Eastern Research Group, Inc.

Eliminating Tailpipe Testing from the Inspection and Maintenance Program

FINAL REPORT

Prepared for:

Texas Commission on Environmental Quality

Prepared by:

Eastern Research Group, Inc.

July 30, 2010

ERG No. 0230.03.013.0022/2
TCEQ Contract No. 582-07-84004
Work Order No. 13

Eliminating Tailpipe Testing from the Inspection and Maintenance Program

Final Report

Prepared for:

Mr. Edgar Gilmore
Texas Commission on Environmental Quality
P. O. Box 13087
Austin, TX 78711-3087

Prepared by:
Jim Lindner
Michael Sabisch
Sandeep Kishan
Cindy Palacios
Alan Stanard

Eastern Research Group, Inc.
3508 Far West Blvd, Suite 210
Austin, Texas 78731

July 30, 2010

Table of Contents

List of Tables

List of Figures

1.0 Executive Summary

Eastern Research Group (ERG) was asked to undertake this work to study how the reduction in tailpipe testing due to the attrition of pre-model year (MY) 1996 (pre-MY96) vehicles will impact the Texas Inspection and Maintenance (I/M) program in the coming years. In addition to this, it was also desired to develop a sense of how the reclassification of some counties into nonattainment areas could impact emission inventories and program requirements. Modeling runs were performed for a limited number of scenarios using the MOVES (Motor Vehicle Emission Simulator) model to gain an understanding of what level of emission reductions would be impacted by the phase-out of tailpipe testing and these are presented in Section 3. To provide a point of reference, Section 4 compares this modeling output to the data-based emission reduction estimates that were recently done in a separate study, as well as compare the overall MOVES average reductions between the counties in the current program and the expanded set of proposed counties.

The testing possibilities available through the use of remote OBD (On-Board Diagnostic) testing, as well as OBD kiosks are discussed in Section 5. Included in this section is a summary of the pros and cons of implementing this type of testing. To date, there have only been limited pilot studies in this area and there is currently an Environmental Protection Agency (EPA) Remote OBD workgroup formed as a part of the Mobile Source Technical Review Subcommittee under the provisions of the Federal Advisory Committee Act. Given these facts, it would seem prudent to wait for the EPA Remote OBD workgroup guidance, which should be released in the near future before making any firm decisions with regard to how a remote OBD program element should be implemented, if so desired.

Section 6 provides information on a number of test alternatives to consider that could allow tailpipe testing to be phased-out, yet still provide some level of emission test for pre-MY96 vehicles. These test alternatives could also be applied to the OBD fleet if desired. The concepts in this section can be broadly grouped into three topics. The first is a remote sensing (RS) based high emitter identification program that would use remote sensing to identify potential high emitting vehicles. This RS-only work includes paired RS-I/M data, projected future I/M failure rates and RS fleet coverage estimates that are used to make emission benefit projections for a series of RS cutpoints as well as estimates of tons reduced for the different cutpoint scenarios. The second analysis employs a modeling high emitter profile (HEP) approach that uses historical vehicle emission data to project emissions failure rates. This HEP work also includes emissions benefit projections and estimates of tons reduced. The third topic in this section focuses on a review of how other state programs have addressed this same problem of the declining size of the pre-MY96 fleet. Functional and visual testing options are included in this section, such as liquid leak, catalyst, or evaporative canister checks; however, it seemed most programs found expanding OBD testing to additional counties to be preferable to implementing non-tailpipe testing alternatives on the non-OBD fleet.   The use of RS to detect evaporative emissions is also discussed, but that technology is not yet sufficiently mature to be implemented at this time.

It is important to note that this project did not include a review of the emission credits claimed or needed in the current state implementation plan (SIP). Therefore, it is difficult to make definitive recommendations with regard to what type of program change or changes to pursue since the choice will have emissions credit implications and without a detailed review of the SIP credit claims, any such recommendations would be of questionable value.

2.0 Introduction

In 2000, the Texas Commission on Environmental Quality (TCEQ) adopted an air pollution control strategy that involved emissions inspections to reduce nitrogen oxides (NO_x) and hydrocarbons (HC). The strategy was implemented in 2002 in the nonattainment areas of Dallas-Fort Worth (DFW), Houston-Galveston-Brazoria (HGB) and El Paso areas. The Austin area, including Williamson and Travis counties, began I/M testing in 2005.

Acceleration Simulation Mode (ASM), Two-Speed Idle (TSI) and OBD inspections are currently performed in the DFW and HGB areas, while OBD and TSI inspections are conducted in El Paso County and the Austin area. The ASM inspection measures NO_x, carbon monoxide (CO) and HC emissions, the TSI inspection measures CO and HC, and the OBD inspection monitors the functionality of the entire emissions control system on a vehicle. This information is summarized in Table 2-1.

Table 2-1. I/M Coverage by County

<table>
<tr><th colspan="2">Coverage Period</th><th>County</th><th>Subject Vehicles (Vehicle Class/Model Year)</th><th>Test Types (Exhaust/Evaporative)</th></tr>
<tr><td colspan="2">1990-1996</td><td>El Paso, Dallas, Tarrant</td><td>LDGV, LDGT/ >=1975</td><td>Idle/-</td></tr>
<tr><td rowspan="2">1997-</td><td>April 2002</td><td>Harris, Dallas, Tarrant</td><td rowspan="2">All/All</td><td rowspan="2">TSI/GC</td></tr>
<tr><td>2006</td><td>El Paso</td></tr>
<tr><td>May 2002</td><td rowspan="2">through 2040</td><td>Harris, Dallas, Tarrant, Collin, Denton</td><td rowspan="2">HDGV, HDGB/All
LDGV, LDGT/<=1995,
LDGV, LDGT/>=1996</td><td rowspan="2">TSI/GC
ASM-2/GC
OBD/OBD & GC</td></tr>
<tr><td>May 2003</td><td>Brazoria, Ellis, Ft. Bend, Galveston, Johnson, Kaufman, Montgomery, Parker, Rockwall</td></tr>
<tr><td>Sept. 2005</td><td rowspan="2">through 2040</td><td>Travis, Williamson</td><td rowspan="2">HDGV, HDGB/All
LDGV, LDGT/<=1995,
LDGV, LDGT/>=1996</td><td rowspan="2">TSI/GC
ASM-2/GC
OBD/OBD & GC</td></tr>
<tr><td>2007</td><td>El Paso</td></tr>
</table>

These I/M programs, mandated by the EPA in the 1990 Clean Air Act, have contributed to improvements in air quality and become standard components in SIPs. However, as the fleet ages, fewer and fewer vehicles receive tailpipe I/M tests such as ASM or TSI. Registration data from the Texas Department of Motor Vehicles indicate that approximately 88 percent of the registered vehicles in the I/M program areas are model year 1996 or newer, which means they are subject to OBD testing. The model year 1995 and older fleet will continue to diminish in size through January 1, 2021, at which time they will no longer be subject to emissions testing.

For this reason, it is important to begin exploring what options will be available to wind-down the tailpipe exhaust testing element of the I/M program.

As part of that effort, this report estimates the light-duty vehicle (LDV) emissions in future calendar years using EPA's most recently released mobile source model known as MOVES and then examines what other alternative non-ASM or TSI testing options may be available and what level of air quality benefit these alternatives may provide. Included in these test alternatives are program concepts obtained from discussions with other state I/M program personnel as well as the use of remote OBD technology, RS device measurements HEP. These ideas and their potential use as part of an evolving I/M program are discussed in more detail in the sections that follow.

3.0 MOVES Runs

ERG set up and executed three scenarios in MOVES in order to determine both the benefit of tailpipe testing, as well as the overall benefit of the I/M program, for both current and proposed counties. These scenarios included modeling the current I/M program (with TSI or ASM tailpipe testing for each county, as appropriate), modeling an I/M program with OBD testing only, and modeling without any I/M program at all.

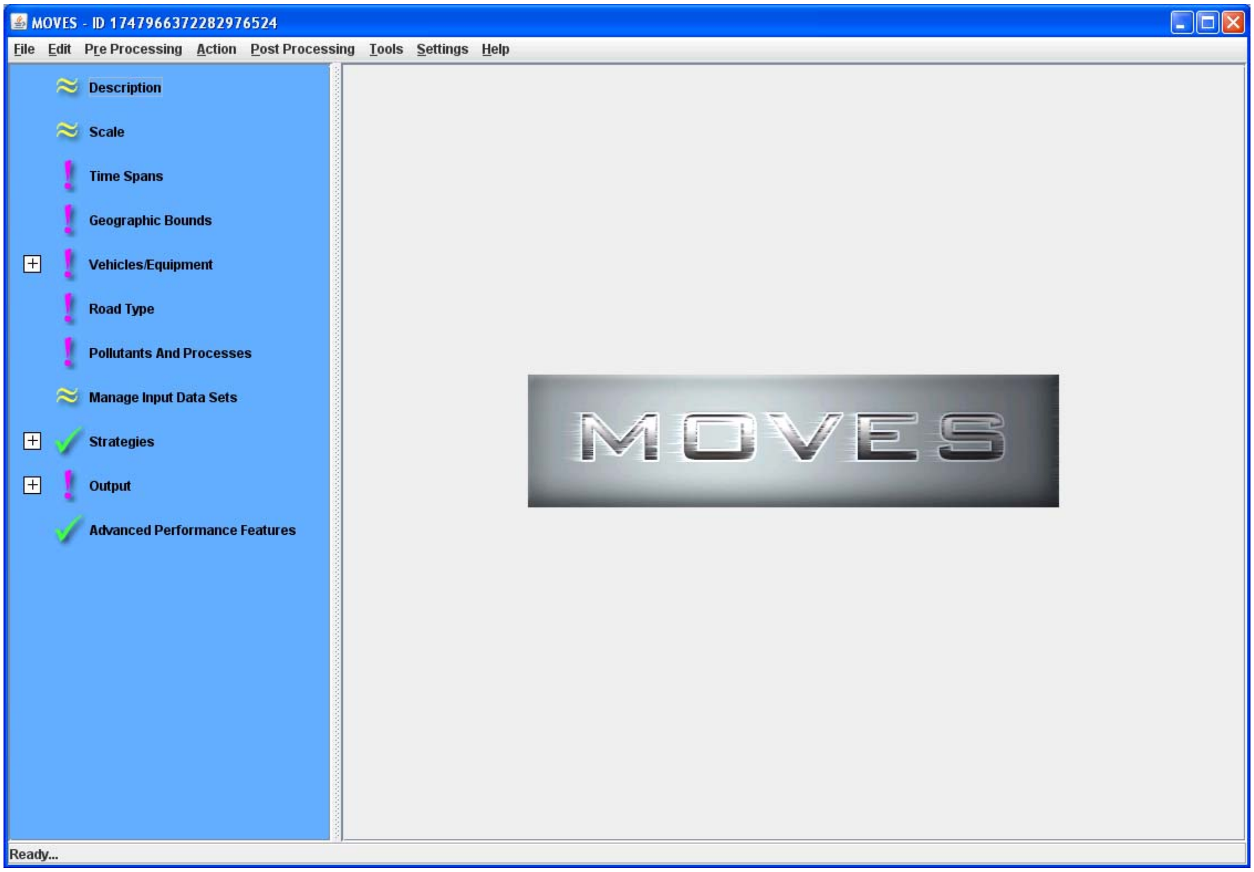
Model Option Selection

The first step in setting up model runs for the scenarios described above was to make appropriate selections for each model option on the submenus listed in the main MOVES interface, which is shown below in Figure 3-1.

Selections were made for each of the submenus pictured, and they are described below.

- **Description** – A text description was entered in this field. A typical description might consist of text like "TCEQ MOVES Runs, DFW Area, Scenario 2".
- **Scale –** The National scale, along with an Inventory calculation type, was used for all MOVES runs performed for this analysis. This allowed for use of MOVES defaults for parameters such as vehicle miles traveled, vehicle population, ambient conditions, etc.

Figure 3-1. MOVES Interface Example



- **Time Spans** – Yearly aggregation was selected for each of the following calendar years: 2012, 2014, 2016, and 2018. All months and hours of the day were modeled, including both weekdays and weekends.
- **Vehicles/Equipment - On Road Vehicles**: A Gasoline fuel type was selected, and combined with three source use types: Passenger Cars, Passenger Trucks, and Light Commercial Trucks, for a total of 3 fuel/source combinations.
- **Road Type** – All five available road types were selected.
- **Pollutants and Processes** – Exhaust emissions of Carbon Monoxide, Oxides of Nitrogen, and Total Gaseous Hydrocarbons, were all selected.
- **Manage Input Datasets**: I/M scenarios imported via the Data Importer were reflected in this submenu. I/M was implemented for vehicles 2-24 years old. A compliance factor of 93.12 was modeled for all scenarios, which reflects a 96% compliance rate and a 3% waiver rate[1]. The following scenarios were modeled and are also listed in Table 3-1:

---

[1] This is calculated, per EPA guidance, as the regulatory class coverage * compliance rate * (1 - waiver rate). This produces 1 * .96 * (1 – 0.03) = 0.9312.

- **OBD + Tailpipe**. This included OBD for model years 1996 and newer, and either TSI or ASM, as appropriate for the county being modeled, for model years 1995 and older. TestStandardsID 21 (ASM 2525 Phase-in Cutpoints) was selected for ASM testing, and TestStandardsID 12 (Two-mode, 2500 RPM (or revolutions per minute)/Idle Test) was selected for TSI testing. OBD testing was modeled using TestStandardsID 51.
- **OBD Only**. This included ONLY OBD for model years 1996 and newer. OBD testing was modeled using TestStandardsID 51.
- **No I/M**. All I/M was disabled.

- **Strategies**: No selection was made in this submenu.
- **Output – General Output**: We selected units of tons for mass, million BTU for energy, and miles for distance. In the Activity section, we checked boxes for distance traveled.
- **Output -Output Emissions Detail**: A time period of “Year” was selected, along with a location of “County”, for ease of calculating annual emissions on a by-county basis. We also selected calculation of emissions by source use type.
- **Advanced Performance Features**: No selection was made in this submenu.
- **Geographic Bounds**: Having fully populated all of the model options in each of the above submenus, ERG then returned to the Geographic Bounds submenu. For each run performed, a group of counties was selected representing a particular area of the state. The runs performed were grouped by counties in the Austin, DFW, Houston, and El Paso areas, and included both the current and proposed expanded county list provided by TCEQ.

