Advanced Technology in Terminal Design

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"A Firm Focused on the Waterfront"

- Over 60 Years Experience
- Offices in North America, Europe and Latin America
- Port & Intermodal Planning
- Terminal Planning & Analysis
- Port Financial Analysis
- Port Infrastructure Design
- Dredging & Reclamation
- Marinas
- Environmental
- Urban Waterfronts
- Bridge & Highway Design

Quotes

"The real driving force behind globalization is….the declining cost of international transport."

The Journal of Commerce

"The Box That Changed the World"

Efficiency

- Since its inception, the container shipping industry has strived to increase the efficiency of goods movement
  - Larger vessels
  - Larger terminals
  - Computers & software
  - Elimination of paper documentation
  - The internet
  - Container handling automation

Efficiency

- What is efficiency?
  - Capacity
    - TEU's per hectare
    - TEU's per annum
  - Productivity
    - Containers moved per hour
    - Man-hours per container moved
  - Cost (terminal)
    - Land
    - Infrastructure
    - Equipment
    - Computers and software
    - Labor

Presentation Outline

- Automated terminals
- Integrated terminal design
- Simulation as a design decision-making tool

Automated Terminal

- The "automated terminal" is just the latest step in the evolution of containerization
- What does "automated" mean?
  - Robotics
    - Automated yard cranes
    - Automated horizontal transport
  - Decisions are made by the Terminal Operating System
    - Instead of planning ahead, the automated terminal can make decisions at the last minute

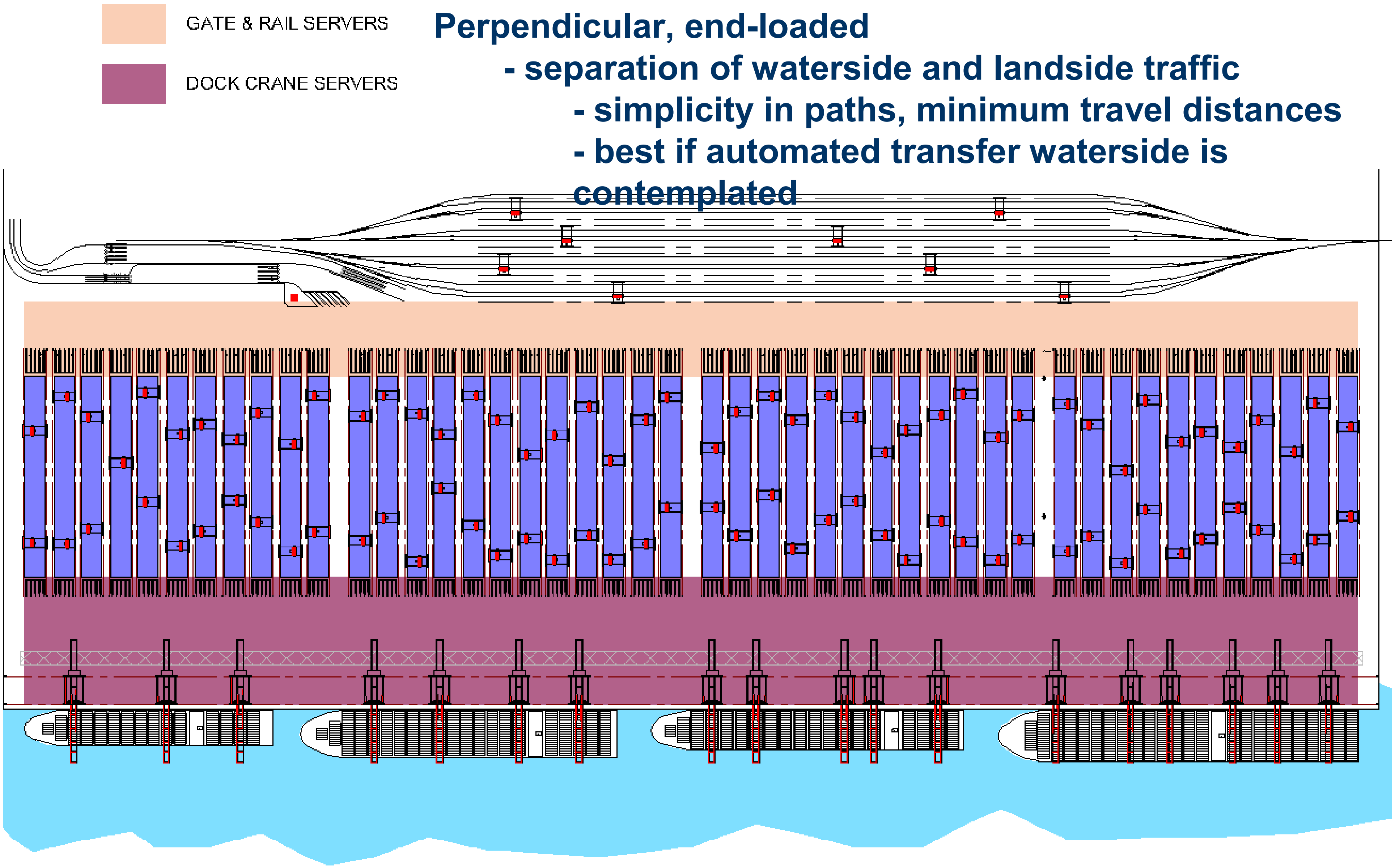
Efficiency

- The goal of an automated terminal is to strike the best balance between;
  - Capacity
  - Productivity
  - Cost
- "Automation" is not the goal

End-Loaded Design Seperates Vessel and Gate Traffic

Perpendicular, end-loaded

- **separation of waterside and landside traffic**
  - **simplicity in paths, minimum travel distances**
  - **best if automated transfer waterside is contemplated**

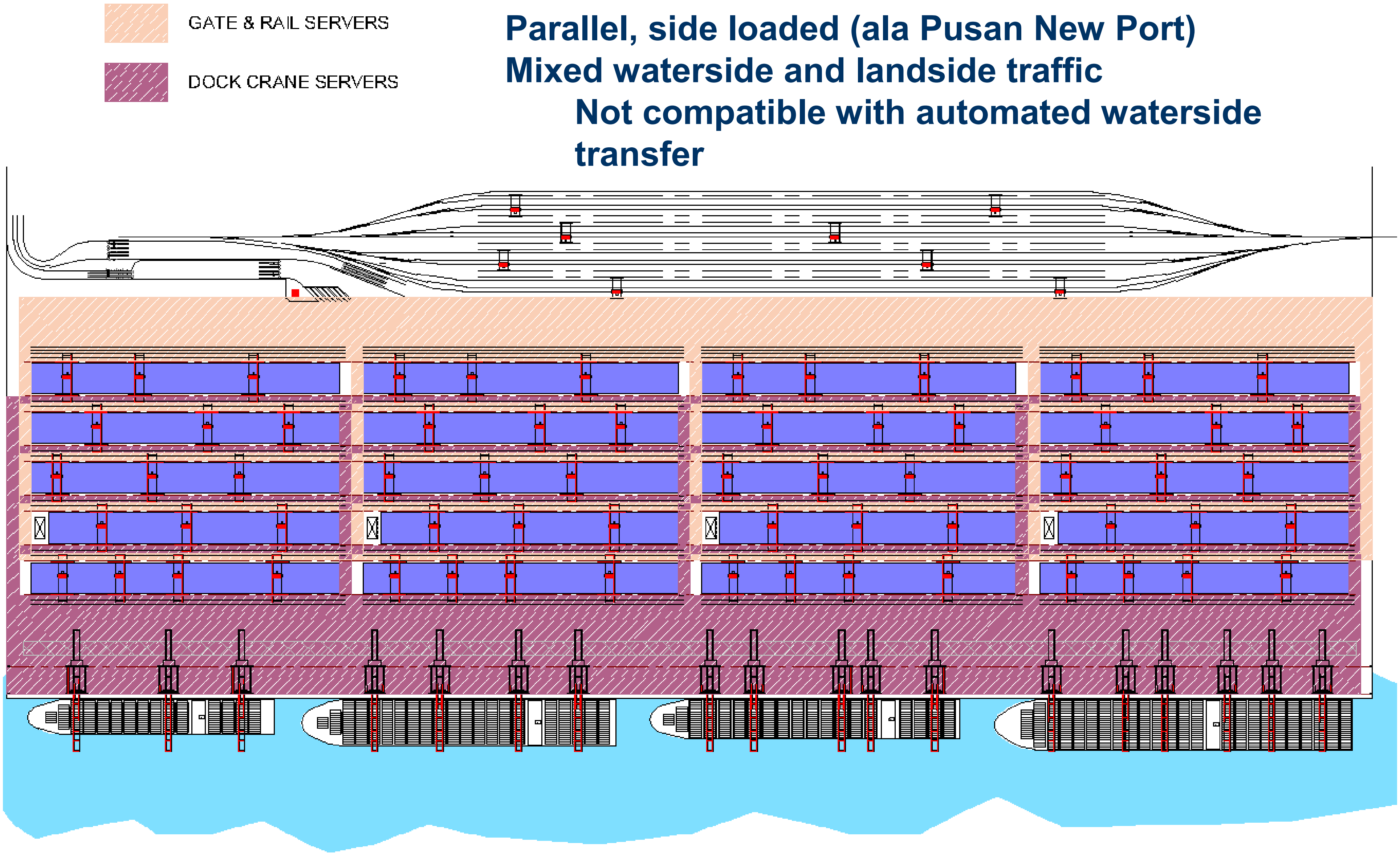


Side-Loaded Causes Traffic to Mix

Parallel, side loaded (ala Pusan New Port)

