# MOVES-NONROAD Model Plans and Data Updates

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# Model Summary: Coverage

- First public release of stand-alone model in 1998
- Incremental updates in 2000, 2002, 2005, 2008, 2014
- Coded in FORTRAN95 and integrated into MOVES2014
- Temporal coverage: 1970-2050. Spatial coverage: county to national



Over 80 distinct equipment types. Excluded: locomotives, commercial marine vessels, aircraft

Over 200 fuel+equipment type combinations
Over 1200 fuel+equipment type+horsepower SCCs

# Model Summary: Coverage

## Pollutants



**Processes**

Running Exhaust

Crankcase Running Exhaust

Refueling Displacement Vapor Loss

Refueling Spillage Loss

Evap. Tank Permeation

Evap. Hose Permeation

Diurnal Fuel Vapor Venting

Hot Soak Fuel Vapor Venting

Running Loss Fuel Vapor Venting

→ **239 pollutant+process combinations**

# Model Summary: Methodology

Power algorithm approach to calculating NONROAD exhaust emissions:

| **Emissions** | = | **Population** | ✖ | **Activity** | ✖ | **Emission Factor** | ✖ | **Load Factor** | ✖ | **Rated Power** |
|---|---|---|---|---|---|---|---|---|---|---|

| (tons/year) | | Equipment population for a defined base year, to which growth factors and geographic and temporal allocations are applied | | Annual activity (hrs/year) | | In-use exhaust emission factor (g/hp-hr) | | Fraction of available power (unitless) | | Average rated horse-power (hp) |
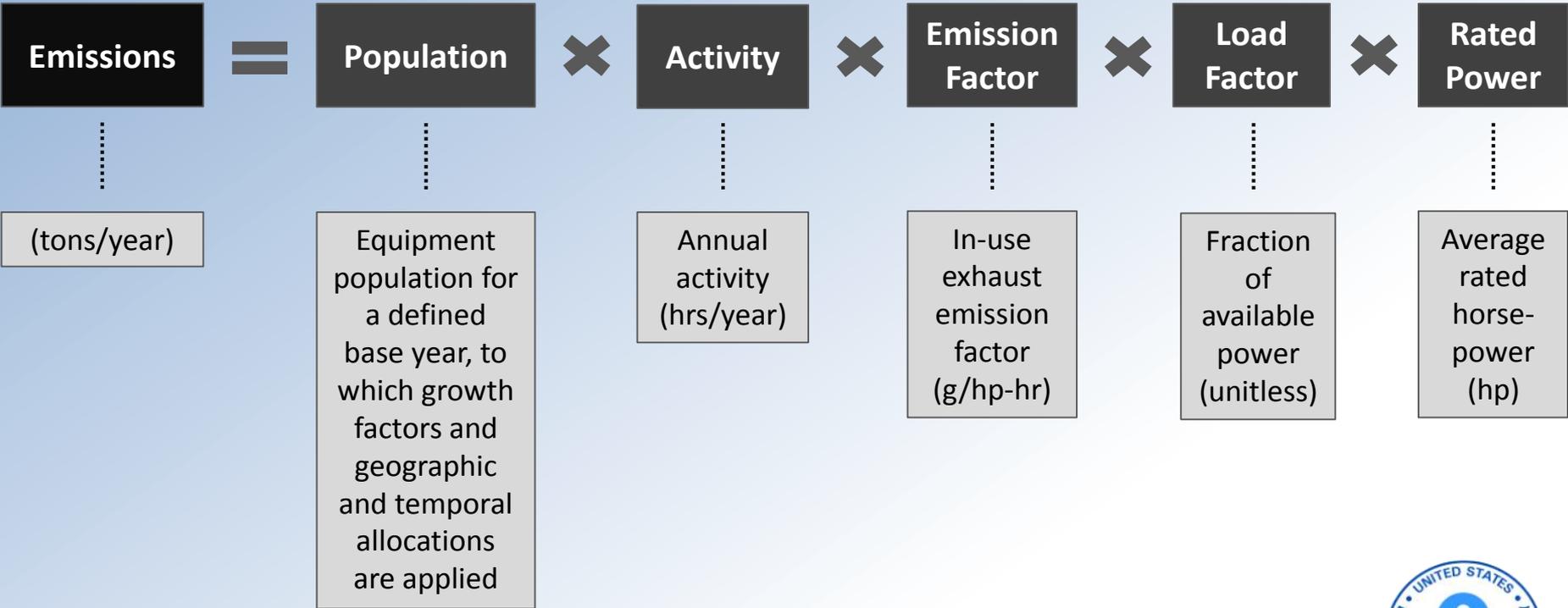
# Model Summary: Default Data

