




Port Emissions Inventory Guidance

Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions

Public Webinar

October 29, 2020

Presented by:

Office of Transportation and Air Quality

U.S. Environmental Protection Agency






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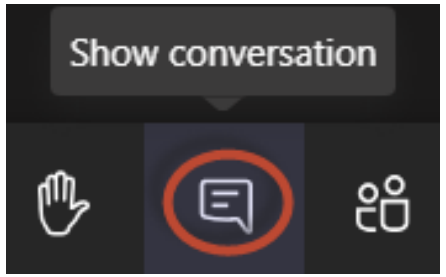

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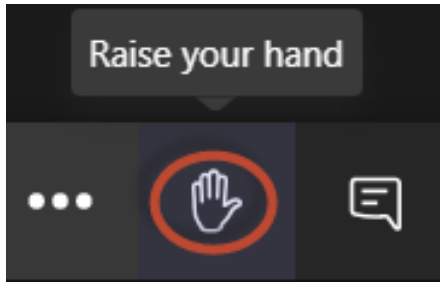
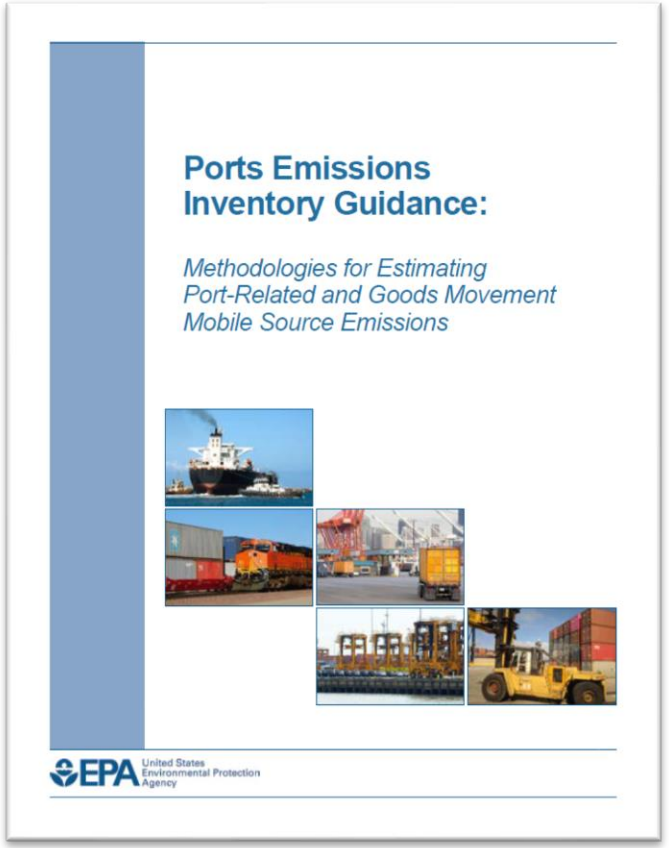







Webinar Overview

- Background
- Planning a port emissions inventory
- Sector description for:
  - Ocean-Going Vessels
  - Harbor Craft
  - Recreational Marine
  - Cargo Handling Equipment
  - Onroad
  - Rail
- Q&A

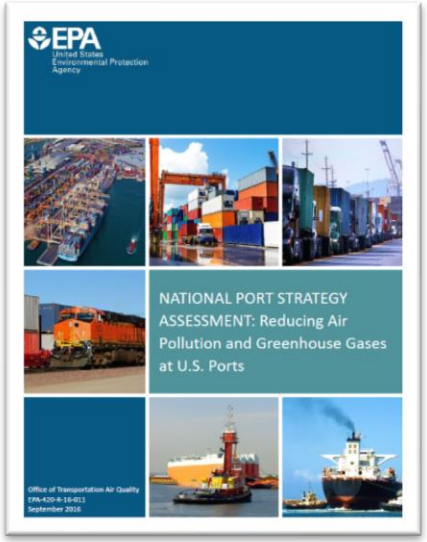


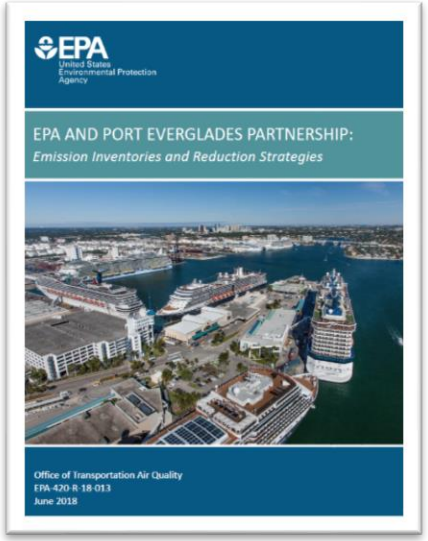





Background

- Guidance describes the latest, state-of-the-science methodologies and models used to prepare a port-related inventory
- Builds on other EPA work:
  - *EPA–Port Everglades Partnership: Emission Inventories and Reduction Strategies* (released 2018)
  - *National Port Strategy Assessment* (released 2016)
  - EPA rulemakings and regulatory impact analyses
  - EPA guidance documents for mobile source inventories, emission reduction strategies, and models (e.g., MOVES/Nonroad)



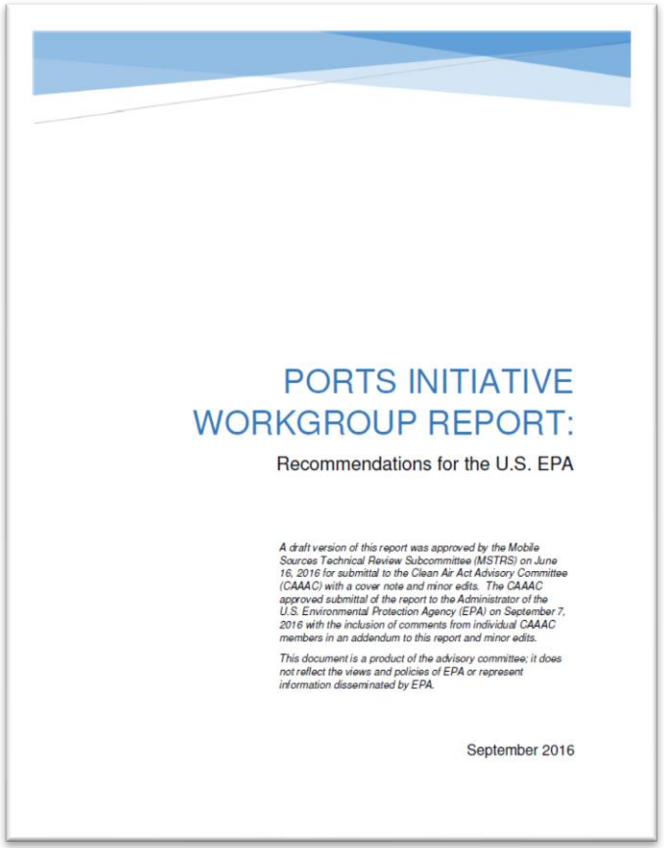







Update Process

- As part of EPA's Ports Initiative, this was released in response to MSTRS Ports Initiative Workgroup recommendations
- Draft Methodologies released in February 2020
- Updates from the Draft Methodologies include:
  - New tables of harbor craft emission factors
  - Downloadable tables in CSV format
  - Technical revisions to the calculation of OGV propulsion engine load
  - Text clarifications


PORTS INITIATIVE WORKGROUP REPORT:

Recommendations for the U.S. EPA

A draft version of this report was approved by the Mobile Sources Technical Review Subcommittee (MSTRS) on June 16, 2016 for submittal to the Clean Air Act Advisory Committee (CAAAC) with a cover note and minor edits. The CAAAC approved submittal of the report to the Administrator of the U.S. Environmental Protection Agency (EPA) on September 7, 2016 with the inclusion of comments from individual CAAAC members in an addendum to this report and minor edits.