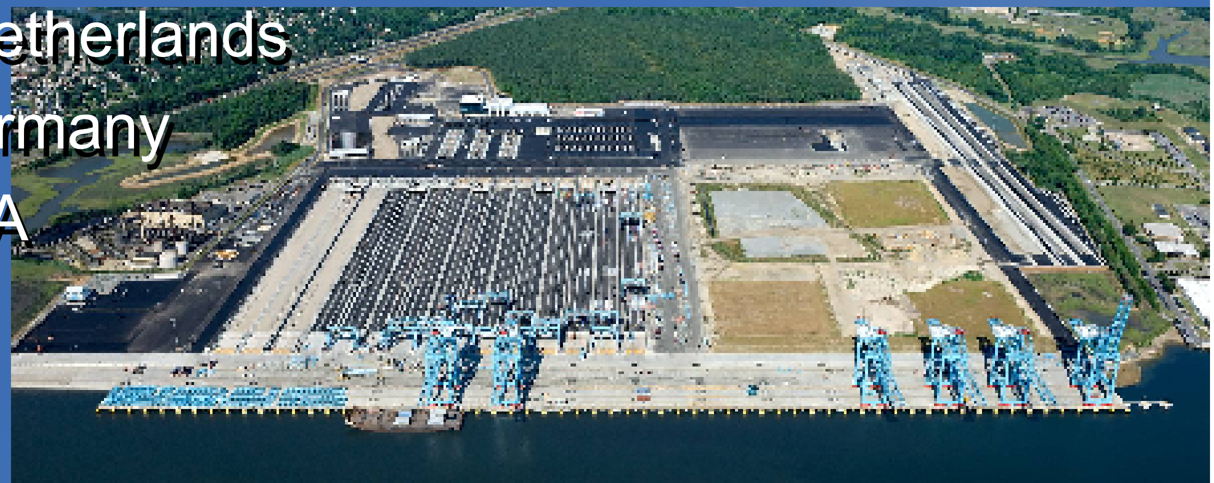
Mixed waterside and landside traffic

- **Not compatible with automated waterside transfer**



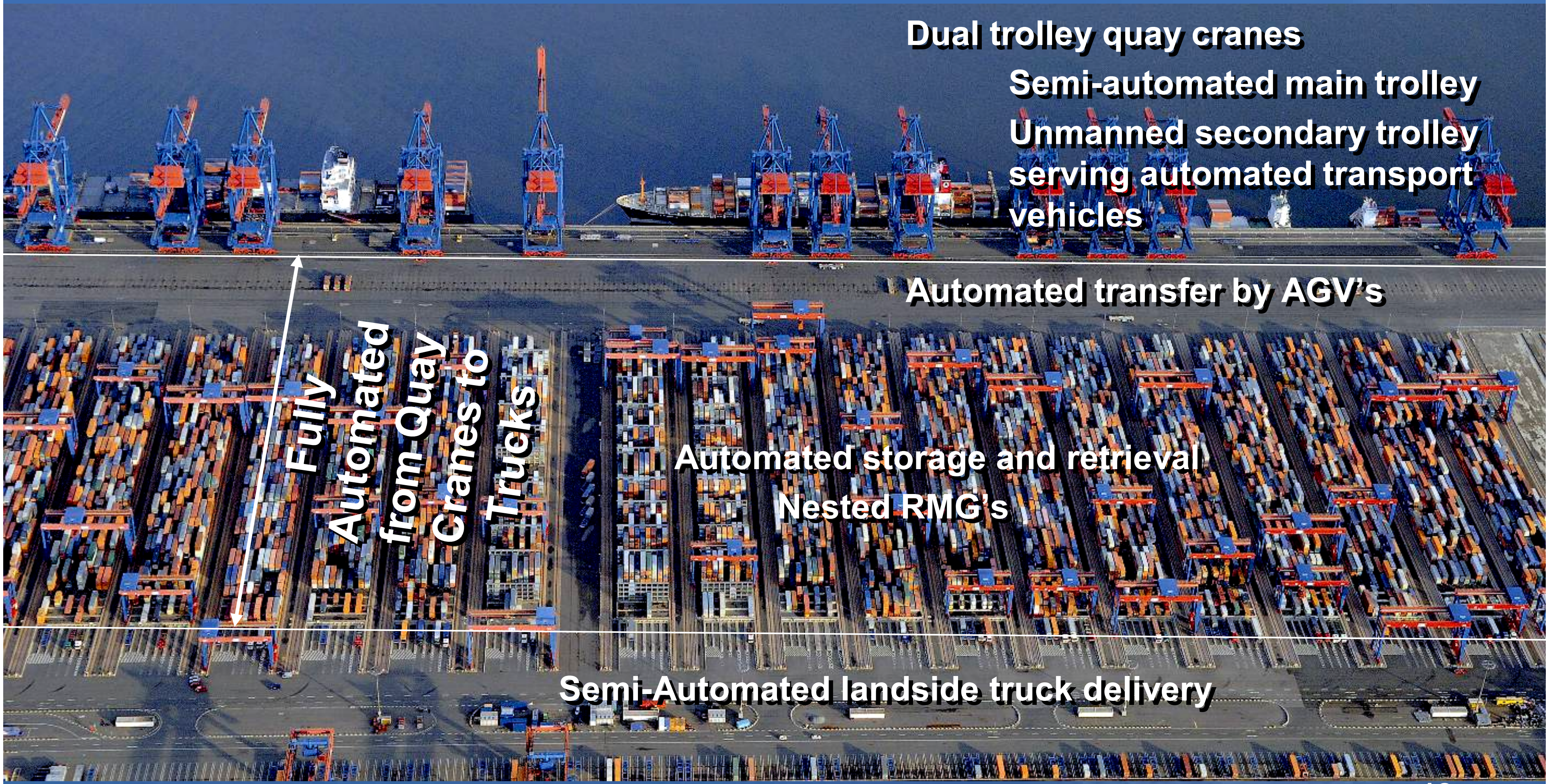
“Automated” Container Terminals

- ECT, Rotterdam, Netherlands
- CTA, Hamburg, Germany
- APMT, Norfolk, USA
- Antwerp
- Abu Dhabi
- London Gateway
- Many others under consideration



A State-of-the-Art Automated Terminal

- CT-A, Hamburg, Germany



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Automated Horizontal Transfer

- AGV's
  - Unmanned, diesel powered, rubber tired, bottom-supported container
- Shuttle/straddle carriers
  - Unmanned, diesel powered, rubber-tired, top-lifted container

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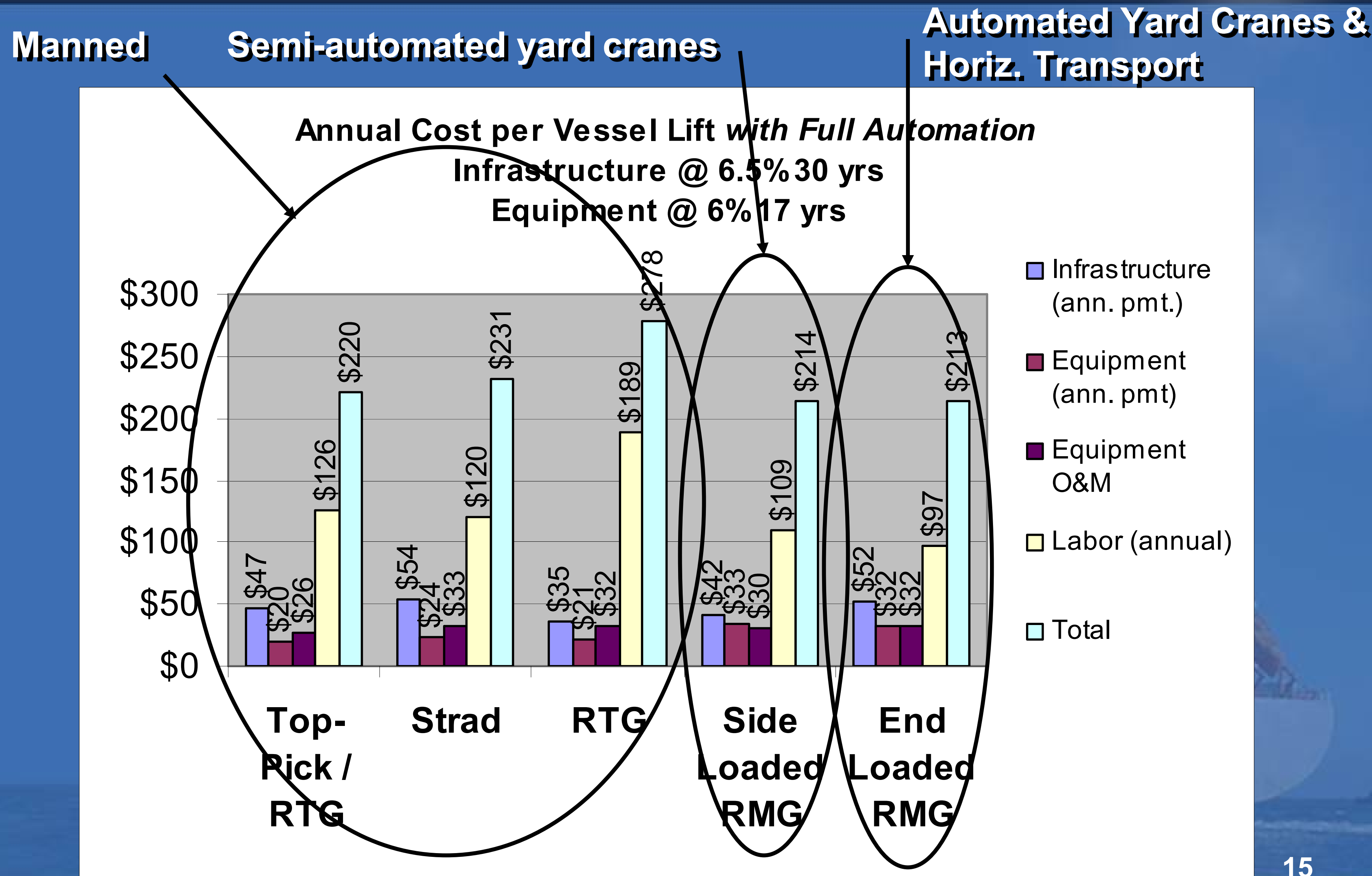
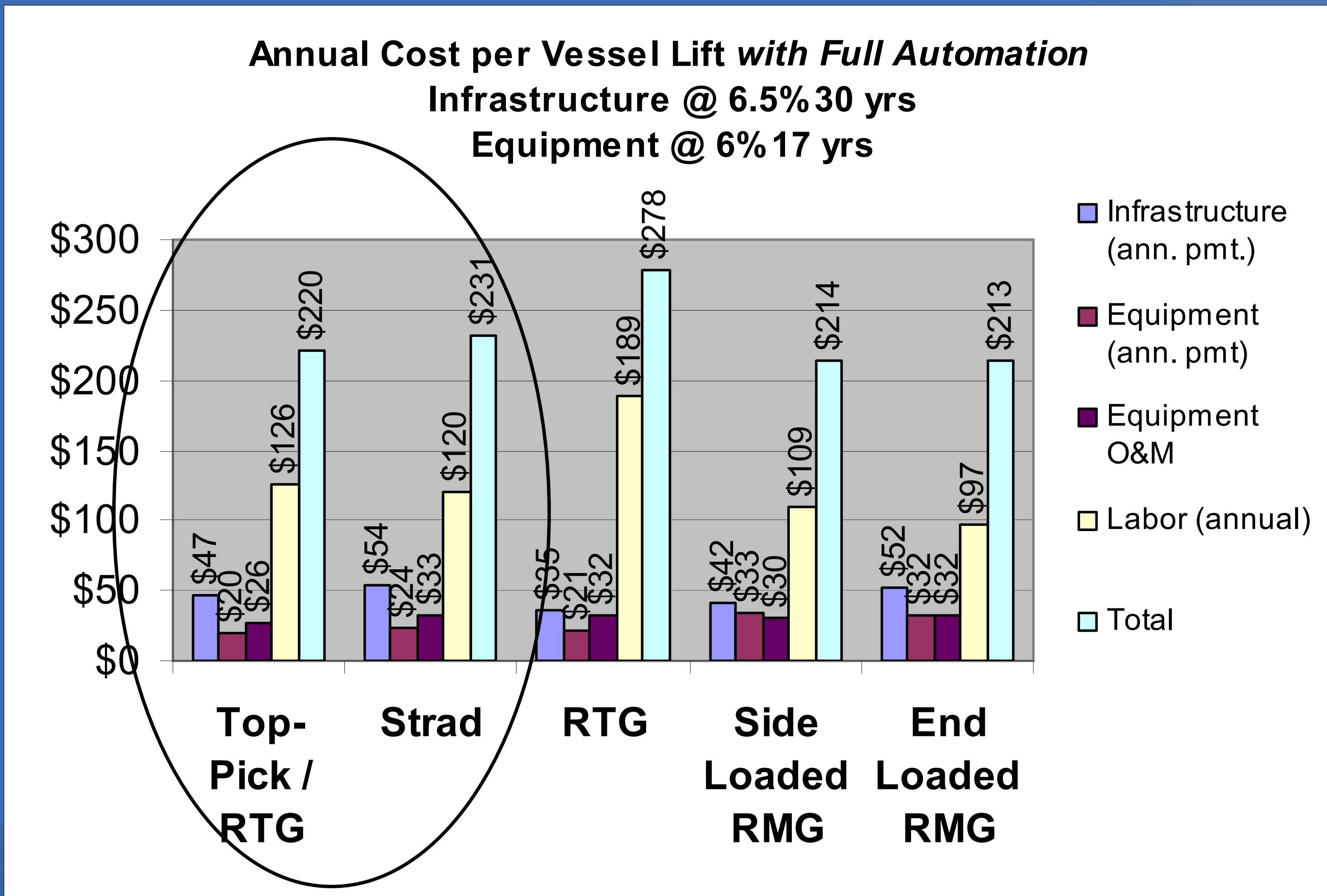
Cost is Driving Terminal Automation