Table 3-1. MOVES Inputs

Area	Vehicles Covered (Source Type)	MOVES Modeling Evaluation Date	Exhaust I/M Program (TestStandards ID)	Evap I/M Program (TestStandards ID)
Houston-Galveston-Brazoria area: Brazoria, Fort Bend, Galveston, Harris, Montgomery Counties.	Passenger Cars, Passenger Trucks, and Light Duty Commercial Trucks (21, 31, 32) Gasoline only	2012, 2014, 2016, 2018	1995 and older: ASM 2525 phase in (21) 1996 and newer: OBD (51)	1995 and older: Gas Cap (41) 1996 and newer: Gas Cap + OBD (45)
Dallas-Fort Worth area: Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, Tarrant Counties.	Passenger Cars, Passenger Trucks, and Light Duty Commercial Trucks (21, 31, 32) Gasoline only	2012, 2014, 2016, 2018	1995 and older: ASM 2525 phase in (21) 1996 and newer: OBD (51)	1995 and older: Gas Cap (41) 1996 and newer: Gas Cap + OBD (45)
Austin-Round Rock area: Travis and Williamson Counties.	Passenger Cars, Passenger Trucks, and Light Duty Commercial Trucks (21, 31, 32) Gasoline only	2012, 2014, 2016, 2018	1995 and older: Two-speed idle (12) 1996 and newer: OBD (51)	1995 and older: Gas Cap (41) 1996 and newer: Gas Cap + OBD (45)
El Paso area: El Paso County.	Passenger Cars, Passenger Trucks, and Light Duty Commercial Trucks (21, 31, 32) Gasoline only	2012, 2014, 2016, 2018	1995 and older: Two-speed idle (12) 1996 and newer: OBD (51)	1995 and older: Gas Cap (41) 1996 and newer: Gas Cap + OBD (45)

Model Output

Output from the model was processed using the Summary Report post-processor included in MOVES. Outputs included HC, CO, and NO_x exhaust emissions aggregated by calendar year, source type, and county. ERG further processed the modeling results using pivot tables in Microsoft Excel in order to arrive at calculated I/M benefits by Metropolitan Statistical Area provided by the TCEQ. The annual tons of emissions output by the model for the scenarios described above are presented below. This includes the calculated emissions benefits for tailpipe and OBD, as well as OBD only. These results should be useful for preliminary comparisons with the emission reductions claimed in the current SIP, as well as for planning any changes that may be needed in future SIP revisions. Mass-based emissions by calendar year for the counties with I/M programs are in Table 3-2, and similar values for the proposed new counties are in Table 3-3. Tables 3-4 and 3-5 provide MOVES I/M reductions benefit for this same set of counties.

Table 3-2. Exhaust Emissions from Light Duty Vehicles in Current I/M Counties

Current I/M Areas (tons/yr of emissions)	*Pollutant*	*Tailpipe + OBD*				*OBD Only*				*NO I/M*			
		2012	***2014***	***2016***	***2018***	***2012***	***2014***	***2016***	***2018***	***2012***	***2014***	***2016***	***2018***
Austin Area, 2 counties	HC	6,380	5,370	4,582	3,988	6,595	5,558	4,737	4,083	7,202	6,116	5,268	4,611
	CO	70,239	63,277	57,479	53,784	72,480	64,971	58,618	54,378	79,339	71,608	65,155	61,040
	NOx	8,963	7,406	6,090	5,052	9,151	7,559	6,200	5,109	10,105	8,357	6,877	5,712
DFW Area, 9 counties	HC	32,317	27,404	23,567	20,704	33,906	28,824	24,720	21,415	37,001	31,647	27,394	24,077
	CO	365,475	327,813	296,436	276,656	379,678	338,571	303,705	280,507	414,892	372,403	336,869	314,220
	NOx	47,951	39,676	32,754	27,311	49,775	41,107	33,723	27,814	54,943	45,421	37,386	31,073
El Paso Area, 1 County	HC	3,110	2,641	2,269	1,984	3,223	2,738	2,348	2,034	3,505	2,996	2,593	2,279
	CO	36,992	33,346	30,326	28,397	38,152	34,225	30,915	28,705	41,679	37,634	34,271	32,124
	NOx	4,963	4,094	3,363	2,789	5,068	4,180	3,424	2,822	5,598	4,622	3,797	3,154
Houston Area, 5 counties	HC	25,709	21,812	18,780	16,537	27,022	22,983	19,734	17,123	29,565	25,308	21,946	19,333
	CO	289,662	258,938	233,162	217,028	301,469	267,888	239,213	220,234	330,735	295,969	266,697	248,153
	NOx	38,203	31,611	26,089	21,736	39,646	32,741	26,856	22,134	43,771	36,189	29,786	24,745

Table 3-3. Exhaust Emissions from Light Duty Vehicles in Proposed I/M Counties

Expanded I/M Areas (tons/yr of emissions)	*Pollutant*	*Tailpipe + OBD*				*OBD Only*				*NO I/M*			
		2012	***2014***	***2016***	***2018***	***2012***	***2014***	***2016***	***2018***	***2012***	***2014***	***2016***	***2018***
Austin Area, 6 counties	HC	7,847	6,608	5,640	4,909	8,111	6,841	5,833	5,029	8,864	7,534	6,494	5,683
	CO	86,607	78,039	70,898	66,343	89,361	80,125	72,302	67,077	97,771	88,266	80,321	75,249
	NOx	11,013	9,108	7,494	6,219	11,237	9,291	7,629	6,292	12,407	10,272	8,462	7,034
DFW Area, 19 counties	HC	35,578	30,160	25,925	22,765	37,311	31,710	27,187	23,545	40,724	34,824	30,140	26,484
	CO	402,791	361,594	327,293	305,687	418,364	373,392	335,269	309,908	456,991	410,534	371,703	346,927
	NOx	52,536	43,489	35,919	29,963	54,530	45,056	36,978	30,511	60,191	49,784	40,998	34,087
Houston Area, 12 counties	HC	27,557	23,379	20,130	17,724	28,959	24,633	21,151	18,350	31,690	27,131	23,531	20,728
	CO	310,979	278,122	250,581	233,331	323,639	287,728	257,074	236,770	354,992	317,822	286,545	266,717
	NOx	40,893	33,853	27,946	23,291	42,437	35,057	28,769	23,718	46,855	38,752	31,908	26,518
Beaumont Area, 3 counties	HC	2,440	2,075	1,786	1,565	2,533	2,155	1,851	1,606	2,791	2,391	2,078	1,832
	CO	29,765	26,799	24,323	22,746	30,725	27,527	24,813	23,002	33,649	30,357	27,604	25,843
	NOx	3,716	3,072	2,528	2,099	3,793	3,135	2,573	2,123	4,188	3,467	2,854	2,373
Corpus Christi Area, 5 counties	HC	2,812	2,362	2,015	1,758	2,908	2,449	2,086	1,799	3,182	2,699	2,327	2,038
	CO	31,004	27,883	25,277	23,633	32,042	28,668	25,806	23,908	35,212	31,736	28,823	26,977
	NOx	3,915	3,235	2,660	2,205	3,992	3,300	2,705	2,228	4,414	3,649	3,003	2,493
El Paso Area, 1 County	HC	3,110	2,641	2,269	1,984	3,223	2,738	2,348	2,034	3,505	2,996	2,593	2,279
	CO	36,992	33,346	30,326	28,397	38,152	34,225	30,915	28,705	41,679	37,634	34,271	32,124
	NOx	4,963	4,094	3,363	2,789	5,068	4,180	3,424	2,822	5,598	4,622	3,797	3,154
Lower Rio Grande Valley Area, 3 counties	HC	4,921	4,118	3,500	3,033	5,085	4,262	3,614	3,104	5,564	4,702	4,035	3,521
	CO	52,594	47,388	43,004	40,259	54,349	48,720	43,902	40,733	59,791	53,989	49,090	46,015
	NOx	6,604	5,454	4,481	3,710	6,740	5,567	4,560	3,751	7,447	6,158	5,061	4,199
Northeast Texas Area, 6 counties	HC	3,837	3,240	2,770	2,414	3,964	3,354	2,864	2,472	4,334	3,692	3,188	2,796
	CO	42,899	38,691	35,199	32,947	44,238	39,709	35,884	33,309	48,250	43,592	39,717	37,220
	NOx	5,347	4,433	3,657	3,042	5,459	4,522	3,721	3,075	6,026	5,000	4,128	3,438
San Antonio Area, 8 counties	HC	11,204	9,413	8,015	6,959	11,588	9,753	8,292	7,130	12,679	10,750	9,238	8,075
	CO	121,526	109,442	99,414	93,035	125,465	112,433	101,419	94,084	137,446	124,014	112,833	105,723
	NOx	15,606	12,899	10,608	8,799	15,934	13,163	10,793	8,901	17,601	14,559	11,982	9,959
Waco Area, 1 county	HC	1,649	1,389	1,185	1,033	1,704	1,438	1,225	1,057	1,859	1,581	1,362	1,192
	CO	18,321	16,521	15,029	14,072	18,897	16,958	15,323	14,227	20,648	18,652	16,992	15,929
	NOx	2,310	1,909	1,572	1,305	2,358	1,948	1,599	1,320	2,602	2,154	1,774	1,476

Table 3-4. I/M Benefit for Light Duty Vehicles in Current I/M Counties

Current I/M Areas (% Benefit)	***Pollutant***	***Tailpipe + OBD***				***OBD Only***			
		2012	***2014***	***2016***	***2018***	***2012***	***2014***	***2016***	***2018***
Austin Area, 2 counties	HC	-11.4%	-12.2%	-13.0%	-13.5%	-8.4%	-9.1%	-10.1%	-11.5%
	CO	-11.5%	-11.6%	-11.8%	-11.9%	-8.6%	-9.3%	-10.0%	-10.9%
	NOx	-11.3%	-11.4%	-11.4%	-11.6%	-9.4%	-9.5%	-9.8%	-10.6%
DFW Area, 9 counties	HC	-12.7%	-13.4%	-14.0%	-14.0%	-8.4%	-8.9%	-9.8%	-11.1%
	CO	-11.9%	-12.0%	-12.0%	-12.0%	-8.5%	-9.1%	-9.8%	-10.7%
	NOx	-12.7%	-12.6%	-12.4%	-12.1%	-9.4%	-9.5%	-9.8%	-10.5%
El Paso Area, 1 County	HC	-11.3%	-11.8%	-12.5%	-12.9%	-8.0%	-8.6%	-9.4%	-10.8%
	CO	-11.2%	-11.4%	-11.5%	-11.6%	-8.5%	-9.1%	-9.8%	-10.6%
	NOx	-11.3%	-11.4%	-11.4%	-11.6%	-9.5%	-9.6%	-9.8%	-10.5%
Houston Area, 5 counties	HC	-13.0%	-13.8%	-14.4%	-14.5%	-8.6%	-9.2%	-10.1%	-11.4%
	CO	-12.4%	-12.5%	-12.6%	-12.5%	-8.8%	-9.5%	-10.3%	-11.3%
	NOx	-12.7%	-12.7%	-12.4%	-12.2%	-9.4%	-9.5%	-9.8%	-10.6%

Table 3-5. I/M Benefit for Light Duty Vehicles in Proposed I/M Counties

Expanded I/M Areas (% Benefit)	***Pollutant***	***Tailpipe + OBD***				***OBD Only***			
		2012	***2014***	***2016***	***2018***	***2012***	***2014***	***2016***	***2018***
Austin Area, 6 counties	HC	-11.5%	-12.3%	-13.2%	-13.6%	-8.5%	-9.2%	-10.2%	-11.5%
	CO	-11.4%	-11.6%	-11.7%	-11.8%	-8.6%	-9.2%	-10.0%	-10.9%
	NOx	-11.2%	-11.3%	-11.4%	-11.6%	-9.4%	-9.6%	-9.8%	-10.5%
DFW Area, 19 counties	HC	-12.6%	-13.4%	-14.0%	-14.0%	-8.4%	-8.9%	-9.8%	-11.1%
	CO	-11.9%	-11.9%	-11.9%	-11.9%	-8.5%	-9.0%	-9.8%	-10.7%
	NOx	-12.7%	-12.6%	-12.4%	-12.1%	-9.4%	-9.5%	-9.8%	-10.5%
Houston Area, 12 counties	HC	-13.0%	-13.8%	-14.5%	-14.5%	-8.6%	-9.2%	-10.1%	-11.5%
	CO	-12.4%	-12.5%	-12.6%	-12.5%	-8.8%	-9.5%	-10.3%	-11.2%
	NOx	-12.7%	-12.6%	-12.4%	-12.2%	-9.4%	-9.5%	-9.8%	-10.6%
Beaumont Area, 3 counties	HC	-12.6%	-13.2%	-14.1%	-14.6%	-9.2%	-9.9%	-10.9%	-12.3%
	CO	-11.5%	-11.7%	-11.9%	-12.0%	-8.7%	-9.3%	-10.1%	-11.0%
	NOx	-11.3%	-11.4%	-11.4%	-11.5%	-9.4%	-9.6%	-9.8%	-10.5%
Corpus Christi Area, 5 counties	HC	-11.6%	-12.5%	-13.4%	-13.7%	-8.6%	-9.3%	-10.4%	-11.7%
	CO	-12.0%	-12.1%	-12.3%	-12.4%	-9.0%	-9.7%	-10.5%	-11.4%
	NOx	-11.3%	-11.3%	-11.4%	-11.6%	-9.6%	-9.6%	-9.9%	-10.6%
El Paso Area, 1 County	HC	-11.3%	-11.8%	-12.5%	-12.9%	-8.0%	-8.6%	-9.4%	-10.8%
	CO	-11.2%	-11.4%	-11.5%	-11.6%	-8.5%	-9.1%	-9.8%	-10.6%
	NOx	-11.3%	-11.4%	-11.4%	-11.6%	-9.5%	-9.6%	-9.8%	-10.5%
Lower Rio Grande Valley Area, 3 counties	HC	-11.6%	-12.4%	-13.3%	-13.9%	-8.6%	-9.4%	-10.4%	-11.8%
	CO	-12.0%	-12.2%	-12.4%	-12.5%	-9.1%	-9.8%	-10.6%	-11.5%
	NOx	-11.3%	-11.4%	-11.5%	-11.6%	-9.5%	-9.6%	-9.9%	-10.7%
Northeast Texas Area, 6 counties	HC	-11.5%	-12.2%	-13.1%	-13.7%	-8.5%	-9.2%	-10.2%	-11.6%
	CO	-11.1%	-11.2%	-11.4%	-11.5%	-8.3%	-8.9%	-9.7%	-10.5%
	NOx	-11.3%	-11.3%	-11.4%	-11.5%	-9.4%	-9.6%	-9.9%	-10.6%
San Antonio Area, 8 counties	HC	-11.6%	-12.4%	-13.2%	-13.8%	-8.6%	-9.3%	-10.2%	-11.7%
	CO	-11.6%	-11.8%	-11.9%	-12.0%	-8.7%	-9.3%	-10.1%	-11.0%
	NOx	-11.3%	-11.4%	-11.5%	-11.6%	-9.5%	-9.6%	-9.9%	-10.6%
Waco Area, 1 county	HC	-11.3%	-12.1%	-13.0%	-13.3%	-8.3%	-9.0%	-10.1%	-11.3%
	CO	-11.3%	-11.4%	-11.6%	-11.7%	-8.5%	-9.1%	-9.8%	-10.7%
	NOx	-11.2%	-11.4%	-11.4%	-11.6%	-9.4%	-9.6%	-9.9%	-10.6%

4.0 Comparison of MOVES to 2009 Report Emission Trends

Tables 4.1 and 4.2 summarize the percent reductions calculated in the 2009 Program Evaluation report [1]. These values were based on Texas Information Management System (TIMS) data from October 1, 2006 through March 31, 2009. Table 4.1 is for the ASM test, while Table 4.2 contains the TSI values. As described in Section 5.1 of the 2009 Program Evaluation report, sequence 1P refers to “single pass” (a vehicle completes its annual I/M requirement with a pass on the first inspection) and sequence FP refers to “Initial Fail, then Final Pass” (a vehicle fails its first annual emissions inspection and then ultimately passes its last annual inspection to meet the I/M requirements).

