Identification of Excessive Emissions System Failure Rates in High-Mileage Fleet Vehicles Based on Networkcar's Continuous On-Board Emissions Monitoring System

Presentation by Networkcar
October 15, 2003

networkcar

Outline

- Company Overview

- Technology Overview

- On-Board Diagnostics (OBD) Systems for Vehicles

- Analysis of Diagnostic and Location Data

- Remote Emissions Monitoring in California

Company Overview

- Networkcar based in San Diego, CA

- purchased by Reynolds and Reynolds in 12/02

- currently two main products: Networkcar and Networkfleet

- launched product in 2001

- ~100 dealerships selling system in US; primarily in Southern California

- large fleet deployments with Southern Cal. Edison, Marines

- on-line 'smog check' program with CARB, EPA

- 19 pending and issued patents

- recently earned 4 awards for entrepreneurship and technology development, including R&D 100 Award for technologically significant products in 2002

Technology Overview

- Networkcar system collects diagnostic/location information from host vehicle and sends it wirelessly to an Internet-accessible website

- system operates with both light and heavy-duty vehicles

- GPS system collects location data for fleet management, stolen-vehicle recovery, roadside assistance

- installs in ~30-60 minutes

- data are analyzed in 'quasi' real time to determine EPA-approved emissions test

- currently offer on-line emissions monitoring to California-based customers

- system analyzes selected diagnostic data to determine odometer, fuel consumed, fuel efficiency, other properties
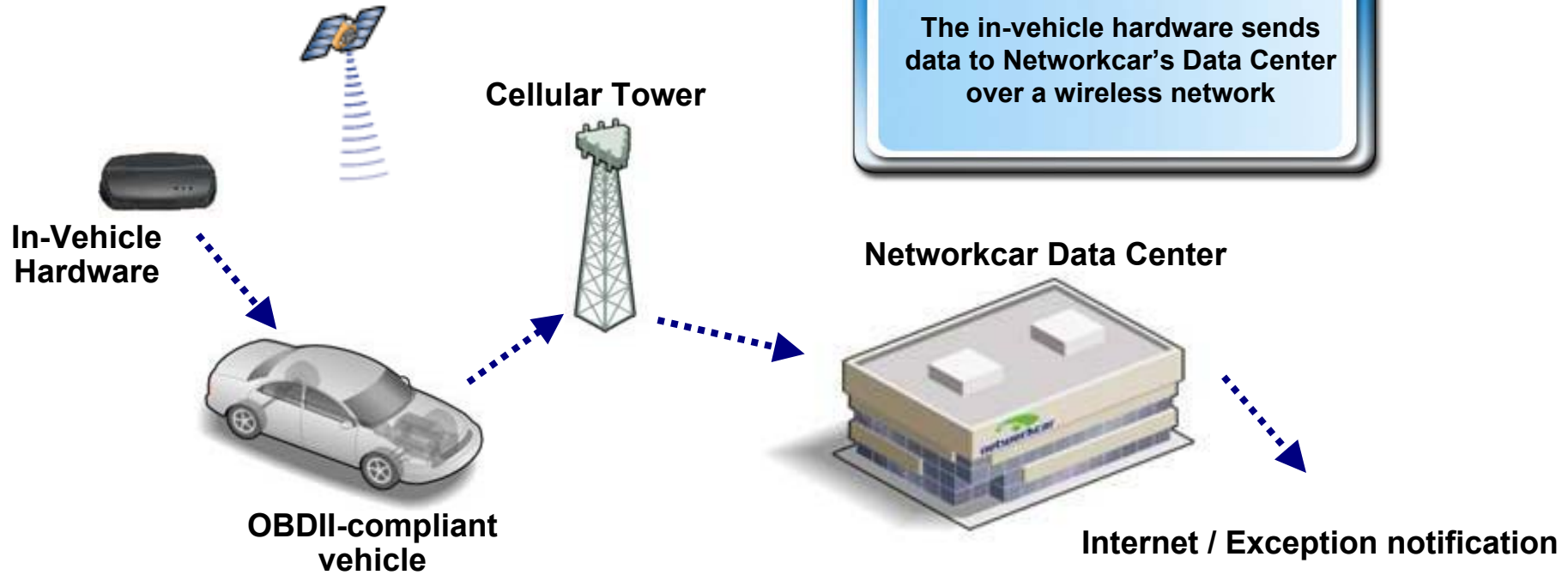
The Networkcar System

networkcar

IT Overview

Networkcar's in-vehicle hardware is installed in a car equipped with a performance-monitoring (OBDII) system and monitors diagnostic data

