Investigating Highway-Rail Intermodal Terminal Capacity Relationships via Simulation

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C. Tyler Dick, PhD, PE**

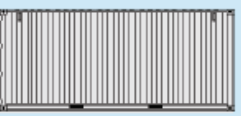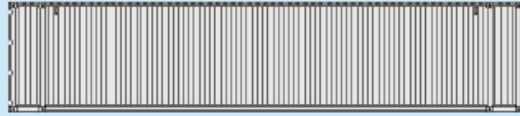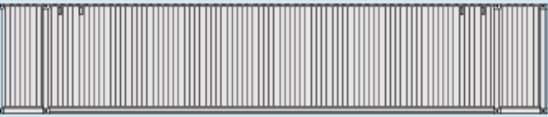INFORMS Annual Meeting - Seattle, WA

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RAILTEC
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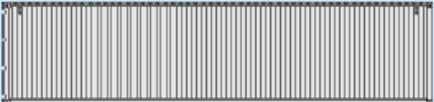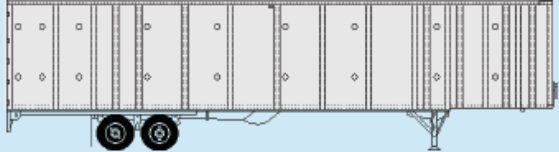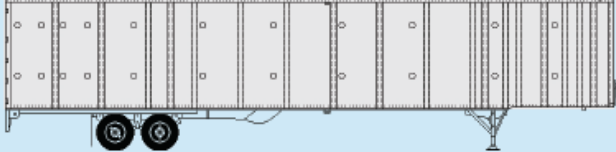
Intermodal Facilities

► Three types: seaport, inland (dry) port, inland domestic

► Previous simulation efforts have focused primarily on port facilities

- Ports can handle only certain types of containers

► This research focuses on inland domestic facilities

- These facilities can handle a greater variety of traffic

20' Marine (ISO) Standard Container

40' Marine (ISO) Standard Container

45' Marine (ISO) High Cube Container

48' Domestic High Cube Container

40' Marine (ISO) High Cube Container

53' Domestic High Cube Container

28' Domestic Pup Trailer

48' Domestic Trailer

53' Domestic Trailer

Intermodal Facilities (cont'd)

inland (dry) port

inland domestic

Problem and Research Objectives

► Current terminal resources are unable to keep up with existing traffic levels

- Increase in dwell time decreases overall terminal capacity

► Facilities are costly to build and operate

- Capital: what is the ideal facility size to handle projected traffic volumes?
- Operating: how to best allocate available resources to maximize productivity of an existing facility?

► Research Objectives

- Better understand the relationships between the various factors affecting terminal capacity and performance
  - Quantify the influence of specific layouts

Past Simulation Efforts

▶ **Past North American efforts are limited in project scope**

- "Gray literature": project-specific objectives
- Little academic study of fundamental relationships
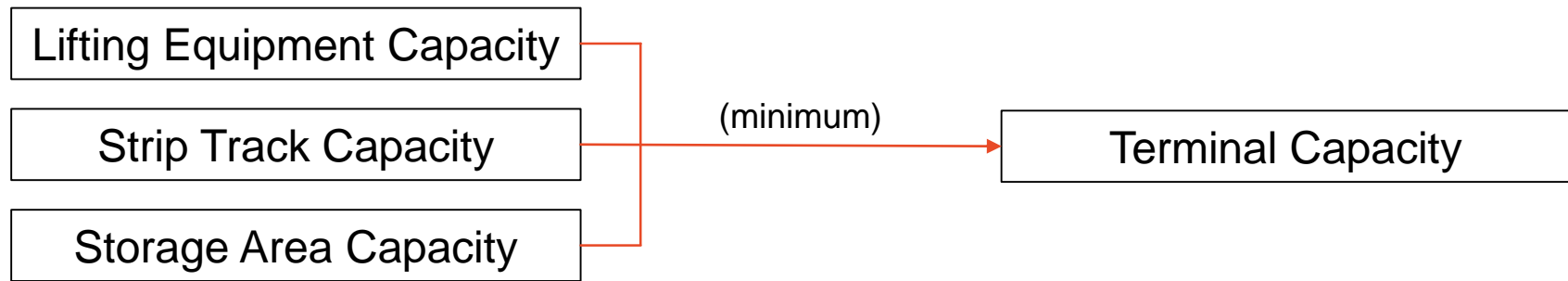
▶ Canadian National (1984)