It can be seen from the composite DFW & HGB 1P + FP rows that for the ASM test, emission reductions for HC ranged from 13-18%, for CO from 28-36% and for NO_x from 14-16%. For the TSI test, the HC reductions were ranged from 28-30% and for CO from 28-35%. Note that since these reductions are based on ASM and TSI tests, these results are concentration-based rather than mass-based, which limits the value in comparing these reductions with MOVES results that are provided on a mass-basis. Therefore, these reductions are provided only for an additional point of reference.

The overall reductions by calendar year based on the MOVES runs from Section 3 are summarized in Tables 4.3 and 4.4 below. These values were obtained by averaging the emission reductions in tons presented in Tables 3.1 and 3.2. By comparing Table 4.3 to 4.4, it can be seen that the overall MOVES percent reductions do not change appreciably with the addition of the new nonattainment counties, although the tons of pollutants removed from the new and larger inventory are increased.

It can also be seen that transitioning from a tailpipe plus OBD program to OBD-only does have an impact on emissions reductions. However, the significance of this may or may not be important depending on the requirements in the Texas SIP, as only a couple percent of CO and NO_x emissions reductions are lost from switching to OBD-only, while HC losses are more in the range of 4-6%.

Table 4-1. 2009 Report Annual I/M Benefit Using TIMS Data for ASM Emissions

Area	Seq.	Count	ASM HC (ppm)						ASM CO (%)						ASM NO (ppm)					
			5015			2525			5015			2525			5015			2525		
			Initial	Final	% Red.	Initial	Final	% Red.	Initial	Final	% Red.	Initial	Final	% Red.	Initial	Final	% Red.	Initial	Final	% Red.
DFW	1P	1,242,445	64.63	64.63	0.00%	40.52	40.52	0.00%	0.195	0.195	0.00%	0.132	0.132	0.00%	434.52	434.52	0.00%	307.34	307.34	0.00%
	FP	114,413	179.68	65.49	63.55%	155.22	46.44	70.08%	1.114	0.205	81.55%	1.047	0.160	84.76%	1297.32	462.90	64.32%	1088.42	351.34	67.72%
	1P + FP	1,356,858	74.33	64.70	12.95%	50.19	41.02	18.28%	0.272	0.196	28.13%	0.209	0.134	35.77%	507.27	436.91	13.87%	373.20	311.05	16.65%
HGB	1P	1,000,998	64.94	64.94	0.00%	41.30	41.30	0.00%	0.192	0.192	0.00%	0.133	0.133	0.00%	432.88	432.88	0.00%	311.56	311.56	0.00%
	FP	92,806	181.38	66.04	63.59%	156.80	46.73	70.20%	1.106	0.201	81.86%	1.043	0.158	84.88%	1261.82	463.48	63.27%	1061.95	352.96	66.76%
	1P + FP	1,093,804	74.82	65.03	13.08%	51.10	41.76	18.27%	0.269	0.193	28.51%	0.210	0.135	35.75%	503.21	435.47	13.46%	375.23	315.07	16.03%
DFW & HGB	1P	2,243,443	64.77	64.77	0.00%	40.87	40.87	0.00%	0.193	0.193	0.00%	0.132	0.132	0.00%	433.79	433.79	0.00%	309.22	309.22	0.00%
	FP	207,219	180.44	65.73	63.57%	155.93	46.57	70.13%	1.110	0.203	81.69%	1.045	0.159	84.81%	1281.42	463.16	63.86%	1076.56	352.07	67.30%
	1p + FP	2,450,662	74.55	64.85	13.01%	50.60	41.35	18.28%	0.271	0.194	28.30%	0.210	0.135	35.76%	505.46	436.27	13.69%	374.11	312.85	16.38%

Table 4-2. 2009 Report Annual I/M Benefit Using TIMS Data for TSI Emissions

Area	Seq.	Count	TSI HC (ppm)						TSI CO (%)					
			Curb Idle			High Idle			Curb Idle			High Idle		
			Initial	Final	% Red.	Initial	Final	% Red.	Initial	Final	% Red.	Initial	Final	% Red.
DFW	1P	164,392	67.303	67.303	0.00%	35.737	35.737	0.00%	0.180	0.180	0.00%	0.175	0.175	0.00%
	FP	12,806	472.859	85.459	81.93%	266.783	47.949	82.03%	1.677	0.274	83.65%	1.269	0.246	80.59%
	1P + FP	177,198	96.612	68.615	28.98%	52.434	36.620	30.16%	0.288	0.187	35.21%	0.254	0.180	29.07%
HGB	1P	133,775	66.152	66.152	0.00%	35.501	35.501	0.00%	0.183	0.183	0.00%	0.173	0.173	0.00%
	FP	9,633	452.337	83.524	81.53%	263.543	47.361	82.03%	1.699	0.269	84.19%	1.261	0.236	81.29%
	1P +FP	143,408	92.093	67.319	26.90%	50.819	36.298	28.57%	0.284	0.188	33.77%	0.246	0.177	28.02%
DFW & HGB	1P	298,167	66.787	66.787	0.00%	35.631	35.631	0.00%	0.181	0.181	0.00%	0.174	0.174	0.00%
	FP	22,439	464.049	84.628	81.76%	265.392	47.697	82.03%	1.686	0.272	83.88%	1.266	0.242	80.89%
	1P + FP	320,606	94.591	68.035	28.07%	51.712	36.476	29.46%	0.286	0.187	34.57%	0.250	0.179	28.61%

Table 4-3. Current Counties Projected MOVES Average Emissions (tons) and Reductions (%)

		Tailpipe + OBD				*OBD Only*				*NO I/M*			
		2012	***2014***	***2016***	***2018***	***2012***	***2014***	***2016***	***2018***	***2012***	***2014***	***2016***	***2018***
Overall Current County Totals and % Reductions	HC	67,516	57,227	49,198	43,213	70,746	60,103	51,539	44,655	77,273	66,067	57,201	50,300
		13%	13%	14%	14%	8%	9%	10%	11%				
	CO	762,368	683,374	617,403	575,865	791,779	705,655	632,451	583,824	866,645	777,614	702,992	655,537
		12%	12%	12%	12%	9%	9%	10%	11%				
	NOx	100,080	82,787	68,296	56,888	103,640	85,587	70,203	57,879	114,417	94,589	77,846	64,684
		13%	12%	12%	12%	9%	10%	10%	11%				

Table 4-4. Proposed Counties Projected MOVES Average Emissions (tons) and Reductions (%)

		Tailpipe + OBD				*OBD Only*				*NO I/M*			
		2012	***2014***	***2016***	***2018***	***2012***	***2014***	***2016***	***2018***	***2012***	***2014***	***2016***	***2018***
Overall Proposed County Totals and % Reductions	HC	100,955	85,385	73,235	64,144	105,386	89,333	76,451	66,126	115,192	98,300	84,986	74,628
		12%	13%	14%	14%	9%	9%	10%	11%				
	CO	1,133,478	1,017,825	921,344	860,450	1,175,232	1,049,485	942,707	871,723	1,286,429	1,156,596	1,047,899	978,724
		12%	12%	12%	12%	9%	9%	10%	11%				
	NOx	146,903	121,546	100,228	83,422	151,548	125,219	102,751	84,741	167,329	138,417	113,967	94,731
		12%	12%	12%	12%	9%	10%	10%	11%				

5.0 Remote OBD

5.1 General Remote OBD Operation

"Remote OBD" programs for several states were explored in order to evaluate using this type of OBD testing in the Texas Inspection and Maintenance (I/M) Program. In simple terms, "remote OBD" in this context refers to "permanent" installation of a transmitter to an OBDII diagnostic link connector (DLC) on a 1996 or newer vehicle in order to communicate OBD related information about the vehicle, such as the vehicle's powertrain and MIL command status, to a receiving intermediate database. This intermediate database would perform some data management tasks and transfer vehicle data in some specified format and frequency to the state's I/M program's vehicle information database (VID) in the TIMS. Pass/fail decisions and vehicle maintenance alert tasks could either be managed by the intermediate database or the VID, depending on the design of the program. In either case, the I/M program and motorist would be notified of vehicle malfunctions and repairs would need to be made within a certain time period, according to program guidelines. If effectively enforced, this would result in timely repairs and eliminate the need for motorists to visit I/M stations to receive periodic OBD I/M testing.

OBD inspection kiosks used for motorist self-testing (similar principle to grocery store "self-checkout" registers) are evaluated in the next section. "Wireless" OBD, a system in which a traditional OBD I/M inspection is performed but the handheld component of the inspection system communicates with the inspection analyzer via wireless transmission instead of a cable, is excluded from the evaluation.

The use of remote OBD in various I/M programs was researched in order to evaluate the feasibility of implementing such a program into the Texas program and to assess some of the benefits and drawbacks of remote OBD. Information was gathered from programs in Utah, California, Nevada and Oregon. Work performed by the Remote OBD Technical Sub-Group of the Transitioning I/M Workgroup (Remote OBD workgroup) was also reviewed to determine the current state of technology and to identify issues associated with implementing remote OBD into an I/M program. The Remote OBD workgroup was formed by EPA as a part of the Mobile Source Technical Review Subcommittee under the provisions of the Federal Advisory Committee Act. This section provides a compilation of information collected during evaluation of remote OBD pilot programs and review of the Remote OBD Workgroup's work.

Remote OBD may offer several program benefits, some of which are listed below.

- Emission reductions resulting from near-continuous monitoring: As opposed to traditional I/M programs in which vehicles are inspected annually (or less frequently), remote OBD would indentify malfunctions "mid-cycle", likely prompting repairs before significant emission increases. Since some unattended malfunctions have been shown to lead to increased repair costs (such as replacement of catalytic converters saturated by a misfire fault), these timely repairs could also result in lower overall vehicle repair costs. On the other hand, more frequent repairs of non-emission diagnostic trouble codes or DTCs (such as transmission DTCs) could result in a high financial burden on motorists. Although this could be minimized through the application of a strategic waiver plan, the negative implications of allowing vehicles operate with an illuminated MIL remain.
- Providing enhanced vehicle failure and repair effectiveness information: As opposed to capturing vehicle status once per year, remote OBD could provide MIL illumination and DTC information nearly immediately after they occur. This near-immediate MIL illumination information could also help provide insight into how long MILs stay extinguished after certain types of repairs (categorized by type of DTC).
- Motorist (and fleet manager) convenience: Motorists and fleet managers participating in a remote OBD program would not be required to visit I/M stations for their emission inspection. However, this benefit is somewhat diminished if vehicles still have to visit a station to receive a safety inspection.

At the time this review was performed, remote OBD was only being used in a few exploratory pilot programs and had not been fully integrated into any I/M program. In addition, guidance for implementing remote OBD into an I/M program was under development but had not been finalized by the Remote OBD Workgroup. Therefore, many issues which were identified during our review will be addressed in the Workgroup's guidance document. Once this document is finalized and as remote OBD becomes more prevalent around the country, many of the steps necessary for implementing an effective remote OBD program should become clearer. Similarly, the true cost benefit of remote OBD programs will be better known once full-scale remote OBD programs are launched.

Various issues to consider with remote OBD programs are described in the following bullets. These issues were identified during conversations with various parties involved in remote OBD programs and through review of work performed by the Remote OBD Workgroup.

- Compatibility among program providers (remote OBD vendors) – This issue pertains to what is generally referred to as the "middle layer protocol". In summary, the "middle layer protocol" refers to the communication protocol between the wireless OBD transmitter installed in a vehicle as part of the remote OBD system and the remote OBD database which receives OBD information from each vehicle's transmitter (i.e., the "intermediate" database). At this point in time, there is no standardization in this protocol, which may result in issues with interstate operability and increase the impact of I/M program vendor changes and equipment obsolescence, among other things. However, implementation of a national standard could add additional burden to remote OBD vendors, limit technological advances and require consensus among participating states and program and equipment providers. The Remote OBD Workgroup's general consensus (at the time of this analysis) appears to be to not require development and adoption of a national standard, but instead require data format and communication protocol standardization for data sent from the intermediate database to the state I/M program's VID (this is described in the next bullet).

- Transmitting remote OBD data to the I/M program's VID - This refers to specifying how communication takes place between the remote OBD intermediate database to the I/M program's VID. This is somewhat analogous to the current standardization of communication protocols, data tables and data fields used to transmit information from inspection analyzers to the VID, except in this scenario a remote OBD intermediate database (instead of an inspection analyzer) is communicating with the I/M program's VID. The Remote OBD Workgroup's guidance document will likely contain recommendations for these standards. Our research did not identify any programs in which records from the intermediate database were transmitted to the VID.

- Acquisition frequency and enforcement – This refers to the number of times a vehicle is "seen" by the remote OBD receiving network. The number of records received from any specific vehicle will be dependent on several factors, including the type of communication network (Wi-Fi network, cellular, or other type of system), where receiver stations are placed (for Wi-Fi networks) and how frequently and under what conditions a vehicle transmits. I/M program administrators need to determine conditions under which a vehicle should report, such as elapsed time since last transmission, change of MIL status, change of monitor and readiness status, change of status of stored codes, prolonged or anomalous unreadiness, or other factors. Steps need to be in place to identify and enforce testing of vehicles which are not "seen" within the specified period of time, and provisions are needed to handle special situations such as vehicles which don't regularly pass any Wi-Fi receivers or motorists who only live in the region part-time. Reporting frequencies should support the I/M program's reporting and repair compliance requirements.

- Record management - From a record management standpoint, multiple identical records from the same vehicle can quickly become unmanageable. I/M programs with remote OBD will need guidelines on how to manage multiple records from an individual vehicle, including what should be transmitted from the intermediate database to the VID. A clear delineation of responsibility for each of the stages of data management is also required, including which database is used to determine pass/fail status, which database is used to notify state program administrators and motorists when action is needed, which database is used for performing repair enforcement, etc.

