



Draft Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emission Inventories

Public Webinar
February 25, 2020

Presented by:

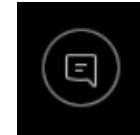


Office of Transportation and Air Quality
U.S. Environmental Protection Agency



General Housekeeping

- We are using Skype for Business for this webinar
 - We are muting the audience for this presentation
 - Please use the IM icon to ask a question or to comment
- If you are experiencing technical difficulties connecting to this webinar, please email TalkAboutPorts@epa.gov
- Purpose today is to provide an overview of the methodologies presented in the draft Port Emissions Inventory document
- Public feedback is requested by March 31st, 2020
 - If you have comments, please email them to TalkAboutPorts@epa.gov





Webinar Overview

- Background
- Planning a port emissions inventory
- Sector description and summary of data sources and methodologies for:
 - Ocean-Going Vessels
 - Harbor Craft
 - Recreational Marine
 - Cargo Handling Equipment
 - Onroad
 - Rail
- Feedback



Background

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



Draft Released 2/4/2020



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



Document Outline

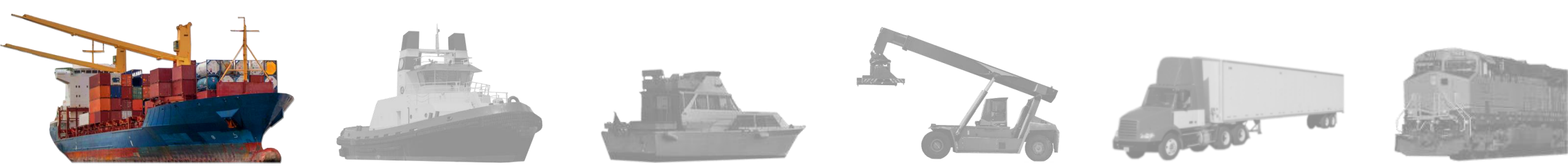
- Section 1: An Introduction to Port-Related Inventories
- Section 2: Decisions Related to Planning and Scoping an Inventory
- Section 3: Ocean-Going Vessels (OGV)
- Section 4: Harbor Craft
- Section 5: Recreational Marine
- Section 6: Cargo Handling Equipment (CHE)
- Section 7: Onroad Vehicles
- Section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



Planning a Port Emissions Inventory

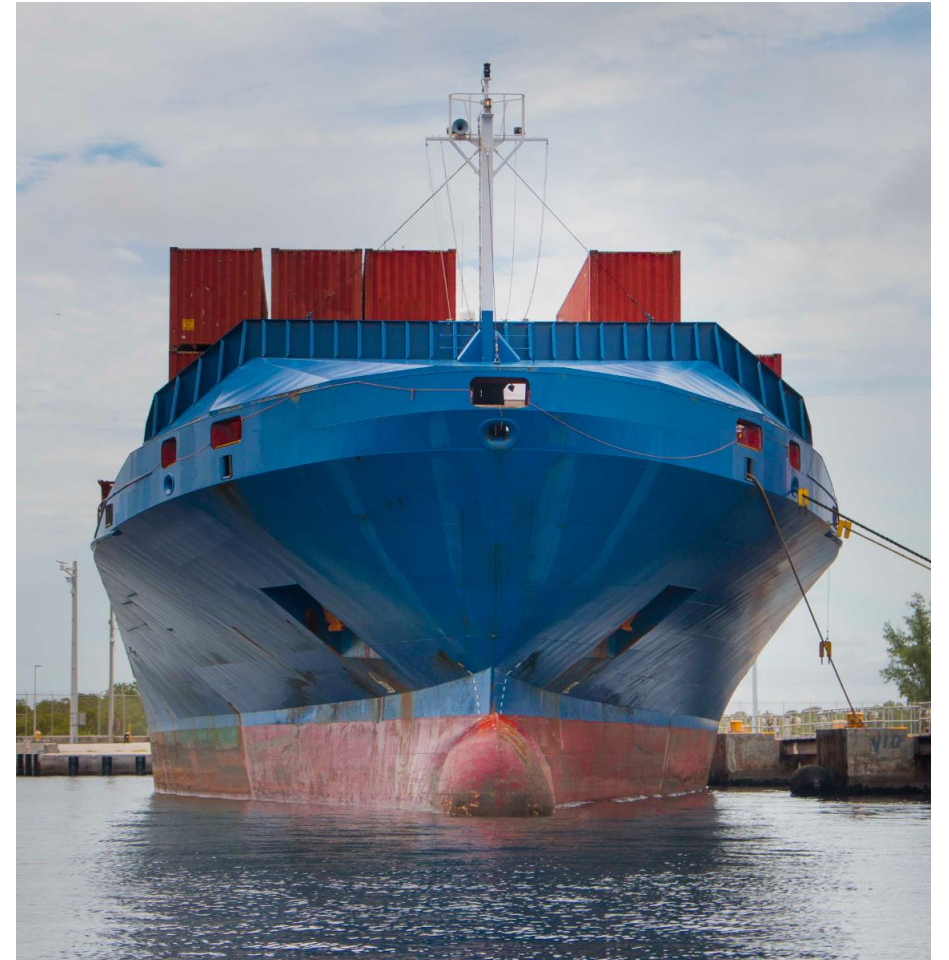
Inventory preparers need to decide:

