

MOVES2004

Software and Database Design

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Outline

- **Model Inputs and Pre-processing**
- **Model Execution**
- **Outputs and Post-processing**
- **Model Categories**
- **Guide to Model Software Documentation**

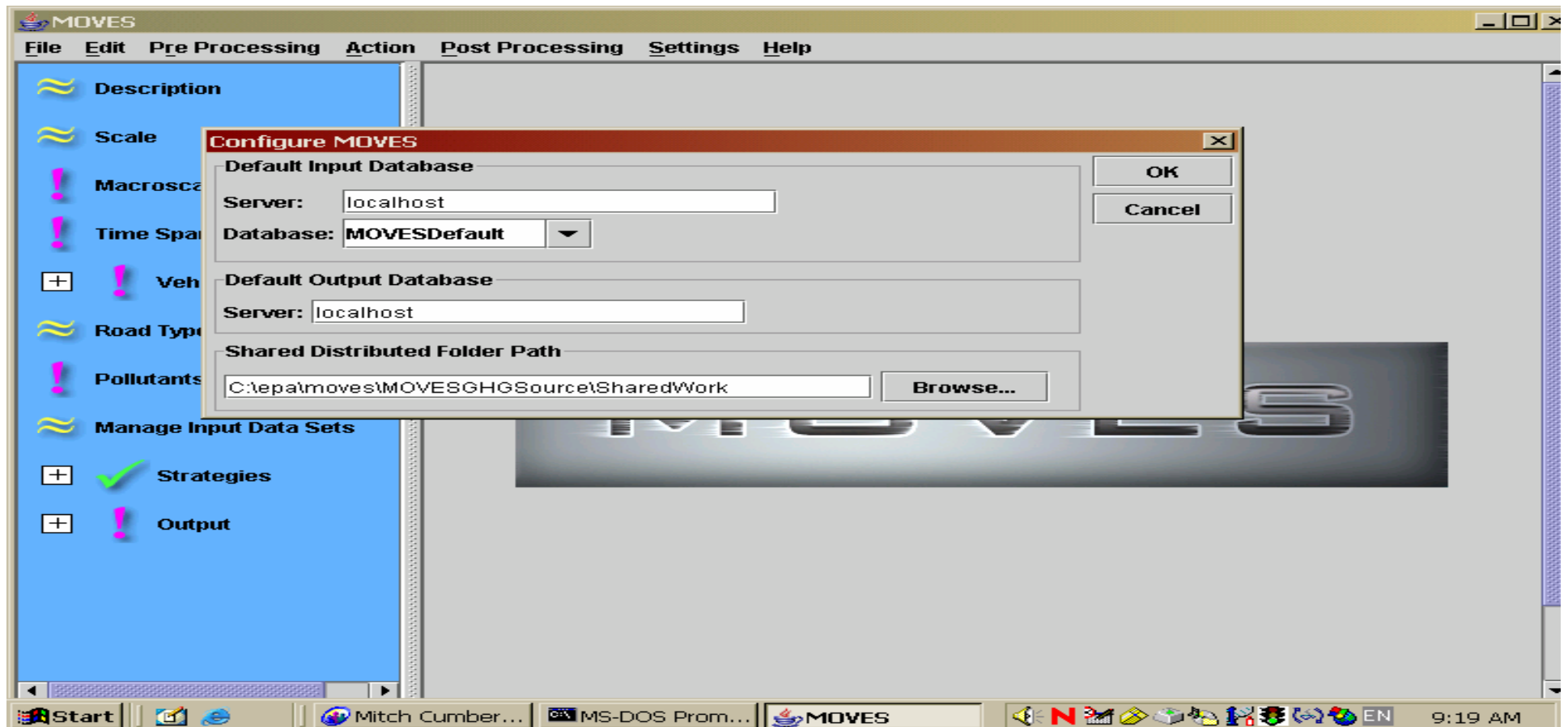
Model Inputs

- **System Configuration Information**
- **MOVESDefault Database**
- **Optional User Input Database(s)**
- **Run Specification**
- **Control Strategies**

System Configuration

- **Established when MOVES is installed**
 - not normally a concern afterwards
- **The MySQL database server to use**
- **The MOVESDefault database to use**
- **The location where the Master Program and Worker Program can communicate**

Accessing the System Configuration from the GUI



MOVESDefault Database

- **Provided by EPA as part of the model**
- **Contains all information necessary for many model runs**
- **Technical Characteristics:**
 - Relational, highly normalized
 - Implemented with the MySQL "open source" DBMS
- **Reference: Chapter 11 of the Software Design and Reference Manual (SDRM)**

Optional User Input Database(s)

- Same structure as MOVESDefault
- Used to replace or add to MOVESDefault information
- But just because you can doesn't mean you have to!
- Can be produced by model users
- Can also result from pre-processing steps
 - GREET Model Interface
 - Future Emission Rate Calculator
 - Data Importers

