Development of Detailed Railyard Emissions to Capture Activity, Technology and Operational Changes

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Overview

- Union Pacific Railroad, the J. R. Davis Yard, and railroad operations in general
- Emission inventory issues for railyards
- Specific activities at the J. R. Davis Yard
- Activity data and emission factors
- Activity and emission trends
- Conclusions

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Union Pacific Railroad

The Largest Railroad in North America

23 states

32,615 route miles

7,500 locomotives

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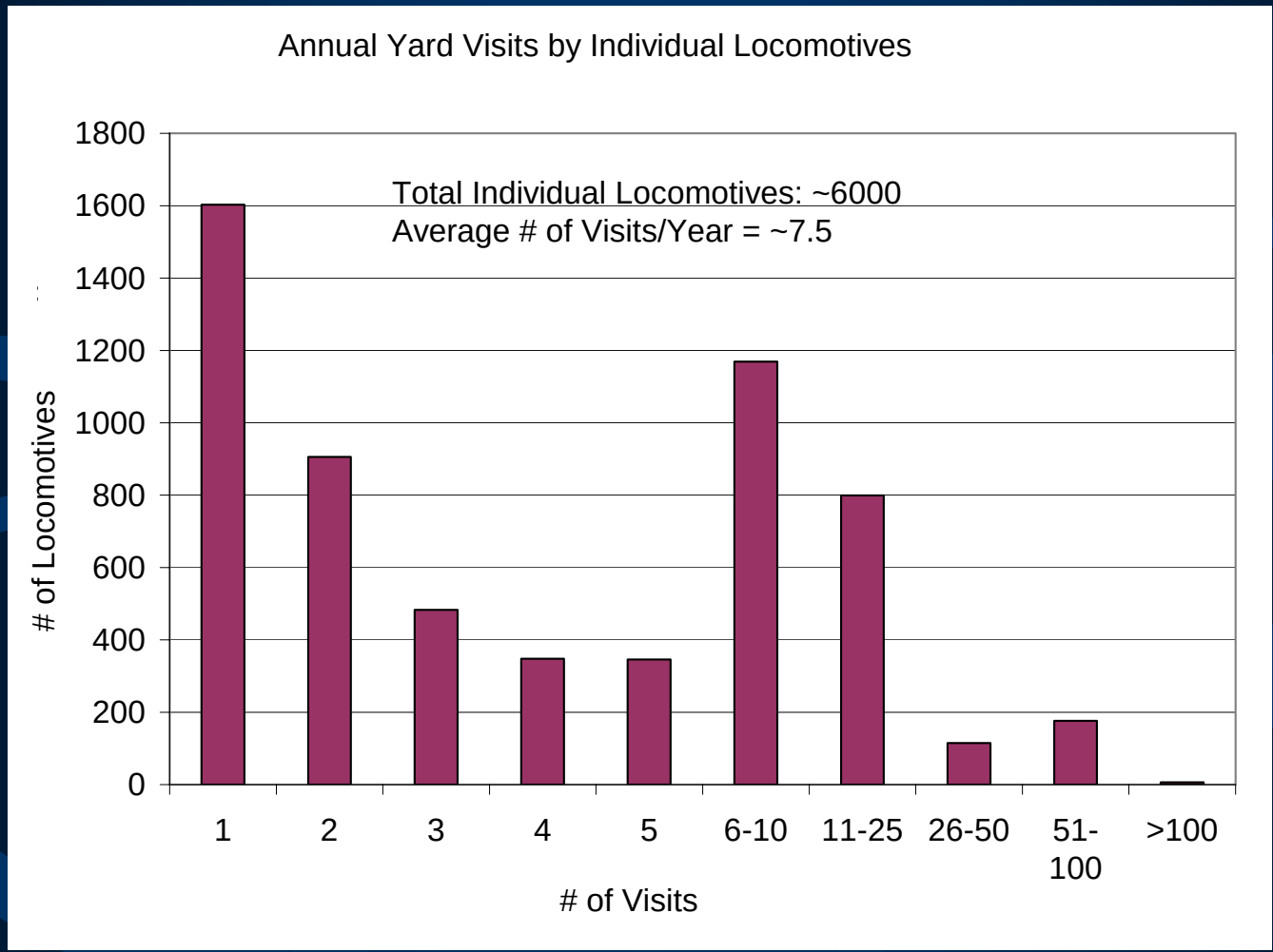
J. R. Davis Yard, Roseville, CA