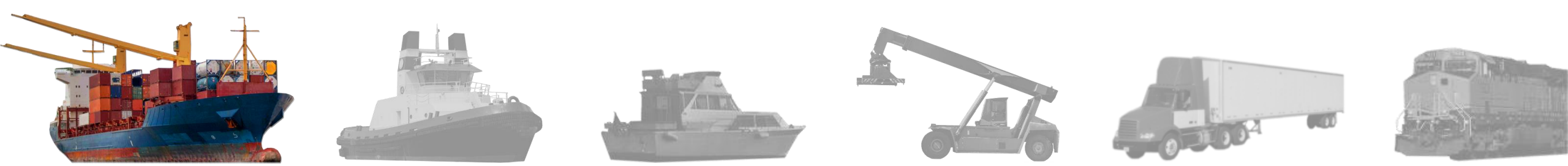
- Mobile source sectors to include
- Pollutants to include – document includes information for estimating:
 - criteria pollutants and precursors
 - climate-related pollutants
 - air toxics
- Geographic area to be covered: marine boundary, land-side boundary, transportation corridors outside the jurisdiction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



Ocean-Going Vessels (OGV)

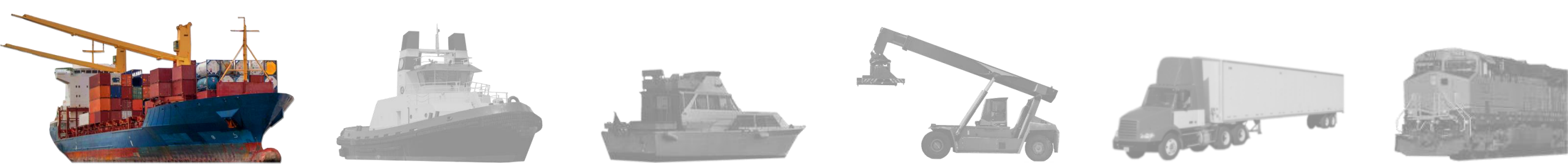
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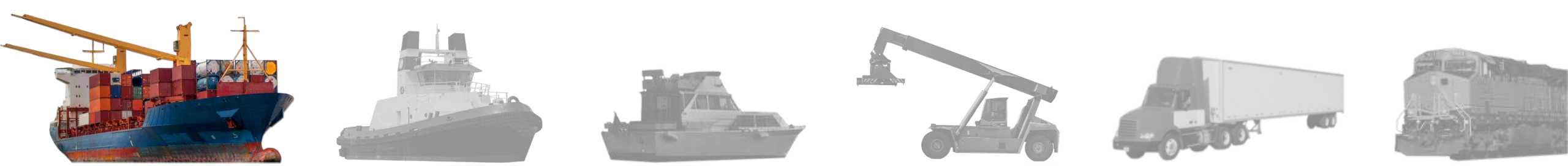
OGV: Source Description

- 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 $\geq 30L$), 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)
<p>Note: For modeling purposes, some ship types also include engine category (e.g., C3) to distinguish between OGV, harbor craft, and recreational marine.</p>	



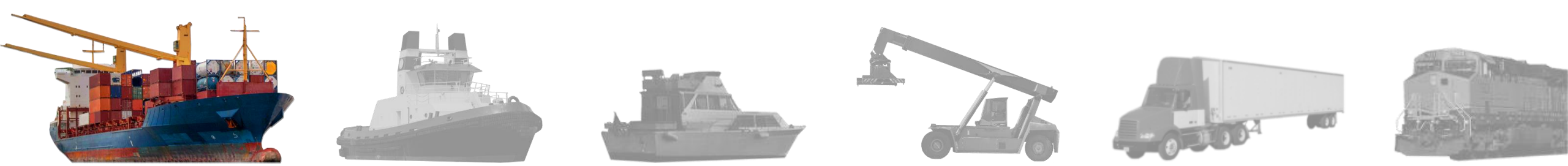
OGV: Emissions Estimation Overview

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

- *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

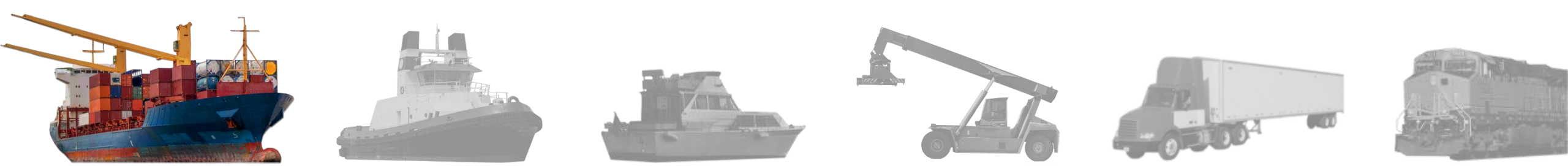


OGV: Vessel Characteristics

- 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

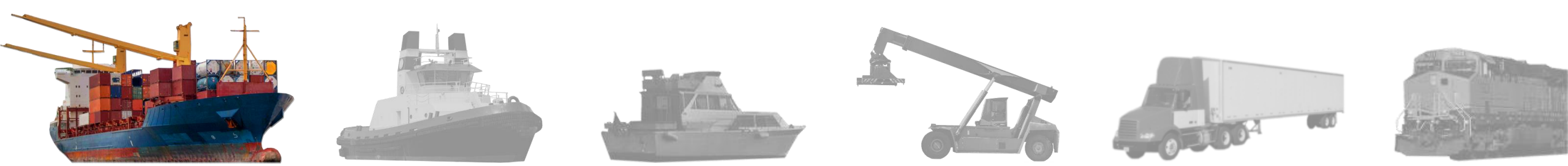
Example:





