

The VW Story and Its Impact on Future In-use Emissions Compliance and Control Technologies

6th International PEMS Conference & Workshop

University of California, Riverside
College of Engineering - Center for Environmental Research and Technology (CE-CERT)
March 17 - 18, 2016

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Center for Alternative Fuels, Engines, and Emissions
West Virginia University



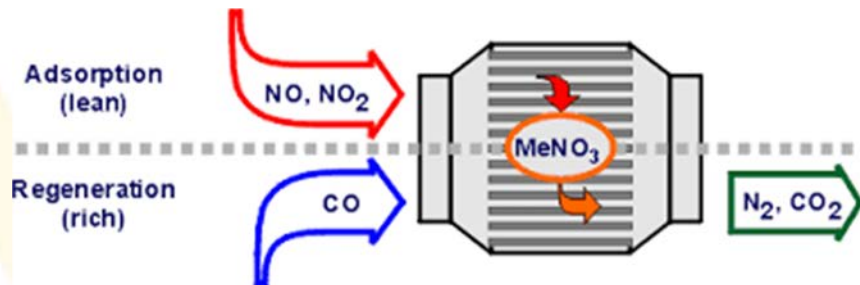
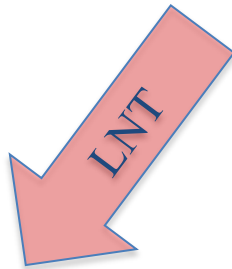
ICCT Light-Duty Diesel Project

- Initial Request by ICCT
 - Initial Contact by Representatives from Horiba Ltd. on 11/15/2012
 - Identify European-based Diesel Engines Sold in the United States Meeting at Least Tier 2 Bin 5, LEV II Emissions
 - Propose a Plan to Evaluate the In-use Emissions from a Representative Selection of Suggested Vehicles – Request Specified Two SCR-Equipped and One Lean NOx Trapped-Equipped Vehicles
 - Proposed Budget ~\$193,662 with Multiple Options
 - Project Award ~ \$69,387

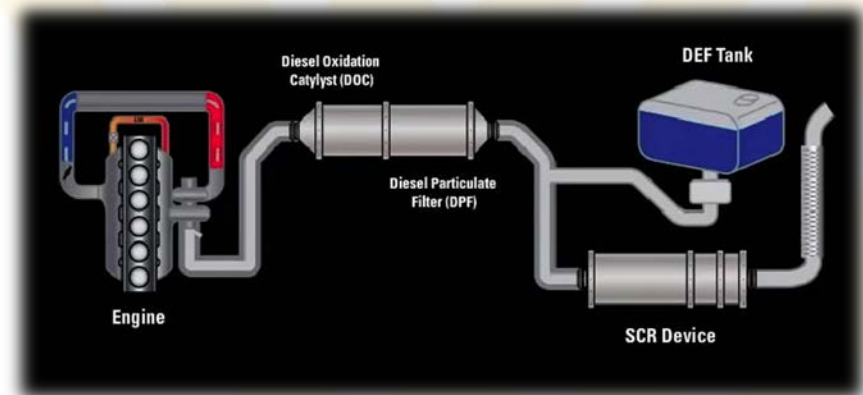


Emissions Control

- Typical Diesel OEM Solutions
- Exhaust Gas Recirculation (EGR)
- Diesel Oxidation Catalyst (DOC)
- Diesel Particulate Filter (DPF)
- And:



https://www.dieselnet.com/tech/cat_diesel.php



<https://www.demanddetroit.com/performance/emissions.aspx>

Richard Dorenkamp



12th Diesel Engine-Efficiency and Emissions Research (DEER) Conference

August 20-24, 2006, Detroit, Michigan

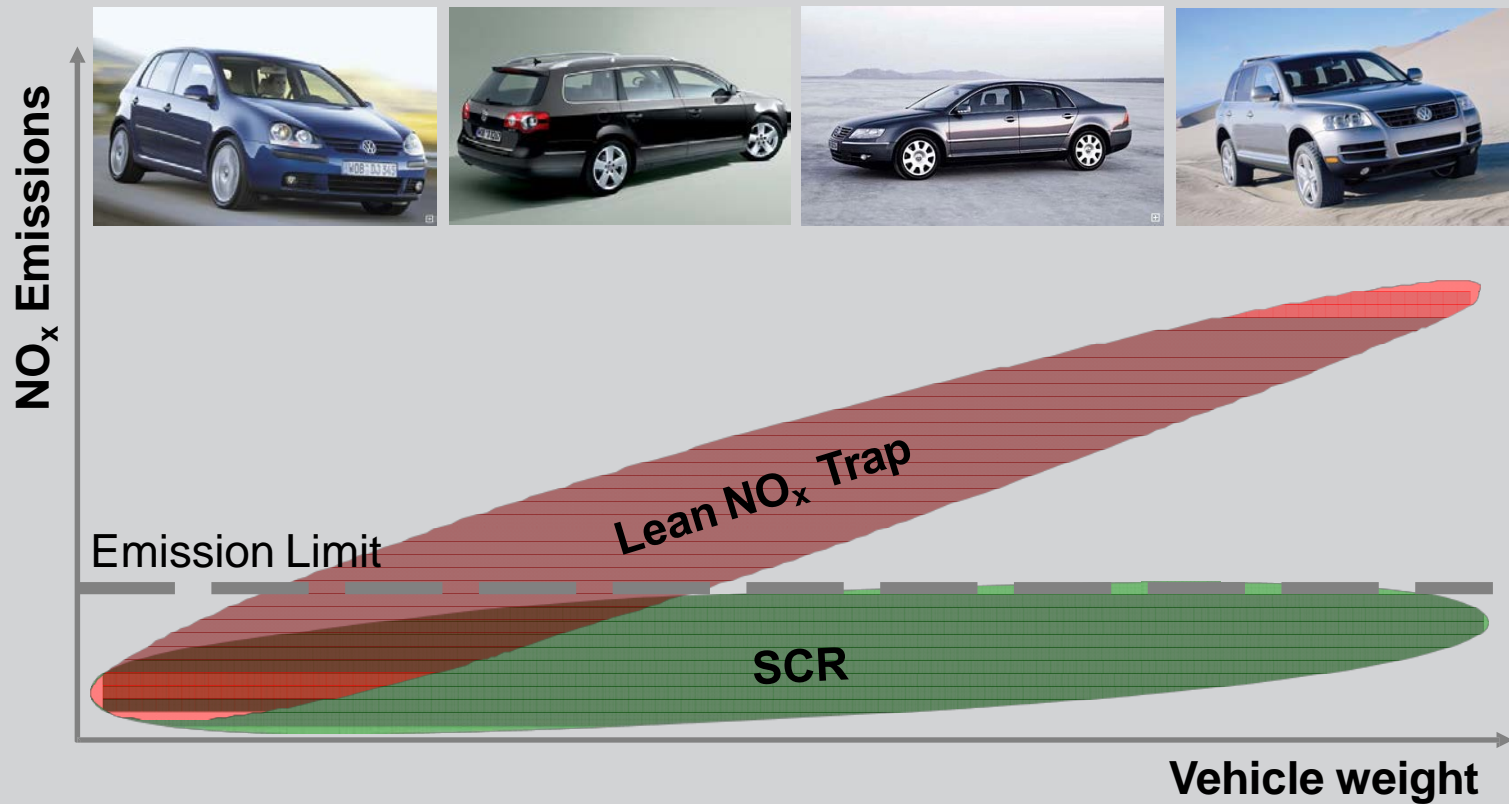
LNT or Urea SCR Technology:

Which is the right technology for TIER 2 BIN 5 passenger vehicles?

