TRB TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

# Comparative Simulation Study of Intermodal Yard Operations in Automated Container Terminal

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Irvine, California

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creative people, practical solutions.

# Presentation Outline

- **Background**
- **Simulation of the two proposed intermodal yard layout**
- **Results and conclusions**

- **A consultant firm providing many engineering services.**




- **Expertise in maritime related infrastructures included planning and designing**
- **Port planning group**
  - **Mainly container terminal planning and design**

# Container Terminal Operation - Berth

# Container Terminal Operation - Yard

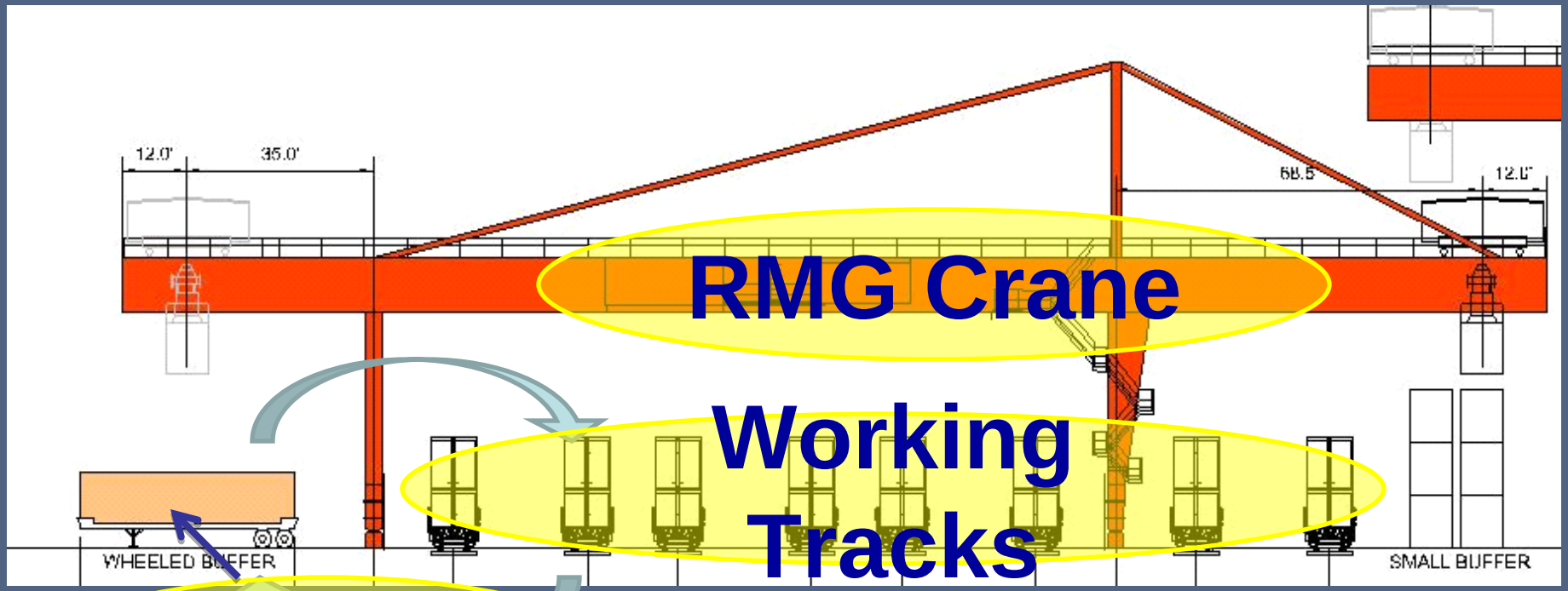
# Container Terminal Operation - Gate

# Container Terminal Operation – Intermodal

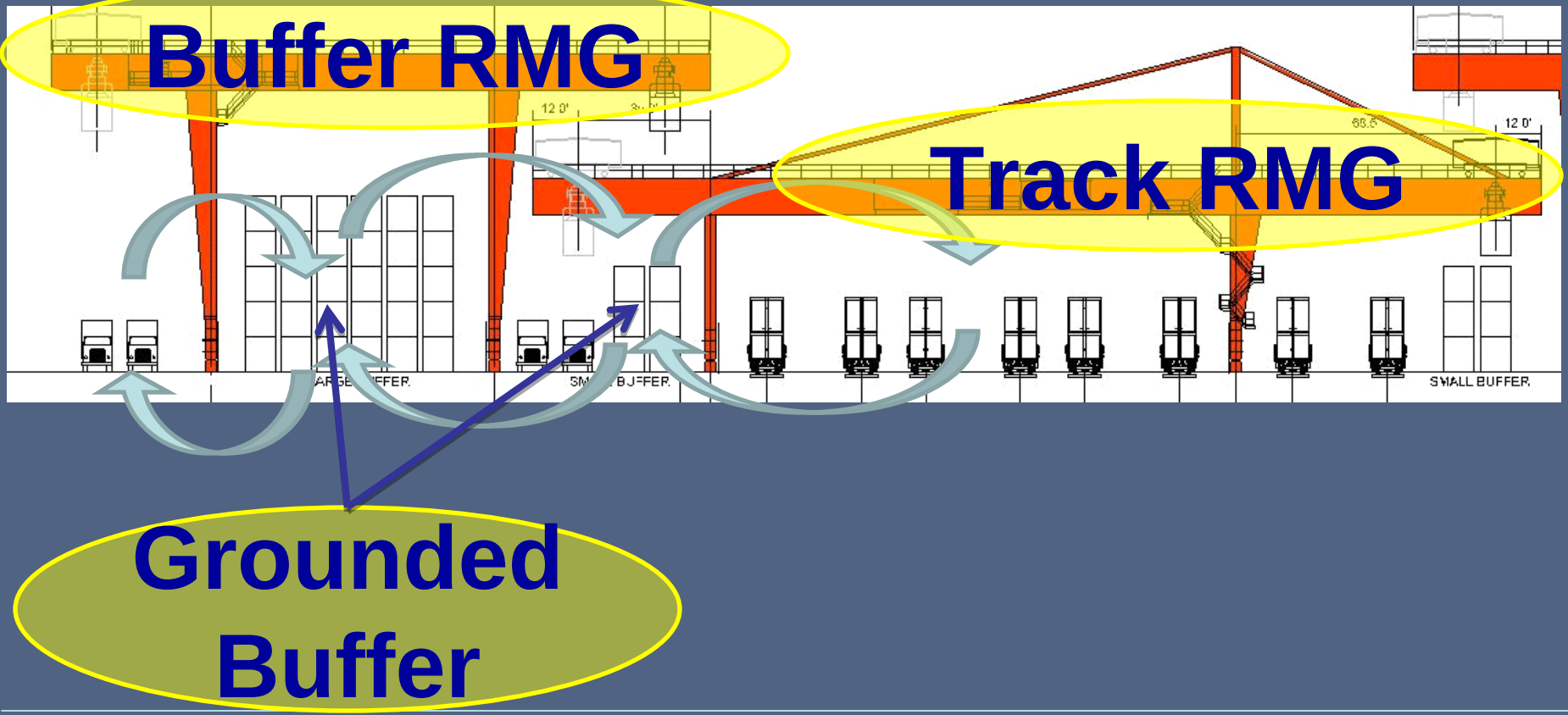
# Project Background

- **US west coast automated container terminal**
- **3 M+ TEU annual throughput capacity**
- **Large vessels**
- **Limited backland**
- **High percentage of Intermodal Yard (IY) throughput**

