New Generation Mobile Source Emissions Model - Initial Proposal and Issues

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April 10, 2001

Why Undertake A New Approach?

- Current questions exceed current tools
  - → Analyses at finer scales
  - → Cross-pollutant and cross-source impacts
  - → Toxics, PM, Greenhouse Gases
- Improve the science
- Improve the software
- Respond to external review
  - → National Research Council, "Modeling Mobile Source Emissions", May 2000

What Analyses Should a New Model Address?

- National Inventory Generation
  → Trends
- Local Area Inventory Generation
  → SIP Inventories
  → Conformity Analyses
- Transportation Scenario Evaluation
- Corridor/Intersection Emission Analysis
  → NEPA analyses
  → Hot-Spot analyses
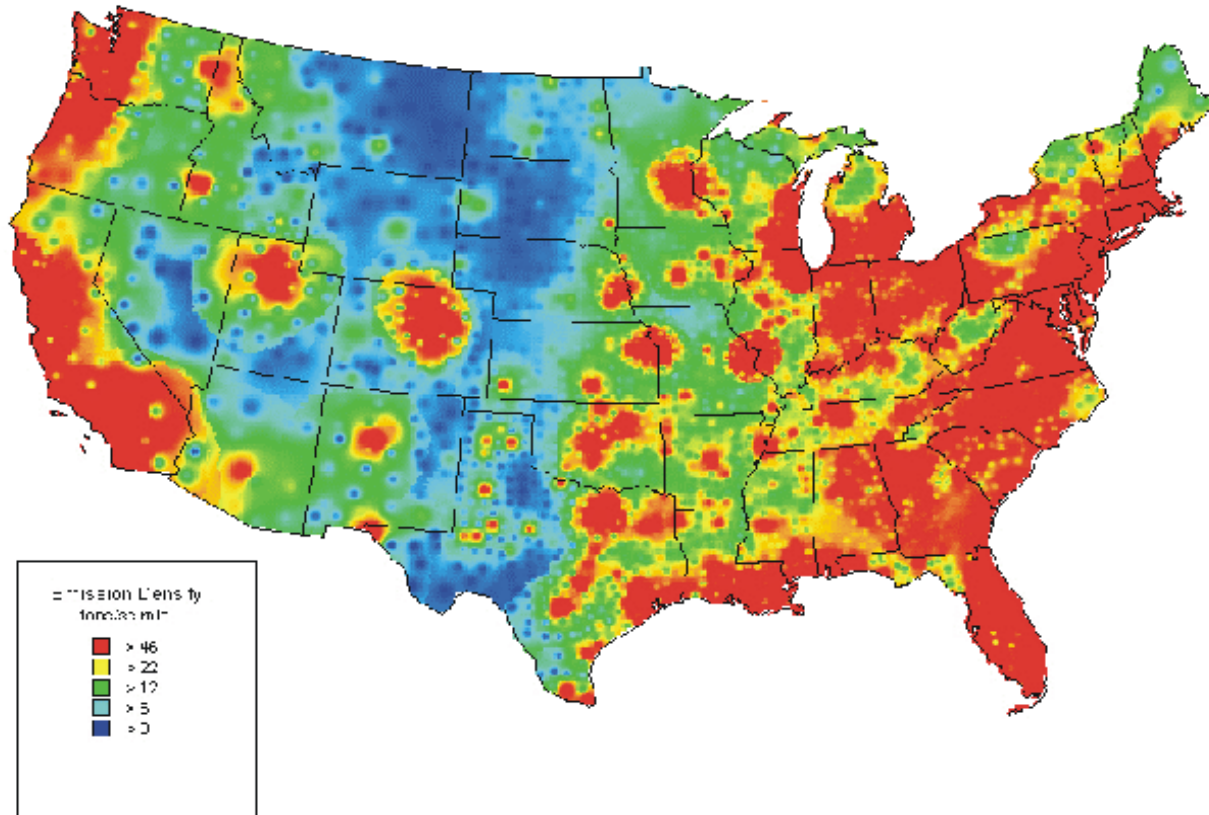
Multiple Analysis Scales Required

- ## Macroscale
  - → Focus: Inventory generation for large area
  - → Basis: County

- ## Mesoscale
  - → Focus: Inventory generation for urban area
  - → Basis: Roadway link & analysis zone

