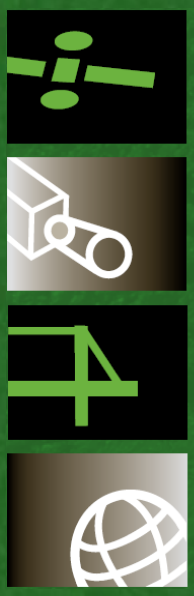
Federal Highway Administration

Exploratory Advanced Research Program



Casual Carpooling Scan Report

Washington, DC; Houston, TX; and San Francisco, CA

November 17–December 8, 2010

U.S. Department of Transportation
Federal Highway Administration

Foreword

The Federal Highway Administration's (FHWA's) Exploratory Advanced Research (EAR) Program addresses the need to conduct longer term and higher risk breakthrough research with the potential for transformational improvements to plan, build, renew, and operate safe, congestion free, and environmentally sound transportation systems. The program addresses underlying gaps faced by applied highway research programs, anticipates emerging issues with national implications, and reflects broad transportation industry goals and objectives.

During November and December 2010, the EAR Program supported a team that consisted of transportation professionals, academic faculty, and business entrepreneurs who visited informal carpool lines (also called *slug lines* or *casual carpool lines*) in Washington, DC; Houston, TX; and San Francisco, CA, to observe "slugs" and to compare practices among locations. The team also met with private ride–match providers, regional planners, carpool participants, and transportation planners and engineers, with the overall goal of studying these ridesharing systems to evaluate whether to fund research on the potential for and value of expansion or replication.

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Director, Office of Transportation Management

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Director, Office of Corporate Research, Technology, and Innovation Management

Notice

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16. Abstract During November and December 2010, the Exploratory Advanced Research (EAR) Program supported a team that consisted of transportation professionals, academic faculty, and business entrepreneurs who visited informal carpool lines (also called *slug lines* or *casual carpool lines*) in Washington, DC; Houston, TX; and San Francisco, CA, to observe "slugs" and to compare practices among locations. The team also met with private ride–match providers, regional planners, carpool participants, and transportation planners and engineers with the overall goal of studying these ridesharing systems. The foundational knowledge gained on this scan will serve as a jumping-off point for future projects, collaborations, and system expansion. Appendix B to this report is published as FHWA-HRT-13-023, *Appendix B to the Casual Carpooling Report.*		
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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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Introduction

Despite the long history of dynamic ridesharing (sometimes called *slugging* or *casual carpooling*) in several U.S. cities, little research has been undertaken to understand its challenges and opportunities. The Federal Highway Administration's (FHWA's) Exploratory Advanced Research (EAR) Program has been exploring how slugging works, taking a two-part approach (scanning and focus groups) to studying the mechanics, logistics, and success of the practice.

Many academics and entrepreneurs have been looking at ways to facilitate dynamic ridesharing through technological means. These efforts are most often justified as feasible by pointing to the success of the dynamic ridesharing systems that exist in the three cities evaluated. These three systems have no formal leadership or management; rather, they have evolved at the grassroots level to fulfill a need for carpools created by the presence of high-occupancy vehicle (HOV) lanes. These naturally occurring dynamic ridesharing systems operate by having drivers and riders meet at central, easily accessible locations, such as park-and-ride lots, where they create instantaneous carpools based on desired destinations. The robust commuting system is highly successful and long-lasting (30+ years in the case of Washington, DC) and serves thousands of people each weekday.

This scan trip evaluation brought a select group of academics and transportation professionals (see table 1) to the slug/casual carpool lines in each of the three cities to observe the dynamic ridesharing phenomenon, to meet with State and regional transportation officials, and to talk to dynamic ridesharing participants. The overall goal of studying these ridesharing systems is to evaluate whether to fund research on the potential for and value of expansion or replication. This report was produced by the scan team participants, who outlined what they learned at the dynamic ridesharing sites and identified what gaps exist in the data and research. The report suggests where funds and efforts could be targeted for expanding or replicating the dynamic ridesharing systems. The foundational knowledge gained on this scan will serve as a jumping-off point for future projects, collaborations, and system expansion.

The EAR Program is supporting qualitative research by assembling focus group participants from those who slug or casual carpool to work in three cities—Washington, DC; Houston, TX; and San Francisco, CA—to gain first-hand knowledge from both the drivers and riders. The first set of focus groups was held on May 22 and 23, 2012, in Washington, DC; the second set was held on July 11 and 12, 2012, in Houston, TX; and the final set of focus groups took place on August 21 and 22, 2012, in San Francisco, CA. For the focus groups, an independent firm contracted by FHWA asked participants about their experiences, practices, satisfaction, suggestions, and decisions related to slugging. The research firm will develop a report that summarizes the results of each of the focus groups as well as overall lessons learned.

Table 1. Scan team participants.

NAME	AFFILIATION
Dr. Mark Burris	Texas A&M University
Ed Christopher	FHWA, Resource Center
Patrick DeCorla-Souza	FHWA, Office of Innovative Program Delivery
Allen Greenberg	FHWA, Office of Operations
Susan Heinrich	San Francisco Bay Area Metropolitan Transportation Commission, 511 Traveler Information Program
Dr. Jim Morris	Carnegie Mellon University
Marc Oliphant	Department of the Navy
Eric Schreffler	ESTC Consulting
Peter Valk	Transportation Management Services (TMS) Consulting
Phil Winters	University of South Florida, Center for Urban Transportation (CUTR)

Summary of Activities

During November and December 2010, the EAR Program supported a team that consisted of transportation professionals, academic faculty, and business entrepreneurs who visited informal carpool lines (also called *slug lines* or *casual carpool lines*) in Washington, DC; Houston, TX; and San Francisco, CA, to observe "slugs" and to compare practices among locations. The team also met with private ride–match providers, regional planners, carpool participants, and transportation planners and engineers.

