Introduction to MOVES

Michael Claggett and Jeff Houk
FHWA Resource Center

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National Webinar

U.S. Department of Transportation
Federal Highway Administration

Housekeeping Items

- All participants are in listen only mode
- Questions will be taken through the chat pod
- Slides are available for download in the web room

Purpose

- This Webinar provides an introduction to the U.S. Environmental Protection Agency's (EPA) MOVES Onroad model within the context of regional transportation conformity analyses for ozone
- It is based on EPA's MOVES2014a 2-Day Hands-On Training Course for New MOVES Users
- This Webinar focuses on the types of information and data required for running MOVES
- It does not provide technical guidance or technical assistance for using MOVES in a regulatory application

Outline

- EPA resources and guidance
- Graphical user interface
- Navigation panel
- County Data Manager
- Summarizing data needs and sources
- Obtaining results
- Training and technical assistance

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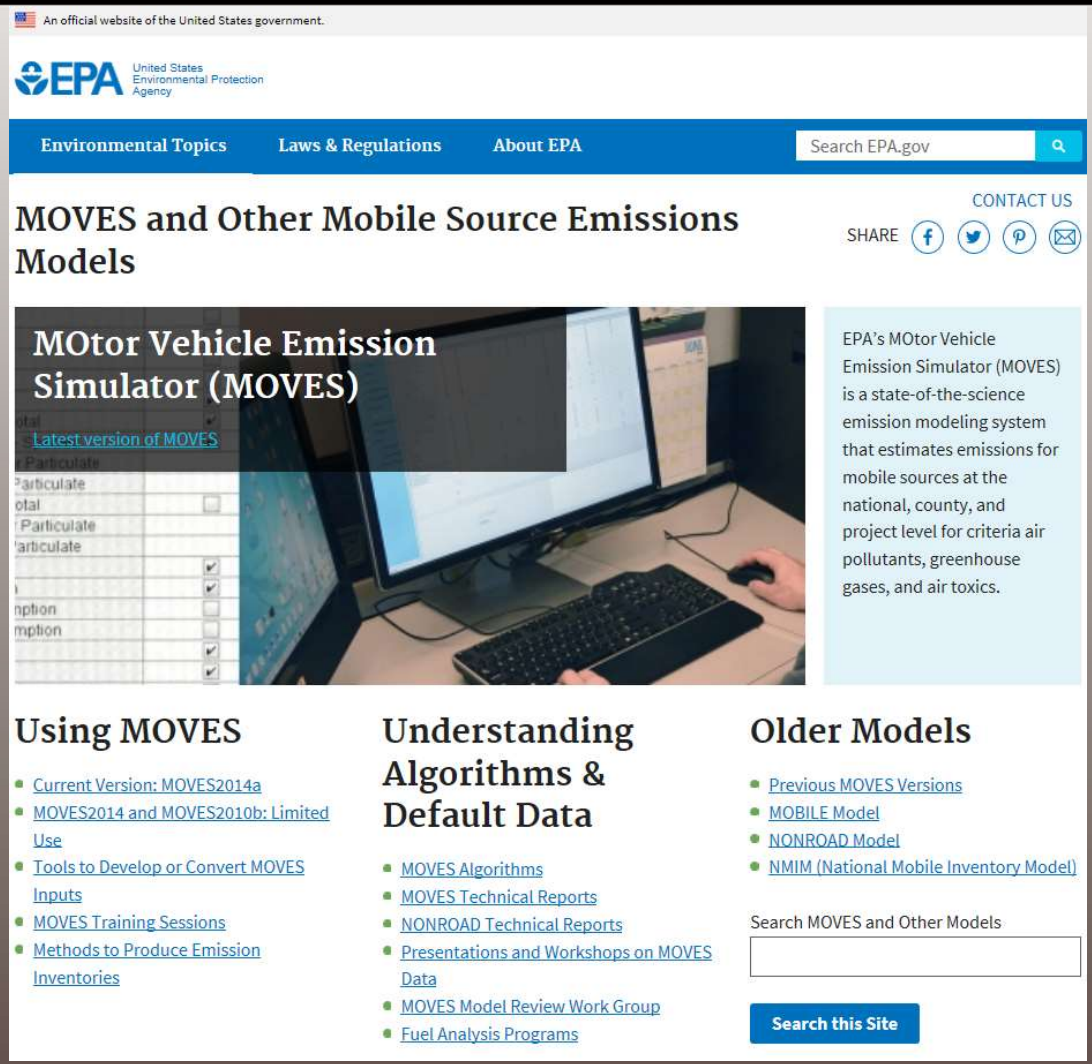
MOtor Vehicle Emission Simulator (MOVES)

- EPA's model for estimating emissions from mobile sources
- The current version, MOVES2014a, is approved for regulatory applications of criteria air pollutants at the county and project-level in all states except California for:
  - New State Implementation Plans (SIPs)
  - Regional transportation conformity analyses
  - Project-level transportation conformity analyses

EPA Resources (https://www.epa.gov/moves)



EPA Guidance

- MOVES2014 SIP and Conformity Policy Guidance
  - Guidance on when MOVES should be used in SIPs and transportation conformity analyses
  - nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100K4EB.txt
- MOVES2014a Q&A document
  - nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100NNR0.txt
- MOVES2014 and MOVES2014a Technical Guidance
  - Detailed guidance on appropriate inputs for MOVES in SIPs and regional conformity analyses
  - Defaults vs. local information
  - Developing appropriate local inputs
  - nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100NN9L.txt

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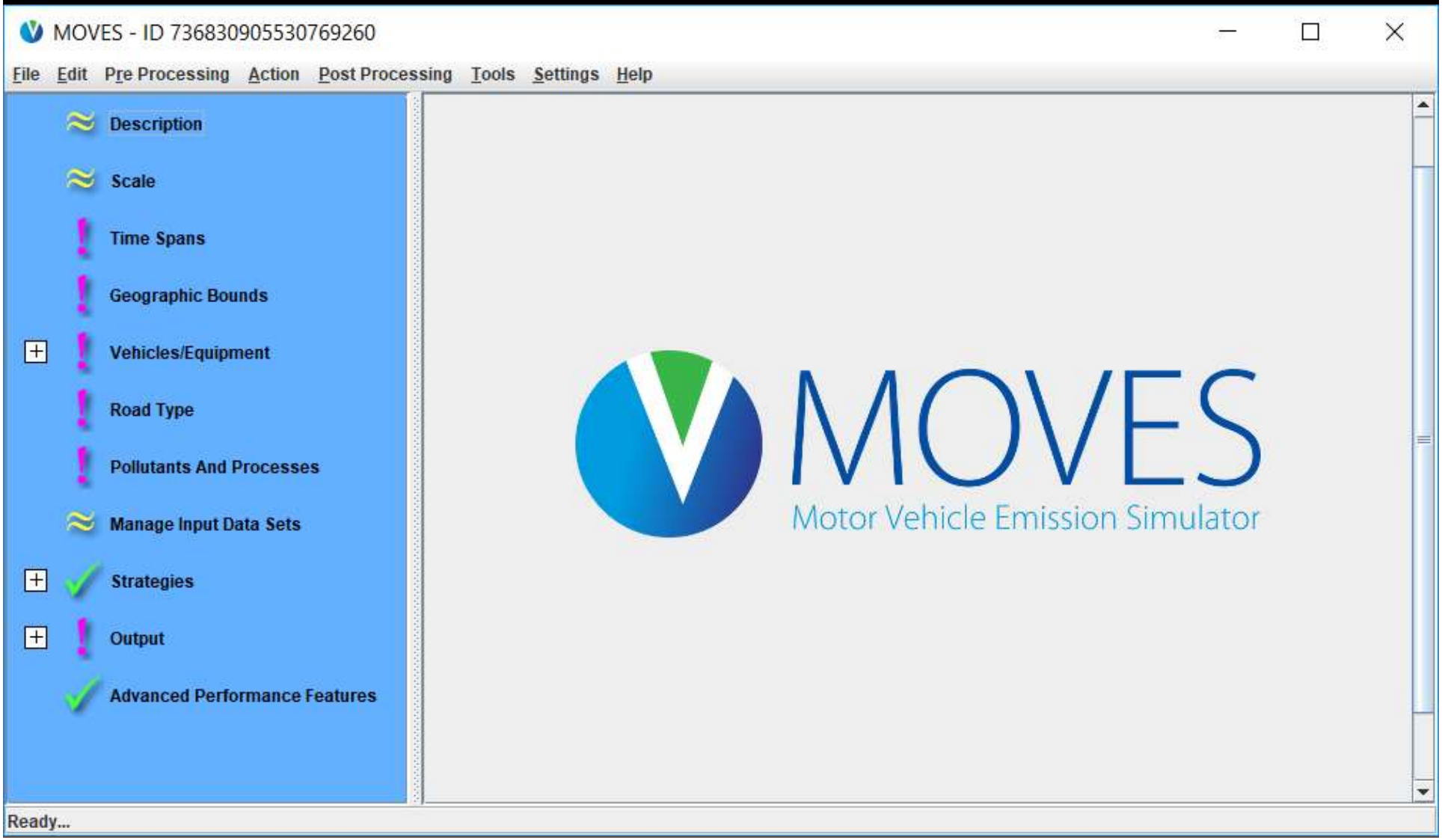
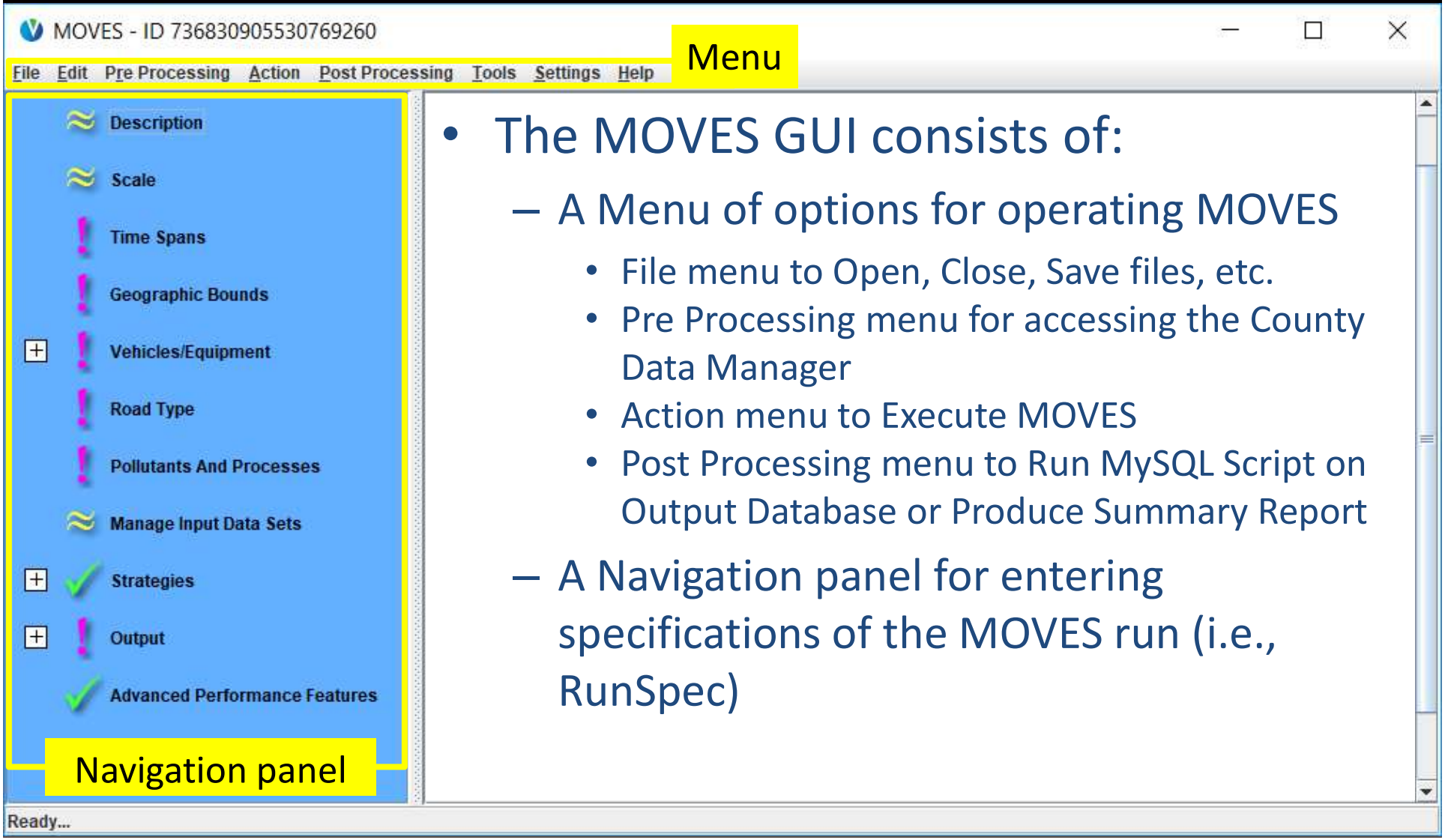
Graphical User Interface (GUI)

