The Future of Transportation

Significant Progress

...And the challenges Looking Ahead

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The Future of Transportation

• We’ve come a long way...
  • With significant improvement in air quality and health

• The Challenges ahead:
  • Fine-tuning the newest internal combustion technologies and accelerating replacement
  • Making way for the newest technologies, especially electric drive
  • Taking a broader look at mobility solutions

• Looking Ahead... and our Session Today
We’ve Come a Long Way...
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We’ve Come A Long Way:
Carbon Monoxide Levels in Los Angeles
1960s – 2000
Vehicles Doubled, and Miles Driven Tripled
CO fell by > 75%
Source: National Research Council 2003

1956 – 1967
CO > 40 ppm

2000
CO < 10ppm

CO NAAQS = 9 ppm
We’ve Come a Long Way: Improvements in PM and NO\textsubscript{x} Diesel Emission Standards
We’ve Come a Long Way:

ACES: Dramatic Progress on Mass and Particle Number

(A) Mass Emissions

(B) Particle Number Emissions

ACES = Advanced Collaborative Emissions Study
We’ve Come a Long Way
More new technology clean diesel trucks and buses on the road
Over 40% now meet at least 2007 Standards

Percent Fleet Penetration

---2007 and Later Engines------ 2010+ Engines

National 40% 41% 37% 41% 53% 24%
New York 41% 41%
California 37%
Colorado 41%
Utah 53%
National 24%

Source: Diesel Technology Forum and IHS/Polk
http://dieselforum.org/in-your-state
We’ve Come a Long Way: Effect of Diesel Rules in Southern California

• On-road measurements show diesel rules reducing PM and NO\textsubscript{X} on a truck-dominated freeway near the Ports of Los Angeles and Long Beach
• Continued reductions expected as the Truck and Bus Rule is implemented

Kozawa et al. (2014) Environmental Science & Technology, 48, 1475-1483
And even recent VW on-road tests demonstrate progress…

PM emissions were dramatically below US EPA Tier 2 – Bin 5 emissions standard (ICCT/WVU tests)

(there were, of course, NOx emission in-use issues…) 

Figure 4.11: Average PM emissions of test vehicles over the five test routes compared to US-EPA Tier2-Bin5 emissions standard; repeat test variation intervals are presented as ±1σ; Route 1 for Vehicle A includes rush-hour/non rush-hour driving, no PM data collected for Vehicle C, ‘R’ designates routes including a test with DPF regeneration event, ‘nd’ - no data available
We’ve Come a Long Way: Greenhouse gas (GHG) and Fuel Economy Standards

Passenger car CO₂ emissions and fuel consumption, normalized to NEDC

* Note that Japan has already exceeded its 2020 statutory target, as of 2013.
With Progress in Nearly Every Country
Largely Enhanced Technology Internal Combustion (IC) Engines: Gasoline Direct Injection, Diesel, Hybrids

Figure 1: Average new LDV fuel economy by country, normalised to the WLTC, 2005-15

Improved Fuel Economy 2005 – 2015 (Source: GFEI)
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Continued Challenges with Ozone

Figure 1. Levels of Four Air Pollutants from 1994 to 2011 in Five Southern California Communities.

Colored bands represent the relevant 4-year averaging period for the analysis of lung-function growth in each of the three cohorts, C, D, and E. PM$_{2.5}$ denotes particulate matter with an aerodynamic diameter of less than 2.5 μm, and PM$_{10}$ particulate matter with an aerodynamic diameter of less than 10 μm.

Source: Gauderman, et al NEJM 2015
Challenge: Real World Emissions Compliance

High Europe Light Duty Diesel NO\textsubscript{x} In Use Emissions (Beyond VW)

\( \text{NO}_x \) emissions of selected diesel vehicles sold in Europe, average ratio of actual emissions to EU regulatory limit 180 mg/km, for cars sold 2009-14 (Euro 5) 80 mg/km, for cars sold 2014-current (Euro 6)

Renault-Nissan
Fiat Chrysler (incl. Alfa Romeo & Jeep)
General Motors (Opel-Vauxhall)
Hyundai
Suzuki
Ford
Kia
Volvo
Daimler (Mercedes-Benz, Smart)
PSA (Peugeot-Citroën)
Honda
Mazda
Tata (Land Rover)
Toyota
Volkswagen
BMW

Source: International Council on Clean Transportation

European Cities, EU respond

Mayors of Paris, London, Seoul Call for action, new consumer Websites

Tougher EU Real Driving Emissions (RDE)
Next Steps: Fine-Tuning, Enhancing Internal Combustion (IC) Technology

- **NO\textsubscript{x} Controls:**
  - Under certain conditions, selective catalytic reduction (SCR) may be too cool to work efficiently
    - Manufacturers and others are developing new technologies
  - Strong push in California (and Northeast) to lower the current heavy duty 2010 NO\textsubscript{x} standard
    - Session at this conference on the science of NO\textsubscript{x} contributions to Ozone – Tuesday Morning

- **Diesel Particulate Matter (PM) Filters:**
  - Seem to work well under a variety of conditions
  - Robust technology, but some early evidence of failure in a relatively small number

- **Gasoline Direct Injection (GDI)**
  - Do particle numbers raise possibility of filters?