Washington, DC, November 17–19, 2010

The scan members arrived in Washington, DC, on the evening of Wednesday, November 17, 2010, and stayed in Woodbridge, VA, about 48 km (30 mi) south of the city. At 6 a.m. the following morning, the group visited the Horner Road Park-and-Ride lot to interact with and observe the "slugs" (casual carpoolers) who gather there in the hopes of obtaining a ride to Washington, DC, or the surrounding metropolitan area (see figures 1 and 2). The scan members spent approximately 1.5 hours observing and photographing the slug lines, as well as conversing with those waiting to make ride matches.

Figure 1. Slugs queuing to the left and vehicles approaching the line from the right at Horner Road Park-and-Ride lot.

There are three individual slug lines located at the Horner Road lot, which serve the destination areas of the Pentagon, L'Enfant/Navy Yard, and 18th Street, NW; occasionally there are other destinations, and drivers will sometimes use signs to announce their destination to riders, as shown in figure 3. Scan group members visited each individual line during the course of the morning. At 6:30 a.m., the L'Enfant/Navy Yard line had 45 people queuing to become passengers, whereas the Pentagon line had 6 vehicles waiting for passengers. This difference could lead to several conclusions. Parking may be more readily available at the Pentagon, and thus more commuters might be willing to drive. It could also mean that the busy time for the Pentagon line is earlier than 6:30 a.m. One man waiting in the slug line noted that parking for him (in the Crystal City area of Arlington, VA) can cost $18 per day, which is a strong incentive not to drive. Others pointed out that the slugging volume tends to be lighter on Mondays and Fridays because many Federal workers work 9-hour days and take every other Monday or Friday off.

Figure 2. A slug enters a vehicle at Horner Road Park-and-Ride lot in Prince William County, VA.

Figure 3. A driver holds up a sign indicating his or her destination.

The scan group members joined the slug line (i.e., passenger-waiting queue) for the 18th Street corridor with instructions to catch rides individually and then rendezvous at a coffee shop on 14th Street in Washington, DC. The entire group made it to the coffee shop safely (and separately) by slugging. At the coffee shop, the group members convened to debrief one another on their individual slugging experiences. Eric Schreffler of the scan group drove alone in the group's rental van to 14th Street because there were no slugs to pick up by the time he departed from the Horner Road Park-and-Ride lot. It took Schreffler 1.5 hours to drive to the 14th Street coffee shop by using the general purpose lanes, whereas it took less than 30 minutes for each of the team members who slugged.

Figure 4. Amber Carran-Fletcher of DDOT, Masoud Hamedi of the University of Maryland, Patrick DeCorla-Souza of FHWA, and Peter Valk of Transportation Management Services Consulting (left to right).

At 9 a.m., the group met with Amber Carran-Fletcher of the District Department of Transportation (DDOT) for a walking tour of the slug line locations on 14th Street. Carran-Fletcher detailed DDOT's efforts to move some of the slug lines currently located on 14th Street to side streets to avoid the lane slowdowns that can occur when vehicles stop in a travel lane to pick up passengers. For many years, vehicles have stopped illegally along 14th Street to pick up slugs—enforcement was rather lax so it occurred "under the radar," and citations were rarely issued, perhaps because commuter and local Metro buses also stop in the curb lanes in the same area to pick up passengers.

The scan group walked down 14th Street with Carran-Fletcher to the National Mall to visit DDOT's new proposed slug line locations. Masoud Hamedi, a civil engineering student enrolled in a doctoral program at the University of Maryland, College Park, and who is interested in technology-facilitated dynamic ridesharing also joined the group (see figure 4). The afternoon slug lines are located on 14th Street. The slugs like to be able to see commuter bus stops from their line locations so that they can catch the bus if it arrives before a driver looking for a slug does.

On the afternoon of November 18, the scan group drove across the Potomac River to Virginia to meet with transportation-planning staff at the Pentagon and to learn more about the slug lines there. The tour was guided by two Department of Defense (DOD)–Washington Headquarters Services[1] contractors who discussed how the slug lines function there and what the Pentagon does to help accommodate them. The Pentagon public works department provides signage that indicates to which destination(s) each slug line pertains. Facility planners there have also taken advantage of a former bus-queuing area with shelters and lots of curb space to accommodate several of the slug lines.

The Pentagon is the most popular morning slug line destination, has the most individual afternoon lines of any location, and also has the highest total slugging volume of any location. The group again interacted with slugs there and observed the slug lines but took no photos because of security restrictions. After spending approximately 2 hours observing the Pentagon slug lines, the group members lined up at the Horner Road slug line for the afternoon reverse commute and caught rides back to the Horner Road Park-and-Ride lot.

In the evening, the scan team reconvened to discuss the day's observations and to meet with David LeBlanc. LeBlanc wrote the book *Slugging: The Commuting Alternative for Washington, D.C.* in 1998 and subsequently started the Web site www.slug-lines.com, which is a central information clearinghouse for

[1] Washington Headquarters Services is a DOD field activity that provides operational and support services to DOD tenants in the National Capital Region.

slugging. As both a long-time slug and author, LeBlanc is an expert in the "operational" side of slugging and has used his Web site to help slugs with line information, discussion forums, lost-and-found postings, and promotions for new slug lines. LeBlanc said that he resisted slugging for a number of years before finally giving it a try. All it took was trying it once, and he was converted. Being frustrated by the lack of information on the subject, he decided to write the book to help provide information to slugs. The Web site was originally an afterthought to be used for marketing the book, but it has turned out to be the best asset for distributing information about slugging. LeBlanc's Web site has more than 18,000 registered users (you must register to post on the message boards) and is also used to help create new lines or move the locations of existing lines.

The next morning, November 19, the scan group visited the slug lines at Potomac Mills Mall, a major regional outlet mall in Prince William County, VA, with easy access to Interstate 95 (I-95). For many years, Potomac Mills furnished about 1,000 parking spaces each weekday for commuter use, until March 2011 when that number was scaled back to 250 spaces to provide space for new construction at the mall. There were three individual slug lines at the mall that served downtown DC; Rosslyn, VA; and the Pentagon; one of these lines is shown in figure 5. The group again interacted with people in line and drivers of vehicles who were waiting to pick up slugs. The group asked the slugs questions, such as how they got started slugging and what it took for them to try it for the first time. Many people responded that a testimonial from a trusted co-worker or family member was one of the most popular ways to convince people to try slugging for the first time.

