



## Off-Road Demonstration Projects

With DPF



Without DPF



IN USE RETROFIT SECTION

JOHN KARIM



PRESENTATION  
OUTLINE

SHOWCASE  
PROJECT

SUPPLEMENTAL  
ENVIRONMENTAL  
PROJECT

SNOWCATS  
PROJECT

Retrofit  
Evaluation  
(PEMS)





**Showcase Program**

**Demonstrating Low Emission Construction Equipment**

A joint program of:

 **Clean Transportation**  
Funding from the NRECA

 California Environmental Protection Agency  
 **Air Resources Board**

 **South Coast Air Quality Management District**



# Objectives

- Reduce Diesel Emission from Off-Road Equipment (Level III Systems)
- Demonstrate Durability and Effectiveness of DPFs on Off-Road Construction Equipment
- Demonstrate New Emission Control Systems
- Increase Number of Verified Retrofit Devices
- Fill Gaps in Vehicle Matrix
- Monitor DPF Performance (Data-loggers)
- Support Verification Section
- Measure Emission Benefit Under Real World Conditions (PEMS)

	Target Emission		
	<75	<40	<100
Bore/Drill Rigs	2	0	0
Cranes	2	2	0
Crawler Tractors	5	4	2
Excavators	0	2	2
Graders	2	2	0
Off-Highway Tractors	2	2	2
Off-Highway Trucks	0	2	2
Other Mobile Off-Road	2	0	0
Pavers	2	0	0
Rollers	0	2	0
Rough Terrain Forklifts	2	0	0
Rubber Tired Dozers	2	2	0
Rubber Tired Loaders	5	4	2
Scrapers	0	2	2
Skid Steer Loaders	20	2	0
Tractors/Loaders/Backhoes	20	4	2
Typemakers	5	0	0



# Vehicle Matrix

	<i>Target Vehicles</i>		
	<i>&lt;175</i>	<i>&lt;&gt;</i>	<i>&gt; 500</i>
Bore/Drill Rigs	2	0	0
Cranes	2	1	0
Crawler Tractors	5	4	1
Excavators	4	7	1
Graders	1	3	0
Off-Highway Tractors	1	3	1
Off-Highway Trucks	0	2	1
Other Mobile Off-road	2	0	0
Paver	2	0	0
Rollers	3	2	0
Rough Terrain Forklifts	4	0	0
Rubber Tired Dozers	1	1	0
Rubber Tired Loaders	5	6	1
Scrapers	0	2	1
Skid Steer Loaders	10	1	0
Tractors/Loaders/Backhoes	10	4	1
Trenchers	5	0	0



# Role of the Fleet Owner

- Submit EQ Information, Confirmation
- Ensure Vehicles Meet OEM Specifications
- Approve Retrofit Designs and Locations
- Make Vehicle(s) Available for Retrofitting
- Inform ARB of Any Issues
- Allow Access for Periodic Monitoring
- Allow On-site Emission Testing



18 Fleets

5 Public Fleets

13 Private Fleets

188 Total Vehicles

Private	Public
Community Recycling & Resource Recovery Inc.	<b>CALTRANS Division of Equipment</b>
Albert W. Davies, Inc.	City of Burbank Public Works Department
Recycled Materials Company of CA	City of Los Angeles, General Services Department
Dan Copp Crushing	County Sanitation Districts of L.A. County
ECCO Equipment Corp.	City of Culver City Transportation Department
Griffith Company	
PEED Equipment Company	
Altfillisch Contractors, Inc.	
Reed Thomas Company, Inc.	
Shimmick Construction Co.	
Skanska USA Civil West California District Inc.	
Tiger 4 Equipment Leasing	
Sukut Equipment Inc	

A joint program of:

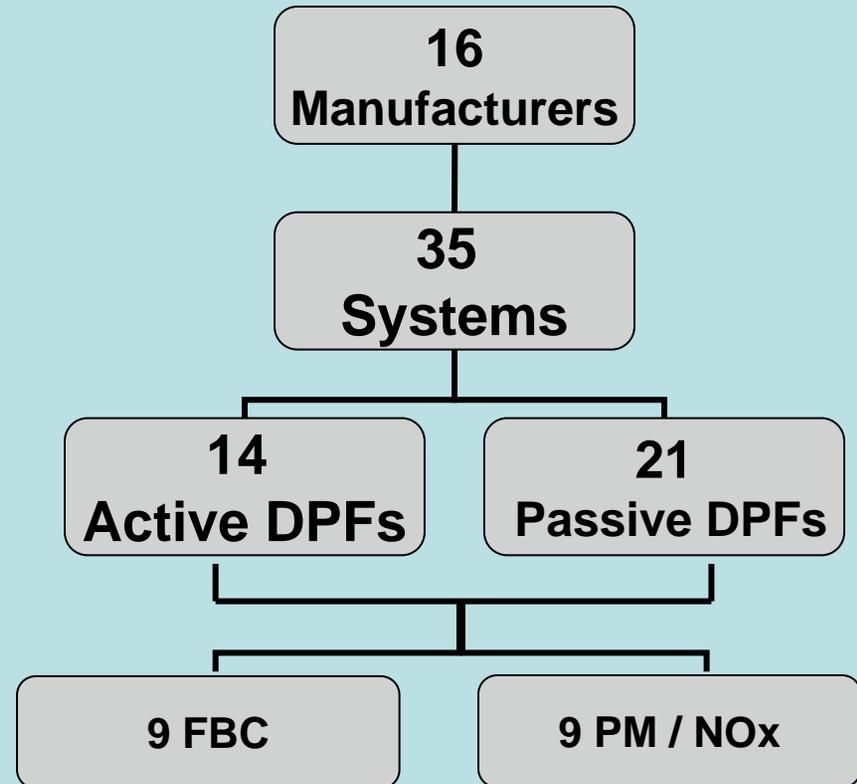


# Role of Device Manufacturers

- Data Log
- Submit Proposal
- Submit Designs and Location of Device to Fleet Owners and ARB
- Install DPF
- Install ARB Approved Data Loggers
- Respond within 24 hrs.
- Implement Warranty and Maintenance Agreement (2707)
- Provide Technical Support
  - 1 YR Fuel Additive Supply
  - 1 YR Maintenance
- Obtain Experimental Permit

**(626) 575-6848 [rcastror@arb.ca.gov](mailto:rcastror@arb.ca.gov)**

# EMISSION CONTROL MANUFACTURER PARTICIPANT LIST



# Evaluation Report

Qualified  
516 / 1100

Manufacturer

ET

Evaluation ID

154

Technology Type

DEF (active) + PSC

Product ID

21

Date:

8/13/2007

Product name

[REDACTED]

Final Score

516 out of 1000

## Rating Factors

MANDATORY	1.	<b>Verification</b> Does applicant currently have a verified product with U.S. EPA, VERT or ARB?	<input checked="" type="checkbox"/>
	2.	<b>Verification of Showcase Product</b> Does applicant agree to complete the verification process for this product?	<input checked="" type="checkbox"/>
	3.	<b>Equivalent to Level 3: 85% Reduction</b> Does this device meet the minimum PM reduction?	<input checked="" type="checkbox"/>
	4.	<b>Technical Support</b> Does applicant agree to provide technical support during the demonstration project period?	<input checked="" type="checkbox"/>

## Comments

Has VERT under the COMBIA name. Excellent was COMBIA before acquisition

AND answer in any of the above categories will automatically dis-

FORMER	5.	<b>NOx Reduction:</b> Percentage of NOx reduction greater than 25%	10	<input type="text" value="1"/>	10	
	6.	<b>Other Pollutants</b> Does this system show potential increase in other pollutant? Assign 2500 Points	5	<input type="text" value="0"/>	0	
		Does this system show potential decrease in other pollutant? Assign maximum Points.	1	<input type="text" value="4"/>	5	
	APPLICABILITY	7.	<b>Vehicle Profile:</b> How well does the diesel oxidation control system meet the required off-road vehicle population?	10	<input type="text" value="10"/>	100
		8.	<b>Target Groups:</b> Does the application identify specific target groups?	10	<input type="text" value="10"/>	100
		9.	<b>Multiple Target Groups:</b> Will this device apply to more than one area of off-road? Report equipment? Part equipment?	3	<input type="text" value="10"/>	30
10.	<b>Feasibility of Control Device</b> Is this device easy to use and install? Will this device fit in the same compartment of the new engine?	3	<input type="text" value="1"/>	3		
	11.	<b>Older Engines:</b> Will this system provide options for older pre-regulated engines?	10	<input type="text" value="5"/>	50	
TOTAL	12.	<b>Cost</b> Cost of device Cost of installation	10	<input type="text" value="1"/>	10	
	13.	<b>Commercial Availability:</b> Is this device/system currently available in California?	1	<input type="text" value="0"/>	0	
	14.	<b>Cost Effectiveness:</b> Will this system be competitive with other available systems?	5	<input type="text" value="1"/>	5	
	15.	<b>Demonstrated Retrofit:</b> Is data provided on previous retrofits for this device?	10	<input type="text" value="5"/>	50	
REMARKS	16.	<b>Multimedia</b> Will this device require multi-media verification? Is previous multimedia data available? (If NO multimedia is required, enter 0 in rating column)	-10	<input checked="" type="checkbox"/>	0	
	17.	<b>Warning System</b>	10	<input type="checkbox"/>	0	