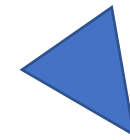
OGV: Activity Data Sources

- 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. 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



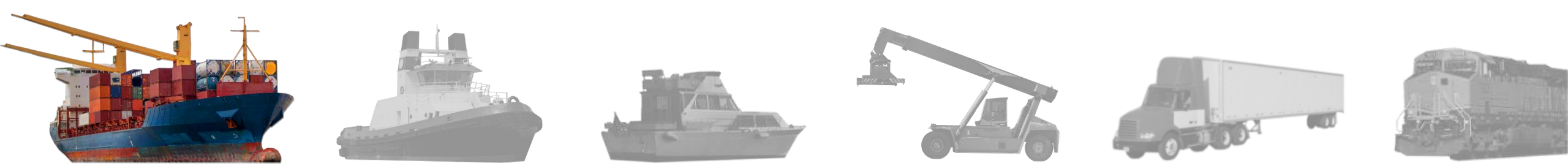
Vessel 9999999
1/1/2019 12:00pm
Speed: 12 knots
Draft: 20'



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



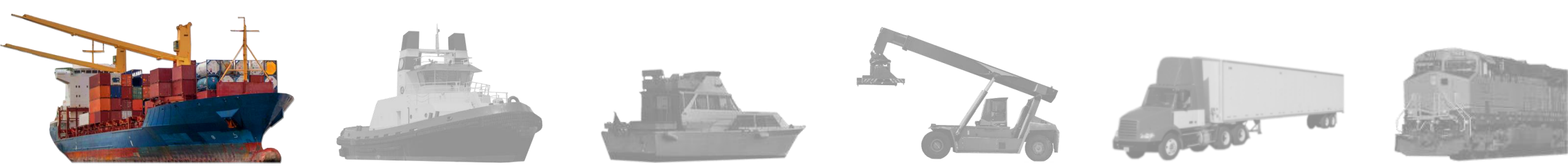
Vessel 9999999
1/1/2019 12:10pm
Speed: 10 knots
Draft: 20'



OGV: Inventory Calculation (Vessel Call Method)

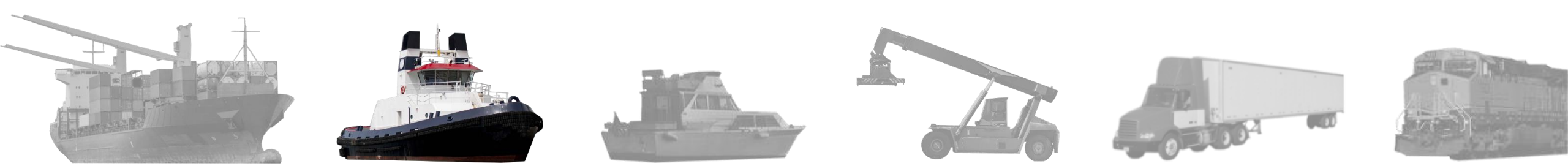
Vessel call data can come from port logs, Entrances & Clearances, Waterborne Commerce, pilot surveys, etc.

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

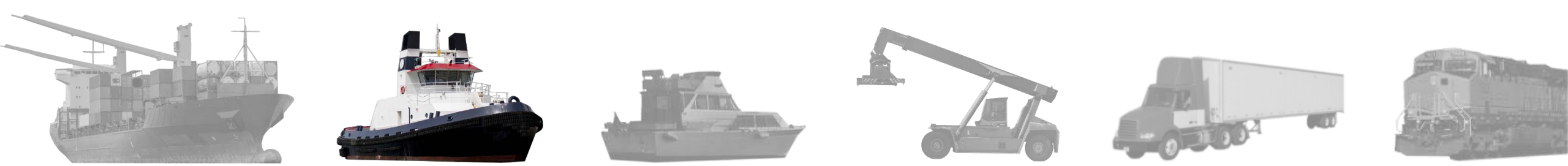
1. Future growth factors should come from local port estimates
 - Alternatively, the Freight Analysis Framework (FAF4) can be used for region-specific growth estimates
2. Apply future growth factors to base year activity estimates
3. Estimate future age distribution from base year age distribution
4.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