The in-vehicle hardware sends data to Networkcar's Data Center over a wireless network

Cellular Tower

In-Vehicle Hardware

Networkcar Data Center

OBDII-compliant vehicle

Internet / Exception notification

GPS within in-vehicle hardware monitors satellite signals to determine the vehicle's location

networkcar

On-Board Diagnostic System

• Networkcar system collects diagnostic data through the OBD connector

• 16-pin connector standard for light-duty vehicles MY 1996 and newer

• mandated by EPA for next-generation emissions test

• Networkcar system connected via 'Y' harness with snap-on adaptors

• supports multiple communication protocols

• standard diagnostic data set available on all light and heavy-duty vehicles

• heavy-duty trucks will use OBD connector by ~2007
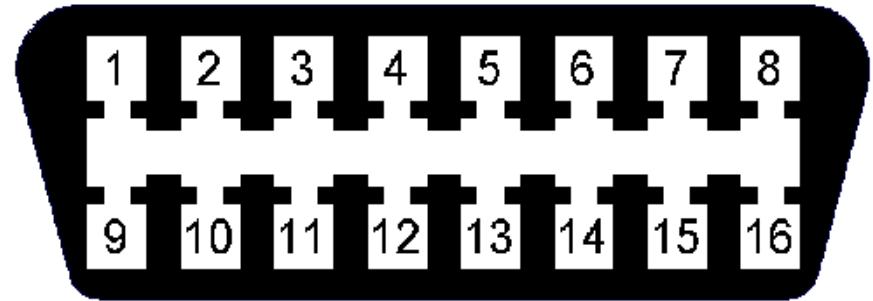
Pin 2 - J1850 Bus+
Pin 4 - Chassis Ground
Pin 5 - Signal Ground
Pin 6 - CAN High (J-2284)
Pin 7 - ISO 9141-2 K Line
Pin 10 - J1850 Bus
Pin 14 - CAN Low (J-2284)
Pin 15 - ISO 9141-2 L Line
Pin 16 - Battery Power

networkcar

Diagnostic Data Analysis - General

- web-based interfaces display diagnostic data for consumers, dealers, call center, fleets, state agencies

- data collected and analyzed every 20-seconds → 1 hour from vehicle's OBD bus

- essentially same data collected by diagnostic scan tool used by service center

- data transmitted and displayed on web site with ~60-second latency

- allows on-line diagnoses of vehicle malfunctions, trouble codes

Diagnostic Data Analysis – Emissions Monitoring

- patented real-time, internet-based emission test

- algorithm follows EPA-mandated calculation

- calculation based on status of 'I/M readiness flags' and MIL

- program currently in place in CA with fleet and consumer vehicles

- exception-based program: customers get notified when they don't comply

- currently in second year of CARB program for taxicabs in the LA and SF Bay areas

- program shown to reduce NOx, hydrocarbons, CO from polluting vehicles

Inspection / Maintenance Report Legend

Comp	Test Complete
Incomp	Test Incomplete
Nsup	Test Not Supported
✅	Pass
⚠	Hold / Retest
❗	Fail

KNOW WHAT YOUR CAR IS THINKING. ™   Log Out   Help

Jane Doe   1998 TOYOTA CAMRY

1998 TOYOTA CAMRY   Last CAReader Update: Jan 26 09:35:35 PST
VIN#: WP0CA2993XS651063   ☑ Emissions   ℹ Vehicle Mileage: 13096 miles

Customer Profile | Vehicle Check | Service | Recalls

Back to Vehicle Check   Vehicle-Related Information

Inspection / Maintenance

Found 7 entries with information on your vehicle's performance.

Skip to page 1 of 1 GO

| Parameter	03/15/2001 17:53:05	03/15/2001 16:53:05	03/15/2001 16:29:27	03/15/2001 8:00:11	03/13/2001 12:00:11	03/11/2001 16:14:11	03/15/2001 16:00:00
DTCs	none	none	P0100	none	none	none	none
MIL Light	off	off	on	off	off	off	off
Misfire Monitor	comp	incomp	incomp	comp	comp	comp	comp
Fuel System	comp	comp	comp	comp	comp	comp	comp
Comprehensive Comp	comp	comp	comp	comp	comp	comp	comp
Catalyst	comp	comp	comp	comp	comp	comp	comp
Heated Catalyst	nsup	nsup	nsup	nsup	nsup	nsup	nsup
Evaporative System	comp	comp	comp	comp	comp	comp	comp
Secondary Air System	comp	comp	comp	comp	comp	comp	comp
A/C Sys Refrigerant	comp	comp	comp	comp	comp	comp	comp
Oxygen Sensor	comp	comp	comp	comp	comp	comp	comp
Heated Oxygen Sensor	comp	comp	comp	comp	comp	comp	comp
Exhaust Gas Recirc	comp	comp	comp	comp	comp	comp	comp
Status	✅	⚠	❗	✅	✅	✅	✅