# Proposed Option – Wheeled Buffer



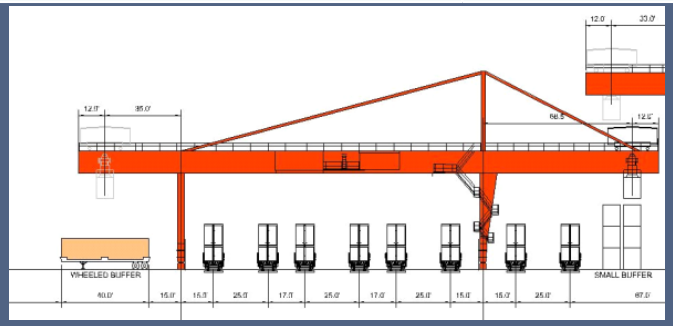
# Alternative Option – Grounded Buffer

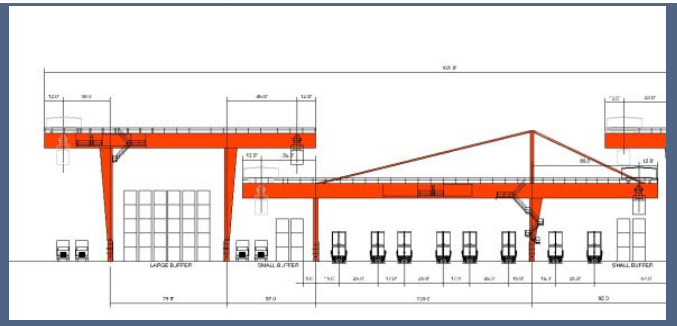


# High Level Comparison of Two Options

| | Wheeled Buffer | Grounded |
|---|---|---|
| Equipment | ? | ? |

Can proposed layouts finish given throughput?
Equipment requirement?
Which layout to recommend?