- ## Microscale
  - → Focus: Project-Level emission analysis
  - → Basis: Specific Corridor/Intersection

Macroscale Analysis
EPA Trends Report

1998 Carbon Monoxide Emissions

Emission Density
tons/sq mi

- > 46
- > 22
- > 12
- > 5
- > 0

Mesoscale Analysis
Raleigh-Durham, NC (MEASURE model)

CO Emissions – Daily

2x2 Km Grid Cells

Major Roads
Study Area Boundary
Gridded Emissions (g/day)
0
0 - 9635.159
9635.159 - 43818.549
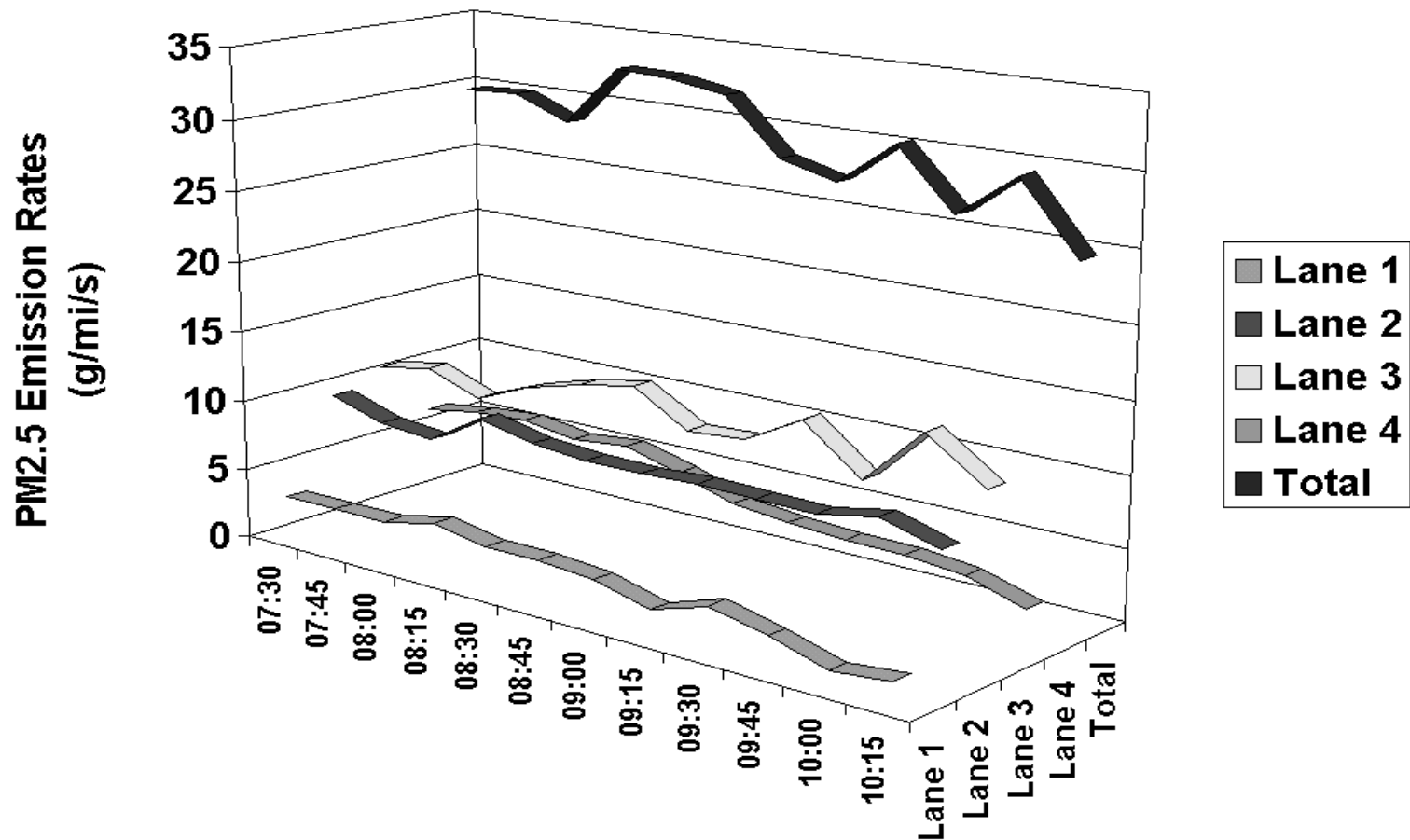43818.549 - 273622.877
273622.877 - 10217468.529

