Module 9:
Nonroad Mobile Source Emission Inventory Development

Nonroad Mobile Source Categories

- Aircraft
- Locomotives
- Commercial marine vessels
- Other major nonroad categories:
  > Agricultural equipment
  > Construction equipment
  > Industrial equipment
  > Recreational boats
  > Light commercial equipment
Aircraft

Aircraft Types

- Commercial Air Carriers
- Air Taxis
- General Aviation
- Military Aircraft
Estimating Aircraft Emissions

- Identify all airports to be included in the inventory
- Determine airport activity as the number of landing and take off (LTO) cycles for each aircraft. Obtain data from:
  - Air Traffic and Navigation Services
  - South African Civil Aviation Authority
  - South African Department of Transportation
  - Local airport authority
  - Surveys

LTO cycle

- LTO modes:
  - Takeoff/landing
  - Taxi/idle
  - Climb-out
  - Approach
General Approaches

- In general there are two approaches that can be taken to estimate emissions
  
  > Detailed approach: requires aircraft specific data, typically available for large commercial airlines
  
  > General aircraft type approach: typically used to estimate emissions from smaller air taxis, general aviation, and military aircraft

Aircraft Specific Approach

\[ E = \sum TM \times FU \times EF \times NE \times LTO \]

Where:
- \( E \) = Aircraft make/model emissions (kg per year)
- \( TM \) = Time in mode (min)
- \( FU \) = Fuel usage rate (kg of fuel /min)
- \( EF \) = Emission factor (kg of pollutant / kg of fuel)
- \( NE \) = Number of engines
- \( LTO \) = Landing and take off cycles per year
Aircraft Make/Model Specific Approach

- Emission Dispersion and Modeling System (EDMS)
  - Matches aircraft make and model to engines and emission factors
  - Default time in mode values can be easily changed
  - Also calculates associated ground support equipment and airport parking
  - Inexpensive ($45) and easy to use

General Aircraft Type Approach

- Use representative aircraft emission factors in conjunction with annual LTO data:

\[ E = EF \times LTO \]

Where:
- \( E \) = Aircraft type emissions (kg per year)
- \( EF \) = Emission factor (kg of pollutant / LTO)
- \( LTO \) = Landing and take off cycles per year
General Aircraft Type Approach

- Representative aircraft emission factors can be obtained from:
  
  > U.S. EPA, Documentation for Aircraft, Commercial Marine Vessel, Locomotive and Other Nonroad Components of the National Emission Inventory (February 2005)
  
  > European Environmental Agency: Air Traffic Chapter of CORINAIR
    (http://reports.eea.eu.int/EMEPCORINAIR4/en/B851vs2.4.pdf)

Documenting Aircraft Emissions

- Identify all airports in the inventory

- Report aircraft LTO data, assumptions for TIM, and seasonal adjustment factors

- If EDMS is used, document options selected and provide electronic disc file of program. If generic approach is used show the emission factors used in calculations.

- Document correspondence with military airfields and civil airports
Two distinct locomotive types:

- Line haul
- Yard
Locomotives

- Emissions based on fuel use and emission factors

\[ E = EF \times AD \]

Where:
- \( E \) = Emission (kg/yr)
- \( EF \) = Emission Factor (kg/liter)
- \( AD \) = Activity Data = Fuel Use (liter/yr)

- Source of emissions factors

  > U.S. EPA, Documentation for Aircraft, Commercial Marine Vessel, Locomotive and Other Nonroad Components of the National Emission Inventory

  > European Environmental Agency, CORINAIR (http://reports.eea.eu.int/EMEPCORINAIR4/en/B810vs3.2.pdf)
Estimating Locomotive Emissions

• For line haul locomotives obtain fuel consumption data from:
  > South Africa Department of Transportation
  > Southern African Railways Association, and
  > Spoornet Railway System

• Track mileage can be used to apportion estimates that cover various geographical regions

Estimating Locomotive Emissions

• Yard locomotive fuel consumption can be estimated based on the number and hours yard locomotives operate at a specific railway yard. These data can be obtained by:
  > Contacting local railway yards
  > Survey/observe the number of locomotives in use
Documenting Locomotive Emissions

- Provide railway fuel data used, yard engine populations, and any assumptions or adjustments made to account for seasonal variations.
- Note emission factors used in the inventory.
- Document how emissions were spatially allocated.
- Document correspondence with Department of Transportation and Spoornet.
- If yard surveys are implemented, provide survey results.