- Program participation guidelines – The general consensus appears to be that remote OBD programs should initially be offered on a voluntary basis. However, pilot programs have shown that enforcement can be a challenge in these voluntary programs. For example, in a traditional annual I/M inspection program, MIL illumination repairs are only enforced when an inspection is due, and the program's enforcement technique (such as registration denial) helps ensure repairs are made. In a voluntary remote OBD program, the motorist has a relatively short time frame in which to repair the vehicle after the MIL is illuminated (i.e., he cannot wait for 6-months until the vehicle is due for an inspection). If repairs are not made during the remote OBD program's allowed "repair window", the voluntary program typically has no enforcement recourse but to drop the motorist out of the voluntary remote OBD program and back into the traditional I/M cycle. This type of remote OBD program has little enforcement authority, or "teeth". Steps may be put in place to have licenses and/or registrations revoked for noncompliance, but this results in additional steps and additional burden on multiple cooperating enforcement agencies, additional program administration costs and a possible reduction in public acceptance of the program.
- Vendor changes and equipment obsolescence – At this point, it's unclear what level of compatibility will be seen among program providers (i.e., remote OBD vendors). If non-standardized systems evolve, significant program costs could be incurred if the I/M program changes (or adds) equipment vendors, and also when technological changes render existing equipment obsolete. Costs may be minimized to an extent by requiring equipment upgrades be "backwards compatible".
- Record security and encryption – Remote OBD programs should have provisions in order to prevent unauthorized access to vehicle records as they pass from the vehicle's onboard computer through the remote OBD transmitter, intermediate OBD database, and eventually to the State's VID. Each of these additional data communication and storage steps allow opportunities for unauthorized record access and manipulation. Consequently, record integrity safeguards for a remote OBD program will differ from those in a traditional OBD I/M program.
- Fraud and tamper prevention- In addition to the system being designed to prevent record hacking, provisions are also needed to prevent equipment tampering, code clearing, clean scanning or other forms of fraud. The remote OBD test system should also be capable of detecting devices such as oxygen sensor simulators, OBD monitor bypass equipment or OBD emulators. Several suggestions for identifying and preventing this type of fraud are provided in "Enhancements to On-Board Diagnostics Components of the Inspection and Maintenance Program" Section 4, and most of the steps listed there would be applicable for a remote OBD program (except possibly steps in which an inspector intervenes during a test to affect live data parameters). In order to prevent the remote OBD link from being used on another vehicle, downloaded parameters such as the vehicle's enabled monitor pattern, the vehicle's power control module vehicle identification number (PCM VIN) when available, the OBDII communication protocol used by

the vehicle, or the vehicle's PCM module IDs, calibration IDs and calibration verification numbers (CVN) could be used to obtain a unique signature used to verify the record for each vehicle. The vehicle's calibration ID and CVN may be used to detect PCM reflashing. "Live data" (such as engine RPM or oxygen sensor output signals) may also be collected during each broadcast and be useful in identifying potential fraud through use of non-compliant devices. A remote OBD device could also be designed so it would only function on a particular vehicle showing correct parameters (such as VIN, calibration ID and CVN). In general, while these safeguards may be effective in identifying and reducing fraud, our research also did reveal concern within the I/M industry of a potential for increase fraud in a remote OBD program (as compared with traditional in-station OBD testing).

- Compliance monitoring and program enforcement – When repairs are required for a participating vehicle, the program must have in place a system to notify the motorist (and State) that repairs are required, verify repairs were made and are effective (likely by monitoring post-repair readiness, MIL command status and DTCs), and collect repair information as needed. Enforcement strategies for non-compliant vehicles requiring repairs also need to be in place. As described in the "program participation guidelines" bullet, repair enforcement in a voluntary remote OBD program can be problematic, resulting in non-compliance, fallback into the traditional I/M program, and motorist/public discontent. The remote OBD program should be designed to mitigate these issues.
- Vehicle compatibility and acceptance testing – As with traditional I/M testing, full acceptance testing will need to be performed on the program's remote OBD test system. The acceptance testing will be based on the program and system design. Acceptance testing will need to address performance of the onboard system/transmitter, receiver system, intermediate database, and transmission and storage of the data to the I/M jurisdiction's VID. In addition to testing the remote OBD system, traditional OBD I/M functionality would also need to be addressed, including vehicle and model-specific anomalous OBD system responses and communication peculiarities. Operation of the remote OBD link should be verified with various types of vehicles, including hybrids (one pilot program has seen hybrid battery drains resulting from the vehicle's inability to enter "sleep" mode with the remote OBD link connected to the vehicle's DLC).
- Public acceptance – Although it's likely most programs will be implemented as voluntary, program administrators should plan on and prepare for negative feedback regarding government intrusion and monitoring. The extent of this may be better known if and when more of these programs are implemented around the country. Public acceptance of a remote OBD program (as with an OBD-only program in general) could also be negatively affected by older, higher-mileage vehicles with high MIL illumination rates, in particular when the MIL illumination is a result of a non-emission related DTC.
- Program costs - A cost analysis of remote OBD program implementation was beyond the scope of this evaluation, but a widespread remote OBD program could

reduce the overall I/M program costs due the reduced need for fewer I/M stations, fewer I/M inspectors, and less motorist time lost while waiting for vehicle inspections. However, the type of data transmission system, such as cellular communications or Wi-Fi receivers around the program area, can greatly influence program costs, and increased vehicle repair costs are also possible. In addition, implementing a remote OBD program alongside a traditional annual or biennial OBD inspection program would likely dilute any cost benefit of a stand-alone remote OBD program. Before implementing a remote OBD program, a detailed cost analysis of the specific program under consideration would be beneficial.

The points listed above briefly summarize some issues to consider when implementing a remote OBD test program. This is only a summary and other issues will arise as a program is developed. Some other issues that will likely arise when implementing a remote OBD program may include:

- How will mileage associated with a vehicle be collected on each record transmission?
- How will repair information be collected for vehicles for which the MIL was illuminated and extinguished?
- How will data from the remote OBD program be integrated with other I/M data (including other OBD data)?
- How will changes in remote OBD equipment providers affect the program, or how could multiple equipment providers in a remote OBD program (multiple systems reporting to the same VID) be managed?
- How will implementing a remote OBD program affect the participation and income of traditional I/M inspection stations?
- How will repair enforcement and program dropout be managed, and how will repair effectiveness and program emission benefits be calculated for the remote OBD program?
- What memory should be required for onboard devices to ensure triggered events, live data stream records and other info can be stored until transmission?
- How long should triggered events (i.e., MIL illumination) be stored, and what storage and reporting redundancy should the system offer?
- What performance requirements (such as system up-time, transmission speeds, communication rates, etc. should be specified for each of the data management systems)?

Other issues will also arise. Careful planning for management of foreseeable issues will be critical in implementing a successful remote OBD program. Information provided by other jurisdictions suggests significant personnel would be required to develop such a program. We recommend not beginning implementation of such a program until EPA's Remote Workgroup guidance has been finalized and the future of remote OBD programs (and remote OBD equipment and services providers) becomes clearer.

5.2 OBD Kiosks

During our review, only one state we spoke with operated a self-serve OBD kiosk (in a pilot mode), although several I/M equipment and services providers were identified which offer OBD kiosks (and another state was identified which did have several kiosks available but not for self-service). A representative from another state indicated they had decided against using OBD self-test kiosks because a gas cap test was required. In any self-test program, the most likely scenario would be two or more kiosks with an "oversight representative" onsite to oversee operations and offer guidance to motorists who need it (similar to multiple grocery store self-checkouts monitored by one employee to provide assistance and overrides). An "oversight representative" could also manage multiple kiosks remotely by watching live video feeds and real-time data screens and communicating with the motorists by live video / audio feed. Based on our review, the following issues were identified which should be considered when evaluating use of self-test OBD kiosks in an I/M program:

- Inspection complexity and potential fraud – Vehicle testing requiring safety inspections or inspector keyboard entry of other pass/fail items (such as MIL bulb check) are not ideal candidates for a self-test due to the potential for fraud and unintentional incorrect entries. Programs where motorist insurance coverage is verified would need to either eliminate the coverage verification or integrate that into the test somehow, such as having the oversight inspector check insurance cards prior to the inspection, or require insurance information entry into the analyzer (which may offer a potential for fraud). Gas cap testing is typically automated in the inspection but also adds a layer of complexity to the inspection process. Finally, the potential for motorists to attempt to "clean-scan" a vehicle is likely higher in an OBD self-test program than a traditional inspector-based program. However, clean scanning may be deterred by use of a system which captures and transmits images real-time to remotely-located supervisors monitoring all inspections (systems such as this are currently offered by I/M equipment and services contractors).
- Data entry errors – A higher potential for typographical errors may exist when motorists instead of certified inspectors enter vehicle information. This potential may be minimized by using alternatives such as VIN download from the ECM (in particular for newer vehicles), bar-code scanned VINs, automated electronic capture and transcription of vehicle license plate information and entry verification by an "oversight representative" (either onsite or remote).

- DLC location – It's reasonable to expect that many motorists will initially be unfamiliar with the location of their DLC and method for connecting the analyzer link to the DLC. The oversight representative could assist with this, along with on-screen guidance provided by the inspection analyzer.
- Sticker security – Inspection programs which use a sticker affixed to the window carefully track each sticker to reduce the potential for fraud. Preventing sticker fraud and tracking sticker inventories could be more complex with an OBD kiosk program. Several options exist for managing this, which include printing a vehicle inspection record with an embedded sticker (for passing inspections), managing sticker distribution and application by the oversight representative, or providing the sticker after the inspection, such as through an Internet-based request system. However, past experience has shown motorists are reluctant to perform this "self test" if a sticker is not issued immediately once the test is passed. When dispensing a sticker to a motorist (rather than sticking it on the windshield), a greater potential exists for stickers obtained for one vehicle's test to be used for another vehicle (similar to the current potential for registration stickers to be used on incorrect vehicles).
- Motorist acceptance – An OBD inspection can be viewed as more complex than a grocery store checkout, and motorists may be reluctant to perform their own OBD inspections, even in a program where stickers are immediately provided. Monitoring the acceptance of OBD self-testing kiosks in other programs may provide an indication of whether this type of testing would be accepted by motorists in the Texas I/M program. Fleet managers (who need to regularly test vehicles) may be more likely to embrace such a program.
- Payment – The mechanism for payment would need to be established, and could take the form of payment collection by the onsite representative or a card-swipe system integrated into or alongside the OBD test kiosk.
- Equipment damage / security – A higher potential for equipment damage exists when the general public is testing their own vehicles (rather than inspectors using their own analyzers). Video cameras, onsite representatives, and facility inaccessibility during off-hours would help minimize the potential for equipment damage.

As with remote OBD, our review did not identify any fully operational self-test programs. Although this technology may be promising in terms of resources and test efficiency, we recommend postponing implementation of such a program until more is known about its feasibility in an I/M program.

6.0 Test Alternatives

6.1 Background and General Considerations

The MOVES modeling runs in the Section 3 outlined the emissions impacts of eliminating TSI and ASM testing in the coming years. This and some of the other options considered in the MOVES section are in the discussion below; however, at this time it was not possible to provide MOVES modeling estimates for each option below because the MOVES model has not yet been developed in sufficient detail to make such projections.

As the fleet ages, the MY95 and older vehicles required to be tested will continue to diminish in size and by 2020 none of these vehicles will be required to have an I/M test performed. Although there will still be a need and perhaps a legislative requirement to continue an I/M test for this segment of the fleet until 2020, it may no longer be feasible or desirable to test 100% of this population as is currently done. With these considerations in mind, the sections below describe different concepts that could be considered to test a portion of the non-OBD fleet in the coming years. However, each of these proposals are inherently dependent on four key elements that must be addressed for any I/M test option. These four elements will be discussed in broad terms, but the details of how they would be implemented or addressed for each of the test options is beyond the scope of this report.

1. Identify Vehicles & Notify Owner
2. Evaluate Vehicle
3. Repair Vehicle
4. Certify Repair/Enforcement

The first element, identifying vehicles and notifying the owner, could be accomplished through a RS-only program, an HEP program, or during the vehicle's routine safety inspection. With the RS-only or M- HEP options, fleet coverage is a concern that is not an issue if vehicles are identified and the owners notified during the safety inspection process since that covers 100% of the fleet and the owner notified during the safety inspection that his or her vehicle failed its emissions evaluation. In theory, fleet coverage should also be 100% for the HEP option since that program would use the Texas vehicle registration database as its source of vehicles to be evaluated; however, both the HEP and RS-only options would require the owner to be notified by letter that their vehicle had failed the emissions evaluation. Details with regard to emission benefits for the RS-only and HEP options are discussed in more detail in Sections 6.2 and 6.3 below.

The second element, evaluating the vehicle, involves how will the result from the RS-only, HEP or safety inspection emission evaluation be verified. Section 6.3 provides an overview of alternative tests, functional checks, and visual emission component checks. The information in this section also contains input obtained from other state I/M programs that have begun to focus their attention on addressing the same concerns that will be confronting the Texas program. There are a number of evaporative procedures in this list, and many of these tests have been or are being performed in different I/M programs. However, there are no known methods available to verify high exhaust emissions that do not involve some form of tailpipe testing. In the case of Texas, this verification testing would probably be most easily done at designated existing decentralized or referee stations that would conduct an ASM or TSI confirmatory exhaust test. If performing some type of confirmatory exhaust emission test is not possible, it may be decided to have the owner proceed directly to a repair facility to have the vehicle fixed; however, since RS-only and HEP are not approved I/M short tests, this option may be difficult to get EPA to approve. Additionally, there will be a high level of motorist inconvenience since the results of the RS-only and HEP will have a high level of false-positives. This latter point is discussed in more detail below in Sections 6.2 and 6.3.

The third element, repairing the vehicle, could very well be done as it is in the current system, i.e. at uncertified decentralized repair stations or by the owner. More program control could be obtained if all repairs were required to be done at certified repair stations, and this could be desirable since the evaluation of the vehicle emissions element becomes much less well-defined for the non-OBD fleet if ASM and TSI testing are no longer available.

The fourth, and last element, is certification of repair and enforcement. This could be approached as in the current program where those in the safety inspection only counties receive a safety sticker while those in the safety plus I/M counties are subject to registration denial if they do not receive an emissions sticker. The best way to issue the emissions sticker will depend on what choice is made with regard to evaluating the vehicle's emissions after it has been identified and the owner notified. For example, if a confirmatory exhaust test is performed at a designated station, then issuing the emissions sticker at that point would appear to be a logical path to follow. However, if it is decided that no confirmatory emission test of any kind will be performed, then the discussion on the best method for issuing emissions stickers becomes more complex and beyond the scope of this study.

An alternative method to the current procedure for issuing an emission sticker might be worth considering. The safety inspection only counties would remain unchanged, but now the emission sticker would be modified so that it is issued to all those vehicle owners during their safety inspection that have not been flagged by the alternative test, e.g. RS-only. Those vehicles that were flagged by the alternative test would be required to show proof of repair during their safety inspection before they would be issued their emission sticker. This procedure would require the TIMS database to be linked to the database of alternative test procedure results.