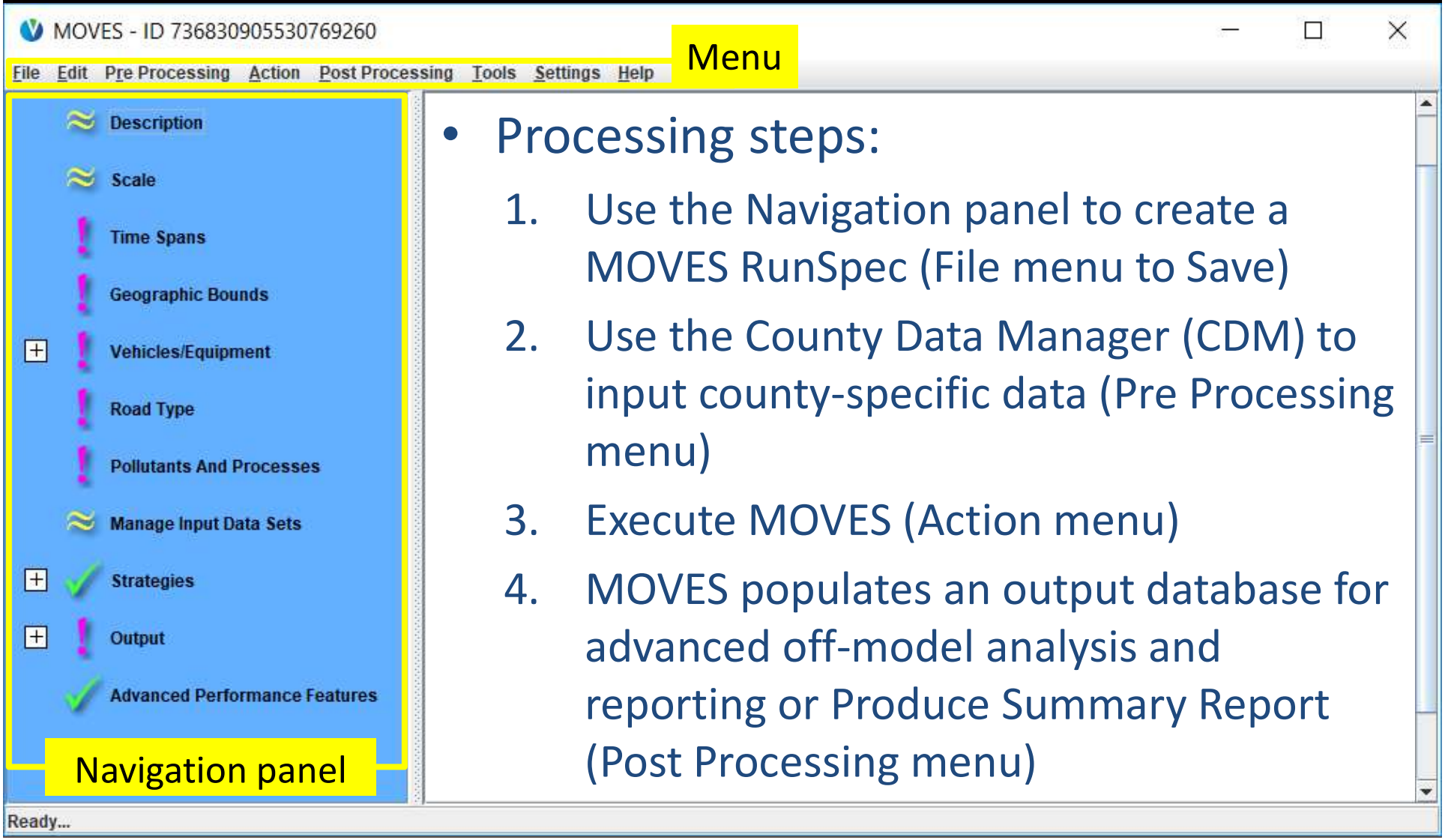


Graphical User Interface (GUI)



- The MOVES GUI consists of:
  - A Menu of options for operating MOVES
    - File menu to Open, Close, Save files, etc.
    - Pre Processing menu for accessing the County Data Manager
    - Action menu to Execute MOVES
    - Post Processing menu to Run MySQL Script on Output Database or Produce Summary Report
  - A Navigation panel for entering specifications of the MOVES run (i.e., RunSpec)

Graphical User Interface (GUI)



- Processing steps:
  1. Use the Navigation panel to create a MOVES RunSpec (File menu to Save)
  2. Use the County Data Manager (CDM) to input county-specific data (Pre Processing menu)
  3. Execute MOVES (Action menu)
  4. MOVES populates an output database for advanced off-model analysis and reporting or Produce Summary Report (Post Processing menu)

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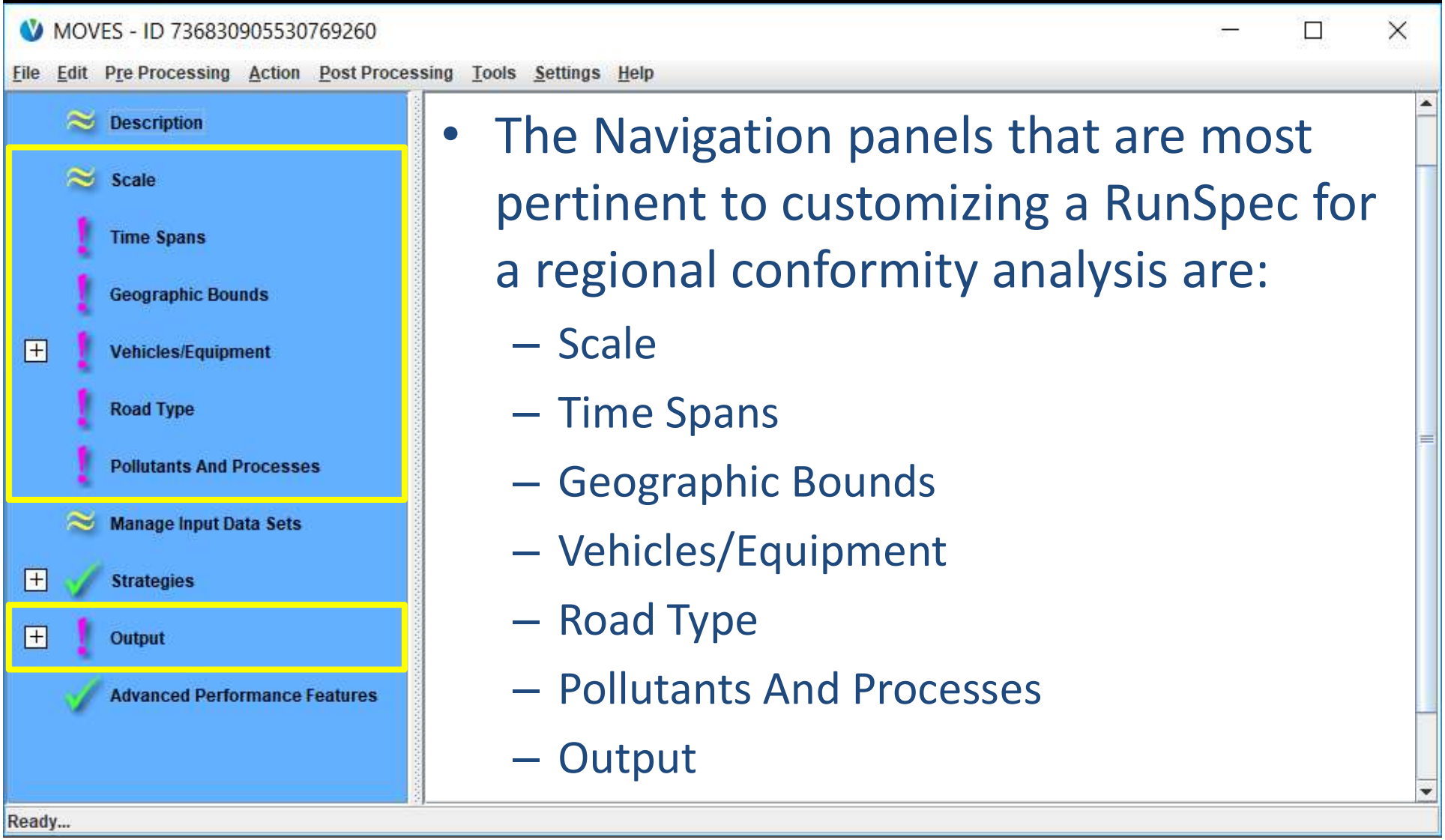
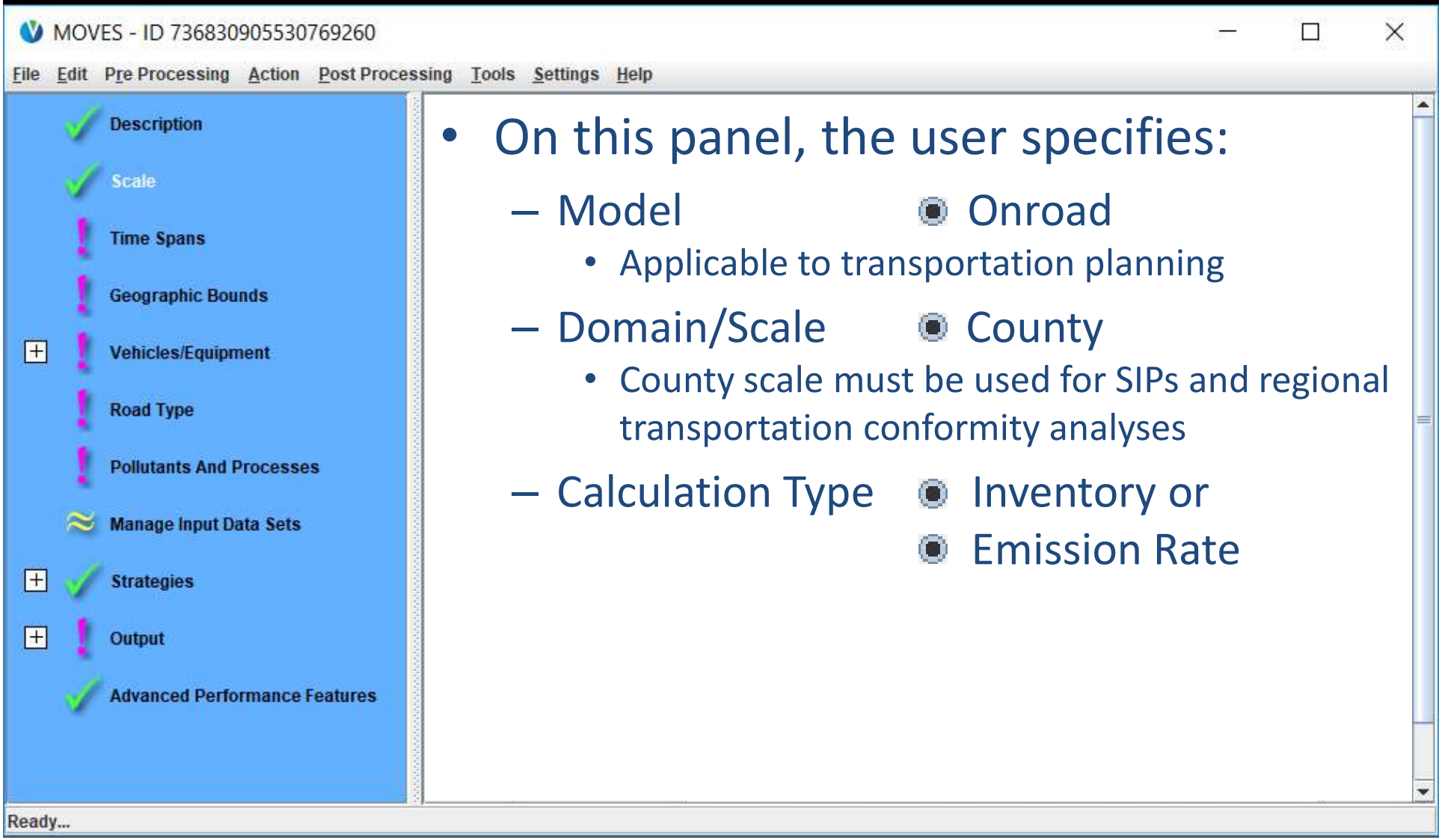
Navigation Panel