Engine Starts + Engine Load Model + Minor Roads

Microscale Analysis
EPA/ORD MicroFac model

Real-time PM$_{2.5}$ Exhaust Emissions
Interstate-40; March 10, 1999; 7:15 - 10:15

	National Inventory	Local Inventory	Transportation Scenario Evaluation	Corridor/ Intersection Analysis
Macroscale	███	███		
Mesoscale		███	███	
Microscale			███	███

Proposed Framework

- Supports all three analysis scales
- Which scale to use depends on:
    → Analysis category
    → Available input data
        - Macroscale contains national default information
        - Input data is "price of entry" for meso/micro scales.
- Scales linked by emission rate estimation process

Emission Rates

- Emission rates are core of NGM (e.g. AP-42)
- Establish systematic process to derive emission rates from instantaneous emissions data

- Macroscale emission rates
  → Cycle-based (e.g. MOBILE)

- Modal emission rates
  → Characterize accel, cruise, decel, idle
  → Several approaches possible
    - vehicle speed/accel map is common

Emission Rate Approach 1 - Correction Factors

- Emission rates reflect "base" emission
- Additional effects (e.g. fuel) tacked on
- Test samples, test methods and data quality behind each effect vary significantly
- Many effects become outdated
- Doesn't account for emissions synergies
- Does allow for analysis of individual effects

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Emission Rate Approach 2 - "Comprehensive" Rates

- Reflect in-use emissions as they are
  → no additional corrections
- Would require on-board emissions measurement
- Accounts for all emissions synergies
- <u>Probably</u> more accurate
- Isolation of effects is more difficult

Emission Rate Estimator

- Establish systematic process to derive emission rates from instantaneous emissions data

- Goal is comprehensive emission rates from on-board measurement data (e.g. PEMS)

- Short term may require a hybrid of lab and in-use data
    - → Evap will continue to be based on lab data

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Emission Rate Estimator

NGM Components
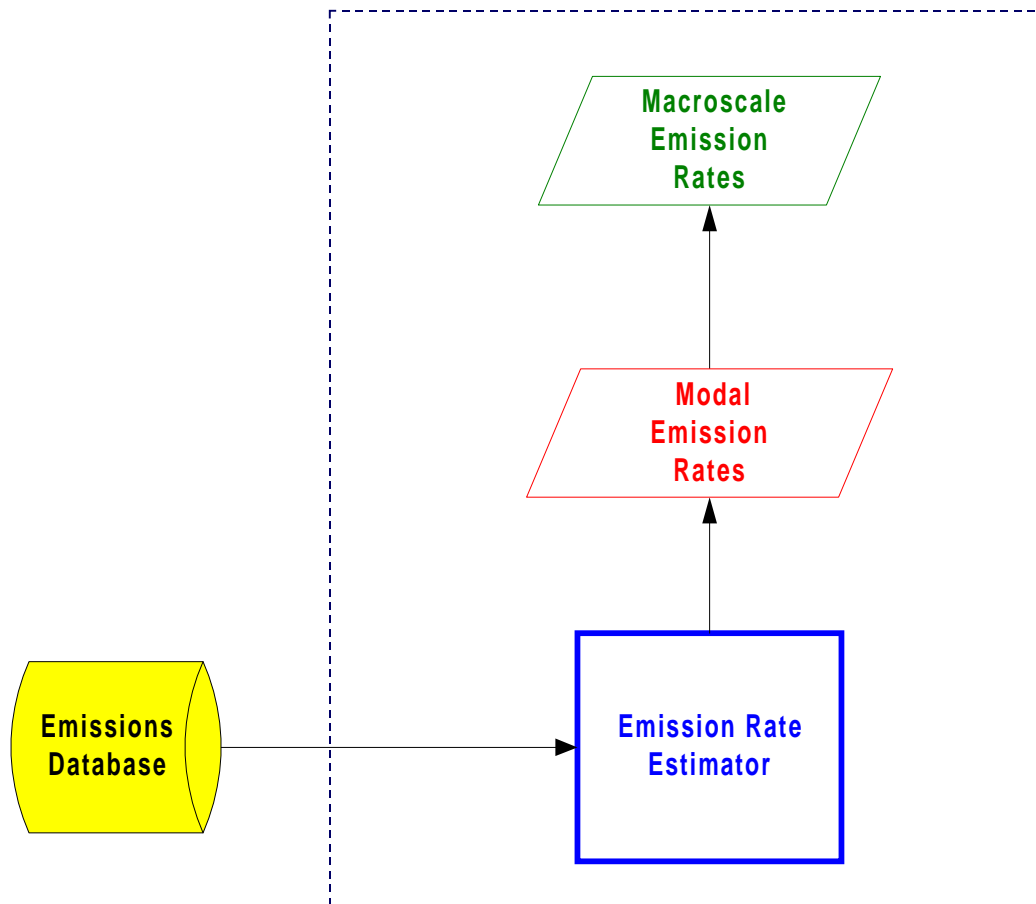
Emission Rate Estimator Approaches