This document is a product of the advisory committee; it does not reflect the views and policies of EPA or represent information disseminated by EPA.

September 2016






Port-Related Inventories Are:

- Quantifications of air emissions for:
  - Ocean-going vessels (OGV), harbor craft, recreational marine, cargo handling equipment (CHE), onroad vehicles, and rail
  - Activity occurring at seaports, Great Lakes ports, river ports, rail yards, freight terminals, intermodal facilities, or freight corridors
- Developed for regulatory, voluntary, or research purposes
- Useful to a wide range of stakeholders






Guidance Outline

- Section 1: An Introduction to Port-Related Inventories
- Section 2: Decisions Related to Planning and Scoping an Inventory
- Section 3: Ocean-Going Vessels
- Section 4: Harbor Craft
- Section 5: Recreational Marine
- Section 6: Cargo Handling Equipment
- Section 7: Onroad Vehicles
- Section 8: Rail
- Appendices A-K: Additional Information (e.g., how to calculate energy consumption)



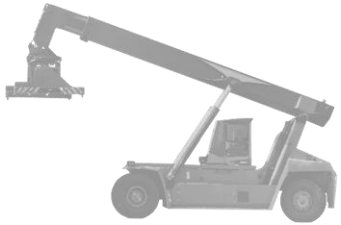



Planning a Port Emissions Inventory

Inventory preparers need to decide:

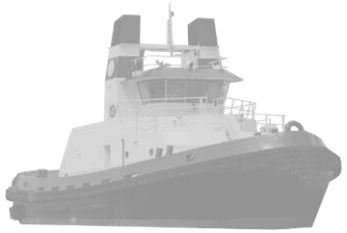
- Mobile source sectors to include
- Pollutants to include – guidance includes information for estimating:
  - criteria pollutants and precursors
  - climate-related pollutants
  - air toxics
- Geographic area to be covered: marine boundary, land-side boundary, transportation corridors outside the jurisdiction of the port
- Time period to be covered: annual, seasonal, daily; current or future year

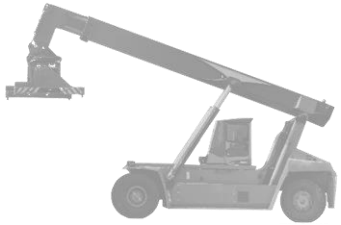


Ocean-Going Vessels (OGV)

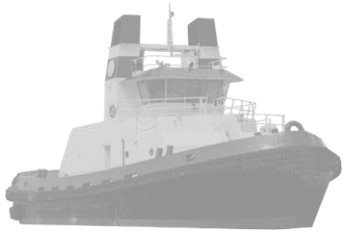
Section 3

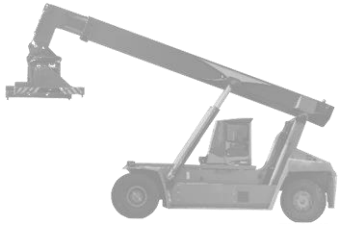





OGV: Source Description

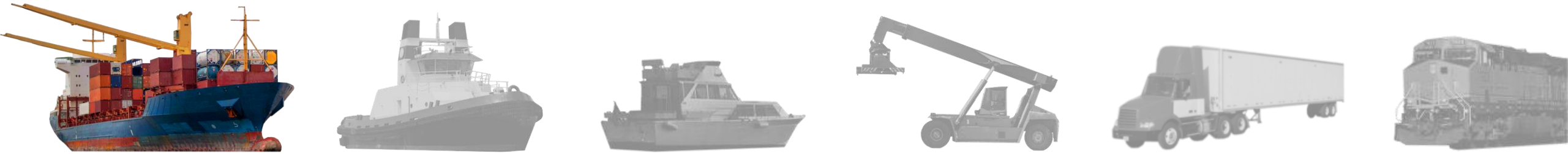
- Ships that transport cargo and/or people between different ports
  - Many of these operate in the oceans
  - Also covers vessels that operate in the Great Lakes and inland rivers
  - Distinction from harbor craft is based on activity for modeling purposes
- Most OGV have C3 propulsion engines (cylinder displacement ≥30L), but some have smaller C1/C2 engines
- Also have auxiliary engines and boilers



OGV: General Ship Types

Bulk Carrier	Miscellaneous (C3)
Chemical Tanker	Offshore Support/Drillship
Container Ship	Oil Tanker
Cruise	Other Service
Ferry/Passenger (C3)	Other Tanker
Ferry/Roll-on/Passenger (C3)	Reefer
Fishing (C3)	Roll-on/Roll-off (aka RORO)
General Cargo	Vehicle Carrier
Liquified Gas Tanker	Yacht (C2/C3)
Note: For modeling purposes, some ship types also include engine category (e.g., C3) to distinguish between OGV, harbor craft, and recreational marine.	



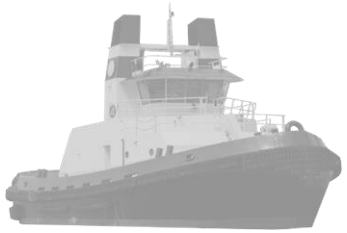
OGV: Emissions Estimation Overview

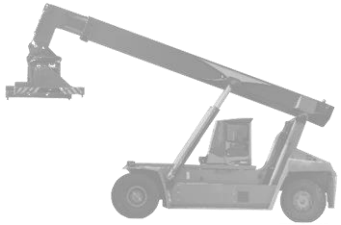
$$Base\ Year\ Emissions = P \times LF \times A \times EF \times LLAF$$

- P: Installed power (kW), from vessel characteristic databases, vessel surveys, or national defaults
- LF: Load factor (%), from AIS + vessel characteristics, vessel surveys, or national defaults
- A: Activity (h) from AIS or vessel call logs
- EF: Emission factor (g/kWh), from tables or equations in document
- $LLAF$: Low load adjustment factor, from table in document
  - Based on load factor
  - Only applies to propulsion engines