Figure 5. Slugs lined up at Potomac Mills parking lot with vehicles approaching from the right side.

The scan members waited in the Rosslyn slug line and slugged individually to the Rosslyn destination in Arlington, VA. There they met with Peggy Tadej of the Northern Virginia Regional Commission and representatives of Arlington Transportation Partners to learn more about the commuting situation in the Northern Virginia region. The meeting focused on the effects of the DOD Base Realignment and Closure (BRAC) Act workforce movements happening in the area, their impacts on traffic, and how slugging might help. Afterward, the group had a meeting with a representative of AVEGO, a private firm that markets dynamic ridesharing software for smart phones (e.g., iPhone, Android, etc). The discussion centered on the possibilities for technology to help facilitate non-organic dynamic ridesharing in new locations and corridors.

Afterward, the team adjourned the Washington, DC, portion of the scan with instructions to reconvene 3 weeks later in Houston, TX.

Summary of Lessons Learned and Analysis of Practices

Slugging in Washington, DC, is unique for several reasons. The two dedicated (HOV) lanes along I-95 stretch for 43.5 km (27 mi) south of the city. Washington has, by far, the best information Web site (www.slug-lines.com) of the three cities, which does an excellent job of publicizing this commute mode.

The high number of unique origins and destinations in Washington, DC, is also of great interest. This probably has been facilitated by the existence of the slug line Web site, whereas other cities share information more so via word-of-mouth. The fact that Washington has so many Federal Government employees also may serve as a catalyst for slugging. These workers have regular, consistent work schedules and similar work situations (down to the identification badges that they wear around their necks), which probably helps increase the level of trust among participants.

General Observations

These general observations are largely based on the trip summary of scan member Phil Winters and others' discussions with slugs in line on November 17 and 19. The key elements for slug line success appear to involve the following characteristics:

- HOV 3+ requirement, that is, two strangers in a car feels safer than one. (The number associated with "HOV" is the State's designation for a vehicle requiring a specified number of occupants to be allowed to drive in a designated HOV lane.)
- Large park-and-ride lots with easy access to HOV lanes.
- Transit service as backup (e.g., OmniRide commuter buses).
- Strong travel demand at both the trip origin and destination.
- Expensive and/or limited parking at destination.

When discussing how slugs first heard about the concept of slugging, the following sources were frequently mentioned:

- Word-of-mouth from neighbors and co-workers. (Social media sources, like Facebook and Twitter, were not mentioned).
- Web site www.slug-lines.com, which is operated by a slug who receives little outside financial support to maintain the Web site.
- New employee orientation at work.

Individuals cited the following advantages to slugging:

- Direct trip to destination; no multiple stops like transit.
- No parking costs.
- Free (unlike transit).

- Riders can remain anonymous. There is no pressure to socialize with others like there may be in a traditional carpool.

- Conversely, slugging may create *more* social opportunities than taking transit (depending on whether the driver wishes to initiate conversation with the other passengers). One driver said he met his wife while slugging.

Additional observations of the slug lines include the following:

- There is a wide diversity of participants in terms of gender, socio-economic status, ethnicity, and employment type. Participants do not appear overly adventuresome but instead appear to be a very pragmatic group.

- Many participants choose to drive as well as ride. Individual schedules (e.g., need to leave work early) determine whether they choose to drive on any given day (if they have parking at their destination).

- Some park-and-ride lots have different peak times, so drivers may choose different pick-up locations based on departure time (e.g., Horner for early departures followed by Potomac Mills, then Tackett's Mill).

- Participants did not note any social or familial stigma associated with slugging. Many participants cited that their spouses also slugged and thus felt secure with slugging as a travel option (e.g., in case of vehicle breakdown).

- Email contact is infrequent among participants.

- Participants are orderly in nature and most observed the following etiquette (some of which are mentioned in the "Etiquette/Rules" section of the Web site www.slug-lines.com):

    - Little talking in line and no coffee or eating observed in line (not allowed in vehicles).

    - First person in line yells out destination of drivers until his or her ride.

    - Split lines are formed for different destinations when demand is high; negotiation between riders and drivers may occur when the line is short.

    - No talking to the driver unless spoken to first.

    - Limit to three-person carpools unless there are many more riders than available vehicles in line, especially when approaching the end of the traditional commuting period. Otherwise, drivers could be stealing riders from the next vehicle.

- Some drivers travel much farther than do passengers; carrying slugs on HOV lanes for part of a trip cuts some of their commute time.

- Unsafe drivers eventually are identified by fellow slugs, and this information is shared among the slugging community via word-of-mouth. Speeding and weaving in traffic were common safety problems cited by some.

- Slugging does not appear to work on I-66 (based on slugs' understanding). This is likely due to HOV-2, rather than HOV-3, passenger requirements and non-barrier separated lanes.

- Travel speeds were high when first departing from the pick-up location but slowed when approaching Washington, DC. The return trip from the Pentagon and the trip to Rosslyn were quick.

- Slugs are generally tolerant of single-occupancy vehicle (SOV) hybrids in HOV lanes as long as flow is maintained. (Hybrid cars are exempt from the HOV passenger restriction on some Virginia roadways and thus are permitted to travel in HOV lanes with no additional occupants.)

- Slugs and public agencies (e.g., DDOT, Pentagon) seem committed to keeping the control of the slugging enterprise under the direction of the slugs but recognize the importance of supporting infrastructure.

- DDOT involvement with slugs in the development of a commuter solution should be applauded; however, establishing communication with slugs is a challenge.

- A flyer was used to announce the splitting of a line serving multiple locations into additional lines, each serving fewer or only one location.

- Public agencies and employers seem reluctant to actively encourage slugging, although they provide staging areas and signage. There appears to be a lack of understanding of legal standing in the promotion of slugging by employers.

- There is little officially known about slugging, including the number of active slugs (e.g., census), frequency of slugging, duration of travel, etc.

