Marine Terminal Management Training Program
Jacksonville, FL

Trends in Container Terminal Design
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Introduction

• Container terminal design trend
• Factors driving the trend
• Planning and engineering of a terminal
  – Number of berths, water depth
  – Land usage
  – Site elevation
  – Infrastructure
Container terminal design trend
North America

Historically operating at low density and high labor cost

Due to growing environmental concerns pressure to operate with
  • Fewer air emissions
  • Higher density

Automation has been slow but growing
  • Perceived inefficiency of the first systems
  • Resistance of organized labor
  • Capital cost of implementation
Container terminal design trend

North America

APMT Terminal in Norfolk, VA leading the trend

- ASCs with manual shuttle carriers
- 50% increase in avg QC productivity
- Ports America Concession at Port of Oakland with similar scheme

Strong interest in hybrid RTGs

- Reduce pollution
- Increase fuel savings
- Battery and flywheel-based

Tandem 40 Quay Cranes arrived in Deltaport, Vancouver
Container terminal design trend

Asia

High density, low labor cost (RTG + tractors)

Low but growing environmental concern

Trending towards semi-automation
- Overhead bridge crane system at Singapore
- Automated RTGs – Toshima terminal in Japan
- Double cantilever RMGs at Pusan and Shanghai

Early adapters of Tandem-40 cranes
Container terminal design trend

Europe

Medium density, high labor cost (straddle carrier based)

High environmental concerns

Moderately strong union

Pioneer of highly automated terminals

• Robotic AGVs + ASCs
• Dual hoist cranes (2\textsuperscript{nd} hoist automated)
Factors Driving the Container Terminal Design

- Cargo Projections
- Increase in Vessel Size
- Site Location
- Capacity Constraints
- Automation Technology
- Environment Concerns
- Safety and Security
North America Container Port Traffic (% of total)

- TOTAL PACIFIC
- TOTAL ATLANTIC
- TOTAL GULF COAST
Length Distribution of Recently Built Container Vessels (Panamax or larger)
Draft Distribution of Recently Built Container Vessels (Panamax or larger)

![Bar chart showing the draft distribution of recently built container vessels. The chart compares vessels built from 2000-2004 with those built from 2005 & later.]
Storage Density at Top North America Ports

<table>
<thead>
<tr>
<th>Port</th>
<th>1997</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port of Los Angeles</td>
<td>12,600</td>
<td>12,700</td>
</tr>
<tr>
<td>Port of Long Beach</td>
<td>9,200</td>
<td>13,600</td>
</tr>
<tr>
<td>Port of NY/NJ</td>
<td>5,100</td>
<td>10,400</td>
</tr>
<tr>
<td>Port of Vancouver</td>
<td>8,400</td>
<td>18,500</td>
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</table>
Automation Technology

Terminal Operating System

3rd party data transfer without manual intervention → Entry/exit gate transaction → Ship, rail and yard planning

Horizontal transport equipment → Yard cranes → Container inventory and identification

Quay crane operations
Safety and Security

Safety
• Fewer people = fewer people getting hurt
• No need for trucks to drive underneath yard cranes

Security
• Street truckers cannot access containers directly
• Fewer terminal personnel
• Computer control and recording of all container movement
• Automated scanning of cargo while in the CY
Brisbane, Australia
Fully Automated Operating System

- Perimeter security fence w/ sensors
- No personnel within the CY
- Reefer Operations separating men and machines
- Barrier between Quay and yard operations
- Automated Straddle Carriers – Uncoupled transfers
Environmental Concerns

Review of Greenest Terminal Features

- On-terminal Y served by electric rail cranes
- Street trucks turn off engines while awaiting service
- End-loaded electric yard cranes
- Gate appointments minimize wait time for street trucks
- Electric dock cranes
- Automated low emission transport vehicles
- Automated mooring to reduce vessel idle
- Electric power for vessels at berth
And…..Site Location… Location… Location