AIS Automatic Identification System

Best Practice: Estimate load factor (LF) and hours of operation (A) from AIS

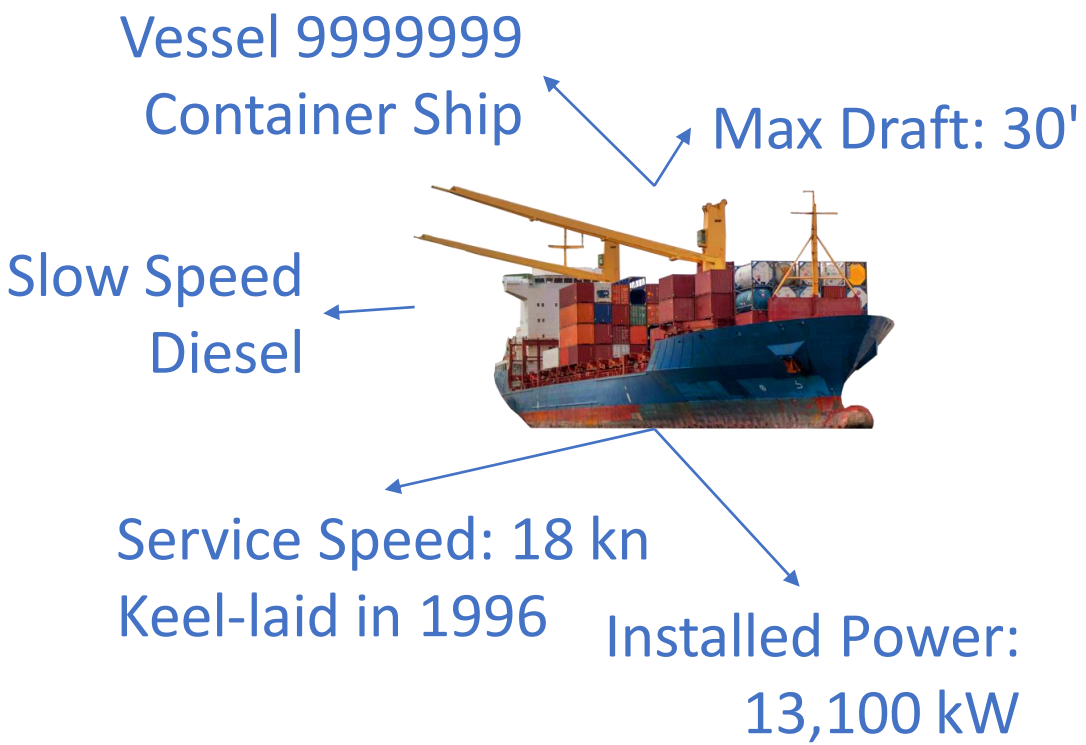



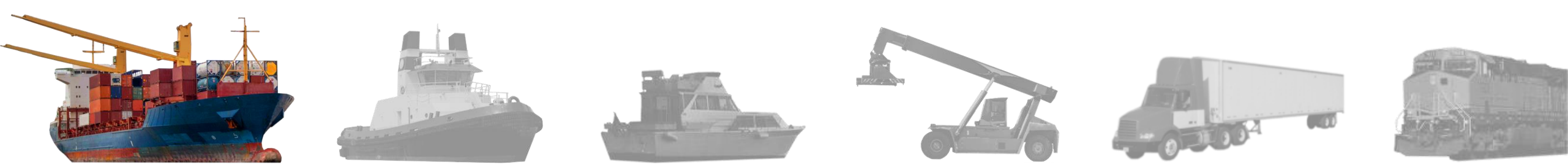


OGV: Vessel Characteristics

- Various vessel characteristic data are needed to calculate an emissions inventory
- For example:
  - Vessel identification data are used to link vessels in various datasets
  - Engine characteristic data are used to assign emission factors
  - Ship type and subtype are used to analyze activity data

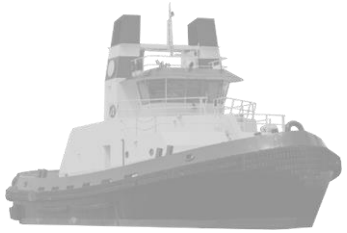
Example:

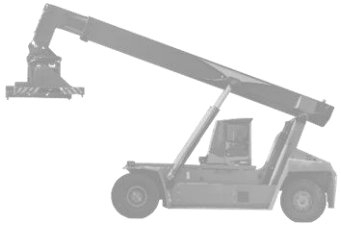




OGV: Activity Data Sources

- AIS
  - Contains vessel identifiers, position, bearing, speed, and draft
  - Used to estimate hours of activity and propulsion engine load
- Local logs
  - Local port authority, marine exchange, and other local organizations may collect data on vessel movements, which could be used to estimate hours of activity
- Survey data
  - Can collect all sorts of data, including auxiliary and boiler loads



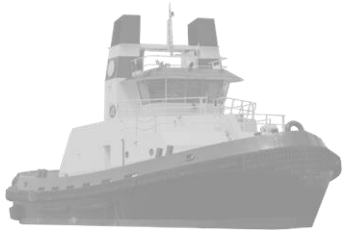
OGV: Inventory Calculation (AIS Method)

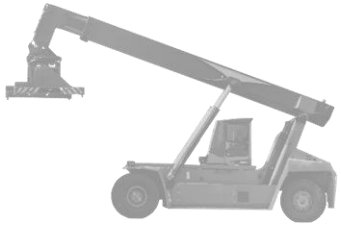
1. Link AIS messages to vessel characteristics and emission factors
2. Clean AIS data and gap fill missing messages (if necessary)
3. Estimate propulsion engine load based on vessel speed and draft
4. Estimate auxiliary & boiler load based on operating mode
5. Calculate emissions for each AIS message
6. Aggregate emissions to the time/geographic scale needed for the inventory

Vessel 9999999
1/1/2019 12:00pm
Speed: 12 knots
Draft: 20'

Vessel 9999999
1/1/2019 12:05pm
Speed: 12 knots
Draft: 20'

Vessel 9999999
1/1/2019 12:10pm
Speed: 10 knots
Draft: 20'

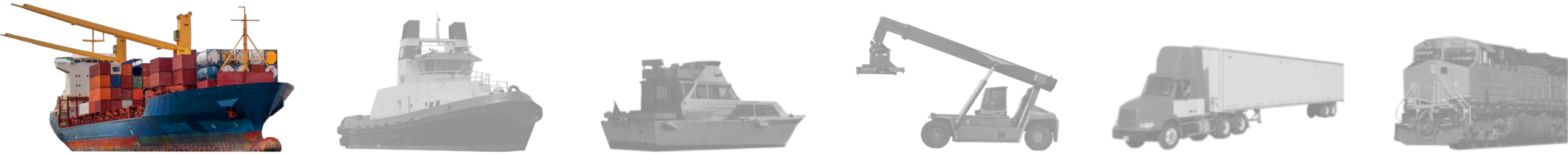





OGV: Propulsion Engine Load

$$P_p = P_{ref} \times \left(\frac{V}{V_{ref}}\right)^3 \times \left(\frac{D}{D_{ref}}\right)^{\frac{2}{3}} \times SM$$

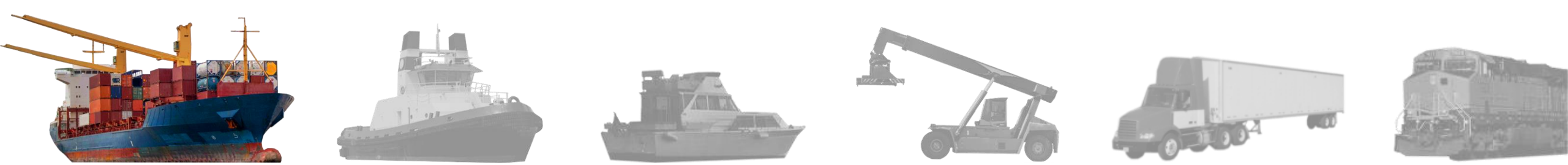
- P_p: Propulsion engine operating power (kW)
- P_{ref}: Vessel's total installed propulsion power (kW)
- V and V_{ref}: AIS-reported speed before the record interval and vessel's maximum speed (kn)
- D and D_{ref}: AIS-reported draft before the record interval and vessel's maximum draft (kn)
- SM: Sea margin, which accounts for average weather conditions
  - 1.10 for coastal operations
  - 1.15 for at-sea operations



OGV: Inventory Calculation (Vessel Call Method)

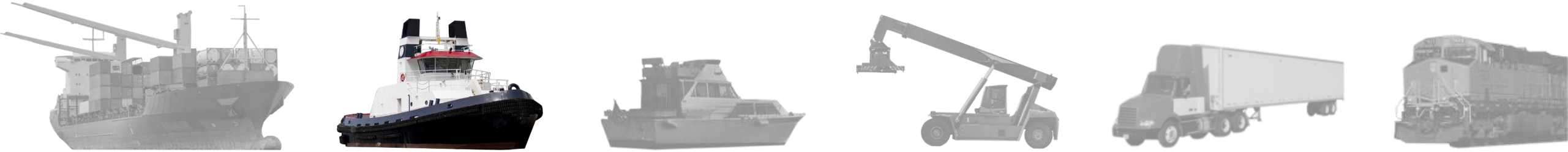
Vessel call data can come from port logs, Entrances & Clearances, Waterborne Commerce, pilot surveys, etc.