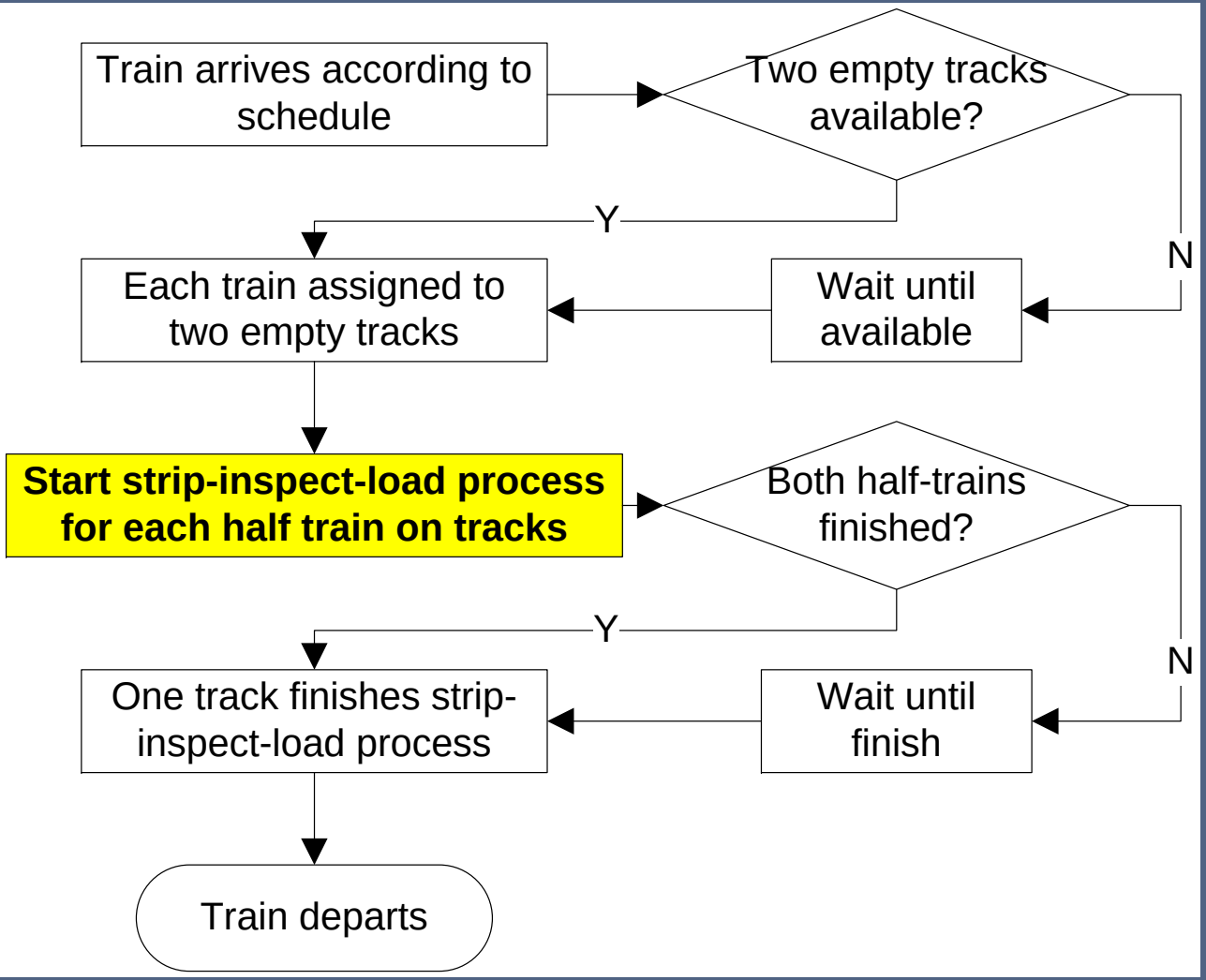
# Operational Constraints

- **Trains are double stacked**
- **20’ containers go to the bottom tier**
- **One trains assigned to two tracks**
- **Safety rule**
  - **Cranes cannot work on a train segment while wheel change is taking place**
  - **Cranes cannot move a container over a moving train engine**
  - **Cranes cannot move a container over workers or inspectors**

# Example Simulation Animation

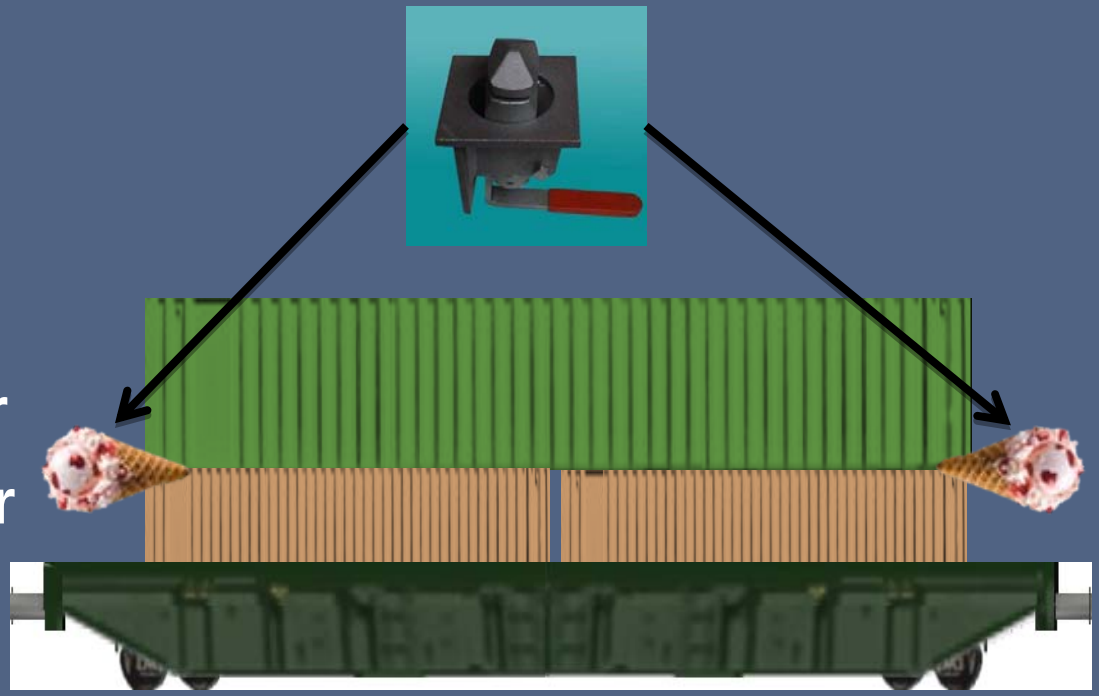
- **Simulation Demo of Container Terminal Operation**