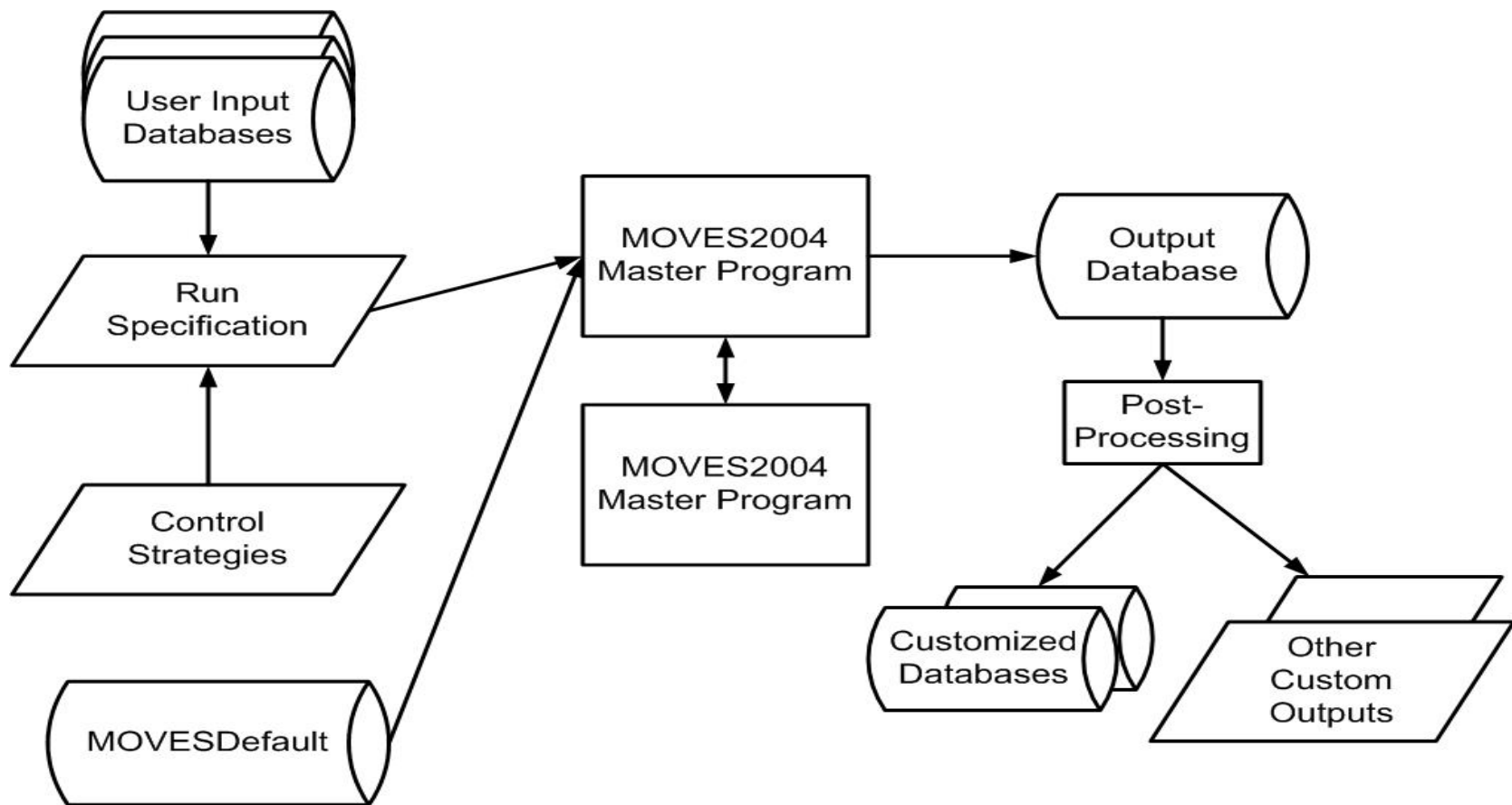
Run Specification

- Specifies the scope of model runs in terms of the “Model Categories”
- Identifies any input databases to be used
- Specifies control strategies
- Gives the output database name
- Specifies the engineering units and levels of detail desired in the output
- May be produced, saved, and reloaded by the MOVES Graphical User Interface (GUI)

Model Execution

- Run Specification may be run individually from GUI,
- Or from a DOS Command Line Interface.
 - Directly by user at the DOS prompt
 - By other computer programs
- MOVES Master Program begins the run.
- One or more MOVES Worker programs participate.
 - Automatically as needed
 - May be on same computer or on other computers on network
- Master Program completes run.
- Execution run time can be excessive if scope of run is very large and/or detailed output is requested

MOVES2004 Processing Diagram



MOVES Output Database

- The direct or “raw” output from the model
- A MySQL database containing four tables
 - MOVESRun for run level information (e.g. run time, runspec)
 - MOVESError for error messages
 - MOVESActivityOutput for activity (e.g. distance) results
 - MOVESOutput for emission results.
- Same database may be used for multiple runs
 - Runs identified by MOVESRunID field
- Accommodates reporting at many levels of detail
 - identifying columns assume null values at higher levels of detail

Model Execution – What happens inside the Master and Worker Programs?