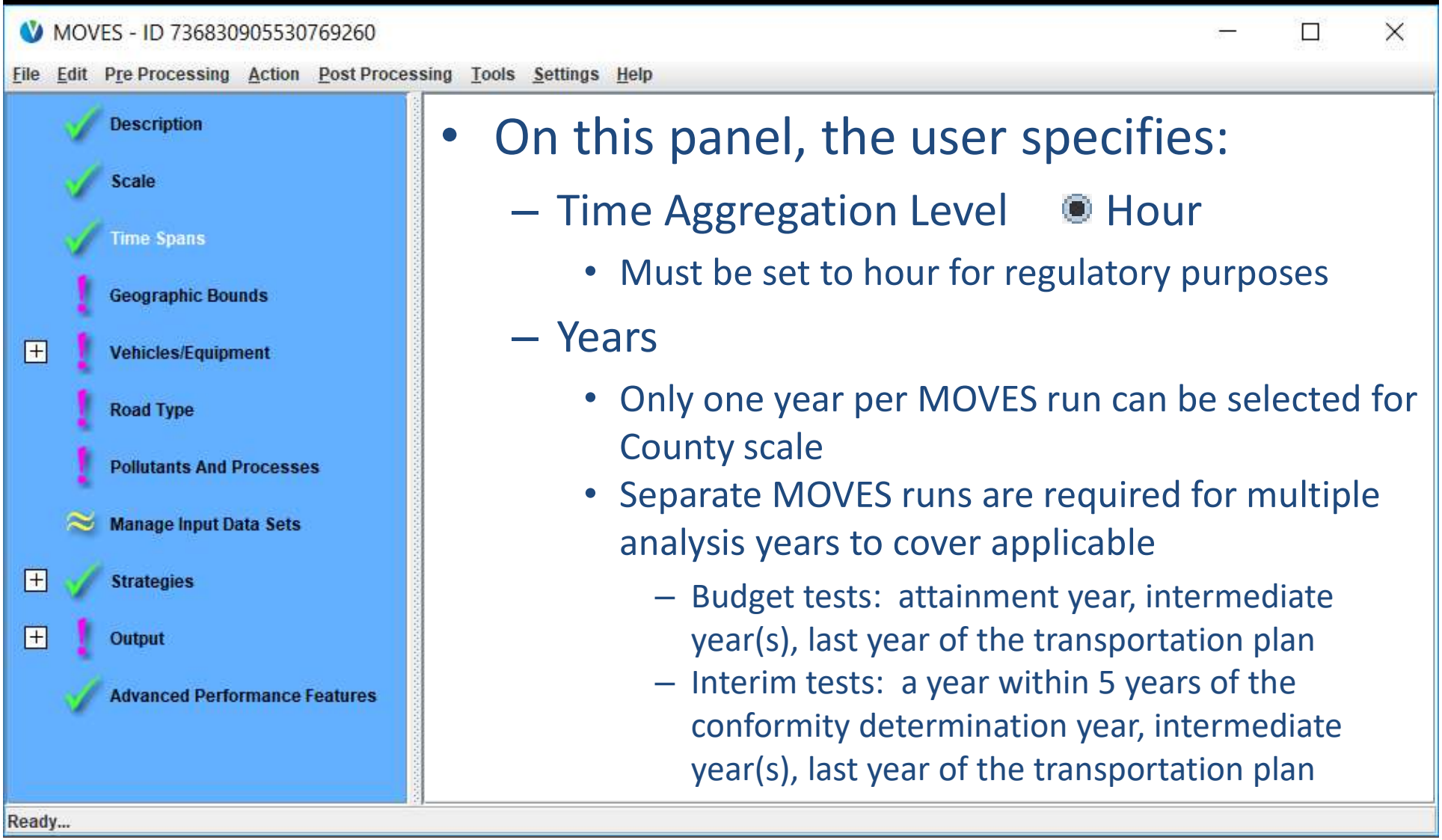
- The Navigation panels that are most pertinent to customizing a RunSpec for a regional conformity analysis are:
  - Scale
  - Time Spans
  - Geographic Bounds
  - Vehicles/Equipment
  - Road Type
  - Pollutants And Processes
  - Output

Scale panel



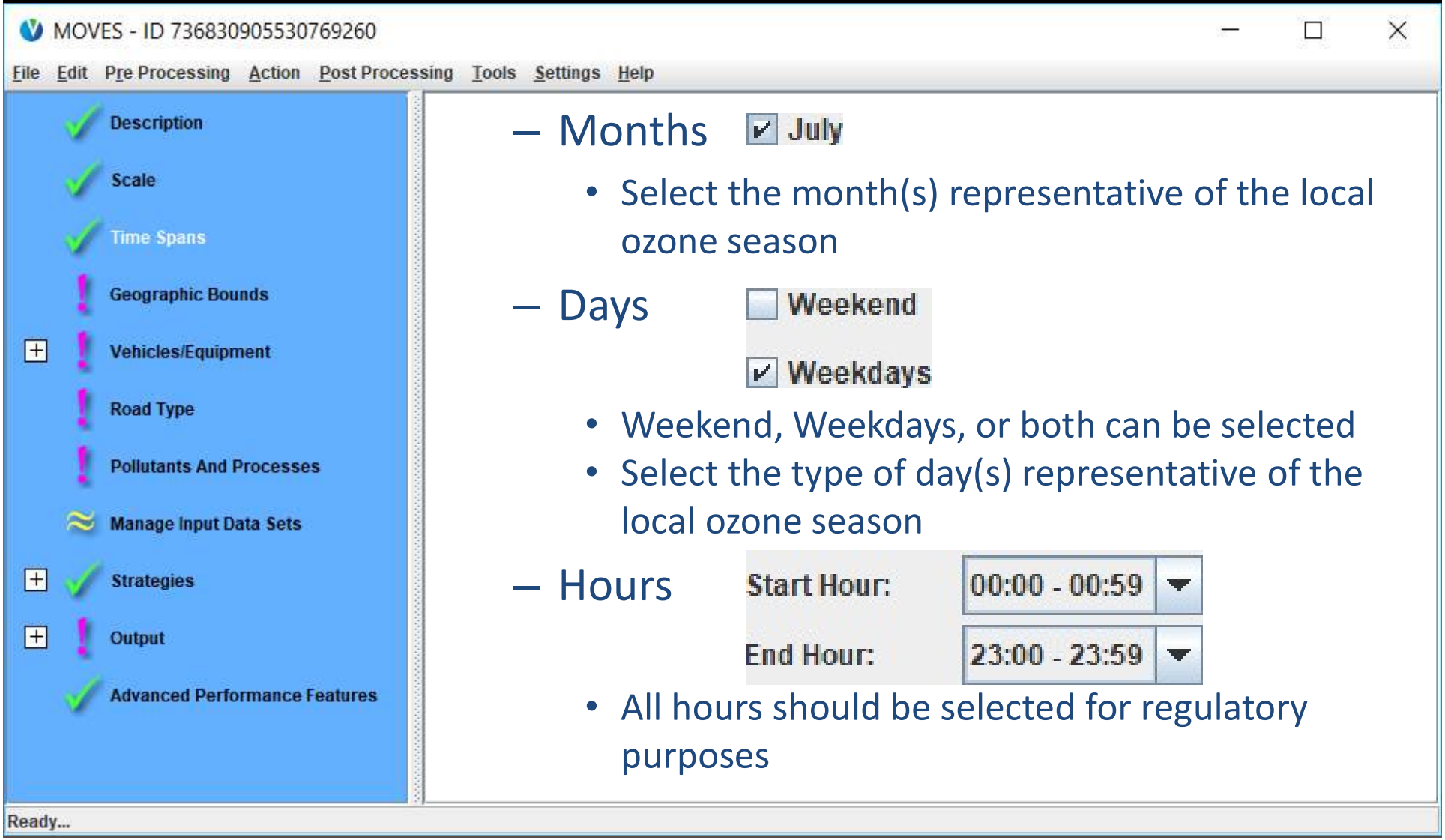
- On this panel, the user specifies:
  - Model — Onroad
    - Applicable to transportation planning
  - Domain/Scale — County
    - County scale must be used for SIPs and regional transportation conformity analyses
  - Calculation Type — Inventory or Emission Rate