1. Link each vessel call to vessel characteristics and emission factors
2. Estimate hours of activity per vessel in each operating mode based on geography & assumed speeds
3. Estimate propulsion engine load based on assumed vessel speeds
4. Estimate auxiliary & boiler load based on operating mode
5. Calculate emissions for each vessel
6. Aggregate emissions to the time/geographic scale needed for the inventory



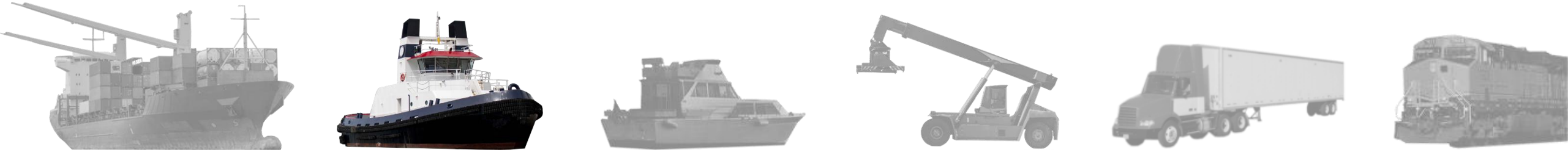
OGV: Projecting Future Inventories

1. Future growth factors should come from local port estimates
   - Alternatively, the Freight Analysis Framework (FAF4) can be used for region-specific growth estimates
2. Apply future growth factors to base year activity estimates
3. Estimate future age distribution from base year age distribution
4. Calculate future inventory using the same methodology as base year inventory



Harbor Craft

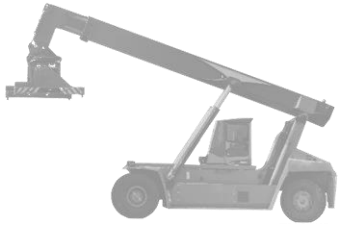
Section 4



Harbor Craft: Source Description

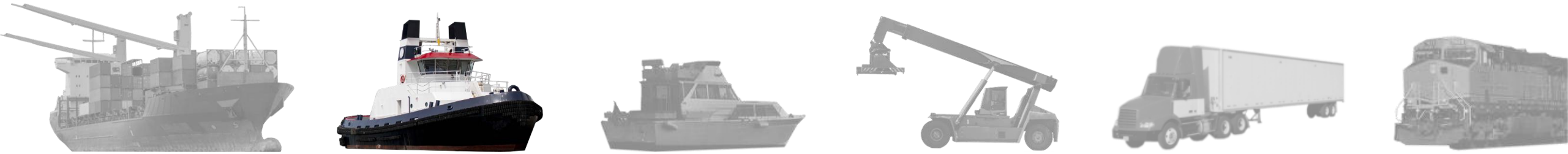
- All commercial marine vessels that are not OGV
  - Generally stay in or near a single port or region
- Most have C1/C2 propulsion engines (cylinder displacement <30L)
- Also have auxiliary engines, but not boilers



Harbor Craft: General Ship Types

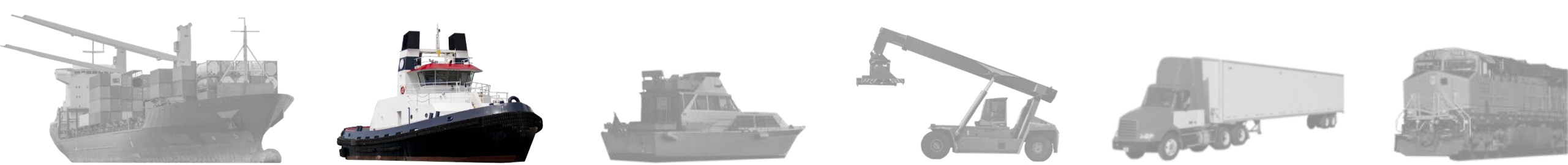
Barge	Harbor Ferry (C1/C2)
Crew and Supply	Miscellaneous (C1/C2)
Dredging	Pilot
Excursion	Towboat/Pushboat
Fishing (C1/C2)	Tug Boat
Government	Work Boat
Note: For modeling purposes, some ship types also include engine category (e.g., C1) to distinguish between OGV, harbor craft, and recreational marine.	



Harbor Craft: Emissions Estimation Overview

$$Base\ Year\ Emissions = P \times LF \times A \times EF$$

- P: Installed power (kW) from vessel surveys or national defaults
- LF: Load factor (%) from local studies or defaults
- A: Activity (h) from Automatic Identification System (AIS) data, vessel surveys, or local logs
- EF: Emissions factor (g/kWh) from tables or equations in document



Harbor Craft: Data Needs

- Similar to OGV, vessel characteristic data are needed
- Vessel surveys are important sources of vessel characteristics and activity data

Best Practice: Estimate hours of operation (A) from AIS and collect vessel characteristics from surveys / interviews

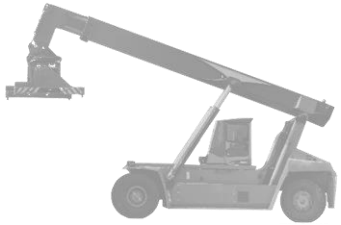
Vessel Characteristics Example:

Vessel 9999999
Tug Boat

Propulsion Engines:
MY1998, 1,720 kW

Installed Power:
3,440 kW

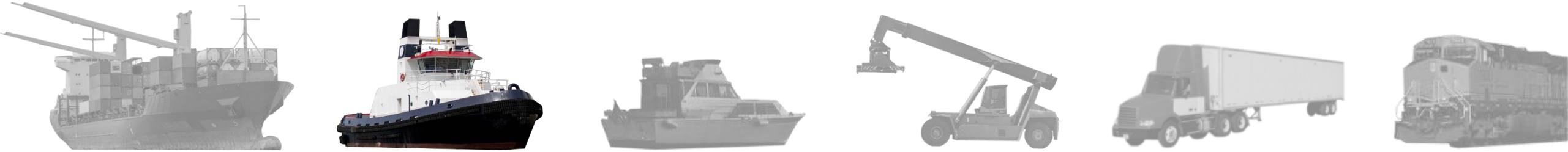


Harbor Craft: Inventory Calculations

- Inventory calculations are similar to OGV, except for:

AIS Inventory Calculations	Alternative Inventory Calculations
AIS is only used for obtaining hours of operation	No distinct operating modes
Engine load is not calculated from AIS for harbor craft as vessel speed may not correspond to engine load (e.g., tugs actively assisting an OGV)	Emissions are just calculated separately for propulsion and auxiliary engines
Instead, load factors are generally assigned by ship type	