6.2 Remote Sensing High Emitter Identification

6.2.1 Background

In this section of the report, the potential emission reductions possible from using only remote sensing to identify high emitters in the absence of an on-going I/M program are examined. We used the available RS data from June 2006 to August 2008 and combined it with Texas I/M data to estimate the efficiency of RS to identify vehicles that would fail the current I/M requirements (ASM for pre-1996 vehicles, and OBD for 1996 and newer vehicles). A dataset of matched remote sensing and I/M inspection records that were close in time were used to develop a pass/fail link between RS and I/M results. We then used the RS-I/M relationship to estimate the number of vehicles that could be identified by RS as high emitters and are likely to fail a potential I/M test. In addition, we also estimated the number of vehicles that would be identified by RS, but would pass a subsequent I/M test. Finally, we estimated the potential emissions reduction possible for a large, wide-spread RS-only program. References to the methods, data sources and previous work used to develop the RS-only described below may be found in citations [2] through [11] at the end of this report.

6.2.2 Preparation of RS Dataset and Paired RS-I/M Dataset

The RS dataset: For this study, remote RS data for a 27 month period were used. Data through August 31, 2008, were available, so the 9.5 million records for the period from June 1, 2006, through August 31, 2008, were used. Twelve million I/M records for a corresponding 24 month period were used: September 1, 2006, through August 31, 2008; this represents two full I/M cycles during which all Texas vehicles should have been inspected. (The extra three months of RS data allow us to identify remote sensing observations that occurred in the three months prior to an I/M inspection.) Only I/M and RS records for light duty vehicles from the two enhanced I/M areas were used (HGB and DFW).

The RS records provided to ERG by the Department of Public Safety (DPS) were already checked for validity by the RS data collection contractor. Therefore, there was no check made for the validity of the values within each of the RS data fields. However, the vehicle specific power (VSP) for each vehicle using the RS speed, acceleration, and the slope at the RS site was calculated. The slope for the RS site was not included in the RS data, but was provided separately by DPS. Once the sites and slopes were matched to the RS records and the VSP calculations were done, a VSP filter was applied. Any records with a VSP outside the range of 5-25 kW/Mg were removed from the dataset. Additionally, the RS dataset was edited by removing any records with no VIN (because the VIN allows us to match the RS record to the I/M record). Finally, any RS vehicles outside the 2-24 year age range for the I/M program were removed. This left 4.3 million RS records for the 27 month period, for 1.9 million unique vehicles.

Table 6-1 shows a summary of the number of records described above and makes a projection for annual counts based on these numbers.

Table 6-1. Summary of the Remote Sensing Data used for this Analysis

Remote Sensing records	Total counts over 27 months	Counts for a one Year Program
Total HGB/DFW records	9,459,700	4,204,311
Take out records with missing VINs	6,520,260	2,897,893
Take out records with out-of-range VSPs	5,418,909	2,408,404
Take out records outside of 2-24 years old	4,343,636	1,930,505
Total Van Days	2,031	903

ERG has noted in the past that the RS data which was collected prior to March 2007 did not contain any negative values. Negative values are expected in RS dataset because of the normal variability in the measurements, but these values had been deleted from the dataset before it was provided to us. This removal does affect the distribution of the RS emissions concentrations, but should not be a significant problem for this study since we are concerned with comparison of RS and I/M records for high-concentration RS records.

The paired RS-I/M dataset: The I/M inspection record dataset was edited by removing any inspections that were aborted, had an invalid VIN, had a result other than “P” or “F” for the emissions inspection result, or were recording a safety-only inspection. Only the initial I/M inspection of each inspection cycle was used. I/M vehicles that were observed by remote sensing within the selected time period prior to the initial I/M inspection (three months were chosen in this study[2]) were flagged as having a matched RS-I/M pair. RS observations after the I/M inspection were not used because the vehicle might have undergone repair after the I/M inspection and RS readings would no longer represent the vehicle in the as-presented to I/M condition. Similarly, RS observations that occurred more than three months prior to the I/M

[2] Note that more pairs of RS-I/M records would be obtained by using a wider allowable time period between the RS and I/M dates, but the correlation between the results might be degraded as measurements become further apart in time.

inspection were not used because of the potential for vehicle changes over time to degrade the relationship between the RS reading and the I/M inspection result. Thus I/M inspections with an RS observation more than three months prior to the I/M inspection, an RS observation after the I/M inspection, or no RS observations were flagged as I/M inspections with no matching remote sensing observation. Then, if a given I/M vehicle had more than one initial I/M inspection in the dataset, only the first I/M cycle with a matching RS observation was used. This resulted in a dataset of 544,000 paired RS-I/M records over the two year period, with the RS observation within a 3 month window prior to the I/M inspection (For one year period the resultant data set numbered 289,540 vehicles). This paired dataset was used to develop the link between RS emission levels and I/M inspection results. Table 6-2 presents the number of inspections and their association with the remote sensing data on an annual basis.

Table 6-2. Annual I/M and RS Vehicle Counts

I/M Inspections	Counts for One Year (12 Months)
Total Inspections	5,972,803
Initial Inspections	5,499,278
Unique Vehicles	5,415,643
Unique Vehicles ever seen by RS	1,431,555
Preceded by an RS within last 12 months	783,266
Preceded by an RS within last 9 months	650,257
Preceded by an RS within last 6 months	494,984
Preceded by an RS within last 3 months	289,540

6.2.3 Calculation of RS “Cutpoints” and Projected Failure Rates

After the RS data was matched to the I/M data to create the paired dataset, RS “cutpoints” were created to identify vehicles that hypothetically “passed” or “failed” the RS inspection. It was desired to create several cutpoints and compare the results. Cutpoints should be high enough that as many as possible of the vehicles that exceed them truly do have high emissions (i.e., would fail an I/M inspection), but should be low enough that a useful fraction of the fleet is targeted. Therefore, for HC, CO, and NO_x separately, and for ASM and OBD vehicles separately, the emissions concentrations for the 75^{th}, 80^{th}, 85^{th}, 90^{th}, and 95^{th} percentiles were found. The concentration at each of those percentiles was used as the cutpoint. The cutpoints are listed in Table 6-3.

Table 6-3. Remote Sensing "Cutpoints"

Pollutant	Calendar Year Group	Cutpoint 1 (75th percentile)	Cutpoint 2 (80th percentile)	Cutpoint 3 (85th percentile)	Cutpoint 4 (90th percentile)	Cutpoint 5 (95th percentile)
HC (ppm)	ASM	127.83	150.26	179.84	222.72	307.51
	OBD	47.42	56.42	68.83	87.83	124.77
CO (pct)	ASM	0.37	0.47	0.61	0.92	2
	OBD	0.08	0.1	0.14	0.2	0.37
NO_x (ppm)	ASM	1250.66	1482.49	1781.85	2187.92	2807.6
	OBD	196.07	260.92	364.29	550.53	961.41

Once the RS Cutpoints had been created, we were able to identify each RS-I/M vehicle as "passing" or "failing" RS, and then compare these results to I/M inspection pass/fail results. This comparison was done separately for vehicles that exceeded the RS HC cutpoint, the RS CO cutpoint, and the RS NO_x cutpoint, and then for vehicles that exceeded any RS cutpoint. Table 6-4 shows the comparison of the RS-I/M results using the criteria that a vehicle "failed" RS if it exceeded the cutpoint for any of the three pollutants. The upper portion of the table represents ASM vehicles (model years older than 1996), while the OBD vehicles (1996 and newer) are shown in the lower portion of the table. For example, the first row gives the number of vehicles with RS emissions below any of the RS cutpoints: these vehicles "passed" their RS inspection and were not flagged for RS. For these vehicles, the I/M failure rate was 5.3%. In the next row, 28,605 I/M vehicles were above the first RS cutpoint; these vehicles "failed" their RS inspection and were flagged. The failure rate was 14.7% for the flagged vehicles - much higher than the 5.3% for the non-flagged vehicles. However, that means that 85.3% of the vehicles that would have been called in for cutpoint #1 would have been "inconvenienced": they passed their I/M inspection. As the RS cutpoint is increased, fewer vehicles are called in, but a higher portion of them fail their I/M inspection, and fewer of them are inconvenienced.

Table 6-4. Comparison of RS "Pass/Fail" with I/M Inspection Result

RS Result	Total I/M Records	Failed I/M Records	I/M Fail Percent	I/M "Inconvenienced" Percent
ASM Vehicles – Pre 1996				
Below RS Cutpoint 1	29065	1528	5.3	
Above RS Cutpoint 1	28605	4206	14.7	85.3
Above RS Cutpoint 2	24111	3789	15.7	84.3
Above RS Cutpoint 3	19305	3264	16.9	83.1
Above RS Cutpoint 4	13814	2551	18.5	81.5
Above RS Cutpoint 5	7466	1584	21.2	78.8
OBD Vehicles – 1996 and Newer				
Below RS Cutpoint 1	257507	6840	2.7	
Above RS Cutpoint 1	254296	13199	5.2	94.8
Above RS Cutpoint 2	214661	11877	5.5	94.5
Above RS Cutpoint 3	167986	10081	6.0	94.0
Above RS Cutpoint 4	119350	7952	6.7	93.3
Above RS Cutpoint 5	63068	4898	7.8	92.2

The cutpoints and corresponding RS and I/M failure percentages were then available for application to the fleet as a whole.

6.2.4 Calculation of Historical I/M Failure Rates

Two other pieces of information that were needed for this study were 1) recent failure rates for Texas I/M inspections, to be used for the projection of future failure rates, and 2) historical failure probabilities (fprobs) for each type of vehicle in the fleet, to be used as another type of cutpoint (this approach is discussed in the next Section).

The four-year set of records that was used for this analysis included 27 million TIMS records for I/M inspections for 2006 through 2009. Again, aborted inspections, safety-only inspections, records for heavy duty vehicles, records with no valid VIN, and records from outside of the DFW/HGB areas were deleted. Retest inspections were also removed from the dataset. This dataset was used to determine the annual I/M inspection failure rate for those four years, separately for OBD (1996 and newer) and ASM (1995 and older) vehicles. The I/M inspection failure rates for each year are shown in Figure 6-1. The lines on the figure show the projected future failure rates for the years 2012, 2014, 2016, and 2018. The failure rates are also listed in Table 6-5.

Figure 6-1. I/M Inspection Failure Rates: Current and (Projected) Future

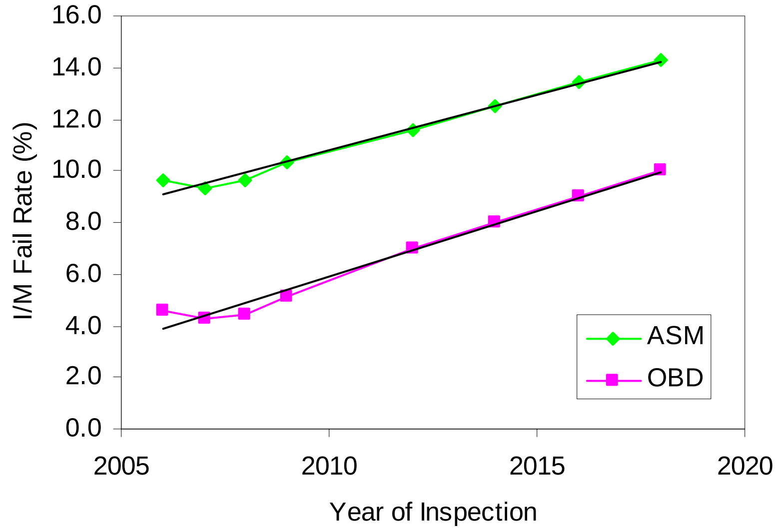


Table 6-5. I/M Inspection Failure Rates: Current and (Projected) Future

Year of Inspection	ASM (pre 1996)	OBD (1996 & newer)
2006	9.6	4.6
2007	9.3	4.2
2008	9.6	4.4
2009	10.3	5.1
2012 (proj.)	11.6	7.0
2014 (proj.)	12.5	8.0
2016 (proj.)	13.4	9.0
2018 (proj.)	14.3	10.0

6.2.5 Quantifying Fleet RS Coverage

The size of an RS data collection effort is driven by the desired coverage of the fleet. RS cannot get measurements on all vehicles in the on-road fleet. RS units can be deployed only in locations meeting special criteria such as the number of vehicles passing at a time, space on the side of the road to safely fit the equipment, and the speed and operating mode of passing vehicles. Also, it is not generally cost effective to measure at sites with little traffic. Since a certain fraction of the fleet will seldom pass by some RS sites, that fraction of the fleet has little chance of getting an RS measurement.

As vehicles pass by an RS unit, the percentage of observations that will produce data that can be used to select vehicles for intervention activities is limited by a number of factors:

- not all of RS measurements are valid,
- not all produce a license plate image that is usable ,
- not all of vehicles are being operated in a way at the time of the RS reading that fairly represents the typical emissions of the vehicle, and
- Some of the vehicles have already been measured by RS.

Small RS programs can rely on sites where the impact of these effects is relatively small. As program sizes increase, sites where the impacts are greater typically must be included in order to obtain the desired fleet coverage. Therefore, the fractions that we use to account for these effects depend upon the size of the program relative to the size of the fleet.

Two definitions of RS fleet coverage – In this analysis, we discuss the coverage of the fleet with RS measurements using two different definitions of coverage. Either definition can express RS coverage relative to either the total number of vehicles in the fleet or the total number of vehicles in the I/M fleet. The important distinction between the two definitions is whether the RS measurements are taken on a vehicle when it is operating in the emissions-representative VSP range (5 to 25 kW/Mg)[3, 4] or whether it is operating at any VSP. The two definitions are:

- **Any-VSP RS coverage –** This refers to the number or fraction of vehicles that receive at least one valid RS reading (as determined by the RS analyzer software) on a vehicle that is matched by the license plate to a record in the registration database. The vehicle-specific-power associated with these RS readings could have any value. The RS readings could be for vehicles that are operating at moderate load, at steady cruise, under deceleration, or under heavy acceleration. RS data collection vendors typically use this definition of coverage.
- **Usable-VSP RS coverage –** This refers to the number of vehicles or fraction of vehicles that receive at least one valid (as determined by the RS analyzer software) RS reading on a vehicle that is matched by the license plate to a record in the registration database, and the VSP is in the emissions-representative range. These RS readings are only those associated with vehicles that are operating at moderate load.

---

[3] 1 Mg = 10^6 g = 1000 kg = 1 metric ton

[4] In this study we used 5 to 25 kW/Mg as the emissions-representative range. We chose this range based on work by J.L. Jimenez in his 1999 Ph.D. thesis Understanding and Quantifying Motor Vehicle Emissions with Vehicle Specific Power and TILDAS Remote Sensing. ESP uses 3 to 22 kW/Mg as their emissions-representative range. Sierra Research advocates using 4 to 14 kW/Mg as the appropriate emissions-representative range (see Appendix C).