Houston, TX, December 5–6, 2010

The scan group arrived in Houston on the evening of Sunday, December 5, 2010, and stayed in the western suburb of Katy, TX. On Monday morning, group members visited three different slug line origin locations in the Houston region: Kingsland Park-and-Ride lot (see figure 6), Addicks Park-and-Ride lot, and Northwest Park-and-Ride lot (none of the group members visited all three individually but collectively all three locations were visited).

Figure 6. A vehicle waits for slugs at the Kingsland Park-and-Ride lot in suburban Houston, TX.

Various members of the group slugged into downtown Houston from each park-and-ride location. Nader Mirjamali (Project Manager, High-Occupancy Toll (HOT) Lanes) of Houston METRO (Metropolitan Transit Authority of Harris County, Houston, TX) met the group at the Addicks Park-and-Ride lot (see figure 7) to orient group members and to explain how slugging works in Houston. Mirjamali often makes his personal commute to work via slugging and thus had an extra measure of insight into the practice. At the bus shelters in each park-and-ride lot, Houston METRO has installed signs and demarcated separate waiting areas for the slugs to queue for rides. Rider volume in the Houston lines was rather small for the duration of the groups' observation (with rider and vehicle queues never exceeding the single digits). Most vehicles tended to pick up just one passenger, consistent with the new rules allowing free travel during most times with two-person carpools, although the group did observe a few vehicles picking up two passengers (and one vehicle even picked up three).

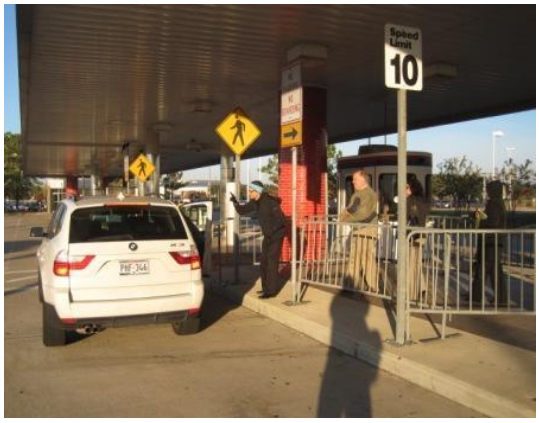

Figure 7. A vehicle picks up slugs at the Addicks Park-and-Ride lot in suburban Houston, TX. Scan member Peter Valk holds up his index finger to inquire whether the driver will take one more passenger.

The Katy Freeway (along which two of the slug line locations sit) underwent major changes within the past 2 years. Additional lanes were added, and the limited access portion was changed from HOV to HOT status. The Katy Freeway now has nine lanes in each direction (three frontage lanes, four general purpose, and two managed HOT lanes), which has significantly increased the capacity of the roadway and reduced congestions on the general purpose lanes. This probably helps to explain the low-slugging volume, as carpools now offer little time savings. (It was confirmed through independent research by Dr. Mark Burris, a scan tour participant, that slugging volume in Houston has decreased by 50 percent.) The HOV discount on the Katy HOT lanes is now available from 5 a.m. until 8 p.m. (15 hours per day).

On the Katy Freeway, drivers have three options, as follows:

- Drive on the general purpose lanes and risk higher traffic congestion.
- Pay to use the HOT lanes (peak-hour toll is $4).
- Pick up slugs or arrange a formal carpool to use the HOT lanes for free.

Drivers may vary their behavior depending on their time of departure, traffic conditions, and whether they are in a hurry.

The group members individually slugged into downtown Houston and reconvened to relate and discuss their slugging experiences. The unwritten rule for slugging drivers in Houston is that they are presumed to be willing to drop off their passengers anywhere that the commuter buses make drop-offs along Smith Street (an 18-block length from Franklin to Pierce Streets). At times, before a passenger enters a vehicle, the driver will inquire how far down Smith Street he or she needs to go, after which the driver may then elect not to take a passenger who wants to be dropped off beyond the driver's destination.

At mid-morning, the team made its way to the Houston METRO offices to meet with Mirjamali and Vincent Obregon (Associated Vice President, Capital Program Implementation). Mirjamali and Obregon briefed the group on the history of slugging in the area, METRO's thoughts about the practice, and plans for other highway projects in the area. METRO tolerates slugging and even helps facilitate it in small ways, such as by providing designated waiting areas at the park-and-ride lots, so long as it does not interfere with their commuter bus operations and that plenty of parking spaces remain available for the bus users. Mirjamali and Obregon estimated that their average fare box recovery for the commuter buses was 20 percent. The full one-way fare to ride a commuter bus can cost up to $4.50, although many employers help reimburse that cost. During the peak travel time, the commuter buses run on 4-minute headways; thus, individuals spend very little time waiting. The Houston region has plans to convert more than 129 km (80 mi) of HOV lanes to HOT lanes by the beginning of 2013.

One METRO employee noted his personal motivation for slugging rather than taking the commuter bus (which he could do for free as a METRO employee) is that the METRO headquarters sits at the end of the bus route and he would have to wait for the bus to make multiple passenger drop-offs before it arrived at his destination. This extra time spent waiting justified the mode switch to slugging for him.

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Figure 8. A Houston METRO bus picks up passengers for the afternoon commute along Louisiana Street downtown.

In the afternoon on the same day, the scan group went to Louisiana Street, the major outbound downtown thoroughfare parallel to Smith Street, to try to locate slugs making the return commute. Afternoon slugging in Houston is much less prevalent than is morning slugging. As shown in figure 8, instead of slugging, many commuters will take a commuter bus back to the park-and-ride lot. The group only saw one dynamic ride–match occur. A pick-up truck drove up

to the commuter bus stop, and the driver asked if anyone was headed to his particular park-and-ride lot. One of the people in line answered in the affirmative and got in. The scan group did not attempt to slug back out to the park-and-ride lots (as passengers) from downtown. The group, however, did pick up a slug from the bus line and drove her to the Northwest Park-and-Ride lot, which is located near the airport. The woman was very helpful in telling the group about slugging and was also invaluable in guiding the group out of downtown and onto the HOV lanes (see figure 9). This raised another interesting question about roadway and transit system literacy. If it had not been for the slug who guided the scan group, they would have been at a loss in trying to access and use the HOV facilities.