**Diesel Engine Development, Volkswagen AG,
Wolfsburg**



System Applicability

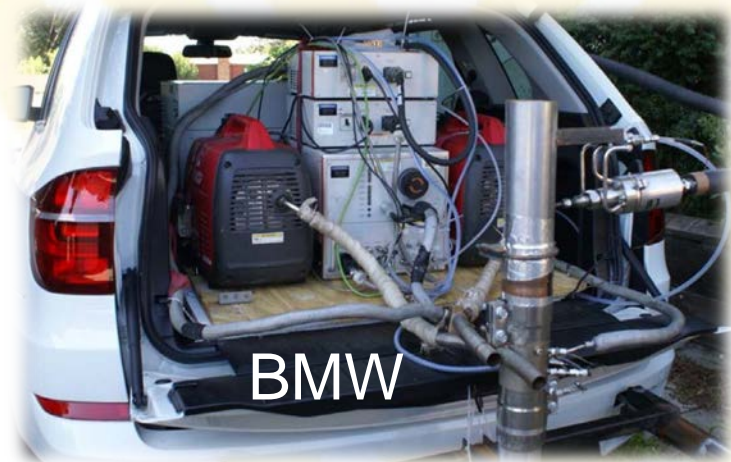
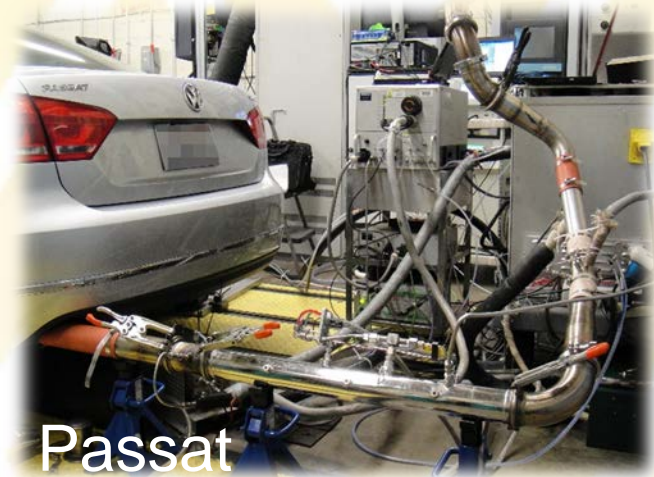


ICCT Light-Duty Diesel Project Protocol

- Initial Proposal Planned Work Around Morgantown, WV, and North Florida
- Vehicle Recruitment Resulted in Location Change to Southern California
- Incorporated CARB Chassis Dynamometer Test Facility to Provide Baseline Data
- Routes Selected to Provide Representative In-use Operation of City, Suburban, and Highway Driving
- Part of the 1970's Route in Los Angeles used to Generate the UDDS Included
- Grade Included for Aftertreatment Effects
- Extended Highway Driving to study PM Regeneration Events



Methodology - Test Vehicles



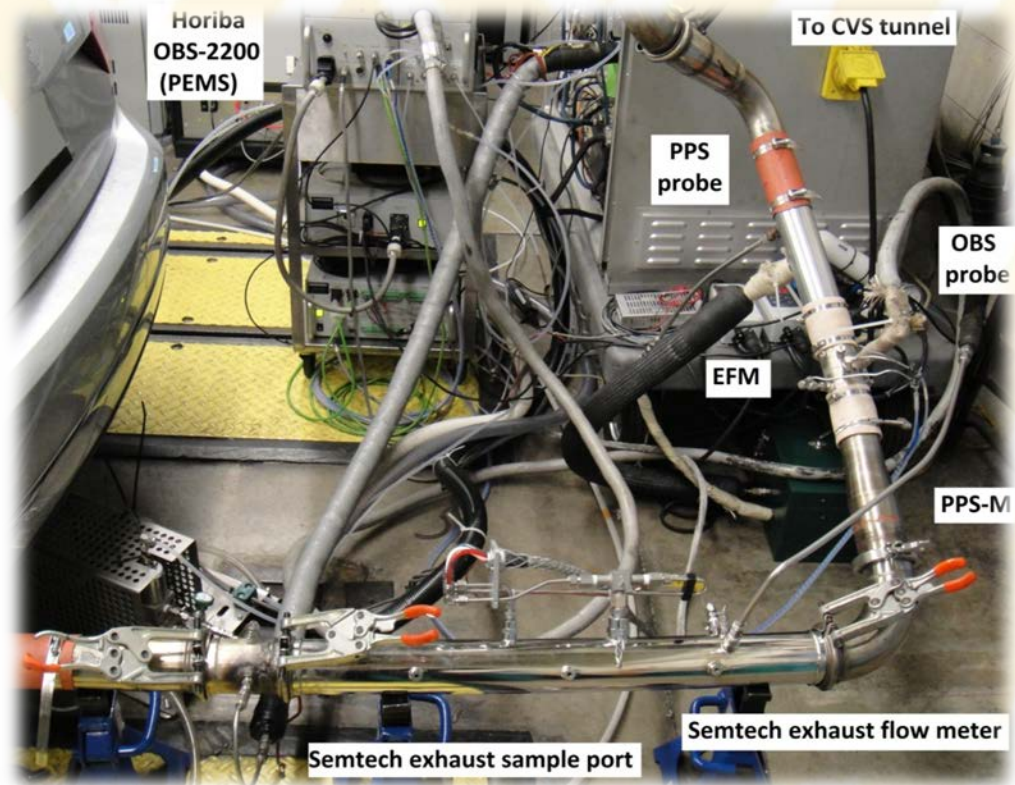
Methodology - Test Routes

- Route 1: highway driving in Los Angeles
- Route 2: urban driving in downtown Los Angeles
- Route 3: rural and uphill/downhill driving in LA's foothills
- Route 4: urban driving in downtown San Diego
- Route 5: urban driving in downtown San Francisco