- Input Data Manager merges user input – making MOVESExecution database
- Any database pre-aggregation performed
- For portions of model run
 - Control Strategies execute
 - Generators execute
 - Calculators execute
- Final result aggregation – units conversion

Output Post-Processing

- EPA envisions that many programs will be written to further process the raw model output for particular purposes
- MOVES2004 includes the ability to run MySQL scripts on the output
- Script files placed in appropriate file directory automatically appear in MOVES GUI Post-processing menu

Existing Post-Processing Scripts

- **Decode output fields**
 - adds text explanation of numeric categories
 - e.g. source type number 21 = “Passenger Cars”
- **Calculate miles/gallon**
- **Convert output database to tab-separated text files suitable for importing into Microsoft™ Excel**
 - But consider size first

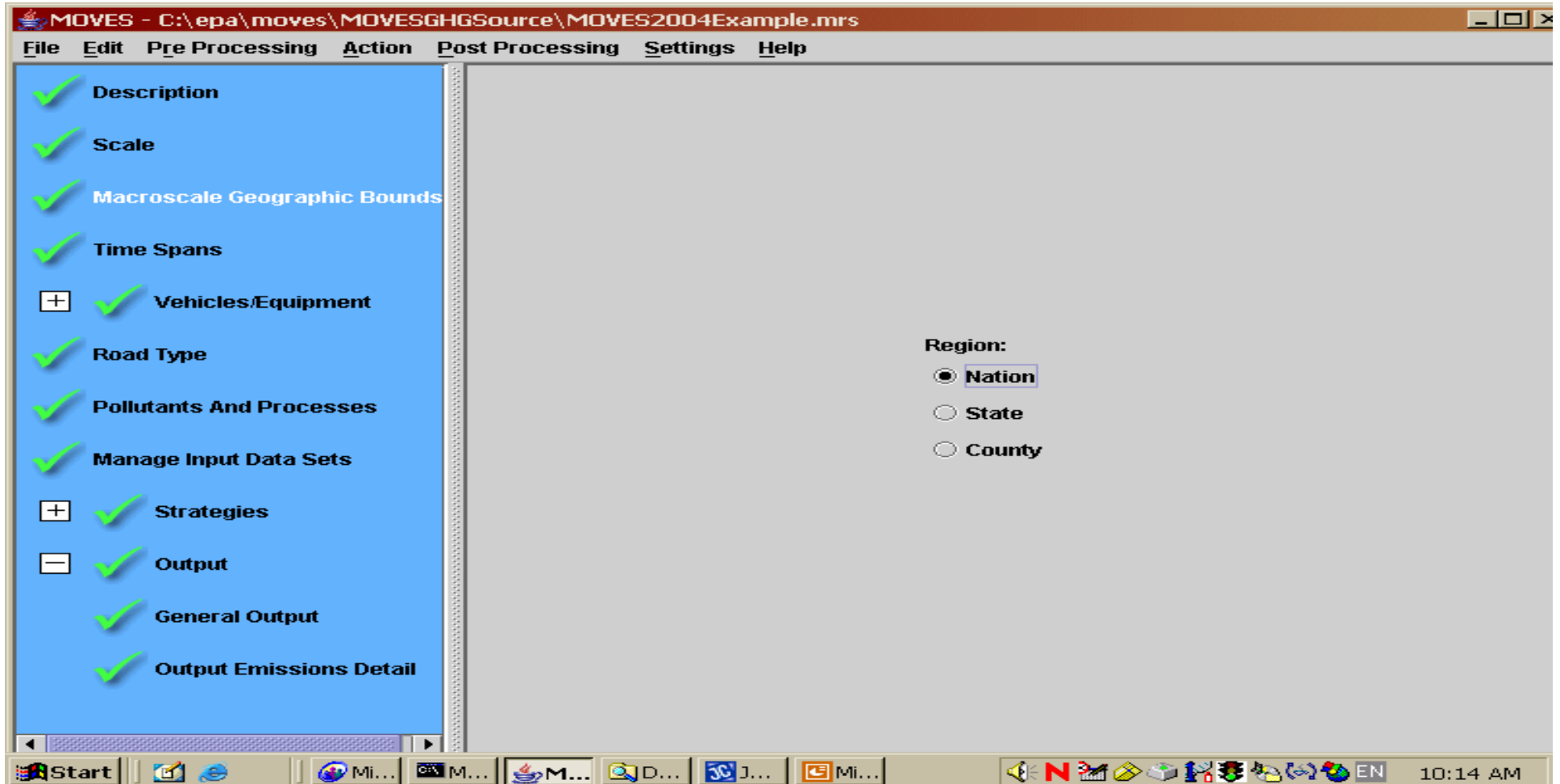
MOVES Modeling Categories

- **Geographic Location**
- **Time Periods**
- **Pollutants**
- **Emission Processes**
- **Mobile Source (Vehicle) Classification**
- **Source Activity**
- **Fuels**
- **Emission Rates**