- UP's largest classification yard in the western U.S.
- 40,000 locomotive arrivals per year
- Subject of a 2004 CARB modeling study
- UP cooperated closely in data collection and analysis for emission inventory
- Methodology extended to assess trends and evaluate emission reduction alternatives

Part of a National Network



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Railroad Operations

- Move the freight!
  - Quickly
  - Efficiently
- 1 double stack train = 280 HHDDTs
- 2-4 x more fuel efficient
- 3-4 x cleaner per ton-mile

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Railyards

- Strategically located
- Get freight to its destination
  - Break and build trains (classification)
  - Intermodal facilities
  - Ports
- Keep them running
  - Refueling and service
  - Locomotive repair
  - Car repair

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Top-Down Rail Emission Inventories

- EPA 1998 Regulatory Support Document
  - Average duty cycles for line-haul and switching
  - Emission factors in g/bhp-hr by model and duty cycle
  - Fuel consumption estimated and converted to bhp-hrs
  - Emissions = (bhp-hrs) x (g/bhp-hr)

	Throttle Position (Percent Time in Notch)									
Duty Cycle	**D.B.**	**Idle**	**N1**	**N2**	**N3**	**N4**	**N5**	**N6**	**N7**	**N8**
Line-Haul	12.5	38.0	6.5	6.5	5.2	4.4	3.8	3.9	3.0	16.2
Switch	0.0	59.8	12.4	12.3	5.8	3.6	3.6	1.5	0.2	0.8

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Problems with Top Down Approach

- Impossible to spatially disaggregate
  - Roseville arrivals likely to have been last fueled in Utah or Oregon
  - Duty cycles are not representative of activity within railyards
- Bottom-up inventory approaches are required

Q: What Goes on in Railyards?

A: It depends on the yard

- J. R. Davis Yard
  - "Hump" yard for classification
  - Locomotive fueling and service
  - Locomotive repair and testing
  - Local train operations
  - Track "maintenance of way" trains

Q: What's a Hump?

A: Gravity-powered classification

- Incoming trains pushed over a hump
- Cars are automatically uncoupled at the hump and directed into "bowl" tracks with computer switching and braking to build new train segments
- Switchers ("trim sets") pull out new train segments and push to departure tracks