- Rising terminal development and labor costs are driving terminals to automate
- On a recent US West Coast terminal study, it was determined that a new terminal could not be competitive with existing terminals unless it was automated

Example: Cost per Lift - US West Coast



Top Pick and Strad Could Not Meet Capacity Goal



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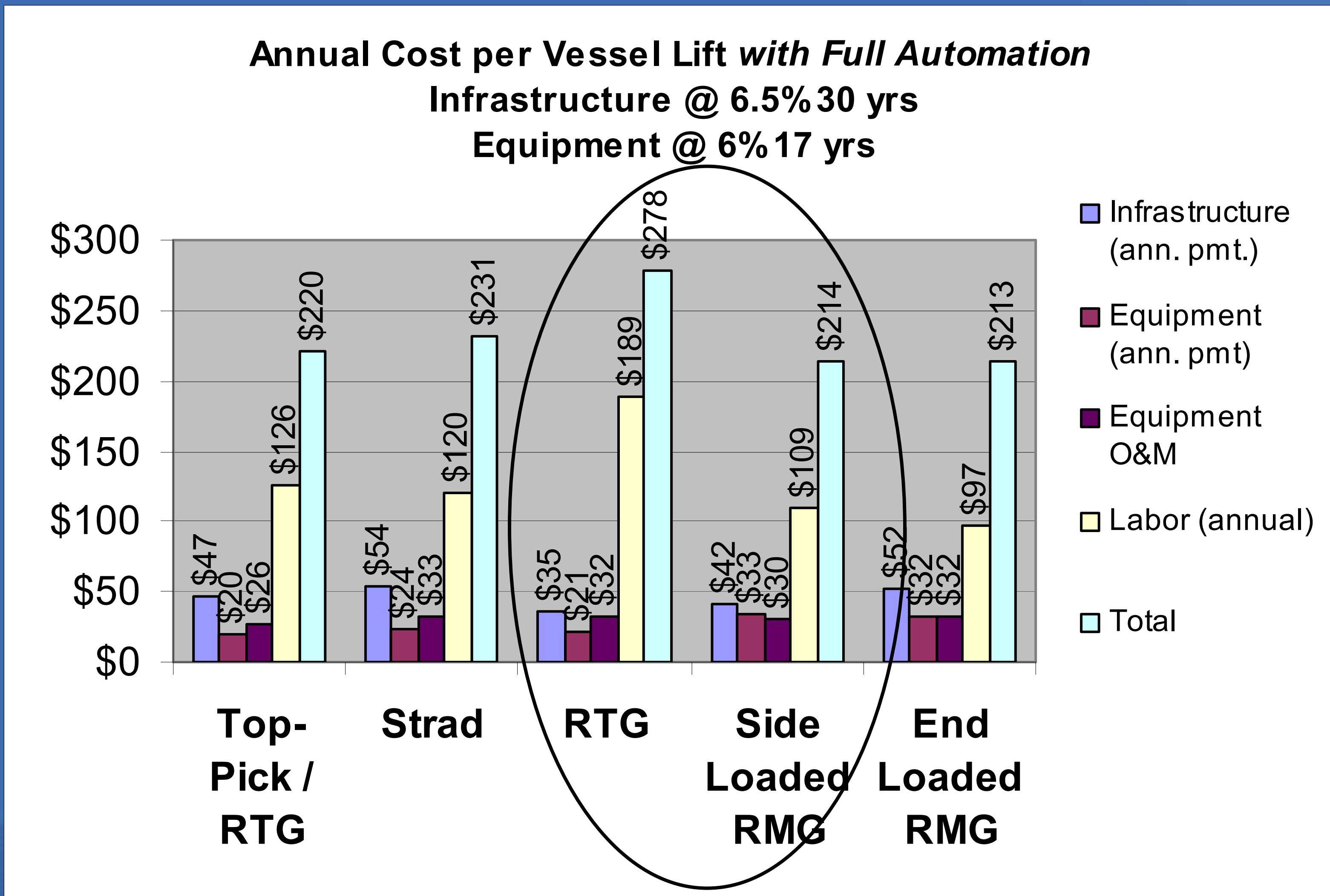
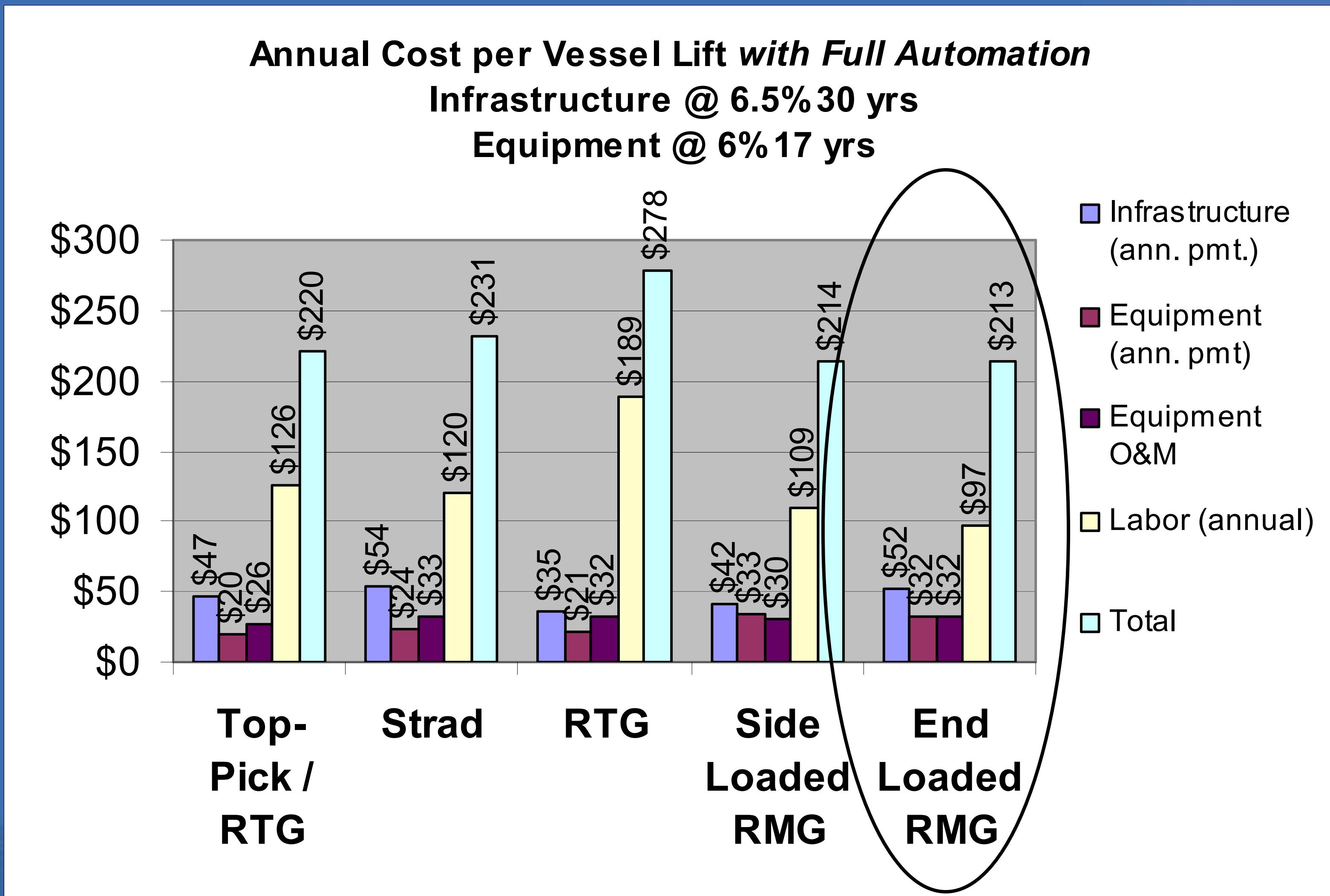
RTG and Side-Loaded RMG Could Not Meet Vessel Productivity Goal Due to Conflict with Gate Traffic



Only End-Loaded RMG's with Automated Horizontal Transport Could Meet all Goals



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A Recent Terminal Planning Project

- Capacity
  - 3 million TEU's per year annual capacity
  - 35% rail, 65% gate, 0% transshipment
  - 3-12,000 TEU vessel calls per week
    - 11,000 moves per vessel call in 96 gross hours
  - 125 hectares, 1,300 m quay
- Productivity
  - Waterside
    - Vessel 160 net container moves per hr x 3 vessels = 480 mph
  - Landside
    - Gate 420 lifts per hr peak day
    - Rail 140 lifts per hr peak day
    - Total 560 moves per hr
  - Horizontal transport to transition from manned bomb carts to automated
- Cost
  - Competitive with existing terminals
  - Lowest cost per lift