- Instantaneous emissions model (e.g. CMEM)
  - → Run modes through to establish modal rates
  - → Run cycles through to establish macroscale rates
- Emissions data processor
  - → Pre-determined statistical process establishes modal emission rates (e.g. Tree-Based Regression)
  - → Important effects fall out
  - → Macroscale emission rates derived from modal rates
- Database query of raw PEMS data

Macroscale Level

- **NGM Components**
  - → Macroscale emission rates
  - → Emission factor estimator (e.g. MOBILE)
  - → Emission inventory estimator (e.g. SMOKE, EMS)
- **Output**
  - → Total emissions by county
  - → Breakdown options consistent with MOBILE6
    - running/start, facility, class, hour
    - aggregation available
 - → Feeds external Grid Processor for AQ modeling

Macroscale Level Inputs

- Activity
  → Speed, trip, soak info consistent with MOBILE6
  → VMT by road class, vehicle class (HPMS format)
- Fleet
  → MOBILE6: Class, technology, MY, standard
  → Emission distribution?
- Meteorological data
- Fuel specifications (e.g. Complex Model)
- Defaults available

Macroscale for Evap and Off-Road

- **Evaporative Emissions**
  - → Current MOBILE6 inputs and outputs

- **Off-Road Emissions**
  - → Same components as on-road
  - → Activity & Fleet
    - Current Approach (NONROAD)
      - direct estimates of hours/year, load factor, population
      - allocation factors
    - Possible New Approach:
      - activity/population surrogates (e.g. housing starts, agricultural acreage)

Macroscale Level Flowchart

NGM Components

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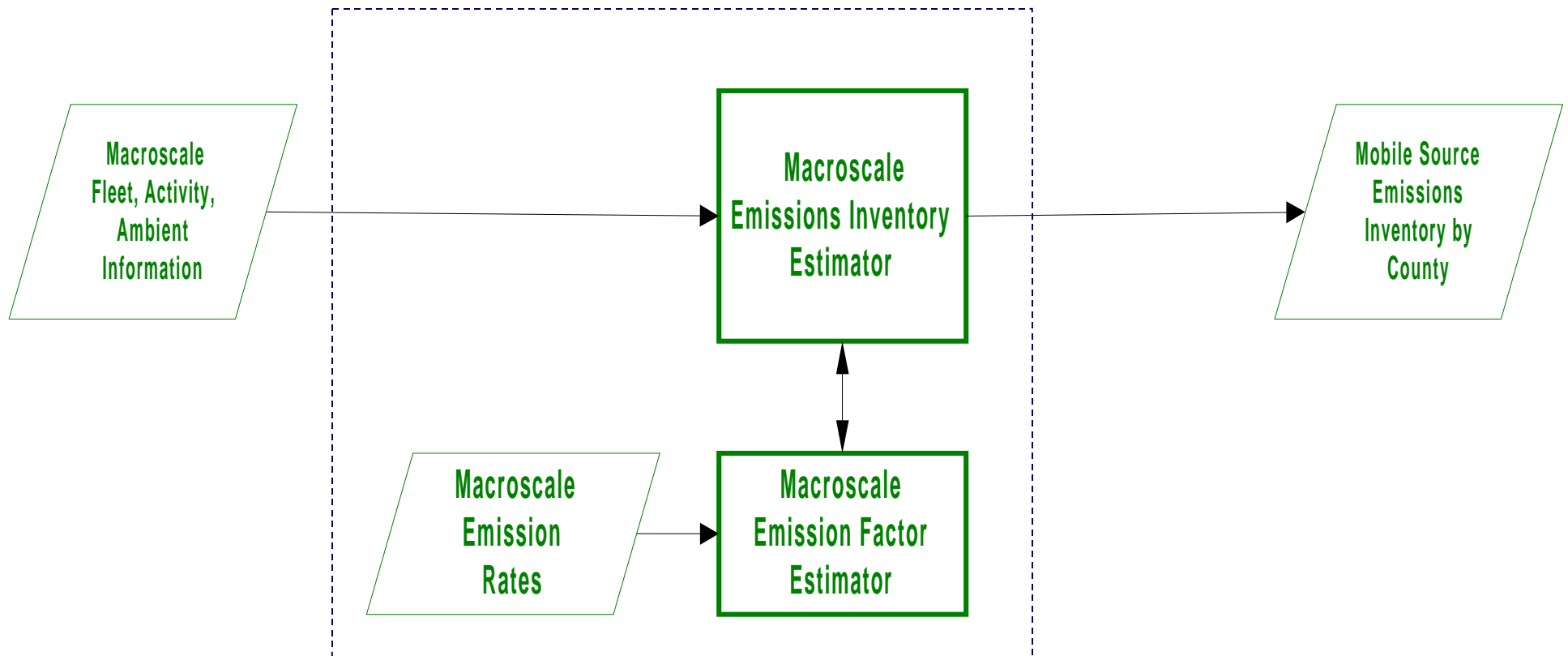
Mesoscale Level