Harbor Craft

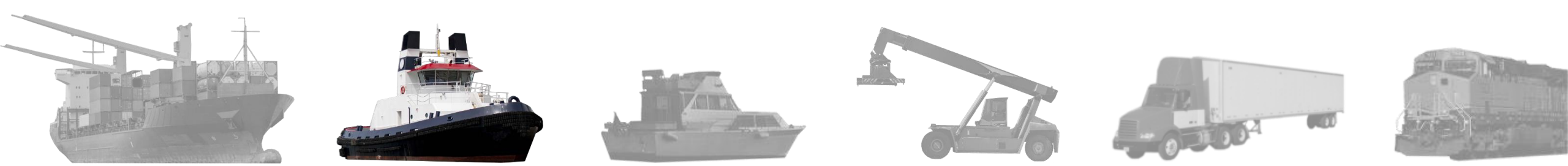
Section 4





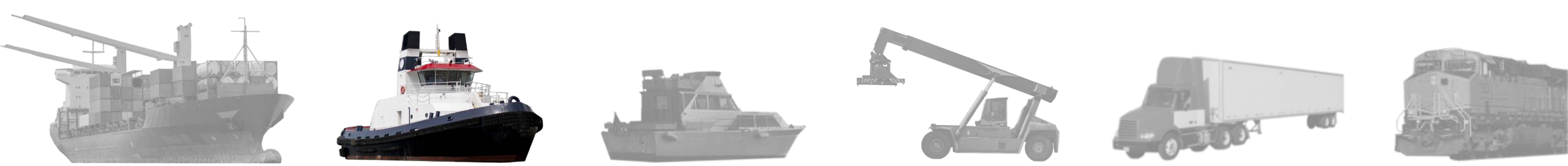
Harbor Craft: Source Description

- 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

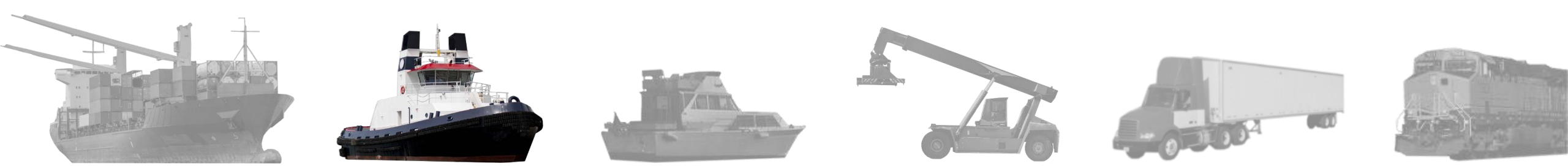
Barge	Harbor Ferry (C1/C2)
Crew and Supply	Miscellaneous (C1/C2)
Dredging	Pilot
Excursion	Towboat/Pushboat
Fishing (C1/C2)	Tug Boat
Government	Work Boat
<p>Note: For modeling purposes, some ship types also include engine category (e.g., C1) to distinguish between OGV, harbor craft, and recreational marine.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



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 guidance



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

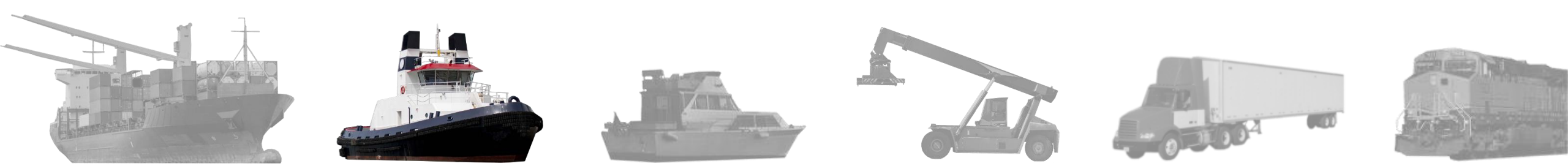
Vessel Characteristics Example:

Vessel 9999999
Tug Boat

Propulsion Engines:
MY1998, 1,720 kW



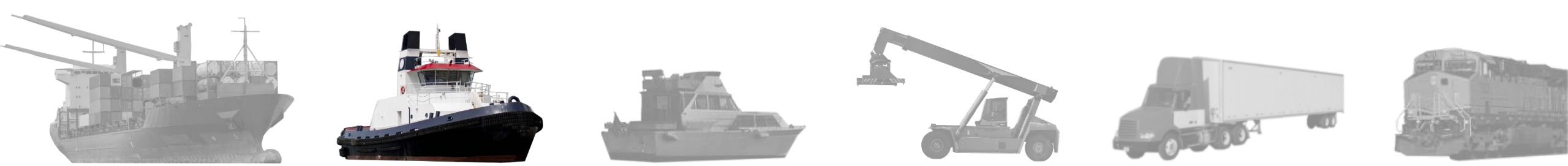
Installed Power:
3,440 kW



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

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

- 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



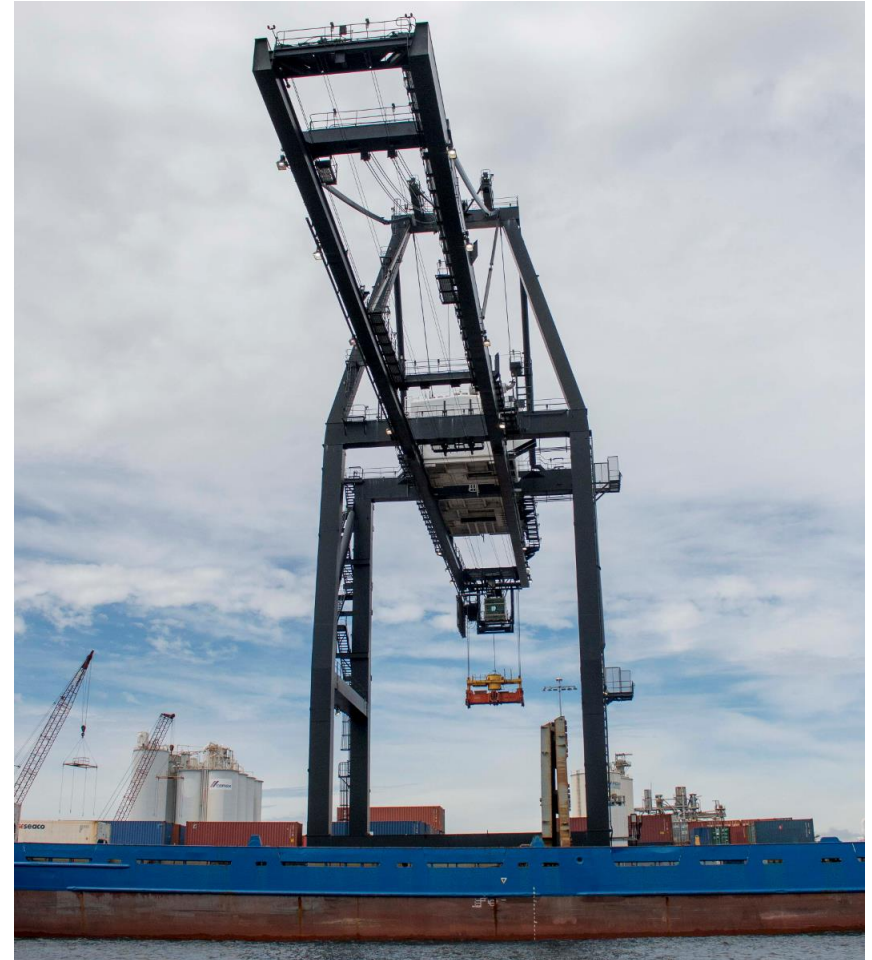
Rec Marine: Projecting Future Inventories