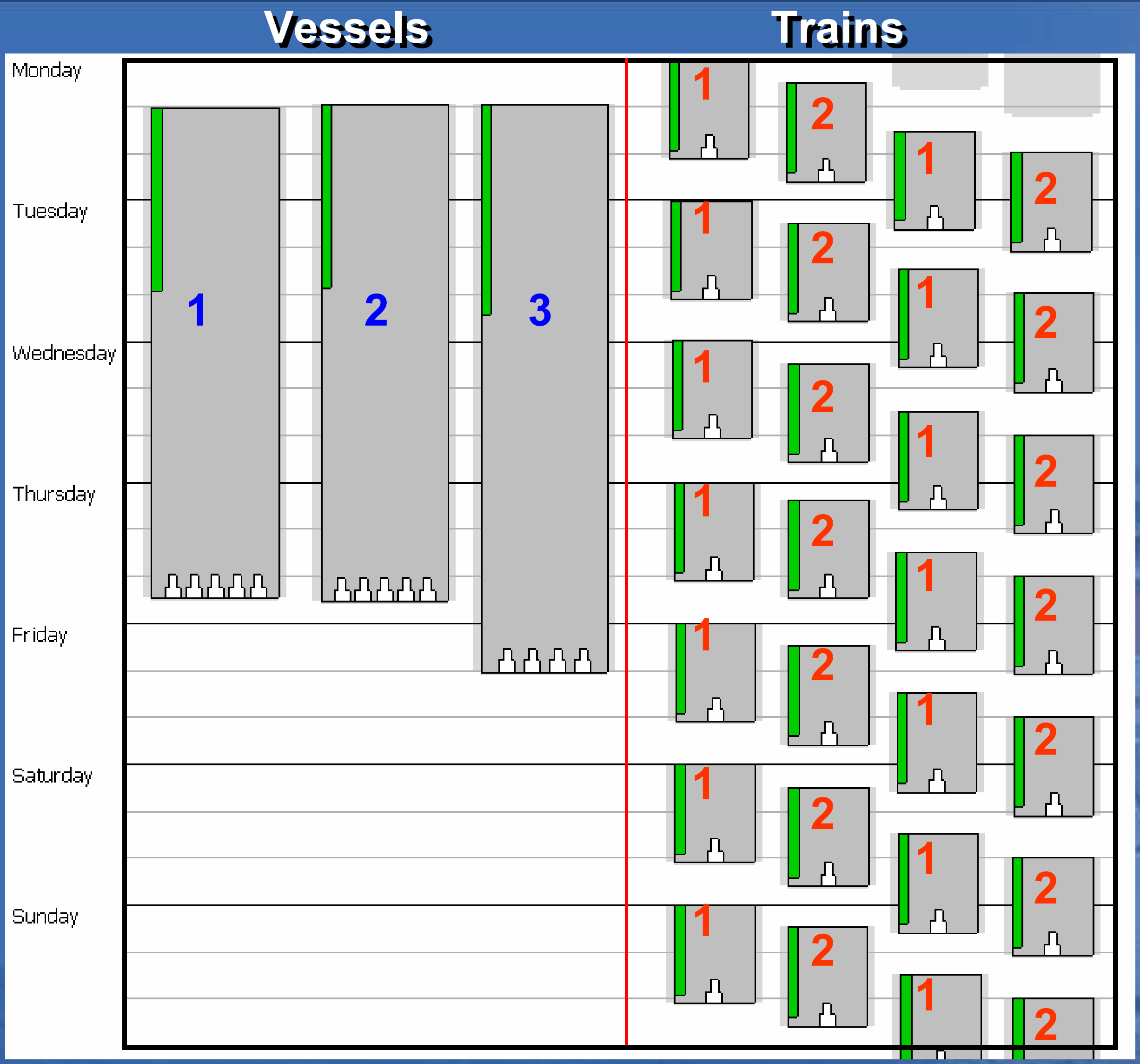
A Recent Terminal Planning Project

- Questions to be answered by simulation;
  - How many and what kind of quay cranes?
  - How much stacking capacity?
  - How many automated stacking cranes and what size stacks?
  - What kind of horizontal transport? How many units?
  - How many rail tracks and how many rail loading cranes?
  - Total cost per lift?

Inventory Simulation

- Tests rail and vessel schedules to determine range of container storage required
- Inventory simulation showed that;
  - Vessel schedule has a profound effect on storage requirement for intermodal cargo
  - At least 60,000 TEU's of storage capacity will be required

Intermodal Inventory Simulation - Worst Case Vessel Schedule



Vessel and Train Schedule – Worst Case

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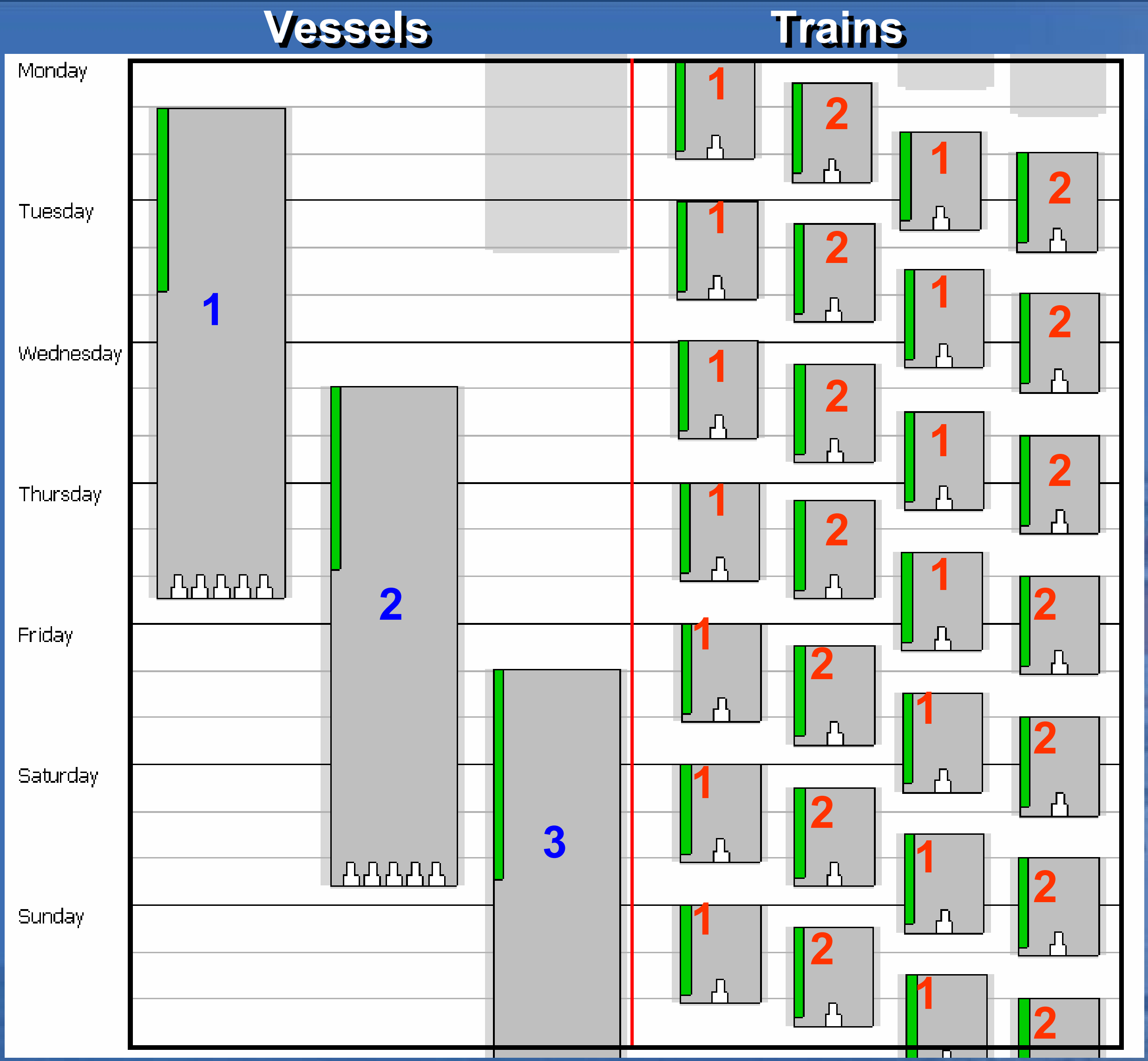
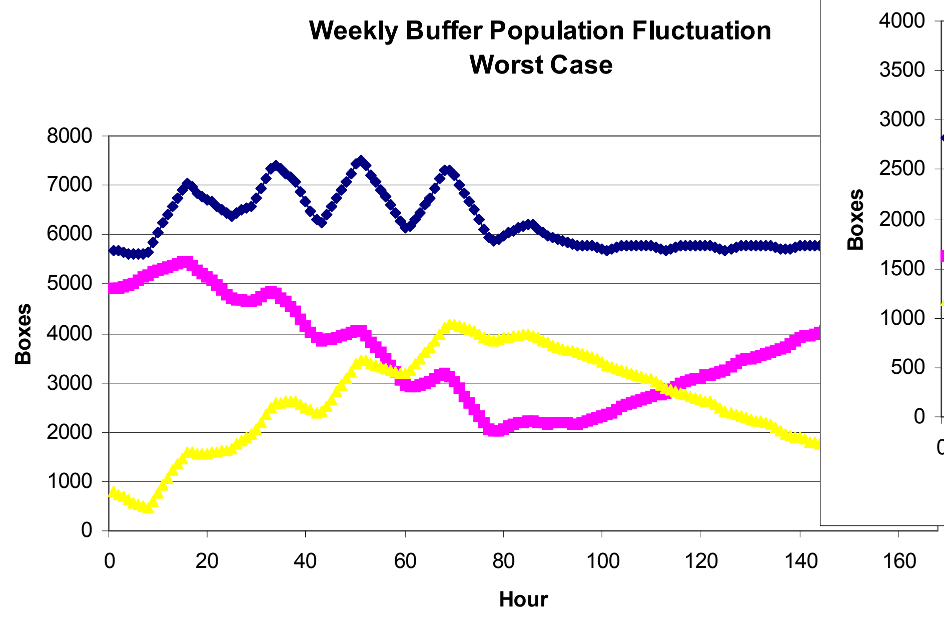
Intermodal Inventory Simulation - Best Case Vessel Schedule