- Three options:
    - → Basic: Macroscale emissions at link/zone level
    - → Modal: Modal emissions, roadway grade
    - → Advanced: Finer resolution of links/zones and fleet characteristics (e.g. MEASURE)
- NGM Components
    - → Macroscale or modal emission rates
    - → Macroscale or modal emission factor estimator
    - → Mesoscale emission inventory estimator
- Output
    - → Emissions by link/zone

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Mesoscale Level Inputs

- Activity
  - → Activity & VMT from Travel Demand Model

- Fleet
  - → Basic: same as macroscale
  - → Modal: may require finer breakdown of vehicle attributes for modal emissions (e.g. cylinder)
  - → Advanced: address matching enables spatial component
  - → Emissions distribution?

Mesoscale Level Inputs, cont.

- Spatial information
  - → Roadway network
  - → Analysis zone boundries
  - → Census, land-use, tax parcel (advanced option)
  - → Road grade (modal and advanced options)
- Meteorology, fuel, control program
  - → Same as macroscale (e.g. county-level)

Mesoscale for Evap and Off-Road

- Evaporative Emissions
  - → Activity from Travel Demand Model
  - → Macroscale emissions
- Off-Road Emissions
  - → Same components as on-road
  - → Activity & Fleet
    - Possible Approaches:
      - top-down allocation factors
      - bottom-up activity/population surrogates (e.g. housing starts, agricultural acreage)
      - direct observation
  - → Emissions: macroscale likely, modal possible

