Estimation of Mobile Source Air Toxic Emissions and Application in Planning and Policy

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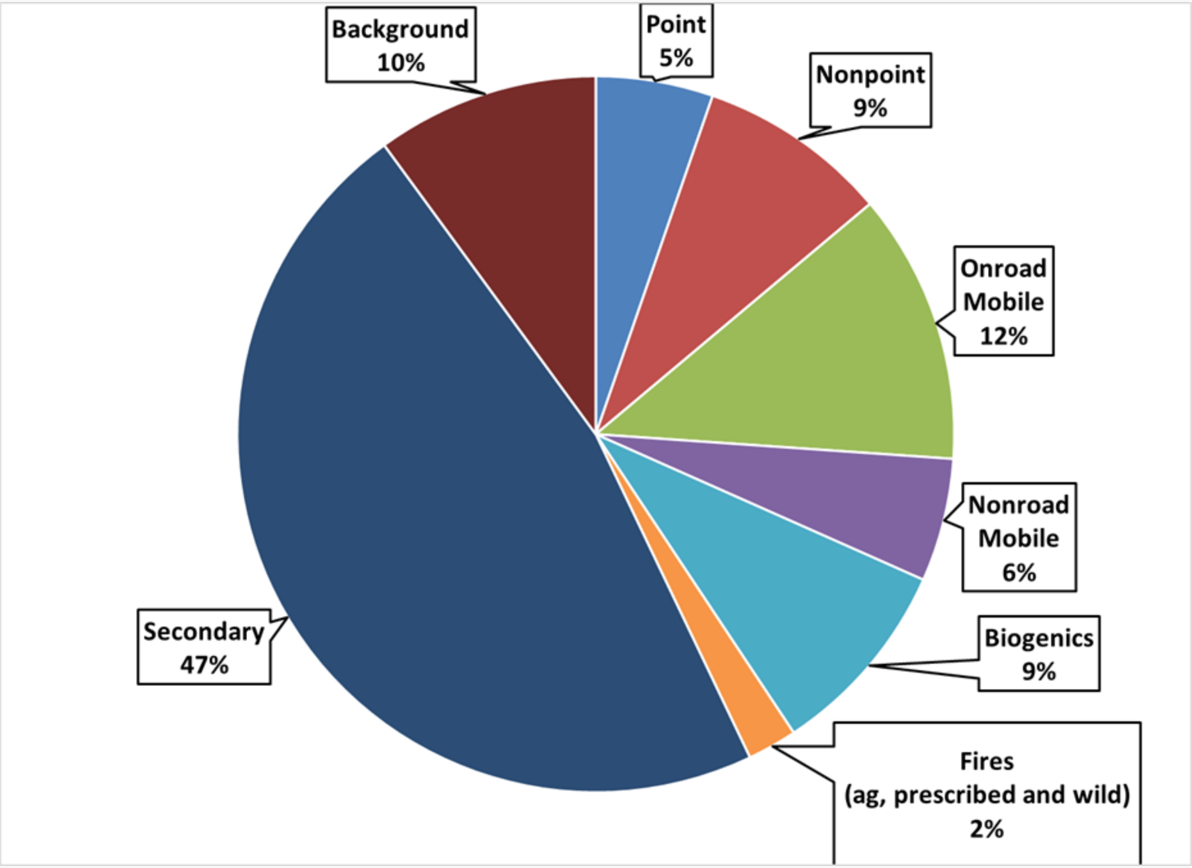
Mobile Source Contribution to Ambient Air Toxics

- More than 1000 compounds have been identified in exhaust and evaporative emissions from onroad and nonroad mobile sources
- A number of these compounds have cancer and non-cancer health effects in animals and humans.

Why Are We Concerned About MSATs?

- Large contributors to overall cancer risks from air toxics.
- In addition, acrolein and diesel PM from mobile sources are large contributors to noncancer risk.



Source: 2014 National Air Toxics Assessment

Key Mobile Source Air Toxics (MSATs)

Based on potential for serious adverse health effects

- Acetaldehyde
- Acrolein
- Arsenic Compounds
- Benzene*
- 1,3-Butadiene
- Hexavalent Chromium
- Dioxins/Furans
- Diesel Exhaust
- Ethylbenzene*
- Formaldehyde
- n-Hexane*
- Lead Compounds
- Manganese Compounds
- Mercury Compounds

Naphthalene*

Nickel Compounds

Polycyclic Aromatic Hydrocarbons (PAHs)

Styrene

Toluene*

Xylene*

*Found in evaporative as well as exhaust emissions.