• Green field or brown field?
  • Relocation of existing tenants

• Excavation vs. dredging
  • Environmental mitigation

• Terminal access and utilities

All Deep Sea Lifts

Lifts by Water

Lifts by Land

by Barge

by Ocean

by Rail

by Road

Transshipment

Deep Relay

Loads

Empties
1. Waterside Infrastructure

Planner’s Concerns

- Throughput across the berth
- Size of vessels (length, draft and beam)
- Type of quay cranes (mobile, gantry etc.) - Moves/hour
- Berth occupancy
- Number of berths
- Size of vessels
- Berth occupancy
- Number of berths
- Throughput
1. Waterside Infrastructure Engineer’s Concerns

- Berth alignment
- Environmental impacts – for permitting
- Type of berth structure (bulkhead, wharf, pier etc.)
- Material to be dredged – Rock, sand, clay?
- Amount of Dredging
Minimal Environmental Impacts

Bulkhead aligned to minimize impacts on St Johns River
Site fill required

Total fill = 460,000 m$^3$
Solution was to dredge at the same time of bulkhead construction
Temporary and permanent spoil cells
Dredge concept was to allow muds to flow into a channel and be pumped over to Bartram Island.
Dredger was placed inside cell to pump excess water and muds over to Bartram Island.
Sand dredged into cells on Dames Point was very good quality
...and muds that separated out were pumped over to Bartram Island via a submerged pipeline.
Construction activities

August 2007
Dredging and bulkhead construction scheduled in parallel

By September, dredging, bulkhead and civil works concurrent
2. Land Usage

Planner’s Concerns

- Type of container handling equipment
- Parallel or perpendicular stacks
- Height and width of stacks
- Number of gates and length of queue lanes
- Interface with Rail

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<table>
<thead>
<tr>
<th>Productivity</th>
<th>Capacity</th>
<th>Service reliability</th>
<th>Flexibility for increased velocity or capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexibility for expansion</td>
<td>Startup risk</td>
<td>Suitability for robotic operation</td>
<td>Flexibility to respond to odd operating situations</td>
</tr>
<tr>
<td>Maintainability and durability</td>
<td>Capital Cost</td>
<td>Labor</td>
<td>Entry and exit gate locations</td>
</tr>
<tr>
<td>Location of any on-terminal queuing locations</td>
<td>Width of traffic aisles</td>
<td>Location of private vehicle parking</td>
<td>Procedure for transporting personnel to and from work locations</td>
</tr>
</tbody>
</table>
Case Study: West Basin Container Terminal
Terminal Layouts (RTG Cases)

OPTION A

OPTION B
ASC Layouts
Left ASC with Straddle Carriers; Right: ASCs with terminal tractors

OPTION C

OPTION D
Berth capacity per WBCT (832k lifts * 1.8 = 1.5M TEU/yr)
Cost per Vessel Move by Option

Relative Cost per Vessel Move Compared to Option C (Percentage)

- Relative IT
- Maintenance
- Energy
- Equipment Capital
- Labor

A, B, C, D
Freeport Bahamas – Transshipment Terminal
Parallel RMGs with Strads

Straddle Carrier with Container

RMG Rows parallel to the quay
2. Land Usage

Engineer’s Concerns

• Geotechnical information of site (suitability for pavements and building foundations)
• Topography of site – cut and fill
• Environmental impacts – for permitting (wetlands?)
• Storm water drainage
• Tide levels
• Flooding (storm surges, hurricanes, heavy rain)
Minimal Environmental Impacts

Yellow – Freshwater wetlands impacts
3 acres of impact

Red – saltwater wetlands impacts
0.4 acres of impact
3. Infrastructure Connectivity

Planner’s Concerns

• Access to main roads
• Access to rail
• Connection to local utility providers
  – Terminal demands (power, lighting, sewer, water)
• Intensity of traffic flows
Road Access and Queuing Capacity
Rail Access and Bottlenecks
Intermodal Container Transfer Facility
3. Infrastructure Connectivity

Engineer’s Concerns

• Traffic studies (impact on local traffic) – solutions?
• Power demands – substation, direct service, voltage etc.
• Sewer – gravity, force main, pump stations etc.
• Water – potable, fire mains, irrigation (local service, wells, salt water etc.)
• Telephones and data
• Permitting
Site Access
Early Concept
Final Layout
Summary of Container Terminal Design Trends

- Longer and deeper container vessels
- Automation of processes and equipment
- Densification of storage
- Sustainable and environmentally friendly

Questions or comments?