Harbor Craft: Projecting Future Inventories

1. Future growth factors should come from local port estimates
   - Alternatively, the Freight Analysis Framework (FAF4) can be used for region-specific growth estimates
2. Apply future growth factors to base year activity estimates
3. Estimate future age distribution from base year age distribution
4. Calculate future inventory using the same methodology as base year inventory

Recreational Marine

Section 5

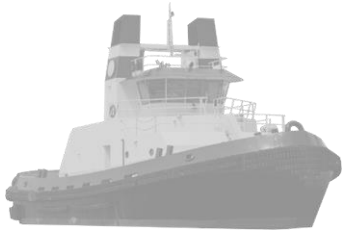
Rec Marine: Source Description

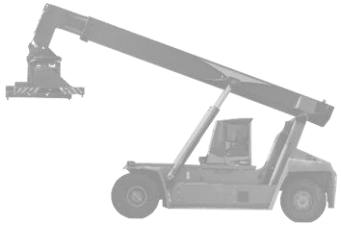
- Vessels operated for pleasure
  - Also includes all gasoline-powered vessels
- May not need to be included in all port-related emission inventories
  - Not all ports have marina facilities or significant recreational marine activity
- Consider including if:
  - Significant and quantifiable recreational marine activity
  - Expect significant increases or decreases in future activity

Rec Marine: Emissions Estimation Overview

$$Base\ Year\ Emissions = N_e \times P \times LF \times A \times EF$$

- N_e: Number of engines on the vessel
- P: Rated engine power (hp)
- LF: Load factor (%)
- A: Activity (h)
- EF: Emissions factor (g/hp-hr) from running MOVES-Nonroad and built-in post-processing scripts



Rec Marine: Data Needs

- MOVES can estimate emissions for the following vessel types:

MOVES Nonroad Recreational Vessel Type	Source Classification Code (SCC)
Gasoline (2-Stroke) Outboard	2282005010
Gasoline (2-Stroke) Personal Water Craft	2282005015
Gasoline (4-Stroke) Inboard/Sterndrive	2282010005
Diesel Inboard/Sterndrive	2282020005
Diesel Outboard	2282020010

- Need to know for each vessel:
  - Model year
  - Rated engine power
  - # of engines

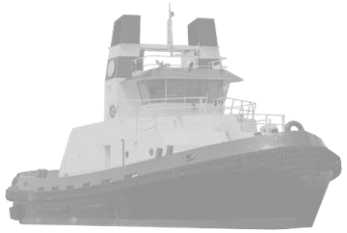
Best Practice: Estimate hours of operation (A) from AIS and collect vessel characteristics from surveys / interviews

Rec Marine: Inventory Calculations

- If AIS is used, the inventory is calculated for each vessel using a similar method as harbor craft
- Alternative inventory calculation is at the sector level
  - National defaults or alternative methodologies are available if there are missing fields:
    - Model year
    - Hours of operation
    - Rated engine power

Rec Marine: Projecting Future Inventories

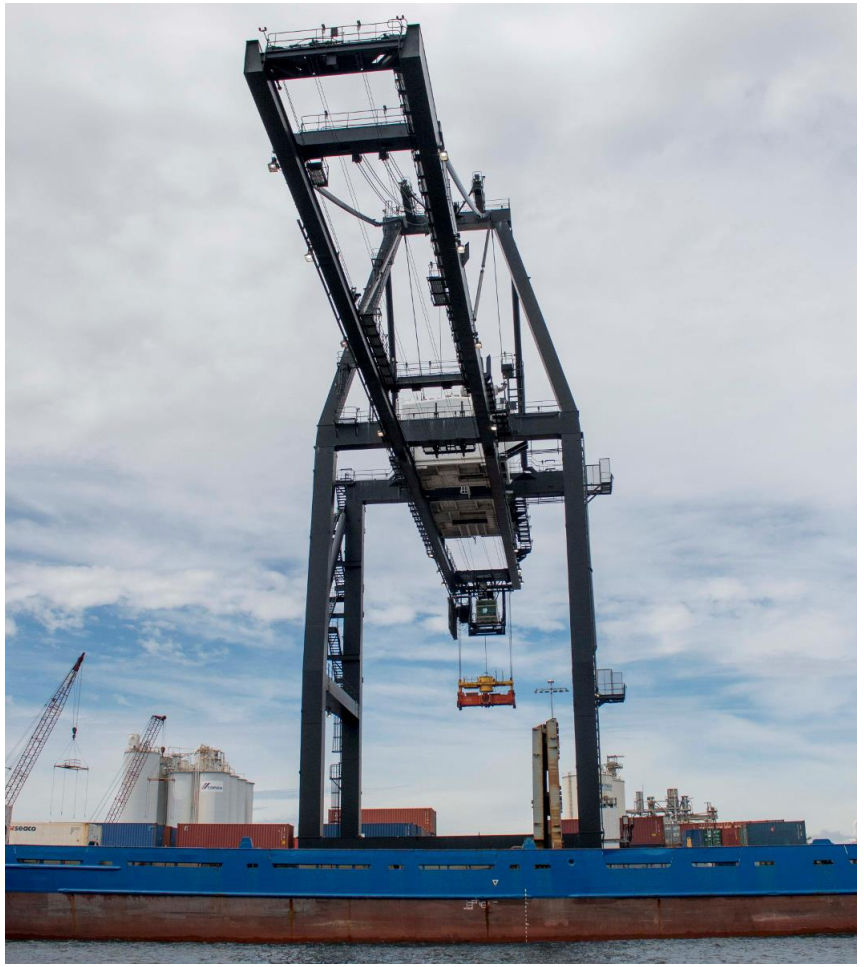
1. Future growth factors should come from local port estimates
   - Alternatively, regional growth factors used by MOVES-Nonroad can be used instead
2. Apply future growth factors to base year activity estimates
3. Use future fleet-average emission factors from MOVES-Nonroad instead of projecting a local age distribution
4. Calculate future inventory using the same methodology as base year inventory



Cargo Handling Equipment (CHE)

Section 6



CHE: Source Description

- Includes equipment used to move cargo, products, and supplies around a port, terminal, or freight facility, including:

Aerial Lifts	Reach Stackers
Compressors	Rollers
Cranes	Rubber-tired Gantry (RTG) Cranes
Empty Container Handlers	Side Handlers
Excavators	Skid-steer Loaders
Forklifts	Sweepers
Generators/Power Packs	Top Handlers
Light Towers	Tractors/Loaders/Backhoes
Manlifts	Welders
Off-highway Trucks	Yard Tractors
Rail Pushers	

CHE: Emissions Estimation Overview

$$Base\ Year\ Emissions = P \times LF \times A \times EF$$

- P: Rated engine power (hp)
- LF: Load factor (%)
- A: Activity (h)
- EF: Emissions factor (g/kWh) from running MOVES-Nonroad and built-in post-processing scripts

CHE: Data Needs

- Need the following equipment characteristics and activity data:
  - Equipment type
  - Fuel type
  - Model year
  - Rated engine power
  - Hours of use

Best Practice: Collect these data from surveys or interviews with terminal operators