6.2.6 Estimating Fleet Coverage Characteristics for California RS Programs

The analysis of the pilot study RS measurements as presented in the previous section demonstrated that:

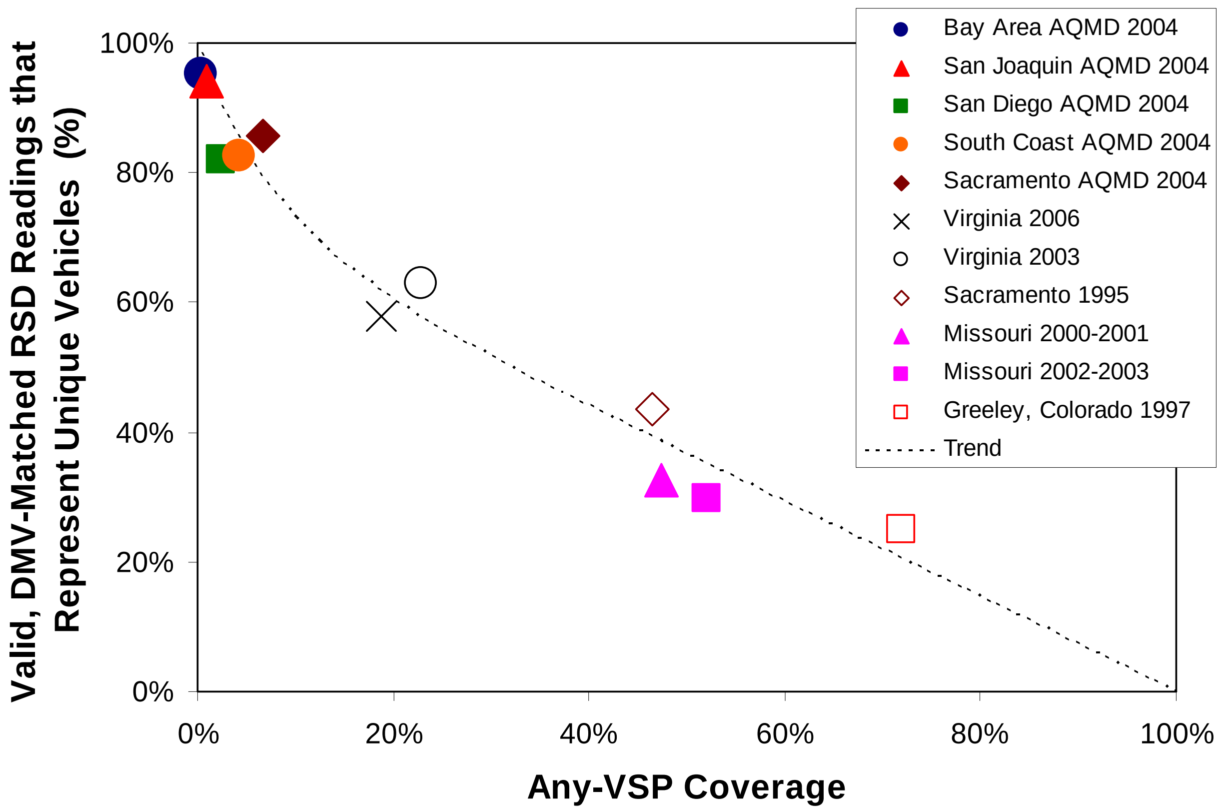
1) the percent uniqueness, and
2) the percent in-range VSP

Percent uniqueness – An RS program can identify vehicles for special strategies only for those vehicles that receive an RS measurement. Unfortunately, to obtain at least one valid, RS measurement matched to a Department of Motor Vehicle (DMV) record on a substantial portion of the vehicles driving in the program area, more RS measurements than the number of vehicles must be collected. This is because a portion of the RS readings are actually replicate RS measurements on the same vehicles obtained as vehicles repeatedly move (e.g., commute) past an RS measurement site. We define the uniqueness of an RS program as the ratio of the number of unique vehicles to the number of valid, DMV-matched RS measurements taken on them. From another perspective, uniqueness is also the reciprocal of the average number of valid, DMV-matched RS measurements per vehicle.

RS measurement uniqueness depends on several factors including the quality of the RS measurement sites, the number of RS measurement sites in the program area, the length of time that an RS measurement unit spends at each RS site, and the any-VSP RS coverage level that the data collection effort achieves. Figure 6-2 shows how the uniqueness has trended with any-VSP RS coverage for several other different RS data collection efforts.

In Figure 6-2 the five points in the upper left corner represent the uniqueness and coverage of the RS data taken in the five air quality management districts in the California pilot study. The other six points are from the other RS programs or studies and have any-VSP coverages of 20% to 72%, which are substantially higher than the California pilot study coverages. The 1995 Sacramento and 1997 Greeley efforts were RS studies. The Virginia and Missouri efforts were ongoing RS programs. While the Sacramento RS pilot study was performed about 10 years before the current pilot study, our intensive examination of potential RS sites during the current pilot study in the Sacramento area indicated that, from an RS perspective, Sacramento has changed as changes to the highway infrastructure (e.g., metering of freeway on-ramps) have degraded many formerly good RS sites.

Figure 6-2. RS Measurement Uniqueness for Several RS Efforts



Two additional theoretical points serve to round out the uniqueness vs. any-VSP coverage trend seen in Figure 6-2. At the limit of 0% coverage, the uniqueness would be 100% since the first few vehicles at each RS measurement site would receive only one RS measurement. This point is the upper left corner of Figure 6-2. Similarly, at the limit of 100% coverage, the uniqueness would be 0% since a very large number of RS measurements would be required to cover all of the vehicles in a fleet. This point is the lower right corner of Figure 6-2.

When we consider all of the eleven data points and the two theoretical points together in Figure 6-2, we see a clear and relatively compact trend. We believe that we can use the higher coverage values to estimate the uniqueness that would be associated with California RS programs that are substantially larger than the pilot study. The following function describes the trend line that passes through the data points subject to the constraints of the two theoretical end points of the trend:

$$\text{Uniqueness (fraction)} = 0.73 - 0.73 \times \text{Coverage} + 0.27 \times \exp(-13 \times \text{Coverage})$$

Where: Coverage = Any-VSP Coverage (fraction).

The locations of the data points in Figure 6-2 are based on uniqueness levels achieved in practice by RS vendors by the particular design chosen for each particular RS measurement program. We would expect that RS vendors would chose program designs that tended to be most efficient for a given area and highway infrastructure, and therefore we believe that the trend in the figure represents typical RS programs.

However, it is certainly possible that constraints could cause RS measurement programs that are atypical. Every RS data collection program chooses a balance for a stay vs. move decision:

Stay: Collect RS data at fewer sites for a longer time at each site
vs.
Move: Collect RS data at more sites for a shorter time at each site.

For moderate variations in the balance, both approaches will cost about the same since RS data collection cost is based on the number of valid, DMV-matched RS measurements. However, the two approaches have different coverage and uniqueness characteristics. An extreme example will serve to illustrate the point.

6.2.7 Fleet Coverage Characteristics of Large RS Programs

ERG has developed a spreadsheet model based on the RS and I/M data collected by Texas. Table 6-6 shows an example of how a large RS program that provides about 25% coverage could be developed using approximately the same number of van days currently deployed by Texas. In the combined Houston and Dallas I/M area there are about 5.4 million vehicles that are subject to inspections. We start with this number to compare any wide spread RS program to the current I/M program. The Table shows that for the Houston and Dallas areas to achieve a 25% coverage program would require that about 1.35 million unique vehicles would need to be measured with RS. Using the equation described above the uniqueness fraction would be calculated to be 55.8% which would estimate the valid reading count to be 2.4 million. Such a program would require a total number of beam blocks to be about 5.28 million using the proportions in Table 6.1. We also estimate that such a number of beam blocks can be achieved with a 1,135 van days/year program would be required which is similar to the 930 van days/year program that is currently deployed. All these statistics are based on the current Texas experience and a choice of 25% coverage, other assumptions can be made and a spreadsheet tool may be provided to the TCEQ, if requested, to estimate the size of the program using different estimates.

Table 6-6. RS Fleet Coverage Calculations

Coverage Calculation	Estimate
Number of vehicles in I/M fleet per year	5,415,643
Coverage	25.00%
No of unique vehicles identified by RS	1,353,911
Uniqueness	55.80%
Number of valid RS	2,426,498
Total beam blocks needed	5,284,500
Total projected van days per year	1,135

6.2.8 Calculation of Fail Rates and Rates of Inconvenienced Vehicles

In this section we will combine the results from Table 6-3 and Table 6-6. Table 6-3 showed the potential fail rates for vehicles whose RS emissions were higher than a set of identified cutpoints. In the above table we projected that the number of vehicles identified by RS would be about 1.3 million. First, we estimate the number of vehicles that would be projected to be above the cutpoints. These are shown in Table 6-7. We also estimate the number of vehicles that would be projected to fail a subsequent I/M test. Note that as the RS cutpoint is raised, the total number of vehicles identified by RS is reduced but a higher percentage of those vehicles are projected to fail an I/M test. Also, as noted in Table 6-3, if all the vehicles identified by RS are invited for diagnosis and repair, a large fraction of the vehicles would be inconvenienced or found to have no significant defective emissions control equipment.

Table 6-7. Projection of Rates for Vehicles that would potentially Fail an I/M Test and the Number of Vehicles Inconvenienced

		Cutpoint 1 (75th percentile)	Cutpoint 2 (80th percentile)	Cutpoint 3 (85th percentile)	Cutpoint 4 (90th percentile)	Cutpoint 5 (95th percentile)
Unique RS measurements	1,353,911					
% of Vehicles Identified by RS		49.68%	41.93%	32.89%	23.38%	12.39%
Number of Vehicles Identified by RS		672,592	567,676	445,281	316,595	167,693
Number of vehicles That would fail I/M	(calendar year)					
	2012	42,413	38,186	32,416	25,476	15,668
	2014	39,836	35,858	30,460	23,971	14,760
	2016	37,964	34,168	29,040	22,878	14,100
	2018	36,765	33,084	28,129	22,177	13,677
Number of vehicles That would be inconvenienced						
	2012	630,179	529,489	412,864	291,119	152,025
	2014	632,756	531,817	414,821	292,624	152,934
	2016	634,627	533,508	416,241	293,717	153,593
	2018	635,827	534,592	417,152	294,418	154,016

In addition, by combining the fail rates for the current I/M program in future years we estimate that the following numbers of vehicles would fail an I/M program similar to the current program.

Table 6-8. Expected Number of Failed Vehicles with Current I/M Program

Year	No. Failures
2012	408,306
2014	452,011
2016	498,781
2018	548,313

Next, we estimated the ratio of failed vehicles based on a RS program as compared with the current I/M program. Table 6-9 provides this estimate for the evaluated RS cutpoints.

Table 6-9. Fraction of Benefit Expected from the Failing the Projected Vehicles in a RS Program Compared to the Existing I/M Program for the Specified Coverage of 25%

	Calendar Yr	Cutpoint 1 (75th percentile)	Cutpoint 2 (80th percentile)	Cutpoint 3 (85th percentile)	Cutpoint 4 (90th percentile)	Cutpoint 5 (95th percentile)
Fraction of benefit	2012	10.39%	9.35%	7.94%	6.24%	3.84%
	2014	8.81%	7.93%	6.74%	5.30%	3.27%
	2016	7.61%	6.85%	5.82%	4.59%	2.83%
	2018	6.71%	6.03%	5.13%	4.04%	2.49%

Lastly, we estimated the emissions reductions for the RS program. These are shown in Table 6-10 for Houston and Dallas. These are based on the MOVES estimates for the current program, and ERG's estimate of the fraction of that benefit associated with a RS program with coverage of 25%. As the coverage is increased, the emissions reductions will also increase, but so will the cost of the program due to more RS van operation and more vehicles being inconvenienced.

Table 6-10. Estimated Emissions Reductions (Tons per year) for the RS Program for a Specified Coverage of 25%

Calendar Year	Ctpt 1 (75th percentile)	Ctpt 2 (80th percentile)	Ctpt 3 (85th percentile)	Ctpt 4 (90th percentile)	Ctpt 5 (95th percentile)
Houston					
HC (tons/year)					
2012	379	341	290	228	140
2014	290	261	221	174	107
2016	223	201	171	135	83
2018	171	154	131	103	64
CO (tons/year)					
2012	4,061	3,657	3,104	2,440	1,500
2014	3,112	2,801	2,380	1,873	1,153
2016	2,435	2,192	1,863	1,468	904
2018	1,996	1,796	1,527	1,204	743
NO_x (tons/year)					
2012	550	495	420	330	203
2014	383	345	293	231	142
2016	268	241	205	161	99
2018	192	173	147	116	72
Dallas					
HC (tons/year)					
2012	458	413	350	275	169
2014	350	315	267	210	130
2016	270	243	207	163	100
2018	208	187	159	125	77
CO (tons/year)					
2012	4,714	4,244	3,603	2,831	1,741
2014	3,615	3,254	2,764	2,175	1,339
2016	2,833	2,549	2,167	1,707	1,052
2018	2,324	2,091	1,778	1,402	864
NO_x (tons/year)					
2012	657	592	502	395	243
2014	459	413	351	276	170
2016	321	288	245	193	119
2018	230	207	176	139	86

6.3 Modeling High Emitter Profiling Identification

6.3.1 Background

The goal in this section is to estimate the emission reductions possible by using an HEP program to identify high emitters in the absence of an on-going I/M program. The four-year set of records that was used for this analysis included 27 million TIMS records for I/M inspections for 2006 through 2009.This four-year dataset was also used to calculate the historical failure rate for every combination of model year/make/series/engine size that received an inspection. The ERG VIN decoder was used to decode the VIN for each inspection record, and the model year, make, series, and engine size from the VIN decoder were used. The VIN for each record collected from 2006 through 2009 was decoded, but the failure rates were calculated only for the vehicles inspected between 2006 and 2008. The historical failure rates were then applied to the 2009 inspection records, to predict the failure probability (fprob) for each vehicle inspected in 2009. We developed this simple HEP for Texas. These fprobs reflect only the probability of failing the overall emissions component of the I/M inspection (i.e., we did not create separate fprobs for HC, CO, and NO_x individually). In addition, we also estimate the number of vehicles that would be identified by Fprobs but would pass a subsequent I/M test. Finally, we will estimate the potential emissions reduction possible by an HEP program.

6.3.2 Calculation of Fprob Cutpoints

After the fprob rates were applied to the 2009 data, fprob "cutpoints" were created to identify vehicles that hypothetically "passed" or "failed" the I/M inspection. Again, we wished to create several cutpoints and compare the results. Therefore, the fprobs for the 75th, 80th, 85th, 90th, and 95th percentiles were found. The Fprob at each of those percentiles was used as the cutpoint. The cutpoints are listed below in Table 6-11.

Table 6-11. Fprob "Cutpoints"

Calendar Year Group	Cutpoint 1 (75th percentile)	Cutpoint 2 (80th percentile)	Cutpoint 3 (85th percentile)	Cutpoint 4 (90th percentile)	Cutpoint 5 (95th percentile)
ASM	0.123	0.133	0.140	0.153	0.181
OBD	0.054	0.059	0.070	0.080	0.095

Once the Fprob Cutpoints had been created, we were able to identify each vehicle as "passing" or "failing" based on Fprob, and then compare these results to the vehicle's actual I/M inspection pass/fail results. These results are shown in Table 6-12.