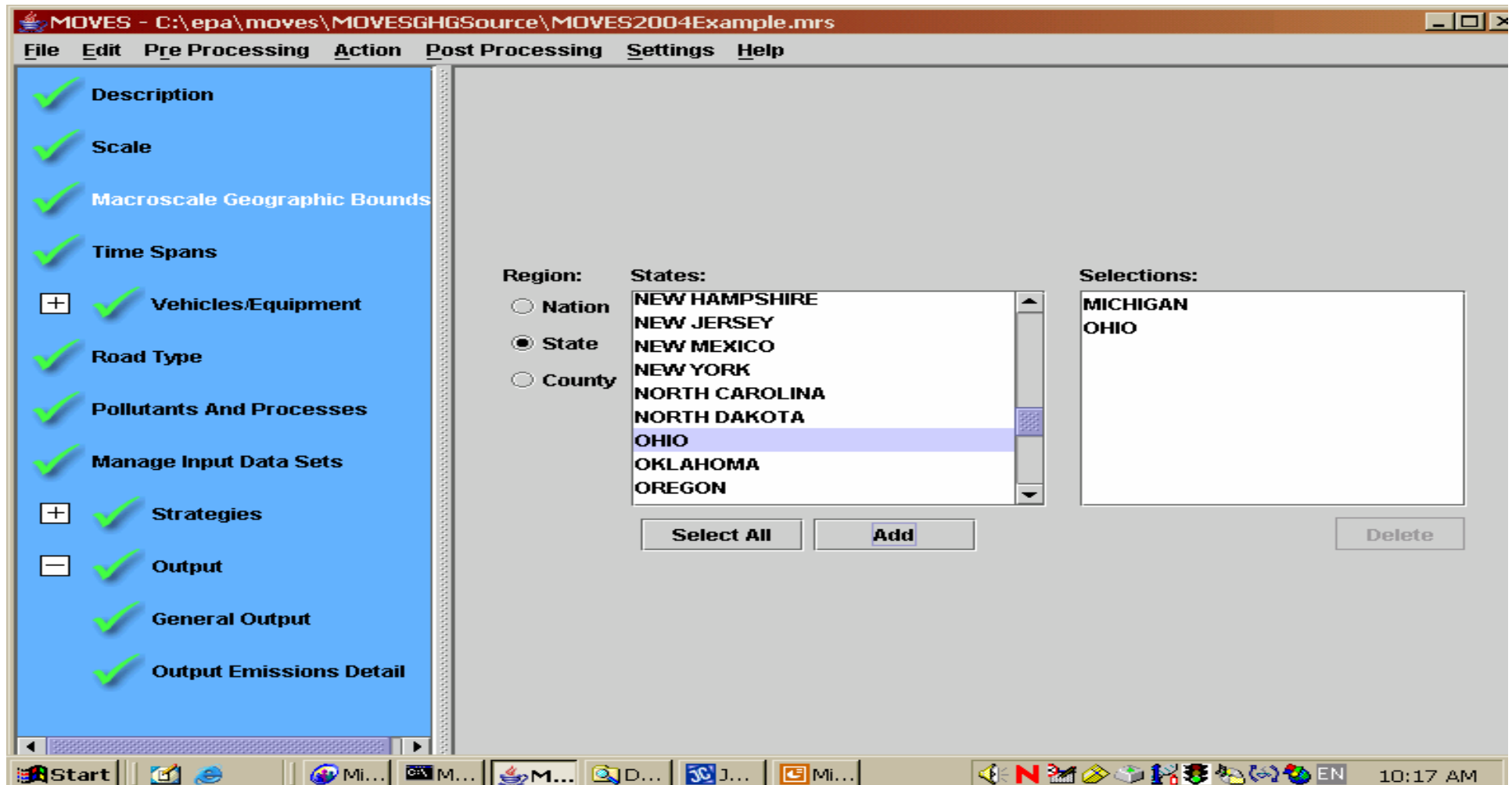
Geographic Location

- **Modeling Domain**
 - The geographic “world” being modeled
 - In MOVESDefault this is the United States
- **States**
 - Top level geographic entity within the modeling domain
 - In MOVES2004 the United States consists of 53 “states”

