California's Heavy-Duty Inspection and Maintenance (HD I/M) Pilot Study

Evaluation of Best Practices for a Full-Scale HD I/M Program

ERG:
Michael Sabisch
Sandeep Kishan
Alan Stanard
Jim Lindner

CARB:
Phuong Ho
Jason Hill-Falkenthal
Kim Heroy-Rogalski

Presented at the North Central Texas Council of Governments' Heavy-Duty Diesel Vehicle Inspection and Maintenance Working Group
August 18, 2022

ERG

CALIFORNIA AIR RESOURCES BOARD

Overview

- California's Senate Bill (SB) 210 (Leyva), approved in September 2019, requires CARB to implement a Heavy-Duty Inspection and Maintenance (HD I/M) program for heavy-duty non-gasoline vehicles operating in California
- A HD I/M pilot program is required as part of SB210
- CARB conducted their pilot in several separate efforts:
  - HD I/M Feasibility Study
  - OBD Data Collection / Repair Cost Characterization (Fall 2019 through Spring 2021)
  - Automated License Plate Recognition Camera Development & Demonstration
  - Roadside Emissions Monitoring Device / OBD Field Testing
  - Other Efforts (Repair Durability / Repair Assistance)
- In December 2021, the Board approved for adoption of the proposed HD I/M Regulation (Heavy-Duty Inspection and Maintenance Program | California Air Resources Board)

Planned Features of CARB's HD I/M Program

- OBD testing for non-gasoline HD vehicles (>14,000 lbs. GVWR) w/ engine MY 2013 +
- Multiple OBD testing / compliance options
  - Fleet self-testing
  - Third-party testing services
  - Certified test systems integrated into telematics / ELDs
- OBD test determination made on CARB central database (analogous to VID in BAR's Smog Check program)
- Pre-OBD remain subject to opacity, plus a new visual inspection
- Information regarding compliance and enforcement, remote sensing, referee networks, timelines, etc., available on CARB's website[1]

1. https://ww2.arb.ca.gov/our-work/programs/heavy-duty-inspection-and-maintenance-program

Methodology

- **OBD Testing Demonstration**
- **Fleet Surveys**
- **Repair Data Collection and Characterization**

OBD Testing Demonstration

- Primary in-field OBD data collection with Drew Technologies' DrewLinQ SAE J2534 pass-through devices programmed by Opus Inspection
- Data was also collected for comparison and evaluation on a subset of vehicles using HEM Data equipment
- SAE J1939 and J1979 parameters collected were based on the draft CARB specifications for the upcoming HD I/M program
- Parameters included extensive identification data, monitor and diagnostic data, cumulative operational data, and select live parameters (complete list of I/M parameters is available in Appendix B of the proposed regulation[2])

2 https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2021/hdim2021/appb.pdf

OBD Testing Demonstration (cont.) – Test Devices

OBD Testing Demonstration (cont.) – Vehicle Sample

- Since travel restrictions affected ERG's ability to travel to California to collect in-field data, we partnered with others, including:
  - Colorado Department of Public Health and Environment performed data collection with DrewLinQ devices at volunteer fleets in Colorado
  - California Environmental Solutions performed data collection as part of their regular operations in California
  - CARB collected OBD data during an already-planned California RSD assessment study (using HEM Data and SilverScan equipment)
  - OBD Data was collected by Opus' staff in Tucson and by ERG staff in Austin
  - ERG gathered OBD test and repair data from a large database developed by a truck repair facility (Fleet Crew) in California