Time Spans panel

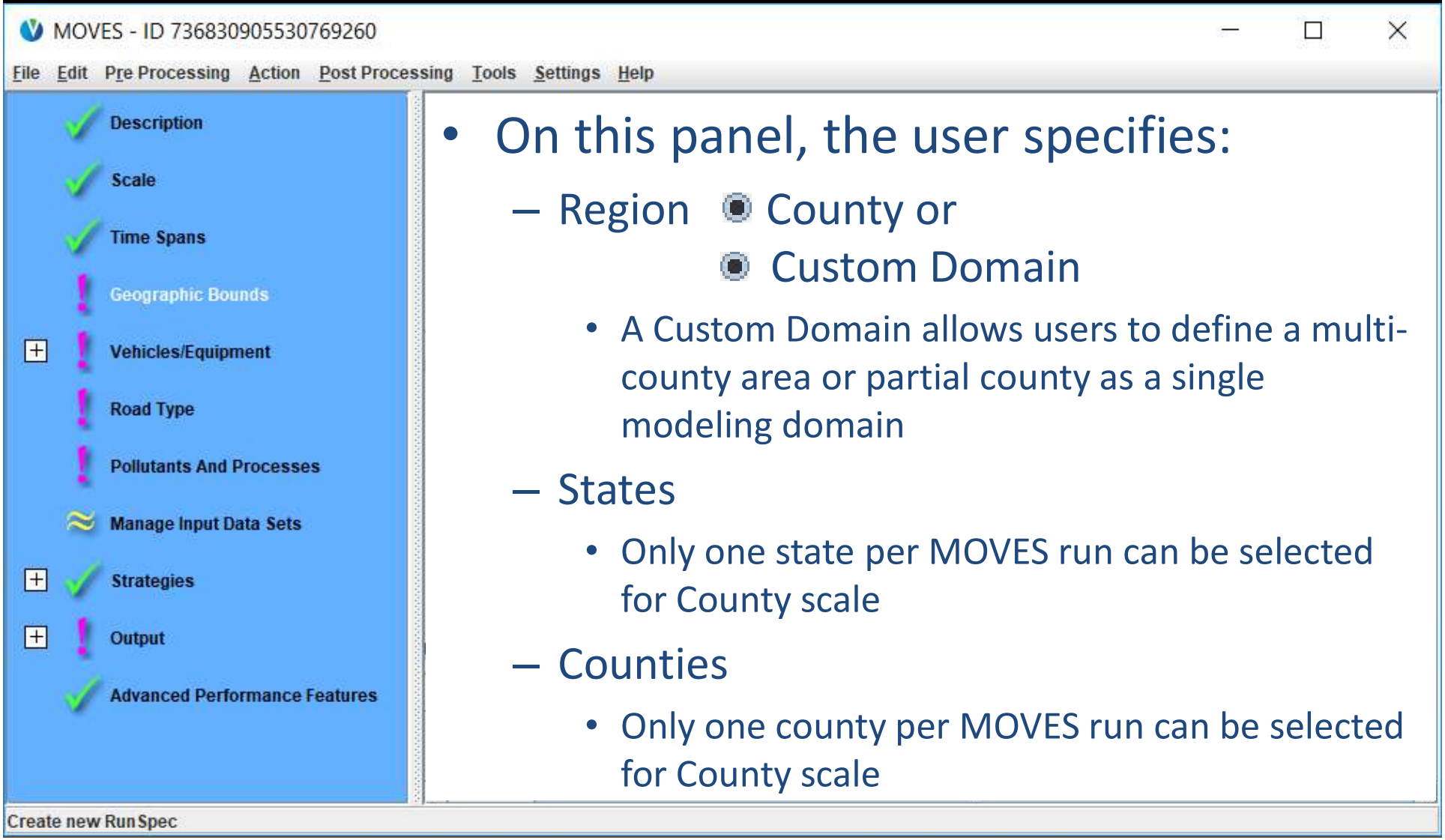


- On this panel, the user specifies:
  - Time Aggregation Level ◉ Hour
    - Must be set to hour for regulatory purposes
  - Years
    - Only one year per MOVES run can be selected for County scale
    - Separate MOVES runs are required for multiple analysis years to cover applicable
      - Budget tests: attainment year, intermediate year(s), last year of the transportation plan
      - Interim tests: a year within 5 years of the conformity determination year, intermediate year(s), last year of the transportation plan

Time Spans panel

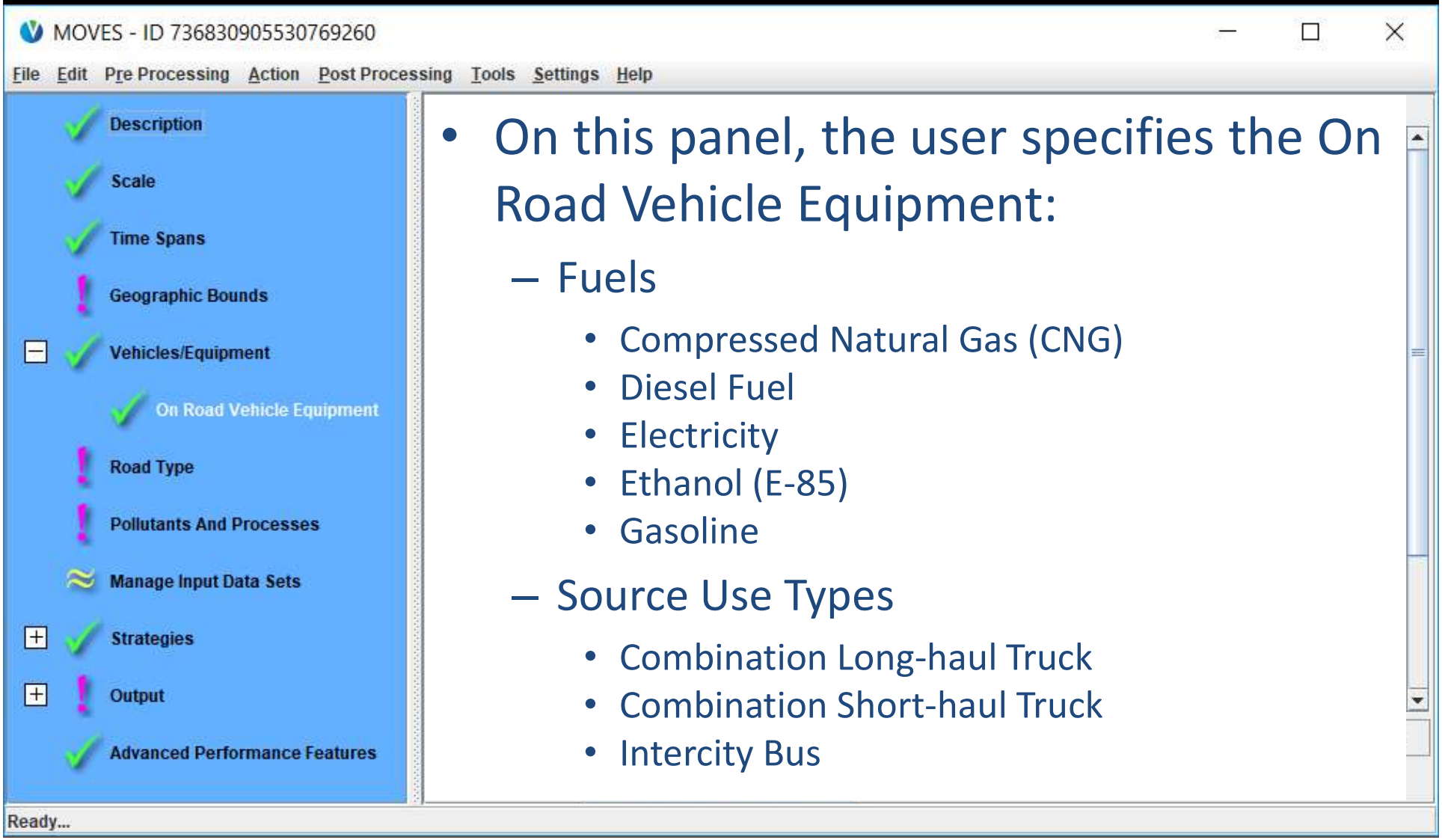


Geographic Bounds panel



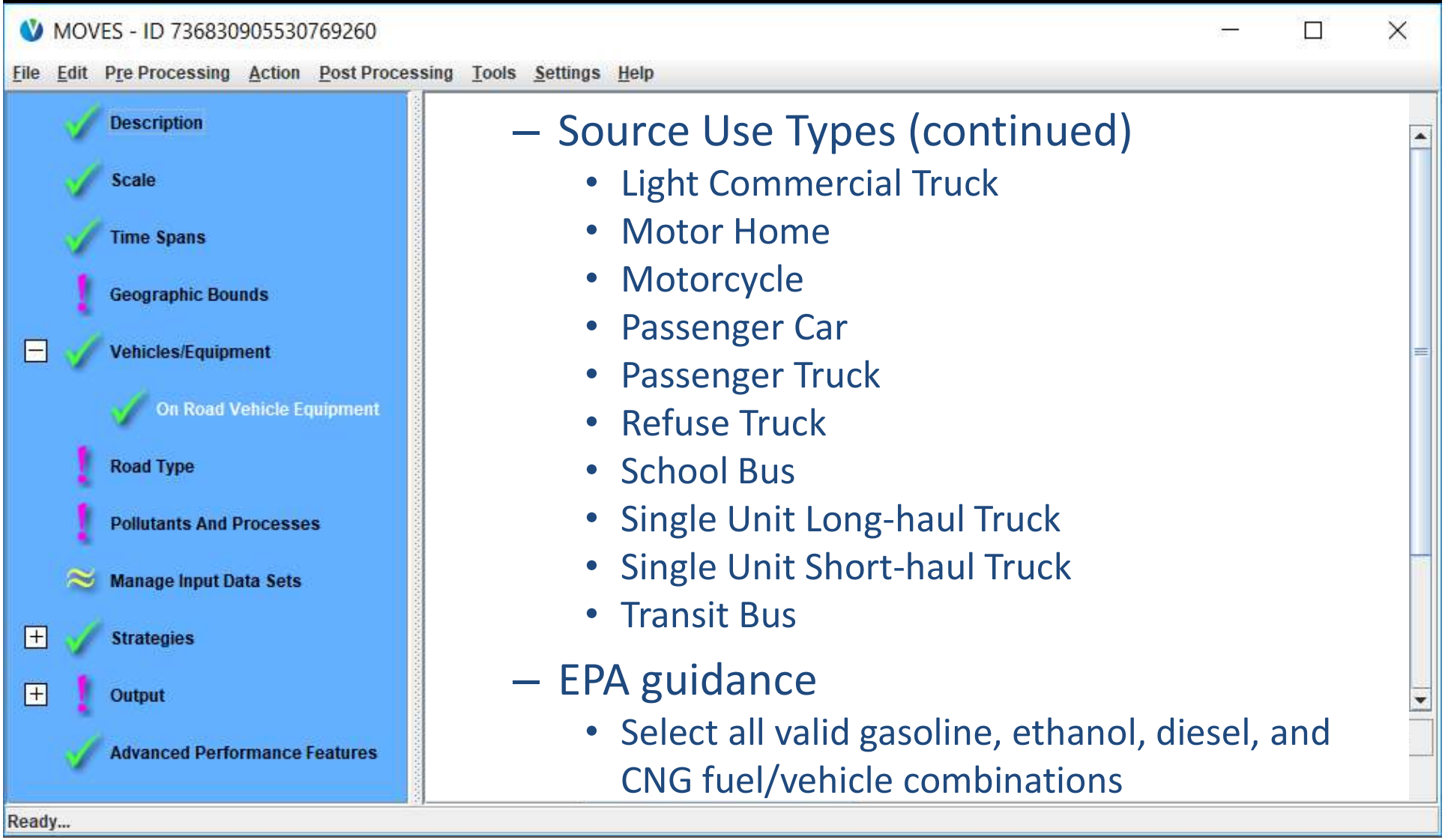
- On this panel, the user specifies:
  - Region ◉ County or
    ◉ Custom Domain
    - A Custom Domain allows users to define a multi-county area or partial county as a single modeling domain
  - States
    - Only one state per MOVES run can be selected for County scale
  - Counties
    - Only one county per MOVES run can be selected for County scale