networkcar

Diagnostic Data Analysis – Speed/Fuel Efficiency

• fuel-efficiency data not available directly from bus

• property is determined with proprietary calculation using MAF/VSS data

• calculation agrees to empirical data to within +/-3%

• graphical display of fuel efficiency indicates vehicle's performance

• histogram and graphical display of vehicle speed

• website simultaneously displays speed and location for fleet customers

• data currently used for fleet management, parents

Speed


Fuel Efficiency

networkcar
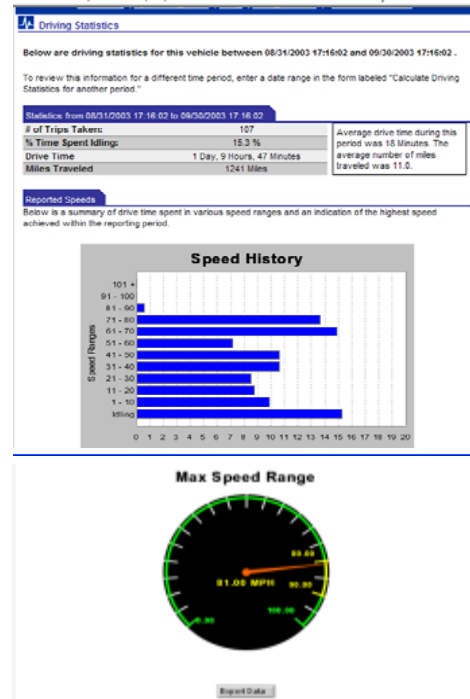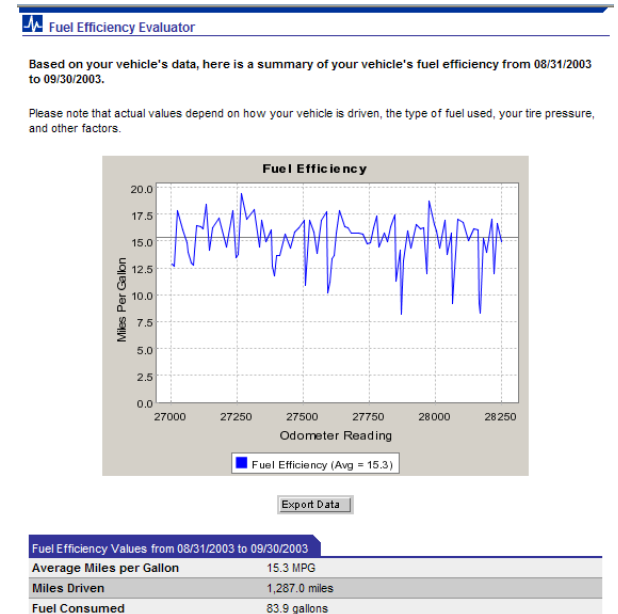
Location Data Analysis

- web-based display of GPS-determined location

- location display for one or more vehicles

- accuracy good to within +/-10 meters

- data used for recovery of stolen vehicles, roadside assistance, fleet management, and 'CARGuardian' web application

- Geofence and display of speed also available

- GPS fixes sent periodically rather than in response to 'ping'

- data shows track of vehicle locations, vehicle stops, etc.