Control of Air Toxics

- EPA's Statutory Authority to Address Mobile Source Air Toxics – primarily under 202(l)(2):
  - Requires EPA to set "air toxics" standards
  - Must reflect the greatest degree of emission reduction achievable, considering cost and other factors
  - Standards must be revised from time to time
- Also, control of criteria pollutants under other CAA authorities have also achieved significant toxics reductions

Estimation of Emissions from MSATs in MOVES

- For all mobile sources except rail, marine and aircraft, MSATs currently estimated using MOVES2014b
- Toxic emissions estimated using:
  - Gaseous HAPs
    - Toxic to VOC ratios
  - PAHs
    - PAH/VOC ratios for gas-phase PAHs
    - PAH/PM ratios for particle-phase PAHs
  - Dioxins, furans, metals
    - Specific emission rates

Estimation of Emissions from MSATs in MOVES

- Toxic ratios vary by:
  - Fuel type (gasoline: E0 and E10, diesel, CNG and LPG)
  - Engine technology (2-stroke/4-stroke design, catalyst or other aftertreatment, engine size)
  - Emission process (exhaust, refueling, evaporative)
- Methods detailed in technical reports
  - "Air Toxic Emissions from On-road Vehicles in MOVES2014," EPA-420-R-16-016, November 2016.
  - "Speciation Profiles and Toxic Emission Factors for Nonroad Engines in MOVES2014b," EPA-420-R-18-011, July 2018

Gasoline Onroad Vehicle Toxics in MOVES

- Exhaust gaseous HAPs
  - Benzene, 1,3-butadiene, formaldehyde, acetaldehyde, acrolein, ethanol
    - Equations that calculate toxic to VOC ratios based on various fuel parameters and vehicle technology
    - Equations mostly from Complex Model for Reformulated Gasoline (2000 and earlier vehicles) and EPAct test program (2001 and later vehicles)
  - Other exhaust gaseous HAPs, evaporative and permeation emissions
    - Simple ratios that vary by fuel type (E0, E10, etc.) from SPECIATE

Gasoline Onroad Vehicle Toxics in MOVES (Cont'd)

- PAHs
  - Gas phase PAHs estimated as fractions of VOC, particle phase PAHs as fractions of organic carbon ($OC_{2.5}$)
    - Data from Kansas City Light-duty Vehicle Emissions Study (KCVES)
- Metals
  - Also based on data from KCVES
- Dioxins/furans
  - Data from 1998 API tunnel study

Diesel and CNG Onroad Vehicle Toxics in MOVES

- Gaseous HAPs, PAHs, and metals
  - For pre-2007 engines relied on a Coordinating Research Council (CRC) database (CRC E-75) of 13 different studies
  - For 2007 and later, used data from Health Effects Institute (HEI) and CRC Advanced Collaborative Emissions Study (ACES)
  - Dioxins/furans, Hg, Cr6+
    - Relied on data from EPA-OTAQ test program
- CNG vehicles
  - Relied primarily on ARB data

Nonroad Spark Ignition (SI) Sources in MOVES

- Exhaust gaseous HAPs
  - Toxic ratios vary by engine type (2-stroke vs. 4-stroke) and fuel type (E0 or E10)
  - Data from 2016 test program at Southwest Research Institute (SwRI)
  - PAHs, metals, dioxins – adapted from onroad data
- SI evaporative adapted from onroad data

Nonroad Compression Ignition (CI) Sources in MOVES

- Exhaust gaseous HAPs and PAHs
  - Ratios vary by level of control (Tier 1 through 4) and aftertreatment (DPF, SCR)
  - From 2004 SwRI test program
  - Metals and dioxins adapted from onroad data