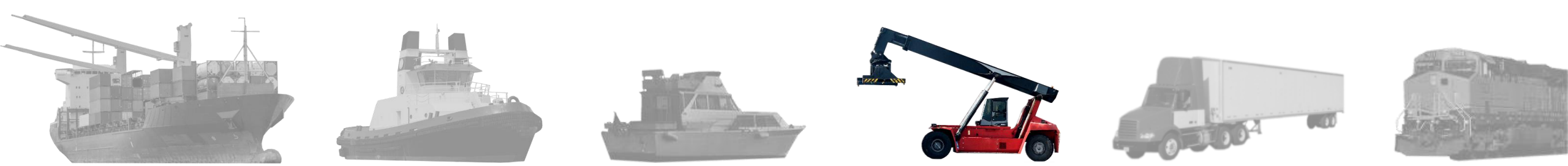
1. Future growth factors should come from local port estimates
 - Alternatively, regional growth factors used by MOVES-Nonroad can be used instead
2. Apply future growth factors to base year activity estimates
3. Use future fleet-average emission factors from MOVES-Nonroad instead of projecting a local 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:

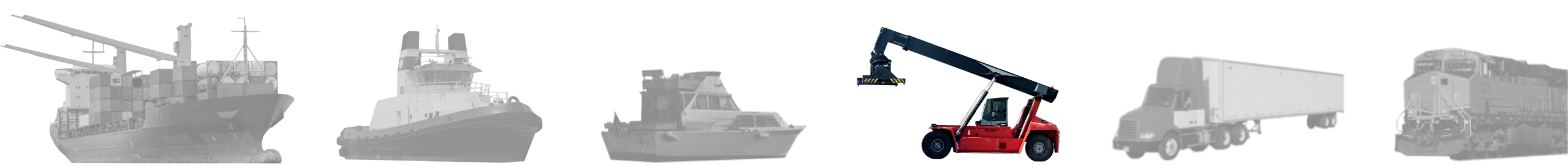
Aerial Lifts	Reach Stackers
Compressors	Rollers
Cranes	Rubber-tired Gantry (RTG) Cranes
Empty Container Handlers	Side Handlers
Excavators	Skid-steer Loaders
Forklifts	Sweepers
Generators/Power Packs	Top Handlers
Light Towers	Tractors/Loaders/Backhoes
Manlifts	Welders
Off-highway Trucks	Yard Tractors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