Fleet Surveys

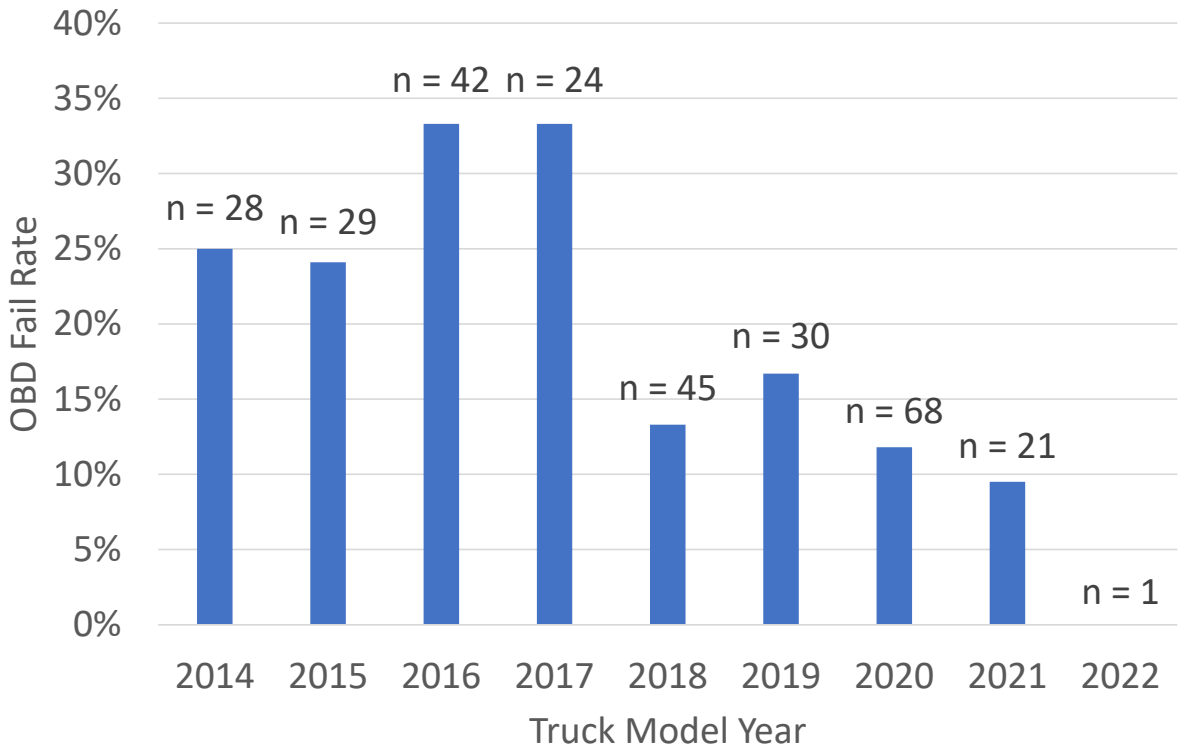
- Since in-person surveys of drivers and fleet managers were not possible, information regarding industry preferences for the program was collected using various alternative approaches, including:
  - Telephone surveys
  - E-mail surveys
  - ERG developed and administered an on-line Qualtrics survey distributed by CARB to workgroup members and posted on CARB's online diesel truck information portal, The TruckStop

Repair Data Collection and Characterization

- The objective of this task was to characterize the types of OBD-related repairs expected in an HD I/M program and estimate repair costs
- As an alternative to collecting in-field repair facility OBD diagnostic and repair data, ERG did the following:
  - Combined fault code results from this and prior studies to determine most common emissions-related faults
  - Used commercial repair guides to draft initial list of typical repairs for common faults
  - Revised list and developed costing in coordination with two independent repair and warranty service organizations (IRWSOs) experienced in repairs and repair costing
  - Developed weighted cost averages within the most common repair categories for emission failures anticipated in an HD I/M program