Mesoscale Level Flowchart
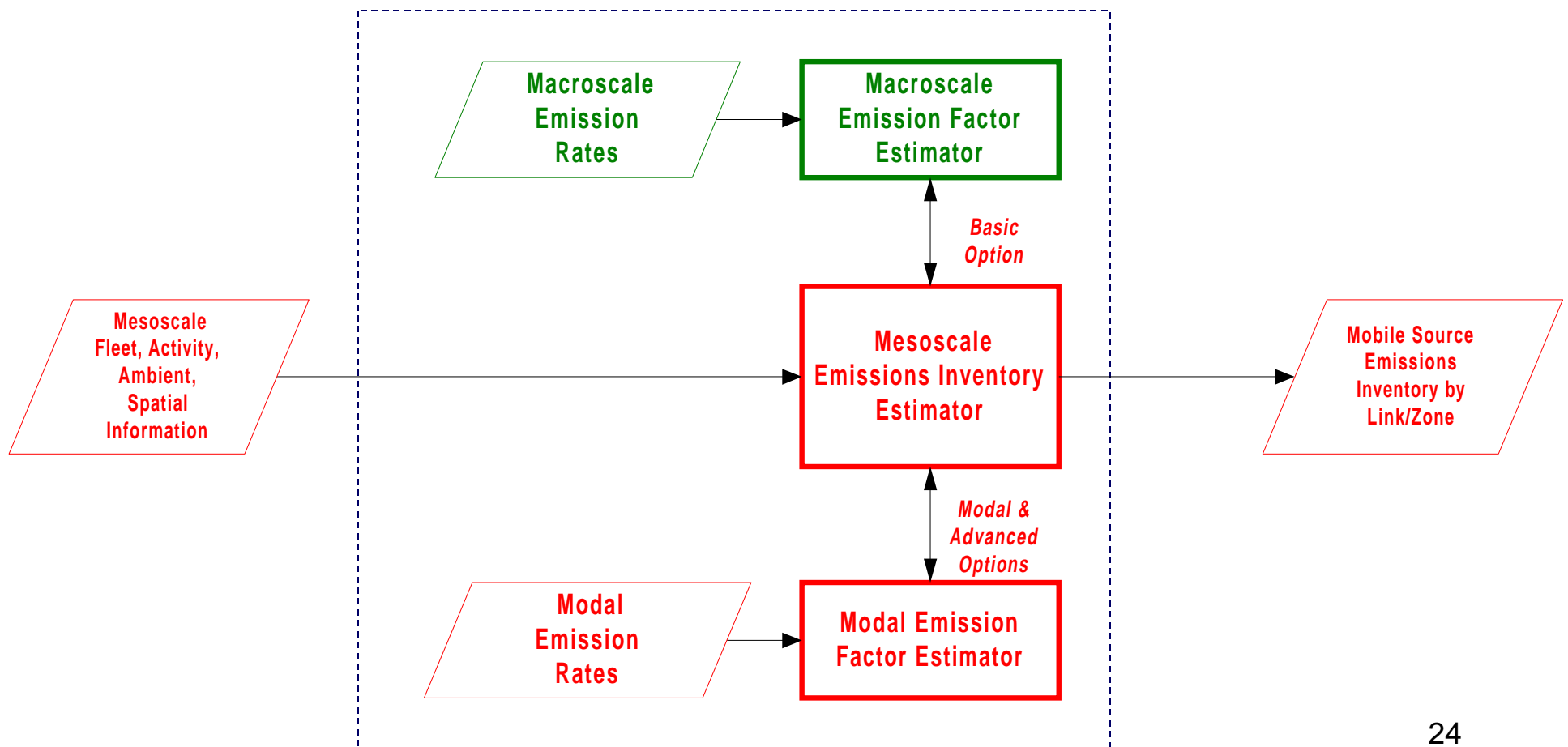
NGM Components

Microscale Level

- NGM Components
    - → Modal emission rates
    - → Mesoscale emission factor estimator
    - → Corridor/Intersection emission inventory estimator
- Output
    - → Emissions for corridor/intersection
    - → Feeds external dispersion model

Mesoscale Level Inputs

- Activity
  - → Transportation models, or
  - → Roadside observation
- Fleet
  - → Same as macro/mesoscale, or
  - → Roadside observation
- Road grade
- Meteorology, fuel, control program
 - → Same as macroscale (e.g. county-level)

Microscale for Evap and Off-Road

- **Evaporative Emissions**
  - → Direct observation for activity?
  - → Macroscale emissions
- **Off-Road Emissions**
  - → Same components as on-road
  - → Activity & Fleet
    - Possible Approaches:
      - bottom-up activity/population surrogates (e.g. housing starts, agricultural acreage)
      - direct observation
  - → Emissions: macroscale likely, modal possible