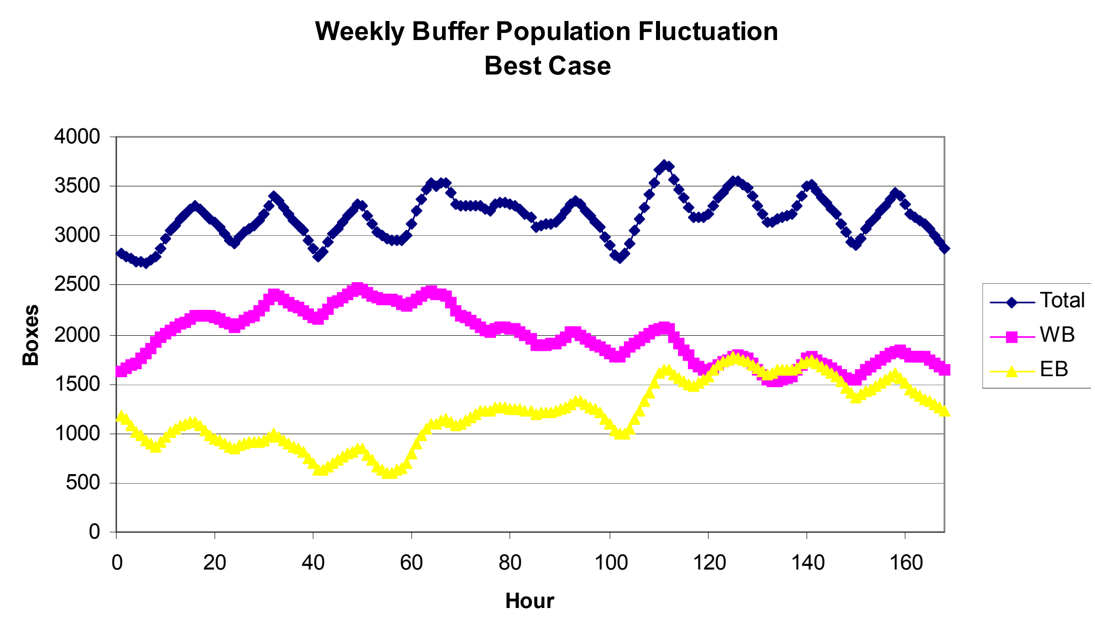


Vessel and Train Schedule – Best Case

Intermodal Inventory Simulation - Container Population

	Maximum Number of Containers (TEU's)		
	Buffer	EB	WB
Best Case	6709	3197	4475
Worst Case	13520	7519	9904
Percent Increase	102%	135%	121%





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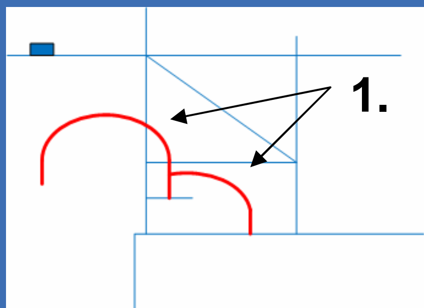
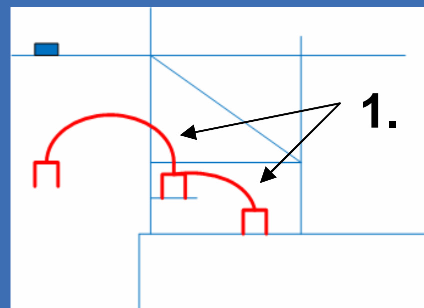
Quay Crane Simulation

- Showed that tandem lift or dual trolley cranes would be required to meet vessel productivity goal
- Showed that tandem lifts would create extreme peaks and valleys in productivity and that the transport and yard crane systems would have trouble keeping up
- Recommended single-trolley tandem lift, quay crane initially working with bomb carts
- Dual trolley, tandem main and single secondary working with AGV's ultimately

Five QC Configurations Were Simulated

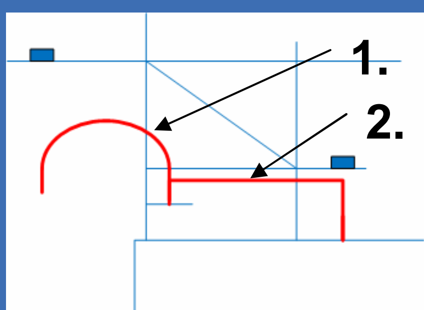


1. Single trolley
Single lift
ST, S
Base Case

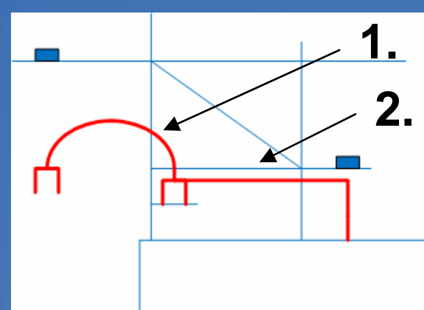


2. Single trolley
Tandem lift
ST, T

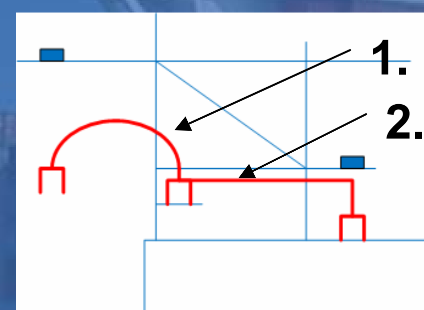
1. = Main trolley
2. = Secondary trolley



3. Dual trolley
Single lift, Single lift
DT, SS

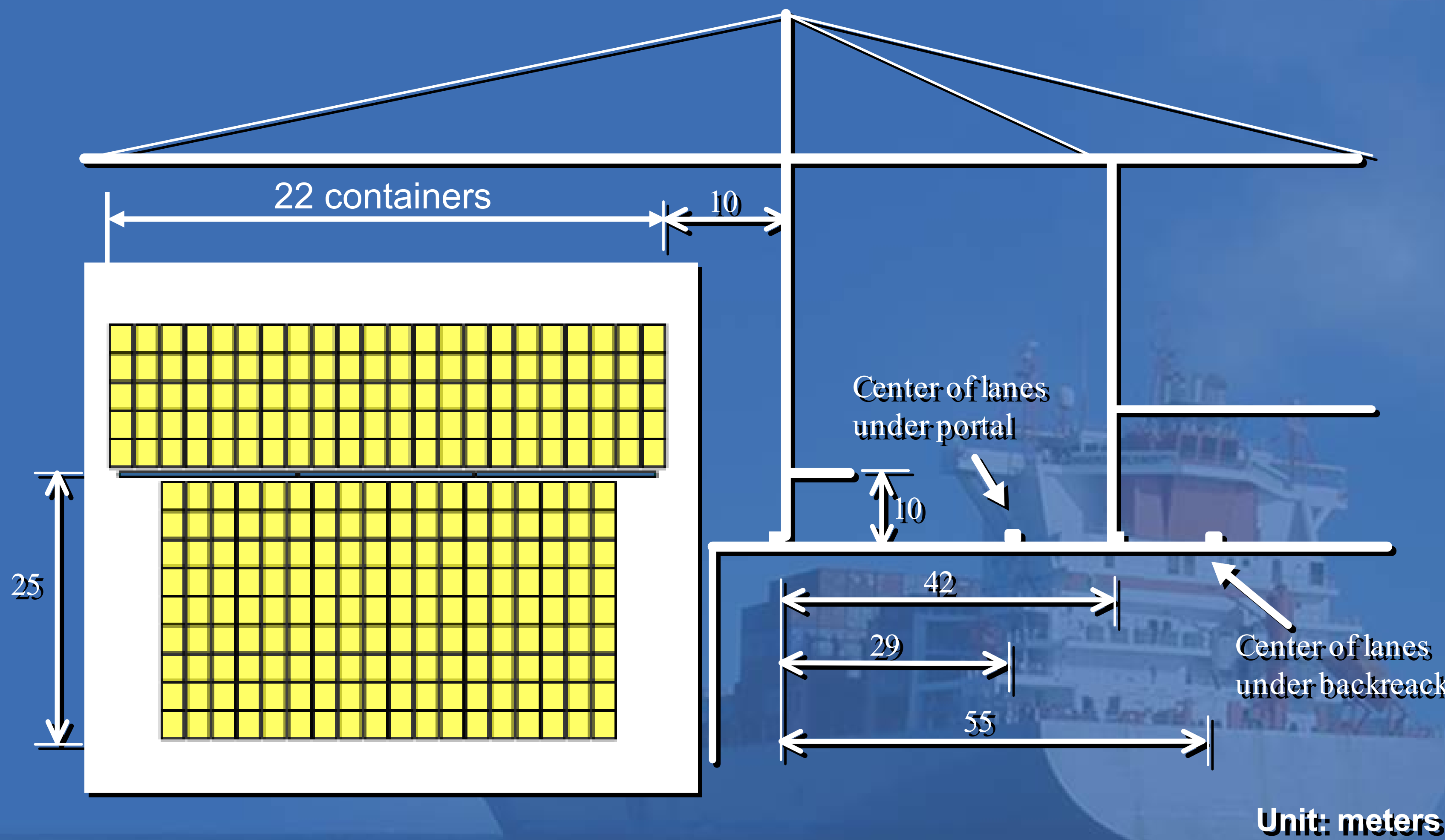


4. Dual trolley
Tandem lift, Single lift
DT, TS



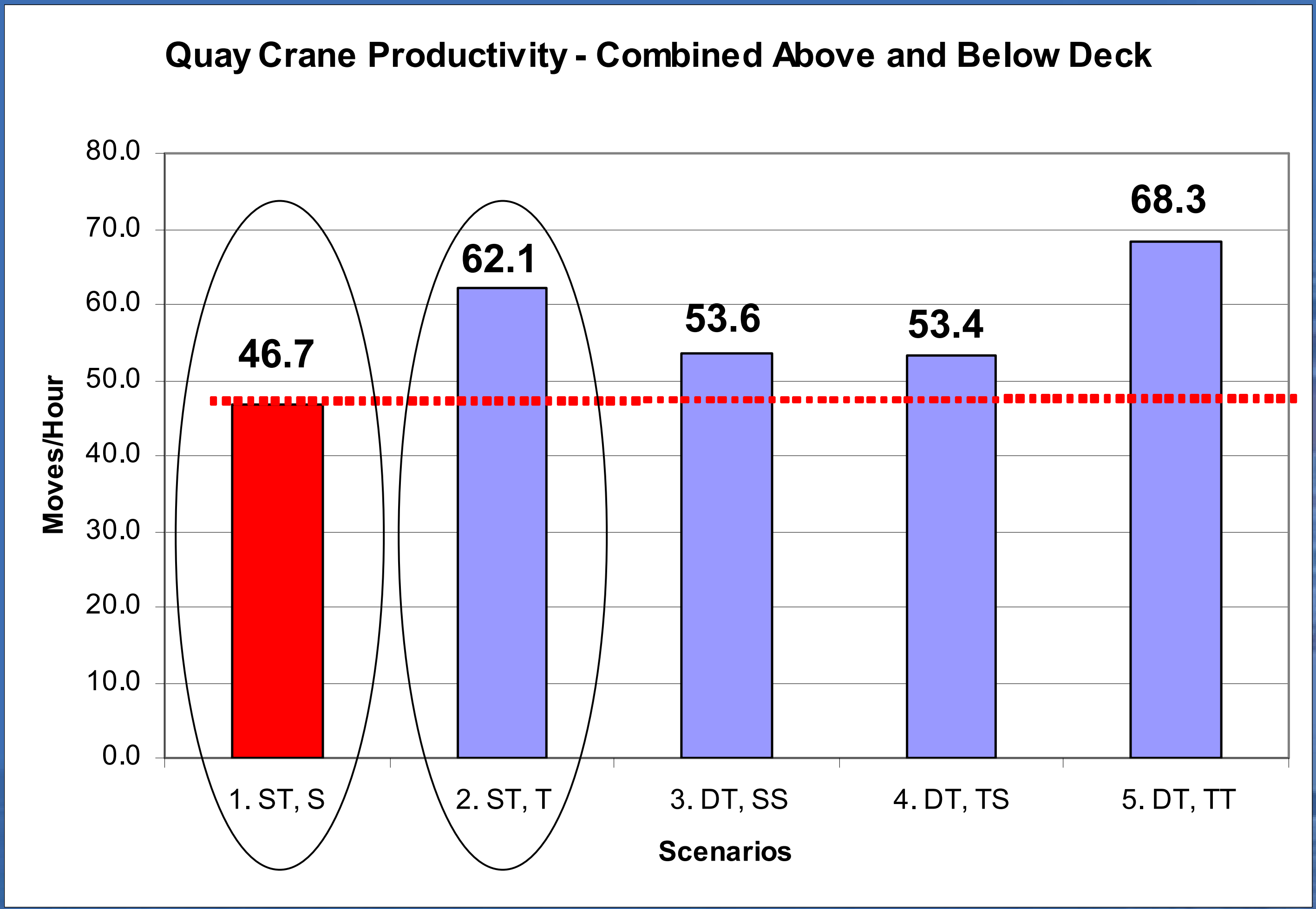
5. Dual trolley
Tandem lift, Tandem lift
DT, TT