- **Fuels...**
  - What are the best fuels to support enhanced IC technology?

- **Need to find ways to accelerate replacement**
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The Challenge: Thinking beyond 2025
GHG and Fuel Economy Standards

Passenger car CO₂ emissions and fuel consumption, normalized to NEDC

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Challenge: Making Progress on Electric Drive
Battery Electric, Fuel Cells

Source: International Energy Agency (IEA) 2016
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Challenge: How Do We Travel in 2050?

The Third Ring Road in Beijing... Today
The Third Ring Road – of many!
The Challenge (and Opportunity): New Ways of Travel
The Challenge (and Opportunity):
Driverless Cars
A world of driverless cars

Fully autonomous vehicles are developing faster than anyone would have thought a few years ago, with many experts predicting that they will be widely available in the next 5-10 years. Many questions remain, but it is already possible to imagine how this new world of driverless cars will work.

PERCEPTION

Vehicles use radar to detect obstacles, a lidar ranging system to map out their environment in three dimensions, and video cameras to identify objects such as traffic lights, construction signs, pedestrians and other vehicles.

COMMUNICATION

Vehicle-to-vehicle (V2V) radios send and receive data between cars, trucks and infrastructure items such as traffic lights.

ROUTE PLANNING

An on-board computer uses sensor data to plot a route that suits the car where it needs to go, while avoiding people, pedestrians and other vehicles.

LOCATION

Mapping software uses Global Positioning System data to tell the car where it is in relation to roads, traffic signals, and other vehicles.

DETECTION AND ACTION

To make the appropriate responses to other cars — such as a tailgating car on a highway or a plastic bag bouncing down the roadway — computer systems refine through millions of kilometers of test drives.

ADAPTIVE TRAFFIC FLOW

Smart infrastructure integrates V2V signals from the various sensors, sensors coupled with traffic management systems, and the number of cars in each direction on the basis of the actual traffic load. The result is a smoother flow, shorter travel times and more energy saved at traffic lights or in traffic jams.

2020s

The decade when driverless cars are predicted to become widespread.

10% Fuel savings for cars that travel in formation.

ROAD TRAINS

Vehicles can take advantage of aerodynamics and save fuel by following one another, allowing a larger gap between them. They are protected from changing weather changes by their virtual coach, which shows all the cars exactly the same place at the same time.

CITIES TRANSFORMED

MASS TRANSIT

People increasingly give up owning cars in favor of sharing companies to pick them up wherever they are and drop them off wherever they need to go — a driverless version of a ride-sharing service.

LAND USE

Urban centers begin to lose the many accommodations they have made for personal vehicles — starting with the vast quantities of real estate devoted to parking, which could be adapted to more productive uses.

800 million

One estimate of the number of US parking spaces. Many could be used for other purposes if people ride-share more.

Source: Nature
The Challenge (and Opportunity): Putting it All Together (NYC DOT 2013)

How do we consider the many different choices for transportation to ensure sustainable mobility and access well into the future?
Putting it All Together
And maybe there is an even better solution???
Looking Ahead…

• We HAVE come a long way!
  • Vehicle air pollution is down substantially even with increased vehicles, travel
  • Enhanced internal combustion (IC) is improving fuel economy, GHG emissions

• There IS still work to do:
  • To fine-tune and enhance the IC technologies
    • And accelerate replacement of the older technologies
  • To build the technology and market for Electric Drive
  • And to put it “all together” for enhanced mobility
Our Session Today

• The GDI Engine: Features, Emissions, and Effect of Fuel Composition
  • Allen Robinson, Carnegie Mellon University

• Looking Ahead: Electric Drive
  • Nic Lutsey, International Council on Clean Transportation

• The Future of Mobility in the Urban Context
  • Susan Zielinski, Former head of the Sustainable Mobility and Accessibility Research and Transformation initiative, University of Michigan

• Wrap-Up: The Way Forward
Thank You

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