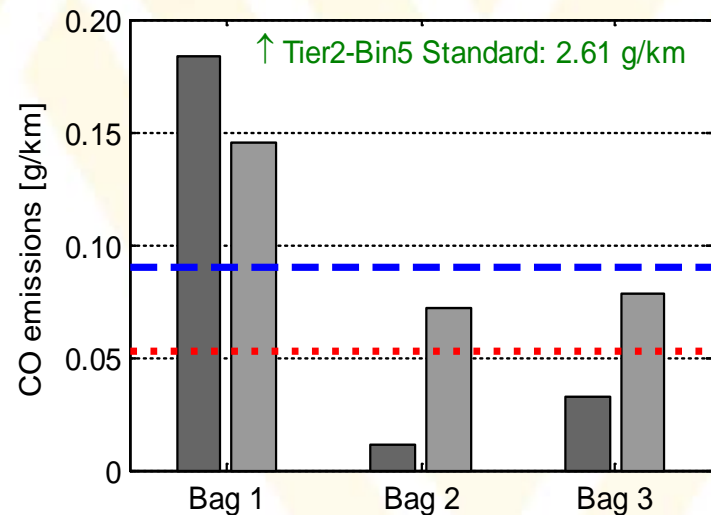
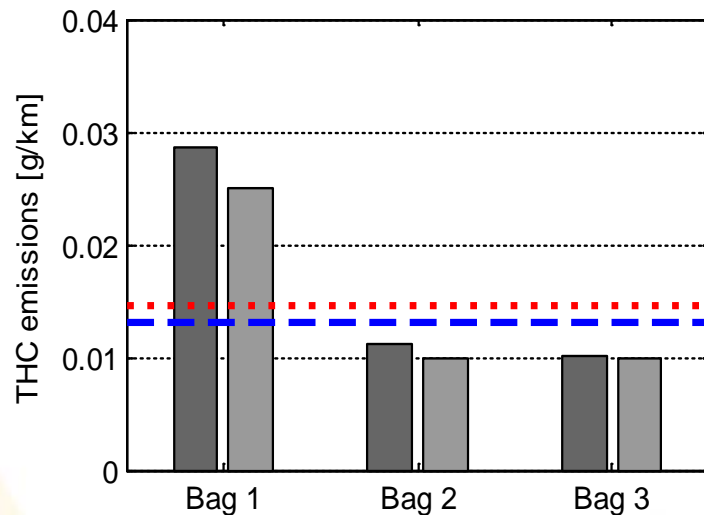
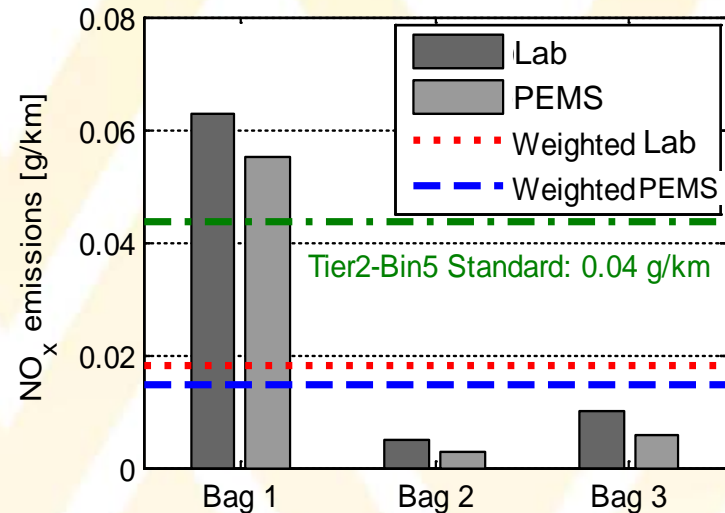
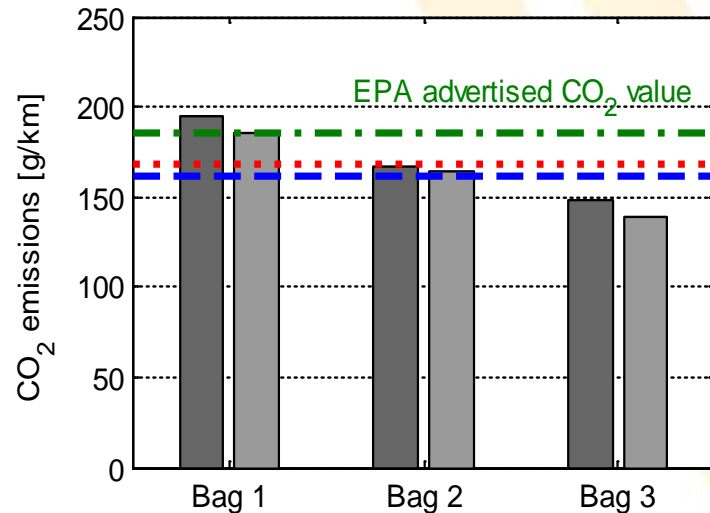