Factors (0-10) Score

## Comments

No NOx reduction
PSC issues < 25% NO2
CO2 < 1%
> 15 kw (725 hp)
Tier 1 + (newer)
Yes
1 week install time
huge price tag/yr
possible used for GenD engines
\$50K price tag
1 week install time
no
not really
yes, some data provided
yes for CO PSC

General Comments:

[REDACTED]

# Tier Table

Table 1. ARB and USEPA Off-Road Compression-Ignition (Diesel) Engine Standards (NMHC+NOx/CO/PM in g/bhp-hr). When ARB and USEPA standards differ, the standards shown here represent the more stringent of the two.

Maximum horsepower	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015+
<11	See Table 2 footnote (a)					7.8 / 6.0 / 0.75			5.6 / 6.0 / 0.6			5.6 / 6.0 / 0.30 <sup>a</sup>									
11≤hp<25						7.1 / 4.9 / 0.60			5.6 / 4.9 / 0.60			5.6 / 4.9 / 0.30									
25≤hp<50	-					7.1 / 4.1 / 0.60			5.6 / 4.1 / 0.45			5.6 / 4.1 / 0.22			3.5 / 4.1 / 0.02						
50≤hp<75									5.6 / 3.7 / 0.30			3.5 / 3.7 / 0.22 <sup>c</sup>			3.5 / 3.7 / 0.02 <sup>c</sup>						
75≤hp<100						- / 6.9 / - / - <sup>b</sup>						3.5 / 3.7 / 0.30			0.14 / 0.30 / 3.7 / 0.015 <sup>b</sup>						
100≤hp<175									4.9 / 3.7 / 0.22			3.0 / 3.7 / 0.22			0.14 / 2.5 / 3.7 / 0.015 <sup>b,c</sup>						
175≤hp<300									4.9 / 2.6 / 0.15						0.14 / 2.2 / 0.015 <sup>b</sup>						
300≤hp<600	-	1.0 / 6.9 / 8.5 / 0.40 <sup>b</sup>							4.8 / 2.6 / 0.15			3.0 / 2.6 / 0.15 <sup>e</sup>			0.14 / 1.5 / 2.6 / 0.015 <sup>b,c</sup>						
600≤hp≤750															0.14 / 2.6 / 2.6 / 0.03 <sup>b</sup>						
Mobile Machines > 750hp															0.30 / 2.6 / 2.6 / 0.07 <sup>b</sup>						
750hp<GEN ≤1200hp						1.0 / 6.9 / 8.5 / 0.40 <sup>b</sup>						4.8 / 2.6 / 0.15			0.14 / 0.50 / 2.6 / 0.02 <sup>b</sup>						
GEN>1200 hp															0.30 / 0.50 / 2.6 / 0.07 <sup>b</sup>						

a) The PM standard for hand-start, air cooled, direct injection engines below 11 hp may be delayed until 2010 and be set at 0.45 g/bhp-hr.

b) Standards given are NMHC/NOx/CO/PM in g/bhp-hr.

c) Engine families in this power category may alternately meet Tier 3 PM standards (0.30 g/bhp-hr) from 2008-2011 in exchange for introducing final PM standards in 2012.

d) The implementation schedule shown is the three-year alternate NOx approach. Other schedules are available.

e) Certain manufacturers have agreed to comply with these standards by 2005.