NONROAD utilizes data from a variety of industry and government sources:

**Power Systems Research**   **U.S. Forest Service**   **National Oceanic and Atmospheric Administration**

**Motorcycle Industry Council**   **U.S. Department of Agriculture**   **Oak Ridge National Laboratory**

**International Snowmobile Manufacturers Association**   **U.S. EPA**   **National Marine Manufacturers Association**

**California Air Resources Board**   **U.S. Energy Information Administration**   **U.S. Census Bureau**

| Incorporation of Source Data | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Equipment Population | Activity | Population Growth Rates | Emission Factors* | Average Horsepower | Geographic Allocation | Load Factor |
| **Small Spark-Ignition** | 1998 | 1998 | 1996 | 1996 | 1998 | 2002 | 1998 |
| **Large Spark-Ignition** | 1998 | 1998 | 1996 | 1996 | 1998 | 2002 | 1998 |
| **Compression-Ignition** | 1998 | 1998 | 1996 | 2002 | 1998 | 2002 | 1998 |

*Emission factors in the model have been adjusted to reflect post-2002 federal emissions standards (SI rules; Tiers 1-4)

# Proposed Model Updates

**Objective: improve the accuracy of nonroad emission inventories by developing a new comprehensive NONROAD model that combines state-of-the-science data with a user-friendly software platform.**

underlying model data — model design

| | Population and Activity | Equipment Scrappage | Population Growth | Emission and Load Factors | Model Code | Graphical User Interface (GUI) | Model Algorithm |
|---|---|---|---|---|---|---|---|
| **Near-term updates** (next MOVES release) | ✔ | | ✔ | | | | |
| **Long-term updates** (later MOVES releases) | ✔ | ✔ | | ✔ | ✔ | ✔ | ✔ |

# Near-Term Plans: Update Growth Factors

- Model currently fits historical engine population estimates from 1989 to 1996 with a linear regression, and then extrapolates to future years.
  - Does not account for yearly variations or large-scale economic trends
  - Concern that this approach overestimates projected populations

- EPA proposing to develop 2014-2040 growth indices using surrogates:

| Equipment Sector | Surrogate growth index data source |
|---|---|
| Lawn and Garden (residential), Recreation | State-level human population (University of Virginia Weldon Cooper Center for Public Service) |
| Lawn and Garden (commercial), Industrial | State-level GDP (Moody's Analytics) |
| Recreational Marine | National-level energy consumption (2016 Annual Energy Outlook (AEO)) |
| Railroad Maintenance | National-level billion ton-miles traveled (2016 AEO) |
| Construction, Agricultural, Logging, Mining, Oil Field | Census region-level energy consumption (2016 AEO); state-level GDP (Moody's Analytics) |
| Airport Service | Federal Aviation Administration Terminal Area Forecast Model |