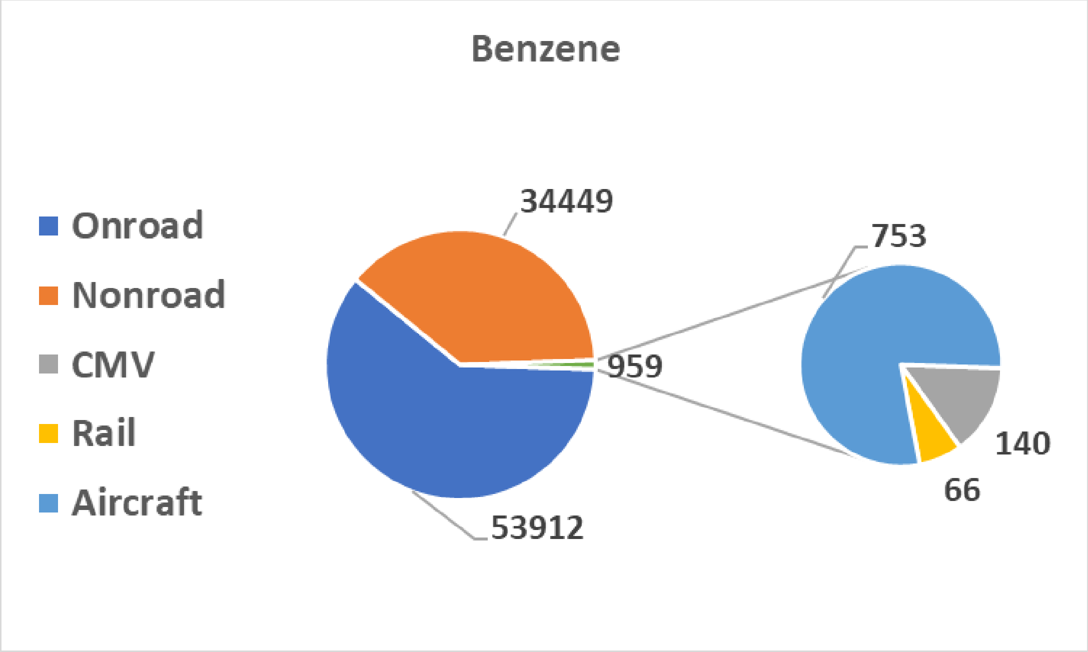
Nonroad Sources not in MOVES

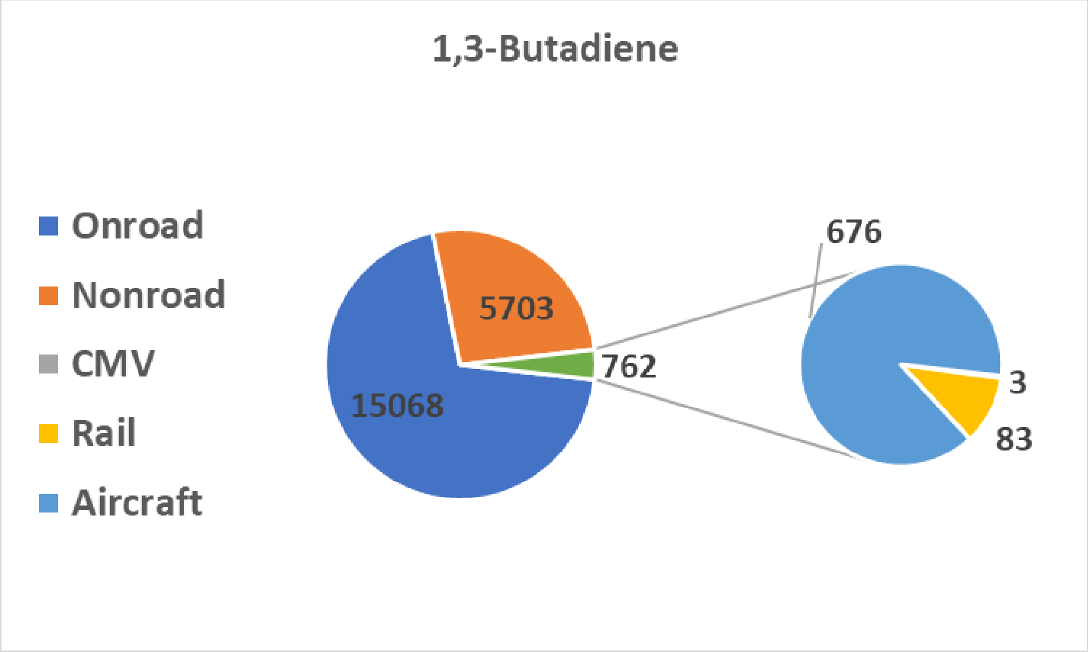
- Commercial Marine Vessels (CMV)
  - Speciation data for estimation of toxics is very limited.
    - Have relied on limited data for a few HAPs from CMV and use of surrogate data from non-marine mobile sources.
    - Currently updating with some newer data
- Rail
  - Limited HAP data from one study by Southwest Research, supplemented by highway diesel data

