battery at the start of each day. GGNRA will gain experience in this management as the PEV fleet grows.

At times, fleet vehicles obtain benefit from using public charging infrastructure. Figure 18 displays the availability of public charging at the time of this writing for the GGNRA area. The green-colored sites are AC sites, while orange-colored sites are DC fast charge sites. This map provides both AC Level 1 and Level 2 public locations. The location indicated in the South Bay region provides AC Level 1 wall outlets at the VA Medical Center and ITSNA does not recommended these for intermediate charging for GGNRA vehicles. AC Level 2 EVSE available at the San Francisco Zoo near Fort Funston also provides little intermediate benefit. They could provide emergency backup sources for BEVs if necessary.

5.4 Support Vehicles Evaluation

Support vehicles provide a specific work function, facilitating the mission of a particular group. The vehicles are generally passenger or light-duty pickup trucks and may contain after-market modifications to support the mission. While assigned to maintenance and service areas, missions may vary depending on agency needs. GGNRA classifies support vehicles as those supporting maintenance activities, repair, or other duties assigned to a specific group.

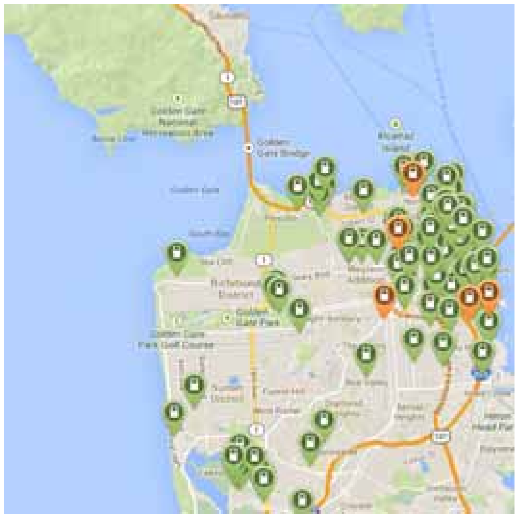

Figure 18. Public charging electric vehicle support equipment in the Golden Gate National Recreation Area.[24]

5.4.1 Summary for Support Vehicles

Appendix D provides the vehicle data sheets for each of the six support vehicles monitored. These date sheets provided data over 63 study days. This section aggregates the data for all support vehicles.

Table 12 summarizes support vehicle travel during the study period. Vehicle use occurred primarily between 0900 and 1900 hours daily. Support vehicles traveled over 4,626 miles, logged 554 hours, and idled for 211 hours during the study period.

Table 12. Support vehicle travel summary.

Support Vehicle Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	19.7/67.1	6.0/66.9	2.0/22.1	4,626
Travel Time (Minutes)	184.0/410	42.3/331	11.8/144	33,260
Idle Time (Minutes)	55.5/NA	16.7/NA	4.5/NA	12,701

Figures 19 and 20 show the travel summary for support vehicles by vehicle, by daily mileage, and daily usage time. Figure 21 shows the composite for all support vehicles.

5.4.2 Support Vehicle Daily Summary

The average travel distance per day for support vehicles is 19.7 miles. On 100% of the vehicle days, the daily travel is less than the 70 miles, which is considered to be within the BEV safe range. That is, while BEV range can vary based on several factors, most BEVs provide at least 70 miles of vehicle range on a single battery charge. None of the support vehicle daily travel is greater than 70 miles (Figure 22).

[24] http://www.plugshare.com/ [accessed February 1, 2014]

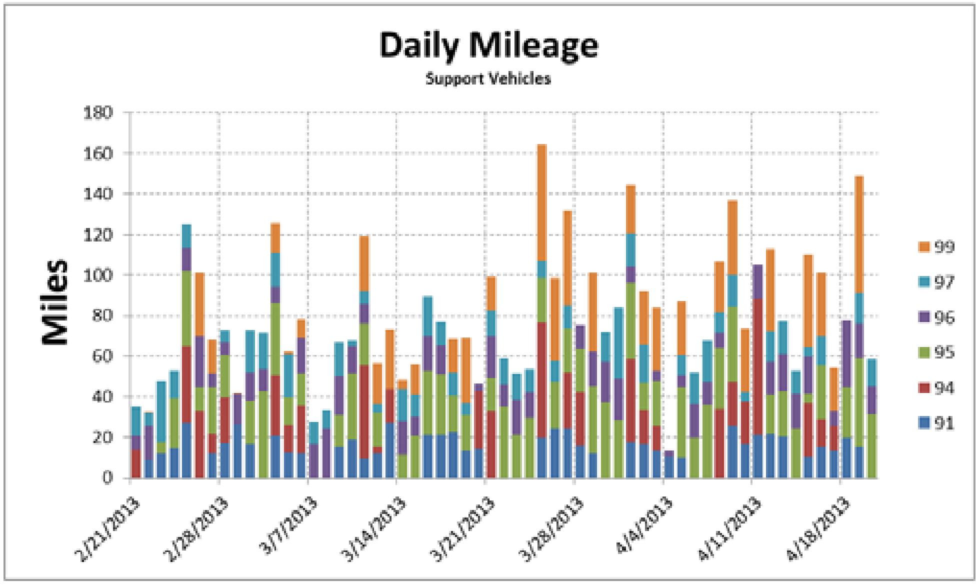

Figure 19. Support vehicle daily travel miles.

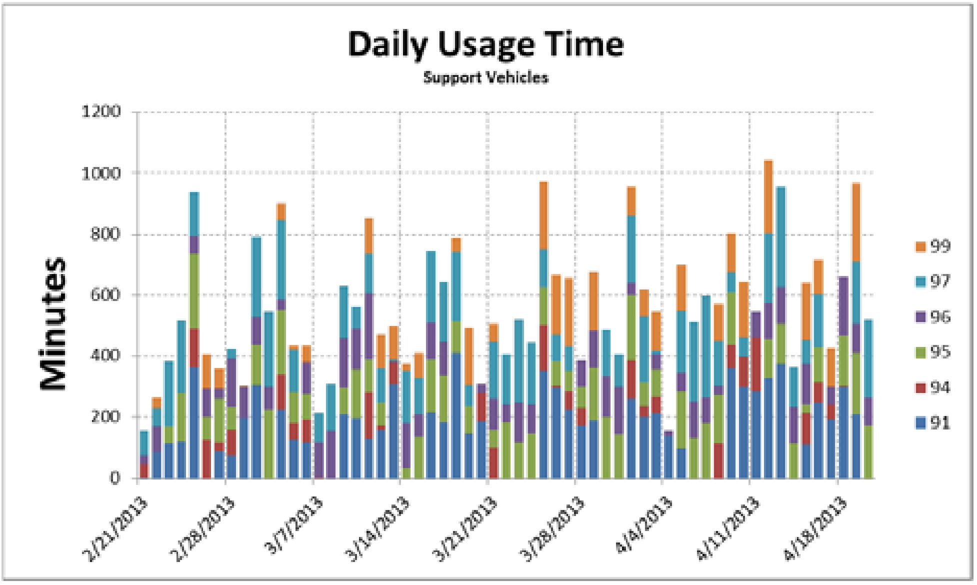

Figure 20. Support vehicle daily usage time.

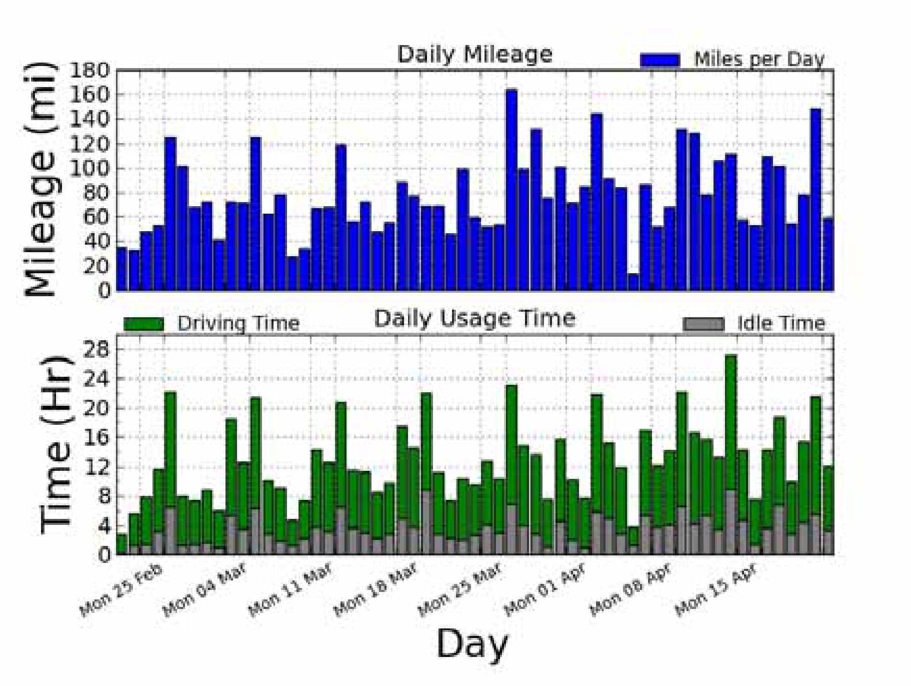

Figure 21. Support vehicle travel summary.

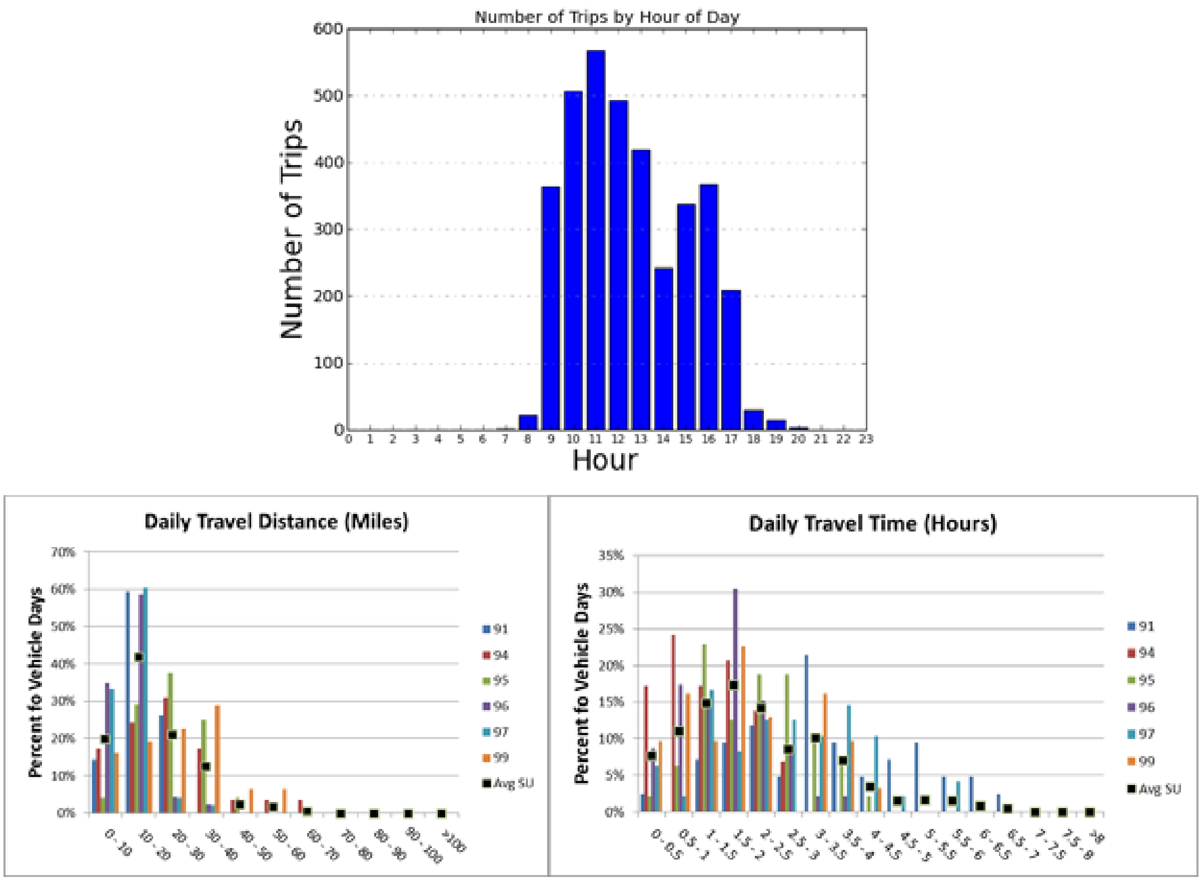

Figure 22. Support vehicles daily travel graphs.

Appendix D provides details for each of the support vehicle's daily travel. At no point in the evaluation period did any support vehicle exceed 70 miles of daily travel. Appendix D also shows that all vehicle outings were less than the 70-mile safe range, as shown in Figure 23.

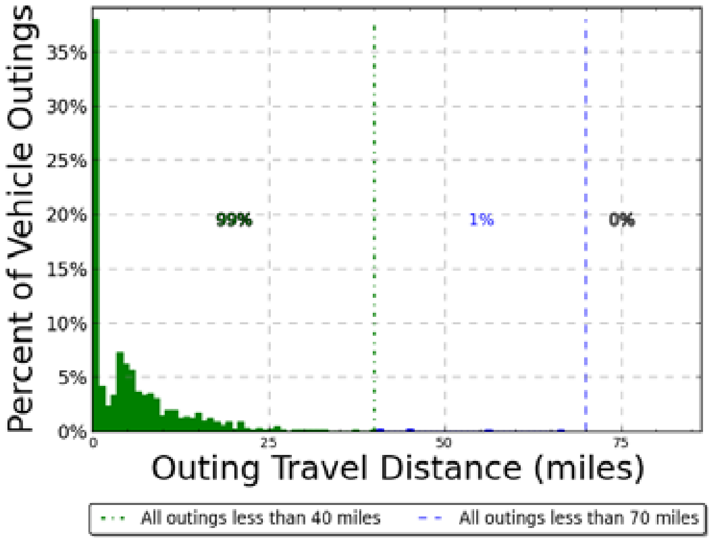

Figure 23. All support vehicles' outing distance.

On 95% of the vehicle days, daily travel was less than 40 miles, which is the typical electric only range of PHEVs. Four of the vehicles exceeded this 40-mile range during the study period.

5.4.3 Support Vehicle Observations/Summary

As a group, the support vehicles have no days when daily travel distances exceed 70 miles. Among vehicles in this study, Vehicles 94 and 99 had the highest percentage of daily travel exceeding 40 miles at 10% and 13%, respectively.

As before, there appears to be three choices for GGNRA in implementing PEVs into the support vehicle fleet. Keep in mind that the optimum goal would be to incorporate as many BEVs as possible to realize the advantages of reduced petroleum usage and reduced emissions of GHG.

1. All BEV fleet: While some BEV manufacturers report vehicle range exceeding 70 miles, ITSNA recommends careful evaluation of experienced range to ensure vehicle missions are accomplished. Nevertheless, assuming the 70-mile safe range for a BEV, an all BEV fleet is possible for support vehicles without additional considerations such as intermediate charging locations.
2. Mixed BEV/PHEV fleet: Certainly, PHEVs can accomplish the same mission as the current fleet when only considering travel times and distances because the PEV's gasoline engine can provide motive power when the battery has been depleted. The data reveal that on 95% of all vehicle travel days the total travel is less than 40 miles, which typically is the maximum distance a PHEV will travel on battery power only. For those days, intermediate charging locations provide the recharge necessary to increase the all-electric drive. Sufficient daily stop time exists to recharge if EVSE are convenient.
3. All PHEV fleet: As noted above, PHEVs can accomplish the same mission as the current fleet when only considering travel times and distances. Replacing all current vehicles with PHEVs only requires an evaluation of the individual vehicle capabilities of currently available PHEVs to meet current support vehicle requirements.

While it would appear that BEVs are suitable replacements for all support vehicles, additional mission analysis and management input is required. The missions of these vehicles likely include considerations other than mileage (such as power demands and load carrying capabilities placed on the vehicle).

The vehicle summary shows sufficient time for charging at the base location during the course of the day and additional opportunities at intermediate charging stations. These stations also provide charging opportunities for the visiting public, whose fees may assist in offsetting operating costs.

ITSNA suggests further mission evaluation be given to support vehicles when considering the adoption of BEVs and PHEVs. However, based on this travel information and providing a conservative approach to the support vehicle fleet, ITSNA suggests that of these six support vehicles, four BEVs and two PHEVs will meet current mission requirements. Additional BEVs may be possible with further management or fleet software attention; however, fleet managers typically desire vehicles that support longer trips.

The fleet of support vehicles in this study included five trucks and one SUV. Section 4.4 provides information on PEV trucks and vans currently or soon to be available.[25]

The vehicle summary also shows that there is sufficient time for charging at the home base during the course of the day. The data suggest that it may be possible for several vehicles to share EVSE charging units in order to reduce the costs of the units and installation. Management attention may be required to establish a rotation strategy, but there is significant opportunity to find time during off-shift hours for charging.

The current fleet contains approximately 75 total support vehicles. A conservative approach would likely mix some PHEVs into the fleet for an occasional outing that might exceed the capabilities of the BEV. Assuming 80% BEV and 20% PHEV, this fleet could be replaced by 60 BEVs and 15 PHEVs and continue to carry out the same mission.

5.4.4 Support Vehicle Charging Needs

The majority of the support vehicle activity occurs during daytime hours, which leaves significant time during the nighttime hours for recharging. ITSNA suggests replacement of the support vehicle fleet with 60 BEV and 15 PHEVs. No available PHEVs at the time of this writing provide for DC fast charging nor do the data suggest that this would be a significant benefit for PHEVs in the support vehicle fleet. Additional charging of BEVs during the day is not a requirement nor would DC fast chargers be required.

As noted above, AC Level 2 overnight charging of BEVs is typical, whereas overnight charging of PHEVs often uses AC Level 1 outlets. Opportunity charging at intermediate stops obtains the greater benefits from AC Level 2 EVSE.

Analysis of the stop locations for the support vehicle fleet that had durations greater than 2 hours shows the following locations were the most frequented (the percentage of all stops also are shown):

1. Howe Road (30%)
2. Fort Funston Road (26%)
3. Ruckman Avenue (18%)
4. Bunker Road (13%).

[25] Note that Via Motors has recently added PEV pickup trucks to PG&E in the San Francisco Bay Area: http://www.viamotors.com/blog/national-plugin-day-2012-cupertino/ [accessed July 19, 2013]

ITSNA notes that the Howe Road and Ruckman Avenue locations are in close proximity. It may be convenient to combine these charging locations. GGNRA also identified McReynolds as a home location and data suggests that the Upper Great Highway also could be a home base.

