Investigating Intermodal Terminal Capacity Using AnyLogic Simulations

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Outline

► Introduction
► Literature Review
► Simulation Model
  • Model Assumptions
  • Model Development
  • Experiments
► Future Work
► Conclusion
Introduction

► In 2017, intermodal accounted for 24% of overall Class 1 revenue
  • Largest single source of revenue
  • 2018 YTD volumes up 5.7% from 2017 values (as of 10/27/18)

► Transloading cost is critical to competing with highway transport
  • Rail + truck + transloading \(\rightarrow\) competitiveness
  • Increasingly important as trucks improve efficiency and reduce costs through automation

► Facilities are costly to build and operate
  • Capital: what is the ideal facility size to handle projected traffic volumes?
  • Operating: how to best allocate a facility’s resources to maximize productivity?

► Strong economic incentive to minimize transloading costs by matching intermodal facility capacity with current and projected demand
Current Methodology

► How is capacity (in lifts per day) currently estimated?
  • Three primary contributing factors (current AREMA practice)

  - Lifting Equipment Capacity
  - Strip Track Capacity
  - Storage Area Capacity

  (minimum)

  Terminal 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

► There is a need to better understand fundamental capacity and performance relationships between truck and rail operations within a terminal
Example Facility Layouts

1 \times 8000 \text{ ft} \\
\\
2 \times 4000 \text{ ft} \\
\\
4 \times 2000 \text{ ft} \\
(one-side parking) \\
\\
4 \times 2000 \text{ ft} \\
(center parking) \\

The current method says that all four of these facilities have equal capacity. But do they really?
Research Objectives

► Better understand the relationships between the various factors affecting terminal capacity and performance
  • Quantify the influence of specific layouts
► Are there other level of service (LOS) metrics to define capacity?
Literature Review

► Past Simulation Efforts
  • Canadian National (1984)
    - Analyze new inland terminal designs and capital improvements
  • BNSF (2017)
    - Terminal-specific models
    - Address capacity issues, mitigate bottlenecks
  • Esmer (2008) and Baldassarra et al (2010)
    - Capacity analyses of seaport facilities

► Understanding the Terminal Process
  • Existing process flowcharts
  • Site visits
*Bottlenecks are hard to locate, and capacity is difficult to estimate!
AnyLogic® Discrete-Event Simulation (DES) software

- Transportation planning and optimization
- Supply chain design
- Warehouse operations problems

Users include Amtrak, CSXT, NS, BNSF, Aurizon and several railway consultants

Used in academia to address capacity questions
- Similar to Rail Traffic Controller (RTC)

**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
AnyLogic® Features

Physical Network

Logic Flowchart

Logic Block Parameters

Java Actions
Unloading Process

• Train Arrival
  - Consist and contents verified
  - Train spotted on strip track(s)
  - Road power removed
  - Cars are inspected for defects

• Unloading
  - Rubber tired gantry crane unloads unit
  - Hostler/reach stacker moves unit to storage
    - Container: stacking
    - Trailer: parking
  *Some units will be picked up directly from the loading/buffer zone

• Truck Departure
  - Driver arrives
  - Driver picks up load from storage or buffer zone
  - Check out at kiosk
  - Exit scan for damages
Loading Process

- **Truck Arrival**
  - Entry scan for damages
  - Check in at kiosk
  - Movement to storage
    - Container: stacking
    - Trailer: parking

- **Loading**
  - Hostler/reach stacker removes unit from storage
  - Unit moved to loading/buffer zone
  - Rubber-tired gantry crane loads unit onto train

- **Train Departure**
  - FRA brake tests
  - Road power arrives, couples to train
  - Dispatcher gives train permission to depart
Experimental Layouts

1×8000 ft
< support yard

2×4000 ft
< support yard

4×2000 ft (one-side parking)
< support yard

4×2000 ft (center parking)
< support yard

trailer parking

loco maint.
Model Assumptions

- Trains arrive at uniform rate (i.e. constant headway)
- Trailer traffic only
  - Containers are placed on chassis
  - No double stacking
- No delays between events
## Model Status

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<th>Unloading</th>
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<tr>
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<tr>
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<tr>
<td>Double stacking on railcars</td>
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Model Animation
Data Collection and Analysis

- Data collection is specified in the logic chain
- Values updated during runtime and exported to Excel
- Run each model under different traffic volumes
  - Dwell-volume curves
  - Pre-determine capacity by level of service (LOS) or minimum acceptable performance

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<th>Tag</th>
<th>Entry Load</th>
<th>Exit Load</th>
<th>Time in</th>
<th>Time Out</th>
<th>Total Time</th>
<th>In</th>
<th>Trailer Idle Start</th>
<th>Out</th>
<th>Idle End</th>
<th>Idle Time</th>
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Future Work

► Additional Development
  • “fine tuning”
    - operational accuracy
  • Grade crossings
  • Road vs switcher locomotives
  • Support yard integration
  • Model validation (Huelsz 2015)

► Future Experiments
  • Varying traffic distributions (peak and off-hours)
  • Varying parameters
    - Containers and trailers
      - Container stacking in storage
      - Double stacked cars
    - Load priority
    - Loads requiring special handling (ex. hazmat)
    - Different crane types (ex. widespan vs gantry)
Thank you for your attention!

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Rail Transportation and Engineering Center (RailTEC)

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