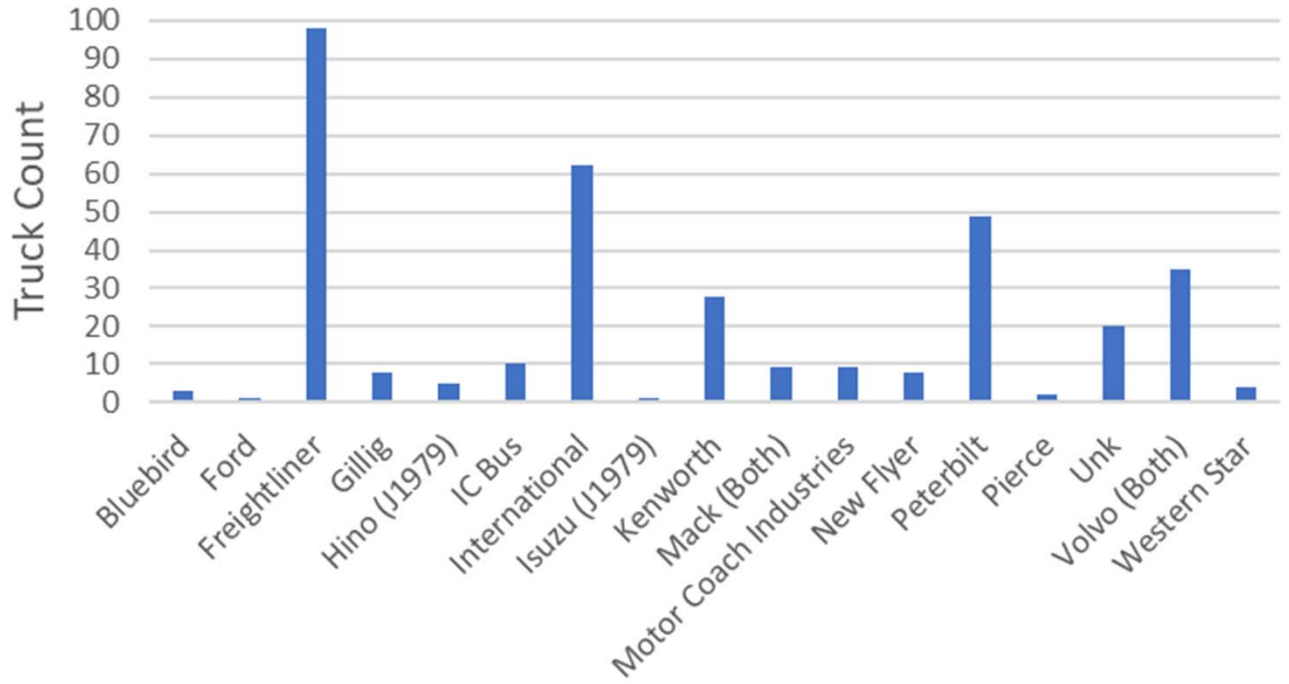
OBD Testing Demonstration Results

Fail Rate During Pilot



Note: Fail rates are not representative of on-road fleet. Only Model Year 2014 and newer are shown

Truck Makes Tested During Pilot



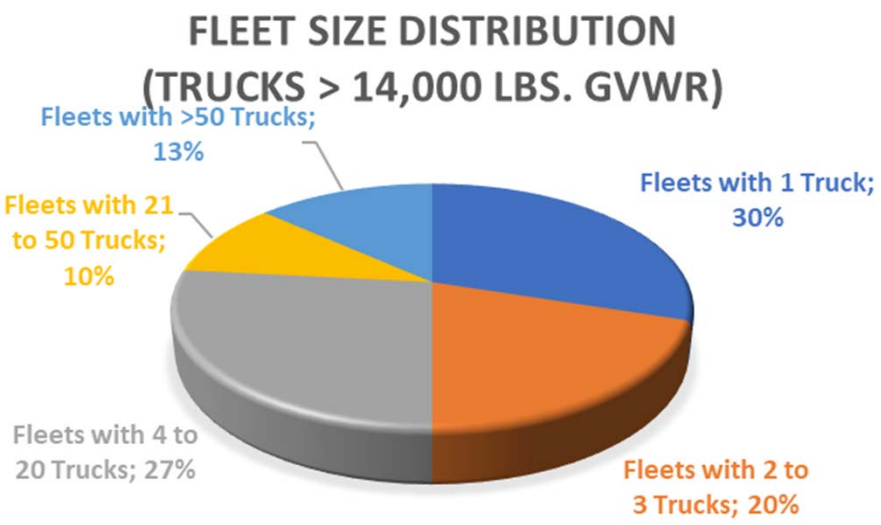
Note: all trucks were SAE J1939 unless otherwise noted. "Both" indicates both J1939 and J1979 were tested.