Figure 9. View of limited-access westbound HOV lane on the Northwest Freeway outside of Houston, TX.

Driving slugs requires a thorough knowledge and experience with the Houston transportation infrastructure (especially because there is no informational Web site for Houston slugs). The Houston HOV and HOT networks appeared to be especially complex.

Summary of Lessons Learned and Analysis of Practices

Time savings is a significant factor for passengers who decide to slug. Congestion has been reduced in recent years because of the improvement made to the Katy Freeway. Because there is no longer a strong time savings incentive to slug over taking transit or even driving alone, there are fewer slugs. There are significant numbers of transit riders paying to ride the bus from the same lots. Drivers continue to save toll money on the Katy Freeway because it is a HOT facility.

Unique to Houston is that slugs use large and visible park-and-ride lots that were established for transit riders. The park-and-ride lots have dedicated entrance and exit ramps from the freeways, making it extremely convenient for drivers to exit the freeway, pick up passengers, and return to the freeway. Despite this convenient infrastructure, the slugging population remains small. It would be interesting to know what impact this infrastructure could have on making slugging more convenient in other regions. Although it does not seem to be a factor in Houston, the lack of parking at the pick-up location, or rather the lack of safe and convenient parking, may be a factor in expanding slugging to other corridors.

Unlike in other cities, the number of people slugging was insignificant compared with the number of commuters taking the express buses, despite the $4.50 one-way bus fare. There was no observation of anyone in the bus line slugging instead of taking the bus, but it was early and only a few cars were

driving by looking for passengers. Therefore, waiting for a car ride might not have been an attractive proposition at that time but might have been later in the commute period. Dr. Mark Burris, the scan team's expert on Houston slugging, indicated that based on his experiences from focus groups in the Houston metropolitan area, he would be surprised if many people passed up the bus en route home, noting that even the more dedicated slugs would use the bus on the trip home unless a car came by first.

Safety concerns remain a factor. The scan group observed that a handful of drivers picked up more than one passenger, even though the requirement was only HOV-2, and stated that they did so because it seemed safer. The female passenger that the scan group picked up during the afternoon peak hour stated that she agreed to ride with the group because it was a group and there was one female in the group. Although there is no available approximation of the percentage of drivers who take more than one passenger, even though they are not required to for HOV access, future dynamic ridesharing systems or slugging efforts could consider how to encourage multiple passengers pairing with a single driver.

Anecdotally, it appeared that many of the Houston slugs were long-time participants from when there was a single HOV-3 lane and were still slugging out of habit after a second managed lane was added and both lanes became HOT-2 lanes (meaning carpools with as few as two participants could use the managed lanes for free, whereas those driving alone could pay to use them). There did not appear to be many new participants, however, which is probably because getting into a car with only one other person—the driver—may be perceived as dangerous by someone who has not previously slugged and also because most of the incentive was removed when the Katy Freeway improvements were made. In general, out of the three cities studied, slugging is least developed in Houston, both in terms of gross number of participants and in the extent of the origin and destination network.

San Francisco, CA, December 7–8, 2010

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Figure 10. Vehicles queuing along Sacramento Street, waiting for casual carpoolers adjacent to the North Berkeley BART station in Berkeley, CA.

The scan group arrived in San Francisco, CA, on the evening of Monday, December 6, 2010, and stayed in Berkeley, CA, on the East Bay. On Tuesday morning, the group visited the casual carpool lines at the North Berkeley Bay Area Rapid Transit (BART) station. There are only two morning destinations for San Francisco *casual carpoolers* (the equivalent term for *slugs* in San Francisco)—Downtown and Civic Center. The Downtown drop-off point is near the intersection of Fremont and Howard Streets. The Civic Center drop-off point is in the general area of 9th and Market Streets. As shown in figures 10 and 11, carpool traffic at the North Berkeley BART station was rather brisk. All scan team members got a ride into the city without incident. The group met to debrief, discuss, and compare their trips. Fellow passengers commented that they like casual carpooling because they are guaranteed a seat, which is not always the case on BART, where trains are frequently "standing room only." The same trip on BART from North Berkeley to Civic Center costs $3.70.

The BART system has a clever way of ensuring that only their paying passengers park at the station. It only costs $1 to park, but the payment must be made inside the station. To enter the station, one must swipe a fare card at the turnstile. Entering and exiting the same station incurs the maximum fee of $5.40. So someone parking at the station but not intending to ride BART, perhaps casual carpooling instead, will pay $6.40 per day to park there. The team later found out that free, on-street parking without time limitations is abundantly available in the neighborhood west of the station.

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Figure 11. A casual carpooler confirms the driver's destination before entering a vehicle outside of the North Berkeley BART station in Berkeley, CA.

San Francisco is different from Washington, DC, and Houston, TX, because in July 2010 it began charging carpools (HOVs) to cross the San Francisco–Oakland Bay Bridge (SFOBB). Since that change, protocol has evolved to dictate (generally, though not universally for all destinations) that casual carpool riders offer a dollar to their drivers. Most of the scan group members followed this protocol, and most of the drivers accepted the token reimbursement. (An HOV now pays $2.50 to cross the SFOBB; thus, if a driver picks up two passengers, and each offers $1 in reimbursement, the driver is only paying $.50 out of pocket to cross the bridge.) The HOV discount on the SFOBB is available from 5 to 10 a.m. and from 3 to 7 p.m. The equivalent toll for an SOV is $6; thus, carpooling can save a driver $3.50 per day. The toll on the

SFOBB is only for westbound traffic; there is no toll in the eastbound direction. One of the major time-saving motivators for casual carpooling is that HOVs get to skip long queues leading up to the toll plaza and instead merge into traffic right at the plaza, which can save up to 30 minutes of commuting time.