For the entire fleet of support vehicles, 60 BEVs require 60 AC Level 2 EVSE for overnight charging and 15 PHEVs require 15 AC Level 1 outlets for home base charging. Table 13 identifies the EVSE locations for support vehicles. (ITSNA recommends a minimum of two EVSE at each location to maximize charge capability without a significant increase in installation costs.) Figure 24 illustrates the potential EVSE locations.

Table 13. Potential electric vehicle support equipment locations for support vehicles.

Location	AC Level 1 Outlet	AC Level 2 EVSE without Mgmt Attn	AC Level 2 with Mgmt Attn
Howe Road/Ruckman Avenue	6	24	16
Fort Funston	4	16	10
Bunker Road	2	8	6
McReynolds	2	6	4
Upper Great Highway	2	6	4
Total	**16**	**60**	**40**

Figure 24. Potential electric vehicle support equipment locations.

Greater management attention provides the possibility of reducing the overall number of AC Level 2 EVSE. A ratio of two AC Level 2 charging stations to three vehicles typically sustains a normal fleet operation. Fleet managers rotate vehicles on the charger to complete charging of all vehicles in the allotted time. This analysis does assume a fully recharged battery at the start of each day. GGNRA will gain experience in this management as the PEV fleet grows.

Figure 24 shows the publicly available EVSE in the region. EVSE near the Presidio Parkway may provide additional charge opportunities.

6. GREENHOUSE GAS EMISSIONS AVOIDED AND FUEL COST REDUCTION ANALYSIS

PEV substitution for an existing conventional vehicle avoids GHG emissions and reduces fuel costs. The GHG emissions avoided occur due to the difference in emissions associated with power plant electricity generation versus fuel combustion that occurs in the engine of a conventional vehicle. This analysis does not account for life-cycle emissions that occur outside of electricity generation and fuel combustion phases (i.e., materials extraction, production supply-chains, and decommissioning are not accounted for). These phases are beyond the scope of this report due to the significant effort required to conduct an accurate environmental life-cycle assessment for a transportation system in a very specific setting. Nevertheless, a previous life-cycle assessment for transportation in the United States indicates that about 40% of GHG emissions associated with gasoline-powered, light-duty vehicles occur outside of the combustion phase.[26] Cost reduction also occurs because the cost of electricity is much less than the cost of gasoline and PEVs are more efficient than conventional ICE vehicles. Because fuel logs were not kept, the mileage accumulated by each vehicle provides the source of fuel estimates for the study vehicles.

In order to perform the analysis, EPA fuel economy ratings were used.[27] Tables 14 and 15 provide these ratings. Ratings for the PHEVs in Table 15 include electric-only operation. Because these data are estimates, assumptions include the following:

1. PHEVs operate in electric mode only. This is reasonable for most daily operations, as described in Section 5. This assumption results in savings calculations slightly higher than those realized through the expected operation of combined electric and gasoline motive operations.
2. The fuel economy for the Mitsubishi Outlander is the same as the RAV4, because the EPA has not yet created ratings for the former vehicle.
3. The Chevrolet Volt replaces the law enforcement sedans and the Nissan Leaf replaces the support vehicles SUV, which is reasonable as described in Section 5.
4. The Mitsubishi Outlander replaces the law enforcement SUVs and the Toyota RAV4 replaces the support vehicles pickups[28].

Table 16 provides a pictorial view of the replacements involved.

Calculations provided for GHG emissions and fuel savings include both a total U.S. perspective and for the local area. The electricity generation mix of power plants for the total United States is different from the local mix of generation in the San Francisco area. Likewise, the national average cost for petroleum fuel is different from the local cost for fuel. This analysis includes both approaches in order to allow for the local evaluation and to inform the potential for fleet vehicles in other locations of the United States, which may be of interest. The final report from ITSNA to INL primarily will consider the national figures.

For the GHG emissions avoided portion of the analysis, the GHG emissions (in pounds of carbon dioxide equivalent (which accounts for other GHGs such as methane and nitrous oxide), *lb-*CO_2*e)* from

[26] http://iopscience.iop.org/1748-9326/4/2/024008/fulltext/ [accessed February 2, 2014]

[27] http://www.fueleconomy.gov/feg/Find.do?action=sbs&id=33558 [accessed February 2, 2014]

[28] Although an SUV replaces the support vehicle pickup due to current market availability, PEV pickup trucks will be increasingly available in the near future. One example is the Via Motors VTRUX (http://www.viamotors.com/wp-content/uploads/VIA-Small-Brochure.pdf). Note that Via Motors has recently provided fleet pickup trucks to Pacific Gas and Electric in the San Francisco Bay Area (http://www.viamotors.com/blog/national-plugin-day-2012-cupertino/). [accessed July 19, 2013]

combustion of gasoline is 20.1 lb-CO_2e/gallon and of diesel is 24.0 lb-CO_2e/gallon.[29] The United States and San Francisco Bay Area averages for GHG emissions for the production of electricity are 1.53 lb-CO_2e/kWh[30] and 0.431 lb-CO_2/kWh[31], respectively. Note that the analysis uses CO_2 instead of CO_2e for San Francisco Bay Area emissions, because non-CO_2 GHG emissions associated with electricity consumption in the San Francisco Bay Area are thought to be negligible according to the local utility company Pacific Gas and Electric.[32] GHG emissions avoided are the annual GHG emitted by the current vehicle (total annual gallons gasoline × GHG emissions/gallon) minus the annual GHG emitted by the replacement PEV (total annual kWh × GHG emissions/kWh).

Table 14. U.S. Environmental Protection Agency internal combustion engine fuel economy ratings.

Vehicle	Mission	Make & Model	Model Year	Fuel Economy-Combined (miles/gallon)
84	Law enforcement	Chevrolet, Tahoe	2012	17
85	Law enforcement	Ford, Crown Victoria	2010	19
86	Law enforcement	Chevrolet, Tahoe	2010	17
87	Law enforcement	Chevrolet, Tahoe	2009	16
88	Law enforcement	Chevrolet, Tahoe	2012	17
89	Law enforcement	Ford, Expedition	2007	15
90	Law enforcement	Chevrolet, Tahoe	2010	17
91	Support	Ford, Ranger	2009	21
93	Law enforcement	Ford, Crown Victoria	2011	19
94	Support	Chevrolet, 2500 (diesel)	2009	15.4
95	Support	Ford, Ranger	2010	21
96	Support	Ford, Ranger	2010	21
97	Support	Ford, Ranger	2006	17
99	Support	Jeep, Liberty	2010	17

Table 15. U.S. Environmental Protection Agency plug-in electric vehicle fuel economy ratings.

Mission	Make & Model	Model Year	Fuel Economy-Combined (Wh/mile)	MPGe
Law enforcement	Chevrolet, Volt	2014	350	98
Law enforcement	Mitsubishi, Outlander	2014	440 (assumed equal to Toyota RAV4)	76
Support	Nissan, Leaf	2014	300	114
Support	Toyota, RAV4	2014	440	76

[29] http://avt.inl.gov/pdf/EVProj/106077-891082.ghg.pdf for the methodology for gasoline [accessed 19 July 2013].

[30] http://avt.inl.gov/pdf/EVProj/106077-891082.ghg.pdf [accessed July 19, 2013]

[31] http://www.pge.com/includes/docs/pdfs/shared/environment/calculator/pge_ghg_emission_factor_info_sheet.pdf [accessed July 19, 2013]

[32] http://www.pge.com/includes/docs/pdfs/shared/environment/calculator/pge_ghg_emission_factor_info_sheet.pdf [accessed July 19, 2013]

Table 16. Current vehicle replacement plug-in electric vehicles.

	Current Vehicle	Analysis Replacement PEV
Law enforcement sedan	 Ford Crown Victoria	 Chevrolet Volt
Law enforcement SUV	 Chevrolet Tahoe	 Mitsubishi Outlander
Support sedan	 Jeep Liberty	 Nissan Leaf
Support SUV/pickup	 Ford Ranger Pickup	 Toyota RAV4 EV

For the cost-avoided piece of the analysis, fuel cost assumptions are $3.75/gallon of gasoline for the United States and $4.05/gallon for the San Francisco Bay Area. Electrical cost assumptions are 0.13 $/kWh for the United States and 0.23 $/kWh for the San Francisco Bay Area. Therefore, fuel costs savings are the current vehicle's calculated annual gasoline cost (total annual gallons gasoline × cost/gallon) minus the electricity cost (total annual kWh × cost/kWh) of the replacement PEV traveling the same distance.

Extrapolation of the actual total distance traveled by each vehicle during the 63 study days to 365 days yields estimates for yearly GHG emissions avoided and fuel cost reductions. The results of this analysis (shown in Table 17) demonstrate that the substitution of a conventional ICE vehicle with a PEV can reduce the GHG emissions and fuel costs dramatically.

Table 17. Greenhouse gas emissions avoidance and fuel cost reduction analysis summary.

Vehicle	Mission	Make and Model	Extrapolated U.S. Yearly CO_2e Avoided (lb-CO_2e/year)	Extrapolated Local Yearly CO_2e Avoided (lb-CO_2e/year)	Extrapolated U.S. Yearly Fuel Cost Reduction ($/year)	Extrapolated Local Yearly Fuel Cost Reduction ($/year)
84	Law enforcement	Chevrolet, Tahoe	6,167	12,023	1,979	1,660
85	Law enforcement	Ford, Crown Victoria	4,526	7,858	1,316	1,149
86	Law enforcement	Chevrolet, Tahoe	3,139	6,119	1,007	845
87	Law enforcement	Chevrolet, Tahoe	5,042	9,223	1,532	1,314
88	Law enforcement	Chevrolet, Tahoe	4,824	9,406	1,548	1,298
89	Law enforcement	Ford, Expedition	6,745	11,636	1,950	1,707
90	Law enforcement	Chevrolet, Tahoe	6,311	12,304	2,025	1,698
91	Support	Ford, Ranger	1,273	3,441	544	411
93	Law enforcement	Ford, Crown Victoria	4,746	8,240	1,380	1,205
94	Support	Chevrolet, 2500	4,170	7,361	1,229	1,068
95	Support	Ford, Ranger	2,152	5,818	920	695
96	Support	Ford, Ranger	1,123	3,036	480	363
97	Support	Ford, Ranger	1,972	3,844	633	531
99	Support	Jeep, Liberty	3,925	5,619	972	912
		Total law enforcement	41,498	76,810	12,737	10,877
		Total support	14,616	29,119	4,778	3,978

For the vehicles analyzed, the potential exists to replace the eight law enforcement and six support vehicles of two sedans, seven SUVs, and five pickup trucks with two PHEV sedans, six PHEV SUVs, and six BEV SUVs. Using an average savings per vehicle, Table 18 provides the avoided GHG and fuel cost savings should the entire fleet of 30 law enforcement and 75 support vehicles be replaced with PEVs of the identified types. Additional savings result if the GGNRA includes their other fleets.

Table 18. Extrapolated greenhouse gas emissions avoided and fuel cost savings.

Mission	Extrapolated U.S. Yearly CO_2e Avoided (lb-CO_2e/year)	Extrapolated Local Yearly CO_2e Avoided (lb-CO_2e/year)	Extrapolated U.S. Yearly Fuel Cost Reduction ($/year)	Extrapolated Local Yearly Fuel Cost Reduction ($/year)
Law enforcement	155,618	288,038	47,763	40,788
Support	182,695	363,982	59,727	49,725

7. OBSERVATIONS

ITSNA appreciates the opportunity to present the results of this evaluation. Observations for possible follow-up action include the following:

Observation #1:

Implementation: GGNRA may move forward in the near future with the replacement of law enforcement and support vehicles with PEVs as current budget and vehicle replacement schedules allow. Certainly, the vehicle types studied in this report are candidates for immediate replacement.

Observation #2:

Fleet Inventory: A more thorough look at the quantities and types of fleet vehicles within each usage category may be beneficial to quantify the potential for replacement by PEVs. While ITSNA suggests a mix of BEVs and PHEVs, a more refined look may be possible. In addition, this study did not look at the other fleet vehicle categories such as pool vehicles, transport vehicles, and shuttles/buses.

Observation #3:

Vehicle Replacement Plan: The development of a detailed vehicle replacement plan could be beneficial. Such a plan would include cost and schedule for vehicle replacement. A more detailed survey and calculation of the use of the fleet vehicles (such as vehicle parking locations, age of vehicle, expected replacement time, expected replacement costs, GSA vehicle costs, EVSE cost, and EVSE installation costs) provide support to this replacement plan. The savings in GHG emissions, petroleum usage reduction, and fuel cost savings flow from this detailed plan.

Observation #4:

Infrastructure Planning: In conjunction with the replacement plan, evaluation of the GGNRA site for the placement of PEV charging infrastructure could be beneficial. ITSNA has significant experience in this area and such plans will consider not only fleet vehicle charging needs, but also the convenience that charging infrastructure benefits employees or visitors. This planning also considers the existing facility electrical distribution system. Vehicle home base considerations factor into the ratio of PEVs to EVSE units to maintain all vehicles at operational readiness.

Charging stations located at various destination points provide adequate infrastructure for PEV charging of the GGNRA fleet. Opportunity also exists to support public use of PEVs. San Francisco Bay Area drivers are leaders in the adoption of PEVs.[33] Charging stations at GGNRA provide an opportunity for charging by the public. GGNRA can benefit through collection of charging fees during times when these stations are not required for the overnight charging of fleet vehicles. The fees avoid the questions associated with a federal agency providing fuel for privately owned vehicles and also support the costs for installation and operation of the EVSE.

[33] http://avt.inl.gov/evproject.shtml# [accessed July 19, 2013]

Appendix A
Fleet Survey Form

Fleet Survey Sample	
Project Name:	BEA-FEMP Fleet II
Agency Name:	National Park Service
Location:	Golden Gate National Recreation Area (GGNRA)
Date Requested:	2/2/2013

The following survey questions are used to lead the discussion concerning the mission of the current fleet of vehicles. If responding by e-mail, please use one form for each vehicle.

Please submit the data sheets to Ian Nienhueser at ian.nienhueser@intertek.com by fax at (602) 443-9007. If you have questions, please contact Ian at the email above or by phone at (702) 738-2706.

Vehicle Information			
Today's Date:	2/17/2013	Odometer Reading:	17,589
Make:	Chevrolet	Data Logger ID:	64
Model:	Tahoe	Data Logger Installed:	2/17/2013
Year:	2012	Fuel Type:	Gasoline
VIN:	1GNSK2E01CR301102	Miles per Gallon:	23/31
Agency Fleet ID:	NA	Miles per Year:	10,000

1.	Vehicle Mission:	
	☐	Pool Vehicle
	☐	Enforcement Vehicle
	☐	Support Vehicle
	☐	Transport Vehicle
	☐	Specialty Vehicle
	☐	Shuttle/Bus
	☐	Low Speed Vehicle
2.	Vehicle Typical Parking Location: (parking lot name/designation, nearest building number)	

Appendix B
Vehicle Characterization

Table B-1. Golden Gate National Recreation Area vehicle index.

Vehicle Index					
ID	Make	Model	Year	Fleet Vehicle Id	Mission
84	Chevrolet	Tahoe	2012	G62-2316M	Law enforcement
85	Ford	Crown Victoria	2010	G14-00831L	Law enforcement
86	Chevrolet	Tahoe	2010	G62-2738K	Law enforcement
87	Chevrolet	Tahoe	2009	G62-2822H	Law enforcement
88	Chevrolet	Tahoe	2012	G62-0976M	Law enforcement
89	Ford	Expedition	2007	G62-1734F	Law enforcement
90	Chevrolet	Tahoe	2010	G42-1742K	Law enforcement
91	Ford	Ranger	2009	G41-4139	Support
*92**	*Chevrolet*	*3500*	*2007*	*G63-1055F*	*Support*
93	Ford	Crown Victoria	2011	G14-0057L	Law enforcement
94	Chevrolet	2500	2009	G43-2788H	Support
95	Ford	Ranger	2010	G41-3506K	Support
96	Ford	Ranger	2010	G41-3508k	Support
97	Ford	Ranger	2006	G61-0091	Support
99	Jeep	Liberty	2010	G61-1350K	Support
*100**	*Chevrolet*	*Silverado*	*2006*	*G63-2918D*	*Support*

*Vehicle provided no data

Appendix C
Definitions

Alternative fuel	An alternative fuel means any fuel other than gasoline and diesel fuels, such as methanol, ethanol, and gaseous fuels (40 CFR 86.1803-01). A fuel type other than petroleum-based gasoline or diesel as defined by the Energy Policy Act (examples include ethanol, methanol, compressed natural gas, propane, and electrical energy).
City fuel economy (MPG)	City fuel economy means the city fuel economy determined by operating a vehicle (or vehicles) over the driving schedule in the federal emission test procedure or determined according to the vehicle-specific 5-cycle or derived 5-cycle procedures (40 CFR 600.001).
Conventional fuel	A petroleum-based fuel (examples include gasoline and diesel fuel).
Daily travel	The sum of daily trips and stops in one day.
Diesel fuel	Diesel means a type of engine with operating characteristics significantly similar to the theoretical diesel combustion cycle. The non-use of a throttle during normal operation is indicative of a diesel engine (49 CFR 86-1803).
E85	Ethanol fuel blend of up to 85% denatured ethanol fuel and gasoline or other hydrocarbons by volume.
Electric vehicle	Electric vehicle means a motor vehicle that is powered solely by an electric motor drawing current from a rechargeable energy storage system, such as from storage batteries or other portable electrical energy storage devices, including hydrogen fuel cells, provided that (1) The vehicle is capable of drawing recharge energy from a source off the vehicle, such as residential electric service (2) The vehicle must be certified to the emission standards of Bin #1 of Table S04-1 in § 86.1811-09(c)(6) (3) The vehicle does not have an onboard combustion engine/generator system as a means of providing electrical energy (40 CFR 86-1803).
Ethanol-fueled vehicle	Ethanol-fueled vehicle-means any motor vehicle or motor vehicle engine that is engineered and designed to be operated using ethanol fuel (i.e., a fuel that contains at least 50% ethanol (C_2H_5OH) by volume) as fuel (40 CFR 86.1803-01).
Federal vehicle standards	The document that establishes classifications for various types and sizes of vehicles, general requirements, and equipment options. It is issued annually by the GSA Vehicle Acquisition and Leasing Service's Automotive Division.
Government motor vehicle	Any motor vehicle that the government owns or leases. This includes motor vehicles obtained through purchase, excess, forfeiture, commercial lease, or GSA fleet lease.
Gross vehicle weight rating	Gross vehicle weight rating (GVWR) means the value specified by the vehicle manufacturer as the maximum design loaded weight of a single vehicle (e.g., vocational vehicle) (US Government Printing Office 2009)
GSA fleet	GSA fleet lease means obtaining a motor vehicle from the General Services Administration fleet (GSA fleet) (41 CFR 102-34).