# Simulation Logic Flow – One Train



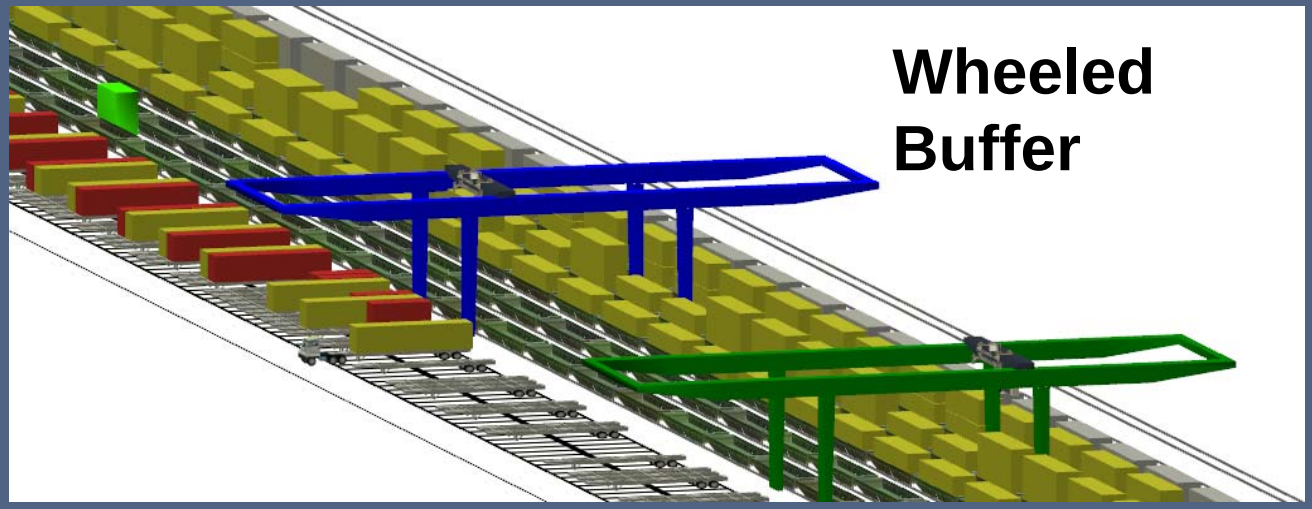
# Train Strip-Inspect-Load Process

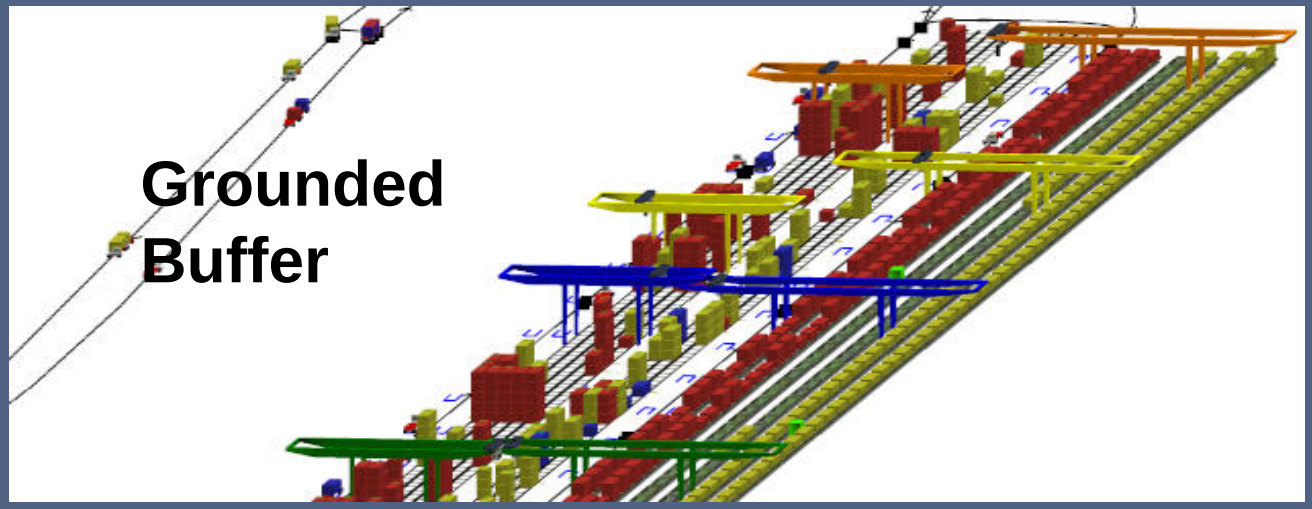
1. Unlock Cones
2. Unload Top Tier
3. Remove Cones
4. Unload Bottom Tier
5. Inspection & Repair
6. Load Bottom Tier
7. Place Cones
8. Load Top Tier
9. Lock Cones and Begin Exit Sequence



**A Well Car**

# Simulation Screen Captures



# Simulation Experiments

- **Scenarios**
  - **Two layouts**
  - **Different working shift assumptions**
  - **Various equipment configurations**
    - **Number of RMGs**
    - **Number of trucks**

# Example Simulation Outputs

| Wheeled Buffer Option Scenarios | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Number of Working Shifts** | 3 | 3 | 3 | 2 | 2 | 2 | 2 |
| **Number of RMG's** | 3 | 3 | 3 | 5 | 5 | 5 | 4 |
| **Number of Trucks** | 5 | 10 | 15 | 15 | 20 | 25 | 40 |
| Avg Train Turn Time (hr) | 44.8 | 9.7 | 8.9 | 12.1 | 10.2 | 10.2 | 12.3 |
| Max Train Turn Time (hr) | 58.3 | 10.4 | 9.5 | 24.2 | 13.5 | 13.2 | 23.9 |
| Avg Track Occupancy (%) | 100 | 34.7 | 31.8 | 43.3 | 36.4 | 36.4 | 43.9 |