# ARB Vehicle Summary

## Proposed Vehicles To Be Retrofit For The Showcase (by fleet)

Rated HP	Equipment ID:	Year	Model	Engine Model Year	Engine Hours	Engine Serial Number	Engine Family	CID	Use / Hrs / Idle Week	City of Equipment during ShowCase	hrs at location 700									
<b>Albert W. Davies, Inc.</b>																				
<b>Extengine ADECII</b>																				
HP Range: 200-500																				
				3	DPF	DOC	FTF	Active	Passive	NOx	FBC	Tier --				OnLine	OffLine	Electric	Fuel	
					<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
<b>Excavators</b>																				
<input checked="" type="checkbox"/>	375	#158, CAT 245B Excavato	1991	3406 Tier0	1991	16388	11N02010	4P4245	893	80%	32	Sites In Orange, Riverside, a 1500 Hour				<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	AQMD
<b>Recat - ESWDC-100</b>																				
HP Range: 50 to 2000 HP																				
				5	DPF	DOC	FTF	Active	Passive	NOx	FBC	Tier --				OnLine	OffLine	Electric	Fuel	
					<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Excavators</b>																				
<input checked="" type="checkbox"/>	250	#125, CAT 235C Excavato	1991	3306	1991	14527	08Z65121	9Y0032	638	90%	36	Sites In Orange, Riverside, a 1500 Hour				<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<b>Sud Chemie ENVICAT</b>																				
HP Range: 80-1000HP																				
				24	DPF	DOC	FTF	Active	Passive	NOx	FBC	Tier --				OnLine	OffLine	Electric	Fuel	
					<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Excavators</b>																				
<input type="checkbox"/>	350	#75, CAT 245B Excavator	1984	3406 Tier0	1984	19773	70V17828	70V17828	893	90%	36	Sites In Orange, Riverside, a 1500 hours				<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/>	692	#191, CAT 385BL Excavat	2002	3456 Tier1	2002	4592	BLC00232	1CPLXL158ESK	964	80%	32	Sites In Orange, Riverside, a 1500 Hour				<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

4 engines retrofit for Albert W. Davies, Inc. for an estimated total amount of: \$84850



# Showcase Project Issues

## Contracts

- Fleets/ MSRC
- Fleets/ Device Manufacturer
- CALTRANS

## Pricing

- Submitted Prices Differ from Actual Cost

## Drop Out

- Device Manufacturer
  - Aaqius
  - Purem
  - Dinex

## Installation

## Economic Effects

- Reduction in Job Availability
- Vehicles Out-of-Service

## Re - match

- Vehicles Retired/Replaced
- Vehicle's Temp Profile
- Rental Issues: Preference for Passive DPF

## Showcase Status

- 188 Vehicles are Participating
- 62 CALTRANS vehicles
- 60 Vehicles Data Logged
- 26 Installations Completed
- 14 vehicles Scheduled for Retrofit in Aug



# Showcase RETROFITS





Vehicle Information 6503 (Altfillisch)	
Year	2001
Horsepower	255
Tier	1
Description	Crawler Tractors
Active/Passive/Nox	Passive
Selected Device	DCL MINE - X



Vehicle Information 325R (Community Recycling)	
Year	1994
Horsepower	168
Tier	0
Description	Excavator
Active/Passive/Nox	Active
Selected Device	Mann Hummel SMF-AR



Vehicle Information 330B (Community Recycling)	
Year	2000
Horsepower	222
Tier	1
Description	Excavator
Active/Passive/Nox	Passive
Selected Device	Nett BlueMax PLUS (SCR and Passive DPF)



Vehicle Information 5002 Front & Rear (County San.)	
Year	2006
Horsepower	632 & 457
Tier	1
Description	Scraper
Active/Passive/Nox	Passive
Selected Device	CDT Permit-FBC



Vehicle Information 3486 (Griffith Company)	
Year	2004
Horsepower	222
Tier	2
Description	Grader
Active/Passive/Nox	Passive
Selected Device	CAT-DPF



Vehicle Information 5052 (County San.)	
Year	1998
Horsepower	370
Tier	1
Description	Dozer
Active/Passive/Nox	Passive
Selected Device	CDT Platinum Plus Purifier Filter



Vehicle Information CMI -047 (Dan Copp Crushing)	
Year	1992
Horsepower	375
Tier	0
Description	Rubber Tired Loaders
Active/Passive/Nox	Passive
Selected Device	MANN+HUMMEL SMF-FBC



Vehicle Information 3368 (Griffith Company)	
Year	1995
Horsepower	170
Tier	0
Description	Rubber Tired Loader
Active/Passive/Nox	Active
Selected Device	Mann Hummel SMF-AR



Vehicle Information 3414 (Griffith Company)	
Year	1998
Horsepower	290
Tier	1
Description	Excavator
Active/Passive/Nox	Active
Selected Device	Nett BlueMax ULTRA (SCR and Active DPF)



Vehicle Information 3478 (Griffith Company)	
Year	2001
Horsepower	107
Tier	1
Description	Forklift
Active/Passive/Nox	Active
Selected Device	Nett BlueMax ULTRA (SCR and Active DPF)



Vehicle Information 37-006 (Shimmick)	
Year	2004
Horsepower	95
Tier	2
Description	Tractors/Loaders/Backhoes
Active/Passive/Nox	Passive
Selected Device	JM CRT