Specifying a National Run



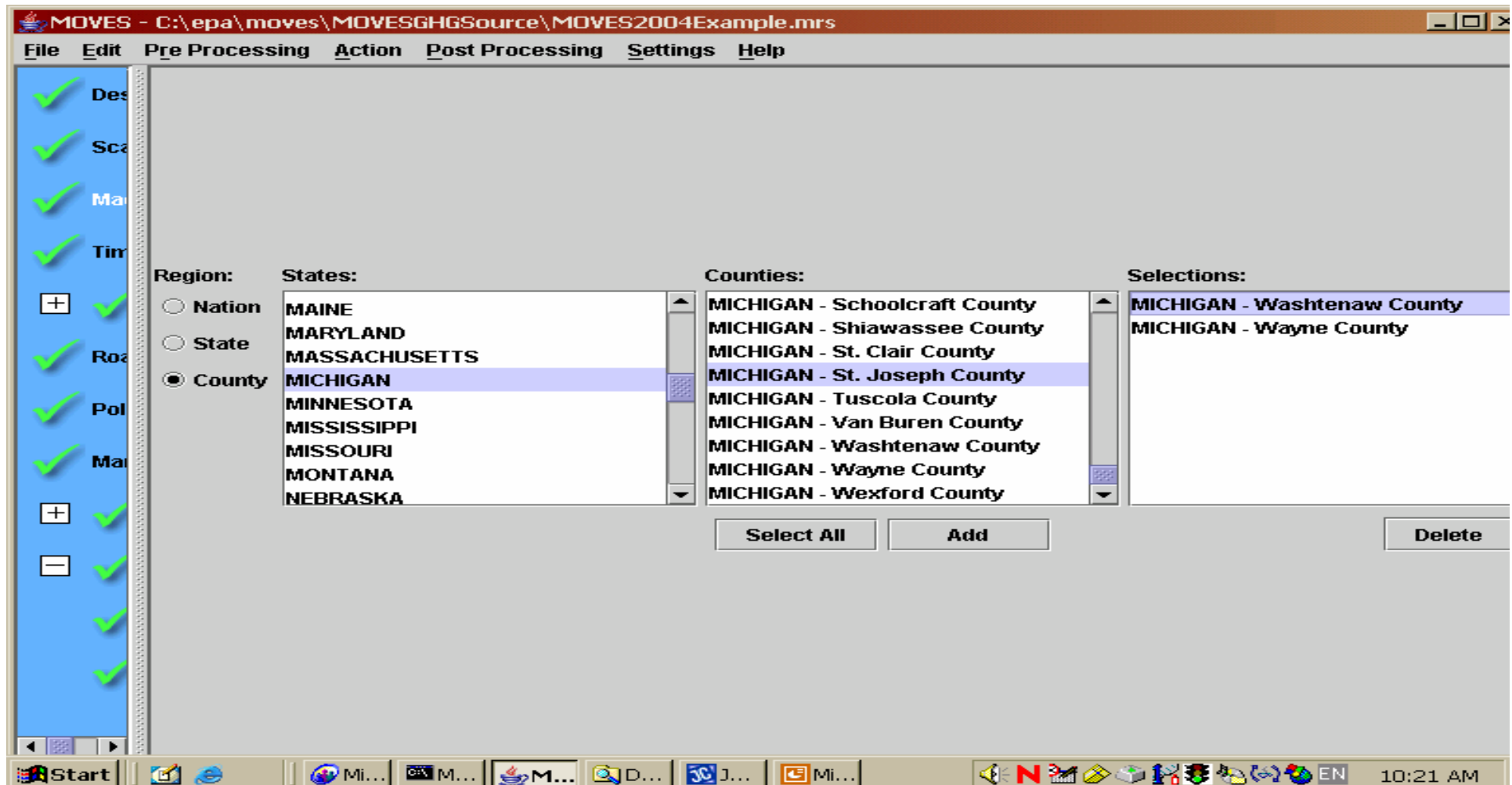
Specifying a State Level Run



Geographic Locations – Counties

- **Political Subdivisions of the States**
- **MOVES2004 includes the 3222 counties existing in 1999**
- **Fuel characteristics are a property of counties**

Specifying a County Level Run



Geographic Locations- Zones

- In MOVES2004 a Zone corresponds to a County
- In future versions a Zone may represent a user-defined sub-county area
- Meteorology data belongs to a Zone