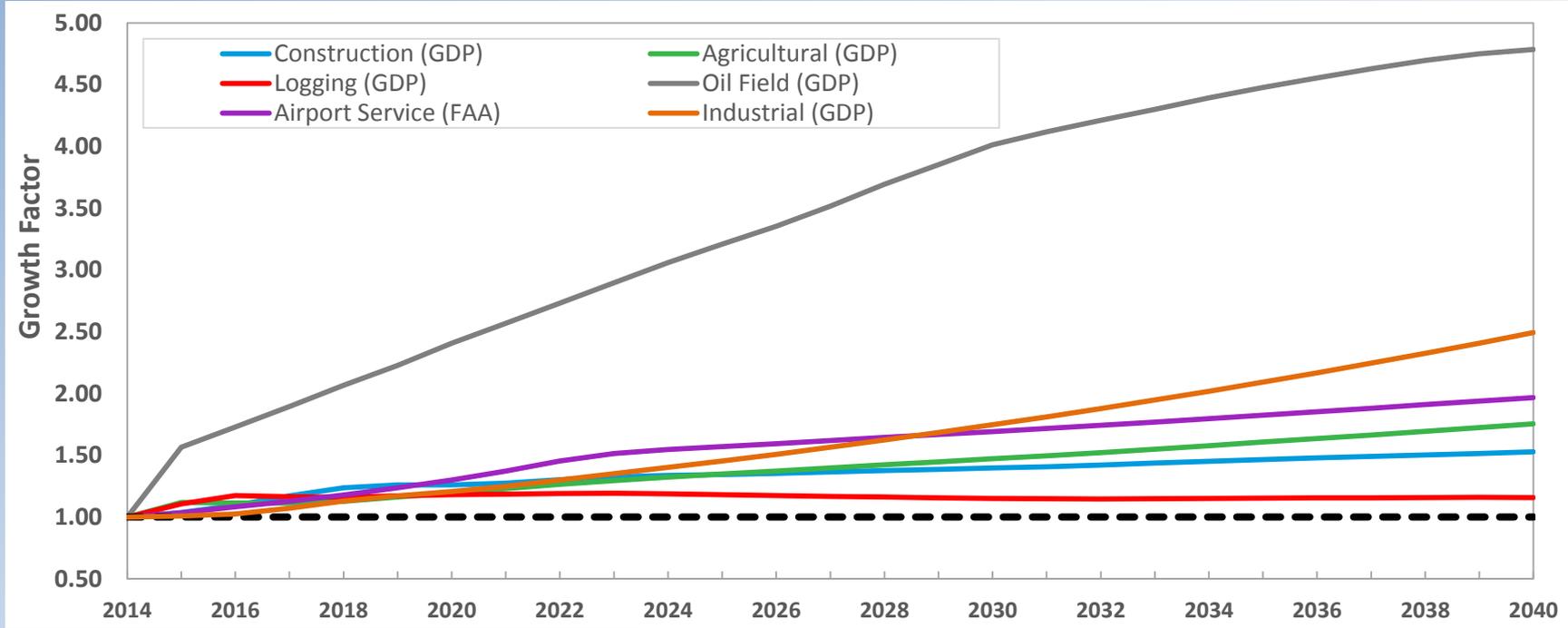# Near-Term Plans: Update Growth Factors (2014-2040)