Microscale Level Components

NGM Components
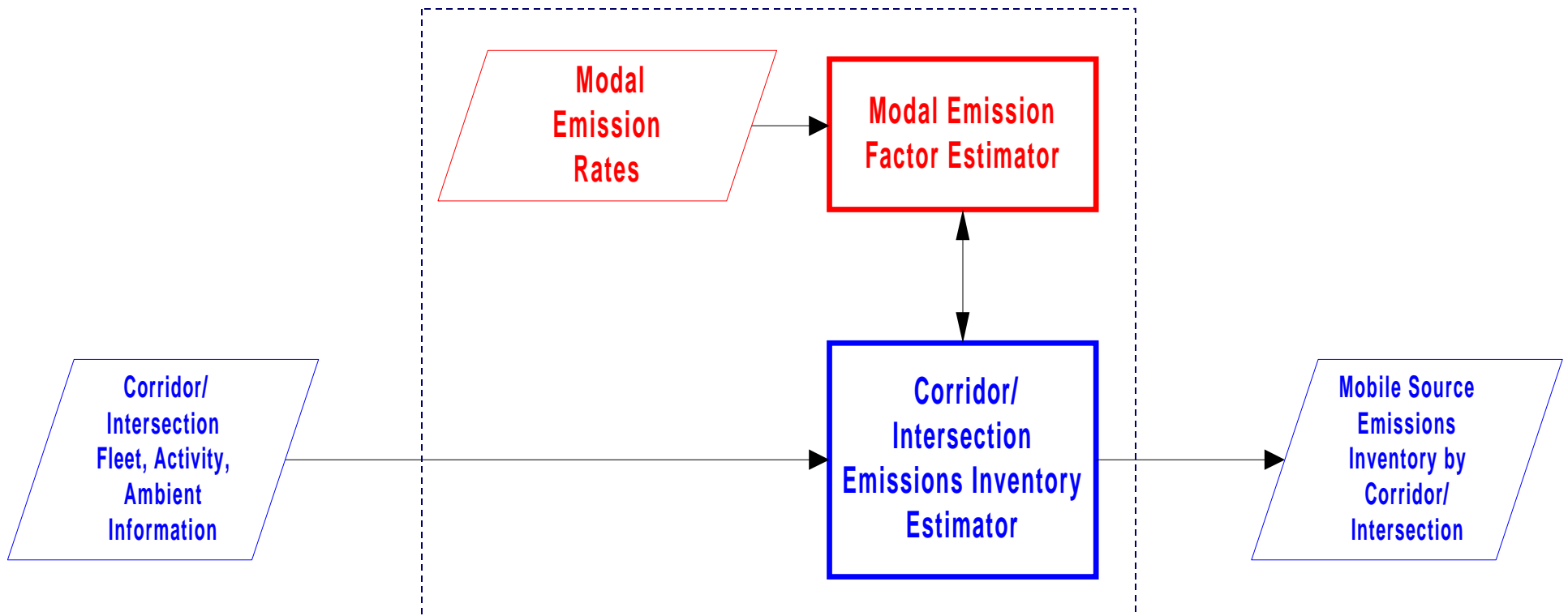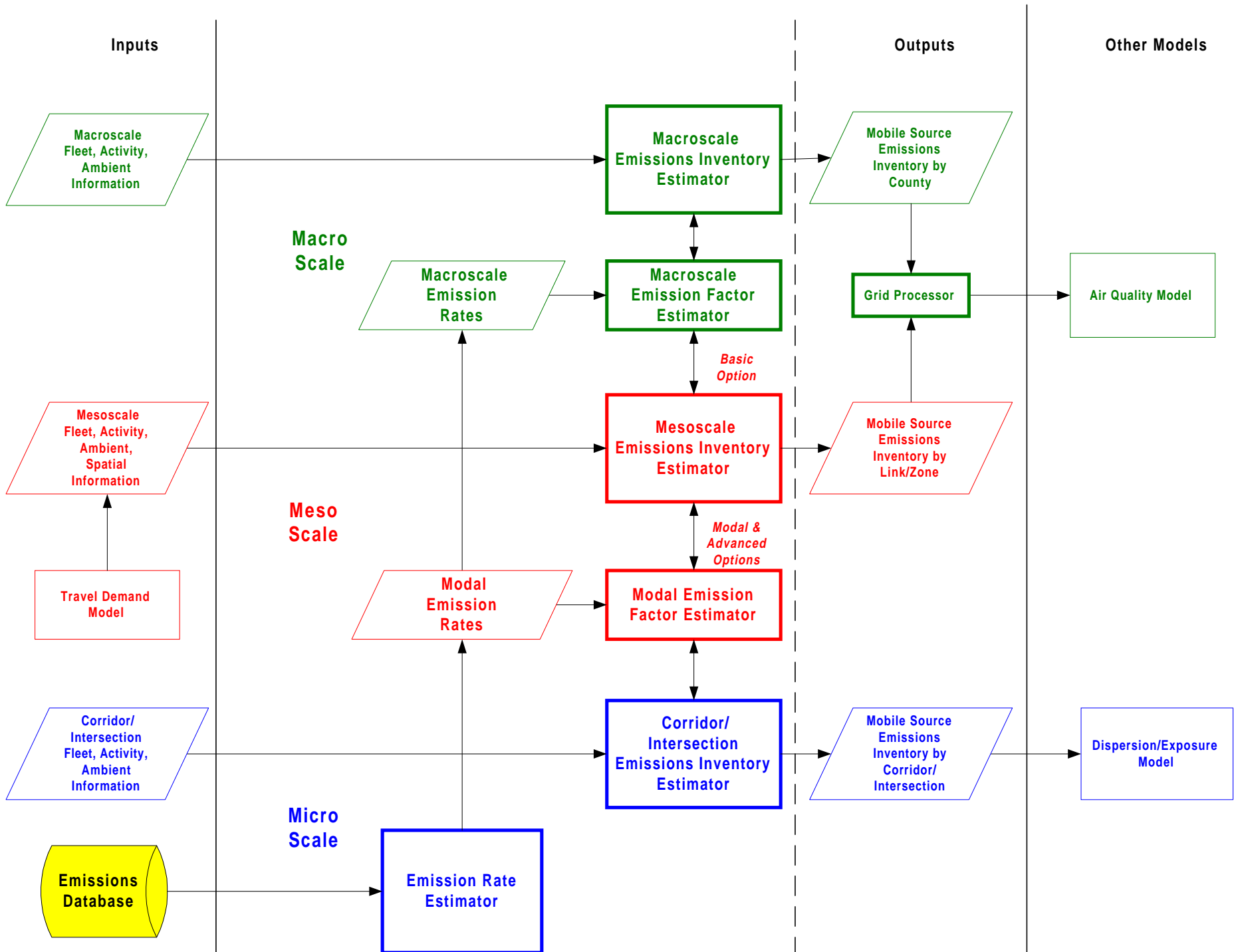
Scope Options