CHE: Emissions Estimation Overview

$$\textit{Base Year Emissions} = P \times LF \times A \times EF$$

- 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



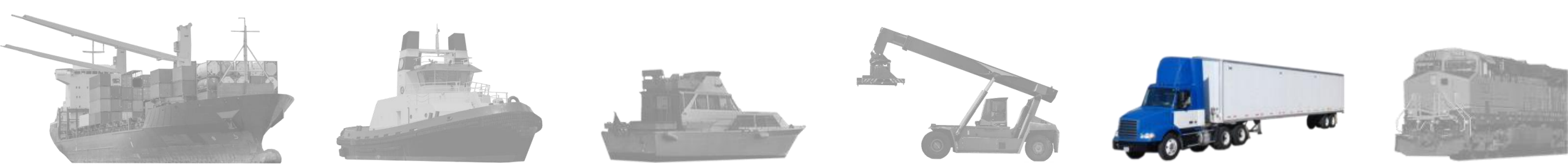
CHE: Alternative Inventory Calculations

- 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



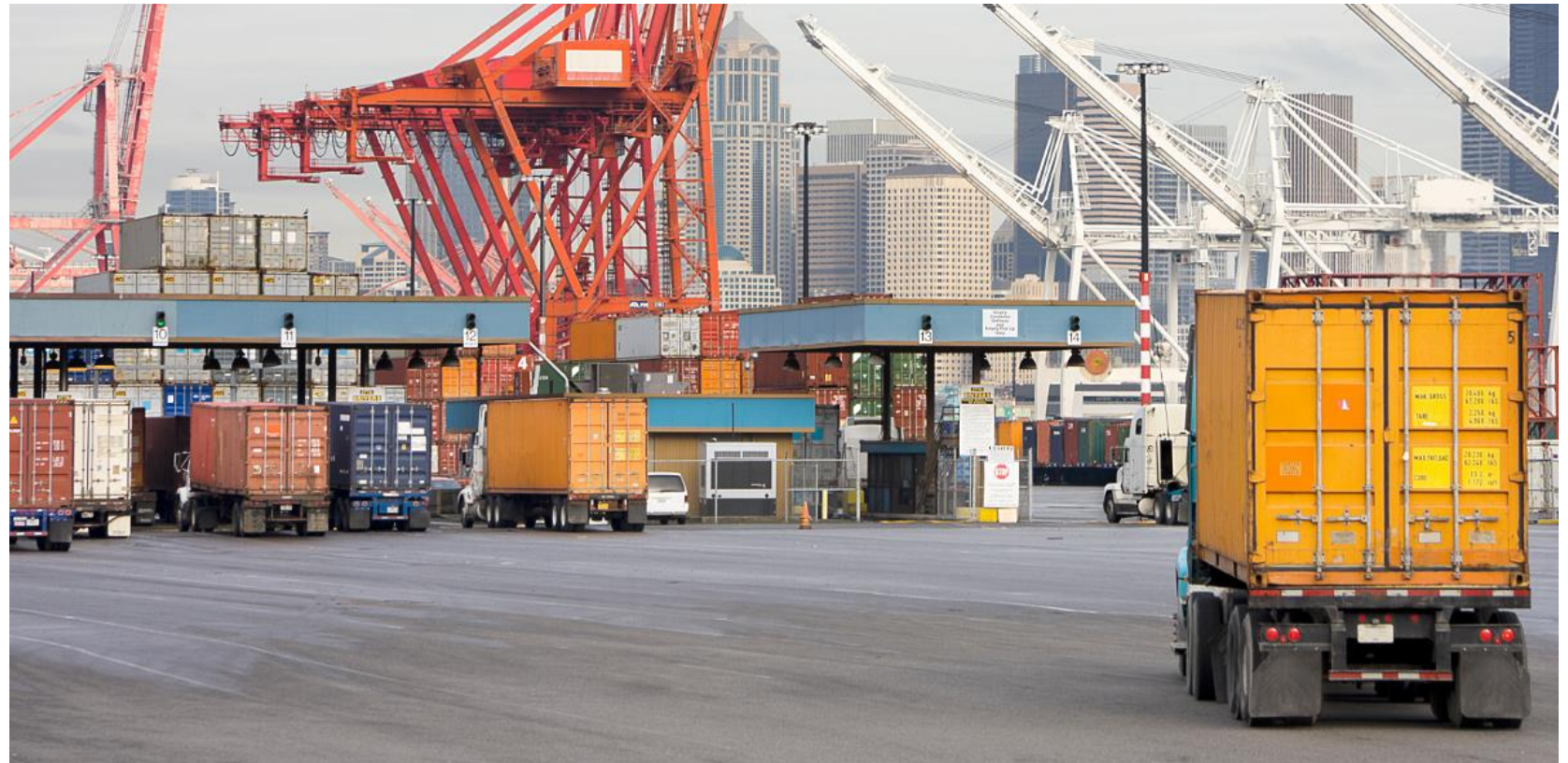
CHE: Projecting Future Inventories

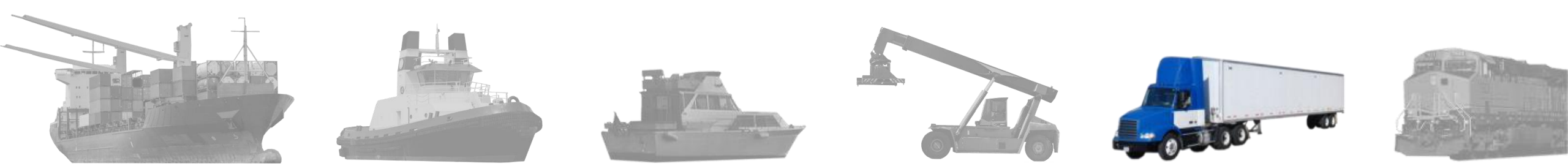
1. Future growth factors should come from local port estimates
 - Alternatively, the Freight Analysis Framework (FAF4) can be used for region-specific growth estimates
2. Apply future growth factors to base year activity estimates
3. Estimate future age distribution from base year age distribution
4.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

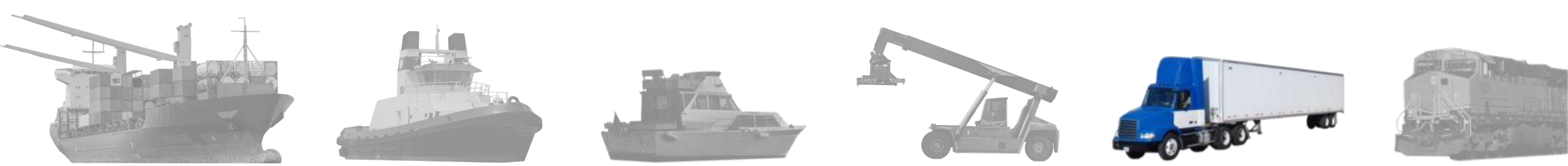
Vehicle types included (but not limited to):

Heavy-Duty Vehicles

- Drayage Trucks
- Long-Haul Trucks
- Shuttle Buses

Light-Duty Vehicles

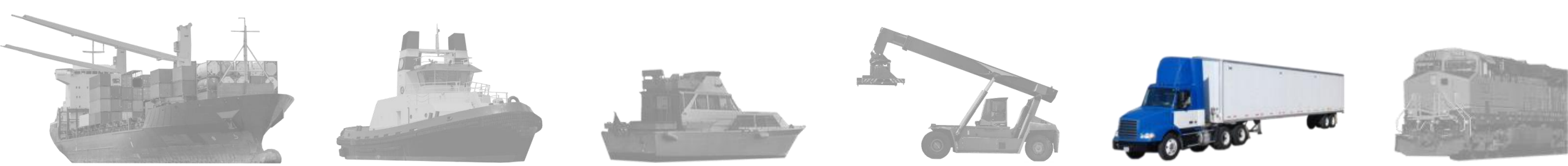
- Passenger Cars and Trucks
- Passenger Vans
- Import/Export Vehicles
- Maintenance Trucks