COMMERCIAL MARINE VESSELS
Commercial Marine Vessels

- Auto Carriers
- Bulk Carriers
- Tugs
- Container Ships
- Cruise Vessels
- General Cargo Carriers
- Ferry
- Refrigerated ships
- Roll-on/ Roll-off Vessels
- Tankers
- Drilling rigs
- Military vessels
- Fishing boats

Vessel Modes of Operation

- Emissions vary based on the type of ship operation
  > Underway,
  > Maneuvering,
  > Hoteling
Estimating Vessel Emissions

Emissions can be developed based on either fuel usage or hours of operation:

\[ E = EF \times AD \]

Where:
- \( E \) = Emissions (kg/yr)
- \( EF \) = Emission factor (kg/liter)
- \( AD \) = Activity data = fuel use (liter/yr) or hours of operation

Commercial Marine Vessel Activity Data

- Hours of operation can be estimated at the port level by obtaining vessel population data from the harbor masters and customs data or by implementing a harbor survey.
- To estimate hours of operation for vessels that do not use South African Ports, there are several global studies available to help quantify the level of traffic around the Cape and typical vessel speeds.
Commercial Marine Vessel Activity Data

• Fuel data can be either approximated by reviewing bunkered vessel withdrawals, or
• Fuel consumption based on hours of operation.

Estimating Vessel Emissions

• Source of emissions factors:
  > U.S. EPA, AP-42
  > Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources Section 7
  > Swedish Methodology for Environmental Data – Calculating Emissions for Ships, 2004
Documenting Vessel Emissions

- Document data obtained from harbor masters, fuel use data and vessel activity data used to estimate emissions.
- Document data source for emission factors.
- Maintain records of communications with harbor masters.
- Describe any spatial allocation methods that were used.

Other Nonroad Equipment
Other Nonroad Sources

- Other nonroad categories:
  - Agricultural equipment
  - Forestry management
  - Construction equipment
  - Industrial equipment
  - Light commercial equipment
  - Lawn and garden equipment
  - Recreational boats

NONROAD Model

Basic NONROAD equation:

\[ E = P \times HR \times L \times HP \times EF \]

Where:
- \( E \) = Emissions (kg/yr)
- \( P \) = Equipment population
- \( HR \) = Hours of operation
- \( L \) = Load factor (%)
- \( HP \) = Equipment horsepower
- \( EF \) = Emission Factor (kg/hp-hr)
NONROAD Model

- Estimates emissions for the major nonroad categories
- Includes more than 80 basic and 260 specific types of nonroad equipment
- Fuel types include petrol, diesel, compressed natural gas (CNG), and liquefied petroleum gas (LPG)
- Pollutants reported are NO\textsubscript{x}, SO\textsubscript{x}, CO, CO\textsubscript{2}, hydrocarbons (HC), and PM

Model components

- Visual Basic GUI
- Fortran core program
- Microsoft Access reporting utility
NONROAD Model - Inputs

- Equipment population
- Average load factor
- Available power in horsepower
- Activity in hours of operation per year
- Emission factor

NONROAD Model - Output

- Emissions totals by:
  - Equipment type
  - Horsepower
  - SCC (source category code)
  - Source classification and horsepower

- Equipment population and fuel consumption by:
  - SCC
  - Source classification and horsepower
NONROAD Model- Technical Documentation

NONROAD Model’s User manual and technical documentation for the default model inputs is available at

http://www.epa.gov/otaq/nonrdmdl.htm

Summary: Nonroad Sources

- Four main categories of nonroad sources
  - Aircraft
  - Locomotives
  - Marine Vessels
  - Nonroad equipment
    (e.g., construction, agricultural, recreational, etc.)
Summary (continued)

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Questions or Comments?
END

Module 8: Nonroad Mobile Source Emission Inventory Development