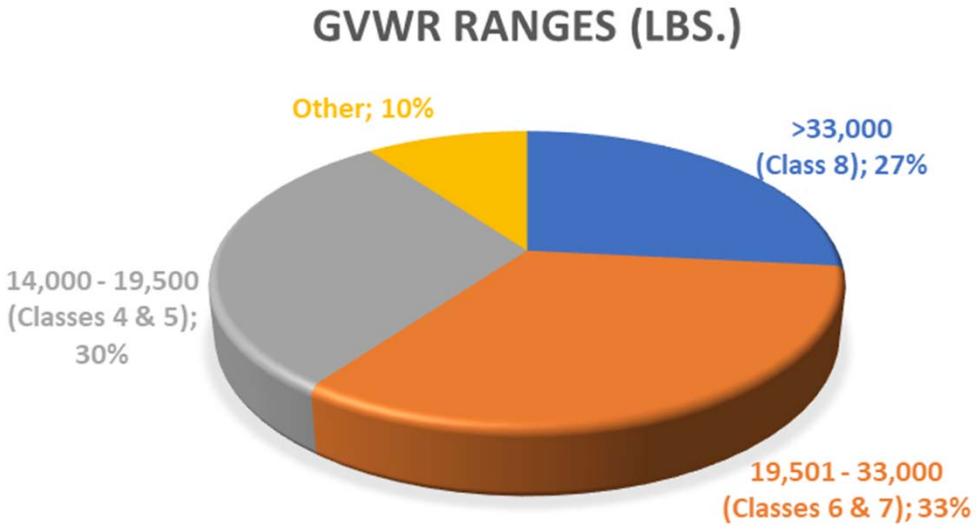
Protocol Differences Observed During Testing

Parameter	SAE J1939	SAE J1979
Average Scan Duration	3 minutes, 28 seconds	1 minute, 15 seconds
Duration Std. Deviation	47 seconds	3 seconds
Max Scan Duration	10 minutes, 13 seconds	1 minute, 22 seconds
Min Scan Duration	2 minutes, 56 seconds	1 minute, 12 seconds
Responding Controllers	Multiple (1 to 20+)	Few (typically 1-3)
Data Availability	Most operational data broadcast, most diagnostic data by request	All legislated data by request (broadcast data is OEM proprietary)
Data Format	Data bundled as parameters (SPNs) within groups (PGNs)	Individual parameters within service modes, parameter IDs, DTCs
Quantity	Approximately 24,000 SPNs within 2400 PGNs (includes diagnostics)	Approximately 1100 PIDs (plus diagnostics)