Draft national-scale growth factors derived from projections of **human population (U.S. Census) and energy consumption (Annual Energy Outlook)** (assumes 2014 population base year)
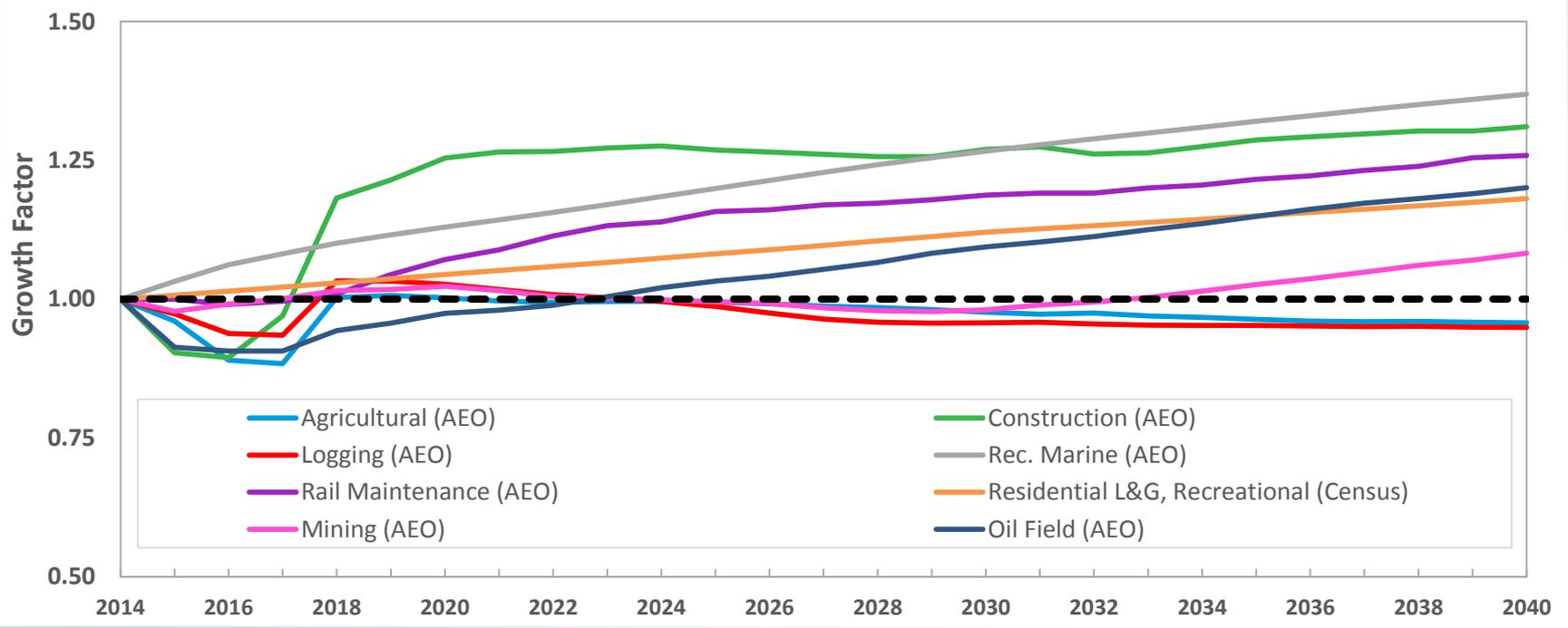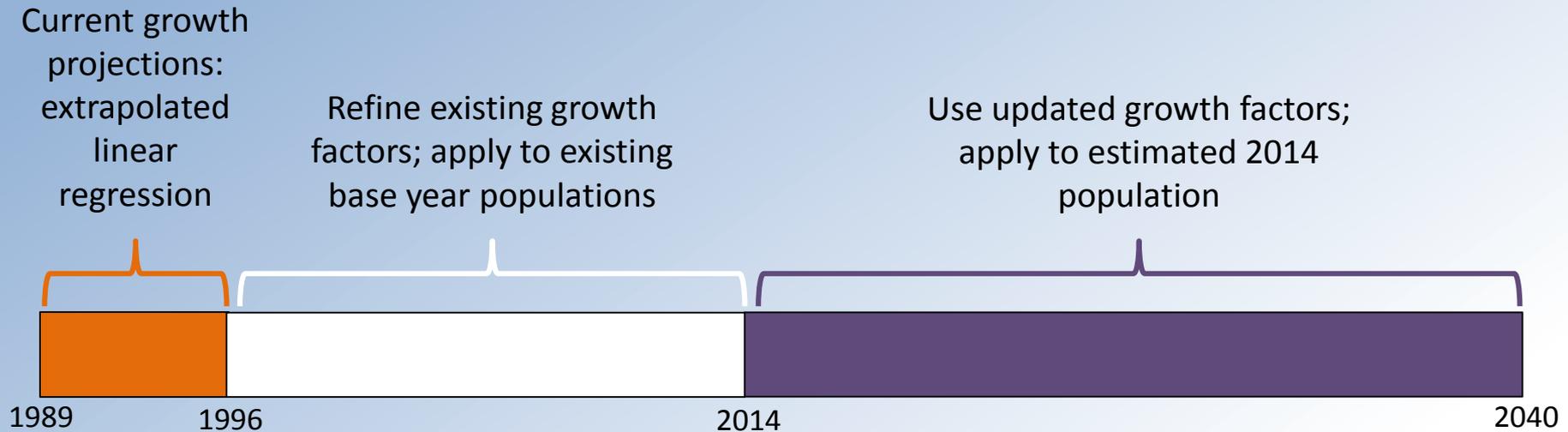
# Near-Term Plans: Update Growth Factors (2014-2040)