- Full Scope
    - → Emission rates for all levels
    - → Software framework for all levels
    - → On-road and off-road

- Reduced Scope
    - → Emission rates for all levels
    - → Software framework for macroscale
    - → Guidance only for mesoscale and microscale
    - → Off-road on different time schedule

Interim vs. Final Product

- **Interim Product**
  → Focus is developing software framework
  → Use existing products for specific components
    - e.g. MOBILE6, NONROAD, SMOKE
  → Emission results unchanged

- **Final Product**
  → Focus is improving emission estimation
  → Would supplant MOBILE6 and NONROAD

Improving the Science

- Process
  - → Define model performance criteria
    - How good does the model need to be?
  - → Validate the model
    - Does the model meet the performance criteria?
  - → Quantify uncertainty
  - → Peer Review
- Data
  - → Improve data (e.g. in-use emission measurement)
  - → Direct link from data to model

Improving the Software

- **Software Platform**
  - → Object-oriented design likely
  - → Evaluating EPA Multimedia Integrated Modeling System (MIMS) initiative
  - → Role of Geographic Information System (GIS) software?
    - Not necessary for macroscale
    - Basic/Modal mesoscale option may require for input data
    - Advanced mesoscale option would require for model itself
- **Improve Usability**
- **Improve Flexibility**
  - → Want easier updates
  - → Modular design (e.g. object-oriented) would enable

Planning Process

- EPA Mobile Source Modeling Workgroup
    → OTAQ, OAQPS, ORD, Regions
- April 2001: Issue Paper / Straw Proposal
    → To be posted for comment on OTAQ Web Site
    → Provide comments to EPA by June 15th
    → Submit Comments to: **newgen@epa.gov**
- Fall 2001: Comprehensive Plan
    → Software Design
    → Science
    → Schedule/Resource Plan

April 19th Meeting

- We want YOUR input
- Reserve a block of time to present/discuss:
    - Comments on the proposal and/or paper
    - Your great idea or pet project (must be pertinent)
    - Your wish list (must be pertinent)
    - General kvetching (5 minute limit)
- Please contact John Koupal by 4/13 to reserve
- Other potential topics:
    - Research Needs
    - Should the workgroup generate group comments?
- No interest = No meeting