Heavy light-duty truck	Heavy light-duty truck means any light-duty truck rated greater than 6,000 lb GVWR. The light-duty truck 3 (LDT3) and LDT4 classifications comprise the heavy light-duty truck category (40 CFR 86.1803-01).
Highway fuel economy (Hwy MPG)	Highway fuel economy means the highway fuel economy determined either by operating a vehicle (or vehicles) over the driving schedule in the federal highway fuel economy test procedure or determined according to either the vehicle-specific, 5-cycle equation, or the derived 5-cycle equation for highway fuel economy (40 CFR 600.001).
Hybrid electric vehicle	Hybrid electric vehicle means a motor vehicle that draws propulsion energy from onboard sources of stored energy that are both an internal combustion engine or heat engine using consumable fuel and a rechargeable energy storage system (such as a battery, capacitor, hydraulic accumulator, or flywheel), where recharge energy for the energy storage system comes solely from sources on board the vehicle.
Idle time	Idle time is logged whenever a vehicle idles with the engine running for 3 minutes or longer.
Law enforcement	Law enforcement motor vehicle means a light-duty motor vehicle that is specifically approved in an agency-s appropriation act for use in apprehension, surveillance, police, or other law enforcement work or specifically designed for use in law enforcement. If not identified in an agency's appropriation language, a motor vehicle qualifies as a law enforcement motor vehicle only in the following cases: (1) A passenger automobile having heavy-duty components for electrical, cooling, and suspension systems and at least the next higher cubic inch displacement or more powerful engine than is standard for the automobile concerned (2) A light truck having emergency warning lights and identified with markings such as "police" (3) An unmarked motor vehicle certified by the agency head as essential for the safe and efficient performance of intelligence, counterintelligence, protective, or other law enforcement duties (4) A forfeited motor vehicle seized by a federal agency that subsequently is used for performing law enforcement activities (41 CFR Part 102-34.35).
Light-duty motor vehicle	Any motor vehicle with a GVWR of 8,500 pounds or less (41 CFR 102-34).
Light-duty truck	Light-duty truck means any motor vehicle rated at 8,500 pounds GVWR or less, which has a curb weight of 6,000 pounds or less and, which has a basic vehicle frontal area of 45 square feet or less, which is as follows: (1) Designed primarily for purposes of transportation of property or is a derivation of such a vehicle (2) Designed primarily for transportation of persons and has a capacity of more than 12 persons (3) Available with special features, enabling off-street or off-highway operation and use. LDT1 means any light light-duty truck up through 3,750-lb loaded vehicle weight. LDT2 means any light light-duty truck greater than 3,750-lb loaded vehicle weight.

	LDT3 means any heavy light-duty truck up through 5,750-lb adjusted loaded vehicle weight. LDT4 means any heavy light-duty truck greater than 5,750-lb adjusted loaded vehicle weight (US Government Printing Office 2009)
Light-duty vehicle	Light-duty vehicle means a passenger car or passenger car derivative capable of seating 12 passengers or less.
Low-speed vehicle	Low-speed vehicle means a motor vehicle (1) That is 4-wheeled (2) Whose speed attainable in 1.6 km (1 mile) is more than 32 kilometers per hour (20 miles per hour) and not more than 40 kilometers per hour (25 miles per hour) on a paved level surface (3) Whose GVWR is less than 1,361 kilograms (3,000 pounds) (49 CFR 571.3 – Definitions).
Medium-duty passenger vehicle	Medium-duty passenger vehicle means any heavy-duty vehicle (as defined in this subpart) with a GVWR of less than 10,000 pounds that is designed primarily for transportation of persons. The medium-duty passenger vehicle definition does not include any vehicle which (1) Is an “incomplete truck” as defined in this subpart (2) Has a seating capacity of more than 12 persons (3) Is designed for more than 9 persons in seating rearward of the driver's seat (4) Is equipped with an open cargo area (for example, a pick-up truck box or bed) of 72.0 inches in interior length or more. A covered box not readily accessible from the passenger compartment will be considered an open cargo area for purposes of this definition (US Government Printing Office 2009)
Model year	Model year means the manufacturer's annual production period (as determined by the administrator), which includes January 1 of such calendar year; provided that if the manufacturer has no annual production period, the term “model year” shall mean the calendar year (40 CFR 86-1803.01).
MPG	“MPG” or “mpg” means miles per gallon. This generally may be used to describe fuel economy as a quantity or it may be used as the units associated with a particular value.
MPGe	MPGe means miles per gallon equivalent. This generally is used to quantify a fuel economy value for vehicles that use a fuel other than gasoline. The value represents miles the vehicle can drive with the energy equivalent of one gallon of gasoline: (c) SCF means standard cubic feet (d) SUV means sport utility vehicle (e) CREE means carbon-related exhaust emissions [76 FR 39527, July 6, 2011].
Non-passenger automobile	A non-passenger automobile means an automobile that is not a passenger automobile or a work truck and includes vehicles described in paragraphs (a) and (b) of 49 CFR 523.5.

Owning agency	Owning agency means the executive agency that holds the vehicle title, manufacturer's Certificate of Origin or is the lessee of a commercial lease. This term does not apply to agencies that lease motor vehicles from the GSA fleet (41 CFR Part 102-34.35).
Passenger automobile	A passenger automobile is any automobile (other than an automobile capable of off-highway operation) manufactured primarily for use in the transportation of not more than 10 individuals (49 CFR 523.4 – Passenger automobile). A sedan or station wagon designed primarily to transport people (41 CFR 102-34).
Pickup truck	Pickup truck means a non-passenger automobile, which has a passenger compartment and an open cargo bed (49 CFR 523.2).
Plug-in hybrid electric vehicle	PHEV means a hybrid electric vehicle that has the capability to charge the battery from an off-vehicle electric source, such that the off-vehicle source cannot be connected to the vehicle while the vehicle is in motion (40 CFR 86.1803).
Vehicle class	The designation of motor vehicle types that include sedans, station wagons, ambulances, buses, and trucks, or different categories of vehicles according to Federal vehicle standards and further defined in 49 CFR 600.315-82.
Vehicle configuration	Vehicle configuration means a unique combination of basic engine, engine code, inertia weight class, transmission configuration, and axle ratio.
Vehicle days	The number of days a vehicle was driven or utilized during the (vehicle) study period.
Vehicle home base	The primary assigned outing beginning and ending parking location for the vehicle.
Vehicle study period	The time period the vehicle, within the study, has been equipped with a data logger.

Appendix D
Vehicle Data Sheets

Vehicle 84

www.edmunds.com

Make/Model/Year	Chevrolet/Tahoe/2012
EPA Class Size	SUV – 4WD
Mission	Law enforcement
GVWR	7,100 lb
Vehicle Identification Number (VIN)	1GNSK2E01CR301102
Fleet Vehicle ID	G62-2316M
Fuel Type	Gas/E85
EPA Label/MPG (City/Hwy)	Gas 15/21; E85 11/16
ETEC Study ID	Vehicle 84; Logger 45
Vehicle Study Period	02/17/2013 to 03/28/2013
Total Vehicle Days/Total Study Days	32/39

Vehicle 84 Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	40.4/91.1	14.2/61.8	5.91/35	1,290
Travel Time (Minutes)	212/533	74.7/343	31.0/187	6,800
Idle Time (Minutes)	78.9/NA	11.5/NA	11.7/NA	2,520

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	219	67%	Less than 1	272
10 to 20	110	33%	1 to 4	28
20 to 40	0	0%	4 to 8	2
40 to 60	0	0%	Greater than 8	27

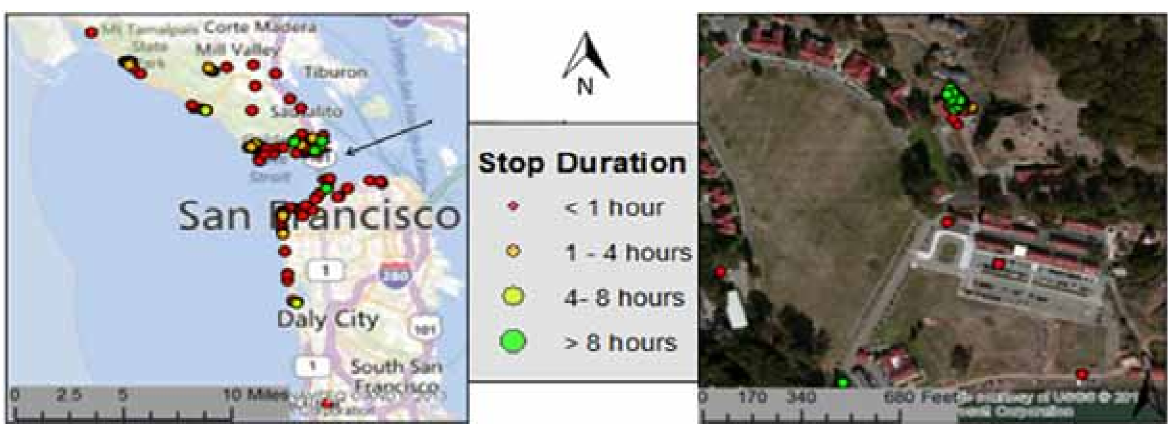

Figure D-1. Vehicle 84 all vehicle stops.

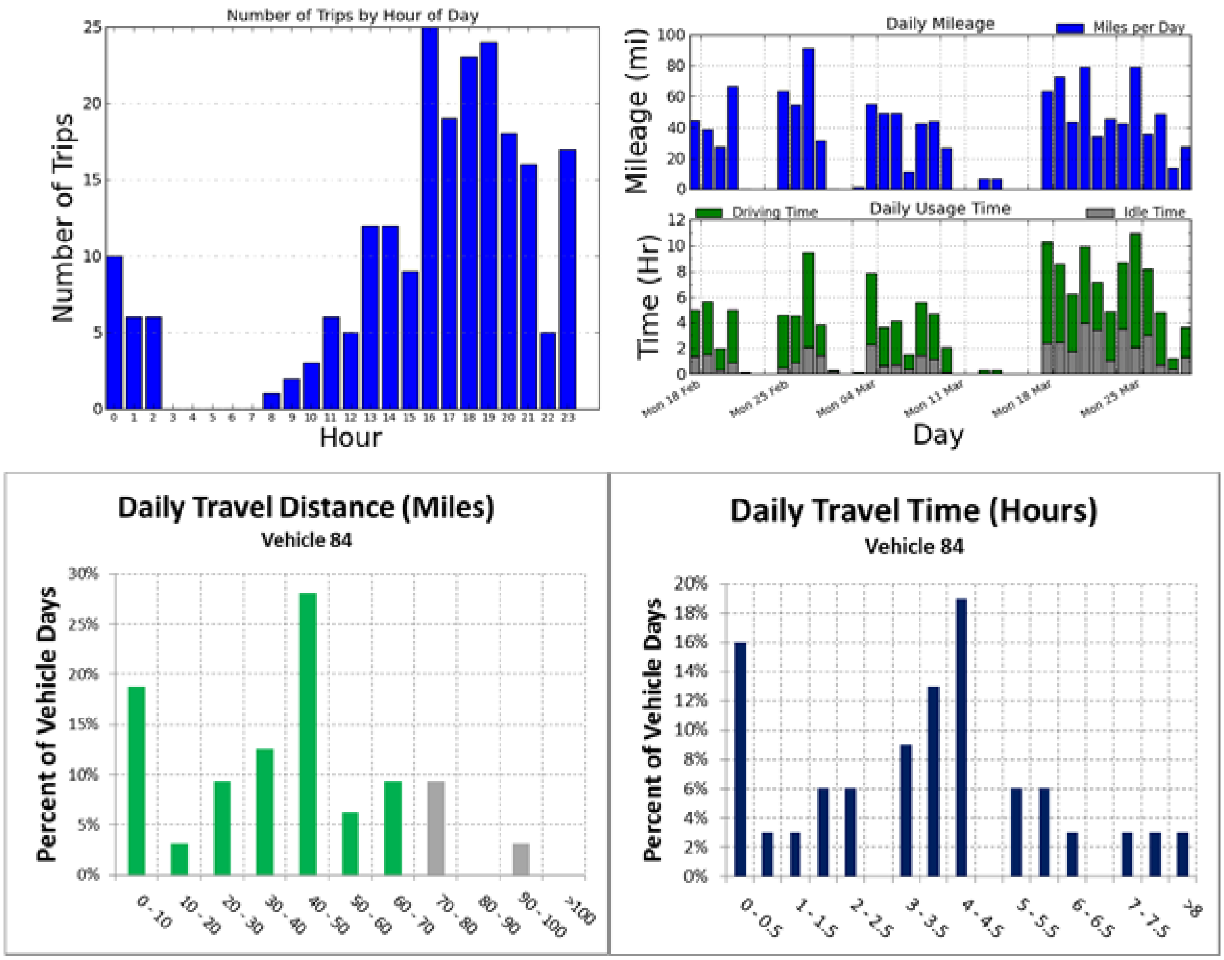

Figure D-2. Vehicle 84 travel graphs.

Vehicle 84 Observations

Logger 45 collected data on Vehicle 84 for a period of 39 study days, during which 32 days showed usage. Data validation occurred on 96% of the vehicle data, while 4% of the data are null values. The vehicle's primary home base is located at McReynolds Road near the Bay Area Discovery Museum and referred to by GGNRA as 507.

During the study period, the vehicle traveled a total distance of 1,290 miles over 113 hours. Of all vehicle travel days, 88% were within the 70- mile BEV safe range (the green bars on Figure D-2), while 16% of the vehicle travel days exceeded this range.

The longest single outing of 61.8 miles occurred on March 18, which remains within the assumed range of a BEV. That outing took 5.4 hours, whereas all travel that day required just over 6 hours. Recharging the vehicle following this trip provides additional capacity for additional outings that day. An EVSE located at the typical parking location allows for the possibility of beginning each drive with a full charge.

The typical BEV safe range limitation was exceeded on 12% of the vehicle travel days. These data indicate that choosing a BEV for this duty may require intermediate charging station opportunities at either the home base or a frequent intermediate stop. Otherwise, a PHEV is required for the days that involve extended trips. A combination of BEVs and PHEVs may be desirable for this fleet.

Vehicle 85

www.indexusedcars.com

Make/Model/Year	Ford/Crown Victoria/2010
EPA Class Size	Large vehicle (sedan)
Mission	Law enforcement
GVWR	NA
Vehicle Identification Number (VIN)	2FABP7BV2AX142459
Fleet Vehicle ID	G14-00831L
Fuel Type	Gas/E85
EPA Label/MPG (City/Hwy)	Gas 16/24; E85 12/17
ETEC Study ID	Vehicle 85; Logger 48
Vehicle Study Period	02/16/20/13 to 3/31/2013
Total Vehicle Days/Total Study Days	28/43

Vehicle 85 Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	36.5/76.5	14.8/63.6	5.13/29.7	1,021
Travel Time (Minutes)	145/263	58.9/130	20.4/118	4,062
Idle Time (Minutes)	23.8/NA	3.35/NA	6.87/NA	666

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	223	97%	Less than 1	161
10 to 20	7	3%	1 to 4	37
20 to 40	0	0%	4 to 8	6
40 to 60	0	0%	Greater than 8	26

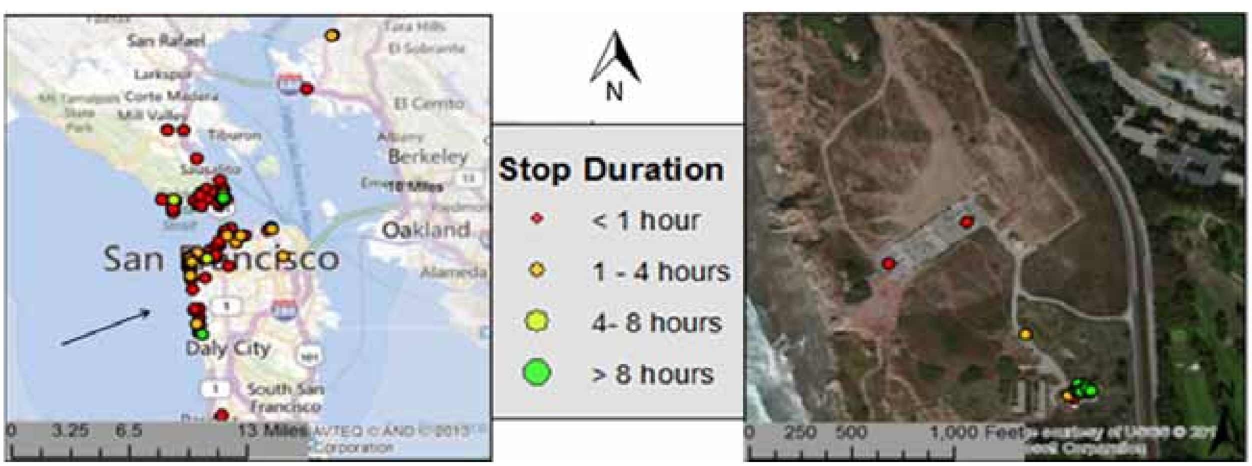

Figure D-3. Vehicle 85 all vehicle stops.