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

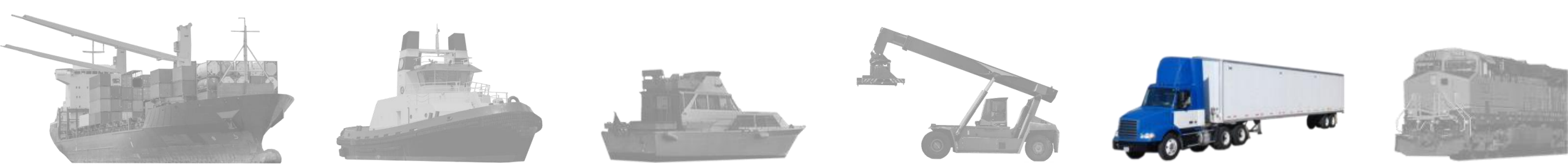
- **Fleet Characteristics**

- 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**

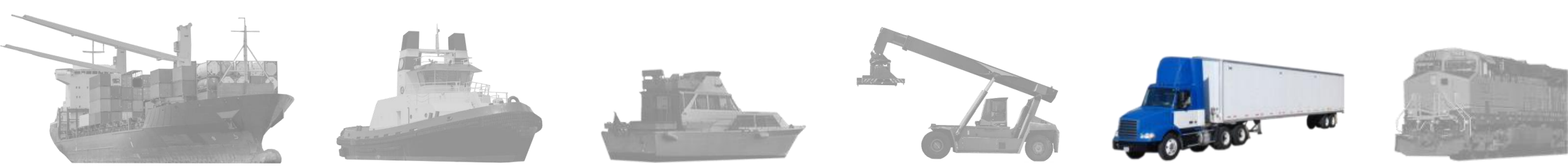
- Activity type and counts (activity by source type)
- Vehicle travel speeds (for running activity)

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



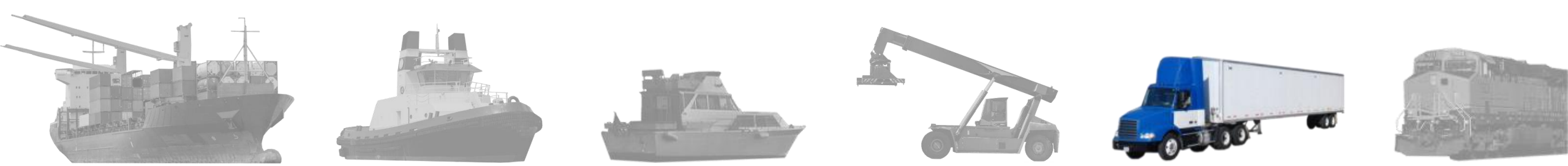
Onroad: County Scale Approach

- 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



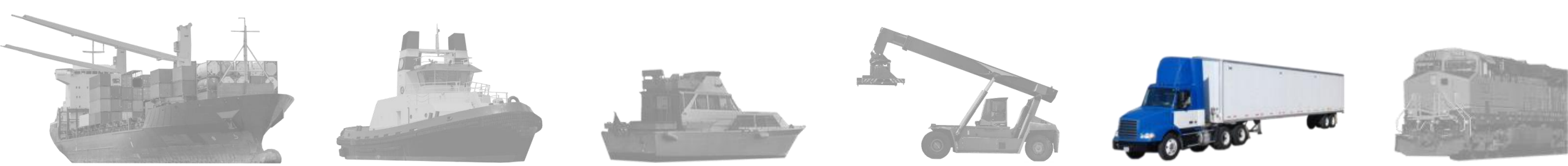
Onroad: Project Scale Approach

- 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



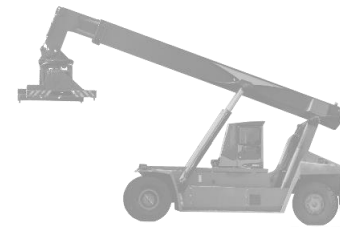
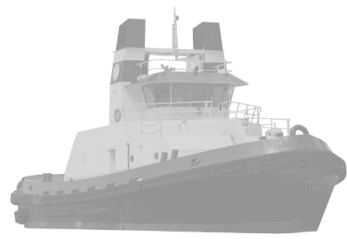
Onroad: Refined Project Scale Approach

- 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

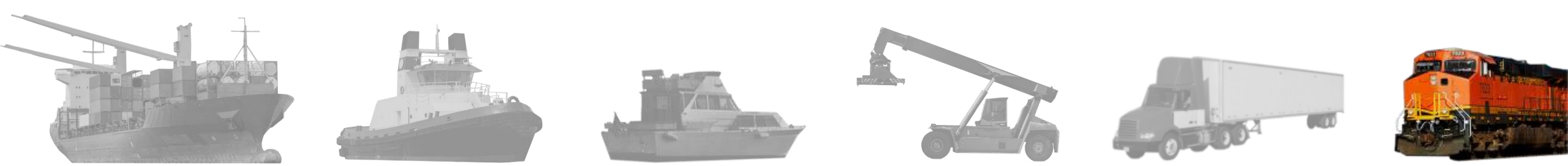
- Future growth factors should come from local port estimates
 - Alternatively, the Freight Analysis Framework (FAF4) can be used for region-specific growth estimates
- Apply future growth factors to base year activity estimates
- Estimate future age distribution from base year age distribution
 - Could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