- Planning/analysis tool
- Simulation and graphical postprocessor replay

▶ BNSF Railway (2017)

- Corwith (Chicago, IL, USA) – evaluate capacity expansion options
- Hobart (Commerce, CA, USA) – identify bottleneck areas
- Alliance (Fort Worth, TX, USA)

How Capacity is Currently Estimated

► Three primary contributing factors, according to the American Railway Engineering and Maintenance-of-Way Association (AREMA)

| Lifting Equipment Capacity |
| Strip Track Capacity | → (minimum) → | Terminal Capacity |
| Storage Area Capacity |

► Limitations

- Assumes full potential utilization of above elements
- Resource allocation (ex. hostlers) not considered
- Facility layout arrangement (tracks, roads, parking) not considered
- Physical capacity with no consideration of performance or level of service

► A need to better understand fundamental capacity and performance relationships between truck and rail operations within a terminal

Example Facility Layouts

▶ AREMA capacity = 1,316 trailers/day

1×8000 ft (2,440 m)

2×4000 ft (1,220 m)

4×2000 ft (610 m)
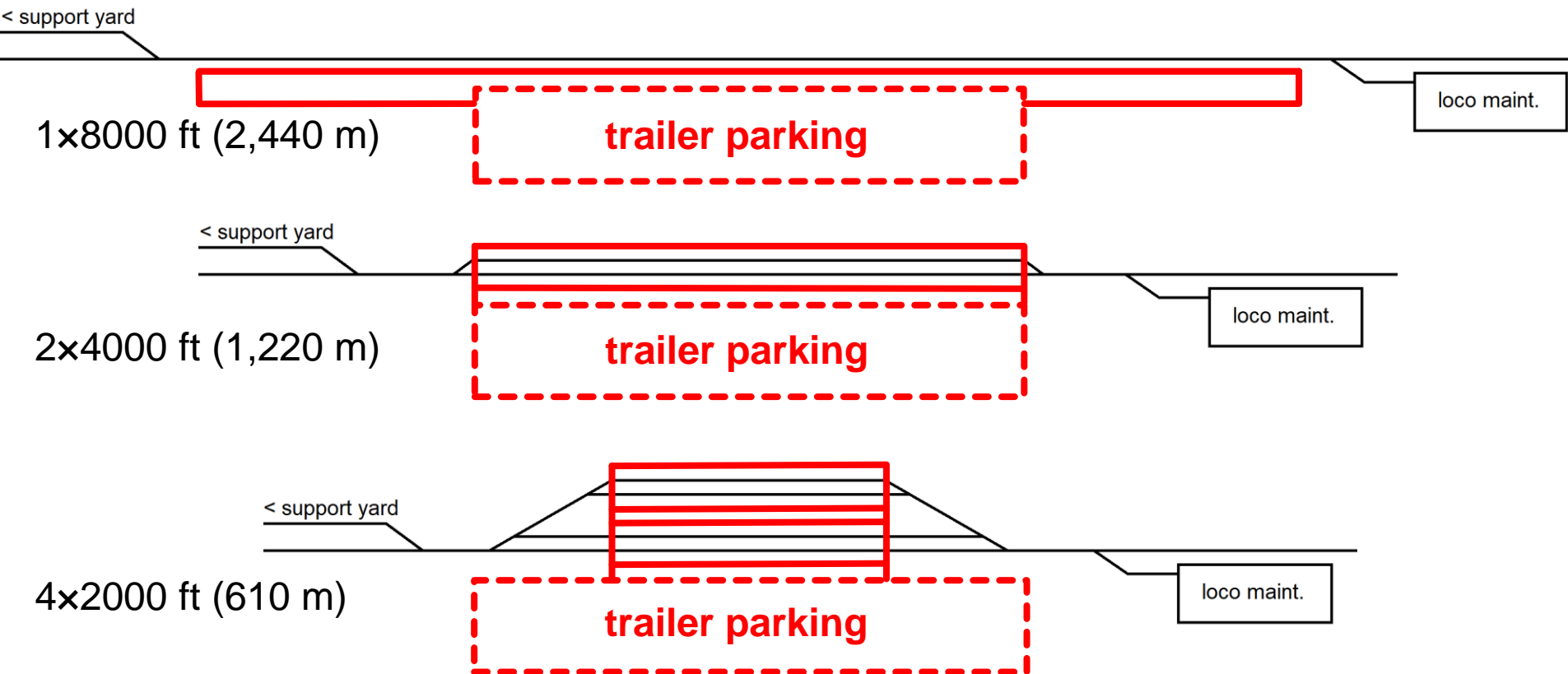
▶ Current method → all three faciilty layouts have equal capacity