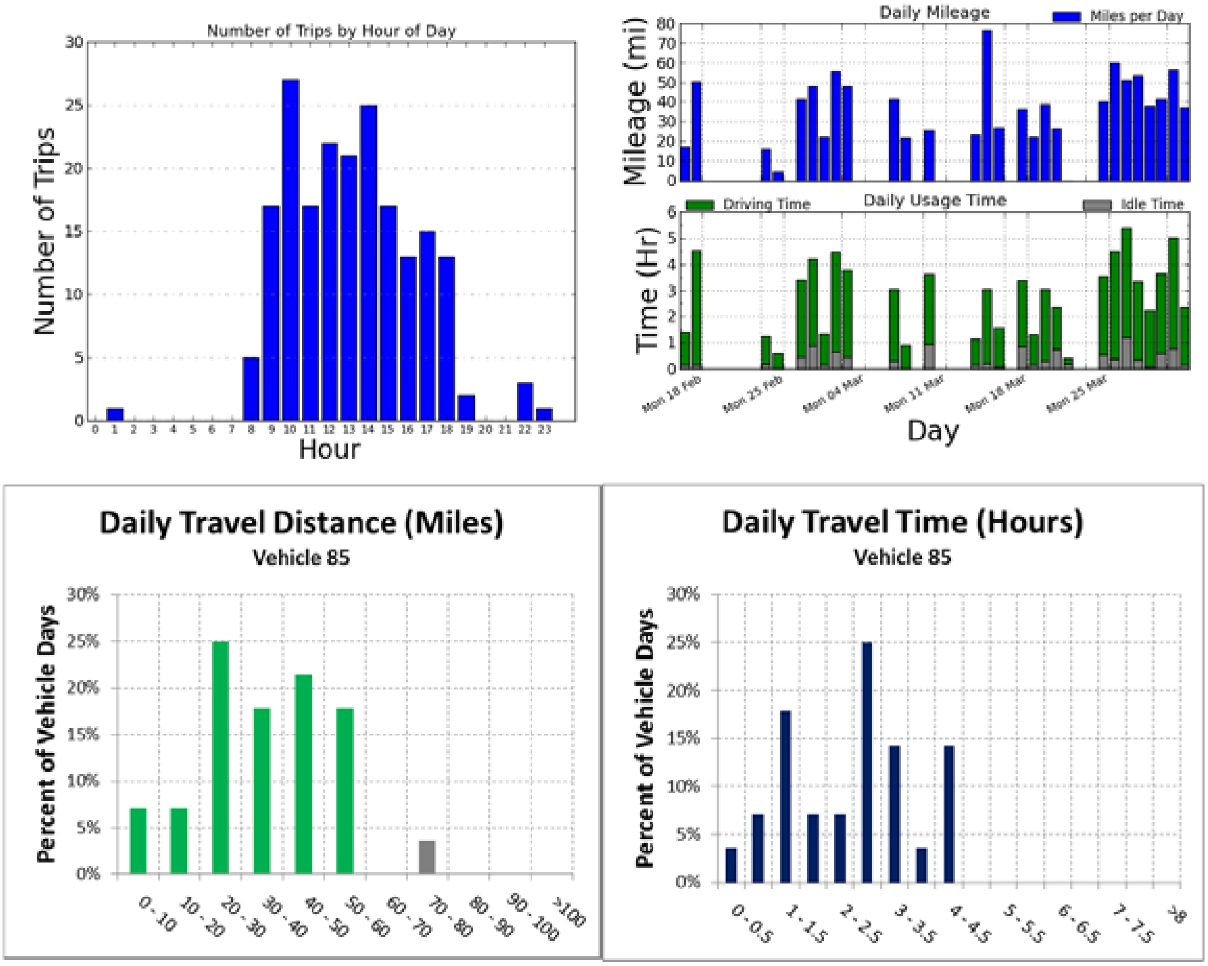

Figure D-4. Vehicle 85 travel graphs.

Vehicle 85 Observations

Logger 48 collected data on Vehicle 85 for a period of 43 study days, during which 28 days showed usage. Data validation occurred on 98% of the vehicle data, while 2% of the data are null values. GGNRA reports the vehicle's primary home base as Fort Funston.

During the study period, the vehicle traveled a total distance of 1,021 miles over 67.7 hours. Of all vehicle travel days, 96% were within the 70-mile BEV safe range (the green bars on Figure D-4), while 4% of the vehicle travel days exceeded this range.

The longest single outing of 63.6 miles occurred on March 14, which remains within the assumed range capability of a BEV. That outing took 2.2 hours of driving time and lasted from 9:12 a.m. until 6:46 p.m. There were four other days where the total outing exceeded 50 miles during the day. However, in each case, the vehicle returned to the home base at the end of the day. March 14 also was the day where total mileage reached the peak of 76.5 miles. Another trip in the early morning added to the 63.6-mile outing. An EVSE located at the typical parking location allows for the possibility of beginning each drive with a full charge and sufficient time existed between these outings to recharge the battery. With a charger at the home base, a BEV can meet this vehicle's mission.

Vehicle 86

www.edmunds.com

Make/Model/Year	Chevrolet/Tahoe/2010
EPA Class Size	SUV – 4WD
Mission	Law enforcement
GVWR	7,300 lb
Vehicle Identification Number (VIN)	1GNUKAEOXAR279942
Fleet Vehicle ID	G62-2738KG62-2316M
Fuel Type	Gas/E85
EPA Label/MPG (City/Hwy)	Gas 15/21; E85 11/16
ETEC Study ID	Vehicle 86; Logger 49
Vehicle Study Period	02/19/20/13 to 04/11/2013
Total Vehicle Days/Total Study Days	22/51

Vehicle 86 Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	39.2/77.9	14.1/77.9	4.92/41.9	861
Travel Time (Minutes)	178/408	64.2/317	22.4/313	3,915
Idle Time (Minutes)	65.4/	8.22/NA	11.2/NA	1,438

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	203	85%	Less than 1	185
10 to 20	31	13%	1 to 4	31
20 to 40	6	3%	4 to 8	4
40 to 60	0	0%	Greater than 8	20

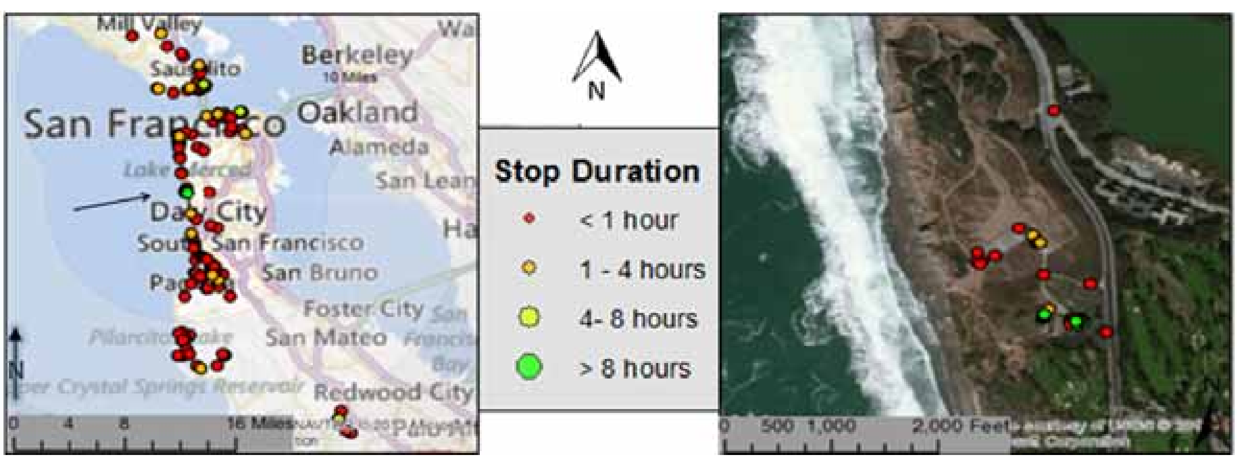

Figure D-5. Vehicle 86 all vehicle stops.

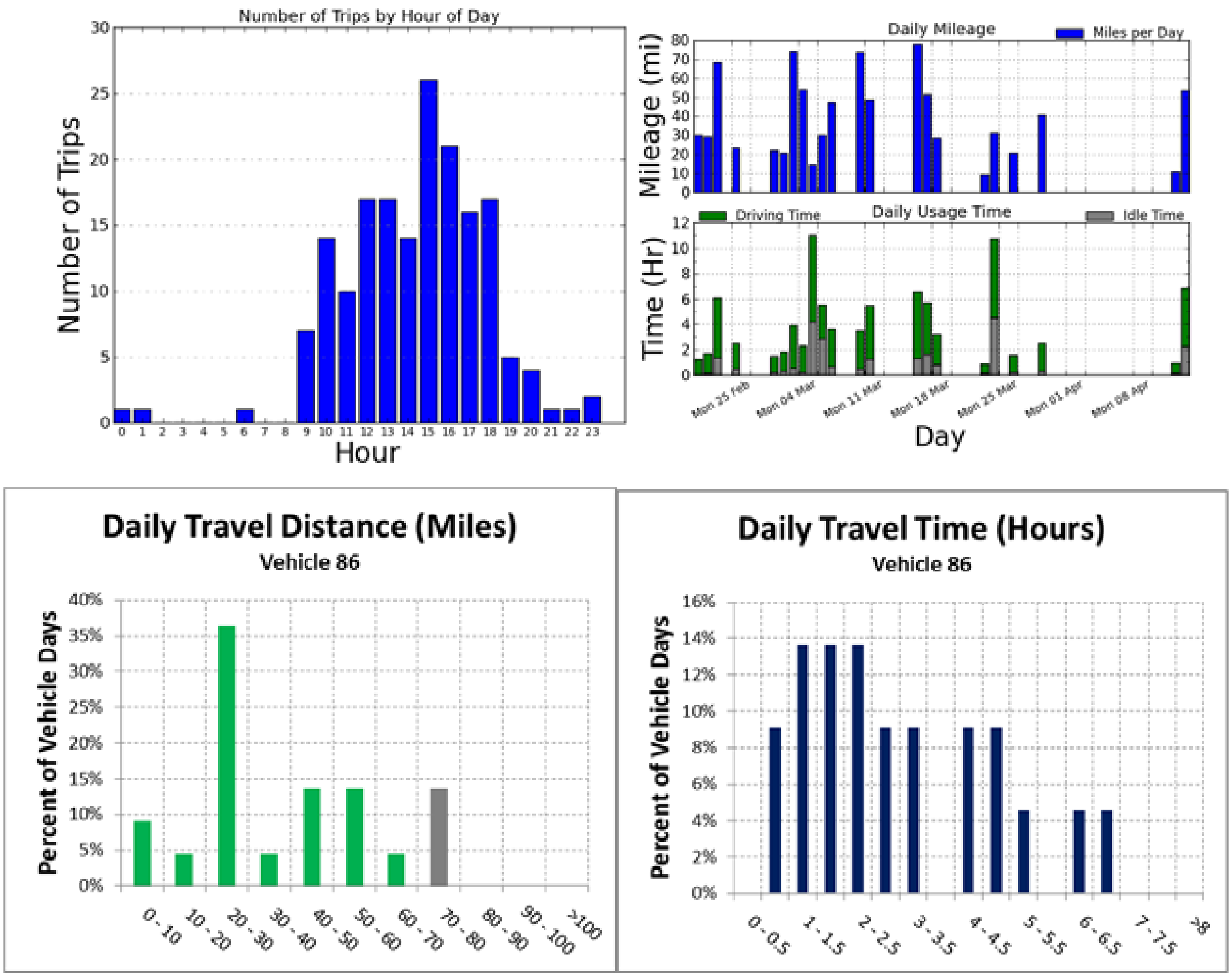

Figure D-6. Vehicle 86 vehicle travel graphs.

Vehicle 86 Observations

Logger 49 collected data on Vehicle 86 for a period of 51 study days, during which 22 days showed usage. Data validation occurred on 97% of the vehicle data, while 3% of the data are null values. GGNRA reports the vehicle's primary home base as Fort Funston.

During the study period, the vehicle traveled a total distance of 861 miles over 65.2 hours. Of all vehicle travel days, 86% were within the 70- mile BEV safe range (the green bars on Figure D-6), while 14% of the vehicle travel days exceeded this range.

The longest single outing of 77.9 miles occurred on March 14, which is slightly beyond the assumed range capability of a BEV. That outing took 5.3 hours of driving time between 12:14 p.m. and 10:45 p.m. Two other outings greater than 70 miles occurred in a similar manner; however, in all cases, the vehicle returned to the home base at the end of the day. An EVSE located at the typical parking location allows for the possibility of beginning each drive with a full charge.

The typical BEV safe range limitation was exceeded 14% of the vehicle travel days, but all of these days are just beyond the assumed range of a BEV. These data indicate that choosing a BEV for this duty may require intermediate charging station opportunities at either the home base or a frequented intermediate stop (i.e.,. McReynolds Road). Otherwise, a PHEV is required for the days that involve extended trips. A combination of BEVs and PHEVs may be desirable for this fleet.

Vehicle 87

www.edmunds.com

Make/Model/Year	Chevrolet/Tahoe/2009
EPA Class Size	SUV – 4WD
Mission	Law enforcement
GVWR	7,300 lb
Vehicle Identification Number (VIN)	1GNFK03079R245040
Fleet Vehicle ID	G62-2822H
Fuel Type	Gas/E85
EPA Label/MPG (City/Hwy)	Gas 14/20; E85 10/15
ETEC Study ID	Vehicle 87; Logger 50
Vehicle Study Period	02/17/2013 to 04/17/2013
Total Vehicle Days/Total Study Days	38/59

Vehicle 87 Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	36.8/78.7	12.9/82.8	4.82/34.6	1,398
Travel Time (Minutes)	159/308	56.0/303	20.9/148	6,052
Idle Time (Minutes)	47.1/NA	6.18/NA	7.46/NA	1,791

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	367	94%	Less than 1	309
10 to 20	23	6%	1 to 4	42
20 to 40	0	0%	4 to 8	4
40 to 60	0	0%	Greater than 8	35

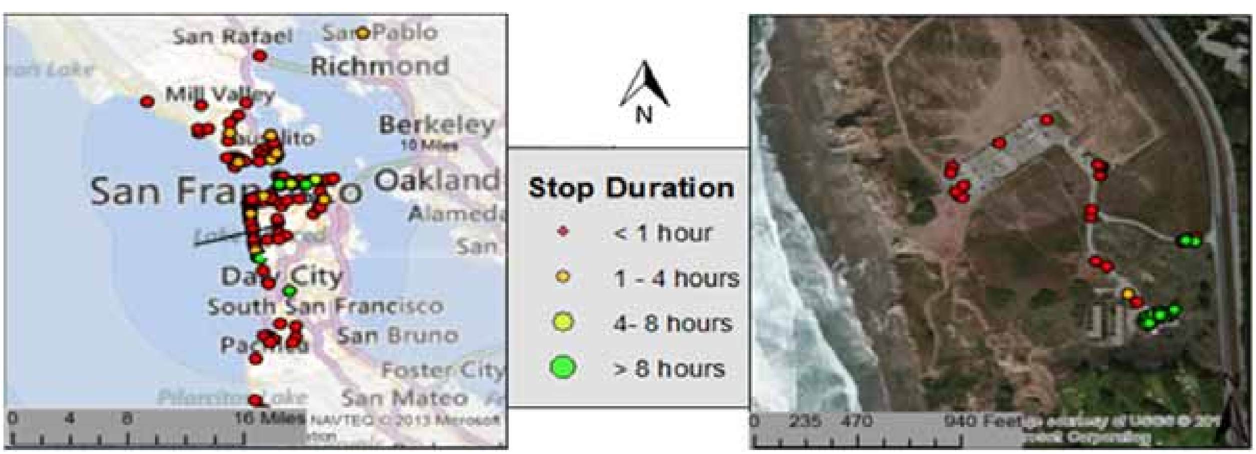

Figure D-7. Vehicle 87 all vehicle stops.

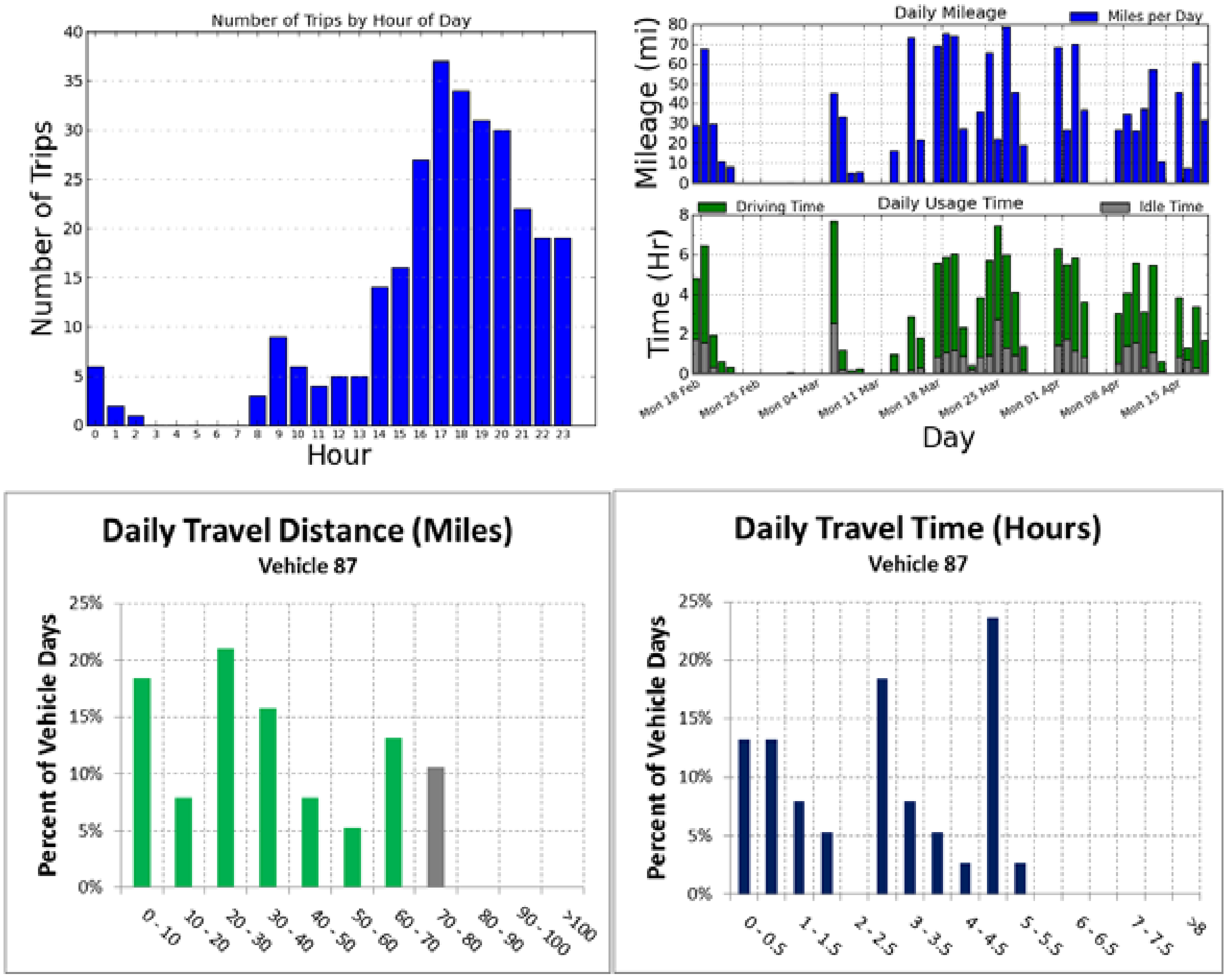

Figure D-8. Vehicle 87 travel graphs.

Vehicle 87 Observations

Logger 50 collected data on Vehicle 87 for a period of 59 study days, during which 38 days showed usage. Data validation occurred on 94% of the vehicle data, while 6% of the data are null values. GGNRA reports the vehicle's primary home base as Fort Funston.

During the study period, the vehicle traveled a total distance of 1,398 miles over 100.7 hours. Of all vehicle travel days, 89% were within the 70-mile BEV safe range (the green bars on Figure D-8), while 11% of the vehicle travel days exceeds this range.