- 'store and forward' algorithm further enhances location-based data
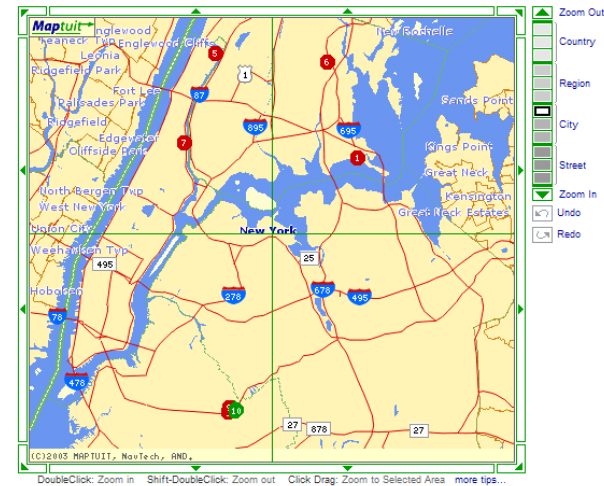
Fleet Map

Vehicle Tracking

networkcar
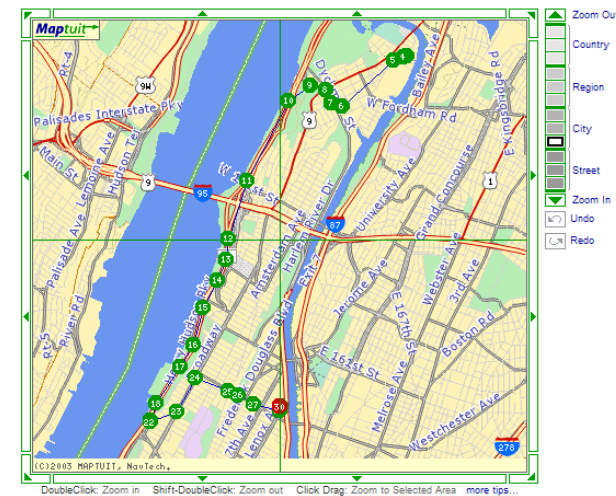
Remote Emissions Monitoring

General

- Currently operational in CA with commercially available Networkcar system

- Meets all EPA and CARB guidelines for I/M-based emissions tests

- Deployed and operational in over 1000 vehicles associated with CARB, USEPA Mobile Sources, California BAR

- Operational on consumer vehicles deployed in California

- Only available technology to monitor real-time diagnostic, emissions, and DTC data

CARB Program

- Currently 830 vehicles undergoing testing in LA; 120 in Oakland

- Failing vehicles flagged in real time

- 14 days allocated to repair vehicle

- Program is voluntary; Networkcar does not 'police'

- Data can be analyzed to detect fraud (e.g., unplugged unit)

Consumer Program

- Currently operational in California; working on expanding to other states

- Service is free with Networkcar system; no cost to CA

- Pass/fail data reported to DMV (just like conventional system)

- Saves ~$70/test and lost productivity

networkcar

CARB 'Clean Fleets' Taxis

### *Why Monitor Vehicles in the Clean Fleets Program?*

- NO_x emissions typically ~6 times those of EPA-mandated levels for new vehicles
- Taxicabs drive average of ~90,000 miles/year
- One taxicab emitted ~50 times the NO_x of compliant vehicle
- Historical problems with emissions tests (27% fail)
- Historical problems with fraud, e.g. tampering with MIL (21% of all vehicles)
- Repairs estimated to improve NO_x emissions by ~0.8 tons/day (297 tons/year) at two years
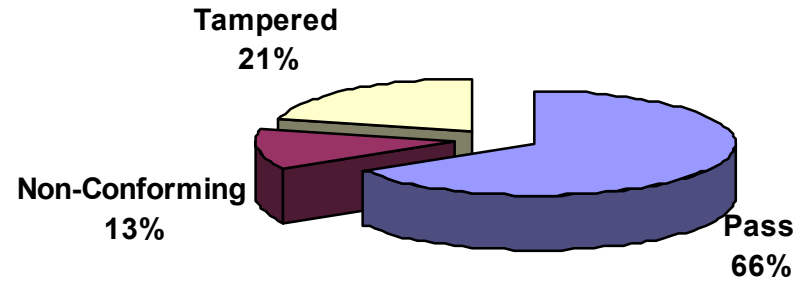

dashboard MIL rewired to fraudulently simulate a normal operating condition

CARB 'Clean Fleets' Taxis – Historical Data

Failed I/M Test
27%

Passed I/M Test
73%
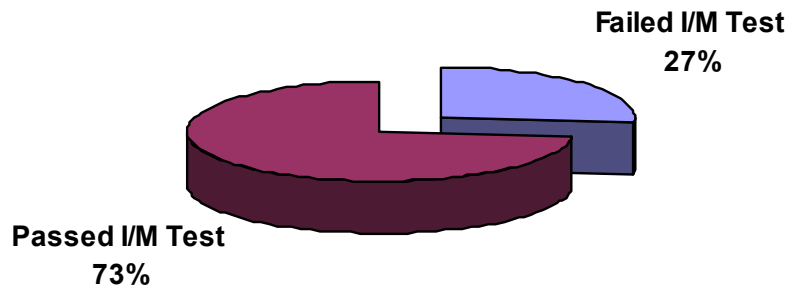
Taxicabs frequently fail emissions tests