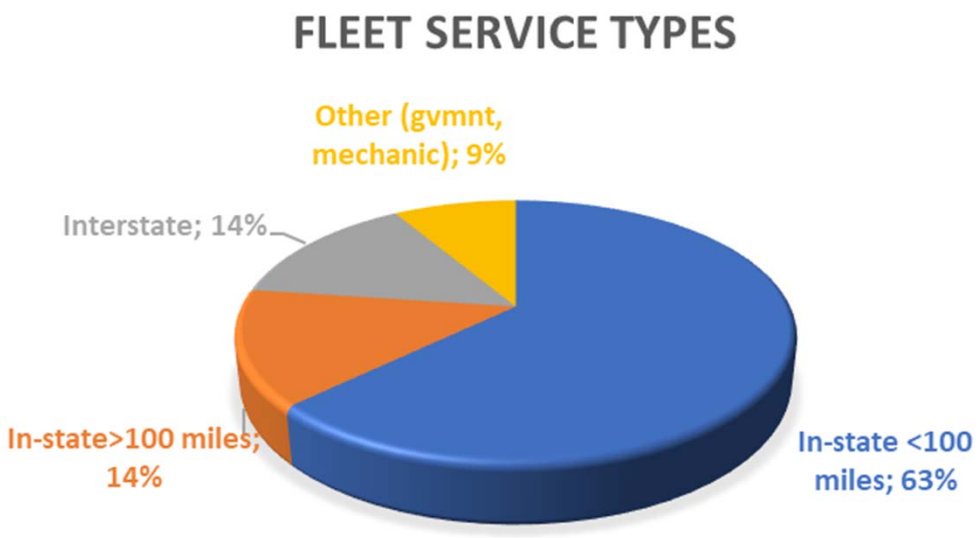
Fleet Survey Results

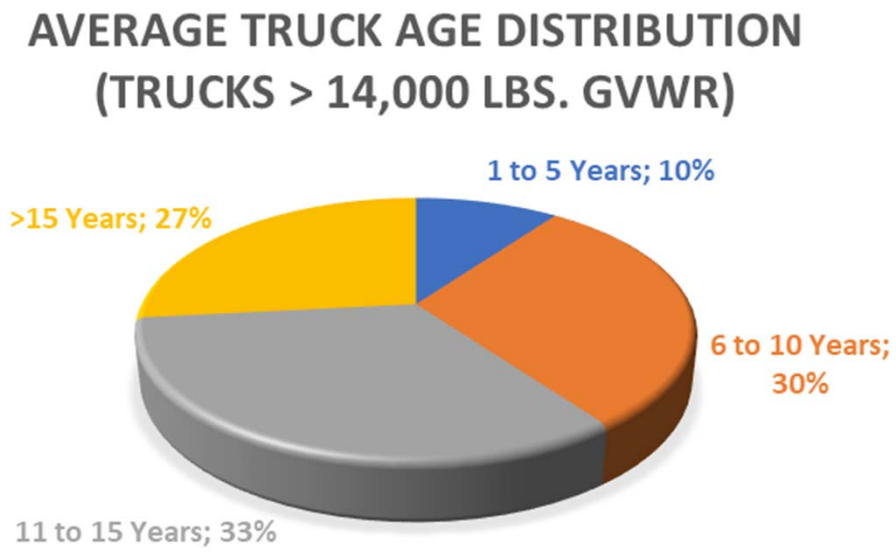
Survey Results – Fleet Characteristics



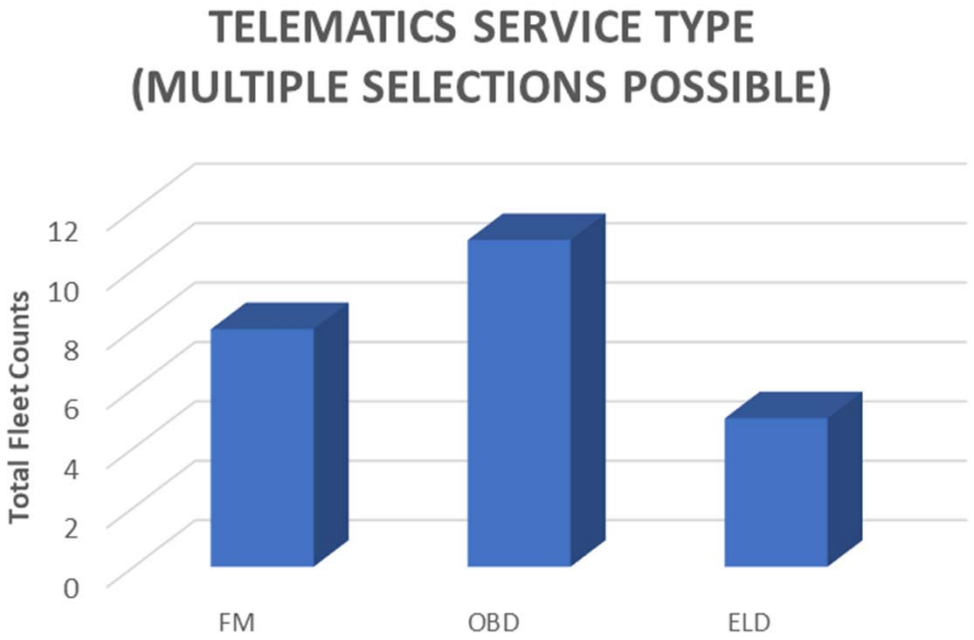


Survey Results – Fleet Characteristics



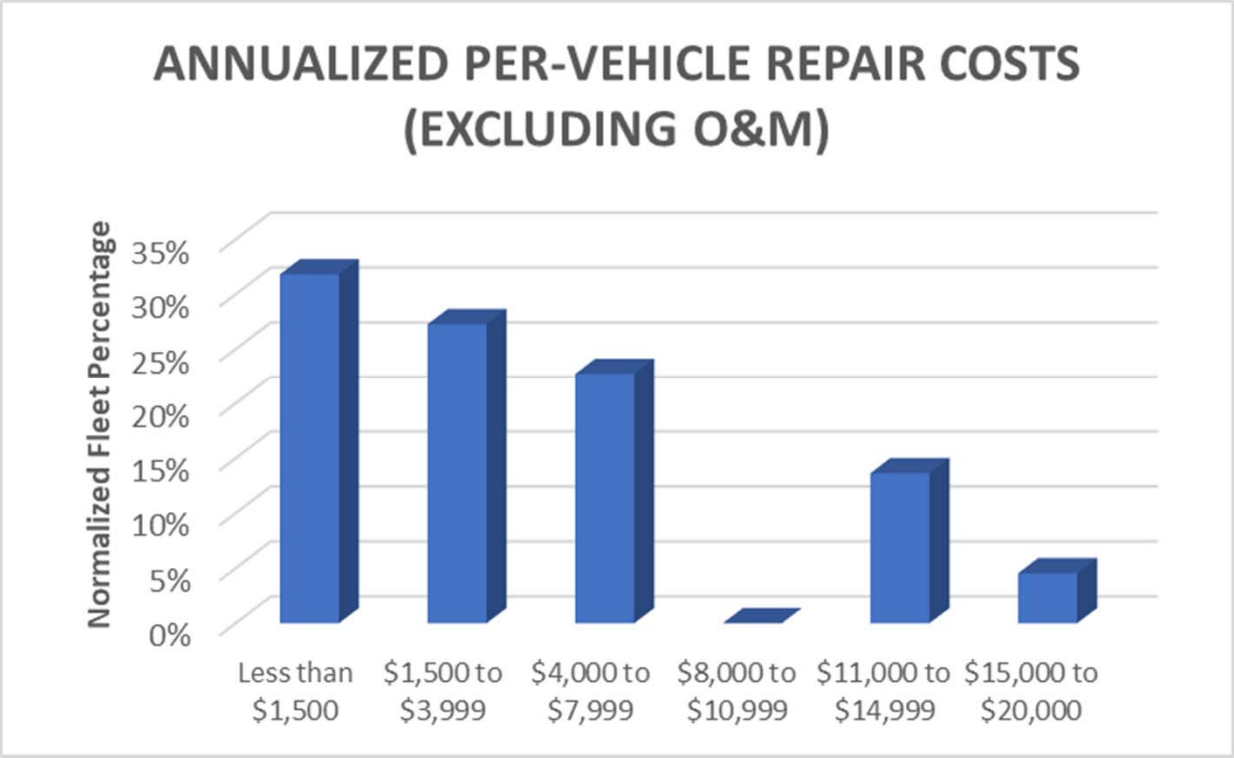


Survey Results – Current Telematics Support

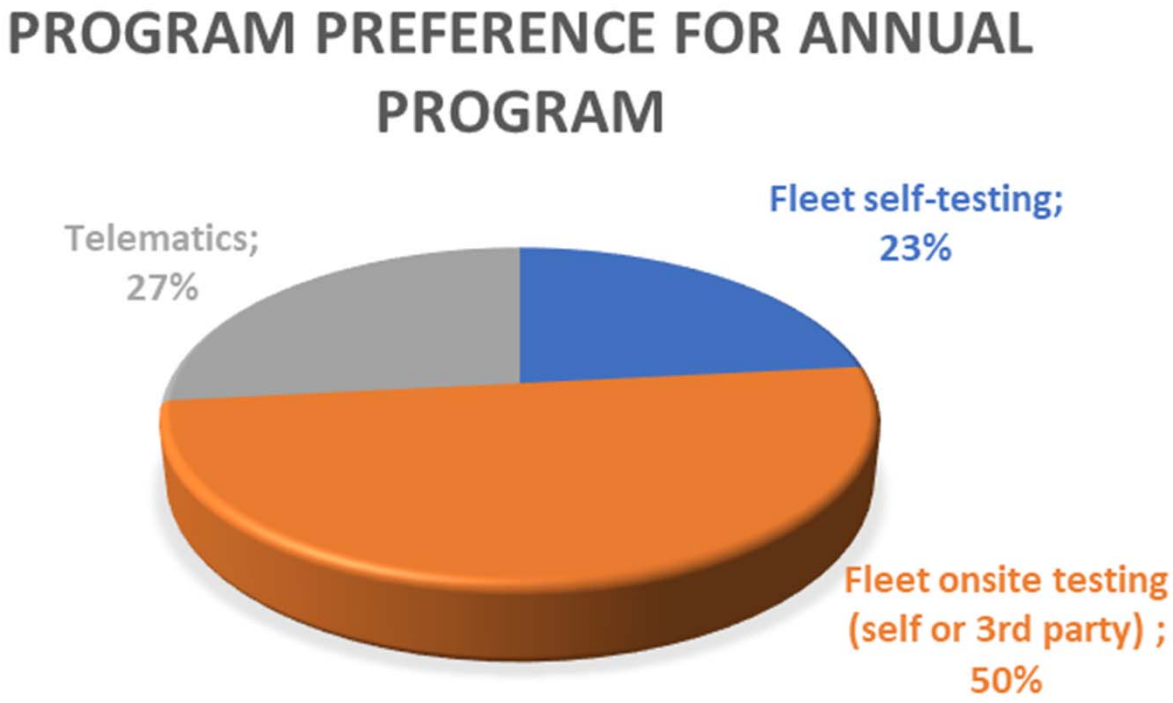


FM = fleet/management/logistics support
OBD = On-board diagnostics for diagnostics, PM repair
ELD = electronic logging device for driver vehicle inspection report compliance

Survey Results – Current Per-Vehicle Repair Costs (excludes Operations and Maintenance)



Survey Results – Future Program Preferences*



* Note, may not represent HD industry. Larger fleets are more likely to elect a telematics option.

Survey Results - Highlights

- Although only roughly ¼ of the fleet indicated they would utilize a telematics solution for I/M compliance, nearly half the surveyed fleet reported already using some form of telematics, suggesting telematics may be a more popular compliance option than shown in the survey.
- A positive correlation was seen between fleet size and the use of telematics, and also between a fleet's average travel distance and the use of telematics (suggesting larger fleets, and fleets that travel long distances, are more likely to use telematics).