▶ Trade-off: driving distance vs switching time

Experimental Parameters

▶ 4 rubber-tired gantry (RTG) cranes

▶ 8,000 feet (2,440 m) of strip track

▶ 120 trailers per train

▶ 5% "reload rate" (arrive and leave with a trailer)

▶ 1,440 parking spaces

▶ Facility area = 163.3 acres (approx. 660,852 m²)

▶ Trailer traffic only
  • Containers are placed on chassis upon unloading from train
  • No double stacking

▶ Models assume "zero duration" for certain events
  • Instantaneous coupling/decoupling
  • Brake tests
  • Verification of inbound contents (train)

Methodology and Experiment Design

► Variables

  - Facility layout
  - Number of hostlers (1-50, increments of 5)
  - Pickup delay distribution (12-hour increments)

$$2 \times \text{agent.color} + \text{uniform}(\ldots)$$

  - Set delay determined at a 2-hour increment for each of five levels of trailer priority
  - Additional uniformly distributed random delay

► Calculate throughput capacity with:

 - AREMA method
  - AnyLogic simulations

AnyLogic®

- ▶ Discrete-Event Simulation (DES) software
  - Transportation planning and optimization
  - Supply chain design
  - Warehouse operations problems

- ▶ Users include Amtrak, CSX Transportation, Norfolk Southern, BNSF Railway, Aurizon and several railway consultants

- ▶ Used in academia to address capacity questions

- ▶ **AnyLogic® can simulate intermodal terminal operations**
  - Special-purpose libraries
  - Operational logic organized as a flowchart
  - Use of agents allows for more fluid modeling
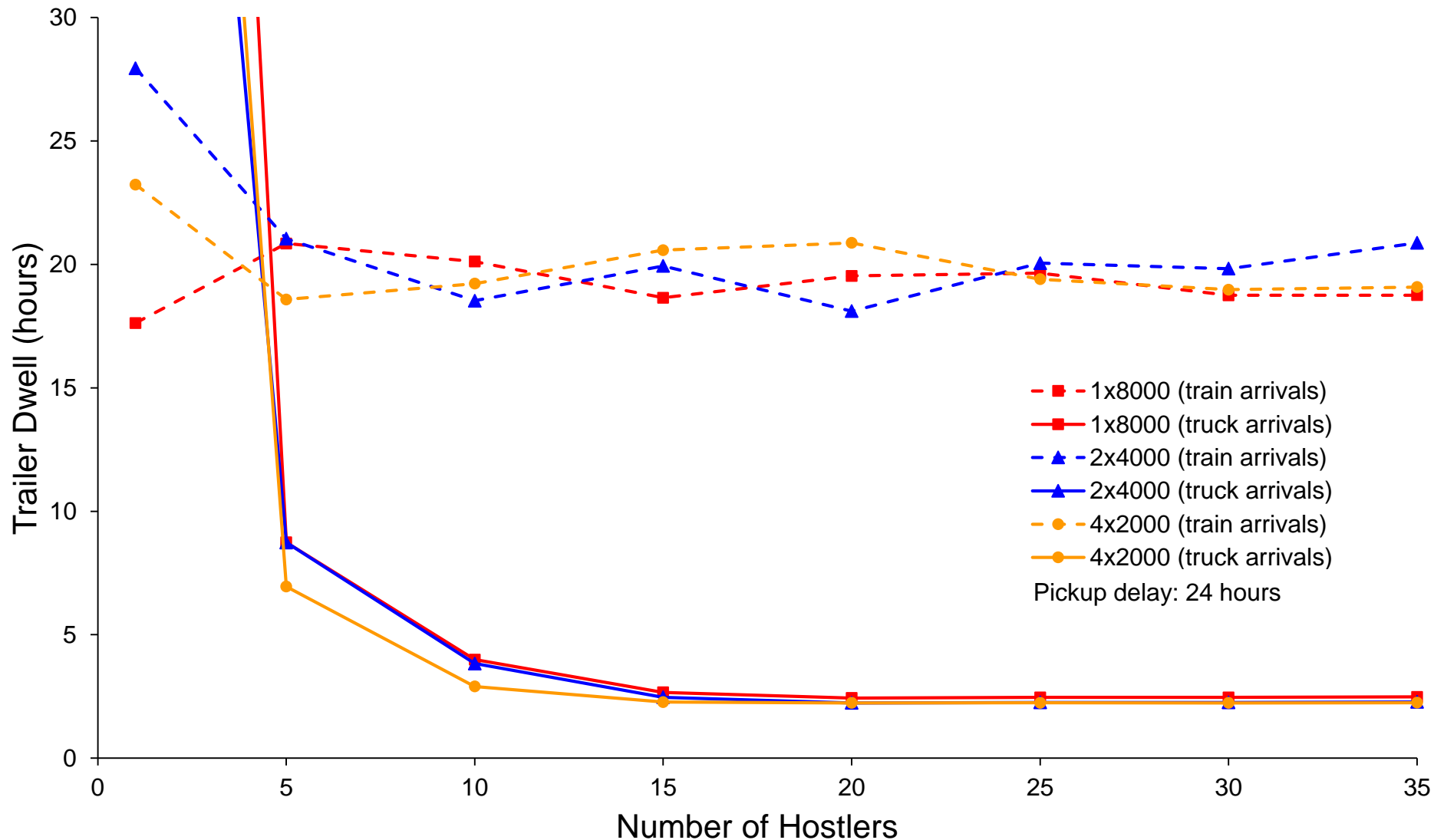 - Combination of logic blocks and Java text coding