Vehicle Information 47-010 (Shimmick)	
Year	1993
Horsepower	295
Tier	0
Description	Rubber Tired Loaders
Active/Passive/Nox	Passive
Selected Device	CAT - EUG/DPF



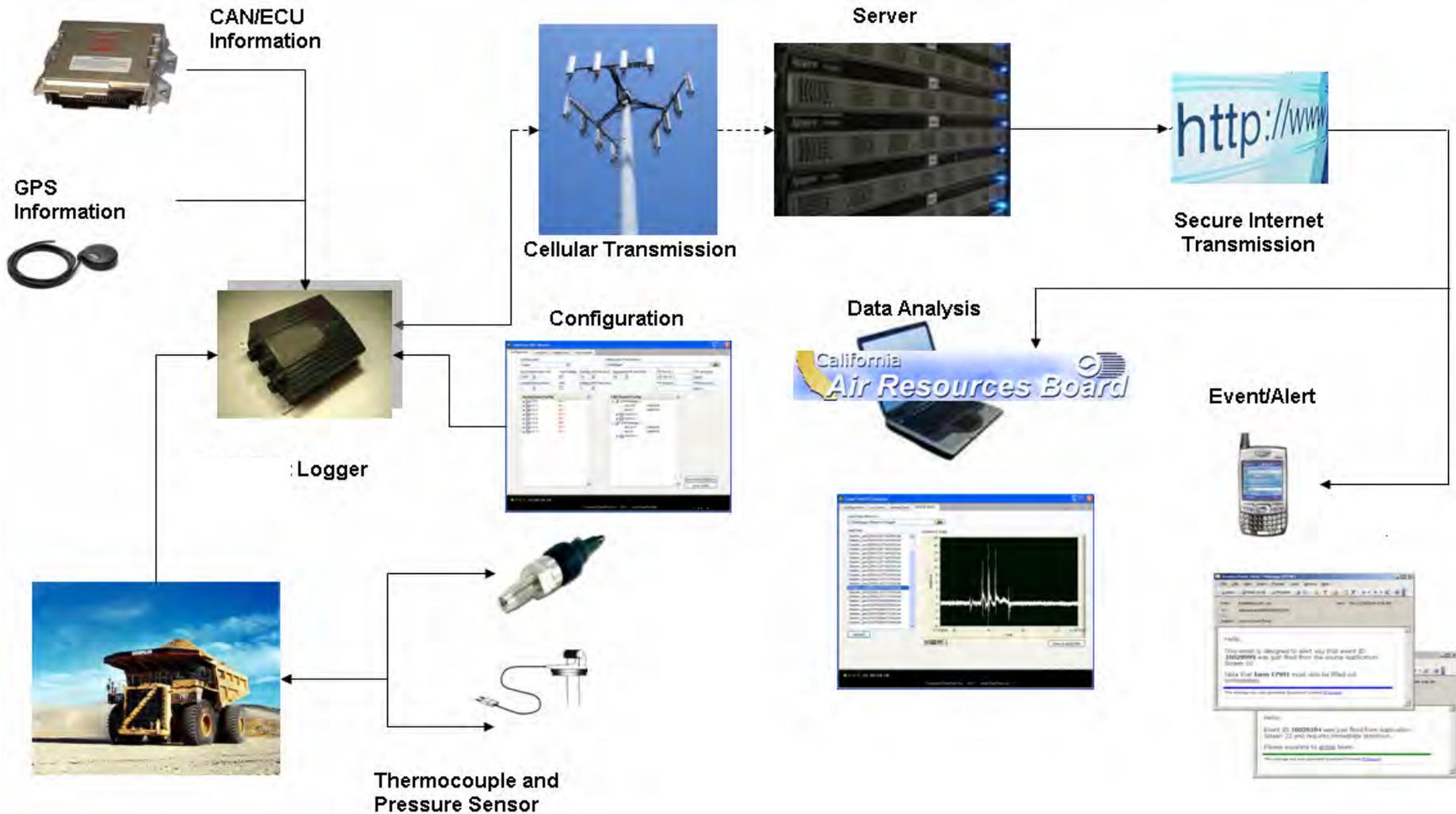
Vehicle Information 83N0670 (Skanska)	
Year	1995
Horsepower	275
Tier	0
Description	Rubber Tired Loaders
Active/Passive/Nox	Passive
Selected Device	CAT/EUG DPF



Vehicle Information Scraper #2 (Tiger 4 Equip.)	
Year	1985
Horsepower	188
Tier	0
Description	Scraper
Active/Passive/Nox	Active
Selected Device	MANN+HUMMEL SMF-AR