Table 6-12. Comparison of Fprob "Pass/Fail" with I/M Inspection Result

Fprob Result	Total I/M Records	Failed I/M Records	I/M Fail Percent	I/M "Inconvenienced" Percent
ASM Vehicles – Pre 1996				
Below RS Cutpoint 1	504,156	41,887	8.3	
Above RS Cutpoint 1	167,933	27,923	16.6	83.4
Above RS Cutpoint 2	133,465	23,203	17.4	82.6
Above RS Cutpoint 3	100,141	18,123	18.1	81.9
Above RS Cutpoint 4	67,129	12,828	19.1	80.9
Above RS Cutpoint 5	33,457	7,054	21.1	78.9
OBD Vehicles – 1996 and Newer				
Below RS Cutpoint 1	3,706,112	142,640	3.8	
Above RS Cutpoint 1	1,235,081	122,813	9.9	90.1
Above RS Cutpoint 2	988,035	103,442	10.5	89.5
Above RS Cutpoint 3	740,866	81,828	11.0	89.0
Above RS Cutpoint 4	492,633	58,641	11.9	88.1
Above RS Cutpoint 5	244,453	32,279	13.2	86.8

6.3.3 Fleet coverage for Large Scale HEP program

The key advantage for an HEP program over an RS program is that virtually all vehicles that are under consideration can be identified with a VIN and a failure probably can be calculated based on historical information. We have estimated that about 95% of the 5.4 million vehicles that would be under consideration in this evaluation would have their VINs decoded and get a failure probability assigned. We believe this estimate is conservative because as stated above, the number of vehicles covered by an HEP program should be very close to 100%; however, we have chosen 95% for this example so that any benefits are not overly-optimistic.

Previously, ERG estimated the number of vehicles projected to be above the I/M program cutpoints, based on the current I/M program fail rates projected to future year vehicle populations. These were shown in previously in Table 6-8, and are repeated in Table 6-13 for convenience. In addition, ERG estimated the number of vehicles that would be projected to fail future I/M tests based on an HEP program, and these projections appear in Table 6-14. Note that as the HEP cutpoint percentile ranking is raised, the total number of vehicles identified by HEP is reduced but a higher percentage of those vehicles are projected to fail an I/M test. Also, as can be seen in Table 6-14, if all the vehicles identified by HEP are brought in for diagnosis and repair, a large fraction of the vehicles would be inconvenienced or found to have no significant defective emissions control equipment

Table 6-13. Expected Number of Failed with Current I/M Program

Year	No. Failures
2012	408,306
2014	452,011
2016	498,781
2018	548,313

Table 6-14. Projection of Rates for Vehicles that Would Potentially Fail an I/M Test and the Number of Vehicles Inconvenienced using an HEP Program

		Cutpoint 1 (75th percentile)	Cutpoint 2 (80th percentile)	Cutpoint 3 (85th percentile)	Cutpoint 4 (90th percentile)	Cutpoint 5 (95th percentile)
Number of vehicles in I/M fleet per yr	5,415,643					
Fraction of vehicles with Fprobs	95.0%					
Unique HEP vehicles	5,144,861					
% of vehicles identified by HEP		24.99%	19.86%	14.90%	9.99%	4.98%
Number of vehicles identified by HEP		1,285,532	1,021,678	766,582	513,874	256,114
Number of vehicles that would fail I/M	(calendar year)					
	2012	137,905	115,249	91,008	65,511	36,185
	2014	134,444	112,403	88,830	64,020	35,372
	2016	131,931	110,337	87,249	62,937	34,782
	2018	130,320	109,012	86,235	62,243	34,404
Number of vehicles that would be inconvenienced						
	2012	1,147,627	906,429	675,575	448,363	219,929
	2014	1,151,088	909,275	677,752	449,855	220,742
	2016	1,153,601	911,342	679,334	450,938	221,332
	2018	1,155,212	912,667	680,347	451,632	221,711

Next, we estimated the ratio of failed vehicles based on a HEP program as compared with the current I/M program. Table 6-15 provides this estimated benefit for the evaluated HEP cutpoints.

Table 6-15. Fraction of Benefit Expected from the Failing the Projected Vehicles in a HEP Program Compared to the Existing I/M Program

	Calendar Yr	Cutpoint 1 (75th percentile)	Cutpoint 2 (80th percentile)	Cutpoint 3 (85th percentile)	Cutpoint 4 (90th percentile)	Cutpoint 5 (95th percentile)
Fraction of benefit	2012	33.77%	28.23%	22.29%	16.04%	8.86%
	2014	29.74%	24.87%	19.65%	14.16%	7.83%
	2016	26.45%	22.12%	17.49%	12.62%	6.97%
	2018	23.77%	19.88%	15.73%	11.35%	6.27%

Lastly, we estimated the tons per year emissions reductions based on an HEP program for various percentile cutpoints, as shown in Table 6-16 for Houston and Dallas. These reductions are based on MOVES estimates for the current program factored by ERG's estimate of the fraction of that benefit associated with an HEP program.

Table 6-16. Estimated Emissions Reductions (Tons per year) for the HEP Program

Calendar Year	Cutpoint 1 (75th percentile)	Cutpoint 2 (80th percentile)	Cutpoint 3 (85th percentile)	Cutpoint 4 (90th percentile)	Cutpoint 5 (95th percentile)
Houston					
HC (tons/year)					
2012	1,233	1,030	814	586	323
2014	977	817	646	465	257
2016	776	649	513	370	205
2018	607	508	402	290	160
CO (tons/year)					
2012	13,206	11,036	8,715	6,273	3,465
2014	10,503	8,781	6,940	5,002	2,763
2016	8,463	7,078	5,597	4,037	2,231
2018	7,075	5,918	4,682	3,379	1,868
NO_x (tons/year)					
2012	1,787	1,493	1,179	849	469
2014	1,294	1,082	855	616	340
2016	930	778	615	444	245
2018	682	571	451	326	180
Dallas					
HC (tons/year)					
2012	1,490	1,246	984	708	391
2014	1,181	987	780	562	311
2016	938	785	621	448	247
2018	737	616	488	352	195
CO (tons/year)					
2012	15,327	12,809	10,115	7,281	4,022
2014	12,201	10,201	8,061	5,810	3,210
2016	4,463	3,733	2,952	2,129	1,177
2018	8,236	6,890	5,450	3,934	2,174
NO_x (tons/year)					
2012	2,137	1,786	1,410	1,015	561
2014	1,549	1,295	1,023	737	407
2016	1,114	932	737	531	294
2018	817	683	541	390	216

6.4 Alternative Tests, Functional and Visual Checks

There are other alternatives than those described above for the inspection of pre-OBD vehicles that do not require the use of tailpipe emissions analyzers or dynamometers. A number of states have eliminated tailpipe testing of pre-OBD vehicles and were consulted in order to explore options for non-tailpipe testing and the prevention of the loss of SIP credit for Texas. Almost all of the states that have eliminated tailpipe testing have eliminated requirements for any emissions-related inspection of pre-OBD vehicles. Generally, the contacts from these states indicated that SIP credit for alternative types of inspection were small enough that they weren't justified. Many states found that it was more appealing to make other changes to the inspection process than to include pre-OBD vehicles.

Further opportunities to expand the I/M program in order to make up for the elimination of tailpipe testing could also include more involved measurement of evaporative emissions. Currently, gas tank cap testing is the only check of evaporative emissions from pre-OBD vehicles. Historically, measuring evaporative emissions from any other vehicle components has been too expensive and time consuming to be effective for I/M programs. Other states have recently been investigating new methods of evaluation of evaporative emissions for the investigation of whether SIP credits can be obtained.

6.4.1 Concepts from Literature and Other States that have Eliminated Tailpipe Testing

Seven states that have eliminated tailpipe testing of pre-OBD vehicles were researched. ERG contacted representatives from these states in order to obtain information about how the state conducted their program change. The representatives were asked about the process, including how SIP credit was maintained, whether non-tailpipe inspections were continued or considered, and general questions about the states' experience with the change. Information gathered from both research and from these telephone discussions is presented in this section. Information reported is based on either the referenced documents or the states' representatives as listed.

The information is presented by state, and is generally divided into four sections. The first outlines the timing and any I/M related changes to maintain SIP credits. The second discusses requirements or options for the inspection of pre-OBD vehicles, and the third provides a general overview of the process. Also given for states that were contacted by telephone are the state I/M representative and contact information.

Massachusetts – In 2008, Massachusetts began the process of eliminating tailpipe testing. SIP credit was maintained by changing OBD inspections from biennial to annual and eliminating the new vehicle exemption, which required only vehicles that were older than 4 years to be inspected. Changing the tests to annual did not have a large effect on motorist inconvenience as they were already required to present their vehicles for an annual safety inspection.

There is no longer any emissions inspection requirement for pre-OBD vehicles, and none were given serious consideration.

The conversion was said to have gone well with no negative political effects. There was consideration of a cash-for-clunkers type program to facilitate fleet turnover, but it was decided that it would not be needed. Massachusetts will also be exempting all vehicles older than 15 model years from OBD inspections when 1996 vehicle are eligible. [12]

Contact: Craig Woleader, 617-348-4046

Illinois – In February of 2007, Illinois eliminated tailpipe testing of pre-OBD vehicles. The state had not previously taken SIP credit for its I/M program, and did not make any other changes to the I/M program.

There is no longer any emissions inspection requirement for light-duty pre-OBD vehicles, and none were given serious consideration.

The state considered how the model year distribution of the light-duty fleet would change over the course of their current contract for I/M services. By the time the current contract will be completed, the percentage of pre-OBD vehicles would be very small.

Contact: Michael Hills, 217-524-9061; Mike Rogers, 217-524-4408

New York – The legislative changes to the New York I/M program primarily affect the greater New York City area, in which tailpipe emissions testing is required. The Upstate area has had no requirements for tailpipe testing. The legislation to eliminate tailpipe testing has passed, but the changes have not yet taken effect. No additional changes were made to the I/M program to maintain SIP credit, but changes were made to non-inspection related sources to prevent backsliding.

In New York, pre-OBD vehicles will still be required to get an emission control device (ECD) check annually. This consists of a visual check for the presence of the catalytic converter, positive crankcase ventilation (PCV) valve, the exhaust gas recirculation (EGR) valve, and the gas tank fill cap. The catalytic converter check will also include a tapping test to audibly check for a substrate to make sure that the converter can is not hollow. The SIP credit for the ECD test was said to be small. New York estimates that 12 percent of its current light-duty fleet is pre-OBD.

The conversion is said to be going well but it remains to see whether there will be any political issues or concerns over the effectiveness of the ECD inspection.

Contact: Gregory English, 518-402-8292

Missouri – The tailpipe program was eliminated from I/M in Missouri near the end of 2007. The state went from centralized I/M to a decentralized OBD program at that time. In order to maintain SIP credit, the state added a requirement for diesel OBD testing for 1997 and newer diesel vehicles.

The state performs anti-tamper inspections as part of the vehicle safety program, but there are no tests or checks of pre-OBD vehicles that relate specifically to the emissions program. [13]

Contact: Charles Dachroeden, 314-406-2115

New Hampshire – The New Hampshire legislature voted to eliminate tailpipe testing in the mid to late 1990's. In order to maintain SIP credit, the state began requiring OBD testing state-wide instead of only the urban counties. Additionally, visual inspections were to be conducted for pre-OBD vehicles.

The visual inspection of pre-OBD vehicles includes the catalytic converter, evaporative canister, EGR valve, and the gas tank fill cap. This inspection was originally required as a part of the changes made to maintain SIP credit, but as these changes took place more than 10 years ago, they may not still reflect acceptable options to pursue today.

The visual inspection requirements are not tightly enforced. The results of inspections of pre-OBD vehicles are not required to be entered in the electronic database, and there is concern that vehicles can pass this inspection even if the proper components are not present. The representative from this program indicated that the pre-OBD part of the program was not as effective as it could have been.

Contact: Tom Hettinger, 603-271-0351

North Carolina – Tailpipe testing of pre-OBD vehicles was no longer required in North Carolina at the end of 2005. In order to maintain SIP credit without tailpipe testing, the OBD I/M program was expanded from 15 to 48 counties.

There are no emissions inspections or tests required for pre-OBD vehicles. There are anti-tamper inspections included in the vehicle safety inspection, but these are not a part of the emissions program.

Contact: Paul Gordey, 919-715-7220

Wisconsin – In the summer of 2008, Wisconsin no longer required tailpipe or gas cap pressure tests of pre-OBD vehicles. The state maintained SIP credit by expanding the vehicles that are required to have OBD testing performed. Vehicles from model years 2007 and newer are rated up to 14,000 lbs. gross vehicle weight rating (GVWR) are now required to be OBD-tested. Previously, the weight limit was 10,000 lbs GVWR. Also, 2007 and newer diesel vehicles are now required for OBD testing. [14]

There are no inspections or visual checks required in Wisconsin for pre-OBD vehicles.

Vermont – Vermont did not eliminate tailpipe testing for pre-OBD vehicles as its program was initially created to be OBD only with no tailpipe testing. Pre-OBD vehicles are subject to a visual check of only the fuel cap and catalytic converter and the state receives a small SIP credit for this procedure. Vermont and a few of the other states interviewed indicated that continued checks of pre –OBD vehicles had some political benefit due to perceived fairness in requiring vehicles of varying age to all be subject to an emissions-related inspection.

Contact: Tom Moye, 802-241-3819

Most of the states that have eliminated tailpipe testing of pre-OBD vehicles no longer require those vehicles to participate in any inspections that affect the states' SIP credit level, however. Even among those states that still require an annual or biennial safety inspection, none continues to require a gas cap pressure test. In terms of maintaining SIP credit, visual inspections are a small part of some of these state's plans. Most states that have dropped tailpipe testing requirements chose to rely on expanding their I/M programs reach to more vehicles that are OBD-testable instead of considering ways to conduct non-tailpipe inspections of pre-OBD vehicles.

6.4.2 Arizona Liquid Leak Program

The Arizona legislature recently required the Arizona Department of Environmental Quality to investigate methods to check for liquid leaks during I/M inspections. ERG was contracted to provide a report documenting options for liquid leak checks, and this section summarizes the findings of that report [15]. Liquid leaks are only one of many sources of evaporative emissions, but taken as a whole, evaporative emissions make up a significant source of volatile organic compounds (VOC) emissions from mobile sources. The sources cited in the report place total evaporative emission levels to be between 70 percent and 100 percent of tailpipe VOC emissions. Liquid leaks can contribute to both running and stationary losses, and can also cause dangerous conditions due to flammability.