Simulated QC Layout



Quay Crane Relative Net Productivities

- Single-trolley tandem showed 33% increase over single-trolley single



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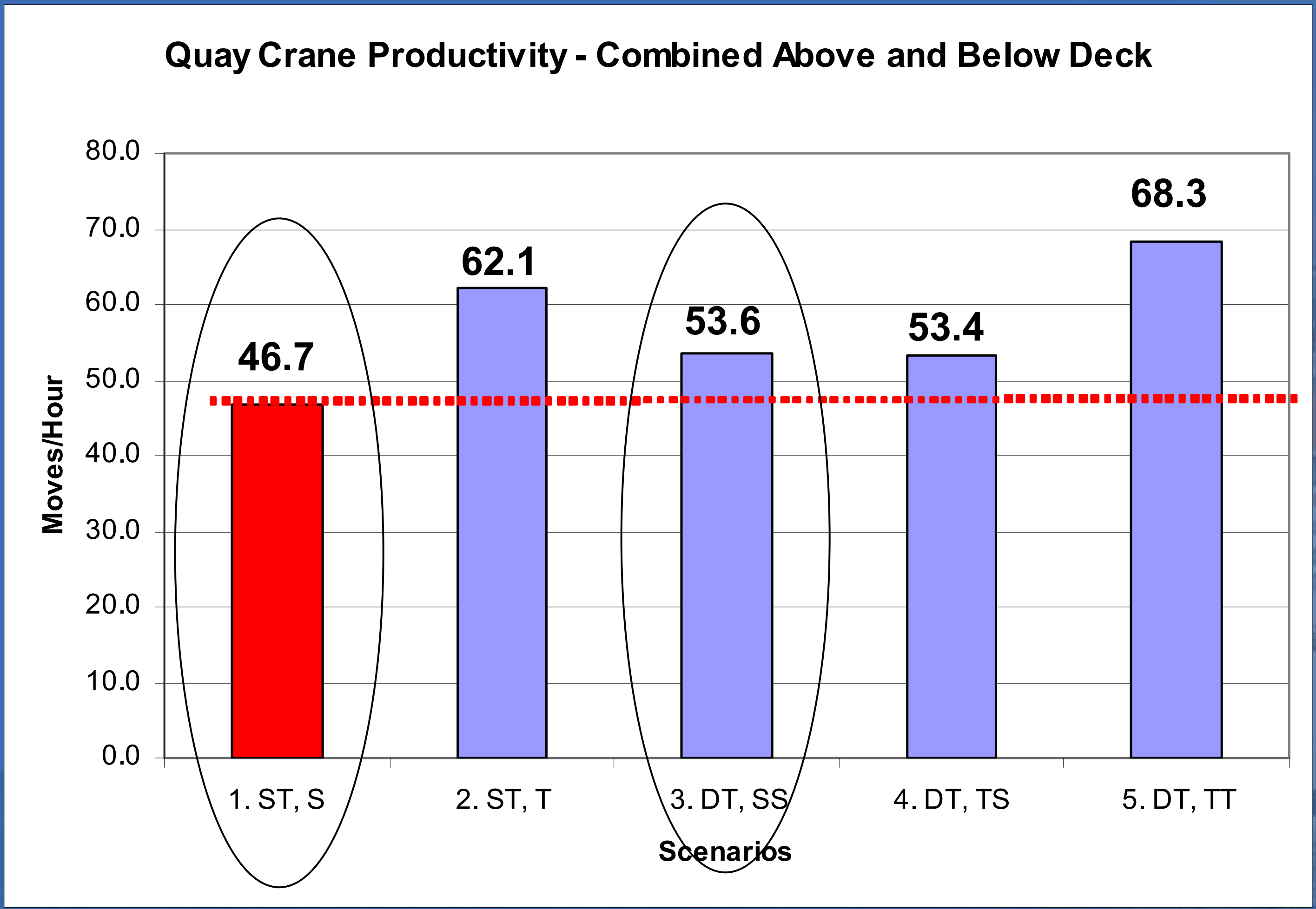
Quay Crane Relative Net Productivities

- Dual trolley single lift showed 15% increase over single trolley single



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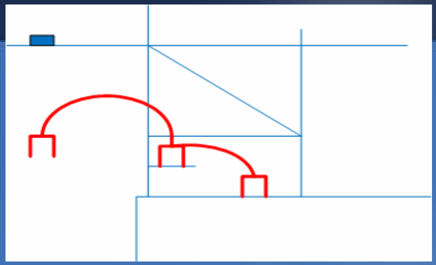
Quay Crane Simulation

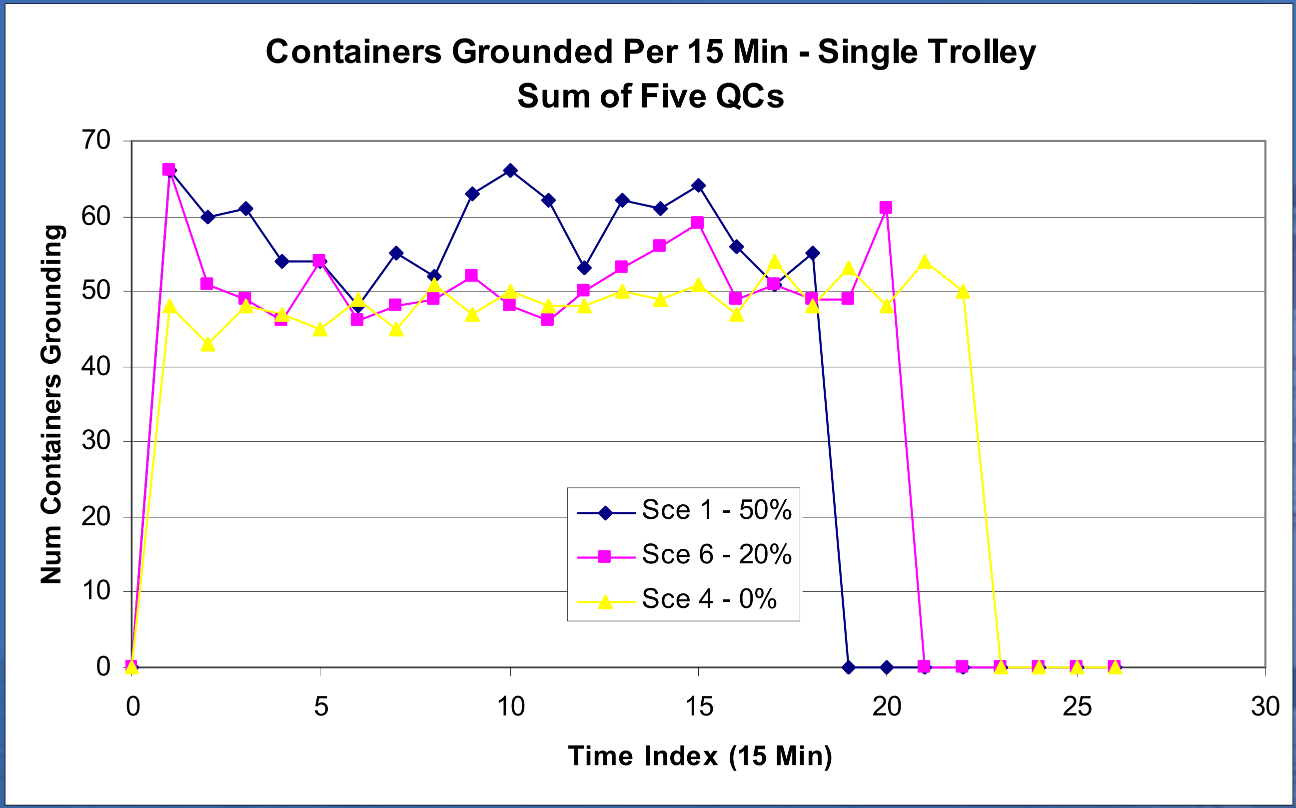
- A common complaint of tandem lift cranes is that “the yard can’t keep up”
- So, a fleet of 5 quay cranes was simulated to test the effect of tandem lifts on the yard crane and transport fleets