# DATA LOGGER





California Environmental Protection Agency

Air Resources Board

**SUPPLEMENTAL  
ENVIRONMENTAL  
PROJECT**



## SEP Objectives

- Reduce Diesel Emission from Off-Road Equipment (Level III Systems)
- Demonstrate Durability and Effectiveness of DPFs on Off-Road Construction Equipment
- Demonstrate New Emission Control Systems
- Increase Number of Verified Retrofit Devices
- Fill Gaps in Vehicle Matrix
- Spending \$900,000 Total
  - SEP I \$250,000 Allocation (Total Vehicle:16) - Chevron
  - SEP II \$200,000 Allocation (Total Vehicles: 11) - Valero
  - SEP III \$200,000 Allocation (Total Vehicles: 11) - Valero
  - SEP IV \$250,000 Allocation (Total Vehicles: 14) - Exxon

### Role of Fleet Owner

- Same As Showcase

### Role of Device Manufacturers

- Same As Showcase



# SEP RETROFITS





Vehicle Information 6695 (County San.)	
Year	1998
Horsepower	241
Tier	1
Description	Excavators
Active/Passive/Nox	Passive
Selected Device	Nett BlueMax PLUS (SCR and Passive DPF)



Vehicle Information 6727 Front & Rear (County)	
Year	2000
Horsepower	632 and 457
Tier	1
Description	Scraper and 657E Scraper
Active/Passive/Nox	Passive
Selected Device	DCL MINE-X



Vehicle Information 6768 (County San.)	
Year	1997
Horsepower	105
Tier	1
Description	Wheel loader
Active/Passive/Nox	Passive, Nox Control
Selected Device	Nett BlueMax PLUS (SCR and Passive DPF)



Vehicle Information 47121 (Public Works)	
Year	2000
Horsepower	185
Tier	2
Description	Motor Grader
Active/Passive/Nox	Active
Selected Device	Recat - ESW DC-100 (Fogger)



Vehicle Information 60656 (LACDBH)	
Year	2006
Horsepower	125
Tier	2
Description	Tractor
Active/Passive/Nox	Active
Selected Device	Recat-ESW Therma Cat System ETI DC-202



Vehicle Information 61619 (LACDBH)	
Year	2007
Horsepower	125
Tier	3
Description	Tractor
Active/Passive/Nox	Active
Selected Device	ECS Purifilter Plus



Vehicle Information 72204 (Public Works)	
Year	1995
Horsepower	105
Tier	0
Description	Wheel Loader
Active/Passive/Nox	Active
Selected Device	Huss FS-MD



Vehicle Information 637 (Fast Lane)/SEP II	
Year	1999
Horsepower	200
Tier	1
Description	Side Handler 6 High
Active/Passive/Nox	Active
Proposed Device	MANN+HUMMEL SMF-AR



Vehicle Information 14267 (City of Long Beach)	
Year	2000
Horsepower	86
Tier	1
Description	Backhoe
Active/Passive/Nox	Active
Selected Device	MANN+HUMMEL SMF-AR



Vehicle Information 14336 (City of Long Beach)	
Year	2005
Horsepower	272
Tier	2
Description	Wheel Loader
Active/Passive/Nox	Passive
Proposed Device	CAT-DPF



Vehicle Information 844 (Fast Lane)	
Year	2005
Horsepower	174
Tier	2
Description	Fork Lift Truck
Active/Passive/Nox	Active
Proposed Device	Nett Vorteq (Active DPF)



Vehicle Information W93301 (DWP)	
Year	2002
Horsepower	260
Tier	1
Description	Wheel Loader
Active/Passive/Nox	Active
Proposed Device	Econix DPF-A



Vehicle Information W93518 (DWP)	
Year	1999
Horsepower	108
Tier	1
Description	Wheel Loader
Active/Passive/Nox	Passive
Proposed Device	CDT Platinum Plus Purifier Filter



Vehicle Information W93524 (DWP)	
Year	2004
Horsepower	95
Tier	2
Description	Wheel Loader
Active/Passive/Nox	Active
Proposed Device	Huss FS-MD



Vehicle Information R85B (Alameda)	
Year	2004
Horsepower	119
Tier	2
Description	Wheel Loader
Active/Passive/Nox	Passive
Proposed Device	CDT Platinum Plus Purifier Filter



Vehicle Information S84A (Alameda)	
Year	2006
Horsepower	80
Tier	2
Description	Broom
Active/Passive/Nox	Active
Proposed Device	CDT Platinum Plus Purifier Filter