- Default load factors are available in the document

CHE: Detailed Inventory Calculations

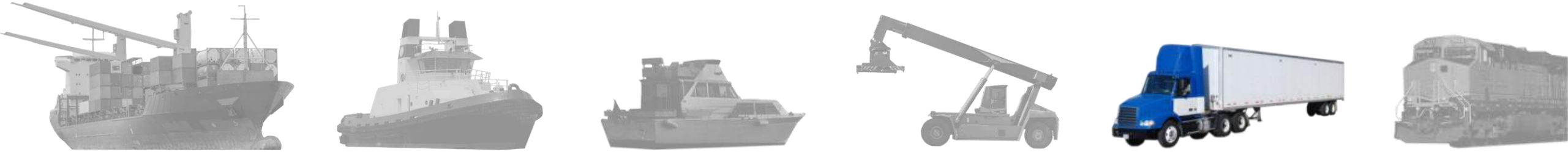
1. Assign each CHE unit to a MOVES-Nonroad SCC, HP bin, and load factor
2. Run MOVES-Nonroad to calculate emission factors
3. Assign each CHE unit the appropriate emission factor
4. Calculate emissions for each CHE unit
5. Aggregate emissions to the time/geographic scale needed for the inventory

CHE: Alternative Inventory Calculations

- If port-specific data on equipment activity, engine power, and/or model year are not available, alternative methodologies are available
- Missing model year data:
  - Calculate a fleet average emission factor, relying on median life and scrappage assumptions in MOVES-Nonroad
- Missing hours and/or engine power data:
  - Use averages from an existing port inventory

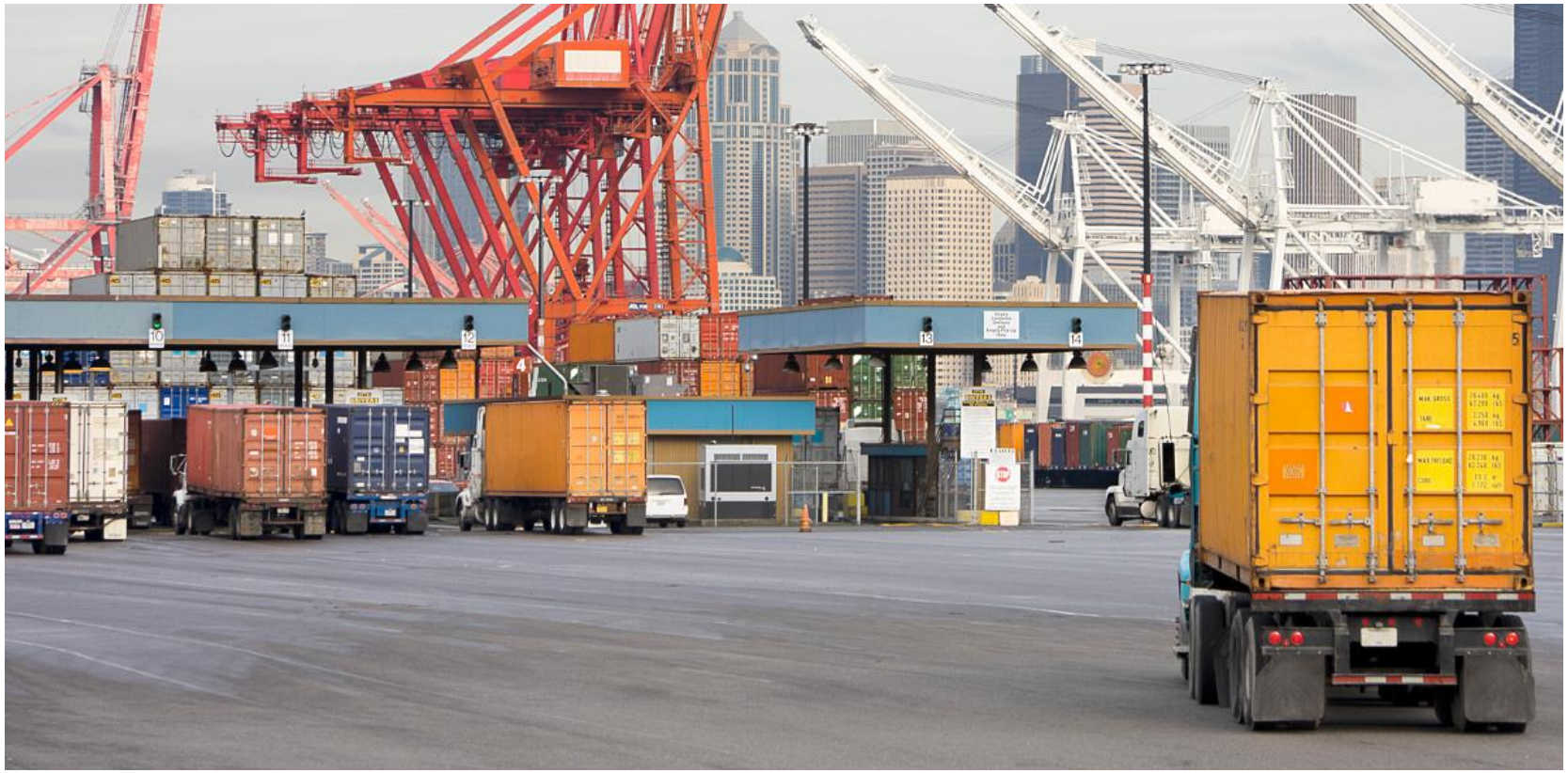
CHE: Projecting Future Inventories

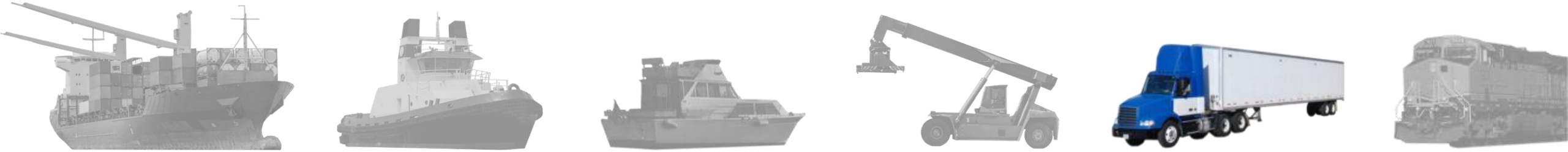
1. Future growth factors should come from local port estimates
   - Alternatively, the Freight Analysis Framework (FAF4) can be used for region-specific growth estimates
2. Apply future growth factors to base year activity estimates
3. Estimate future age distribution from base year age distribution
4. Run MOVES-Nonroad to extract emission factors for the future year
5. Calculate future inventory using the same methodology as base year inventory



Onroad Vehicles

Section 7





Onroad: Source Description

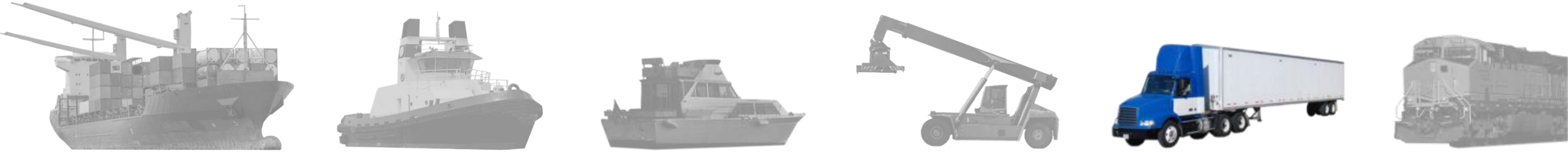
Vehicle types included (but not limited to):