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The J. R. Davis Yard

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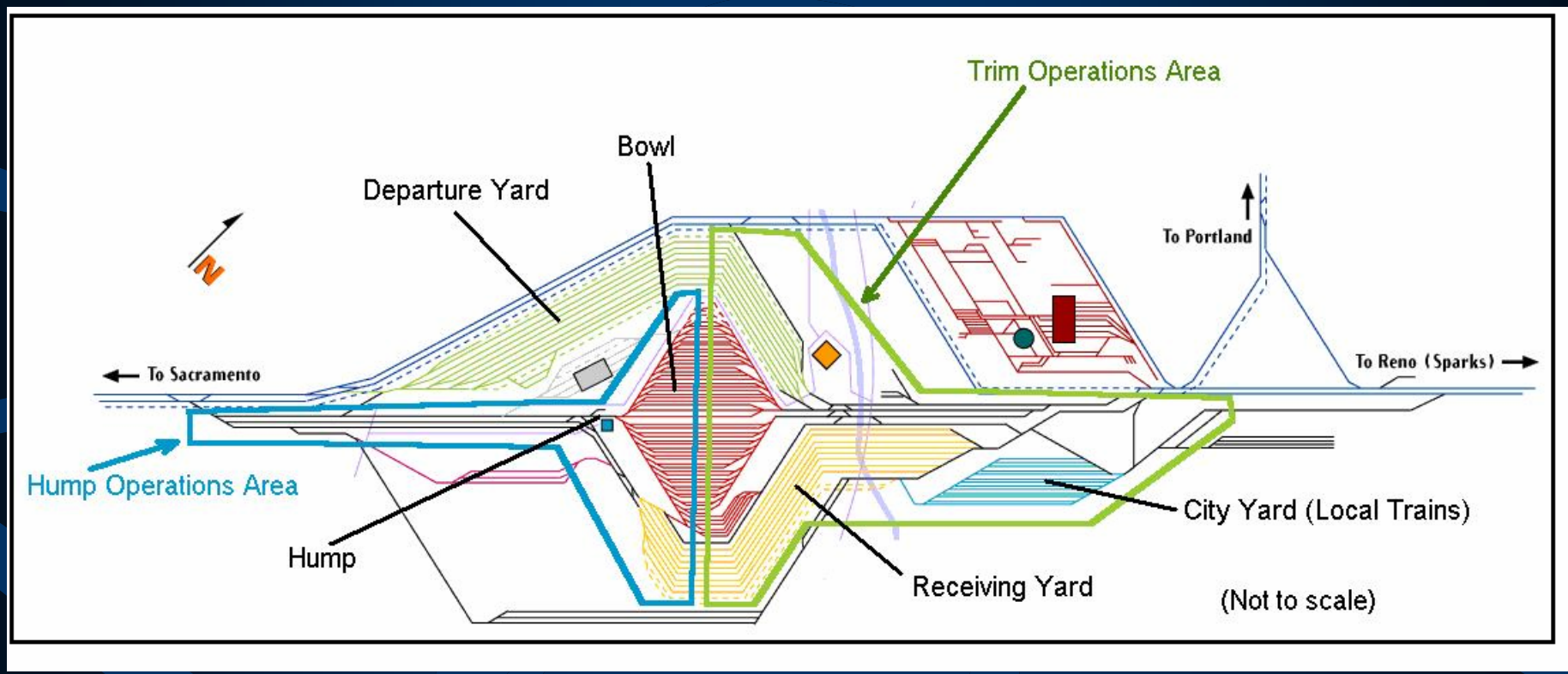
Yard Schematic



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What Happens at J. R. Davis Yard

- Through trains pass on the Northside track
- In-bound line-haul and locals go to the Receiving Yard
  - Consists (groups of locomotives) disconnect and are sent to the Service Track or to out-bound trains
  - Cars are sent to classification (hump)
- Service Track washes, fuels, oils, and sands out-bound consists, and does minor repairs

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What Happens at J. R. Davis (cont.)

- Locomotive repairs and testing handled at the locomotive shop
- Maintenance of way and out-bound local trains handled at the Rockpile and City Yard
- Out-bound line-haul trains are mated with consists in the Departure Yard

What Happens at Other Yards

- J. R. Davis is a hump classification yard with maintenance facilities
- Other yards differ
  - Flat switching classification yards
  - Intermodal terminals
  - Ports and car loading
  - Service and maintenance
  - Geographic layout and types of freight handled

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Emission Inventory Needs

- Activity
  - Number, model and location of consists
  - Paths through the yard
  - Duration of operations and throttle settings
  - Hump set operations
  - Trim set operations

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Train Data (~70,000 Records)

	Used to Identify				
Parameter	Identification of Train Events	Location in Railyard	Consist Composition	Temporal Profile	Train Characteristics
Train Symbol	X	X			
Train Section	X				
Train Date	X				
Arrival or Departure	X	X			
Originating or Terminating	X	X			
Direction		X			
Crew Change?		X			
Arrival & Departure Times				X	
# of Locomotives			X		
# of Working Locomotives			X		
Trailing Tons					X
Locomotive ID #			X		
Locomotive Model			X		

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Hump and Trim

- Dedicated units (sort of)
  - Hump: Specially modified GP-38s with variable throttle
  - Trim: GP-38 or switchers that may be traded out
  - Most equipped with ZTR SmartStart
  - 24/7 operations with fixed number of units