The longest single outing of 82.8 miles occurred from 4:42 p.m. March 25 until 00:24 on March 26, which is beyond the assumed range capability of a BEV. That outing took just over 5 hours of driving time. March 25 also recorded the longest single daily travel. There were three other days of similar driving, with outings and daily travel exceeding 70 miles. An EVSE located at the typical parking home base location allows for the possibility of beginning each drive with a full charge.

The typical BEV safe range limitation was exceeded 11% of the vehicle travel days; however, in all cases, it was just beyond the assumed BEV safe range. These data indicate that choosing a BEV for this duty may require intermediate charging stations opportunities at a frequented intermediate stop (i.e., McReynolds or Ralston Avenue). Otherwise, a PHEV is required for the days that involve extended trips. A combination of BEVs and PHEVs may be desirable for this fleet.

Vehicle 88

www.edmunds.com

Make/Model/Year	Chevrolet/Tahoe/2012
EPA Class Size	SUV – 4WD
Mission	Law enforcement
GVWR	7,300 lb
Vehicle Identification Number (VIN)	1GNSK2EO2CR305062
Fleet Vehicle ID	G62-0976M
Fuel Type	Gas/E85
EPA Label/MPG (City/Hwy)	Gas 15/21; E85 11/16
ETEC Study ID	Vehicle 88; Logger 51
Vehicle Study Period	02/16/2013 to 04/07/2013
Total Vehicle Days/Total Study Days	32/50

Vehicle 88 Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	40.6/80	31.7/73.1	4.02/37.5	1,298
Travel Time (Minutes)	181/333	140.9/333	17.9/113	5,777
Idle Time (Minutes)	63.8/NA	6.32/NA	10.4/NA	2,041

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	254	71%	Less than 1	281
10 to 20	101	28%	1 to 4	41
20 to 40	1	0%	4 to 8	7
40 to 60	0	0%	Greater than 8	27

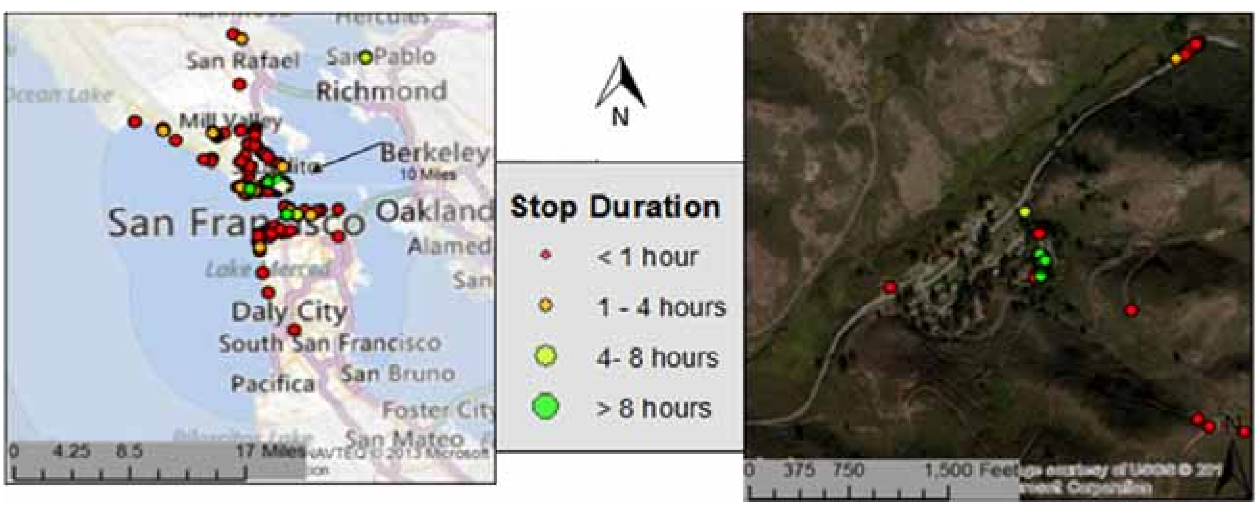

Figure D-9. Vehicle 88 all vehicle stops.

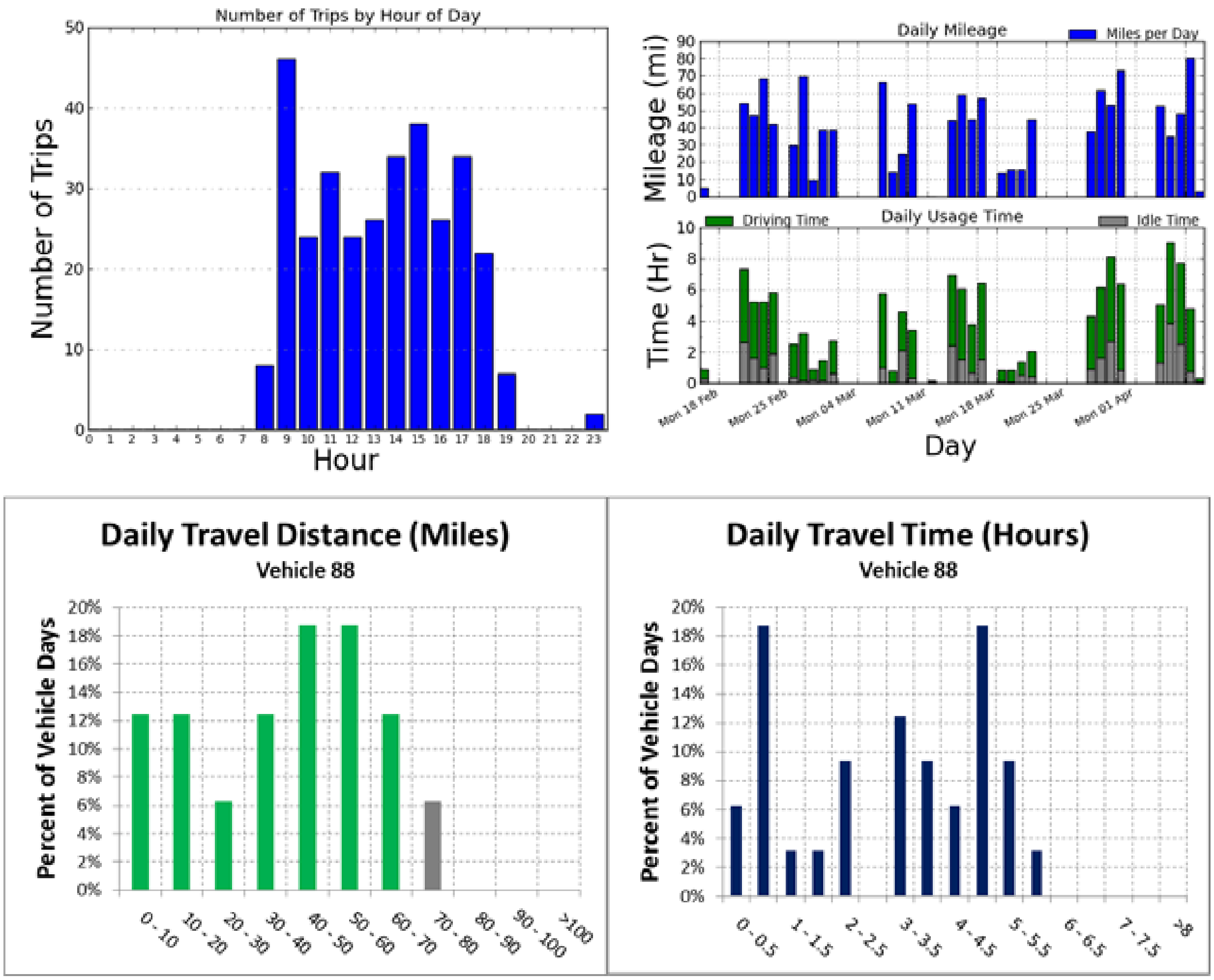

Figure D-10. Vehicle 88 travel graphs.

Vehicle 88 Observations

Logger 51 collected data on Vehicle 88 for a period of 50 study days, during which 32 days showed usage. Data validation occurred on 94% of the vehicle data, while 6% of the data are null values. GGNRA reports the vehicle’s primary home base as area 507 at McReynolds Road near the Bay Area Discovery Museum, although data shows the vehicle starts most days at 805 Lamoraux Drive in Bolinas.

During the study period, the vehicle traveled a total distance of 1,298 miles over 96.3 hours. Of all vehicle travel days, 94% were within the 70-mile BEV safe range (the green bars on Figure D-10), while 6% (2 days) of the vehicle travel days exceeded this range.

The longest single outing of 73.1 miles occurred on March 30, which is slightly beyond the assumed range capability of a BEV. That outing took 5.5 hours of vehicle travel from 9:02 a.m. to 6:12 p.m. An EVSE located at the typical parking location allows for the possibility of beginning each drive with a full charge.

The typical BEV safe range limitation was exceeded 11% of the vehicle travel days; however, in all cases, this was just beyond the assumed BEV safe range. These data indicate that choosing a BEV for this duty may require intermediate charging stations opportunities at either the home base or a frequented intermediate stop. Otherwise, a PHEV is required for the days that involve extended trips. A combination of BEVs and PHEVs may be desirable for this fleet.

Vehicle 89

www.edmunds.com

Make/Model/Year	Ford/Expedition/2007
EPA Class Size	SUV – 2WD
Mission	Law enforcement
GVWR	7,328 lb
Vehicle Identification Number (VIN)	1FMFU16547LA50706
Fleet Vehicle ID	G62-1734F
Fuel Type	Gas
EPA Label/MPG (City/Hwy)	Gas 12/18; E85 N/A
ETEC Study ID	Vehicle 89; Logger 52
Vehicle Study Period	02/16/2013 to 03/29/2013
Total Vehicle Days/Total Study Days	26/41

Vehicle 89 Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	43.7/110.9	22.7/248.4	8.35/52.6	1,136
Travel Time (Minutes)	124/305	64.5/345	23.7/128	3,224
Idle Time (Minutes)	23.6/NA	4.51/NA	8.07/NA	613

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	103	66%	Less than 1	105
10 to 20	45	29%	1 to 4	21
20 to 40	0	0%	4 to 8	4
40 to 60	7	5%	Greater than 8	25

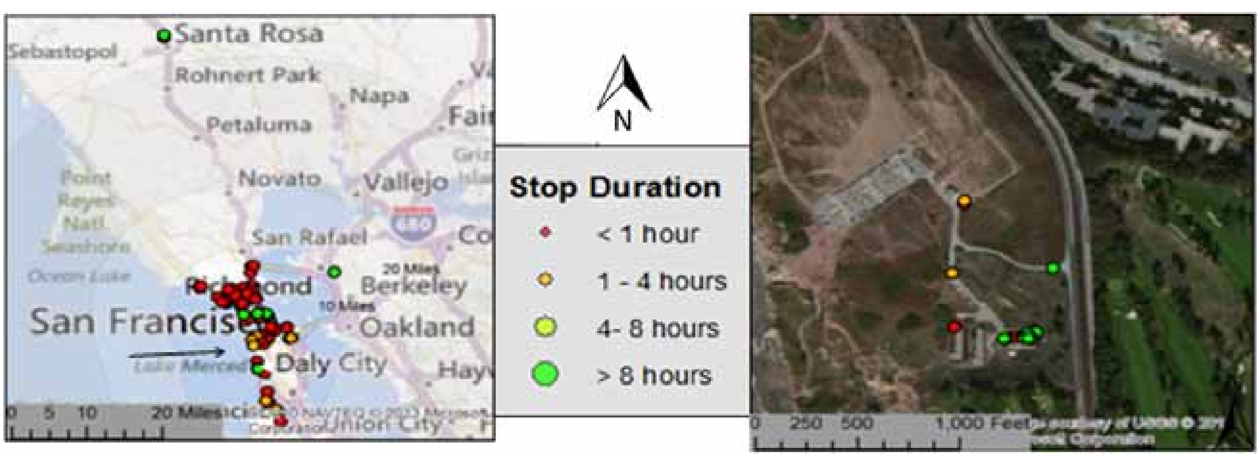

Figure D-11. Vehicle 89 all vehicle stops.

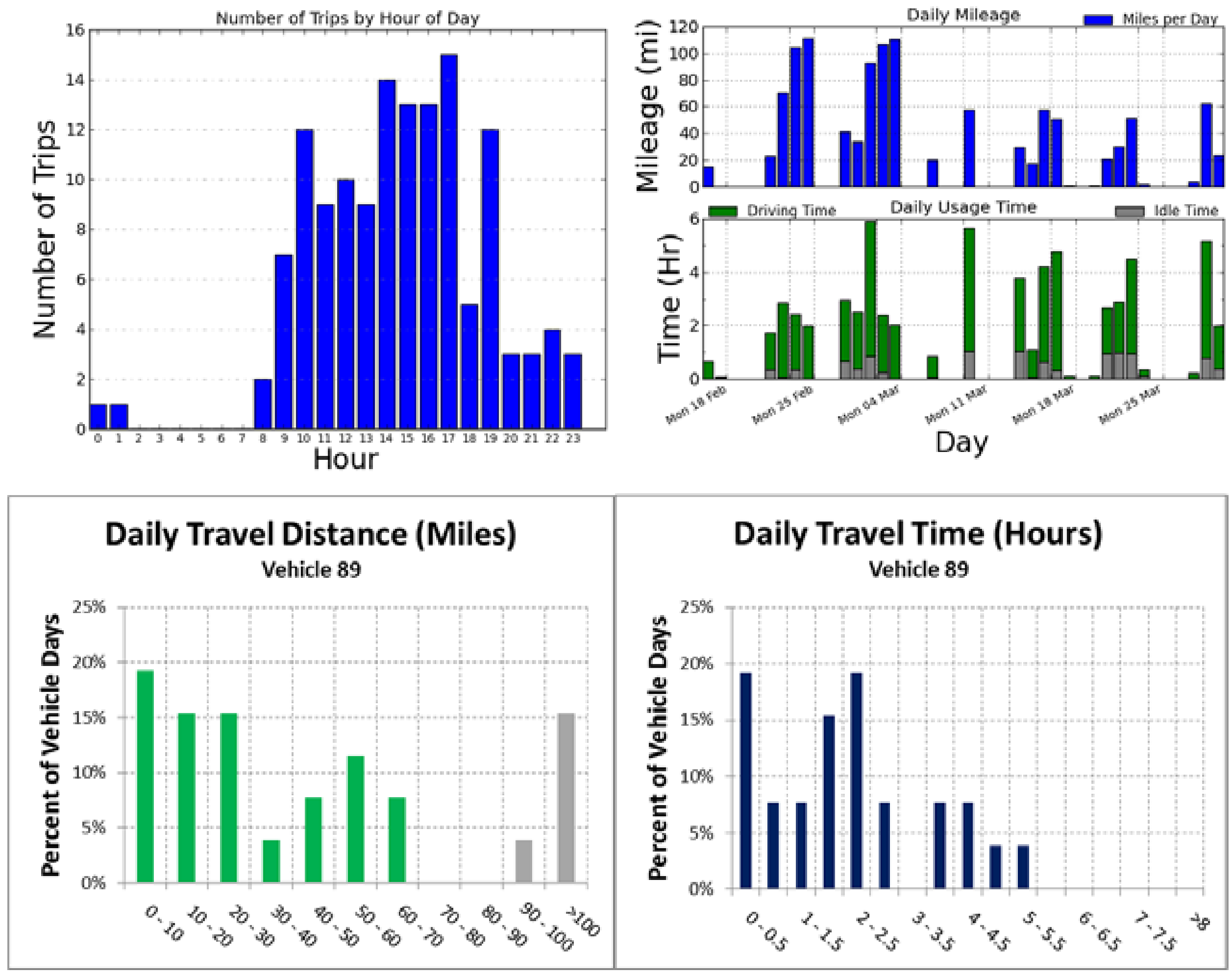

Figure D-12. Vehicle 89 travel graphs.

Vehicle 89 Observations

Logger 52 collected data on Vehicle 89 for a period of 41 study days, during which 26 days showed usage. Data validation occurred on 96% of the vehicle data, while 4% of the data are null values. GGNRA reports the vehicle's primary home base as Fort Funston.

During the study period, the vehicle traveled a total distance of 1,136 miles over 53.7 hours. Of all vehicle travel days, 81% were within the 70-mile BEV safe range (the green bars on Figure D-12), while 19% (5 days) of the vehicle travel days exceeded this range.

The longest single outing of 248 miles occurred from March 22 to March 24, when the vehicle was away from its home base. It involved several trips of greater than 50 miles. An EVSE located at the typical parking location allows for the possibility of beginning each drive with a full charge.

The typical BEV safe range limitation was exceeded 19% of the vehicle travel days. The frequency of days exceeding the typical range of a BEV leads to the suggestion of using a PHEV for this vehicle's mission.

Vehicle 90

 www.edmunds.com	Make/Model/Year	Chevrolet/Tahoe/2010
	EPA Class Size	SUV – 2WD
	Mission	Law enforcement
	GVWR	7,000 lb
	Vehicle Identification Number (VIN)	1GNMCAE05AR263208
	Fleet Vehicle ID	G42-1742K
	Fuel Type	Gas/E85
	EPA Label/MPG (City/Hwy)	Gas 15/21; E85 11/16
	ETEC Study ID	Vehicle 90; Logger 53
	Vehicle Study Period	02/15/2013 to 03/29/2013
	Total Vehicle Days/Total Study Days	27/42

Vehicle 90 Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	52.8/198.3	26.9/101.2	6.42/49.6	1,426
Travel Time (Minutes)	231/494	117.9/577	28.2/157	6,250
Idle Time (Minutes)	81.5/NA	9.91/NA	10.7/NA	2,201

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	128	45%	Less than 1	242
10 to 20	152	54%	1 to 4	22
20 to 40	0	0%	4 to 8	8
40 to 60	2	1%	Greater than 8	10

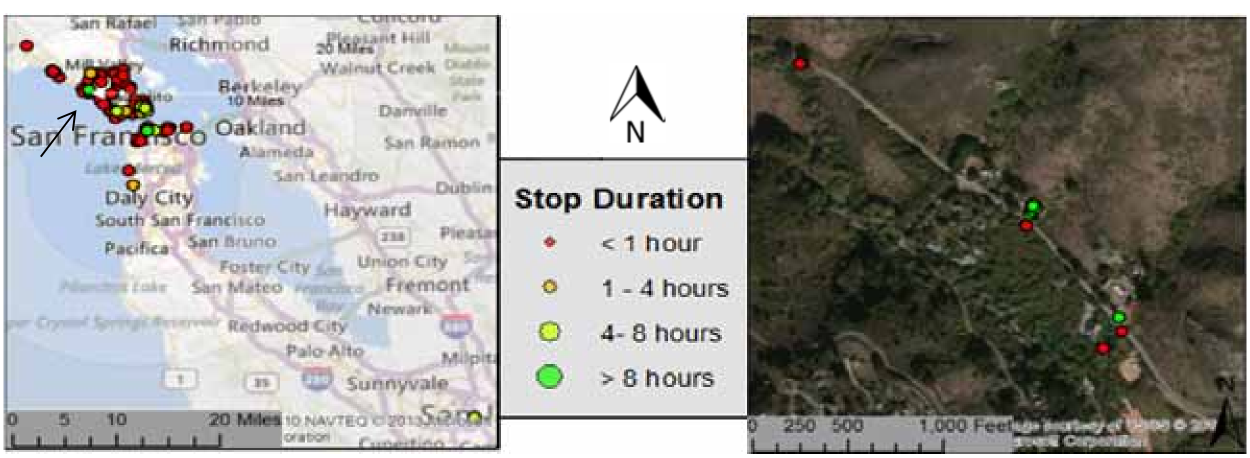

Figure D-13. Vehicle 90 all vehicle stops.