Vehicles/Equipment panel



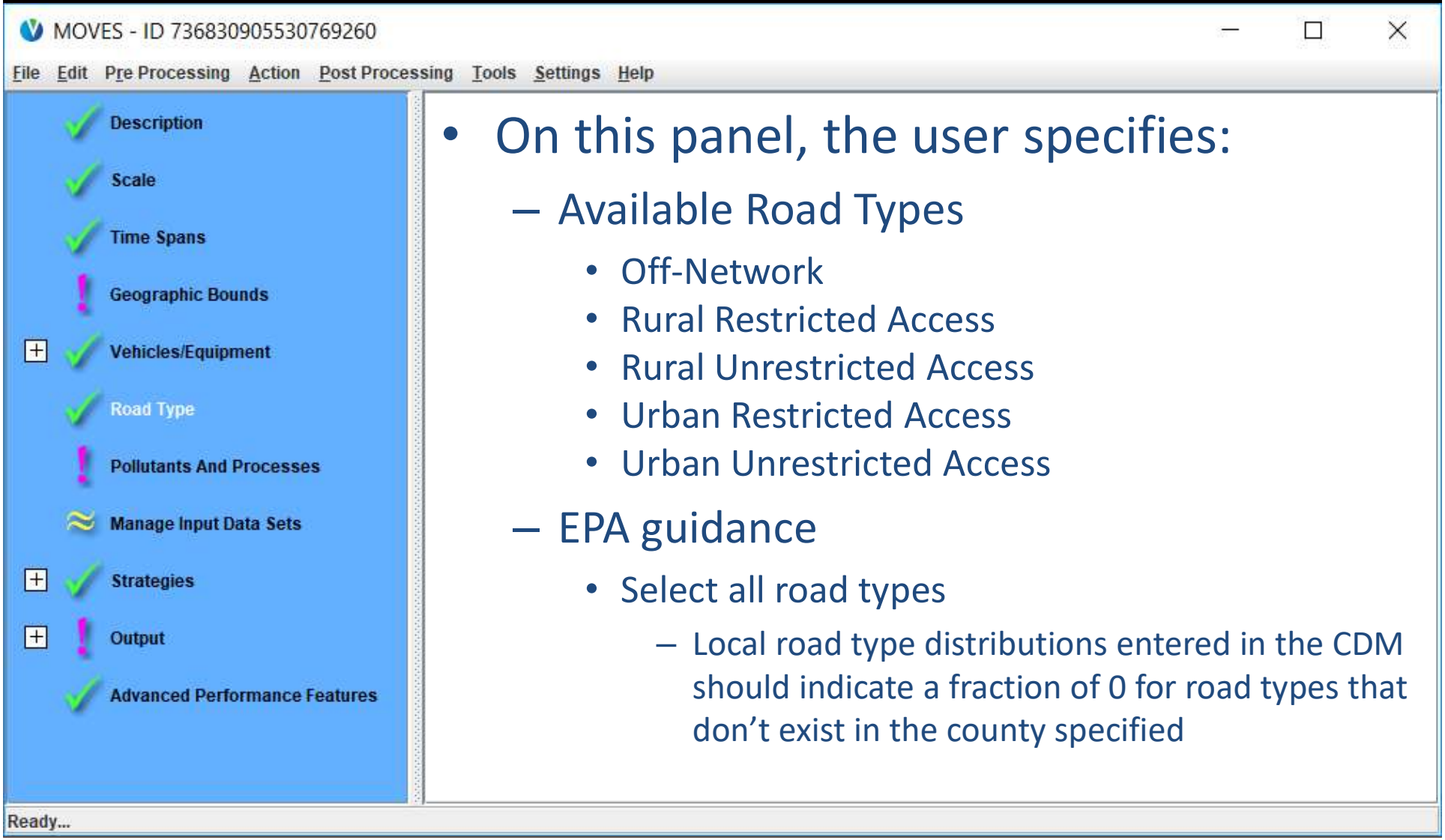
- On this panel, the user specifies the On Road Vehicle Equipment:
  - Fuels
    - Compressed Natural Gas (CNG)
    - Diesel Fuel
    - Electricity
    - Ethanol (E-85)
    - Gasoline
  - Source Use Types
    - Combination Long-haul Truck
    - Combination Short-haul Truck
    - Intercity Bus

Vehicles/Equipment panel



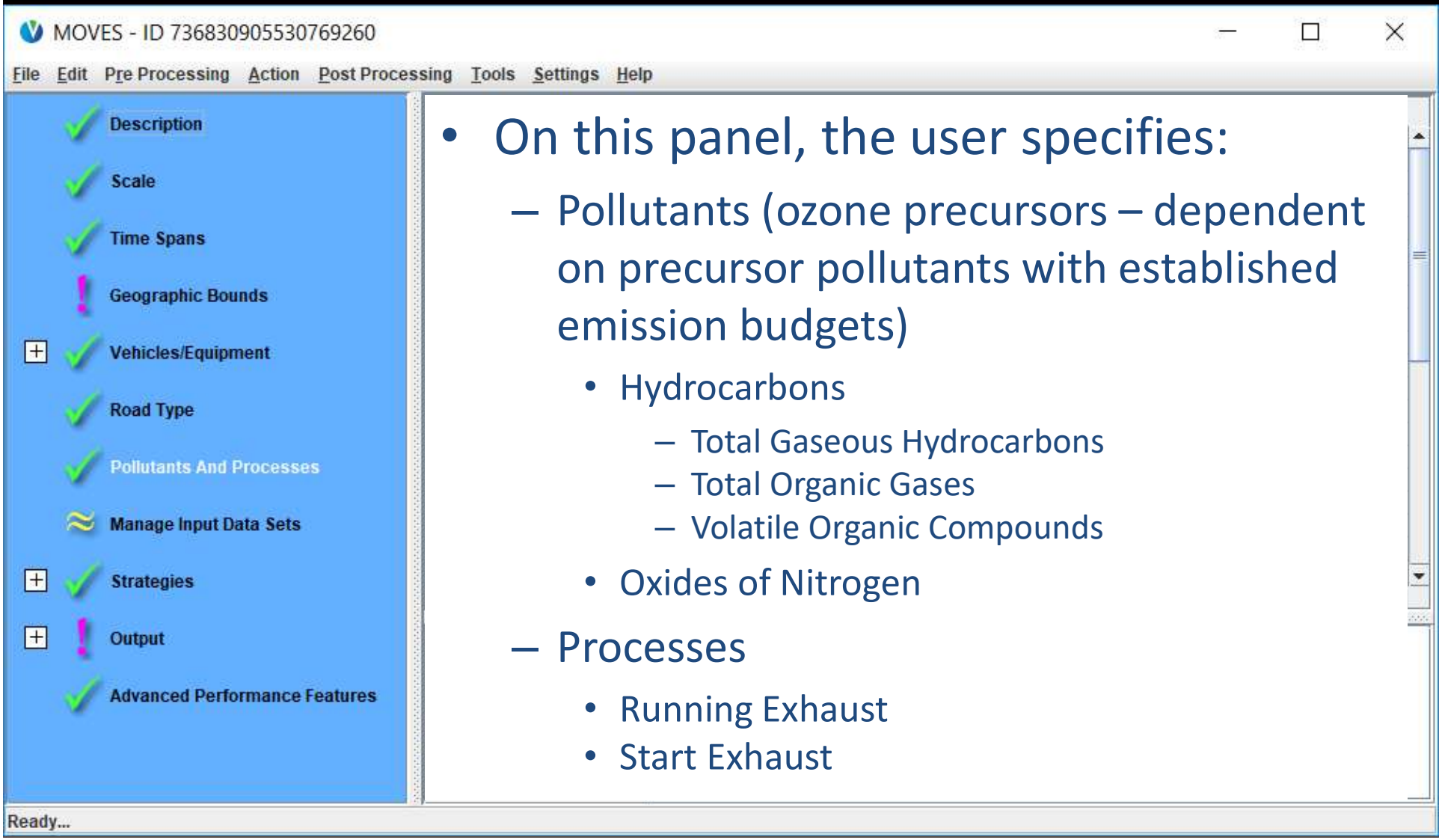
- Source Use Types (continued)
  - Light Commercial Truck
  - Motor Home
  - Motorcycle
  - Passenger Car
  - Passenger Truck
  - Refuse Truck
  - School Bus
  - Single Unit Long-haul Truck
  - Single Unit Short-haul Truck
  - Transit Bus
- EPA guidance
  - Select all valid gasoline, ethanol, diesel, and CNG fuel/vehicle combinations

Road Type panel



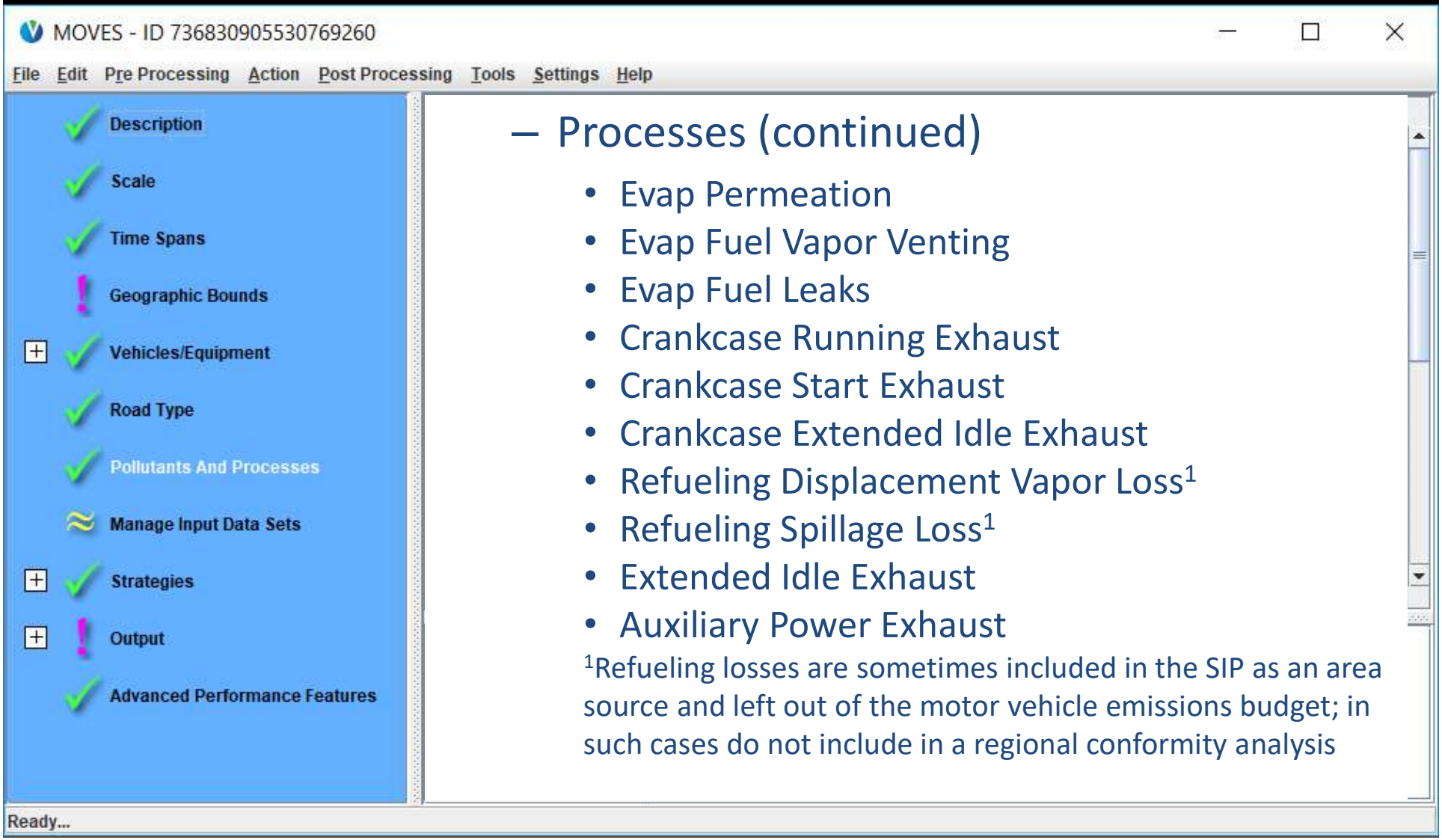
- On this panel, the user specifies:
  - Available Road Types
    - Off-Network
    - Rural Restricted Access
    - Rural Unrestricted Access
    - Urban Restricted Access
    - Urban Unrestricted Access
  - EPA guidance
    - Select all road types
      - Local road type distributions entered in the CDM should indicate a fraction of 0 for road types that don't exist in the county specified