# SNOWCATS PROJECT

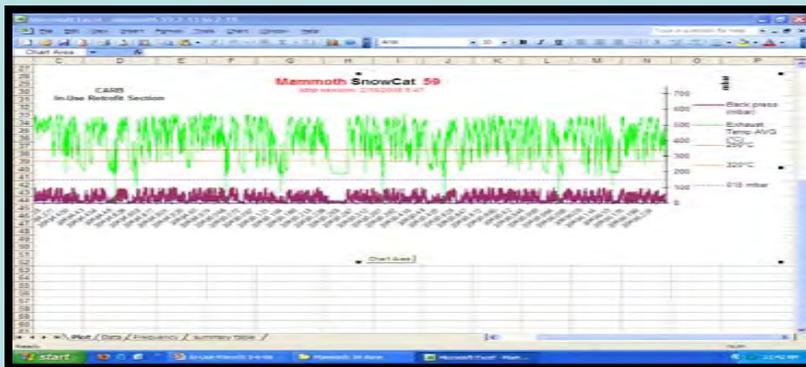




# Snowcat Project

- **Three locations:**
  - Northstar : 5 vehicles
  - Mammoth: 5 vehicles
  - Sugarbowl: 2 vehicles
- **Temperature Profiles**
  - Generated, analyzed and posted on the ARB website for all vehicles
- **Preliminary results** of the temperature profile analysis indicate that vehicles were operating at 400°C or above for 40% of the time regardless of vehicle type.
- **Recommendation:** All vehicles be retrofitted with passive DPFs.
- **Outcome:** Northstar is already retrofitting its vehicles with passive DPFs.

<http://www.arb.ca.gov/diesel/showcase/showcase.htm>





Retrofitted Vehicles





Portable Emissions Monitoring System



PEMS



## PEMS Description

### Purpose:

- To Evaluate Performance of DPF On Off-Road / On-Road Equipment
- To Compare On Road Measurement with Engine Dynamometer Measurements
- To Evaluate Different Techniques of Particulate Measurements
- To Evaluate the Possibility of Measuring Real Time PM Using Low Cost Instruments
- To Establish a Test Cycle in Order to Evaluate the Performance of Retrofit Device

### Measurement:

- Measures Vehicle Exhaust flow rate from either the Engine Electronic Control Module (ECM) and/or the vehicle exhaust tail pipe using Exhaust Flow Meter (EFM)
- NO, NO<sub>2</sub>, CO, CO<sub>2</sub>, THC, PM

### Data:

- Real time vehicle emission data in engineering units
- Report vehicle trap efficiency before/after measurement using 47mm PM filters (gravimetric) , ETaPS and Dust Tracks