Chassis Dynamometer Testing at CARB

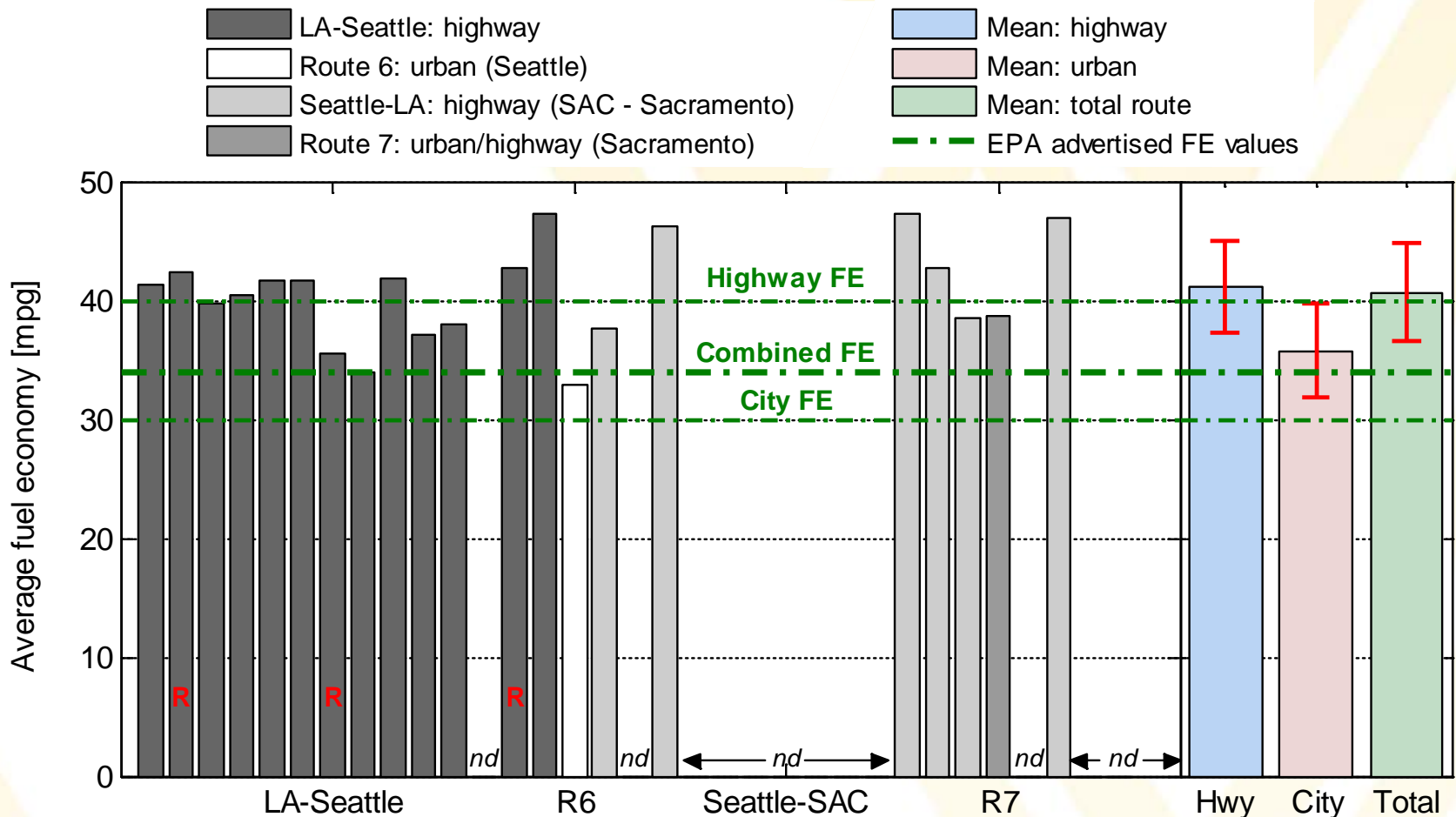
- Volkswagen Jetta and Passat Tested in CARB's El Monte Chassis Dynamometer Laboratory
- Passat Used to Compare PEMS to Lab – Ensure Confidence in PEMS Data
- Integrated (g/mile) and Continuous (g/s) Data Comparison
- Three Different Test Cycles
 - FTP75
 - NEDC
 - US06
- Cold, Warm, and Hot Starts



PEMS vs. CARB Laboratory

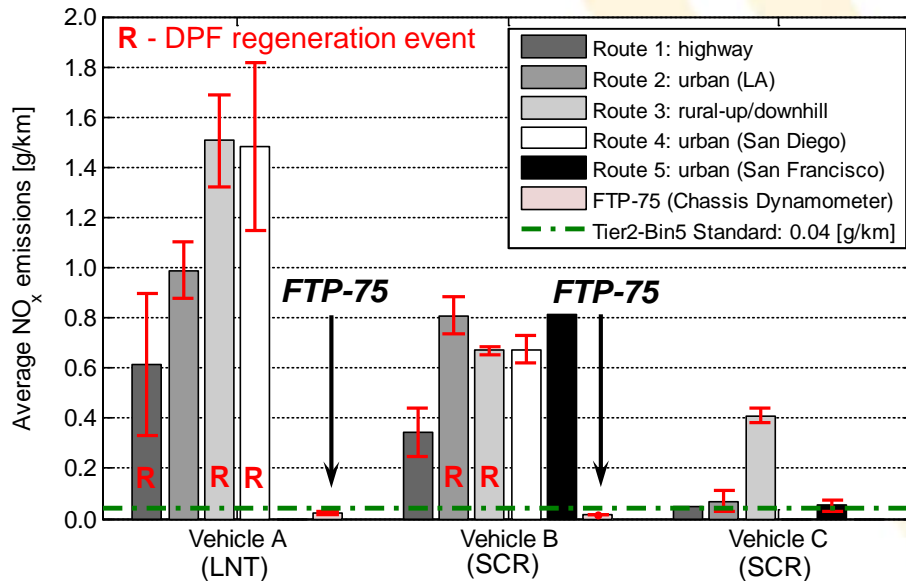


On-Road Fuel Economy Results



Average fuel economy of Passat over cross-multi-state driving route portions expressed as mpg; repeat test variations are presented as $\pm 1\sigma$, 'R' designates segments including a DPF regeneration event, 'nd' - no data available.