**Draft national-scale growth factors derived from GDP and FAA projections (assumes 2014 population base year)**

# Near-Term Plans: Update Growth Factors (1996-2014)

Current growth projections: extrapolated linear regression

Refine existing growth factors; apply to existing base year populations

Use updated growth factors; apply to estimated 2014 population

1989     1996          2014          2040

- Existing population base years are 1996, 1998, 1999, or 2000 (depending on equipment type)
- EPA updating equipment population data for 2014 (not expected to be ready for next model release)

- Start with existing base year populations → apply updated growth factors for the period 1996-2014 → arrive at estimated 2014 population → apply 2014-2040 growth factors to the estimated 2014 population

- Candidate data sources: Energy Information Administration (AEO, fuel sales), U.S. Census Bureau, USDA Census of Agriculture, Army Corps of Engineers

# Near-Term Plans: Additional Fixes and Improvements
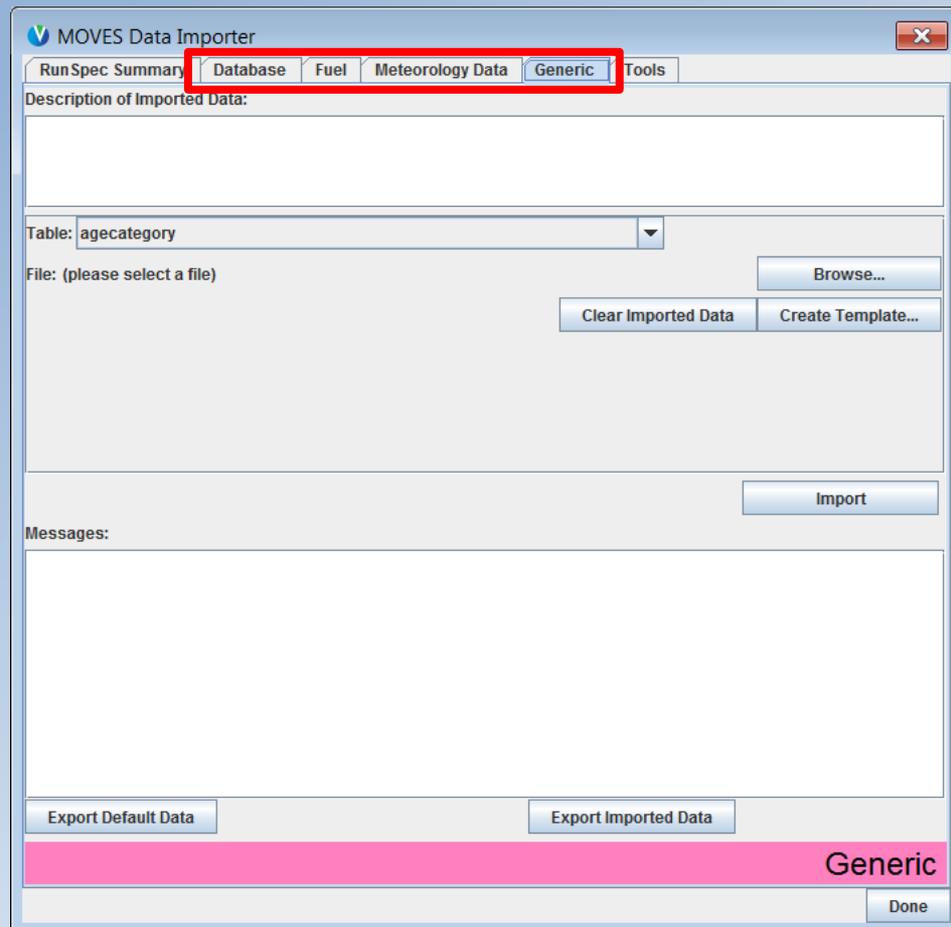


- Nonroad Importer Technical Guidance to assist users in importing the best available local data:
  - fuels
  - meteorology
  - equipment population
  - activity and load factor
  - retrofits
  - month, day, hour allocations