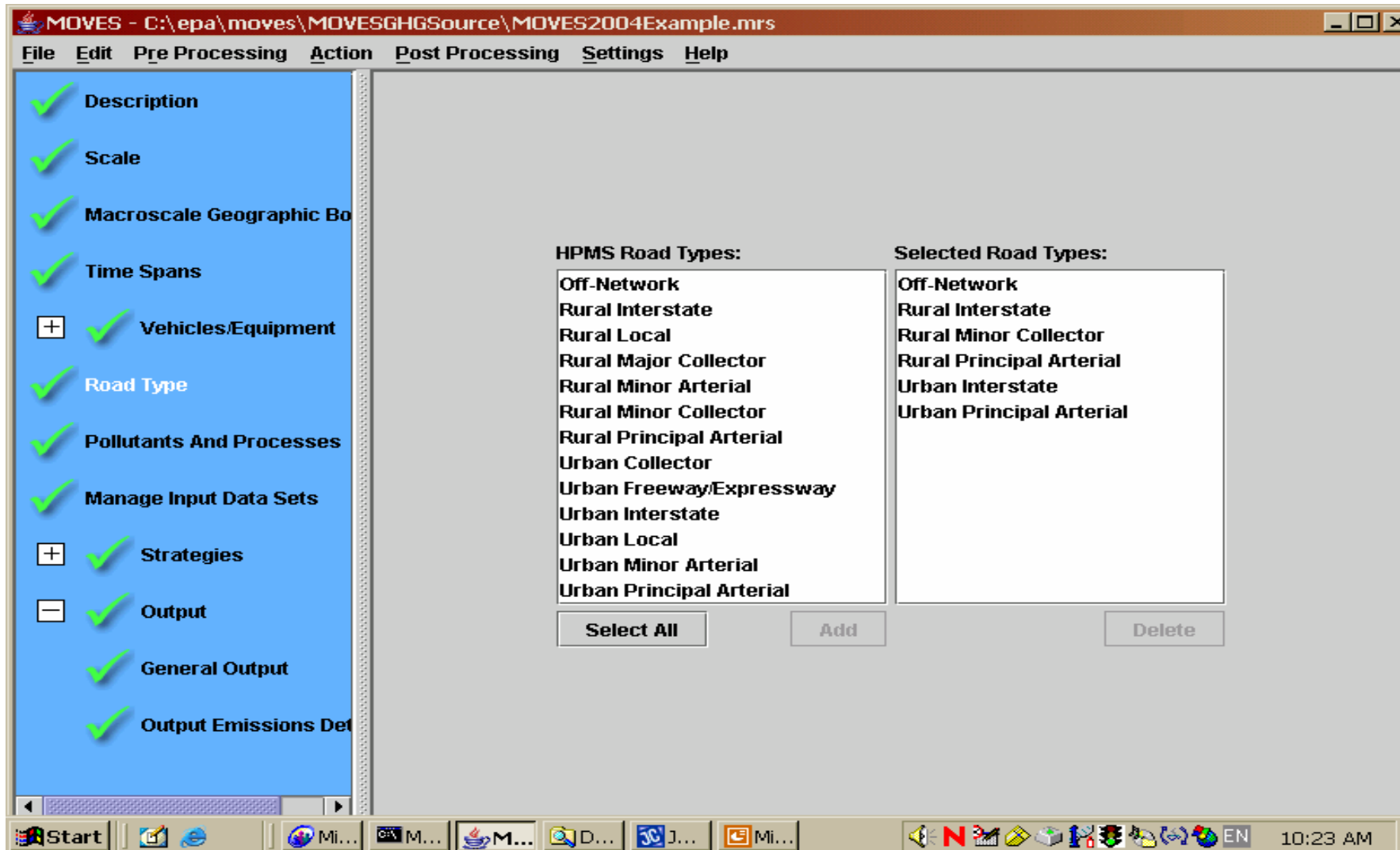
Geographic Locations - Links

- **Links represent locations within Zones**
 - The most detailed location level in MOVES
- **In MOVES2004 Links represent a kind of roadway in a Zone (or County)**
- **At finer scales Links are intended to represent physical roadway segments**
- **All locations modeled must be a Link, or an aggregation of Links**
 - So there is an “off-roadway-network” link in each Zone (or County) in MOVES2004

Road Type – A required characteristic of Links

- Draft MOVES 2004 uses thirteen
- Twelve from Highway Performance Management System (HPMS)
- Plus off-network
- May have a characteristic fraction of ramp driving
- Future versions apt to use five
- Four aggregated from HPMS
 - Rural, Restricted Access
 - Rural, Unrestricted Access
 - Urban, Restricted Access
 - Urban, Unrestricted Access
- Plus off-network