	Throttle Position (Percent Time in Notch)									
Duty Cycle	**D.B.**	**Idle**	**N1**	**N2**	**N3**	**N4**	**N5**	**N6**	**N7**	**N8**
Trim Operations	0.0	44.2	5.0	25.0	2.3	21.5	1.5	0.6	0.0	0.0
Hump Pull-Back	0.0	60.4	12.5	12.4	5.9	3.6	3.6	1.5	0.0	0.0
Hump Push	0.0	0.0	0.0	100	0.0	0.0	0.0	0.0	0.0	0.0

Movement, Service, Repair and Testing

- Consist movements avoid bowl and hump, typically with all but one unit shut down
- Service volume and model distribution data
  - Service codes by locomotive ID give location
  - Maintenance codes identify load tests

	Throttle Position (Percent Time in Notch)									
Duty Cycle	**D.B.**	**Idle**	**N1**	**N2**	**N3**	**N4**	**N5**	**N6**	**N7**	**N8**
Consist Movement	0.0	0.0	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0
Load Tests:										
10-Minute	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80.0
15-Minute	0.0	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	66.7
30-Minute	0.0	33.3	33.3	0.0	0.0	0.0	0.0	0.0	0.0	33.3

Emission Factors

- > 50 locomotive submodels in common use
- Differences may be negligible between models, and in-use emissions data are not available for every model
- 11 model groups were selected based on common engine families

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Locomotive Model Groups

Model Group	Engine Family	Representative Models
Switchers	EMD 12-645E	GP-15, SW1500
GP-3x	EMD 16-645E	GP-30, GP-38
GP-4x	EMD 16-645E3B	GP-40, SD-40-2, SD-45-2
GP-50	EMD 16-645F3B	GP-50, SD-50M
GP-60	EMD 16-710G3A	GP-60, SD-60M
SD-7x	EMD 16-710G3B	SD-70MAC, SD-75
SD-90	EMD 16V265H	SD-90AC, SD-90-43AC
Dash-7	GE7FDL (12 cyl)	B23-7, B30-7, C36-7
Dash-8	GE7FDL (12 or 16 cyl)	B39-8, B40-8, C41-8
Dash-9	GE7FDL (16 cyl)	C44-9, C44AC
C60-A	GE7HDL	C60AC