In the late morning on December 7, the scan group met with Rick Hutchison and Carlo Latasa of San Francisco City CarShare, a non-profit carshare company (comparable with ZipCar on the East Coast) that is trying to integrate ride-sharing into its Web interface. The group had a productive conversation with Hutchinson and Latasa about the psychology of carpooling and how best to sell the idea to their carshare members. As a carshare company, City CarShare can take a slightly different approach to ride-matching, because users are already using their Web site for carsharing transactions (whereas companies that only offer ride-matching services must attract users to their sites for that specific purpose). Past research has revealed that online dynamic ride-matching services can have a very difficult time luring users to their sites, which makes the integration with carsharing all the more valuable. In addition, carshare members have a financial incentive to split rental fees by sharing rides.

Figure 12. Sign prohibiting parking along Beale Street, designating the area as a "passenger zone" for carpool formation during the afternoon commute hours.

At lunch time, the scan group was joined by Mark Evanoff and Jessica Scorpio. Evanoff is president of the AlterNetWays Company, a long-standing ride-matching service based in the Bay Area. Scorpio is affiliated with GETAROUND, a new startup company that offers peer-to-peer carsharing. The premise of peer-to-peer carsharing is that instead of a standalone company like ZipCar or City CarShare owning the shared vehicle, private individuals share their own personal vehicles with one another, thereby saving the capital expense of purchasing or leasing new vehicles that would otherwise be required to make carsharing possible. This concept has some similarities in logistical constraints, user psychology, and technical requirements to organized dynamic ridesharing.

Figure 13. Casual carpoolers queuing for afternoon rides along Beale Street in downtown San Francisco, CA.

In the early afternoon, the scan group met with Jerry Robbins of the San Francisco Municipal Transportation Agency (MTA). Robbins has worked in various positions with the city of San Francisco for more than 25 years and has been following casual carpooling for much of that time. Robbins shared with the group a valuable file of newspaper clippings about casual carpooling (some many years old).

In the late afternoon, the scan group visited the (home-bound commute) casual carpool lines on Beale Street between Howard and Folsom Streets. Signage associated with no parking restrictions to allow for casual carpooling in this location is depicted in figure 12. This was a very impressive casual carpooling site, as can be seen in

figure 13, because of the length of several carpool lines and the speed with which they moved. It is interesting to note that the carpool lines that served locations furthest from downtown San Francisco had the highest number of riders queuing, and those lines also moved the fastest.

©Mark Burris

Figure 14. View of tolling signage on the westbound lanes of the San Francisco–Oakland Bay Bridge. Note that HOVs and buses are directed to reserved lanes at the far right and left sides.

For example, Vallejo is 52 km (32 mi) from San Francisco, and the line had 45 people in it at 4 p.m. Vallejo commuters cross two toll bridges (SFOBB and Carquinez) so the norm for that line is that passengers are expected to pay the driver $1.25 in each direction. Like SFOBB, the Carquinez Bridge is only tolled in one direction, but the tolls are in effect in the opposite direction. Those commuting into San Francisco from Vallejo pay the SFOBB toll in-bound and the Carquinez toll out-bound (see figure 14). Vallejo drivers also often (but not always) took three rather than two passengers, especially at times when the passenger lines were long. Even with three passengers, all are still expected to pay the $1.25; thus, the driver may actually recoup more money than the cost of the tolls (but not more than the total cost of gas, parking, mileage, depreciation, etc).

The scan group casual-carpooled to the Richmond BART station, because afternoon casual-carpooling to North Berkeley is virtually non-existent. The reason for the lack of casual carpooling to North Berkeley appears to be because drivers pay no toll westbound on the SFOBB and thus save no money by picking up riders or time by bypassing tolling queues. In addition, North Berkeley is close enough to the city that the time savings offered by the HOV lanes are not worth the time required to stop and pick up passengers. From Richmond, the team took BART back to the North Berkeley Station where they had begun the day. The casual carpool line for Richmond was much shorter (about 10 people) than the line for Vallejo but also took much longer. Some members of the scan waited as long as 45 minutes for a ride. Because the line moved so slowly, those in line asked each driver if he or she would take a third passenger.

That evening, the scan group met with Dr. Betty Deakin of the University of California (U.C.), Berkeley, to discuss her empirical research of San Francisco casual carpooling. Dr. Deakin has worked with the San Francisco Metropolitan Transportation Commission (MTC) on a study of the effect of adding tolls for HOVs on the SFOBB.

On the morning of December 8, the scan group visited the Grand Avenue casual carpool location in Oakland, CA. This line is located under a highway overpass, sheltered from the elements. The group spent about an hour there observing the riders and drivers. For the duration of the observation period, queuing vehicles outnumbered queuing passengers. At its peak, the line was about 20 vehicles long. The

team timed the wait for several vehicles, which was about 17 minutes; vehicles arriving earlier may have waited even longer. Having more drivers than passengers made it very easy for riders. They had no wait and could hop in a car as soon as they arrived. This also enabled scan team members to talk with waiting drivers, which they had difficulty doing in most other cases. Two notable observations were (1) a man riding up to the line on a foldable bike and placing it in the trunk of the casual carpool vehicle at the front of the line; and (2) a woman walking up to the general area of the line and then getting on the phone to call her co-worker with whom she typically casual carpools (both as passengers) to find out how soon she would be there.

The scan group casual-carpooled to the downtown drop-off location on Howard Street between Fremont and First Streets. San Francisco has installed signs in this area indicating that it is a "Carpool Drop-Off Zone 7–10 a.m." The scan team observed that this drop-off location was especially active.

At mid-morning on the same day, the scan group had a meeting with representatives from AVEGO, a company that markets dynamic ridesharing software for smart phones and is working on dynamic ridesharing pilot projects in Seattle and elsewhere, as well as representatives from the San Francisco MTC and the Climate Protection Campaign of Santa Rosa. AVEGO is currently implementing a Washington State funded dynamic ridesharing pilot project on State Route 520 (http://go520.avego.com/st-pilot/) in the Seattle area. The project involves recruiting 250 regular drivers and 750 regular passengers for a 6-month pilot by using an iPhone application to help facilitate ride matches. The representatives from San Francisco MTC and the Climate Protection Campaign were interested in meeting the scan group because of plans (currently in the works) to fund and implement an organized dynamic ridesharing pilot project (probably with an electronic component) in the Bay Area.