15 Minute Interval, 5 Cranes Working, Scenario 2. "ST, T"

- Peak rate = 260 mph = 52 mph/QC
- QC fleet max/min = 1.55



Single trolley
Tandem lift
ST, T



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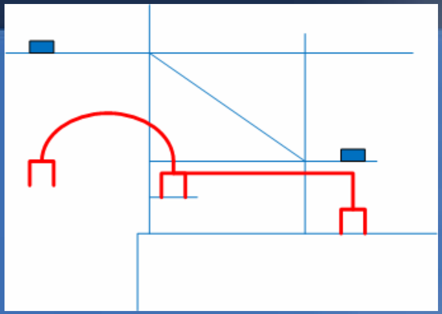
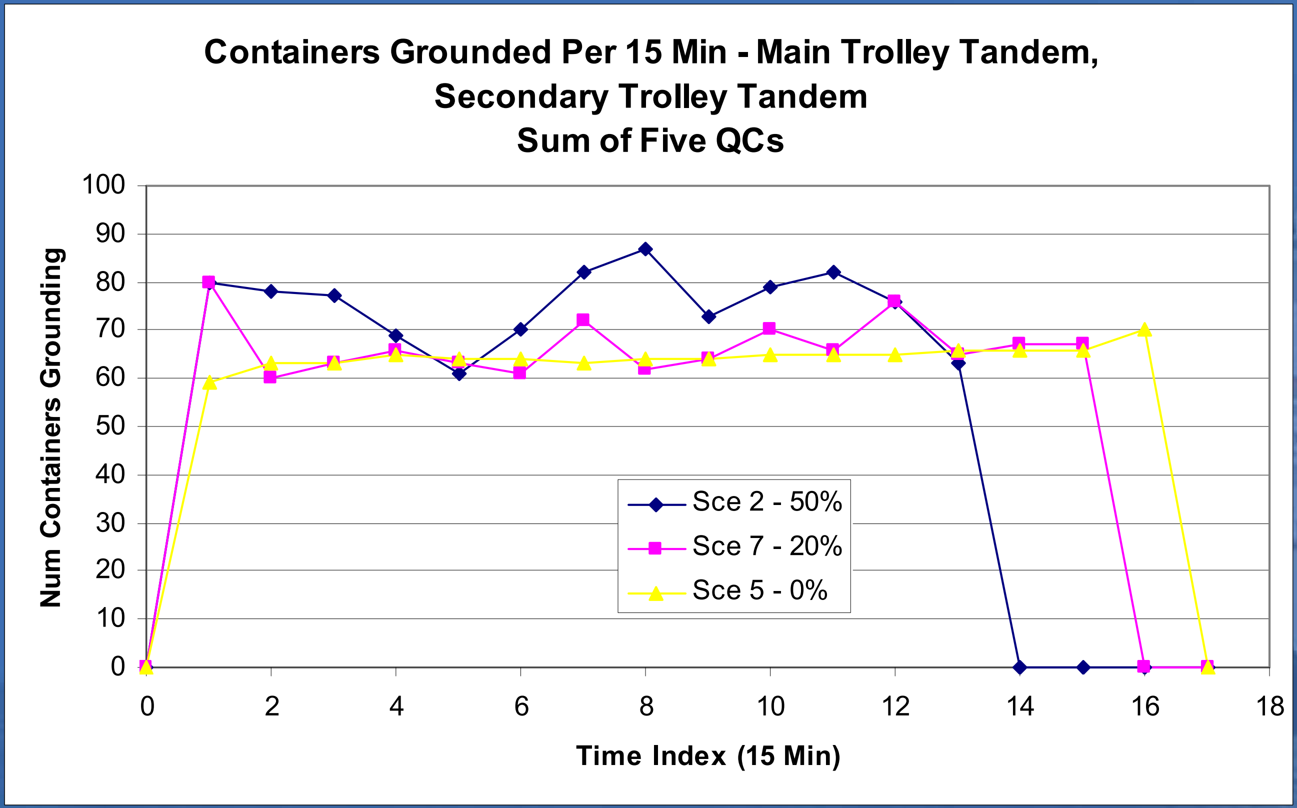
15 Minute Interval, 5 Cranes Working, Scenario 5. "DT, TT"

- Peak rate = 348 mph = 70 mph/QC
- QC fleet max/min = 1.43



Dual trolley
Tandem lift, Tandem lift
DT, TT



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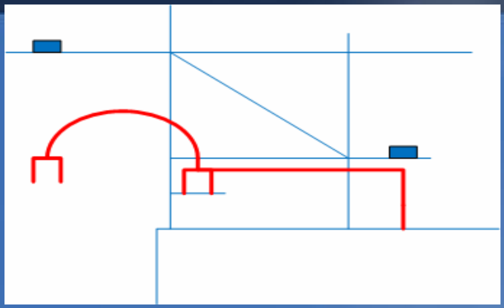
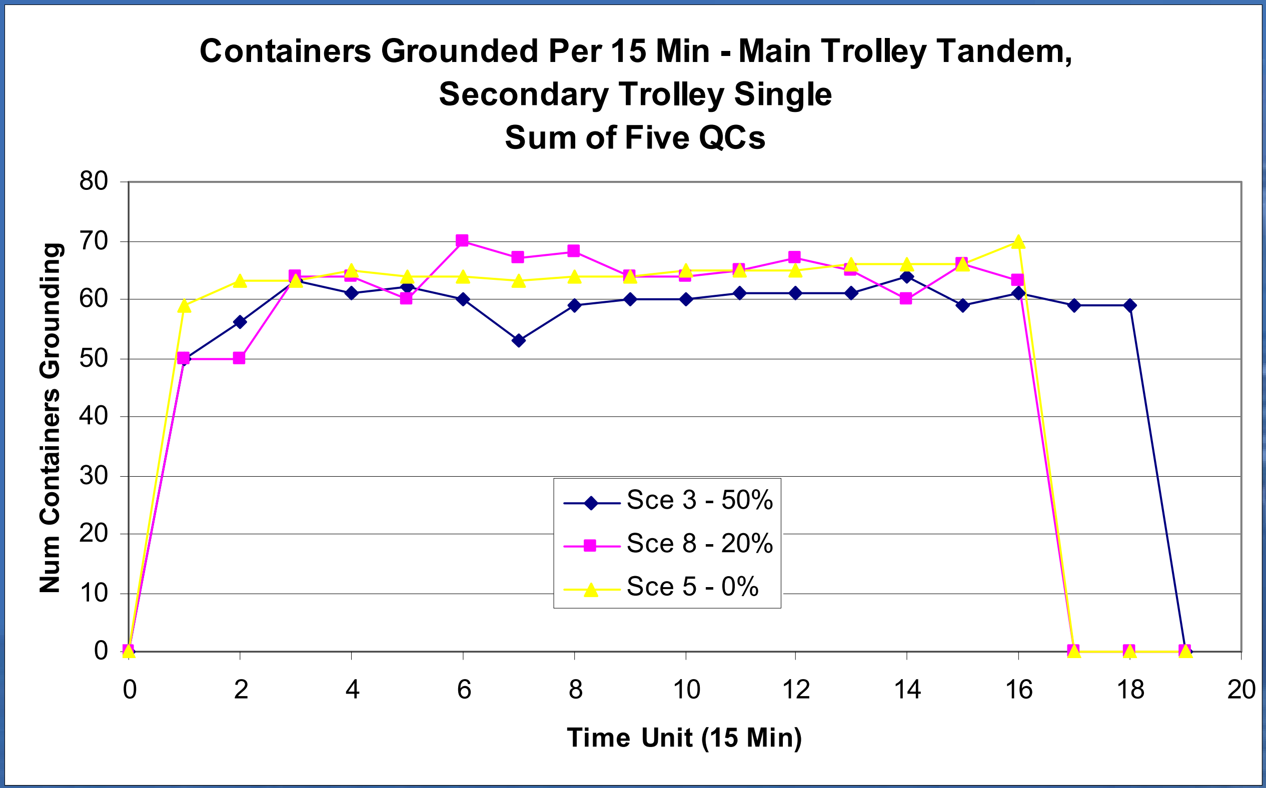
15 Minute Interval, 5 Cranes Working, Scenario 4. "DT, TS"

- Peak rate = 260 mph = 52 mph/QC
- QC fleet max/min = 1.34



Dual trolley
Tandem lift, Single lift
DT, TS



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Quay Crane Simulation

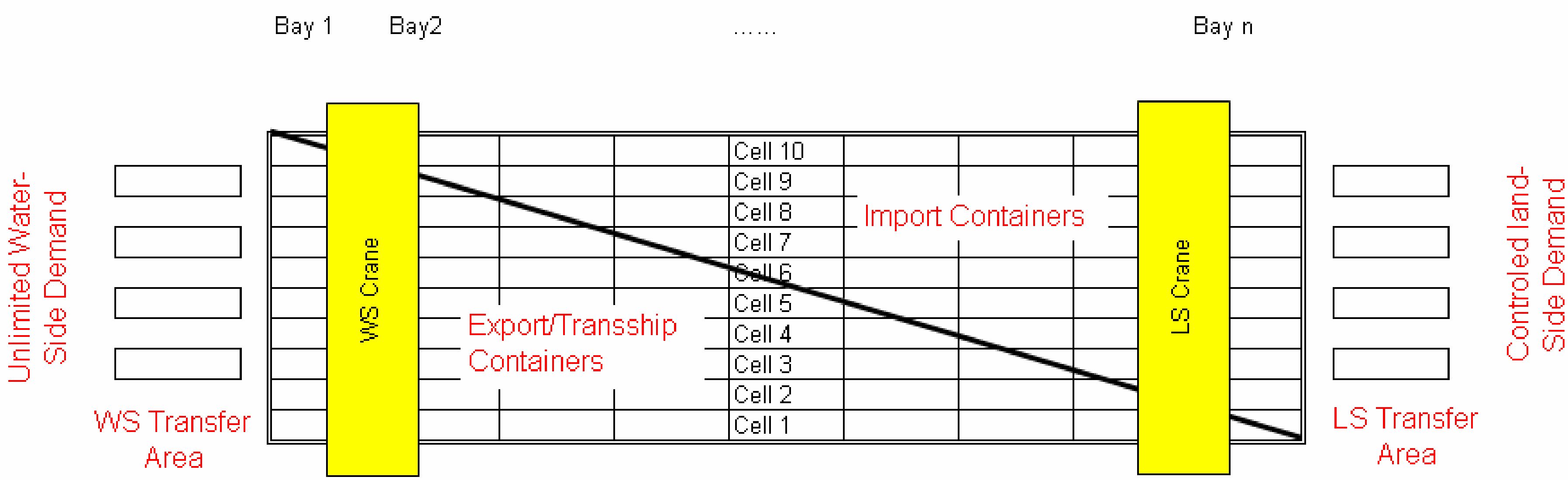
- The dual trolley crane with tandem lift main trolley and automated single lift secondary trolley;
  – Met vessel productivity goal
  – Presented the ASC and transport systems with a manageable flow of work