Cost Estimates for I/M-Related Repairs

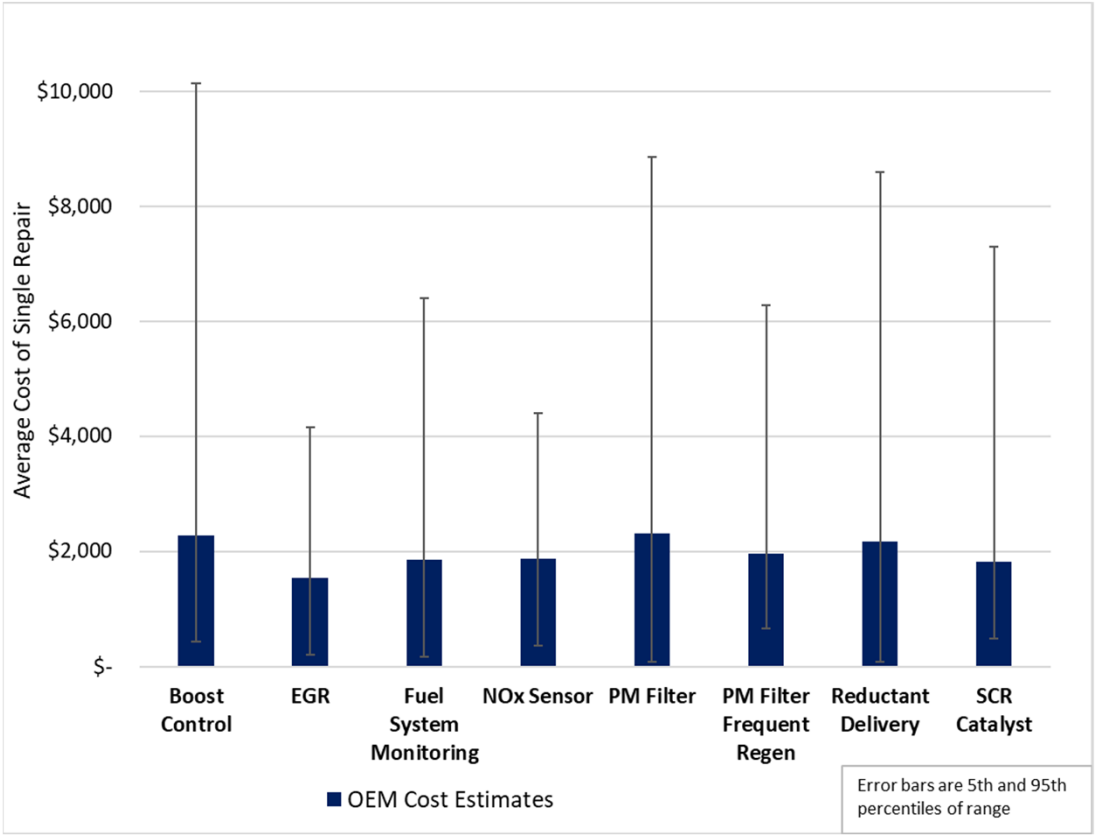
Distribution of Repair Categories

- Repair categories were based on data from this study and a prior CARB HD Truck OBD-Based Emissions Deterioration Study[3]

Repair Category	Relative %	Component / System Examples
Boost Control	10.85%	Ambient pressure sensors, EGR, gaskets, turbo VGT actuator, turbo charger, Intake or turbo temperature sensor, Intake manifold pressure sensor
EGR	11.68%	EGR, EGR valve/actuator, engine oil separator, intake throttle valve, intake throttle valve position sensor, EGR pressure sensor, gaskets, EGR position sensor
Fuel System Monitoring	15.95%	DPF, fuel sending unit/fuel lines, fuel injector, fuel filter, fuel pump, fuel valve, fuel rail, fuel pressure sensor, high pressure injector pump, Intake manifold and turbo sensors, fuel lift pump
NOx Sensor	14.86%	NOx sensor, EGR valve
PM Filter	11.75%	SCR system, PM sensor
PM Filter Frequent Regen	1.58%	Fuel injector, fuel valve, fuel rail
Reductant Delivery	19.45%	SCR system
SCR Catalyst	13.88%	SCR system, SCR temperature sensor, Nox sensor, ammonia sensor

3 https://ww2.arb.ca.gov/sites/default/files/2021-02/carb_hd%20emfac_det_rates_v3_20200721.pdf

Anticipated Program Repair Cost Ranges*



* Overall average weighted repair cost estimate (for OEM/dealer repairs) was $1,977

Results and Discussion

- HD OBD testing is a viable alternative to traditional opacity testing for OBD-equipped vehicles
- Non-conventional I/M approaches are likely generally better suited for the HD vehicle fleet (brick & mortar I/M station visits are less practical)
- Data format, quantity, and content are quite different from LD I/M OBD data, but the data is manageable and provides valuable diagnostic information

Acknowledgements

We would like to acknowledge the following organizations for support throughout this project:

- ***CARB,*** for funding this work and providing technical support, in-field testing, recruiting and survey support and guidance throughout the study
- ***The Colorado Department of Public Health and Environment,*** for data collection and systems assessment support
- ***California Environmental Solutions,*** who provided data collection and systems assessment support
- ***The US EPA,*** for providing project guidance and test systems for use in the study
- ***HEM Data,*** for providing test system and technical support throughout the study
- ***FleetCrew,*** who provided access to OBD data & repair characterization / costing support
- ***TruckSuite***, who provided repair characterization / costing support
- ***Opus Inspection and Gordon-Darby,*** who provided test equipment and significant, fundamental support and analysis throughout the project