<u>Heavy-Duty Vehicles</u>

- Drayage Trucks
- Long-Haul Trucks
- Shuttle Buses
- Other HD Trucks

<u>Light-Duty Vehicles</u>

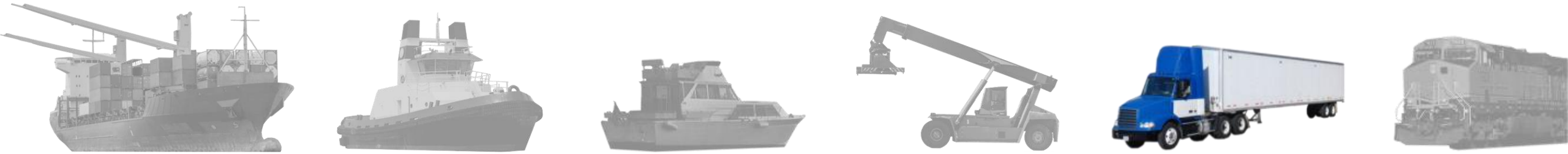
- Passenger Cars and Trucks
- Passenger Vans
- Import/Export Vehicles
- Maintenance Trucks



Onroad: Emissions Estimation Overview

Three Inventory Approaches:

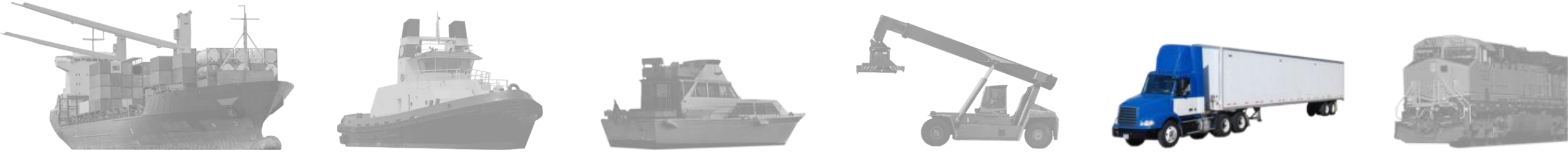
- County Scale Approach – using MOVES at the county scale to model the port as a “county” for the desired time span and pollutants of interest.
- Project Scale Approach – using MOVES at the project scale to model the port as discrete “generic” activity links.
- Refined Project Scale Approach – for refined air dispersion analysis of port related emissions.



Onroad: Data Needs

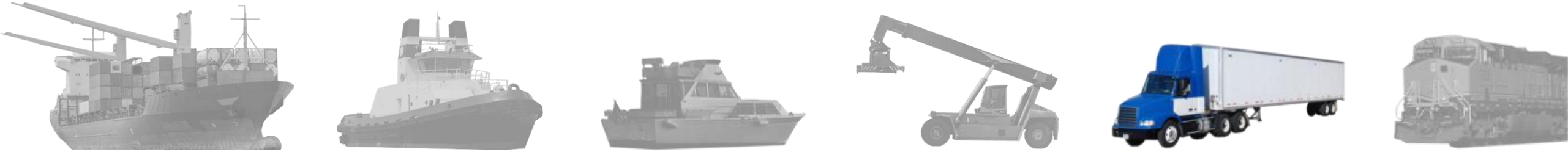
- Fleet Characteristics
  - Vehicle types (classification by MOVES source types)
  - Vehicle counts (by source type)
  - Vehicle age (model years of vehicles are used to determine an age distribution by source type)
- Vehicle Activity
  - Activity type and counts (activity by source type)
  - Vehicle travel speeds (for running activity)

Best Practice: Rely on local data from site-specific traffic counts/surveys or partner with state DOTs



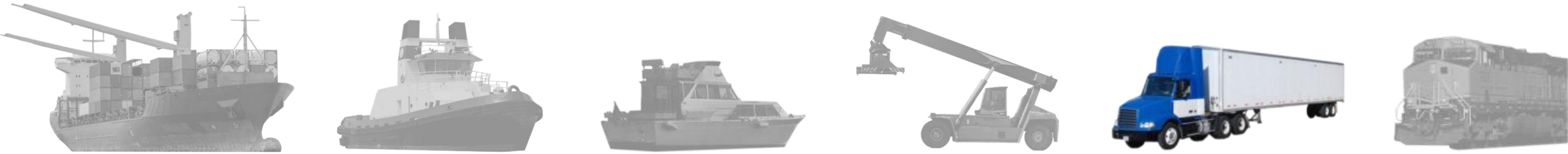
Onroad: County Scale Approach

- Conceptually, treat the port as if it is a “county” and setup a MOVES county scale run
- Setup the run as an Inventory run
- Setup the RunSpec to include appropriate vehicle and road types
- Use the County Data Manager to input the vehicle population, VMT, speed distribution, age distribution, fuels (default), and meteorology to best represent the conditions at the port



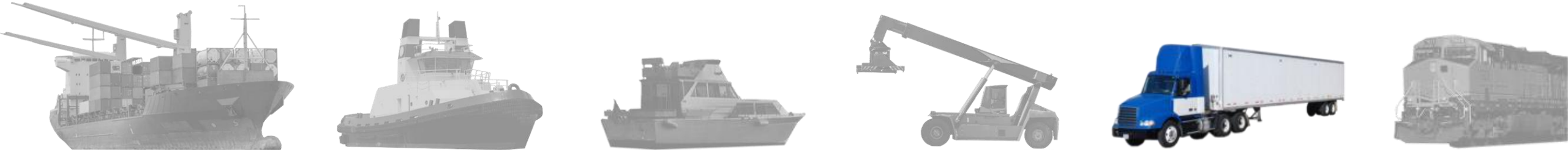
Onroad: Project Scale Approach

- Determine what types of on-road vehicle activity are occurring on-port or within the geographic scope of the analysis
- Conduct a project scale link-based analysis to capture different activity and emission rates
  - Link Examples:
    - Short-Term Idle Link
    - 15 mph Link
    - 30 mph Link
    - Evaporative Process Off-network Link
- Derive link-level activity-based emission factors (g/mi, g/hr) from MOVES runs
- Multiply population and activity (vehicle miles traveled, hours idling, hours soak, etc.) in post-processing step to produce an inventory



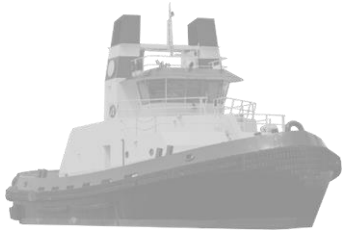
Onroad: Refined Project Scale Approach

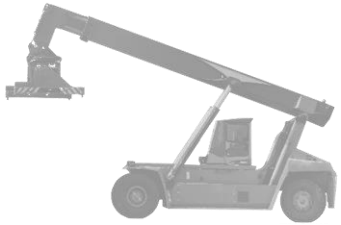
- Air quality modeling requires spatially allocated emissions. MOVES can be used at the corridor or project-scale to produce link-level emissions for use in air quality modeling.
- May require multiple runs depending on inventory purpose
- Requires post-processing of emissions rates for inventory development
- This methodology is introduced in the section and further described in the Onroad Appendix and relies heavily on EPA's PM Hot-spot Conformity Guidance



Onroad: Projecting Future Inventories

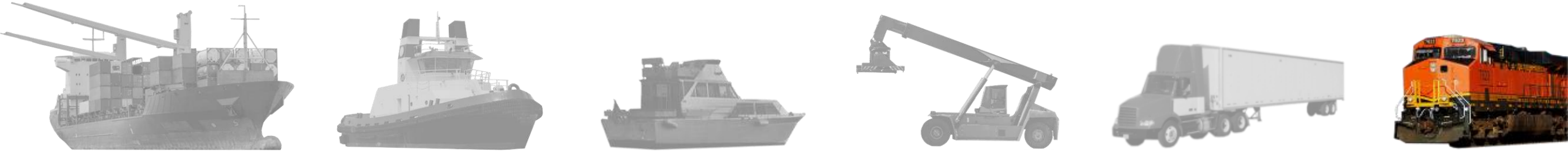
- Future growth factors should come from local port estimates
  - Alternatively, the Freight Analysis Framework (FAF4) can be used for region-specific growth estimates
- Apply future growth factors to base year activity estimates
- Estimate future age distribution from base year age distribution
  - Could use MOVES age distribution projection tool
- Run MOVES for the future year to calculate inventory like the base year inventory