Specifying Roadtypes



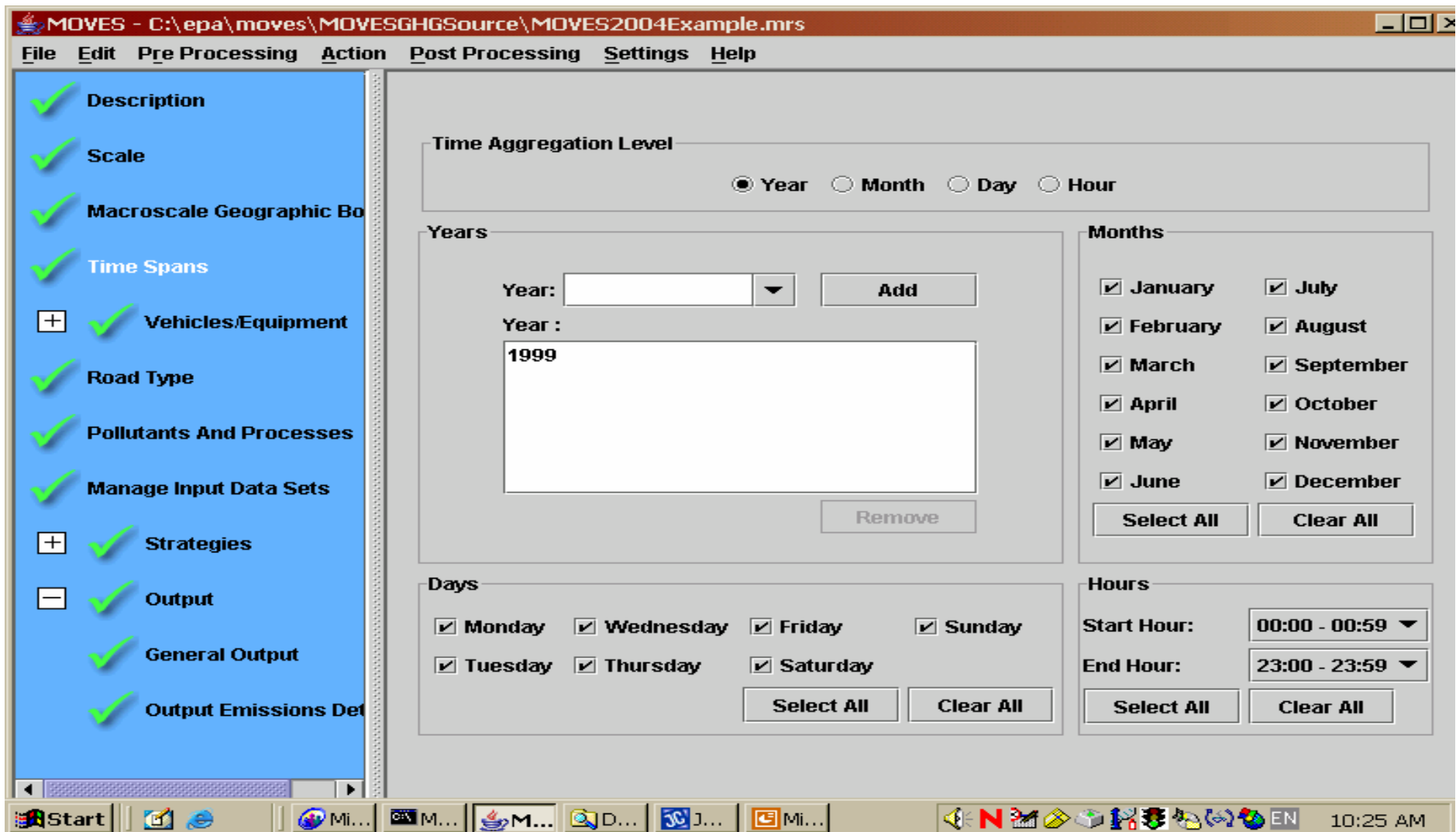
Time Periods

- **MOVES2004 uses familiar hierarchy of time periods**
- **Historical years 1999-2050**
- **Twelve months of the year**
- **Days of the week**
 - Draft MOVES 2004 distinguishes seven days of the week
 - Future versions of MOVESDefault database not likely to distinguish days of the week
- **24 Hours of the Day**

Time Periods (continued)

- User selects Years, Months, Days, Hours from separate lists. All combinations of selected values are run, so same set of hours is run for each day, same set of days of the week for each month, etc.
- Calendar disconnect between weeks and months – simple sum of daily inventories would yield a weekly inventory not a monthly one
 - MOVES automatically scales weeks to months when asked for monthly or annual inventories
 - User must do this if adding up daily results outside the model

Specifying Time Periods



Pollutants

- All results computed by MOVES are in terms of “pollutants”
- Energy consumption results available from draft MOVES2004
 - Total energy consumption
 - Fossil fuel energy consumption
 - Petroleum fuel energy consumption
- Mass pollutants results available from draft MOVES2004
 - Methane
 - Nitrous Oxide (N₂O)

Emission Processes

- Represent mechanisms or pathways by which emissions are produced
- Emission Processes in MOVES2004
 - Running exhaust
 - Start exhaust
 - Extended idling
 - Well-to-pump

Specifying Pollutant-Processes

MOVES - C:\epa\moves\MOVESGHGSource\MOVES2004Example.mrs

File Edit Pre Processing Action Post Processing Settings Help

	Extended Idle Exhaust	Running Exhaust	Start Exhaust	
Fossil Fuel Energy Consumption	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Methane (CH ₄)		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
Nitrous Oxide (N ₂ O)		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
Petroleum Energy Consumption	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Total Energy Consumption	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	

☒ Distance Traveled

Pollutant/Process Requirements

Emission Processes

Must each have an Activity Basis

Running Exhaust	Source Hours Operating (SHO)
Start Exhaust	Number of Starts
Extended Idling Exhaust	Number of Hours of Extended Idling
Well-to-pump	Energy consumed by the above three processes

Emission Processes

Relationship to Locations

- Running exhaust process emissions occur on Links which have running activity.
- Start exhaust and extended idling process emissions occur on off-roadway-network Links.
- Well-to-pump process emissions are associated with the Link locations of the other process emissions which cause them
 - Note that they are not really emitted at these locations