- Streamline the metal and dioxin calculator to remove a redundant fuel volume conversion calculation

- Database updates to reflect changes to Alaska, Virginia, and Montana counties

# Long-Term Plans: Data Updates

- Extensive efforts underway to update population and activity data for the major nonroad engine categories: small spark-ignition, large spark-ignition, recreational equipment, recreational marine, and compression-ignition.

| | |
|---|---|
| • Identify and acquire nonroad engine sales data | • Identify and acquire equipment activity data |
| • Develop scrappage curves | • Nonroad fuel consumption validation |
| • Develop national equipment population dataset | • Develop geographic allocation factors |
| • Develop equipment population growth projections | |

- Multiple data sources are vetted according to three areas of evaluation:
  1. Data contents
  2. Data quality
  3. Data source characteristics

- Longer-term plans to update nonroad emission factors

# Long-Term Plans: Data Updates (Population)

## Sales Data

Sources: Power Products Marketing, Manfredi & Associates, Parker Bay Co., Int. Snowmobile Manufacturers Assoc., National Marine Manufacturers Assoc.

> 100 equipment types from all 12 categories

Classified by fuel type, engine size, equipment type, model year

Minimum coverage: 2000-2014

Extensive QA to compare data sources

## Scrappage Curves

Show the percentage of equipment remaining in use over successive years

Used to determine the age distribution of in-use equipment for a given CY

Requires representative in-use model year distributions and corresponding time series sales data

Exploring multiple data sources and strategies, including a 2-parameter Weibull function

## National Populations

National-scale in-use population dataset for 2014 (new base year)

Estimates informed by sales data and scrappage curves

Population estimates for > 100 equipment types from all 12 categories

Classified by fuel type, engine size, equipment type, model year

Extensive QA against other national datasets (e.g., registrations, equipment censuses)

## Growth Projections

Sources: AEO, Moody's Analytics, U.S. Census

Projections of energy use, population, equipment activity, and economic indicators used as surrogates to project sector-specific equipment population growth

Apply to 2014 base year equipment populations

Coverage: 2014-2040

# Long-Term Plans: Data Updates (Activity and Allocation)

## Activity Data

Data on how frequently nonroad equipment is used on an annual or seasonal basis (total operating time, hr/year)

Sources: national, state, and local field surveys (e.g., California Air Resources Board, Texas Commission on Environmental Quality, USDA), commercial vendors

Level of available detail varies by source, so extensive QA required to assess the engine, equipment, and activity information as well as the temporal and geographic applicability of the data

## Fuel Consumption

Nonroad diesel and gasoline consumption can be used to validate equipment population and activity estimates

Sources: FHWA (Highway Statistics Annual Reports non-highway gasoline use), U.S. Dept. of Energy (state-level fuel consumption), nonroad fuel tax revenues, state surveys, U.S. Energy Information Administration (Fuel Oil and Kerosene Sales)

Must ensure data source estimates can be properly attributed to nonroad equipment categories

## Geographic Allocation

Must allocate national-scale populations and total activity of nonroad engines to the state and county levels

Requires the use of surrogate statistics that correlate with population or total activity in a particular geographic area

Currently identifying candidate surrogate statistics, as well as independent county-level datasets that could be used as validation test data

# Long-Term Plans: Model Redesign

- Priorities in new model design:

    - Use widely available data → facilitates more frequent updates

    - Minimize impact on users → continue to use MOVES structure – MySQL tables and output, graphical user interface, shared tables (meteorology, counties)

    - Improve model performance → underlying calculations to be done in fast, flexible GO language

    - Revisit equipment categories → consider consolidating or removing some equipment types