Most states do not have specific liquid fuel leak test procedures, even if they require vehicles to fail inspections if a liquid leak is observed. Many states require a liquid leak test as a part of vehicle safety inspections instead of emissions tests. California does have specific guidelines for its emissions test liquid leak test requirement, however. This test is conducted with the engine idling, and a technician inspects the vehicle visually using a guide that lists common fuel and evaporative system components. Any liquid observed escaping from a component means that the test must be aborted and the system repaired before the vehicle can pass the inspection. No special tools are required except for a flashlight and inspection mirror, and the vehicle is not required to be raised on a lift or disassembled in any way. Automotive Testing Laboratories (ATL) created a more thorough test based on the procedures required by the California test. This test involves the use of a number of tools in order for the inspecting technician to more accurately evaluate stains or dampness found around fuel system components. One part of the test involves holding a paper towel or blotter paper with forceps and dabbing it into a stain or observed dampness and checking whether any liquid is absorbed by the paper. It also includes the use of a portable, hand-held "sniffer" to evaluate the source and strength of leaks. The sniffer is able to discern vapor leaks in addition to liquid leaks.

The report also cited literature that attempted to quantify the number of vehicles with liquid leaks that were in operation. Most of the documents indicated that vehicles with model years between 1971 and 1991 were much more likely to have liquid leaks than later model years. For these model years, 19 to 21% of sampled vehicles had liquid leaks. Repairs on these vehicles were found to be effective at lowering evaporative emissions. Another source of information on liquid leaks is the inspection data from those states that require inspections be aborted if liquid leaks were observed. The report indicates that this source is not particularly accurate as inspectors often record a general abort reason whether or not the inspection system offers specific abort reasons such as the presence of liquid leaks.

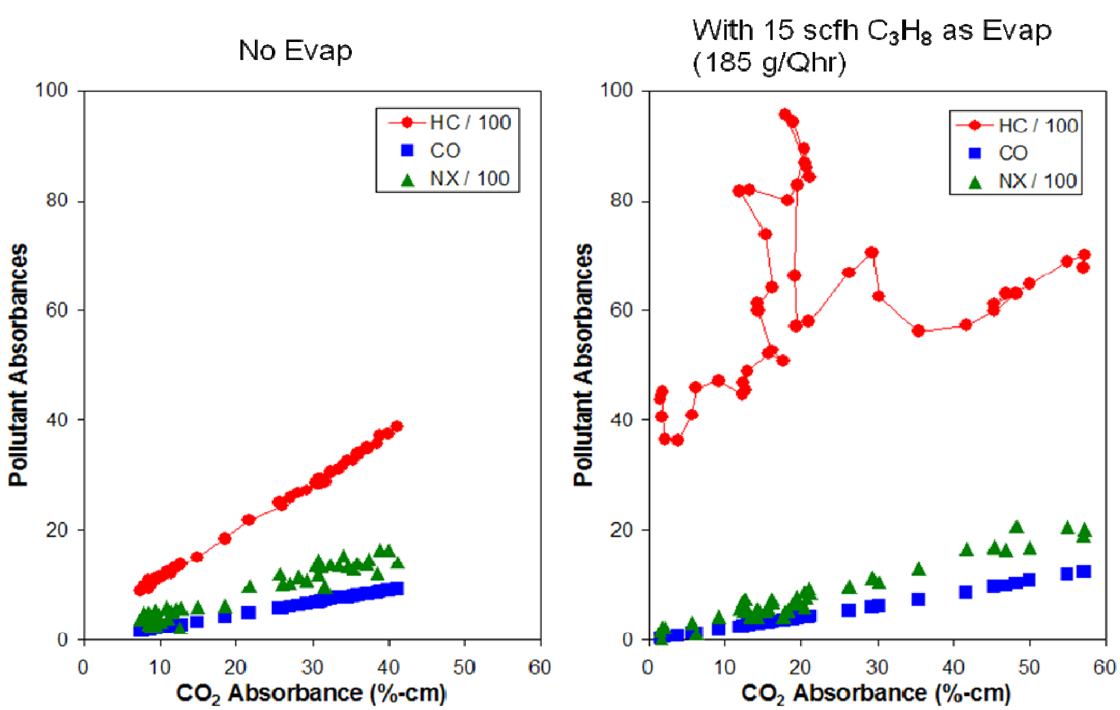
Finally, the report cites possibilities for future investigation and makes a recommendation to the Arizona Department of Environmental Quality. One method discussed involves the use of RS to identify vehicles with high evaporative emissions, and that topic is discussed below in Section 6.4.3. Other future developments could include the use of infrared cameras such as those used to identify leaks of hydrocarbons in refineries. The report concluded that there is currently no viable method to test for evaporative or liquid leaks other than the procedure used in California. It was recommended that Arizona begin with a program similar to that used in California, but it was noted that California does not receive any SIP credit as a result of requiring the liquid leak inspection.

6.4.3 Colorado RS Evaporative Program

In 2001, Colorado began using RS observations to clean screen vehicles. Repeated observations are used to make a determination on whether a vehicle's emission control system is operating properly. If the vehicle is considered clean, the owner is not required to bring the vehicle in for an inspection. The use of RS allows for reduced inspection infrastructure requirements and reduced motorist inconvenience. More recently, the Colorado Department of Public Health and Environment (CDPHE) began to investigate whether RS equipment could discern the difference between evaporative HC readings and exhaust HC readings. They began a multiyear project to investigate this, and the project is ongoing at the time of this report. The project has shown that RS can discern evaporative leaks if they are severe enough, but readings are strongly dependent upon vehicle speed and exhaust hydrocarbon levels [16].

RS systems function by measuring absorbance of the different exhaust constituents. Because the CO_2 concentration in the exhaust can be assumed to be of a known concentration, CO_2 absorbance can be used as a tracer for the other exhaust constituents. In this way, the concentration of pollutants in the exhaust can be calculated even though the RS measurement is taken in the exhaust plume that is being diluted by the ambient air. The RS unit takes a number of sequential absorbance measurements in the brief moment as a vehicle passes. If the vehicle's tailpipe is close to the level of the RS sensor, the initial readings will be high concentrations and they will decay downward as the exhaust plume mixes with the ambient air. If the tailpipe is farther from the RS sensor, the concentrations will rise and then fall as the exhaust mixes into the RS sensor and then continues mixing with the air. For a vehicle with no evaporative system leaks, plotting HC emissions vs. CO_2 emissions for the sequential data collected when a vehicle passes should yield a straight line, regardless of the tailpipe location. The slope of the line is related to the concentration of the pollutant in the exhaust as compared to the known CO_2 concentration. For a vehicle with evaporative system leaks, however, there is not a linear relationship between the HC and CO_2 readings. The level of evaporative emissions could be considered to be related to the lack of linearity. Figure 6-3 shows plots of HC and CO_2 for a vehicle with no evaporative emissions and a vehicle with a large evaporative system leak.

Figure 6-3. When Plotted Against Measured CO_2, the Lack of Linearity of the HC Signal is an Indication of a Vehicle's Evaporative Emission Level



To identify vehicles with high evaporative emissions, the RS computer system can be programmed to look for this lack of linearity, or noise, in the HC readings. Unfortunately, the readings have sources of noise that are not related to evaporative emissions as well. As a result, there is a detection limit for discerning between equipment noise and evaporative emission measurement. This is dependent upon vehicle speed, the exhaust HC level, and possibly vehicle tailpipe elevation and other factors. Increased speed and exhaust HC both increase the level of noise for the equipment, and this can be mistaken for evaporative emissions. Another limitation of the system is that it does not yet have the ability to provide any quantification of the level of evaporative emission, it can only provide a binary result; either the measured vehicle is likely to have high evaporative emissions or it is not. The procedure does not have the ability to quantify evaporative emissions levels because there is no tracer for evaporative emissions as there is with CO_2 for exhaust emissions.

The primary evaluator for RS evaporative readings has been the use of a portable sealed housing for evaporative determination (PSHED) as a reference. Private vehicles were solicited from the fleet and their RS measurements under controlled conditions were compared to the PSHED readings. One challenge of this experimental design was that RS measures running loss emissions while the engine is on, and the PSHED measures hot soak emissions with the engine off. Depending on the specific source of the evaporative emissions, leaks may not be present for both conditions. Also, hot soak measurements using a PSHED do not lend themselves to emissions inventory model improvement as the results cannot be used directly to calculate a vehicle's annual evaporative emission level. In addition to PSHED tests as a reference, a small part of the study involved the use of control vehicles with the ability to release propane at a known rate in order to simulate evaporative leakage. This part of the experiment eliminates the uncertainty that results due to measuring running loss and hot soak losses separately.

The project was divided into 4 phases, 3 of which have been completed at the time of this writing. Each phase involved improvements to both the RS determination process and the direct measurement. The direct measurements evaluated included IR photography, portable HC detector (sniffer) use, and PSHED testing. The PSHED tests have been considered to be the most effective and quantifiable method to use as a reference and each successive phase has continued to place increased focus on SHED-type testing. The final phase of the project will involve the mining of the state's actual RS database, and soliciting vehicles for reference measurements based on their "real-world" RS evaporative measurements. Currently, it appears that typical RS locations measure vehicles that are traveling at speeds that are too high for accurate evaporative leak determination. It may be necessary for RS to be set up at locations with much lower average speeds in order for the technology to be effective at evaporative emission screening. The technology is still being improved, and the method for discernment of evaporative HC from exhaust HC is still being investigated. The success of the method will probably depend on the ability to expand the speed range for which evaporative emissions can be discerned.

At the conclusion of the program, CDPHE and EPA will evaluate whether adding RS screening for evaporative emissions along with repair requirements can be used to increase the state's SIP credit level. Whether or not this is possible could be the deciding factor for whether other states would benefit from adopting this type of program. If this is possible, it could increase the benefit level of adding RS to the Texas I/M plan; however, until the technology is proven successful, adding an RS infrastructure for the measurement of evaporative emissions would carry a risk that the systems could not accurately discern vehicles with malfunctioning but repairable evaporative emissions systems.

6.4.4 Other Testing Options

Two other testing options for the non-OBD fleet are worth considering; however, since they are elements of the current I/M program, they will not be discussed in detail here. The first of these is a visual check for key emission control components such as the catalyst, exhaust gas recirculation valve, evaporative canister, etc. Such a check is done routinely during a normal I/M inspection, and has been modeled in MOBILE6. However, the routines to calculate the credit for such checks in the new MOVES model are not available at this time. The other routine I/M procedure that could also be continued is the gas cap test. This stand-alone procedure could be conducted at the same time as the safety inspection, and as with the visual inspection, MOBILE6 did provide modeling support for this test. The current version of MOVES will also allow this test method to be modeled; however, MOVES runs to determine the emission benefits of a gas cap only program element are not yet easy to perform given the current state of the MOVES program.

7.0 Conclusions and Recommendations

The MOVES results indicate that the impact of the adding the new nonattainment areas will have little impact on the percent emission reductions, but does increase the tons of pollutants removed from the inventory. Moving from a tailpipe plus OBD program to OBD-only does have an impact on emission reductions, but it may or may not be significant depending on the SIP requirements.

Based on the current state of remote OBD testing and the use of OBD kiosks, implementing such a change at this time would not be recommended. This is especially true given the upcoming release of the Remote OBD workgroup report that should at the very least provide some direction with regard to standardization of hardware technology and software protocols.

The test alternatives outlined in Section 6 do not require large up-front capital costs and could be started in the near term if the TCEQ decided to pursue them. Both the RS-only and HEP concepts would require some software or modeling development, as well as periodic updates to the databases in order to maintain the integrity of the emission benefit estimates. The other alternative tests and visual/functional checks described in this section could also be implemented fairly easily; however, based on feedback from other state I/M programs, it appears most programs have decided to expand the OBD I/M coverage area rather than develop alternative test procedures and strategies for the diminishing pre-MY96 fleet.

8.0 References

1. “Evaluation of the Texas Inspection and Maintenance Program in the Dallas-Fort Worth and Houston-Galveston-Brazoria Nonattainment Areas”, Final Report, Eastern Research Group, November 30, 2009.

2. T.H. DeFries, T.J. Petroski, M.F. Weatherby, B. Limsakul, and H.J. Williamson, “Estimating Benefits of Improvement Strategies (including RSD) for the California I/M Program: An Inspection and Emissions Forecasting System,” ARB-080301, Report, Version 7 (final), Eastern Research Group, Inc., Austin, Texas, March 1, 2008.

3. R.F. Klausmeier, S. Kishan, A.D. Burnette, and M.F. Weatherby, “Smog Check Station Performance Analysis – Based on Roadside Test Results,” de la Torre Klausmeier Consulting and Eastern Research Group, Inc., June 27, 2000.

4. Technical Support Document, “Evaluation of California’s Enhanced Vehicle Inspection and Maintenance (Smog Check) Program,” Draft Report to the California Legislature, California Air Resources Board, and California Bureau of Automotive Repair, April 2004.

5. T.H. DeFries, A. Holder, S. Kishan, C.F. Palacios, and R.F. Klausmeier, “Performance of Gold Shield Stations: Analysis and Recommendations,” Eastern Research Group, Inc., July 26, 2001.

6. “On-Road Emissions Testing Program Status: A Report to Virginia General Assembly,” prepared in response to 2006 House Joint Resolution 208 by the Virginia Department of Environmental Quality, December 2006.

7. R.F. Klausmeier and P. McClintock, “Virginia Remote Sensing Device Study – Final Report,” prepared for Virginia Department of Environmental Quality, ESP, 2002 North Forbes Blvd., Tucson, Arizona, February 2003.

8. R.F. Klausmeier, S. Kishan, G.F. Baker, J. McFarland, “Evaluation of the California Pilot Inspection/Maintenance (I/M) Program,” Draft Final Report, prepared for California Bureau of Automotive Repair, Radian Corporation, Austin, Texas, March 31, 1995.

9. P. McClintock, 20041116_Coverage_Statistics.xls

10. R.F. Klausmeier and P. McClintock, “The Greeley Remote Sensing Pilot Program,” Final Report, prepared for the Colorado Department of Public Health and Environment, Remote Sensing Technologies, Inc., 2002 North Forbes Blvd., Tucson, Arizona, November 4, 1997.

11. T.H. DeFries, A.D. Burnette, S. Kishan, T. J. Petrowski, “Estimating Benefits and Costs of Improvement Strategies for the California I/M Program : Implementation Options for Using RSD”, version 9.0, Eastern Research Group, Prepared for California Air Resources Board, March 2, 2008, ERG Report No. ARB-080302.doc

12. Commonwealth of Massachusetts. Department of Environmental Protection. *310 CMR 60.02: Massachusetts Motor Vehicle Emissions Inspection and Maintenance Program, Background Document and Technical Support for Public Hearings on the Proposed Amendments to the State Implementation Plan for Ozone*, February 2007.

13. State of Missouri. Department of Natural Resources. *Draft Emissions Inspection and Maintenance Summit White Paper,* October 27, 2005.

14. State of Wisconsin. Department of Transportation. *Clearinghouse Rule 07-114, Order of the State of Wisconsin Department of Transportation Adopting Rules*, May, 2008. http://www.legis.state.wi.us/cr_final/07-114.pdf

15. Eastern Research Group, *Draft Report: Development and Implementation of a Liquid Leak Inspection Procedure*, March 31, 2008.

16. Sidebottom, Jim. *Identifying Evaporative Emissions Using Remote Sensing Devices*, Presentation to I/M Solutions, Lake Geneva, WI, June 8, 2010.