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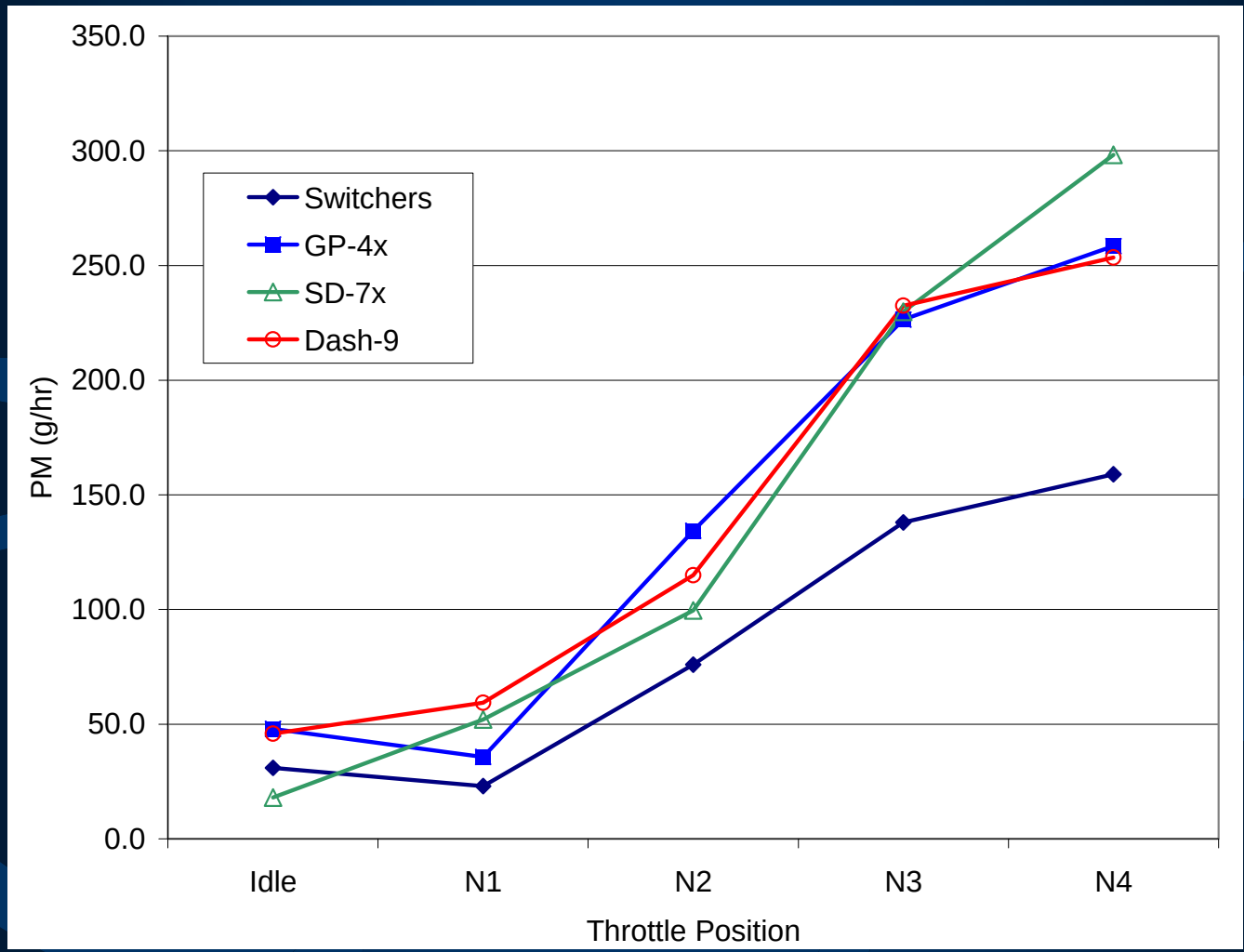
Emission Factors (PM, g/hr)