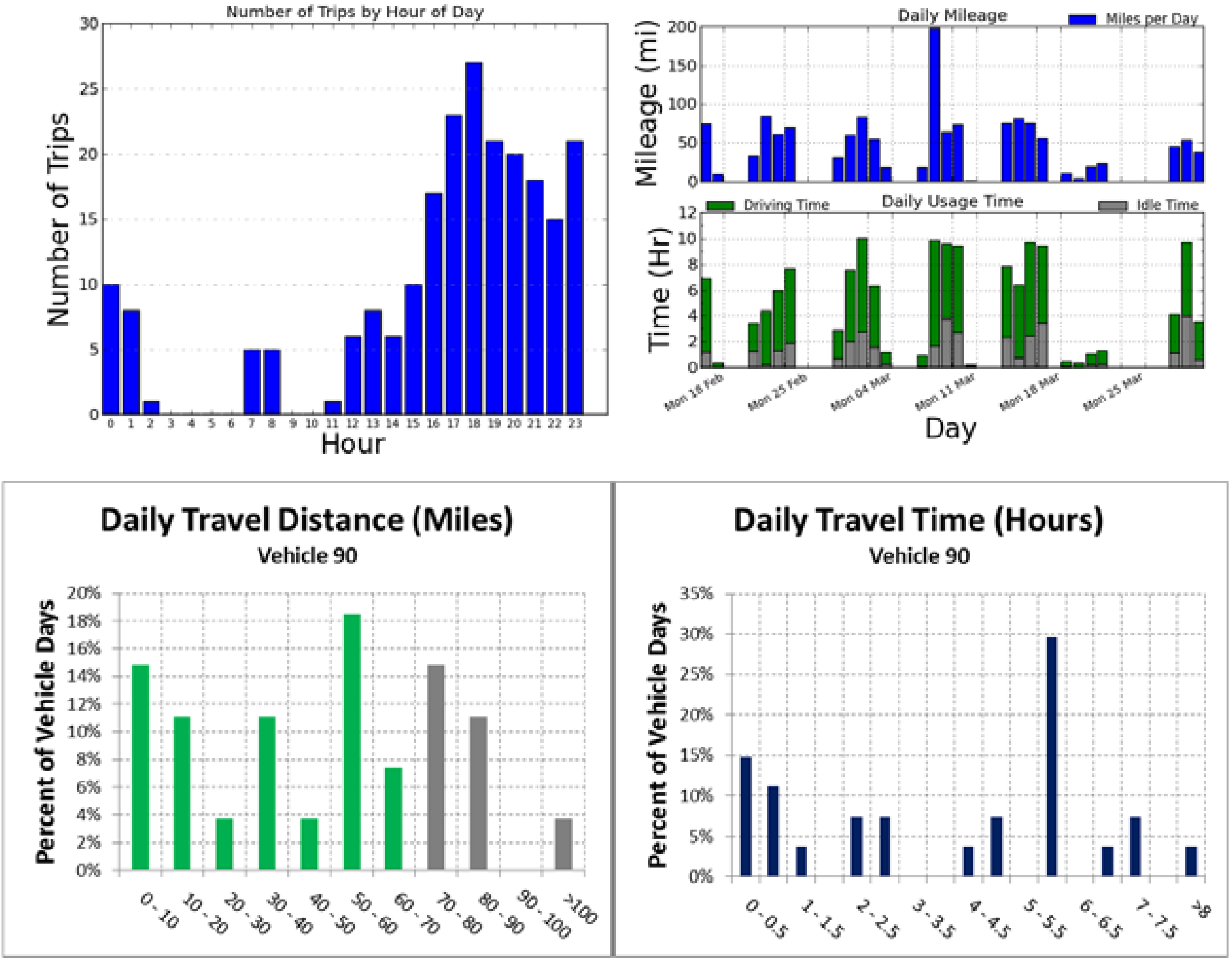

Figure D-14. Vehicle 90 travel graphs.

Vehicle 90 Observations

Logger 53 collected data on Vehicle 90 for a period of 42 study days, during which 27 days showed usage. Data validation occurred on 93% of the vehicle data, while 7% of the data are null values. GGNRA reports the vehicle’s primary home base as Muir Beach.

During the study period, the vehicle traveled a total distance of 1,426 miles over 104 hours. Of all vehicle travel days, 70% were within the 70- mile BEV safe range (the green bars on Figure D-14), while 30% of the vehicle travel days exceeded this range.

The longest single travel day of 198 miles occurred on March 7 and included two trips greater than 45 miles. While several hours of idle time exist between some of these particular trips, such time may not be available for charging or a charging station may not be available. Because the typical BEV safe range limitation is exceeded 30% of the vehicle travel days, a PHEV is required to complete the mission for this vehicle. Charging stations at several intermediate stopping points (i.e., McReynolds Road, Fort Funston, and Shoreline Highway) provide opportunities to maximize the battery for motive power.

Vehicle 91

www.gtcarlot.com

Make/Model/Year	Ford/Ranger/2009
EPA Class Size	Small Pickup Truck 2WD
Mission	Support
GVWR	4,320 lb
Vehicle Identification Number (VIN)	1FTYR10D99PA37411
Fleet Vehicle ID	G41-4139
Fuel Type	Gas
EPA Label/MPG (City/Hwy)	Gas 19/24; E85 N/A
ETEC Study ID	Vehicle 91; Logger 54
Vehicle Study Period	02/21/20/13 to 3/31/2013
Total Vehicle Days/Total Study Days	42/57

Vehicle 91 Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	16.7/27.3	5.74/19.4	1.11/8.5	700
Travel Time (Minutes)	210/410	72.4/270	13.9/140	8,830
Idle Time (Minutes)	101.9/NA	6.76/NA	6.97/NA	4,281

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	897	100%	Less than 1	822
10 to 20	0	0%	1 to 4	33
20 to 40	0	0%	4 to 8	1
40 to 60	0	0%	Greater than 8	41

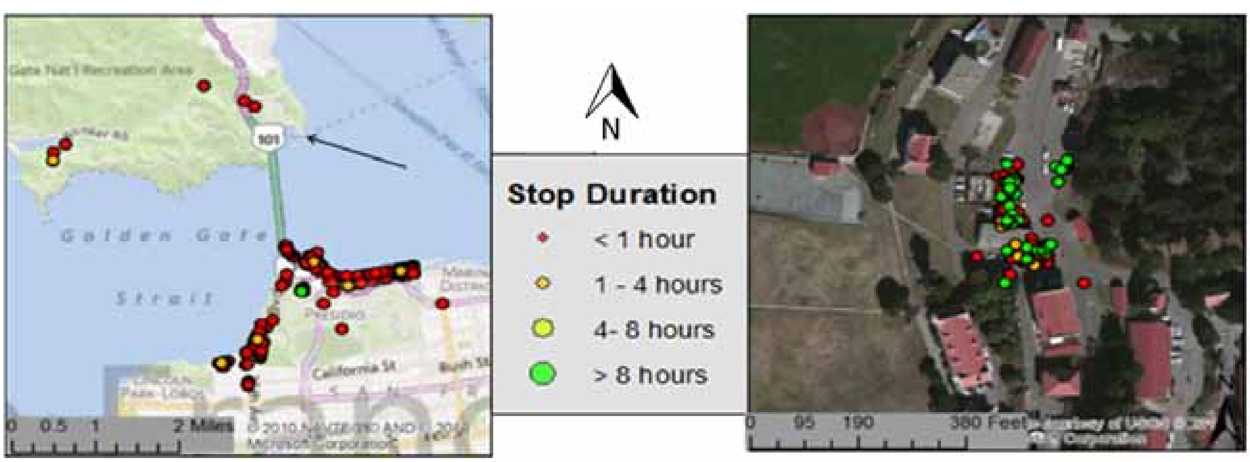

Figure D-15. Vehicle 91 all vehicle stops.

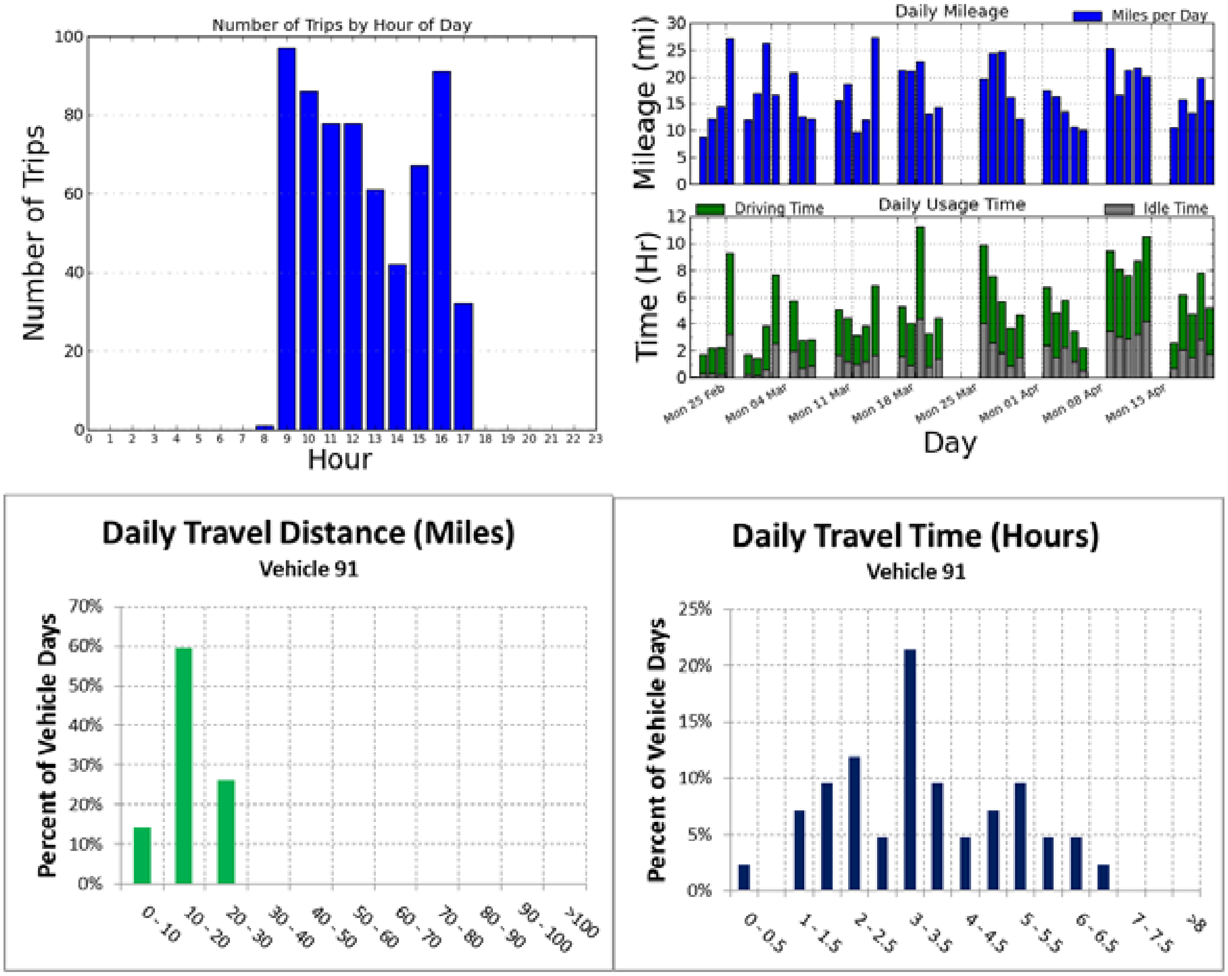

Figure D-16. Vehicle 91 travel graphs.

Vehicle 91 Observations

Logger 54 collected data on Vehicle 91 for a period of 57 study days, during which 42 days showed usage. Data validation occurred on 98% of the vehicle data, while 2% of the data are null values. GGNRA reports the vehicle's primary home base as McReynolds Road near the Bay Area Discovery Museum. GGNRA refers to this area as 507.

During the study period, the vehicle traveled a total distance of 700 miles over 147 hours. Of all vehicle travel days, 100% were within the 70-mile BEV safe range (the green bars on Figure D-16). In addition, all of the outings also were within the BEV safe range.

An EVSE located at the typical parking location allows beginning each drive day with a full charge.

These data indicate that a BEV can accomplish this vehicle's mission.

Vehicle 93

www.drivearabia.com

Make/Model/Year	Ford/Crown Victoria/2011
EPA Class Size	Large vehicle
Mission	Law enforcement
Gross Vehicle Weight Rating (GVWR)	NA
Vehicle Identification Number (VIN)	2FABP7BV0BX152814
Fleet Vehicle ID	G14-0057L
Fuel Type	Gas/E85
EPA Label/MPG (City/Hwy)	Gas 16/24; E85 12/17
ETEC Study ID	Vehicle 93; Logger 57
Vehicle Study Period	02/16/20/13 to 3/31/2013
Total Vehicle Days/Total Study Days	23/46

Vehicle 93 Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	49.8/107.2	14.5/58.6	5.09/26.3	1,145
Travel Time (Minutes)	242/480	70.4/330	24.7/149	5,559
Idle Time (Minutes)	59.6/NA	6.09/NA	9.52/NA	1,371

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	290	89%	Less than 1	279
10 to 20	35	11%	1 to 4	24
20 to 40	0	0%	4 to 8	0
40 to 60	0	0%	Greater than 8	22

Figure D-17. Vehicle 93 all vehicle stops.

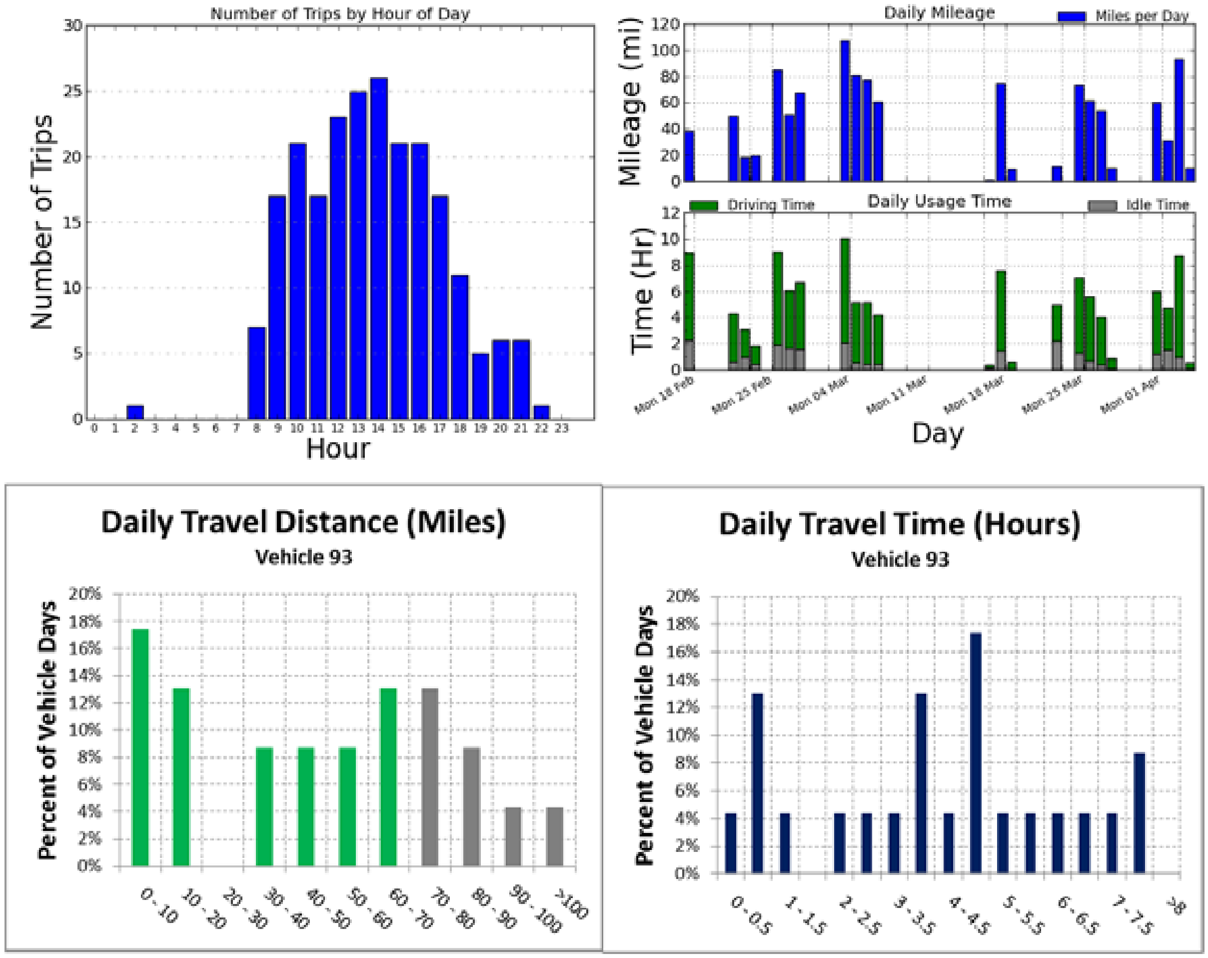

Figure D-18. Vehicle 93 travel graphs.

Vehicle 93 Observations

Logger 57 collected data on Vehicle 93 for a period of 46 study days, during which 23 days showed usage. Data validation occurred on 95% of the vehicle data, while 5% of the data are null values. GGNRA reports the vehicle's primary home base as Fort Funston.

During the study period, the vehicle traveled a total distance of 1,145 miles over 92.6 hours. Of all vehicle travel days, 70% were within the 70- mile BEV safe range (the green bars on Figure D-18), while 30% (7 days) of the vehicle travel days exceeded this range.