Tampered
21%

Non-Conforming
13%

Pass
66%

Tampering with MIL is commonplace
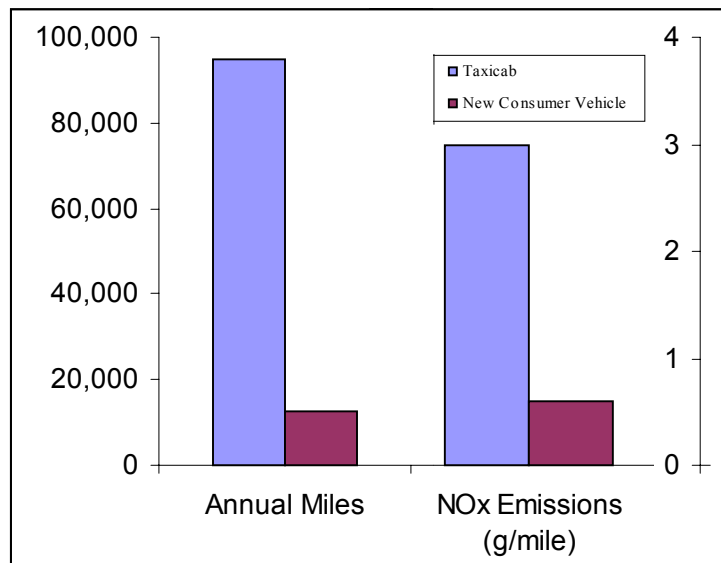
NO_x emissions and annual miles increased significantly relative to normal
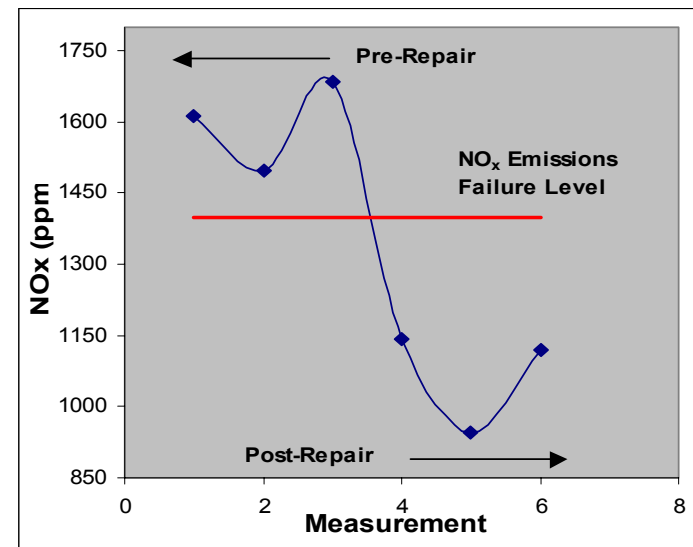
NO_x emissions significantly reduced following repair

networkcar

# Networkcar's Emissions-Monitoring Program -- Summary

- Taxis in program drive about 72,000 miles year on average

- 42% of vehicles currently failing emissions test

- Experimental results measured by CARB:

    - failing vehicle (average):   2.24 g NO_x/mile

    - passing vehicle (average):   0.83 g NO_x/mile

- Majority of emissions failures related to fail catalyst

- Number of emissions failures inversely correlates to model year

- Number of emissions failures correlates very well with mileage

- NO_x Cost/Ton for a single, high-mileage, failing vehicle:

    - Year 1 -- ~$7500

    - Year 5 -- ~$1000

- Emissions failures appear independent of vehicle make

CARB 'Clean Fleets' Taxis – Program Results
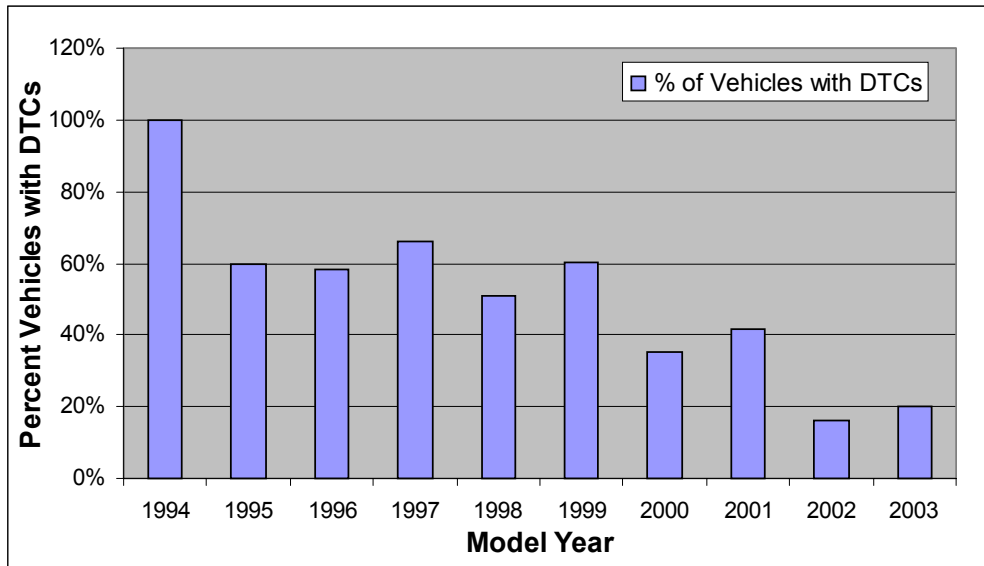
- 42% of all vehicles currently show DTCs
- Each of these vehicles fail I/M emissions test