Pollutants And Processes panel



- On this panel, the user specifies:
  - Pollutants (ozone precursors – dependent on precursor pollutants with established emission budgets)
    - Hydrocarbons
      - Total Gaseous Hydrocarbons
      - Total Organic Gases
      - Volatile Organic Compounds
    - Oxides of Nitrogen
  - Processes
    - Running Exhaust
    - Start Exhaust

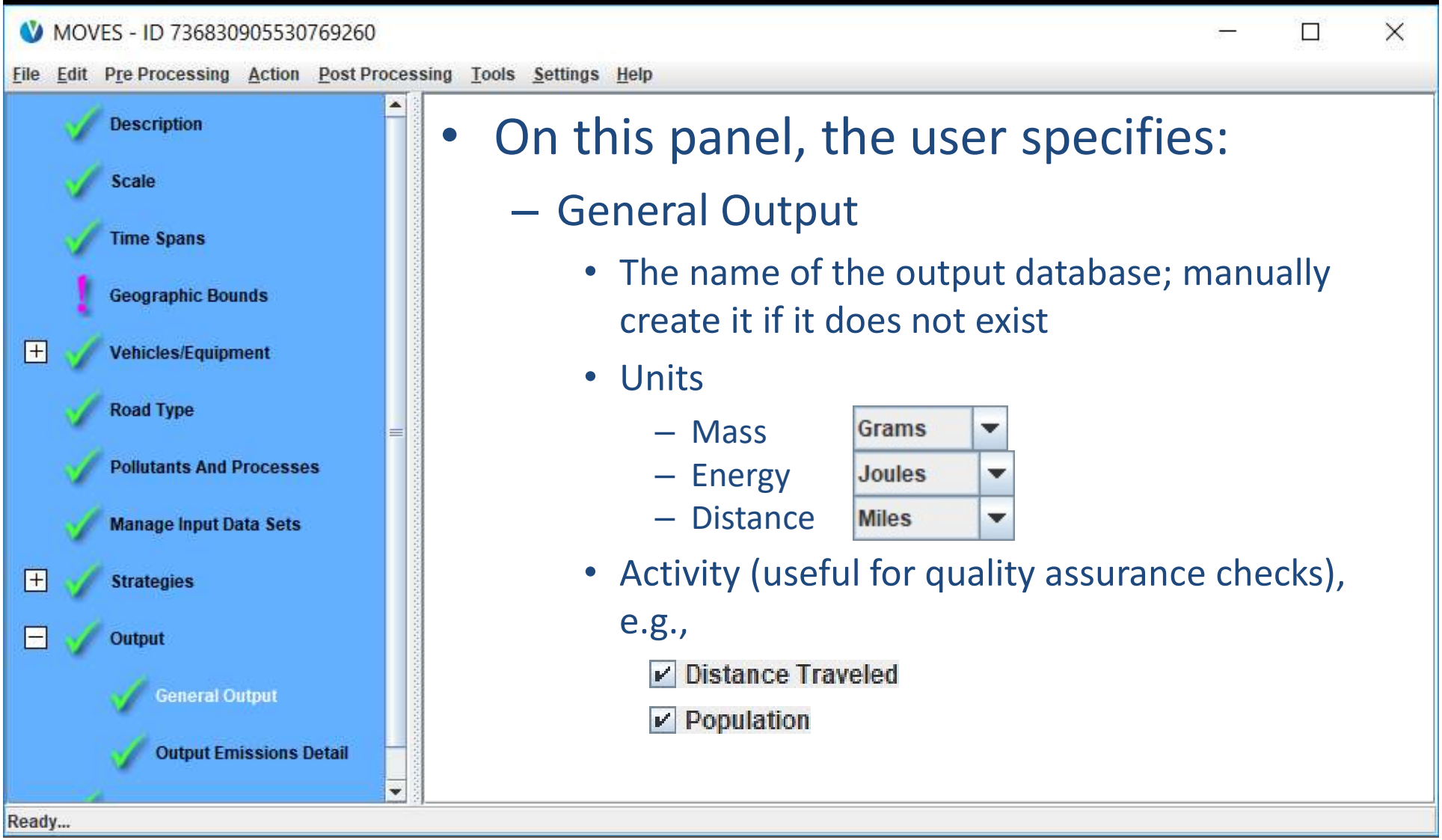
Pollutants And Processes panel



- Processes (continued)
  - Evap Permeation
  - Evap Fuel Vapor Venting
  - Evap Fuel Leaks
  - Crankcase Running Exhaust
  - Crankcase Start Exhaust
  - Crankcase Extended Idle Exhaust
  - Refueling Displacement Vapor Loss[1]
  - Refueling Spillage Loss[1]
  - Extended Idle Exhaust
  - Auxiliary Power Exhaust

[1]Refueling losses are sometimes included in the SIP as an area source and left out of the motor vehicle emissions budget; in such cases do not include in a regional conformity analysis

Output panel

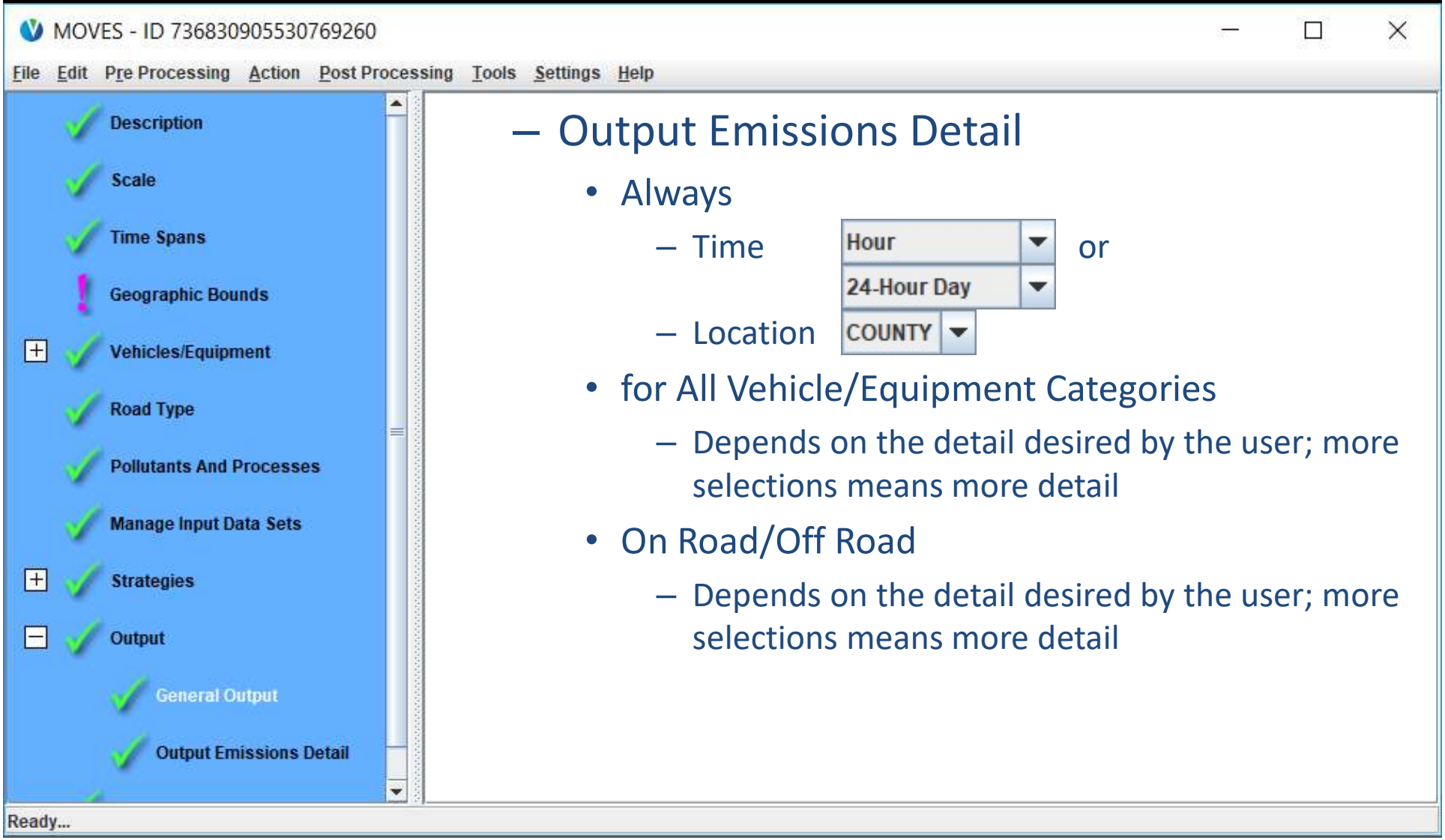


- On this panel, the user specifies:
  - General Output
    - The name of the output database; manually create it if it does not exist
    - Units
      - Mass
      - Energy
      - Distance

      Grams
      Joules
      Miles
    - Activity (useful for quality assurance checks), e.g.,

      ☑ Distance Traveled
      ☑ Population

Output panel



- Output Emissions Detail
  - Always
    - Time Hour or 24-Hour Day
    - Location COUNTY
  - for All Vehicle/Equipment Categories
    - Depends on the detail desired by the user; more selections means more detail
  - On Road/Off Road
    - Depends on the detail desired by the user; more selections means more detail