Summary of Lessons Learned and Analysis of Practices

There is somewhat of a natural pricing experiment that takes place on the Vallejo casual carpool line that merits a particularly close observation. Since the implementation of the carpool toll, passengers are generally expected to offer the driver $1.25, such that two paying passengers would fully cover the costs of the $2.50 carpool toll. The scan group was told by many riders that even if the driver accepts more than two passengers, the passengers are still supposed to each offer $1.25. Thus, although the HOV-3-lane benefits apply to drivers with only two passengers, drivers can receive additional reimbursement if they take more passengers.

If further research showed that this small payment dramatically affected the average number of passengers a driver might pick up, it could be worthwhile for governments to provide such a small incentive to drivers in other circumstances in which this "natural incentive" does not exist in an effort to relieve roadway congestion. (It is probably much less expensive than the typical bus passenger subsidy that governments provide). The MTC is currently conducting an evaluation of the toll changes, including the new carpool toll. A survey and counts were conducted in April 2010 prior to the July 1, 2010, implementation of the carpool toll, and a follow-up count and survey was to be conducted during the

same timeframe in 2011. MTC plans to include survey questions to explore these pricing matters further.

Many HOV lanes in the United States have become congested, and raising occupancy requirements to use such lanes may raise objections. As a result, determining how to persuade casual carpool drivers to take more passengers than what is required to use HOV lanes or to qualify for HOV toll discounts—whether by somehow providing financial incentives, hiring someone to personally coax drivers, or by other means—could be very beneficial.

San Francisco MTC conducted a follow-up survey of casual carpoolers in 2011 , the results of which can be found by accessing the following link: http://www.mtc.ca.gov/library/CasualCarpool_summary_2011.pdf. The survey findings provide additional insights on user behaviors and motivations beyond those garnered directly from the scan.

Total HOV volume has declined since the new toll went into effect in July 2010. Casual carpooling in San Francisco, however, still moves a very high volume of people.

Observations and Lessons Learned from All Cities

Findings

Pricing and Incentives

Dynamic ridesharing participants are highly motivated by two incentives: time savings and money savings. Commuters will go to great lengths to realize appreciable time or money savings.

Safety in Numbers

HOV-3 requirements do seem to lead to participants feeling safer (i.e., passengers feel safer when there is a second occupant in the vehicle), but as attested by the Houston visit, a second passenger is not always required for passengers to feel safe getting into a car. In Houston, the scan group saw multiple two-person (driver and rider) carpools form, and they seemed to work fine. Perhaps these carpools may be composed of people who had been participating long enough under HOV-3 rules to become comfortable with many of the drivers and thus also feel comfortable enough to continue slugging in two-person carpools with largely the same drivers.

Infrastructure

Infrastructure can play a very important role in helping dynamic ridesharers accumulate time and money savings. Contributing infrastructure included barrier-separated reversible HOV lanes, park-and-ride lots, and direct access to HOV lanes from parking areas.

Role of Transit

Transit and dynamic ridesharing are complementary modes of transportation. Dynamic ridesharers tend to use transit as a backup mode. Transit providers could view these carpoolers as part-time customers and not as competitors.

Technology

It is difficult to say what role technology might take in bringing dynamic ridesharing to new locations. A number of Web sites, services, and smart device applications are available on the market but do not appear to be heavily in use yet.

Recommendations

Organic dynamic ridesharing is an incredibly easy and efficient way to transport commuters. It is light on infrastructure, uses a previously unharnessed resource (empty seats in a car), and requires little government involvement. There appears to be a “tipping point” that makes dynamic ridesharing attractive to commuters. The tipping point is difficult to reach under natural circumstances, as attested by the fact that this only exists in three U.S. cities. With the help of the right champion (perhaps from a regional or State government or a benefactor), the scan team believes that new dynamic ridesharing systems could be engineered into existence. This topic deserves further study.

Dynamic Ridesharing: Experts and Researchers

There are only a handful of academics and independent researchers who have addressed dynamic ridesharing in their research. A thorough literature review of the topic has revealed only about half a dozen academic articles on the topic. Those few researchers who have focused on dynamic ridesharing tend to have expertise in certain regions of the country. The academic experts in San Francisco, CA, are Dr. Susan Shaheen and Dr. Betty Deakin of U.C. Berkeley. Non-academic experts are Susan Heinrich of the San Francisco MTC and Dan Kirshner, the founder of RideNow.org.

Houston's slugging expert is Dr. Mark Burris of Texas A&M. As far as the scan group is aware, at present there is no academic expert for slugging in Washington, DC, although David LeBlanc's general expertise is unsurpassed given that dynamic ridesharing has received surprisingly little study. The summary of scan member participation and the cities visited is displayed in table 2.

Table 2. Summary of scan member participation.

SCAN PARTICIPANTS: CITIES VISITED

NAME	DC	HOUSTON	SAN FRAN
Dr. Jim Morris	**X**	**X**	**X**
Peter Valk	**X**	**X**	**X**
Allen Greenberg	**X**	**X**	**X**
Dr. Mark Burris	**X**	**X**	**X**
Susan Heinrich		**X**	**X**
Eric Schreffler	**X**		
Phil Winters	**X**	**X**	**X**
Patrick DeCorla-Souza	**X**		
Ed Christopher		**X**	**X**
Marc Oliphant	**X**	**X**	**X**

Note. An X denotes the city visited by the scan member.

Behavioral and Modeling Aspects of Dynamic Ridesharing: Advisors to the Scan Members

- Dr. Betty Deakin, City Planning, U.C. Berkeley.
- Dr. Susan Shaheen, Transportation Engineering, U.C. Berkeley.

Technology Aspects of Dynamic Ridesharing: Advisor to the Scan Members

- Ali Haghani, Civil Engineering, University of Maryland, College Park.

Appendix A: Working Schedule of Each Scan Visit

Table 3. Working Schedule for Washington, DC, Scan.