The longest single outing of 58.6 miles occurred on March 25, which also was one of the days of higher mileage. An EVSE located at the typical parking location allows for the possibility of beginning each drive day with a full charge.

The typical BEV safe range limitation is exceeded 30% of the vehicle travel days. The frequency of days exceeding the typical range of a BEV leads to the suggestion of using a PHEV for this vehicle's mission. The use of charging stations at frequent intermediate parking locations (i.e., McReynolds Road) will maximize the amount of travel on battery motive power.

Vehicle 94

www.edmunds.com

Make/Model/Year	Chevrolet 2500/2009
EPA Class Size	Truck
Mission	Support
GVWR	9,200 lb
Vehicle Identification Number (VIN)	1GBHC441C89E143991
Fleet Vehicle ID	G43-2788H
Fuel Type	Diesel
EPA Label/MPG (City/Hwy)	Observed 15.4 MPG
ETEC Study ID	Vehicle 94; Logger 56
Vehicle Study Period	02/21/20/13 to 3/31/2013
Total Vehicle Days/Total Study Days	29/38

Vehicle 94 Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	23.7/67.1	6.25/66.9	2.53/17.5	687
Travel Time (Minutes)	78.1/178	20.6/174	8.33/50	2,266
Idle Time (Minutes)	6.31/NA	0.67/NA	4.95/NA	183

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	198	89%	Less than 1	159
10 to 20	23	10%	1 to 4	24
20 to 40	1	0.5%	4 to 8	10
40 to 60	0	0%	Greater than 8	29

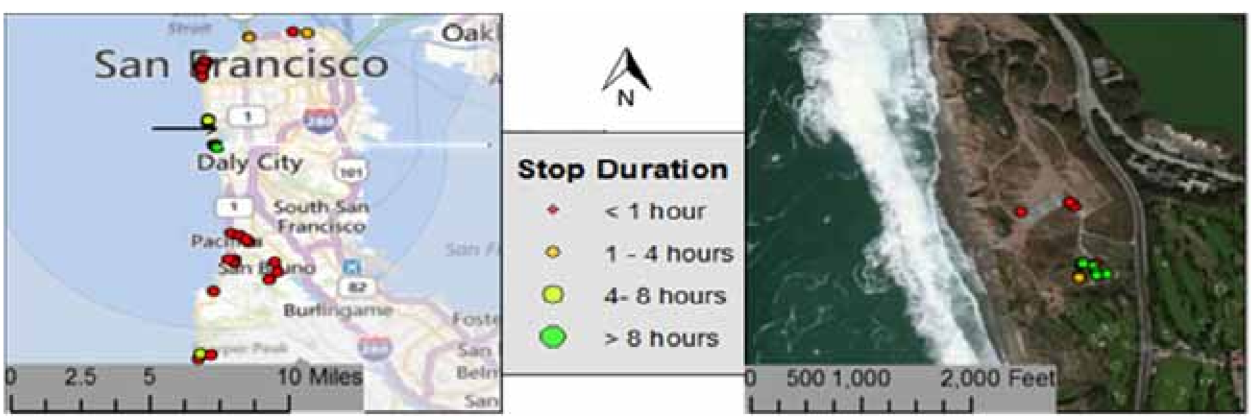

Figure D-19. Vehicle 94 all vehicle stops.

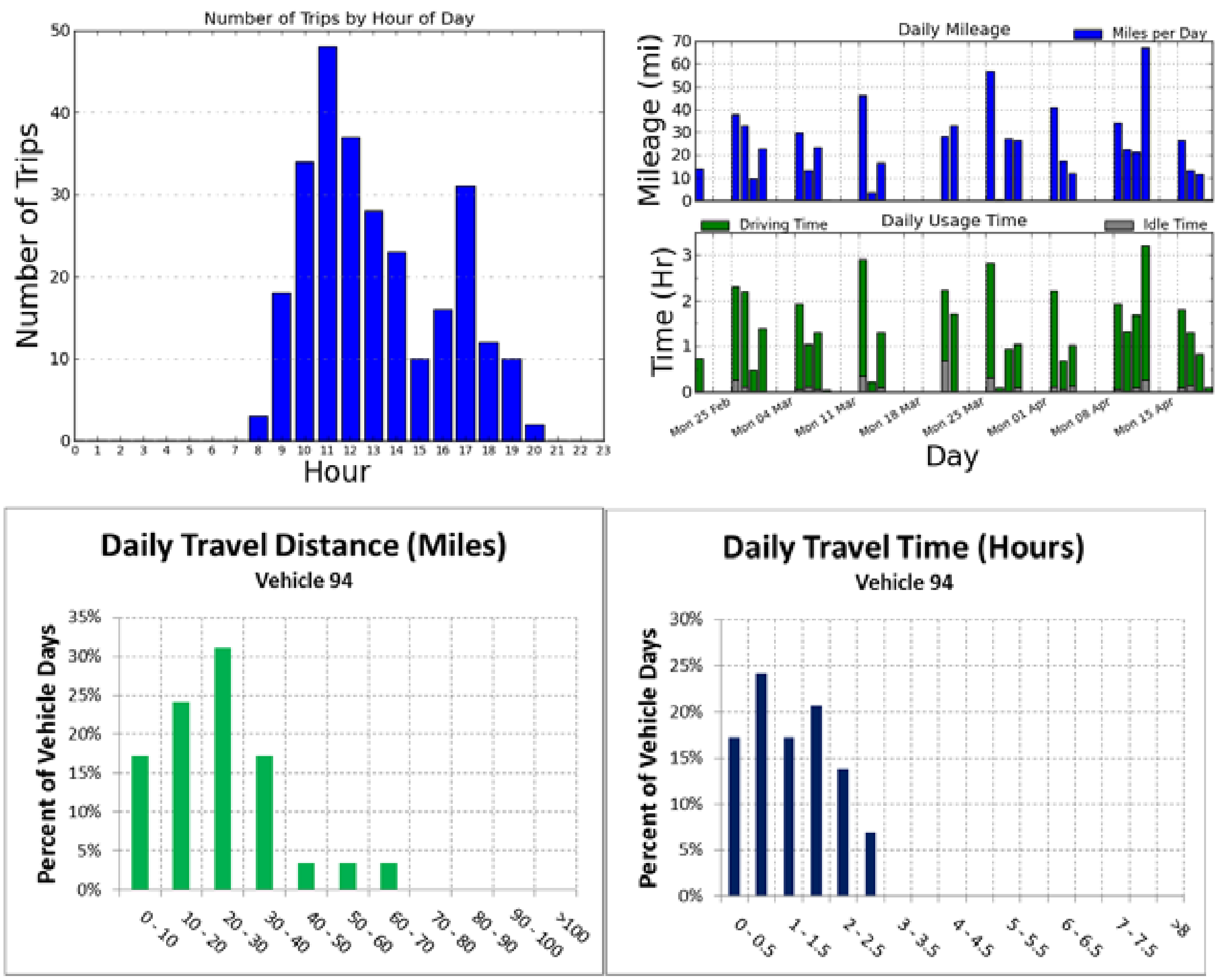

Figure D-20. Vehicle 94 travel graphs.

Vehicle 94 Observations

Logger 56 collected data on Vehicle 94 for a period of 38 study days, during which 29 days showed usage. Data validation occurred on 99% of the vehicle data, while 1% of the data are null values. GGNRA reports the vehicle's primary home base as McReynolds Road near the Bay Area Discovery Museum and referred to by GGNRA as 507.

During the study period, the vehicle traveled a total distance of 687 miles over 37.7 hours. Of all vehicle travel days, 100% were within the 70-mile BEV safe range (the green bars on Figure D-20). In addition, all of the outings were within the BEV safe range.

An EVSE located at the typical parking location allows for the possibility of beginning each drive day with a full charge.

These data indicate that a BEV can accomplish this vehicle's mission.

Vehicle 95

www.dieselstation.com

Make/Model/Year	Ford/Ranger/2010
EPA Class Size	Small Pickup Truck 2WD
Mission	Support
GVWR	5,000 lb
Vehicle Identification Number (VIN)	1FTKR4EE8APA69182
Fleet Vehicle ID	3506K
Fuel Type	Gas
EPA Label / MPG (City/Hwy)	Gas 15/21; E85 N/A
ETEC Study ID	Vehicle 95; Logger 58
Vehicle Study Period	02/21/20/13 to 4/19/2013
Total Vehicle Days/Total Study Days	48/57

Vehicle 95 Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	24.7/43.4	5.04/25.9	1.30/15.5	1,184
Travel Time (Minutes)	130/246	26.6/135	6.88/71	6,244
Idle Time (Minutes)	31.1/NA	1.65/NA	5.58/NA	1,495

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	825	100%	Less than 1	754
10 to 20	0	0%	1 to 4	25
20 to 40	0	0%	4 to 8	2
40 to 60	0	0%	Greater than 8	44

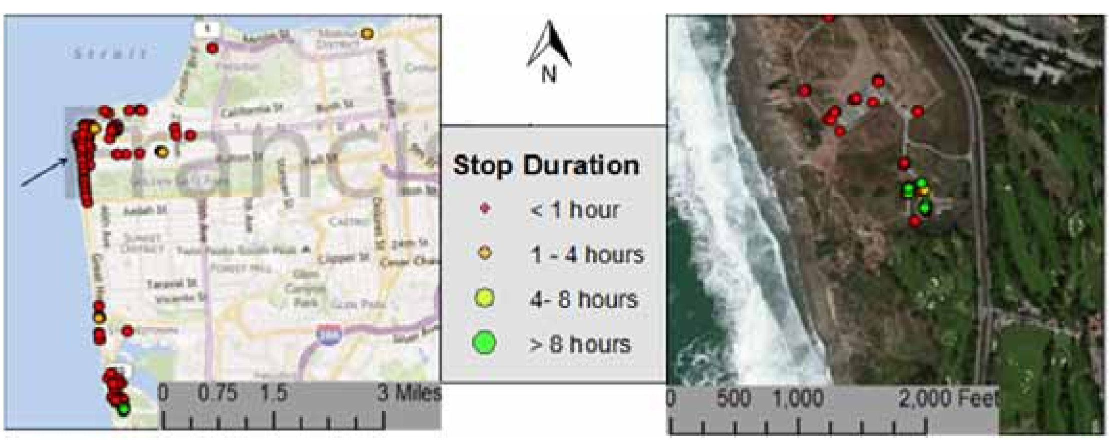

Figure D-21. Vehicle 95 all vehicle stops.

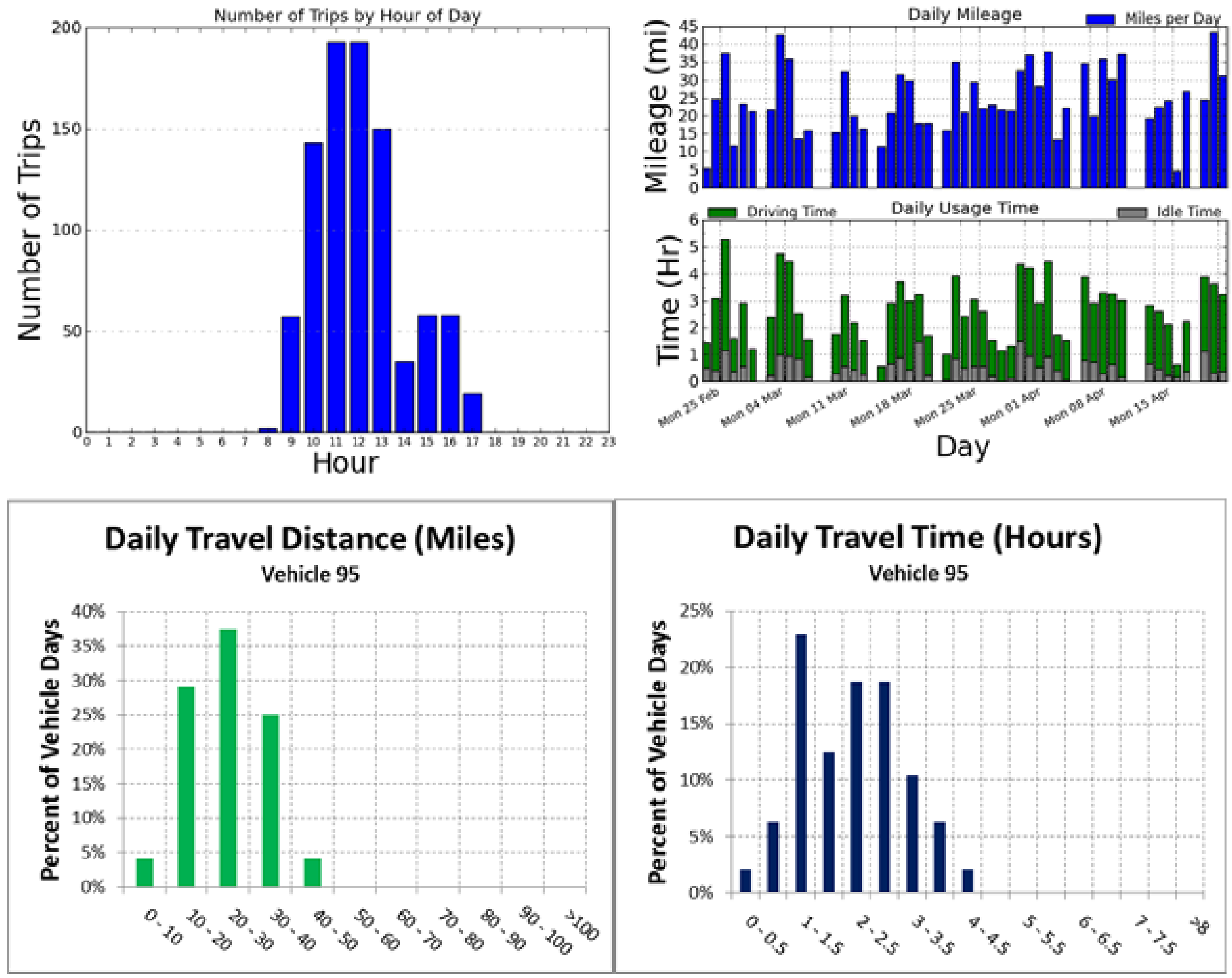

Figure D-22. Vehicle 95 travel graphs.

Vehicle 95 Observations

Logger 58 collected data on Vehicle 95 for a period of 57 study days, during which 48 days showed usage. Data validation occurred on 100% of the vehicle data. GGNRA did not report the vehicle's primary home base, but the travel data suggest that it is the Upper Great Highway at Golden Gate Park.

During the study period, the vehicle traveled a total distance of 1,184 miles over 104 hours. Of all vehicle travel days, 100% were within the 70-mile BEV safe range (the green bars on Figure D-22). In addition, all of the outings were within the BEV safe range.

An EVSE located at the typical parking location allows for the possibility of beginning each drive day with a full charge.

These data indicate that a BEV can accomplish this vehicle's mission.

Vehicle 96

www.dieselstation.com

Make/Model/Year	Ford/Ranger/2010
EPA Class Size	Small Pickup Truck 2WD
Mission	Support
GVWR	5,000 lb
Vehicle Identification Number (VIN)	1FTKR4EEXAPA69183
Fleet Vehicle ID	G41-3508k
Fuel Type	Gas
EPA Label/MPG (City/Hwy)	Gas 15/21; E85 N/A
ETEC Study ID	Vehicle 96; Logger 59
Vehicle Study Period	02/21/20/13 to 3/31/2013
Total Vehicle Days/Total Study Days	46/58

Vehicle 96 Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	13.7/33.4	4.36/32.1	0.63/10.8	629
Travel Time (Minutes)	96.2/218	30.7/159	4.44/124	4,427
Idle Time (Minutes)	16.3/NA	0.75/NA	4.95/NA	748

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	792	100%	Less than 1	701
10 to 20	0	0%	1 to 4	47
20 to 40	0	0%	4 to 8	1
40 to 60	0	0%	Greater than 8	43

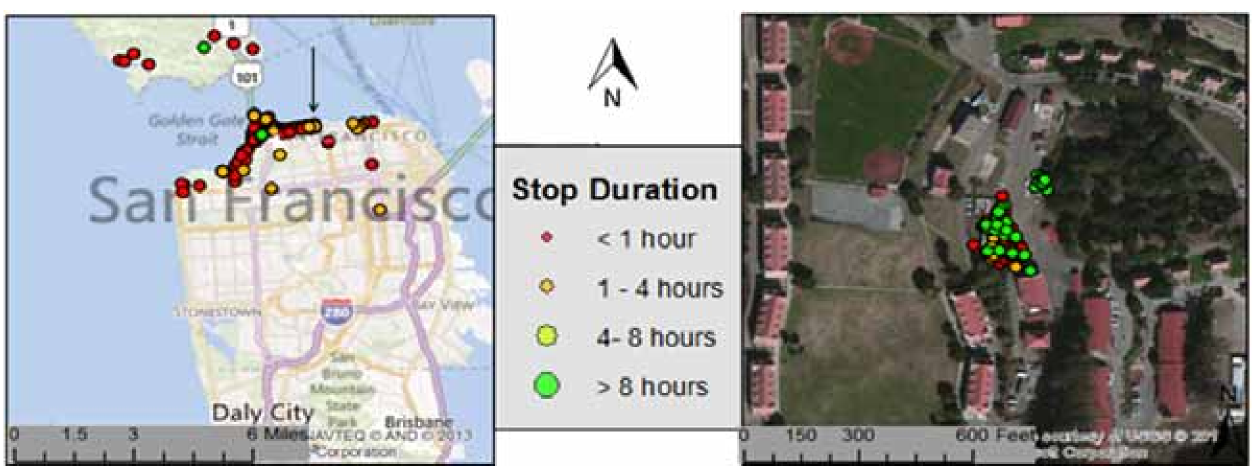

Figure D-23. Vehicle 96 all vehicle stops.