Nonroad Sources not in MOVES (Cont'd)

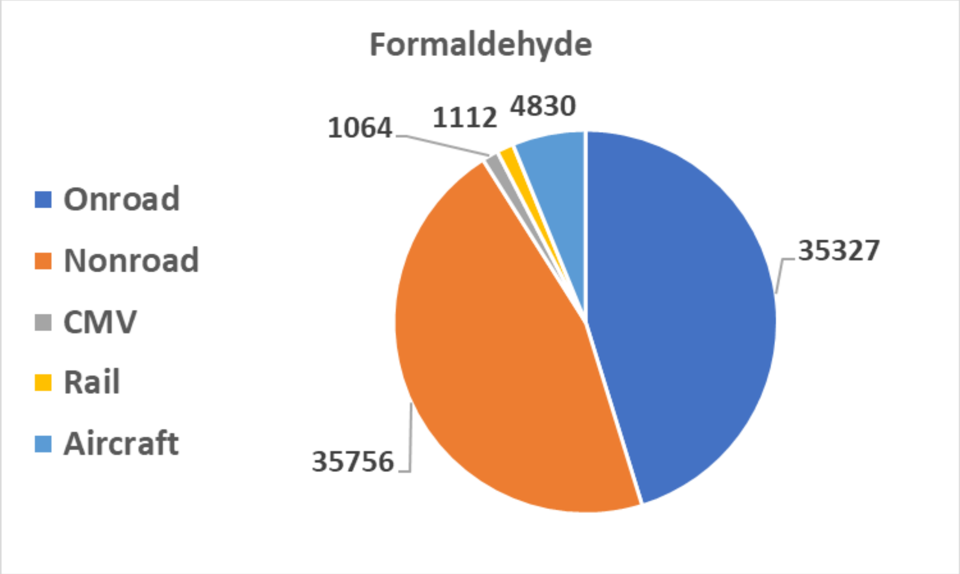
- Aircraft
  - Inventory estimates for Gaseous VOCs, PAHs, lead (from piston aircraft)
  - Gaseous HAP estimates rely on speciation data from SPECIATE profile 5565 for turbine engines and 1313 for piston engines (highway vehicle surrogate).
  - PAH inventory based on limited test data from one turbine engine and a highway vehicle surrogate for piston engine aircraft
  - Piston engine lead emissions rely on complex methodology based on the amount of lead in avgas.

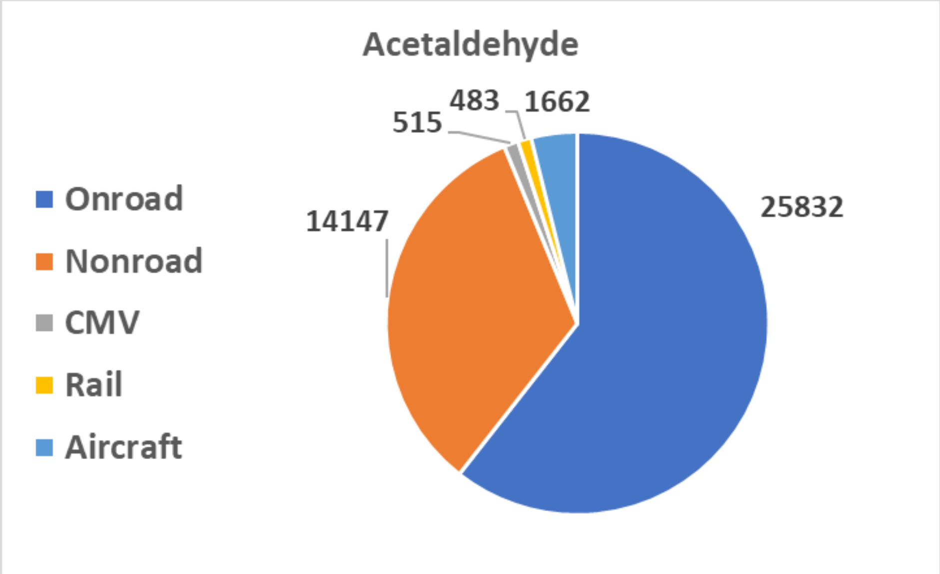
2014 Inventory Contributions from Mobile Source Sectors (tons)