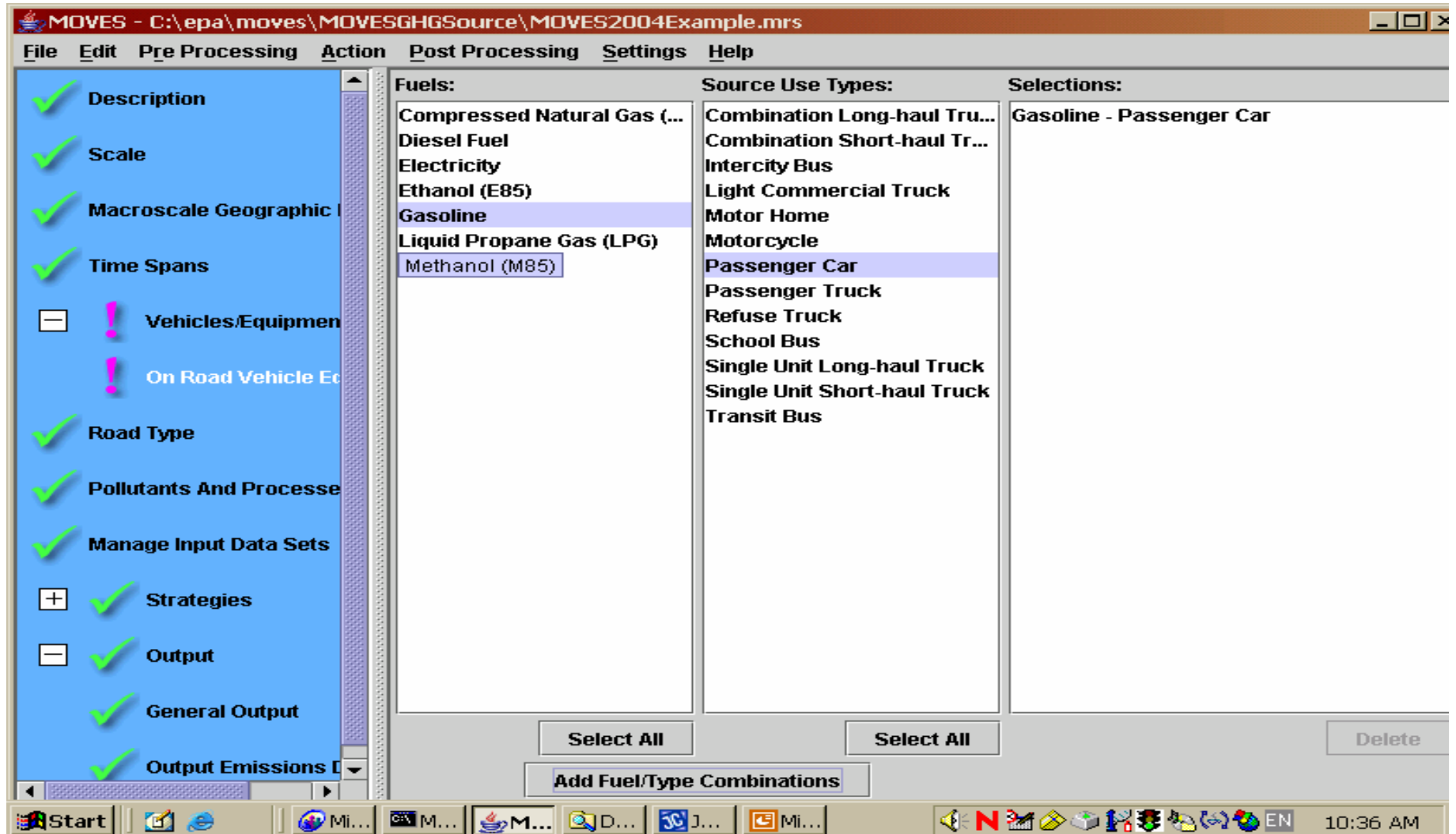
Mobile Source Classification

- **Source Use Type (or just Source Type)**
 - Top Level Classification
 - Reflects major differences in usage pattern
- **Source Bins**
 - Classify sources in terms of characteristics which affect emissions
 - Based on permanent characteristics of vehicles
 - Distribution of these characteristics currently may not vary by location
 - Not reported in output, except for Fuel Type

Fuel Types and Fuel Subtypes

- **Source types are classified by fuel type**
 - Presumed to be made to operate on a kind of fuel
- **Fuel sub-types are alternative formulations of a fuel type that work in the same vehicles**
- **Presence varies by time (Month) and by location (County) as a market share**

Specifying Source Types and Fuel Types



Source Activity Divided into Operating Modes

- Running Process uses VSP-based operating modes
- No other operating modes currently used in MOVES2004
- Start exhaust and evaporative processes will have operating modes in future versions

Emission Rates

- Are central to the database design
- Are relative to SourceBin, the finest level of source classification
- Are relative to Operating Mode, the finest level of activity classification
- Are independent of modeling scale and location
- Are expressed in terms of the activity basis of each pollutant-process

Emission Rate Table Structure

- **Key Fields**
 - PollutantID
 - ProcessID
 - SourceBinID
 - OpModeID
- **Data Fields**
 - MeanBaseRate

MOVES2004 Software Documentation

- **Installation Guide**
- **User Guide and On-Line Help**
- **Software Design Reference Manual**
- **GREET Model Documentation**
- **Detailed Database Documentation**
- **MOVES2004 source code and Javadocs**

Installation Guide

- Visible at top level of installation download or Installation CD
- Intended to function as “Read Me” File
- Intended to be used during actual process of installation

User Guide

- Can be downloaded separately from EPA web site
- Also included in model installation in MOVES/Help/Usersguide
- Documents MOVE Graphical User Interface
- Intended for beginning users
- Intended for use when you are actually trying to run the model
- Forms basis of on-line help facility

Software Design Reference Manual

- Can be downloaded separately from EPA Web Site
- Also included in MOVES installation in MOVES/HELP/UsersGuide
- Intended to be used as a reference to answer more detailed software questions
- Documents all functionality of MOVES2004, except the GUI, including all algorithms

GREET Model Documentation

- **GREET is a separate modeling program from MOVES2004**
- **A version of GREET is included which interfaces with MOVES2004**
- **GREETGUIReadme.doc and .pdf can be found in ...\\GREET folder**

Detailed Database Documentation

- **Can be found in database itself**
 - i.e. at ...\\MySQL\\data\\MOVESDefault\\Readme
- **Entity-Relationship Diagrams**
- **Entity (table) definitions**
- **Field definitions**

Java Source Code and Javadocs

- MOVES2004 is open source software
- Source code in ...gov\epa\otag\moves folder
- Commented to Javadoc conventions
- Javadocs in ...\\javadocs folder
- MySQL scripts in ...\\database folder

Summary

- **MOVES is built around relational databases**
- **MOVES includes an object-oriented graphical user interface (GUI)**
- **Its software design is modular and general**
- **MOVES has a master-worker program structure**
- **MOVES can interface with other models**
- **Software design documentation is available**