| RMG Net Prod (mph) | 23.4 | 35.9 | 38.1 | 33.8 | 36.6 | 36.9 | 35.2 |
| RMG Utilization (%) | 0.71 | 0.71 | 0.66 | 45.2 | 41.6 | 41.3 | 54.1 |
| Truck Turn Time at Buffer (min) | 4.09 | 3.76 | 3.78 | 5.49 | 3.7 | 3.74 | 3.86 |
| Truck Utilization (%) | 99.46 | 88.9 | 67.3 | 75.2 | 68.2 | 57.6 | 41.2 |
| RMG Blocked Time (%) | 1.8 | 0.7 | 0.3 | 2 | 0.6 | 0.4 | 0.4 |
| Weekly Throughput (boxes) | 8956 | 12763 | 12581 | 12788 | 12766 | 12766 | 12788 |

# Recommended Equipment Configuration

| | Num Track RMGs | Num Buffer RMGs | Num Trucks |
|---|---|---|---|
| Wheeled Buffer | 5 | - | 20 |
| Grounded Buffer | 4 | 6 | 25 |

# Conclusions

- **Both layouts can finish the given throughput**
  - **Number of tracks**
  - **Buffer size**
- **Safety rules appears not incur significant delays**
- **Perpendicular layout is recommended**
  - **Less RMG's & trucks**
  - **Less Space**
- **Simulation can help client make smart investment decisions in container terminal master planning**

# Thank you!

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