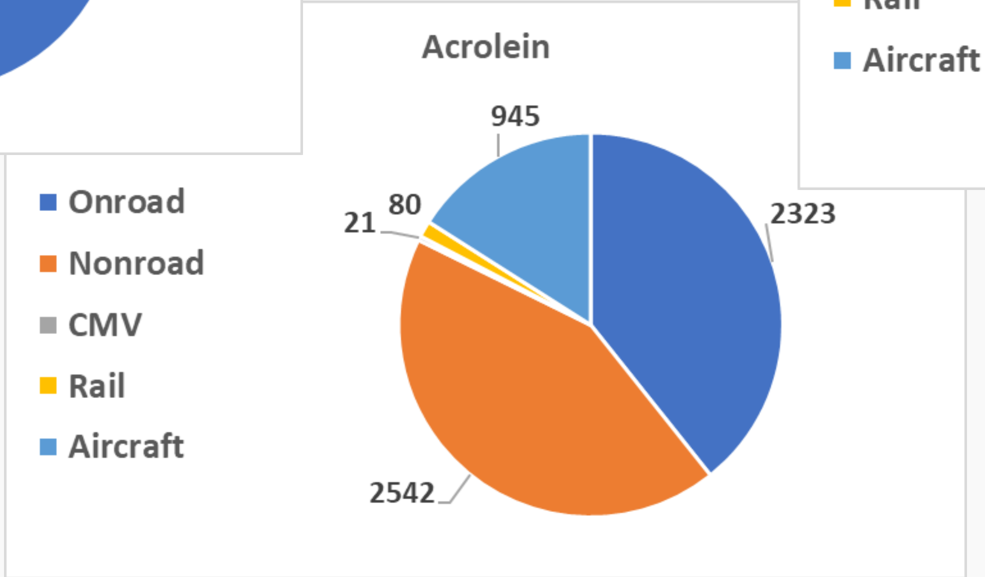




2014 Inventory Contributions from Mobile Source Sectors





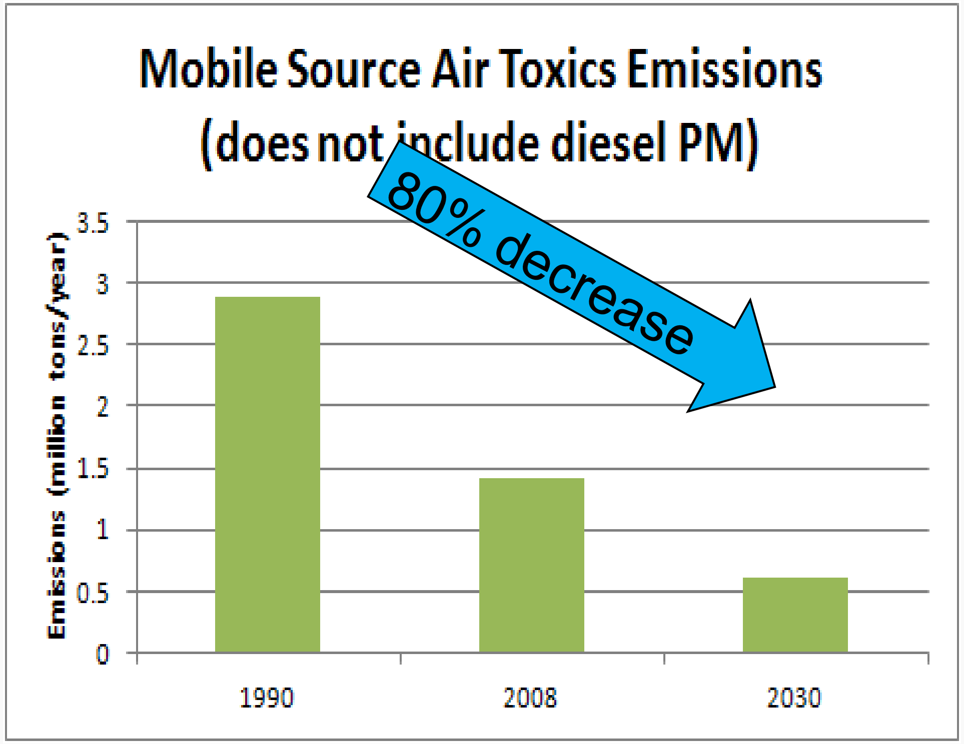


Applications of Mobile Source Air Toxic Emissions Modeling Tools

- Used by EPA, States, local governments, tribes, industry, NGOs, and adapted by foreign governments
- Can be used to:
  - Assess impacts of Transportation Projects
  - Identify potential hotspots
  - Characterize potential population risks
    - E.g., National Air Toxics Assessment
  - Reductions from potential control strategies
    - Inventory and air quality impacts in regulatory impact assessments