- As expected, DTCs correlate to vehicle age
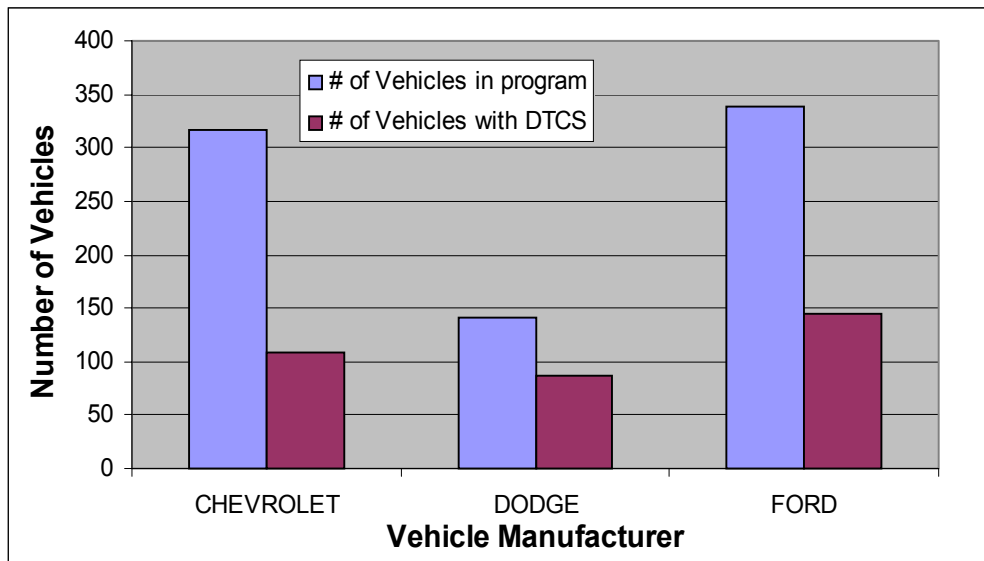
- high percentage of DTCs for all vehicle makes
- DTC Count: 34% Chevy; 61%Dodge; 43% Ford
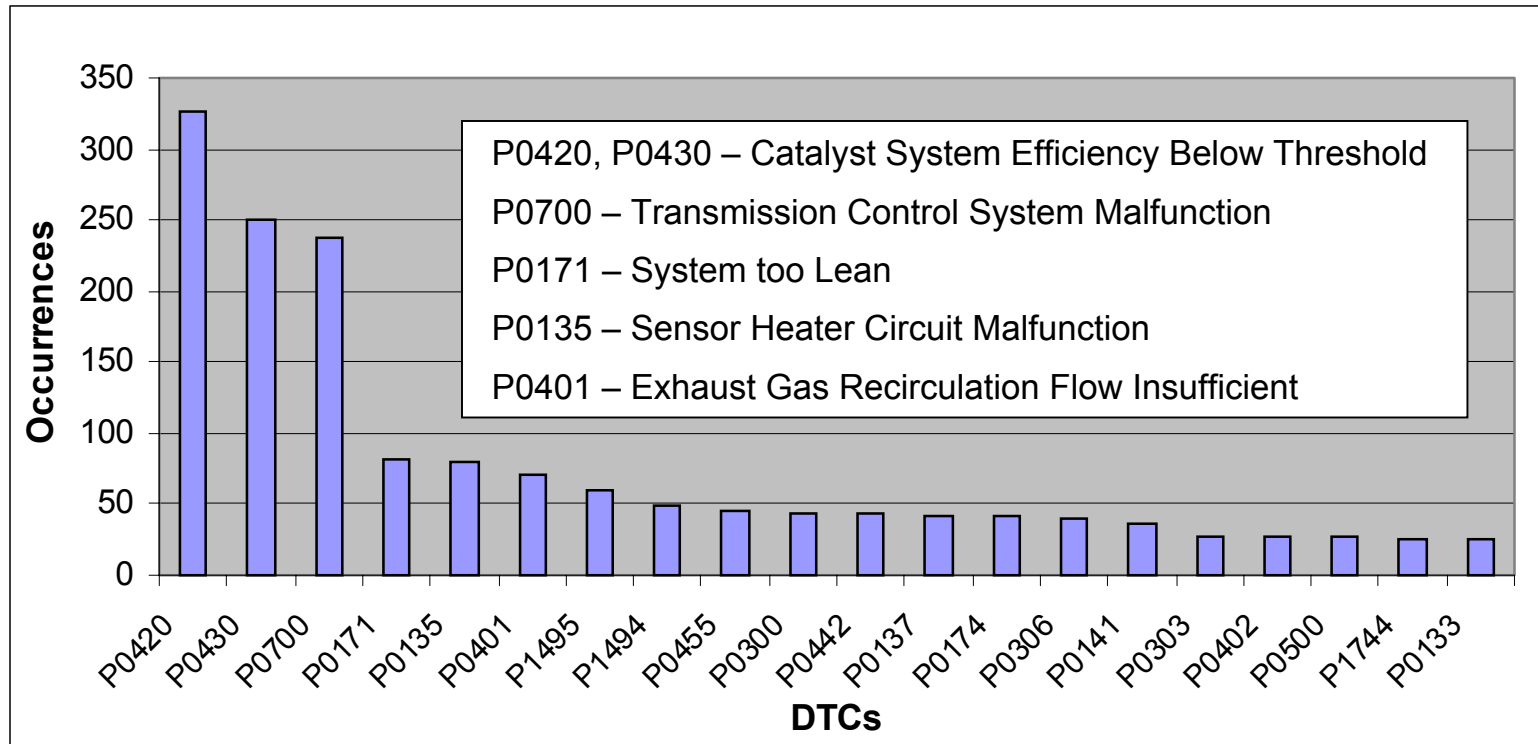- Foreign makes generally not included in study