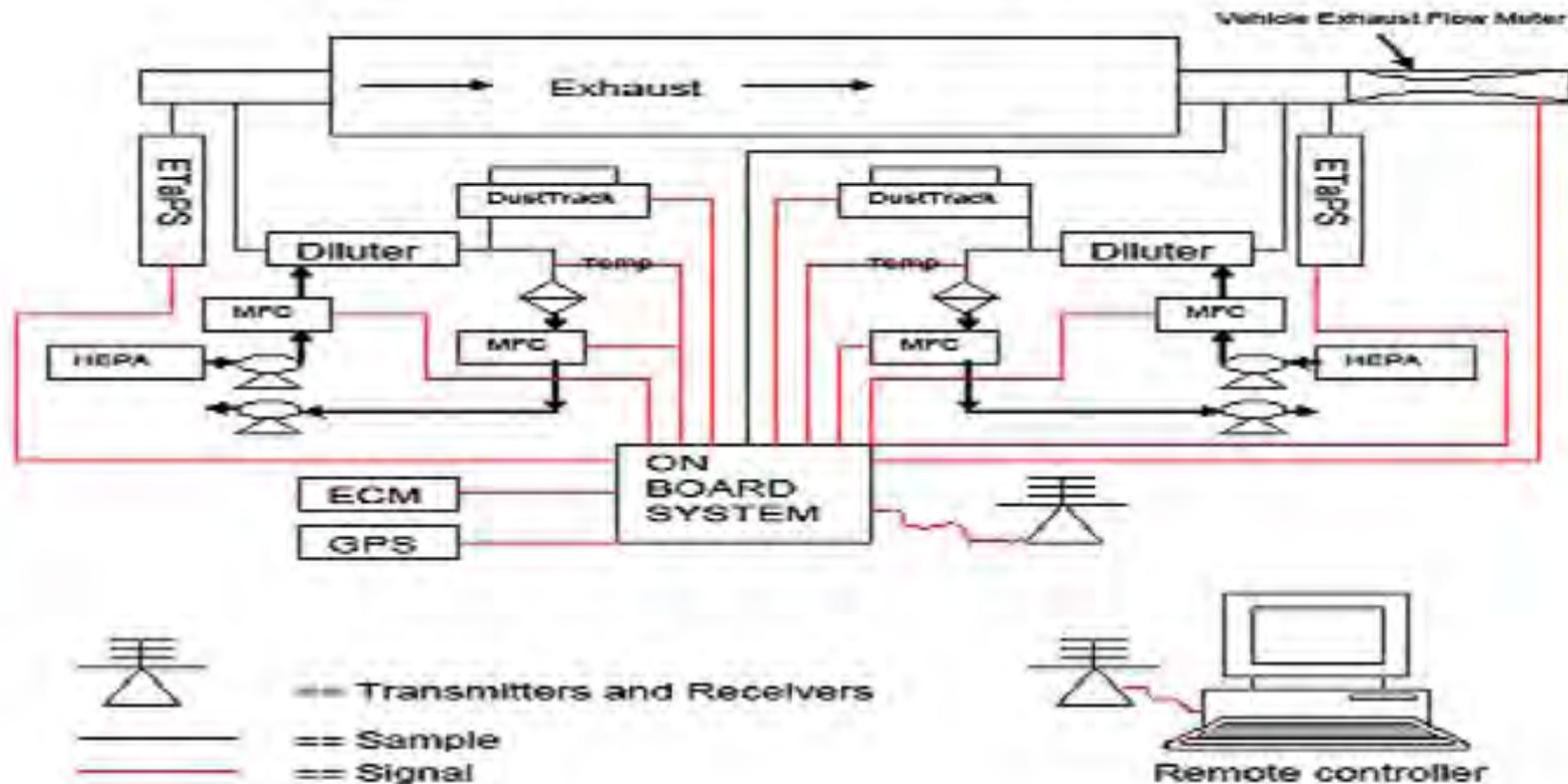
### Real-Time Parameters:

- Gaseous and PM emissions, exhaust flow and temperature, atmospheric conditions, Global Positioning System for location and speed
- Monitor engine parameters using the PEMS Vehicle Interface linked to ECM



# PEMS Diagram Overview

## ON BOARD SYSTEM CONCEPT





# Emission Test Equipment



**Gaseous Emissions:**  
THC, NO<sub>x</sub>, NO, NO<sub>2</sub>,  
CO, CO<sub>2</sub>

**Particulate Matter:**  
PPMD  
DustTrak  
ETaPS  
47mm Filter  
CPC  
DMM  
DiSC



Dekati Mass Monitor (DMM)



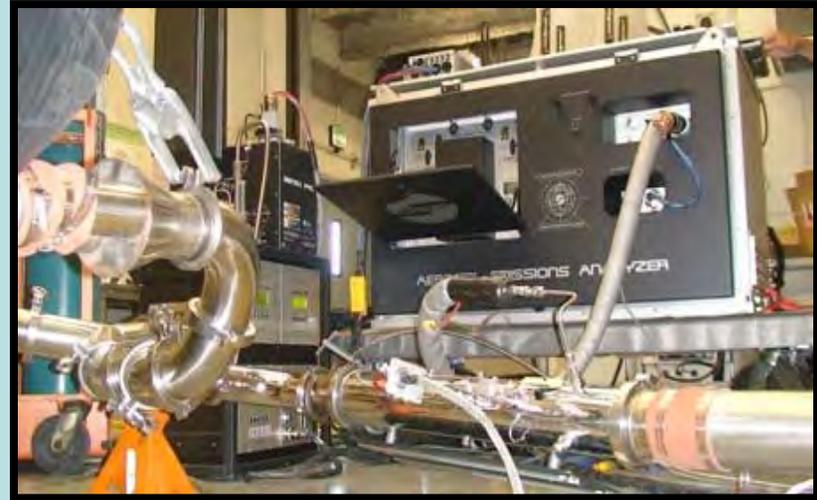
TSI Condensation Particle Counter



Matter Engineering Diffusion Size Classifier



## PEMS Testing in Laboratory





## PEMS on-Road Testing





# Contacts

**Johnny Karim, Manager  
In-Use Retrofit Section**

**(626) 459-4303**

**[jkarim@arb.ca.gov](mailto:jkarim@arb.ca.gov)**

**Website:**

**[http://www.arb.ca.gov/diesel/  
showcase/showcase.htm](http://www.arb.ca.gov/diesel/showcase/showcase.htm)**