MSAT Reductions Achieved & Ahead

- Our most recent programs
  - Tier 3 vehicle and fuel standards
  - MSAT2
  - Diesel engine and vehicle standards:
    - Onroad
    - Nonroad
    - Locomotive
    - Marine



Source: Second Integrated Urban Air Toxics Report to Congress, EPA-456/R-14-001 , 2014

Diesel Exhaust – High Priority MSAT

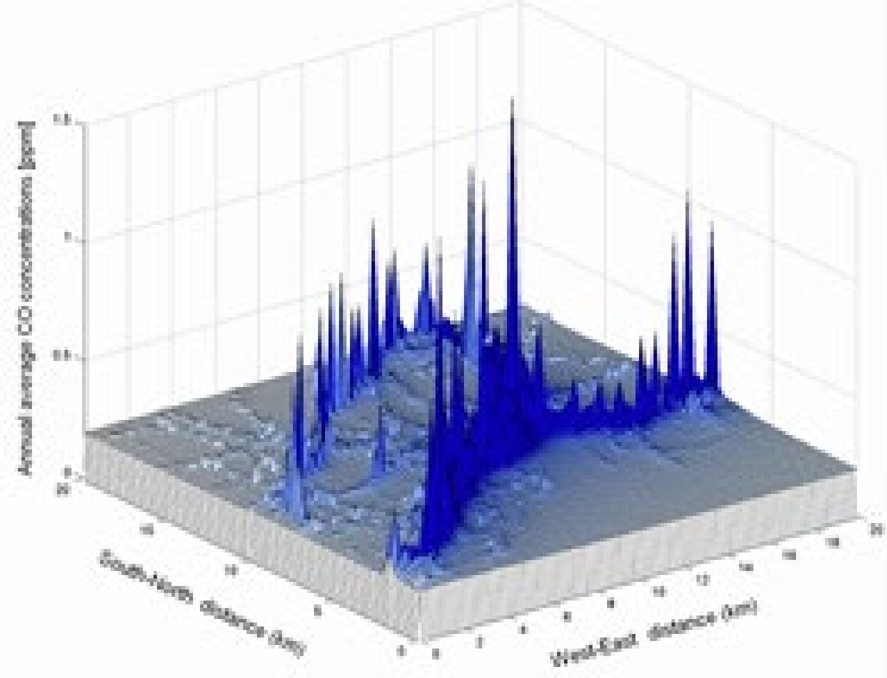
- In 2002, EPA issued the Health Assessment Document for Diesel Engine Emissions
  - Likely human carcinogen at environmental levels of exposure
- Standards for heavy-duty highway engines started taking effect in 2007
- Standards for nonroad diesels (construction, agriculture equipment), locomotives, and ships began applying in 2012

EPA Diesel Programs

- Standards address all types of diesel engines
  - Collectively reduce diesel PM by 90% from 1990-2030
- EPA's National Clean Diesel Campaign voluntary initiatives achieve significant reductions in emissions from older, pre-2007 model year diesel engines
  - EPA's Legacy Fleet Programs target priority areas including ports

Near Source Impacts

- A large body of research shows exposures to air toxics are elevated near roads and other transportation facilities such as ports.



Modeled benzene gradient along roads in New Haven, CT (Source: Cook et al., 2008, JAWMA, 58: 451-461)

Near Source Impacts

- In addition to vehicle standards, OTAQ is addressing these risks through:
  - Supporting and advising research projects
    - e.g., ORD research on vegetation barriers
      - (https://www.epa.gov/air-research/recommendations-constructing-roadside-vegetation-barriers-improve-near-road-air-quality)
  - NEPA reviews (technical assistance to Regions)
  - Ports Initiative
  - National Clean Diesel Campaign
  - Smartway
  - Near Road Q and A
    - https://www.epa.gov/mobile-source-pollution/how-mobile-source-pollution-affects-your-health#near%20roadway
  - Best practices for reducing near road pollution exposure at schools
    - (https://www.epa.gov/schools/basic-information-about-best-practices-reducing-near-road-pollution-exposure-schools)

Looking to the Future

- Our inventories show we have accomplished significant, measurable reductions
- They also show more work to be done to decrease cancer and noncancer risks from MSATs
- Evaluation of fuel and emerging technology effects on air toxics an important area of focus