Results - Routes NO_x Emissions

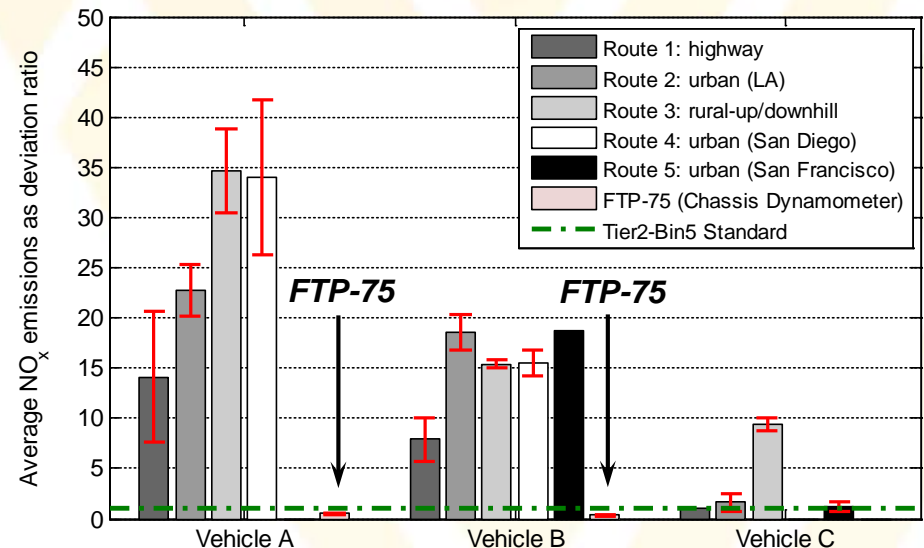


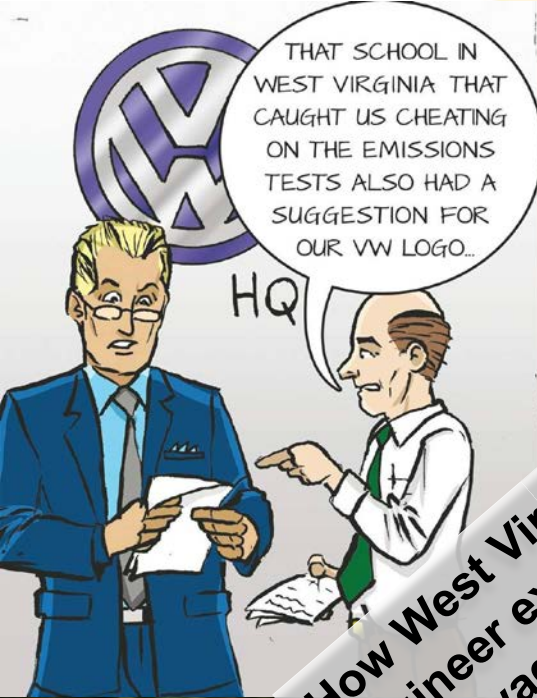
- Highest NO_x emissions during rural/up-downhill and lowest NO_x during highway driving
- LNT shows deficiencies in NO_x reduction over urea-SCR system
- Increase in NO_x emissions during tests with DPF regeneration event => especially pronounced for *Vehicle A* (LNT)
- Route 1, Vehicle A contains rush-hour and non-rush-hour traffic conditions

Chassis dynamometer test results for NO_x

Vehicle	NO _x over FTP-75 [g/km]	Rel. to Tier2-Bin5 [%]
Vehicle A	0.022 ±0.006	50.4
Vehicle B	0.016 ±0.002	64.1
Vehicle C	(no data)	(no data)

NO_x standard EPA Tier2-Bin5, CARB LEV-II ULEV over FTP-75: **0.044 g/km**





How A Little Lab In West Virginia Caught Volkswagen's Big Cheat
September 24, 2015 5:04 AM ET



Das Liars?

EPA's notice of violation of the Clean Air Act to Volkswagen [press statement]

Investigation into "defeat device" alleged emissions tests began with ICCT emissions from diesel passenger cars. Highlights the global laws by regulatory agencies.

Volkswagen swung to a \$1.9 billion dollar third-quarter net loss and issued a full-year profit warning Wednesday, as VW's emissions-cheating crisis continues.

How West Virginia engineer exposed Volkswagen's catastrophic environmental fraud and wiped BILLIONS off company's shares
By Reuters and Daily Mail Reporter
Published: 20:36 EST, 22 September 2015 | Updated: 18:50 EST, 23 September 2015



Volkswagen Shares Plunge On Emissions Scandal

VW CEO Issues Statement on EPA Emissions Violations, Apologizes for Wrongdoing



Japan Broadcasting Corporation



THOMSON REUTERS



GESTIONARADIO

Los Angeles Times



ARD
GERMAN TV

Media Coverage of CAFEE Research/ VW Diesel Emissions (Jan. 2016)

Global locations of note:

- / Dohar, Qatar
- / Brisbane, Australia
- / Jakarta, Indonesia
- / London, England
- / Alberta & Toronto, Canada
- / Mumbai, India
- / Norway
- / Germany
- / France
- / Portugal
- / Japan
- / Italy

Television interviews:

- / I-View
- / NPR-DC
- / MSNBC
- / All In With Chris Hayes/ MSNBC
- / Bloomberg TV
- / German TV ARD
- / The State Journal's Decision Makers with Bray Cary
- / Danish Broadcast Corporation
- / TF-1 French Television
- / La Repubblica
- / NHK Japan Broadcasting Corporation
- / RTS Swiss Public Broadcasting

National publications of note:

- / The New York Times
- / The Washington Post
- / CBS News
- / ABC News
- / NBC & MSNBC
- / CNN & CNN International
- / The Discovery Channel
- / NPR (Los Angeles and Washington, D.C.)
- / Associated Press
- / Reuters
- / Al Jazeera (America and UK)
- / USA Today
- / Huffington Post
- / AOL
- / Bloomberg
- / TIME

State/local publications of note:

- / The Dominion Post
- / WV MetroNews
- / Charleston Gazette-Mail
- / WV Public Broadcasting
- / WBOY-TV
- / The State Journal
- / Pittsburgh-Tribune Review

150+ DIRECT MEDIA INQUIRIES

since the story broke from international, national, state and local media outlets.



100+ INTERVIEWS CONDUCTED (AND COUNTING)

in person, by phone, satellite uplink, radio and Skype, and continue with today's scheduled in-person live interview on NBC's Today Show.

Thousands of SOCIAL MEDIA IMPRESSIONS



WV Public News @wvpublicnews · Sep 21
WVU Researchers Help Bust Volkswagen for Pollution Violations
wvpublic.org/post/wvu-resea...

55 46 ... View summary

TribLIVE.com @TribLIVE · Sep 21
West Virginia University uncovers VW's emission-rigging plot. bit.ly/1tSCub
#TribFrontPage

1 2 ... View photo



Over
3,500 STORIES
appeared in news outlets from as far away as Qatar, Australia, Indonesia, England, Canada, India, South Korea, Norway, Germany, France and Japan.