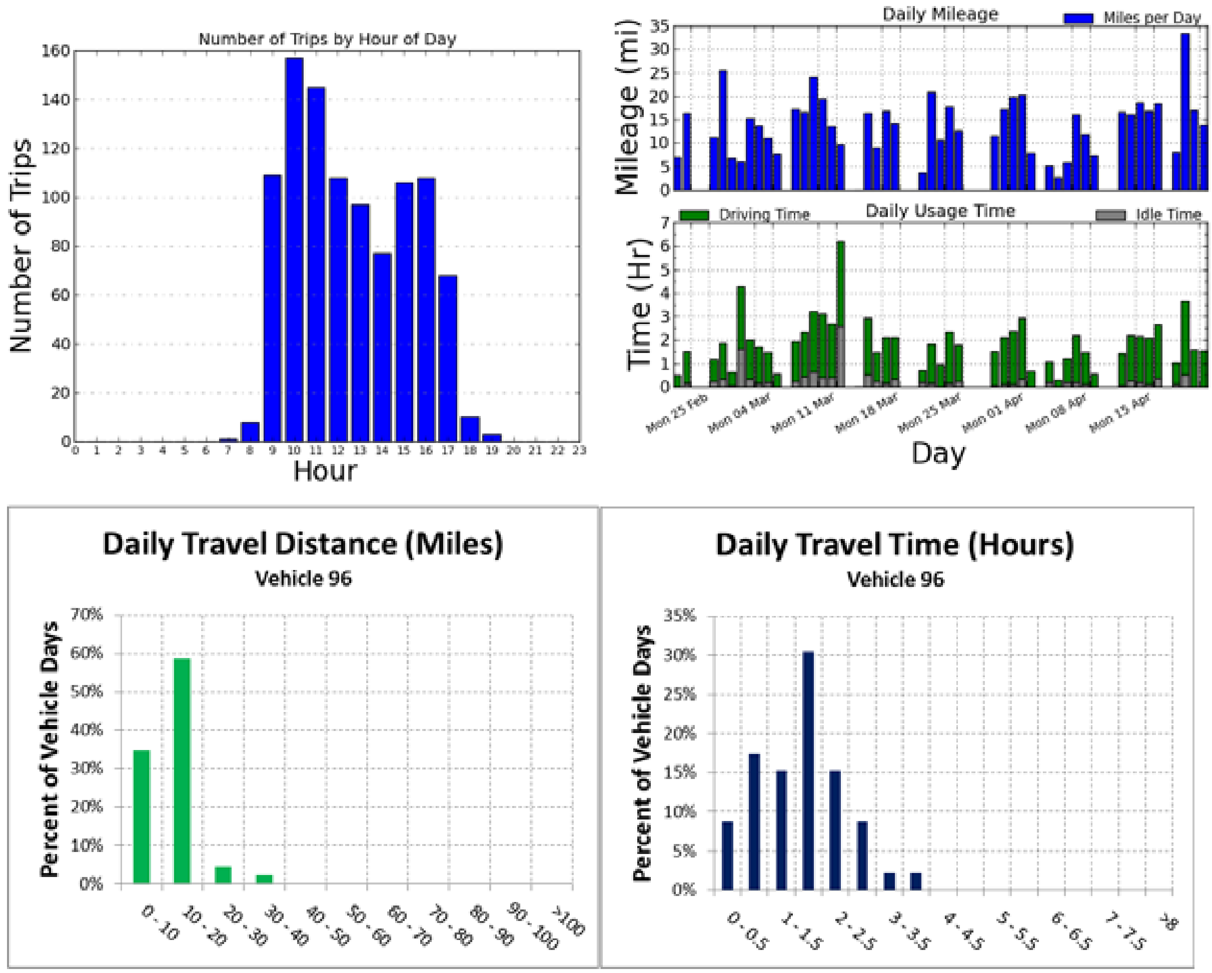

Figure D-24. Vehicle 96 travel graphs.

Vehicle 96 Observations

Logger 59 collected data on Vehicle 96 for a period of 58 study days, during which 46 days showed usage. Data validation occurred on 99% of the vehicle data, while 1% of the data are null values. GGNRA did not report the vehicle's primary home base, but the travel data suggest that it is the Upper Great Highway at Golden Gate Park.

During the study period, the vehicle traveled a total distance of 629 miles over 73 hours. Of all vehicle travel days, 100% were within the 70-mile BEV safe range (the green bars on Figure D-24). In addition, all of the outings were within the BEV safe range.

An EVSE located at the typical parking location allows for the possibility of beginning each drive day with a full charge.

These data indicate that a BEV can accomplish this vehicle's mission.

Vehicle 97

www.caranddriver.com

Make/Model/Year	Ford/Ranger/2006
EPA Class Size	Standard Pickup Truck 2WD
Mission	Support
GVWR	4,760 lb
Vehicle Identification Number (VIN)	1FTYR11U86PA93205
Fleet Vehicle ID	G61-0091
Fuel Type	Gas
EPA Label/MPG (City/Hwy)	Gas 15/21; E85 N/A
ETEC Study ID	Vehicle 97; Logger 61
Vehicle Study Period	02/21/20/13 to 3/31/2013
Total Vehicle Days/Total Study Days	48/58

Vehicle 97 Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	12.8/35.6	4.63/30.6	1.01/12.5	615
Travel Time (Minutes)	162/334	58.4/331	12.7/144	7,770
Idle Time (Minutes)	93.1/NA	7.30/NA	8.54/NA	4,468

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	681	100%	Less than 1	587
10 to 20	2	0.3%	1 to 4	50
20 to 40	0	0%	4 to 8	0
40 to 60	0	0%	Greater than 8	46

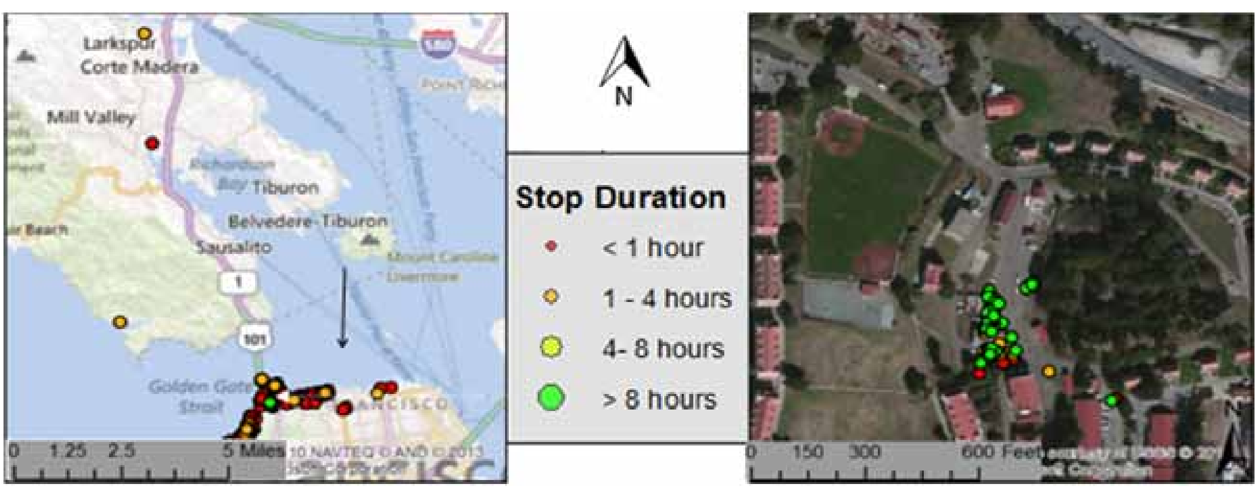

Figure D-25. Vehicle 97 all vehicle stops.

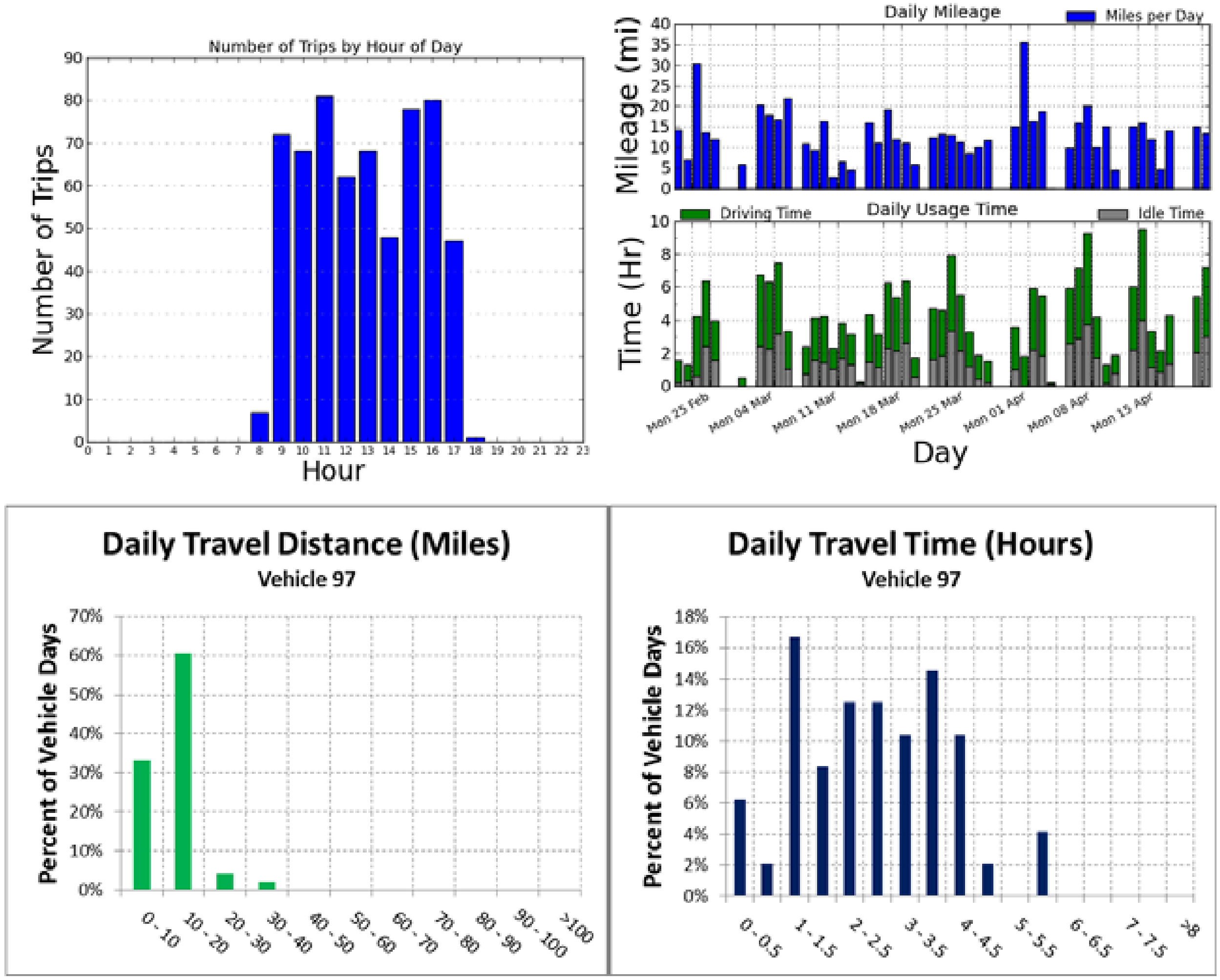

Figure D-26. Vehicle 97 travel graphs.

Vehicle 97 Observations

Logger 61 collected data on Vehicle 97 for a period of 58 study days, during which 48 days showed usage. Data validation occurred on 99% of the vehicle data, while 1% of the data are null values. GGNRA did not report the vehicle's primary home base, but the travel data suggest that it is Howe Road.

During the study period, the vehicle traveled a total distance of 615 miles over 129 hours. Of all vehicle travel days, 100% were within the 70-mile BEV safe range (the green bars on Figure D-26). In addition, all of the outings were within the BEV safe range.

An EVSE located at the typical parking location allows for the possibility of beginning each drive day with a full charge.

These data indicate that a BEV can accomplish this vehicle's mission.

Vehicle 99

www.autoblog.com

Make/Model/Year	Jeep/Liberty/2010
EPA Class Size	SUV – 4WD
Mission	Support
GVWR	5,600 lb
Vehicle Identification Number (VIN)	1J4PN2GK0AW164182
Fleet Vehicle ID	G61-1350K
Fuel Type	Gas/E85
EPA Label/MPG (City/Hwy)	Gas 16/22
ETEC Study ID	Vehicle 99; Logger 67
Vehicle Study Period	02/22/20/13 to 3/31/2013
Total Vehicle Days/Total Study Days	31/56

Vehicle 99 Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	26.3/58.1	9.82/45.3	5.44/22.1	815 mi
Travel Time (Minutes)	120/256	44.9/217	24.8/119	3,723
Idle Time (Minutes)	49.0/NA	10.1/NA	8.88/NA	1,519

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	180	81%	Less than 1	167
10 to 20	41	19%	1 to 4	21
20 to 40	0	0%	4 to 8	3
40 to 60	0	0%	Greater than 8	30

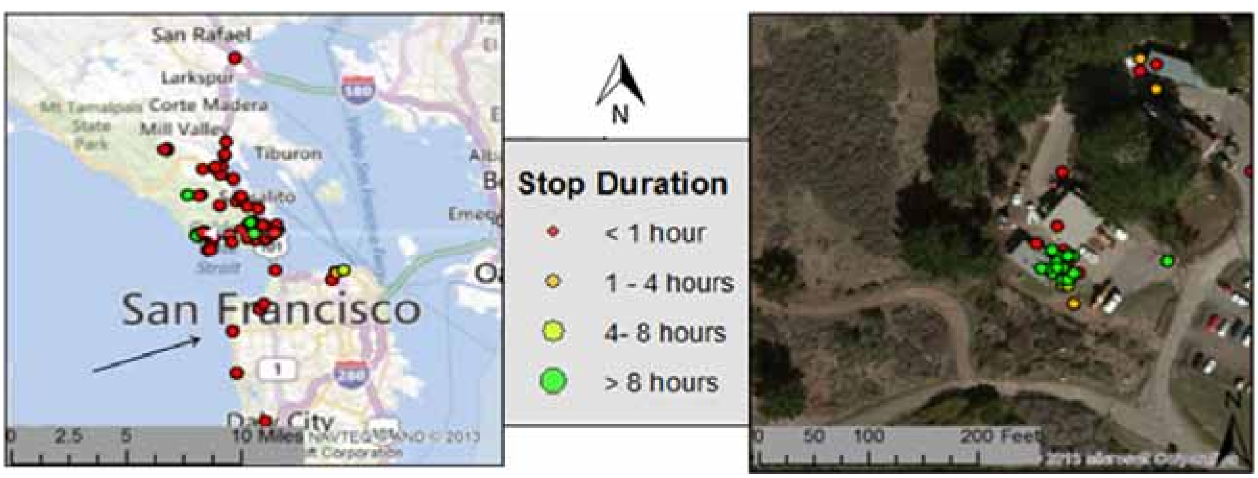

Figure D-27. Vehicle 99 all vehicle stops.

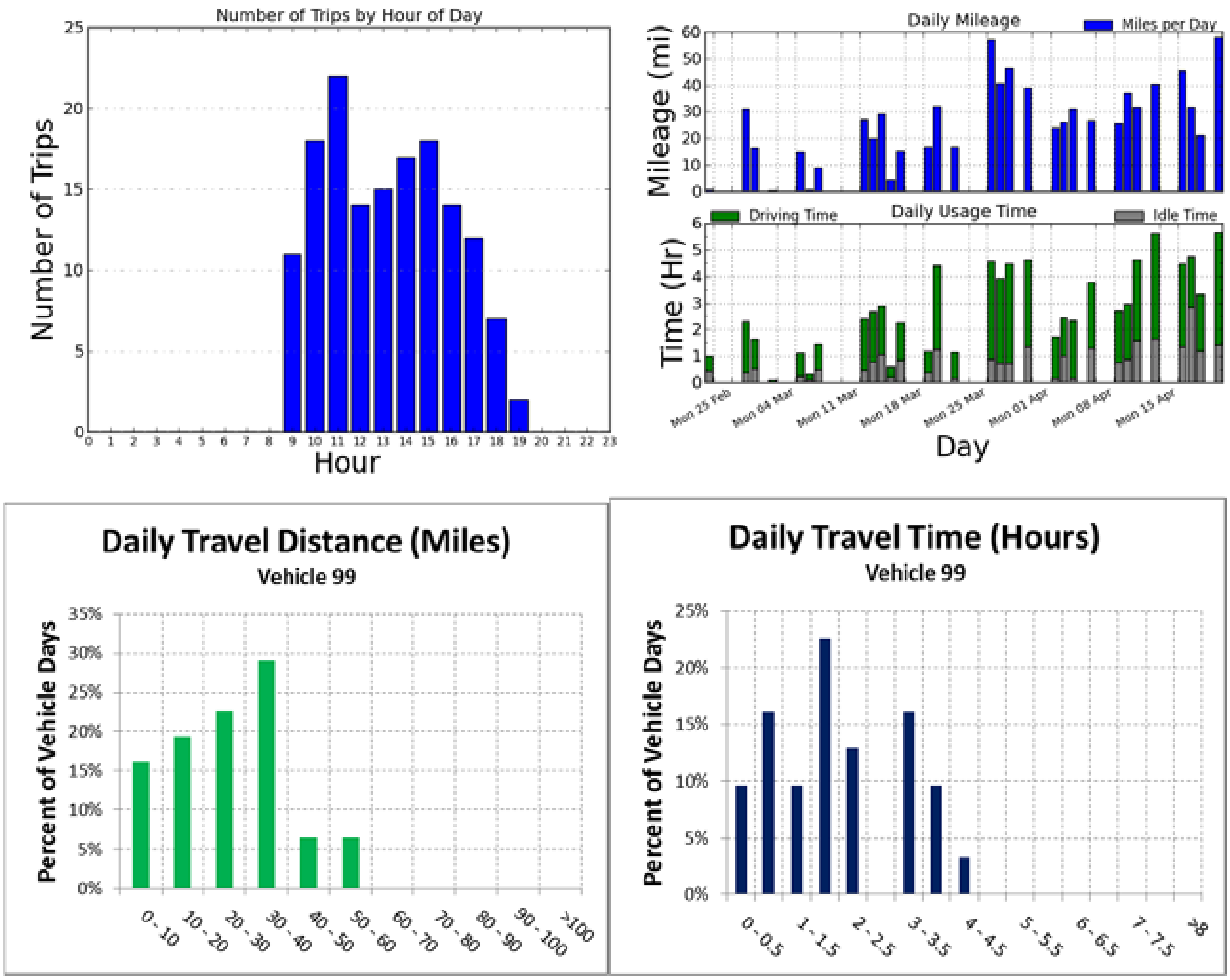

Figure D-28. Vehicle 99 travel graphs.

Vehicle 99 Observations

Logger 67 collected data on Vehicle 99 for a period of 56 study days, during which 31 days showed usage. Data validation occurred on 94% of the vehicle data, while 6% of the data are null values. GGNRA reports the vehicle’s primary home base as Fort Funston.

During the study period, the vehicle traveled a total distance of 815 miles over 62 hours. Of all vehicle travel days, 100% were within the 70-mile BEV safe range (see the green bars on Figure D-28). In addition, all of the outings were within the BEV safe range.

An EVSE located at the typical parking location allows for the possibility of beginning each drive with a full charge.

These data indicate that a BEV can accomplish this vehicle’s mission.