Rail

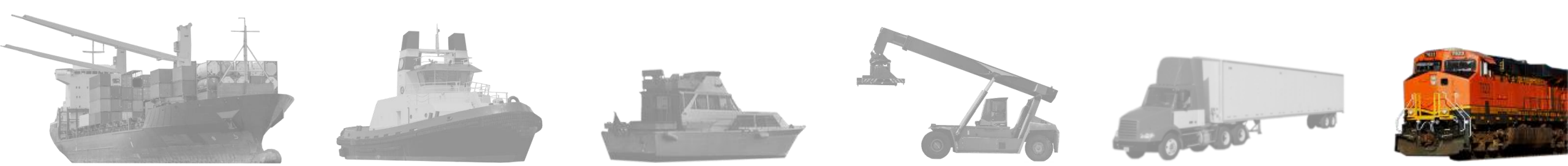
Section 8





Rail: Source Description

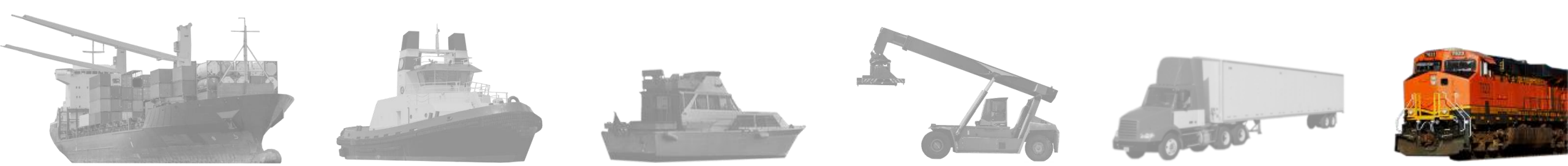
- Two typical sources of rail emissions at ports:
 - Line-haul locomotives
 - Pick up or deliver cargo to off-port locations
 - Typically newer and higher-powered
 - Switcher locomotives
 - Assemble and disassemble trains
 - Typically older and include more idling



Rail: Emissions Estimation Overview

$$\textit{Base Year Emissions} = A \times EF$$

- *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)
 - Number of trains (preferred method for line-haul)
 - Gross ton-miles

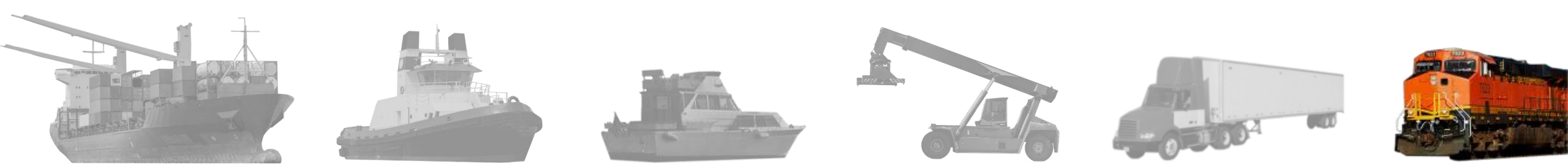


Rail Activity: Fuel Consumption Method

- 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



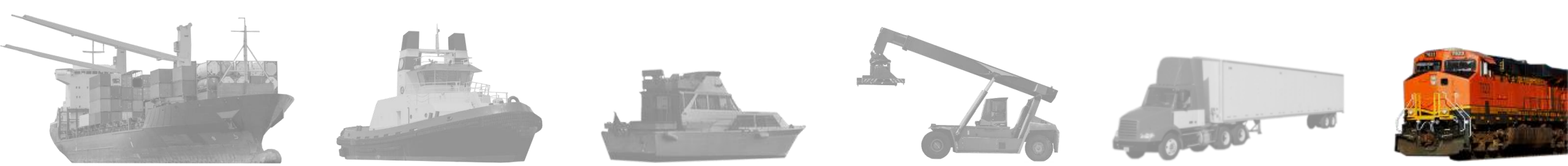
Rail Activity: Number of Trains Method

- 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)

Best Practice: Estimate line-haul activity based on number of trains

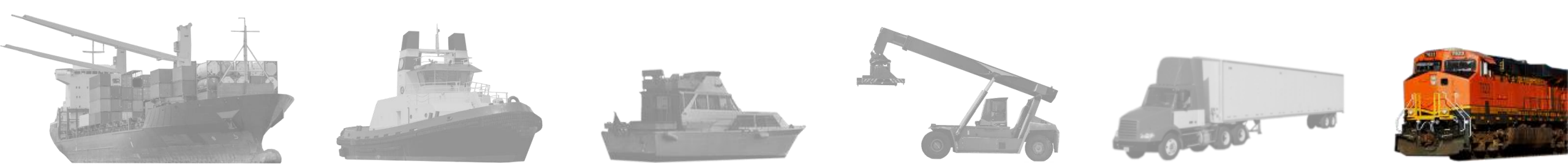


Rail Activity: Gross Ton-Miles Method

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



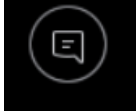
Rail: Alternative Methodologies

- The following methodologies are presented in the guidance 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 ask a question or to comment 
- This document can be used now and is available at:
<https://www.epa.gov/ports-initiative/port-and-goods-movement-emission-inventories>
- Public feedback is requested by March 31st, 2020
 - If you have comments, please email them to TalkAboutPorts@epa.gov
- We anticipate finalizing the document later this year