TIME



The New York Times

Ap Associated Press

THE HUFFINGTON POST



60
MINUTES

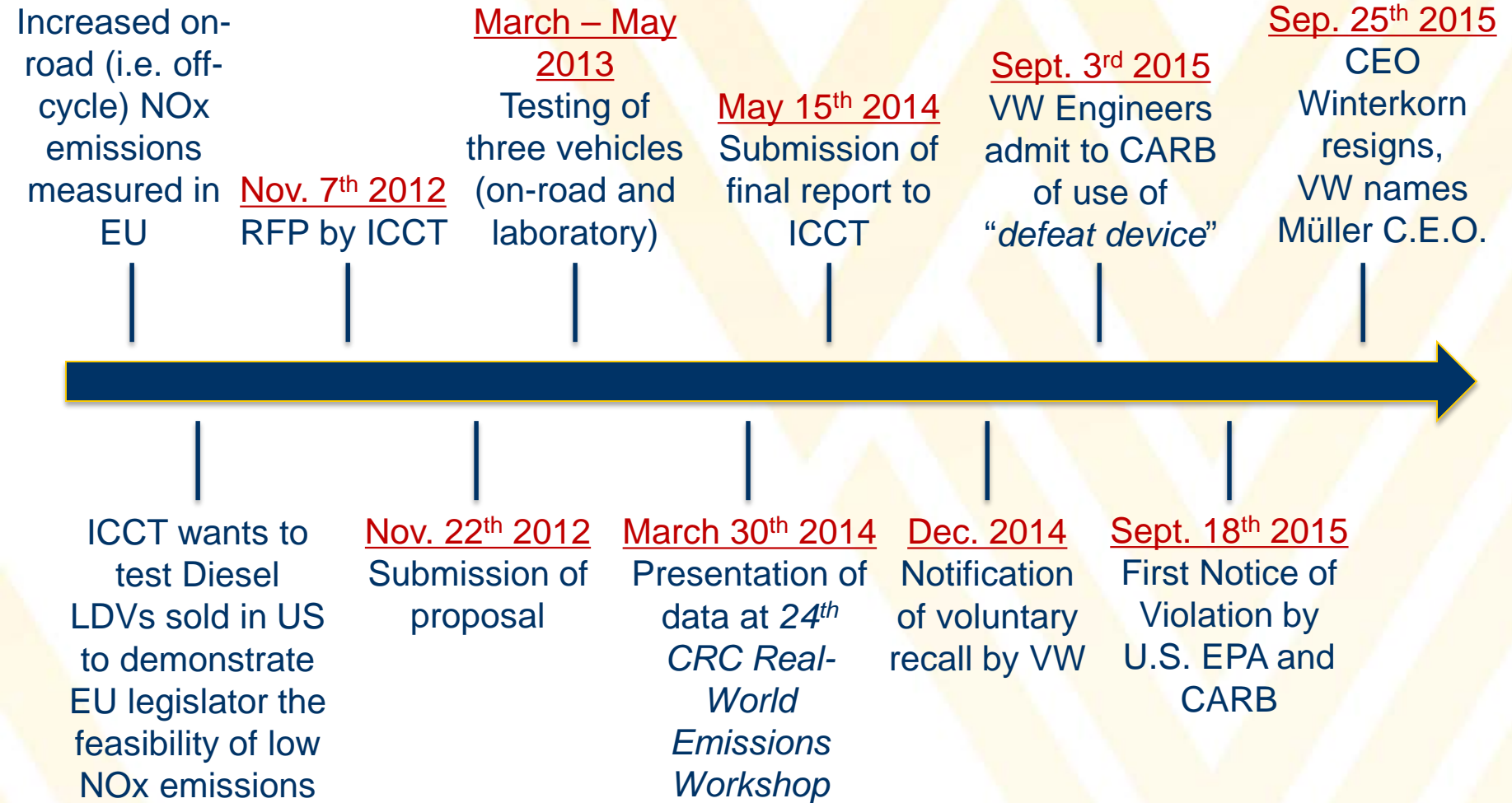
nature



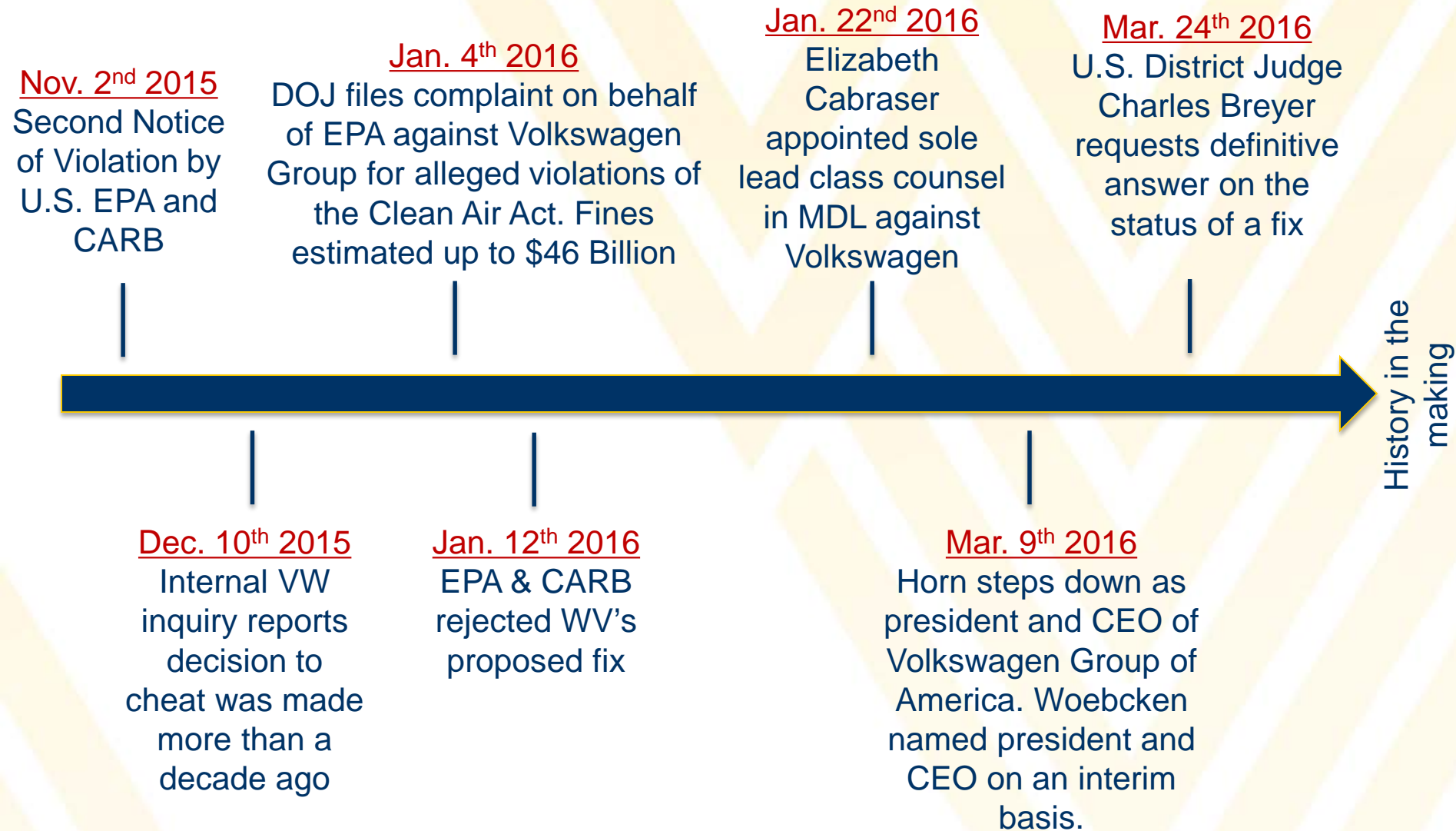
Bloomberg
Businessweek

PITTSBURGH TRIBUNE-REVIEW

Timeline



Timeline....cont'd



Can Diesels be “Clean”?

- “Clean-diesel” Technology is REAL and AVAILABLE
- Volkswagen is the problem, NOT the diesel engine
- WVU has a long history – We are “diesel guys”
- Some history...
 - 1974: Volkswagen was sued by US EPA for emissions defeat devices on four MY1973 vehicles. Settled for \$120,000. Ref: <http://brandilawblog.com/2015/10/01/history-repeats-itself-volkswagen-was-sued-by-the-epa-for-cheating-on-emissions-in-1974>
 - 2005: Failure to promptly notify EPA and to correct a defective oxygen sensor At least 329,000 of 1999, 2000, 2001 Golfs, Jettas, and New Beetles. \$1.1 Million fine.