# Long-Term Plans: Prototype-Data Integration

Newly-acquired population and activity data to be integrated into prototype testing
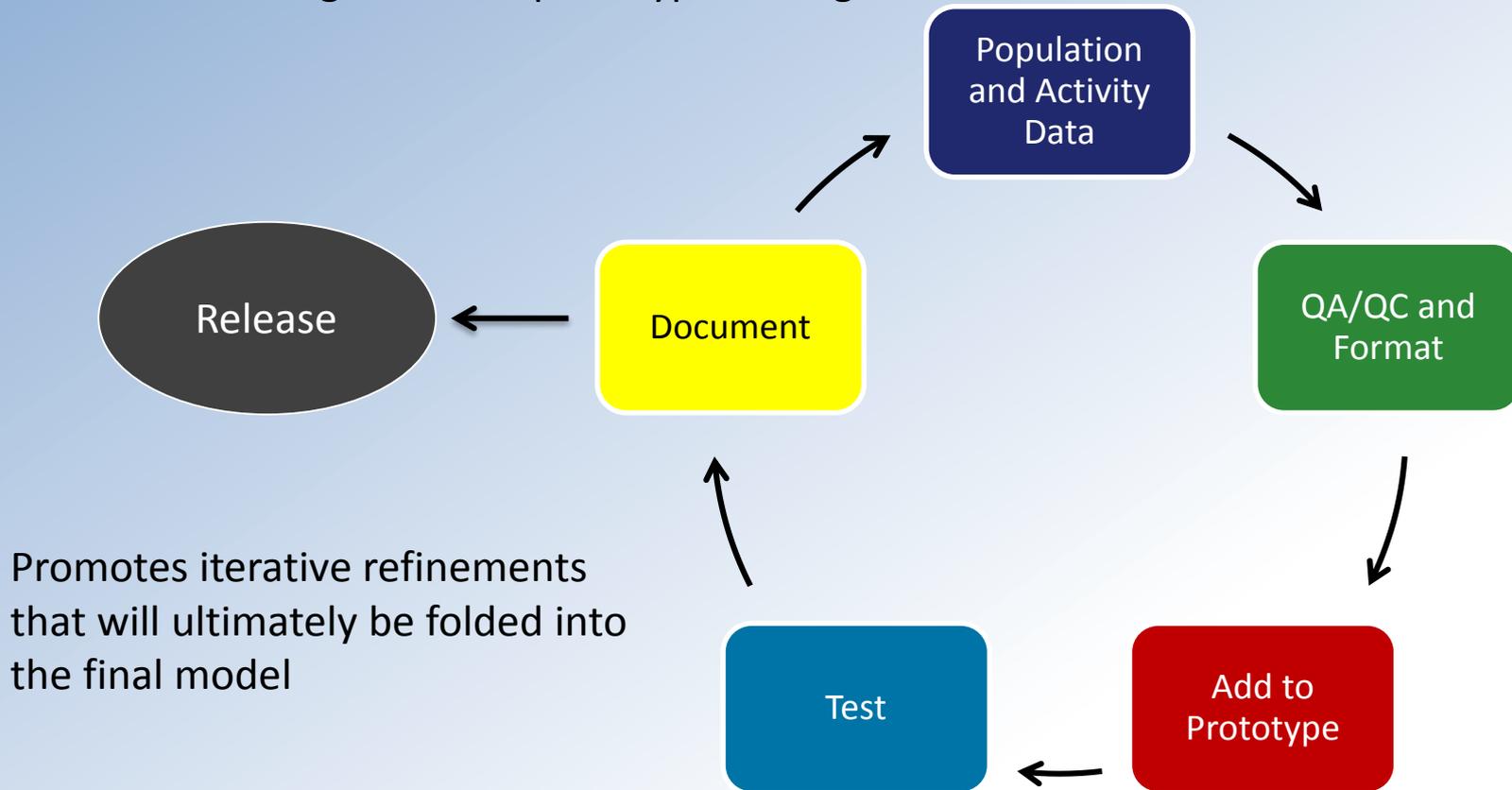
Promotes iterative refinements that will ultimately be folded into the final model