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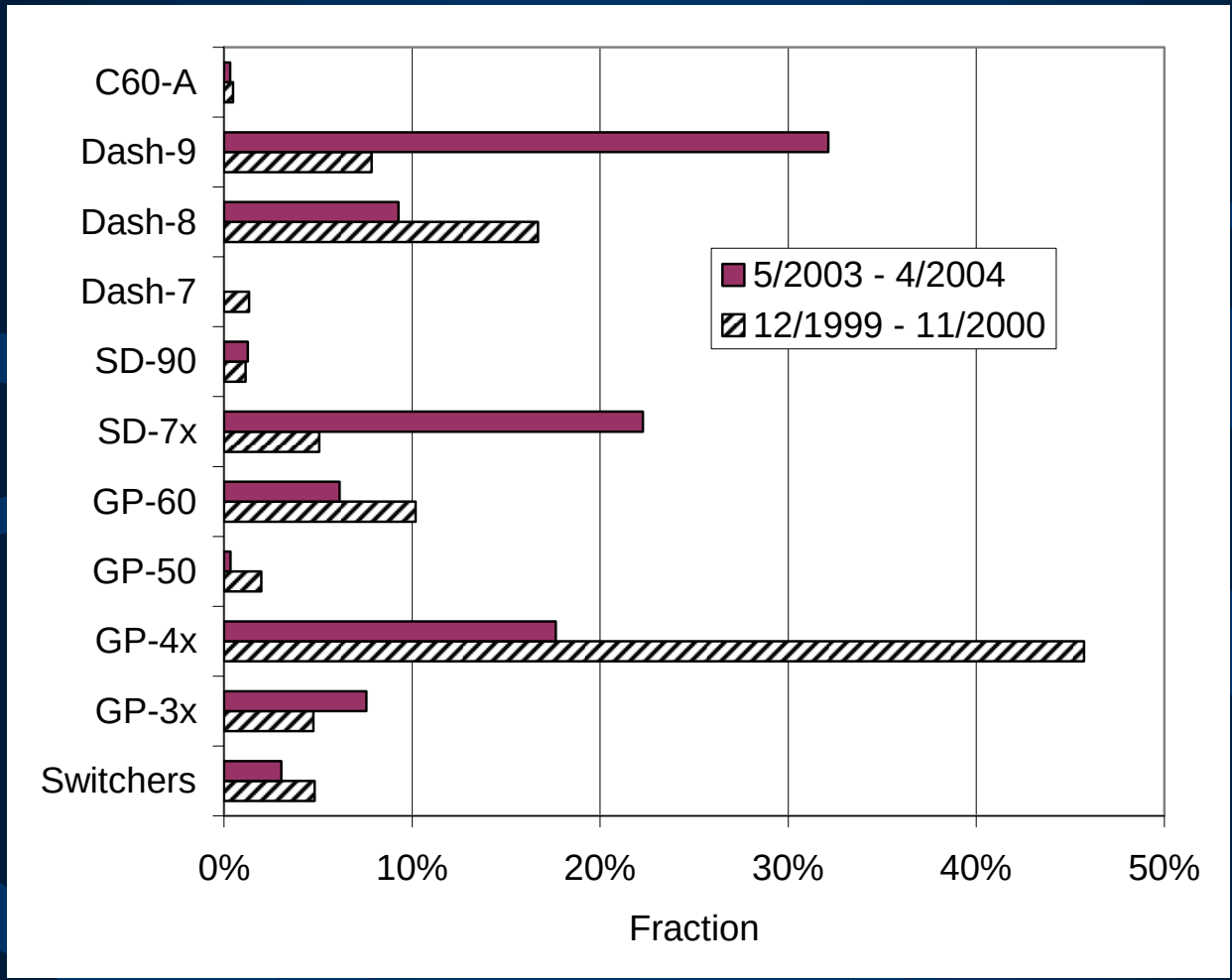
Factors Affecting Emission Trends

- Fleet modernization
  - 1900 new units since January 2000
  - Higher horsepower, Tier 0, 1 and (soon) 2
  - Decrease in GP-4x, GP-50, GP-60, Dash 7 & 8
  - Lower idle emission rates
  - 1800 units now have auto start/stop technology
  - Decrease in maintenance and load testing
- Increased freight volume and operational changes
  - Little change in number of trains
  - Decrease in fraction of trains handled in the yard

Locomotive Model Trends



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Yard Activity Trends

Trains, Locomotives and Freight

	Trains	Locomotives	Trailing Tons
Arrivals	-5.2%	-3.5%	--
Departures	-7.0%	-7.3%	--
Throughs (Bypassing the yard)	8.0%	6.8%	--
Total Arrivals and Departures	-0.3%	-0.9%	15.1%

Load Testing (scheduled and unscheduled maintenance)

10-Minute Tests	-18.9%
15-Minute Tests	14.6%
30-Minute Tests	-43.2%
Total Tests	-12.3%
Idling Hours	-20.6%
Notch 1 Hours	-43.2%
Notch 8 Hours	-12.0%

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Emission Trends

	Estimated Emissions (tons per year)		Percent Change
	12/1999 – 11/2000	5/2003 – 4/2004	
Idling and Movement of Trains	5.2	4.2	-20.3%
Idling and Movement of Consists	8.5	6.8	-20.2%
Testing	1.5	1.3	-14.1%
Hump and Trim	7.0	6.6	-5.7%
Total	22.3	18.9	-15.3%

Conclusions

- Each railyard is unique w.r.t. activities, layout, types of freight, and role in the national network
- Top-down methods don’t apply
- Total activity (trains, tons, locomotives, and models) can be well characterized
- Details of in-yard operations less available, and require expert input

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Conclusions (cont.)

- Disaggregate (bottom-up) data provide verifiable trends and the opportunity to evaluate emission reductions from operational changes and new technologies
- Yards are part of a national network and can’t be treated in isolation
- Yard operations and emissions will reflect the effects of national network changes

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