Ref: <http://www.cnn.com/2015/09/23/vw-had-previous-run-in-over-defeat-devices.html>



<http://auto.howstuffworks.com/fuel-efficiency/alternative-fuels/how-clean-diesel-fuel-works2.htm>

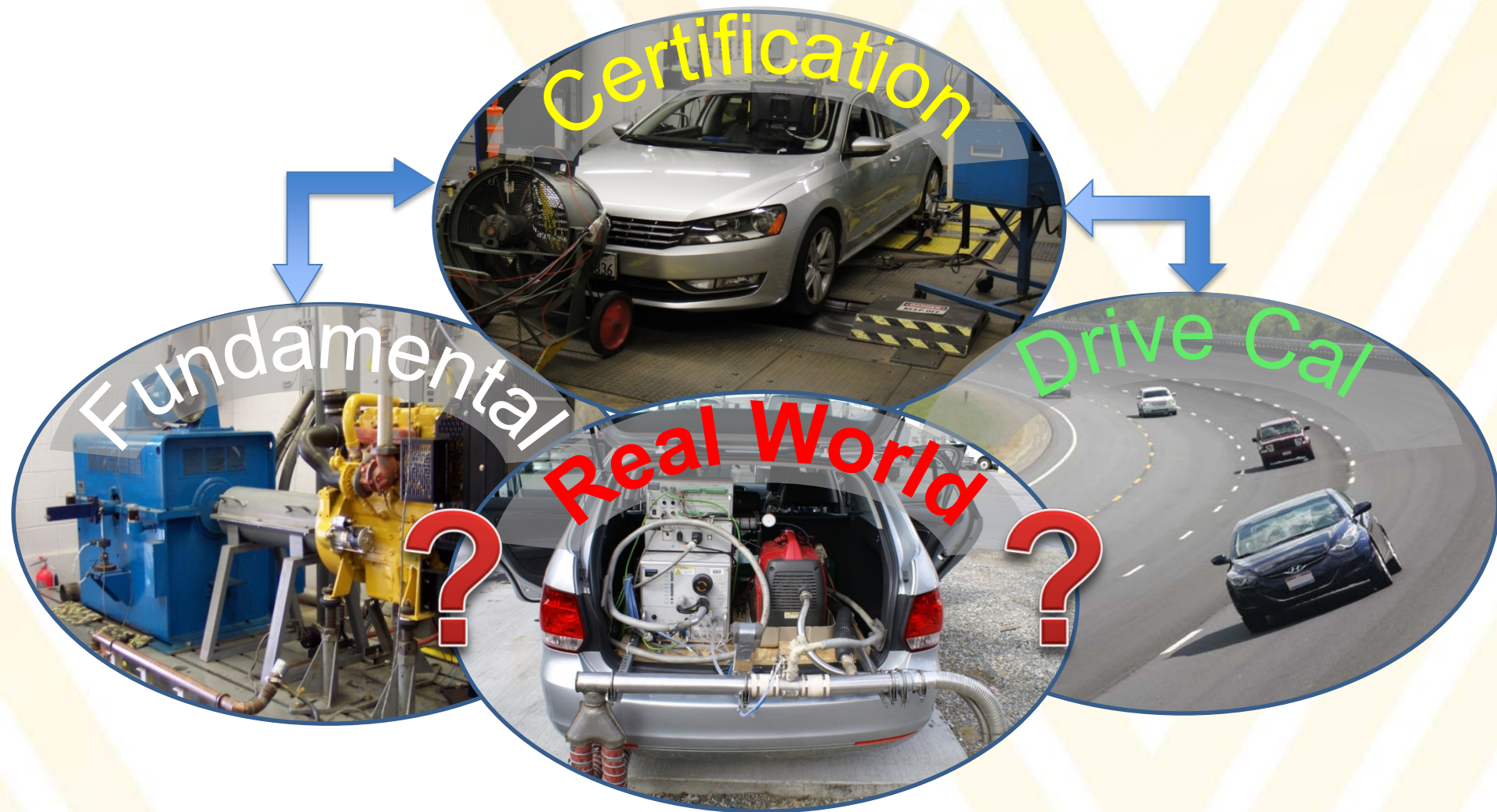


<http://www.roadandtravel.com/roadtests/buyersguides/2012-buyers-guide/green-suv-buyers-guide/bmw-x5--xdrive-35d-clean-diesel.html>



http://clean-green-cars.blogspot.com/2010_01_01_archive.html

Development and Compliance



<http://www.trcpg.com/facility-tour/75-mile-test-track.aspx>

Regulatory Action?

- Increased Certification Procedures to Identify Off-Cycle Emissions
- On-Road Emissions Measurements
 - Similar to HDD Requirements
- Expand Certification Test Ambient Conditions
 - Low/High Temperature, Humidity, Elevation
- Real-world Certification/Compliance
 - Geofencing
 - Incentivize Future Reductions
- Drive Cycles
 - More Representative of “Real-World” Driving
 - “Surprise” Cycles or “Periodically Refreshed”
- NTE and ?-Based Windows
- OBD....I/M....??



Technology Acceleration?

- Aftertreatment Development
- Sensor Development
- Advanced Combustion Techniques
- Advanced Driveline Strategies
- Fuel Alternatives
- Connected Vehicle
- Enhanced Integration