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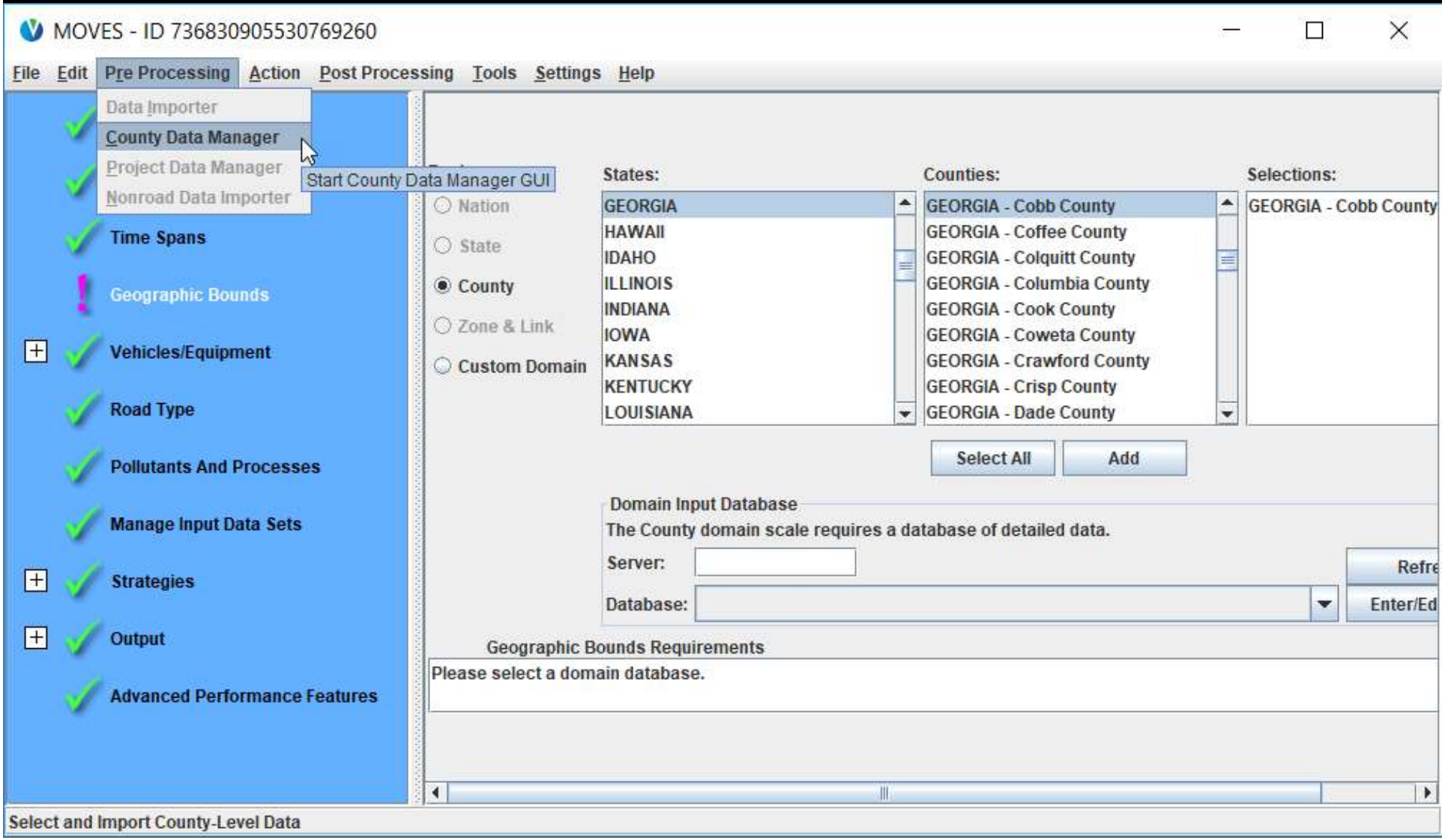
County Data Manager (CDM)



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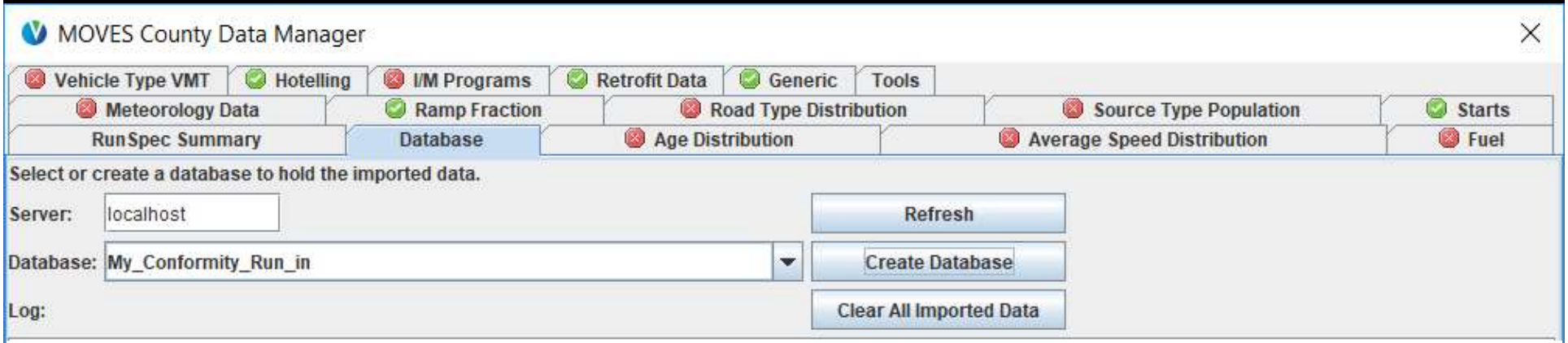
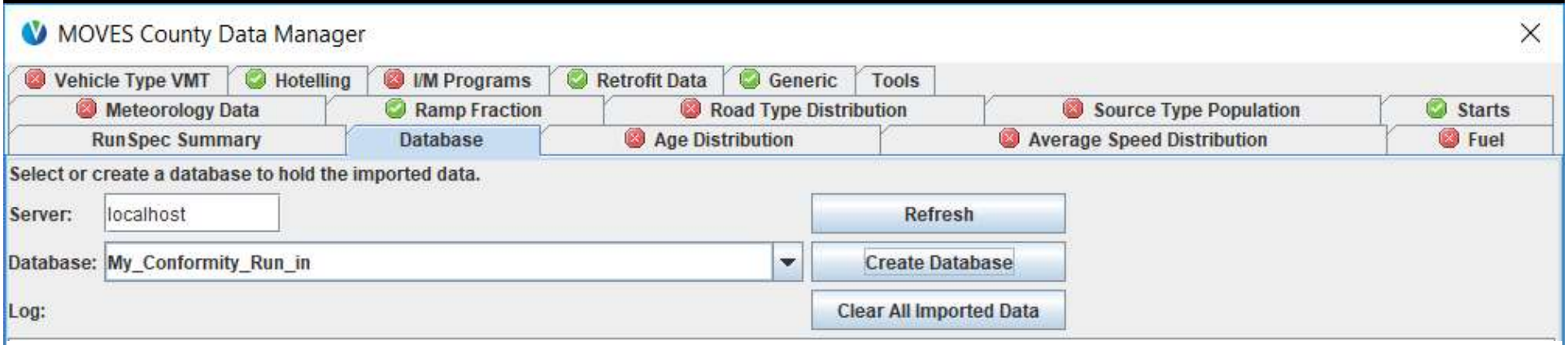


- Data are not entered directly in the CDM
- Data are entered on Excel Worksheets
- All tabs provide an option to create a worksheet template pre-populated with some data based on entries made in the RunSpec created in the Navigation Panel

County Data Manager (CDM)



- Templates contain the proper fields/column headings, but have blank cells for user-specified data
- Data are imported into CDM from an Excel worksheet that has been properly formatted with the correct columns

Age Distribution tab

- Age fractions of fleet by age, year and MOVES source type

	A	B	C	D
1	sourceTypeID	yearID	ageID	ageFraction

- No defaults available in CDM
- National defaults and projection tool available on MOVES Tools web page:
  - https://www.epa.gov/moves/tools-develop-or-convert-moves-inputs#fleet

Age Distribution tab

- EPA Guidance
  - Local age distribution data are recommended and encouraged
  - Example: estimated from motor vehicle registration data
  - Refer to Section 4.4 of MOVES Technical Guidance

Average Speed Distribution tab

- Average speed fraction by average speed bin, hour, road type and MOVES source type

	A	B	C	D	E
1	sourceTypeID	roadTypeID	hourDayID	avgSpeedBinID	avgSpeedFraction

- No local defaults are available in CDM, only National defaults

MOVES Speed Bins

Speed Bin ID	Average Bin Speed (mph)	Speed Bin Range
1	2.5	Speed < 2.5 mph
2	5	2.5 mph ≤ Speed < 7.5 mph
3	10	7.5 mph ≤ Speed < 12.5 mph
4	15	12.5 mph ≤ Speed < 17.5 mph
5	20	17.5 mph ≤ Speed < 22.5 mph
6	25	22.5 mph ≤ Speed < 27.5 mph
7	30	27.5 mph ≤ Speed < 32.5 mph
8	35	32.5 mph ≤ Speed < 37.5 mph
9	40	37.5 mph ≤ Speed < 42.5 mph
10	45	42.5 mph ≤ Speed < 47.5 mph
11	50	47.5 mph ≤ Speed < 52.5 mph
12	55	52.5 mph ≤ Speed < 57.5 mph
13	60	57.5 mph ≤ Speed < 62.5 mph
14	65	62.5 mph ≤ Speed < 67.5 mph
15	70	67.5 mph ≤ Speed < 72.5 mph
16	75	72.5 mph ≤ Speed

Average Speed Distribution tab

- EPA guidance
  - Local speed distribution by road type and source type is necessary
  - Examples: post-process the output from a travel demand forecasting model; process local on-vehicle Global Positioning System data
  - Refer to Section 4.6 of MOVES Technical Guidance

Fuel tab

- The Fuel tab contains four data tables:

1. Fuel Supply

	A	B	C	D	E	F
1	fuelRegionID	fuelYearID	monthGroupID	fuelFormulationID	marketShare	marketShareCV

2. Fuel Formulation

	A	B	C	D	E	F	G	H
1	fuelFormulationID	fuelSubtypeID	RVP	sulfurLevel	ETOHVolume	MTBEVolume	ETBEVolume	TAMEVolume

I	J	K	L	M	N
aromaticContent	olefinContent	benzeneContent	e200	e300	BioDieselEsterVolume

O	P	Q	R
CetaneIndex	PAHContent	T50	T90

Fuel tab

3. Fuel Usage Fraction

	A	B	C	D	E	F
1	countyID	fuelYearID	modelYearGroupID	sourceBinFuelTypeID	fuelSupplyFuelTypeID	usageFraction

4. AVFT (Alternate Vehicle and Fuel Technology)

	A	B	C	D	E
1	sourceTypeID	modelYearID	fuelTypeID	engTechID	fuelEngFraction

- County level defaults available in CDM

Fuel tab

- EPA guidance
  - Review default data and only make changes where precise local information is available
    - Exception: change the value for Reid Vapor Pressure to reflect any specific local regulatory requirements and differences between ethanol-and non-ethanol blended gasoline not reflected in the default database
  - Refer to Section 4.9 of MOVES Technical Guidance

Meteorology Data tab

- Temperature and humidity inputs

	A	B	C	D	E
1	monthID	zoneID	HourID	temperature	relHumidity

- County level defaults available in CDM
- EPA guidance
  - Local temperature and humidity data are required inputs for regional conformity analysis with MOVES
  - Temperatures for regional conformity analysis must be consistent with those used to establish the motor vehicle emissions budgets in the SIP as required in the transportation conformity rule
  - Refer to Section 4.2 of MOVES Technical Guidance

Ramp Fraction Data tab

- Fraction of freeway vehicle-hours traveled (VHT) occurring on ramps for limited access roadway types

	A	B
1	roadTypeID	rampFraction

- Optional input
- National default available in CDM
- EPA guidance
  - Estimates of local ramp fraction are recommended
  - Example: information from travel demand forecasting models
  - Refer to Section 4.8 of MOVES Technical Guidance

Road Type Distribution tab

- VMT Fraction by road type and source type

	A	B	C
1	sourceTypeID	roadTypeID	roadTypeVMTFraction

- No defaults available in CDM
- EPA guidance
  - Local estimates of VMT by road type are needed
  - Should be consistent with the most recent information used for transportation planning
  - Example: information from travel demand forecasting models
  - Refer to Section 4.7 of MOVES Technical Guidance