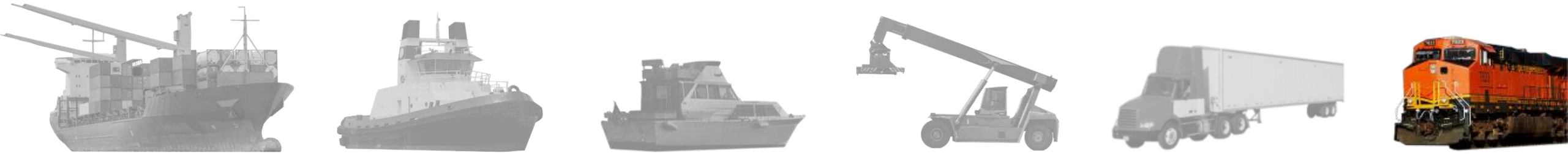
Rail

Section 8



Rail: Source Description

- Two typical sources of rail emissions at ports:
  - Line-haul locomotives
    - Pick up or deliver cargo to off-port locations
    - Typically newer and higher-powered
  - Switcher locomotives
    - Assemble and disassemble trains
    - Typically older and include more idling

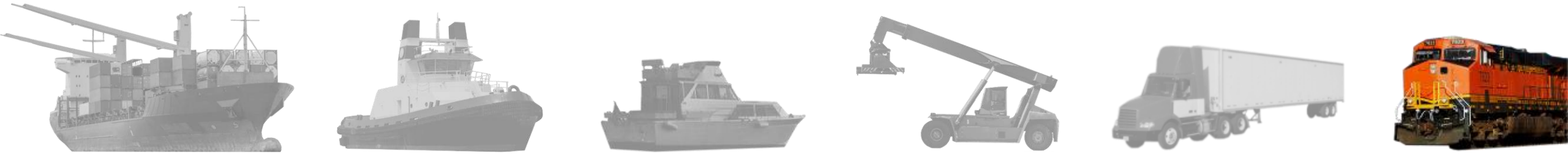


Rail: Emissions Estimation Overview

$$Base\ Year\ Emissions = A \times EF$$

- A: Activity (hp-hr)
- EF: Emissions factor (g/hp-hr) from tables or equations in document

- Three methodologies for calculating activity:
  - Fuel consumption (preferred methodology for switchers)
  - Gross ton-miles (preferred method for line-haul)
  - Number of trains

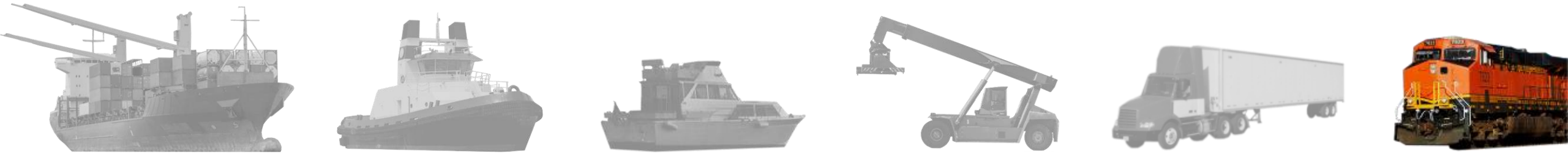


Rail Activity: Fuel Consumption Method

- Fuel consumption data are likely to be more readily available for a captive fleet, such as switcher locomotives
- Use EPA fuel consumption to hp-hr conversion factors:

Locomotive Type	Conversion Factor (hp-hr/gal)
Large line-haul and passenger	20.8
Small line-haul	18.2
Switcher	15.2

Best Practice: Estimate switcher activity based on fuel consumption



Rail Activity: Gross Ton-Miles Method

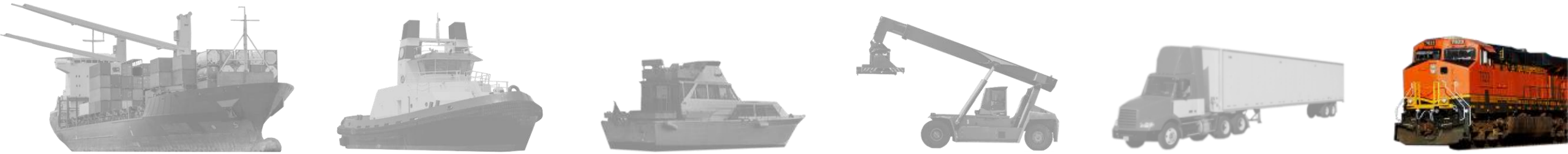
- If port-specific fleet characteristics are unknown, fuel consumption can be estimated from the total work done by the locomotives:

$$FC = GTM \times FCF$$

  - FC: Fuel consumption (gal)
  - GTM: Gross ton-miles (ton-mi)
  - FCF: Fleet average fuel consumption factor (gal/ton-mi)

Best Practice: Estimate line-haul activity based on GTM

- Activity in hp-hr can then be calculated using the fuel consumption methodologies

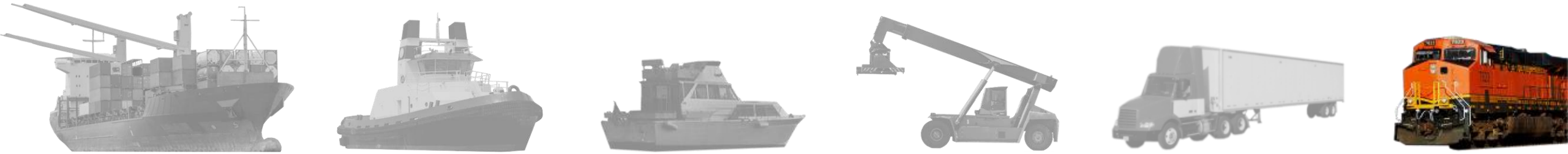


Rail Activity: Number of Trains Method

- Number of trains is useful for line-haul locomotives when fleet characteristics (i.e., rated power) are known

$$A = N_t \times N_l \times H \times P \times LF$$

- A: Activity for fleet (hp-hr)
- N_t: Number of trains visiting the port
- N_l: Average number of locomotives per train
- H: Average time spent on port per train trip (hr)
- P: Average rated power of locomotives (hp)
- LF: Average in-use load factor (dimensionless)



Rail: Alternative Methodologies

- The following methodologies are presented in the document if there is not enough local information to implement the methods described above:
  - Calculate number of container trains based on port throughput of TEUs moved by rail
  - Calculate gross ton-miles by multiplying the average weight of each train, distance traveled by each train, and the number of train visits
  - Calculate switcher activity in hours by estimating the number of rail cars and the number of switching hours per car

TEU Twenty foot Equivalent Unit






Q&A

- Please use the IM icon to type your question
- Alternatively, click “Raise Your Hand” and we will call on you to unmute yourself
- The guidance as well as these slides are available at: https://www.epa.gov/state-and-local-transportation/port-emissions-inventory-guidance
- For information on EPA’s Ports Initiative, see https://www.epa.gov/ports-initiative