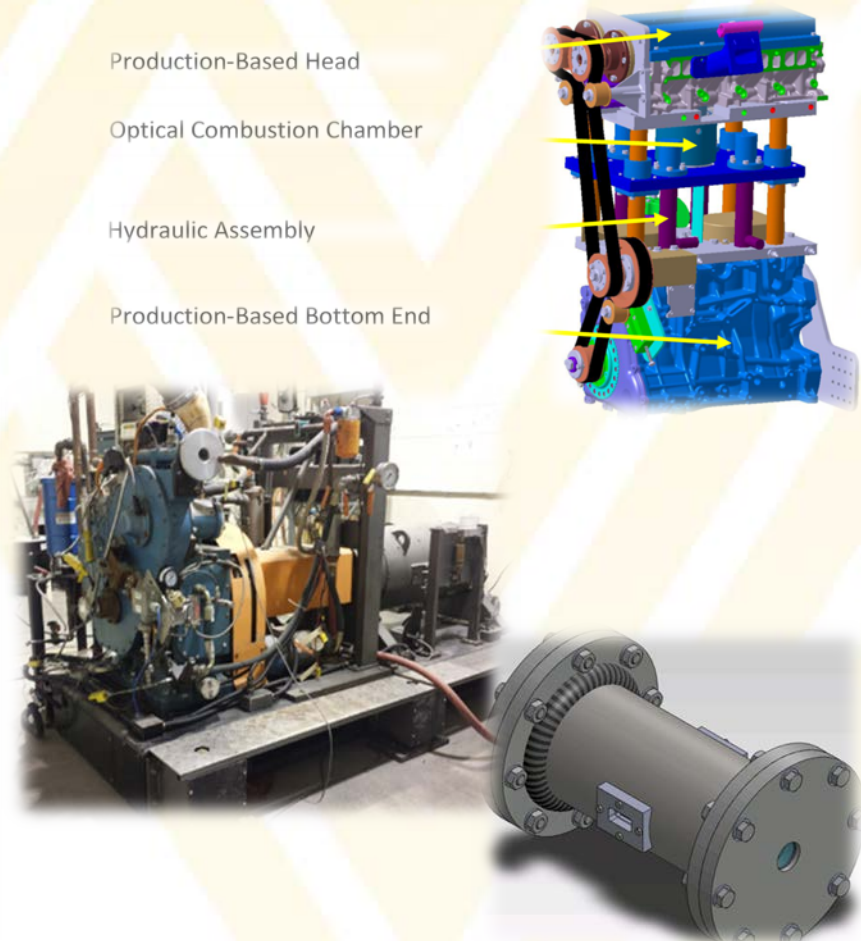
Ref: www.dieselnet.com





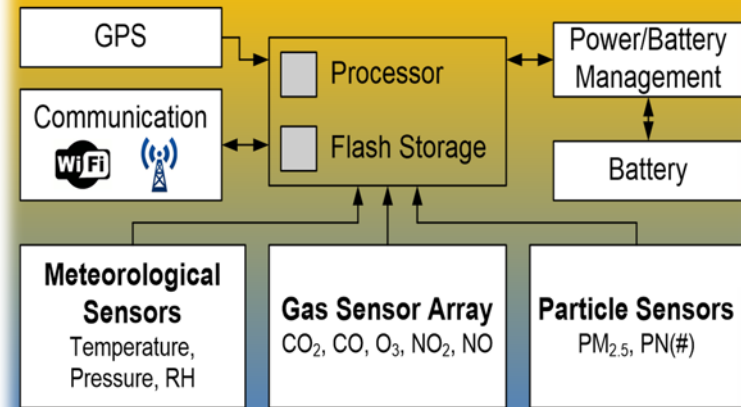
You Like Us...You Really Like Us

- Advanced Combustion Laboratory
- Engine and Emissions Research Laboratory
- Vehicle and Engine Testing Laboratory



AirCom - Prototype

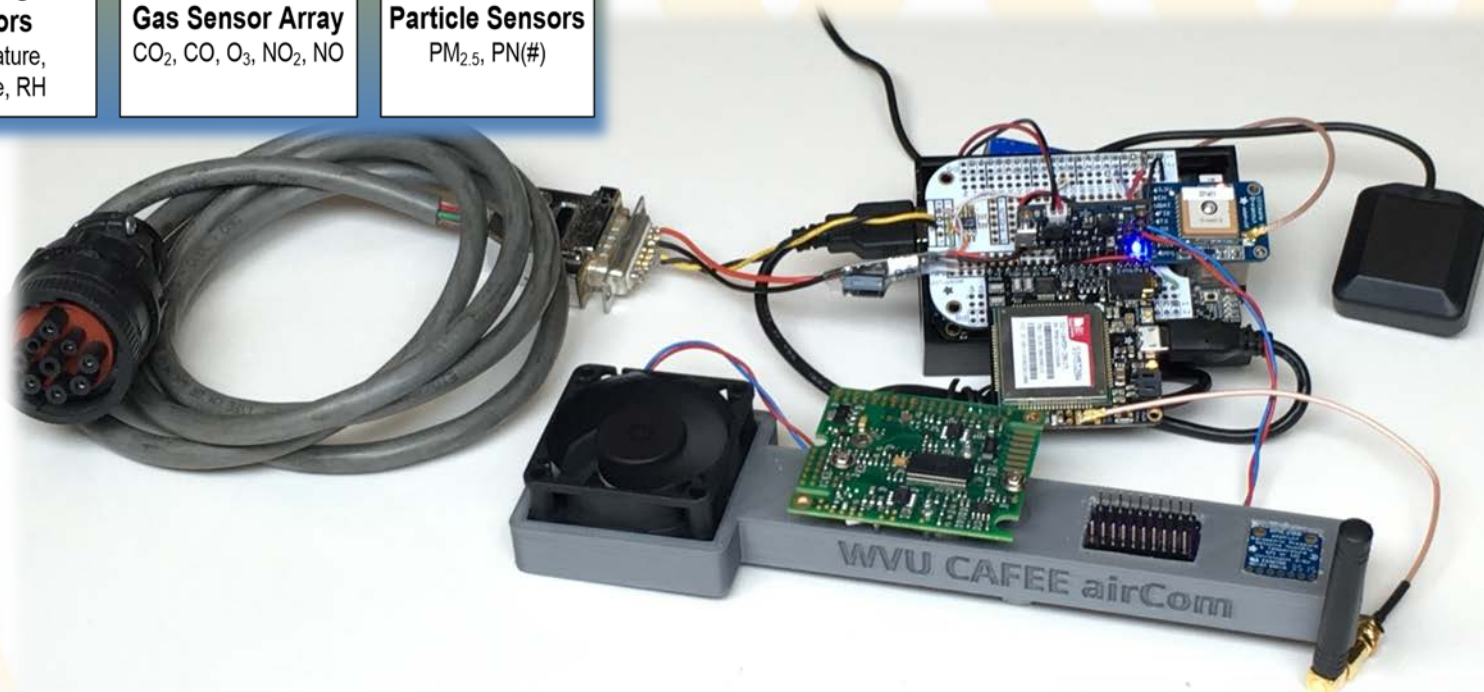
AirCom Sensor and Data Acquisition/Transmission Unit



- Barometric Pressure/Temperature Sensor
 - Bosch BMP180
 - Resolution: up to 0.03hPa / 0.25m (300-1100hPa)
 - T accuracy: $\pm 2^{\circ}\text{C}$ (Range: -40 to $+85^{\circ}\text{C}$)

- CO₂ Sensor
 - NDIR K-30, 1% CO₂ range
 - Accuracy: $\pm 30\text{ppm}$, $\pm 3\%$ of measured value

- Humidity Sensor
 - Sensirion SHT21
 - Resolution: 0.04 %RH, Accuracy: ± 2 %RH



WVU Markov Drive Cycle



Thank You!

www.cafee.wvu.edu

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304-293-0650/304-288-7917

Acknowledgement