Source Type Population tab

- Number (i.e., population) of local vehicles operating in the area

	A	B	C
1	yearID	sourceTypeID	sourceTypePopulation

- No defaults available in CDM
- EPA guidance
  - Local source type (vehicle type) population data are necessary
  - Examples: estimated from motor vehicle registration data; local transit agencies; school districts; bus companies; refuse haulers
  - Refer to Section 4.3 of MOVES Technical Guidance

Starts tab

- Provides information on vehicle starts per day by year, day and zone

	A	B	C	D
1	zoneID	dayID	yearID	startsPerDay

- Optional input
  - Default start activity determined by vehicle population
- EPA guidance
  - Use only if local start data are available; otherwise, rely on defaults
  - Refer to Section 4.12 of MOVES Technical Guidance

Vehicle Type VMT tab

- The Vehicle Type VMT tab contains four data tables:
  1. HPMS Vtype Year

	A	B	C
1	HPMSVtypeID	yearID	HPMSBaseYearVMT

     - Total annual or daily vehicle-miles traveled (VMT) by highway performance monitoring system (HPMS) vehicle type or MOVES source type
  2. Month VMT fractions

	A	B	C
1	sourcetypeID	monthID	monthVMTFraction

  3. Day VMT fractions

	A	B	C	D	E
1	sourceTypeID	monthID	roadTypeID	dayID	dayVMTFraction

Vehicle Type VMT tab

4. Hour VMT fractions

	A	B	C	D	E
1	sourceTypeid	roadTypeID	dayID	hourID	HourVMTFraction

- No defaults available for VMT in CDM
- National defaults available for month, day, and hour VMT fractions in CDM

Vehicle Type VMT tab

- EPA guidance
  - Local VMT estimates are needed and local month, day, and hour VMT fractions are recommended
  - Example: information from travel demand forecasting models developed by Metropolitan Planning Organizations and state Departments of Transportation
  - Refer to Section 4.5 of MOVES Technical Guidance

MOVES Source Types / HPMS Vehicle Types

Source Type ID	Source Types	HPMS Class ID	HPMS Vehicle Class
11	Motorcycle	10	Motorcycles
21	Passenger Car	25	Light Duty Vehicles – Short and Long Wheelbase
31	Passenger Truck		
32	Light Commercial Truck		
41	Intercity Bus	40	Buses
42	Transit Bus		
43	School Bus		
51	Refuse Truck	50	Single Unit Trucks
52	Single Unit Short-haul Truck		
53	Single Unit Long-haul Truck		
54	Motor Home		
61	Combination Short-haul Truck	60	Combination Trucks
62	Combination Long-haul Truck		

Hotelling tab

- The Hotelling tab contains two data tables:
  1. Hotelling Activity Distribution

	A	B	C	D
1	beginModelYearID	endModelYearID	opModeID	opModeFraction

  2. Hotelling Hours

	A	B	C	D	E	F	G
1	hourDayID	monthID	yearID	ageID	zoneID	sourceTypeID	hotellingHours

- Optional input
  - Default hotelling hours are determined by local road type distribution

Hotelling tab

- National defaults available in CDM
- EPA Guidance
  - Use only if local hotelling data are available; otherwise, rely on defaults
  - Refer to Section 4.13 of MOVES Technical Guidance

I/M Programs tab

- Data on inspection/maintenance (I/M) program(s), if any

	A	B	C	D	E	F	G	H	I
1	polProcessID	stateID	countyID	yearID	sourceTypeID	fuelTypeID	IMProgramID	inspectFreq	testStandardsID

J	K	L	M
begModelYearID	endModelYearID	useIMyn	complianceFactor

- County level defaults available in CDM
- EPA guidance
  - Review the details of the I/M program and make any necessary changes to match the actual local program
  - Refer to Section 4.10 of MOVES Technical Guidance

Retrofit Data tab

- Defines retrofit programs

	A	B	C	D	E	F	G
1	pollutantID	processID	fuelTypeID	sourceTypeID	retrofitYearID	beginModelYearID	endModelYearID

H	I
cumFractionRetrofit	retrofitEffectiveFraction

- Optional input
- No defaults available in CDM

Retrofit Data tab

- EPA guidance
  - Not a required input
  - Refer to Section 4.14 of MOVES Technical Guidance
  - Consult EPA's SIP and Conformity Retrofit Guidance for additional information
    - www.epa.gov/otaq/stateresources/transconf/policy.htm#quantify

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Summarizing Data Needs and Sources

Item	Navigation Panel	Recommendations
1	Description	• Use this to document the purpose of each run
2	Scale	• Model – Onroad • Domain/Scale – County • Calculation Type – Inventory or Emission Rate
3	Time Spans	• Time Aggregation Level – Hour • Years – Separate MOVES runs are required for multiple analysis years to cover applicable budget tests and interim tests • Month(s) – Ozone season (e.g., July) • Days – Weekends, Weekdays, or both • Hours – All hours
4	Geographic Bounds	• Region – County or Custom Domain • States – Only one state per run can be selected for County scale • Counties – Only one county per run can be selected for County scale
5	On Road Vehicle Equipment	• Select all valid gasoline, ethanol, diesel, and CNG fuel/vehicle combinations

Summarizing Data Needs and Sources

Item	Navigation Panel	Recommendations
6	Road Type	• Select all road types
7	Pollutants and Processes	• Pollutants – Select precursor pollutants with established emission budgets • Processes – Select all 12 processes, unless refueling losses are included in the SIP as an area source and omitted from the motor vehicle emissions budget
8	Manage Input Data Sets	• No selections needed
9	Strategies	• No selections needed
10	General Output	• Create output database, if needed • Specify Units of Mass, Energy, and Distance • Select Activity, if desired
11	Output Emissions Detail	• Time – Hour or 24-Hour Day • Location – County • For All Vehicle/Equipment Categories – Optional • On Road/Off Road - Optional
12	Advanced Performance Measures	• No selections needed

Summarizing Data Needs and Sources

Data	Run Detail		Data Sources			
	Same for All Runs	Vary by Analysis Year	Local MPO	State Air Agency	State DOT	MOVES Default
Age Distribution	●	Optional		●	●	
Average Speed Distribution		●	●		●	
Fuel | Fuel Supply		●		●		●
Fuel | Fuel Formulation		●		●		●
Fuel | Fuel Usage Fraction		●				●
Fuel | AVFT	●					●
Meteorology Data	●			●		
Ramp Fraction		●	●		●	
Road Type Distribution		●	●		●	
Source Type Population		●		●	●	
Starts			●			●
Vehicle Type VMT | HPMS Vehicle Type Year		●	●		●	
Vehicle Type VMT | Month VMT Fraction	●		●		●	●
Vehicle Type VMT | Day VMT Fraction	●		●		●	●
Vehicle Type VMT | Hour VMT Fraction	●		●		●	●
Hotelling			●			●
I/M Programs		●		●		●
Retrofit	Not a Required Input					

Summarizing Data Needs and Sources

Item	County Data Manager Tab	Recommendations
1	Age Distribution	• Local age distribution data are recommended and encouraged • Example: estimated from motor vehicle registration data • Refer to Section 4.4 of MOVES Technical Guidance
2	Average Speed Distribution	• Local speed distribution by road type and source type is necessary • Examples: post-process the output from a travel demand forecasting model; process local on-vehicle Global Positioning System data • Refer to Section 4.6 of MOVES Technical Guidance
3	Fuel	• Review default data and only make changes where precise local information is available • Exception: change the value for Reid Vapor Pressure to reflect any specific local regulatory requirements and differences between ethanol-and non-ethanol blended gasoline not reflected in the default database • Refer to Section 4.9 of MOVES Technical Guidance

Summarizing Data Needs and Sources

Item	County Data Manager Tab	Recommendations
4	Meteorology Data	• Local temperature and humidity data are required inputs for regional conformity analysis with MOVES • Temperatures for regional conformity analysis must be consistent with those used to establish the motor vehicle emissions budgets in the SIP as required in the transportation conformity rule • Refer to Section 4.2 of MOVES Technical Guidance
5	Ramp Fraction	• Estimates of local ramp fraction are recommended • Example: information from travel demand forecasting models • Refer to Section 4.8 of MOVES Technical Guidance
6	Road Type Distribution	• Local estimates of VMT by road type are needed • Should be consistent with the most recent information used for transportation planning • Example: information from travel demand forecasting models • Refer to Section 4.7 of MOVES Technical Guidance

Summarizing Data Needs and Sources

Item	County Data Manager Tab	Recommendations
7	Source Type Population	• Local source type (vehicle type) population data are necessary • Examples: estimated from motor vehicle registration data; local transit agencies; school districts; bus companies; refuse haulers • Refer to Section 4.3 of MOVES Technical Guidance
8	Starts	• Use only if local start data are available; otherwise, rely on defaults • Refer to Section 4.12 of MOVES Technical Guidance
9	Vehicle Type VMT	• Local VMT estimates are needed and local month, day, and hour VMT fractions are recommended • Example: information from travel demand forecasting models developed by Metropolitan Planning Organizations and state Departments of Transportation • Refer to Section 4.5 of MOVES Technical Guidance
10	Hotelling	• Use only if local hotelling data are available; otherwise, rely on defaults • Refer to Section 4.13 of MOVES Technical Guidance

Summarizing Data Needs and Sources

Item	County Data Manager Tab	Recommendations
11	I/M Programs	• Review the details of the I/M program and make any necessary changes to match the actual local program • Refer to Section 4.10 of MOVES Technical Guidance
12	Retrofit Data	• Not a required input • Refer to Section 4.14 of MOVES Technical Guidance • Consult EPA's SIP and Conformity Retrofit Guidance for additional information www.epa.gov/otaq/stateresources/transconf/policy.htm#quantify

- EPA resources and guidance
- Graphical user interface
- Navigation panel
- County Data Manager
- Summarizing data needs and sources
- Obtaining results
- Training and technical assistance

Obtaining Results

- MOVES output can be accessed via:
  - MySQL Workbench
    - Advantages: flexible and powerful for advanced off-model analysis and reporting
    - EPA recommends using MySQL Workbench for most analysis
  - MOVES Post Processing Summary Reporter
    - Advantages: quick and easy

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Training and Technical Assistance

- EPA
  - MOVES Training Sessions webpage
    - https://www.epa.gov/moves/moves-training-sessions
    - MOVES2014a 2-Day Hands-On Training Course for New MOVES Users
    - Webinar – MOVES2014a: Introduction and New Features
  - Technical assistance
    - Send inquires by email to: mobile@epa.gov or online at https://www.epa.gov/moves/forms/contact-us-about-moves-and-related-models

Training and Technical Assistance

- FHWA
  - The Resource Center Air Quality Technical Services Team offers training and technical assistance on an as needed basis arranged through the FHWA Division in your state. Please contact:
    - Michael Claggett – Michael.Claggett@dot.gov or
    - Jeff Houk – Jeff.Houk@dot.gov

Contacts

Federal Highway Administration
RESOURCE CENTER

U.S. Department of Transportation
Federal Highway Administration

Michael Claggett, Ph.D.

Air Quality Modeling Specialist

FHWA Resource Center

4001 Office Court Drive, Suite 800

Santa Fe, NM 87507

Phone: 505.870.0105

Fax: 505.820.2040

Michael.Claggett@dot.gov

www.fhwa.dot.gov/resourcecenter

Contacts

Federal Highway Administration
RESOURCE CENTER

U.S. Department of Transportation
Federal Highway Administration

Jeff Houk

Air Quality Specialist

FHWA Resource Center

12300 West Dakota Ave, Suite 340

Lakewood, CO 80228

Phone: 720.202.8747

Fax: 720.963.3232

Jeff.Houk@dot.gov

www.fhwa.dot.gov/resourcecenter