Model

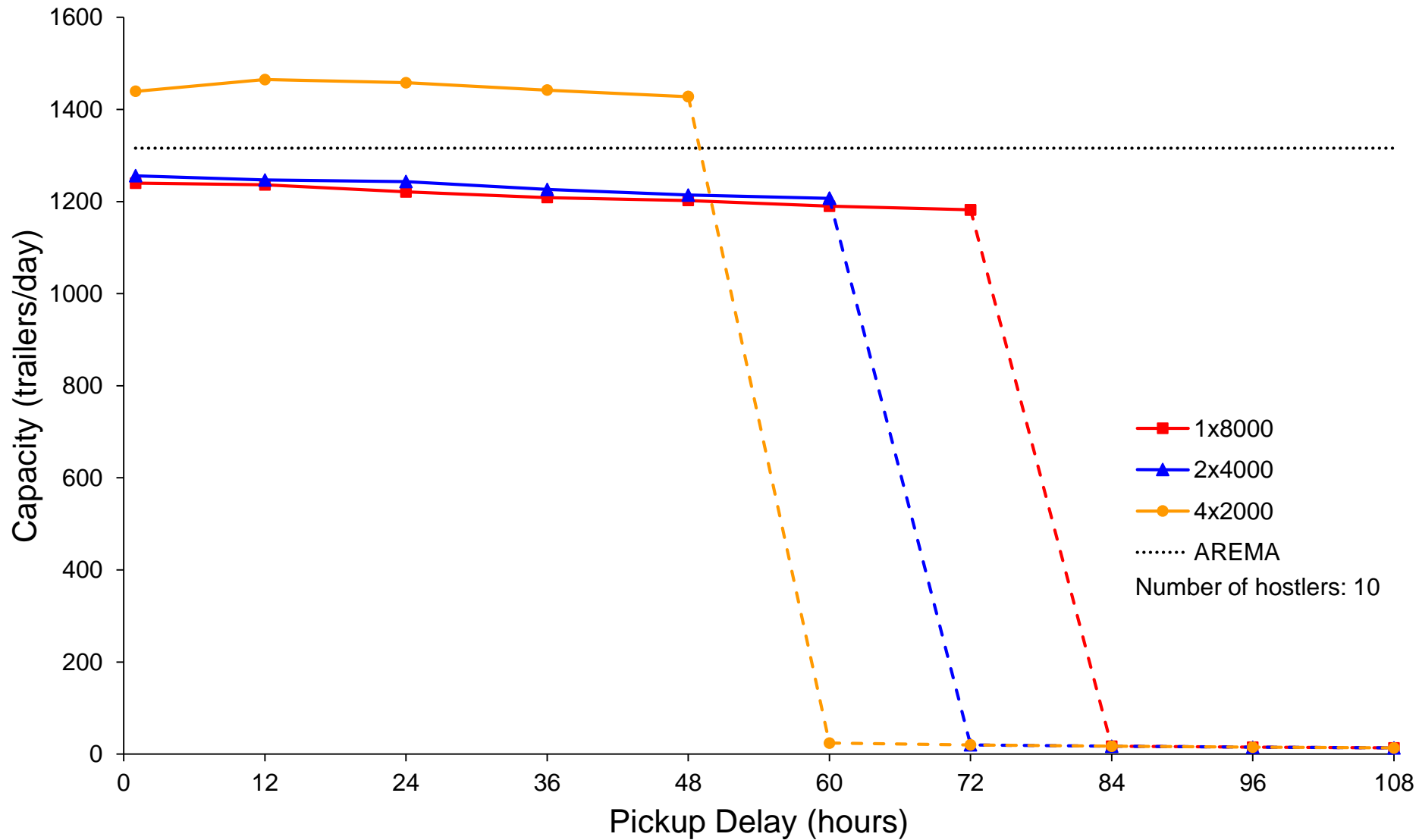► Visualization capabilities allow us to better identify potential bottleneck areas
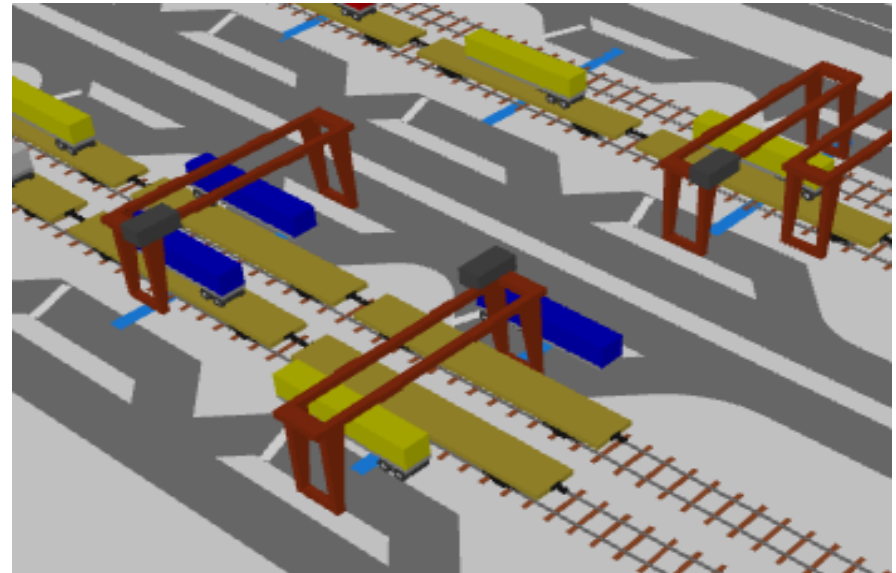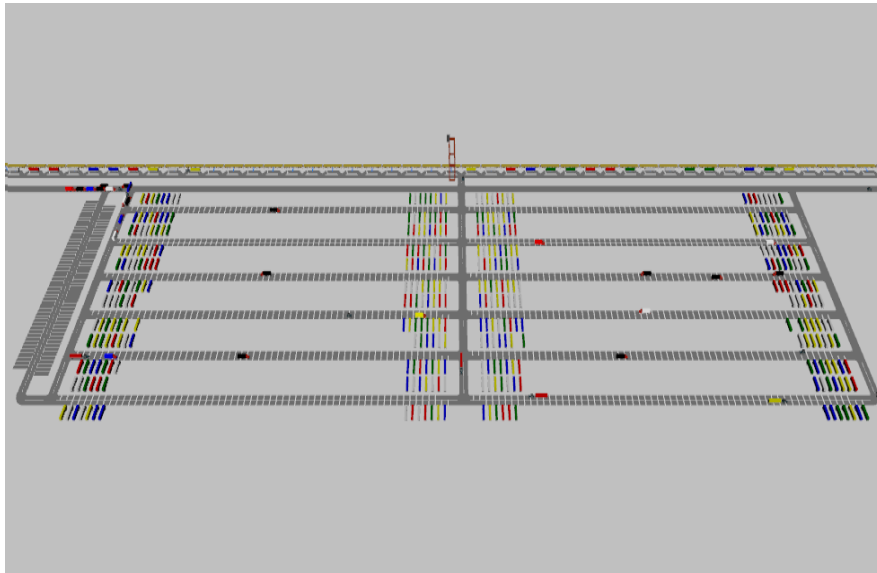
Layout Capacity by Number of Hostlers
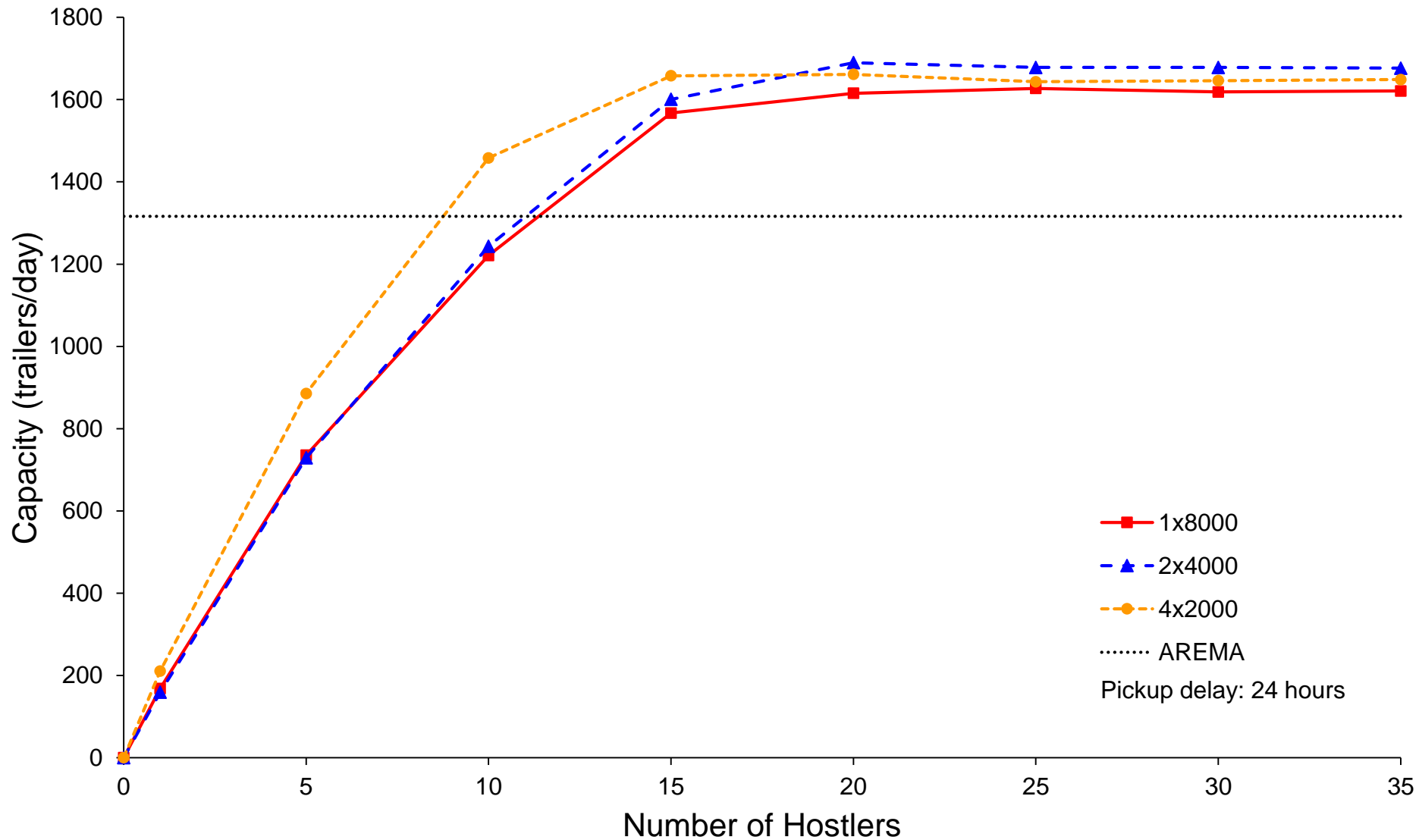
Layout Dwell by Number of Hostlers

Pickup Delay Distribution and Capacity

Conclusions and Future Work

▶ When hostler resources are constraining, physical layout of the terminal can substantially alter capacity of identically sized facilities
- Layout and traffic congestion less of a concern with hostler oversupply
- Does alter LOS for OTR pickup and delivery

▶ Additional Development
- Eliminate remaining no-delay assumptions
- Integrate support yard tracks and process multiple trains in parallel

▶ Future Experiments
- Varying traffic distributions
  - Unloaded truck arrival rate (pickup and reload)
- Different crane types (widespan vs gantry)
- Containerization
  - Double stacking on railcars
  - Container stacking in facility

Thank you for your attention!

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