Date	Day	Activity
17-Nov	Wednesday p.m./eve.	Arrive in Washington, DC. Flying In: Phil Winters (2 days earlier), Eric Shreffler, Mark Burris, Peter Valk. Driving In: Jim Morris. Marc Oliphant will pick up Peter and Eric from Reagan National Airport at about 9 p.m. and drop them off at the Woobridge Holiday Inn Express.
17-Nov	Wednesday night	Out-of-town guests sleep at Woodbridge hotel located at 14030 Telegraph Road, Woodbridge, VA.
18-Nov	Thursday, 5:45 a.m.	Meet in front of the Holiday Inn. Drive to Horner Road commuter lot.
19-Nov	Thursday, 6–8:30 a.m.	Observe Horner Road slug lines; slug into DC.
18-Nov	Thursday, 9–10:30 a.m.	Regroup in DC, meet with Amber Carran-Fletcher of DDOT at the corner of 14th Street and New York Avenue, NW, for a tour of slug-line relocation plans.
18-Nov	Thursday, 11:30 a.m.	Lunch
18-Nov	Thursday, 2 p.m.	Meet Lisa Passagaluppi of Pentagon WHS at Pentagon South Parking lot. Take 1-hour tour of Pentagon parking areas and slug lines.
19-Nov	Thursday, 3–6 p.m.	Observe Pentagon slug lines from 3 to 5:30 p.m., then slug back to Horner Road, Potomac Mills, or Tackett's Mill (depending on demand for slugs at lines for each).
18-Nov	Thursday evening, 6:30–7 p.m.	Meet with David LeBlanc at 2641 Prince William Parkway

18-Nov	Thursday night	Out-of-towners stay at hotel again, locals drive home.
19-Nov	Friday, 5:45 a.m.	Meet again in front of hotel (out-of-towners check-out of hotel). Drive to Potomac Mills Mall slug lines.
19-Nov	Friday, 6–8:30 a.m.	Observe Potomac Mills slug lines.
19-Nov	Friday, 8:30 a.m.	Slug to Rosslyn, VA (or possibly Pentagon/Crystal City, depending on slug demand and space available). The van can pick people up and shuttle them to Rosslyn, or people can use Metro.
19-Nov	Friday, 9:30–11:30 a.m.	Meet with Peggy Tadej, Northern VA Regional Commission BRAC Coordinator (and others who are as yet unconfirmed).
19-Nov	Friday late a.m.	Mark Burris flies out.
20-Nov	Friday, noon	Lunch
20-Nov	Friday, p.m.	Disband. Phil and Eric fly out. Return rental van.

Table 4. Working Schedule for Houston, TX, and San Francisco, CA, Scans.

Date	Day	Activity
5-Dec	Sunday p.m./evening	Arrive in Houston, TX; everyone except Mark Burris and Peter Valk will be driving to the hotel in the rental van.
5-Dec	Sunday night	Stay at hotel located at 21010 Katy Freeway, Katy, TX 77449
6-Dec	Monday, 6 a.m.	Meet in hotel lobby with bags, everyone check out.
6-Dec	Monday, 6:15 a.m.	Visit morning slug lines at: Kingsland Park-and-Ride lot (21669 Kingsland Boulevard between Mason Road and Fry Road). Marty Elder of METRO will meet us at 6:15 a.m. Addicks Park-and-Ride lot (14230 Old Katy Road, east of State Highway 5). Nader Mirjamali of METRO will meet some of us at 7:30 a.m. Northwest Park-and-Ride lot—Mark Burris will be present at the very least (18502 Hempstead Highway, south of West Road at Castlebridge).
6-Dec	Monday late a.m.	Regroup in downtown Houston, meet with Houston METRO at 10 a.m., 1900 Main Street, Houston, TX.
6-Dec	11:30 a.m.–1:30 p.m.	Lunch
6-Dec	Monday early p.m.	OPEN.
6-Dec	Monday, 3:30 p.m.	Observe slug lines along Louisiana Street (between Dallas Street and Rusk Street).
6-Dec	Monday, 4 p.m.	Slug to Northwest Park-and-Ride lot.
6-Dec	Monday, 5 p.m.	Regroup at Northwest Park-and-Ride lot, drive directly to George Bush Intercontinental Airport.

6-Dec	Monday, 6 p.m.	Arrive at airport, check-in.
6-Dec	Monday, 9:45 p.m.	Arrive at SFO, pick up rental van, drive to Berkeley.
6-Dec	Monday night	Sleep at Hotel located at 2600 Durant Avenue, Berkeley, CA 94704,
7-Dec	Tuesday, 6 a.m.	Meet in hotel lobby.
7-Dec	Tuesday, 6:15–8 a.m.	Visit North Berkeley Casual Carpool lines and carpool into San Francisco
7-Dec	Tuesday, 9–10:30 a.m.	Meeting with Rick Hutchison of San Fran City CarShare (scan team members only); 1182 Market Street, Suite 300, San Francisco,
7-Dec	Tuesday late a.m.	OPEN
7-Dec	Tuesday noonish	Lunch
7-Dec	Tuesday early p.m.	Meet with Jerry Robbins at SFMTA offices.
7-Dec	Tuesday late p.m.	Casual carpool out of San Fran lines at Beale Street between Howard and Folsom (cannot go directly to North Berkeley). The plan is to carpool to Richmond, the next closest destination.
7-Dec	Tuesday evening	Dinner in Berkeley with Dr. Betty Deakin of U.C. Berkeley
7-Dec	Tuesday night	Stay at otel in Berkeley again.
8-Dec	Wednesday, 6:15 a.m.	Meet in hotel lobby with bags, check out.

8-Dec	Wednesday, 7 a.m.	Slug from North Berkeley to San Fran again.
8-Dec	Wednesday, 8:30 a.m.	Meet with AVEGO reps at 149 New Montgomery Street, corner of Montgomery and Natoma Streets
8-Dec	Wednesday, 10 a.m.	Adjourn. Fly home.

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For additional information, contact David Kuehn, FHWA, 202-493-3414 (email: david.kuehn@dot.gov); or Terry Halkyard, FHWA, 202-493-3467 (email: terry.halkyard@dot.gov); or Zachary Ellis, FHWA, 202-493-3193 (email: zachary.ellis@dot.gov).

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