CARB 'Clean Fleets' Taxis – Emissions Failure Correlation to Vehicle Mileage

Vehicle Mileage	Total Vehicles in Mileage Category	DTC Occurrences for Mileage Category	Average DTC per Vehicle
0-49,999	194	94	0.5
50,000-99,999	228	176	0.8
100,000-124999	167	238	1.4
125,000-149999	79	199	2.5
150,000-174999	51	183	3.6
175,000+	167	761	4.6

networkcar

CARB 'Clean Fleets' Taxis – Top 20 DTCs

P0420, P0430 – Catalyst System Efficiency Below Threshold

P0700 – Transmission Control System Malfunction

P0171 – System too Lean

P0135 – Sensor Heater Circuit Malfunction

P0401 – Exhaust Gas Recirculation Flow Insufficient

- DTCs generated for a variety of different systems
- Most DTCs indicated failure of catalyst or transmissions systems
- All generated DTCs indicate an increase in the host vehicle's emissions

networkcar

CARB 'Clean Fleets' Taxis – Simulated Results for NO_x and Particulates
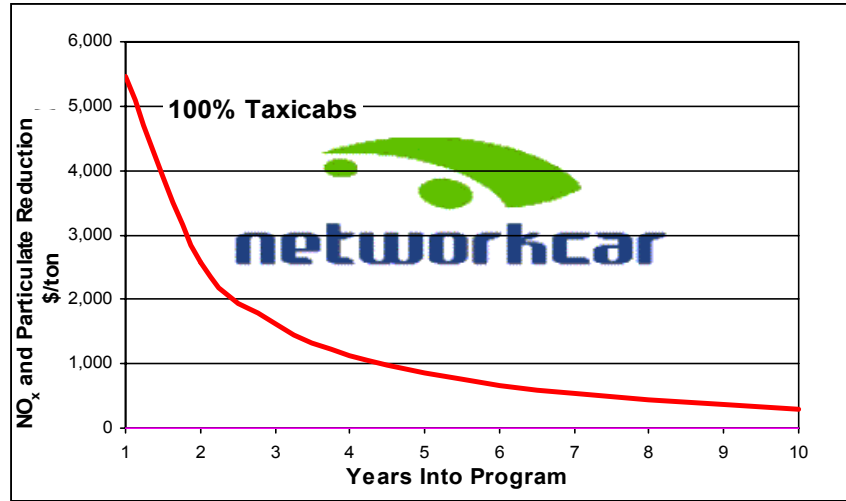
Years	Cost/Ton
2	$2,570
5	$849
10	$301

Cost/Ton ▬▬▬
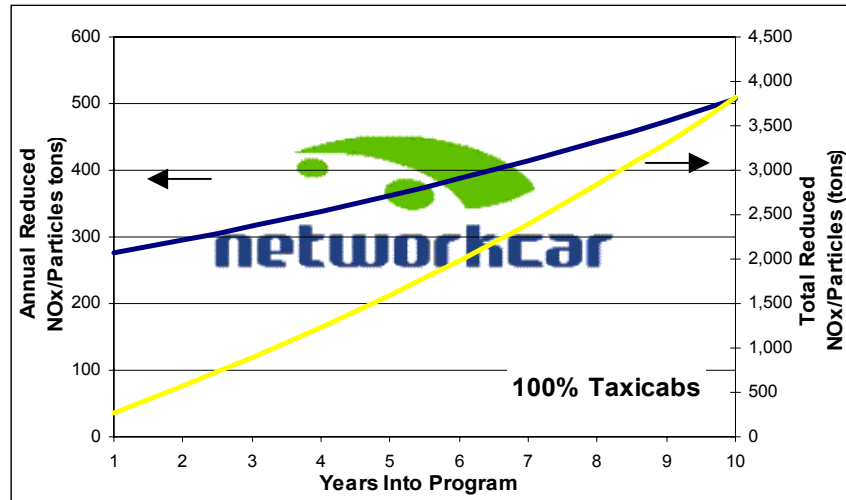
| Years	Annual Tons Reduced	Total Tons Reduced
2	297	572
5	362	1589
10	380	3819

Annual Reduced NOx/Particulate ▬▬▬
Total Reduced NOx/Particulate ▬▬▬

Simulated Results for 5000 Taxicabs in the LA Basin Using EMFAC Model

Benefits of Large-Scale Deployment

CARB Program 'Primes the Pump' for Large-Scale Deployment of Remote Emissions Monitor

9% **2%**

	Light-Duty Vehicles
	Medium-Duty Vehicles
	Heavy-Duty Trucks

89%
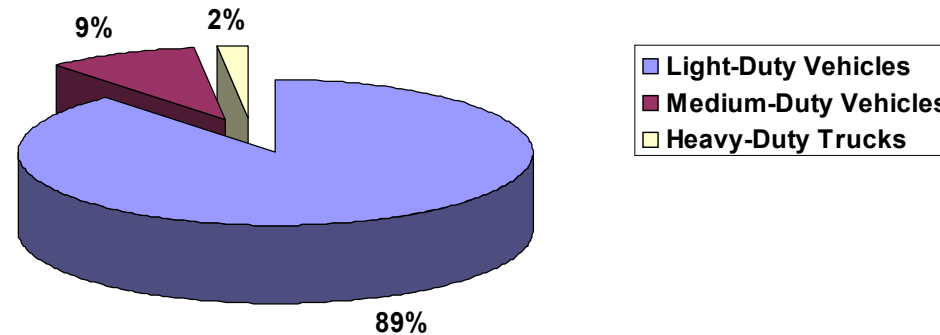
California Vehicle Population   MY 96-00
8.5 Million Vehicles Total

- Networkcar system could be deployed on up to 8.3 million new and used vehicles sold annually in California

- Potentially effective for 98% of the 96-00 vehicle population which emits 46% of the annual NO_x (69,000 tons) in California

- Solution could potentially reduce ~2.5 tons NO_x/day or more at no charge to ARB

networkcar