Quay Crane Simulation Conclusions

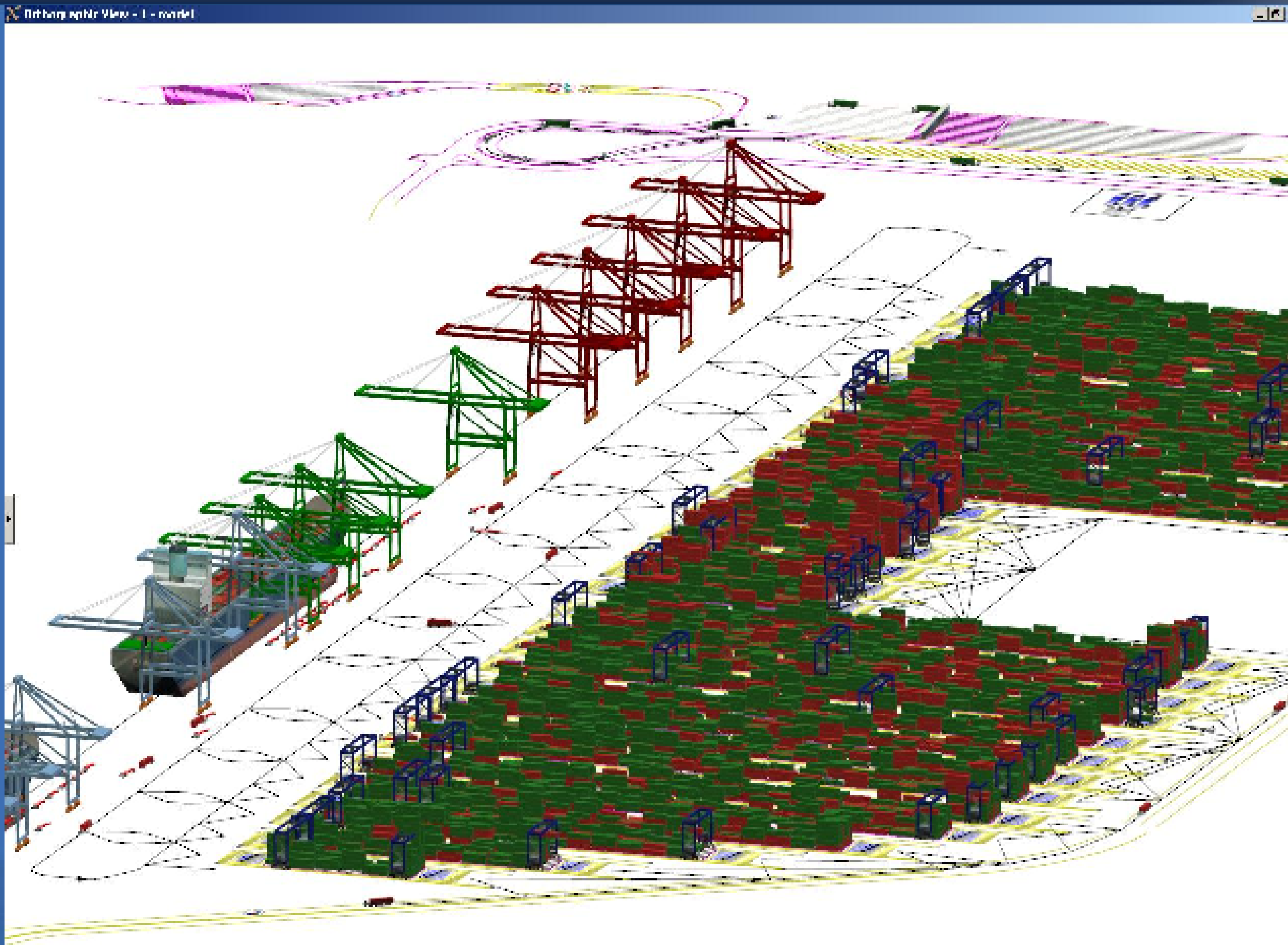
- Tandem lifts
  - Can provide high productivities (50% tandem lifts result in 33% improvement)
  - Adding a secondary trolley without tandem lifts can improve crane productivity by 15%
  - Tandem lifts causes extreme peaks and valleys
    - It is very difficult for the transport and yard systems to deal with and adjust to those peaks
    - Automated transport and stacking systems need a steady supply of work
- Secondary trolley (st)
  - A secondary trolley working in the backreach is preferred for automated transport
  - In terms of pure net productivity, tandem lift is higher
  - In terms of serving the transport and yard systems, single lift, dual trolley is favored
  - If start-up mode is single-trolley, tandem lift, provision for a single-lift secondary trolley is advised

Yard Crane Simulation

- Single-block simulation
  - What can each crane/block do?
- Fleet of stacks
  - What can "the system" do?



End-Loaded ASC Model



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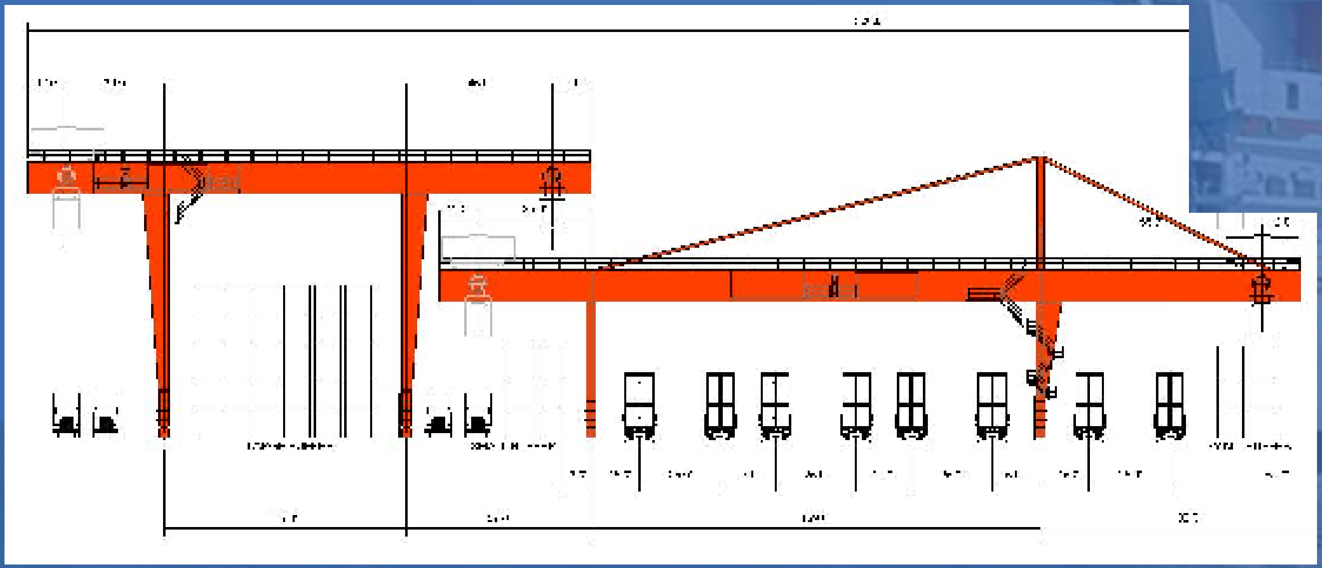
Yard Crane Simulation

- Showed that twin ASC's could achieve 16 moves per hr landside and 18 moves per hr waterside
- Showed that 40 ASC stacks (80 cranes) would be required to meet the peak landside demand of 520 moves per hr
  - 40 x 16 x .90 maint. factor / 1.15 unbalanced workload factor

Railyard Simulation

- Rail Yard simulation showed;
  - That 8, 1175m loading tracks would be required
  - 6 rail loading RMG's would be required
  - Train turn times
  - Track and crane utilization



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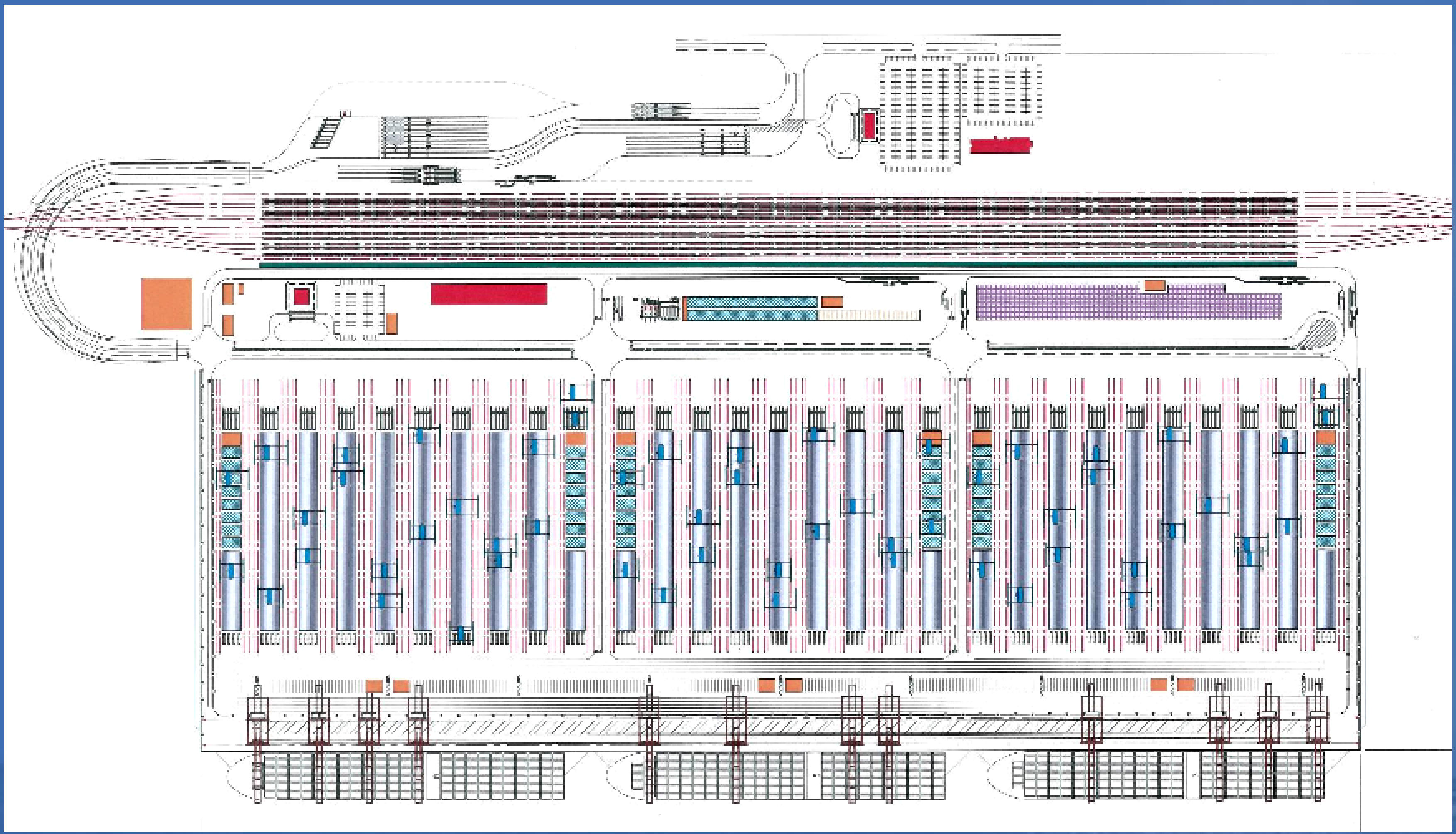
The Result

- The plan that emerged from the planning process
  - Three berths with up to 14 dual trolley quay cranes with;
    - tandem-lift main trolley and automated single-lift secondary trolley or
    - single-lift main and automated secondary trolleys
  - 3 million TEU annual capacity
  - Automated waterside transport using AGV's, 4-5 AGV's per quay crane
  - 40 end-loaded ASC stacks with twin cranes, 8-wide by 5 high by 40 TEU long
  - 6 rail-loading cranes spanning 8 tracks each, 3-4 drivers per rail crane

The Plan That Emerged

- (Looks something like this)



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A Recent Terminal Planning Project

- This planning project required analysis of all aspects of the terminal operation
  - Vessel, gate and rail schedules, traffic projections and resultant container populations
  - Vessel productivity
  - Quay crane configurations
  - Horizontal transport alternatives
  - Yard crane fleet configuration
  - Railyard configuration and sizing
  - Understanding of terminal operating system rules
  - Understanding of unique local labor and safety rules

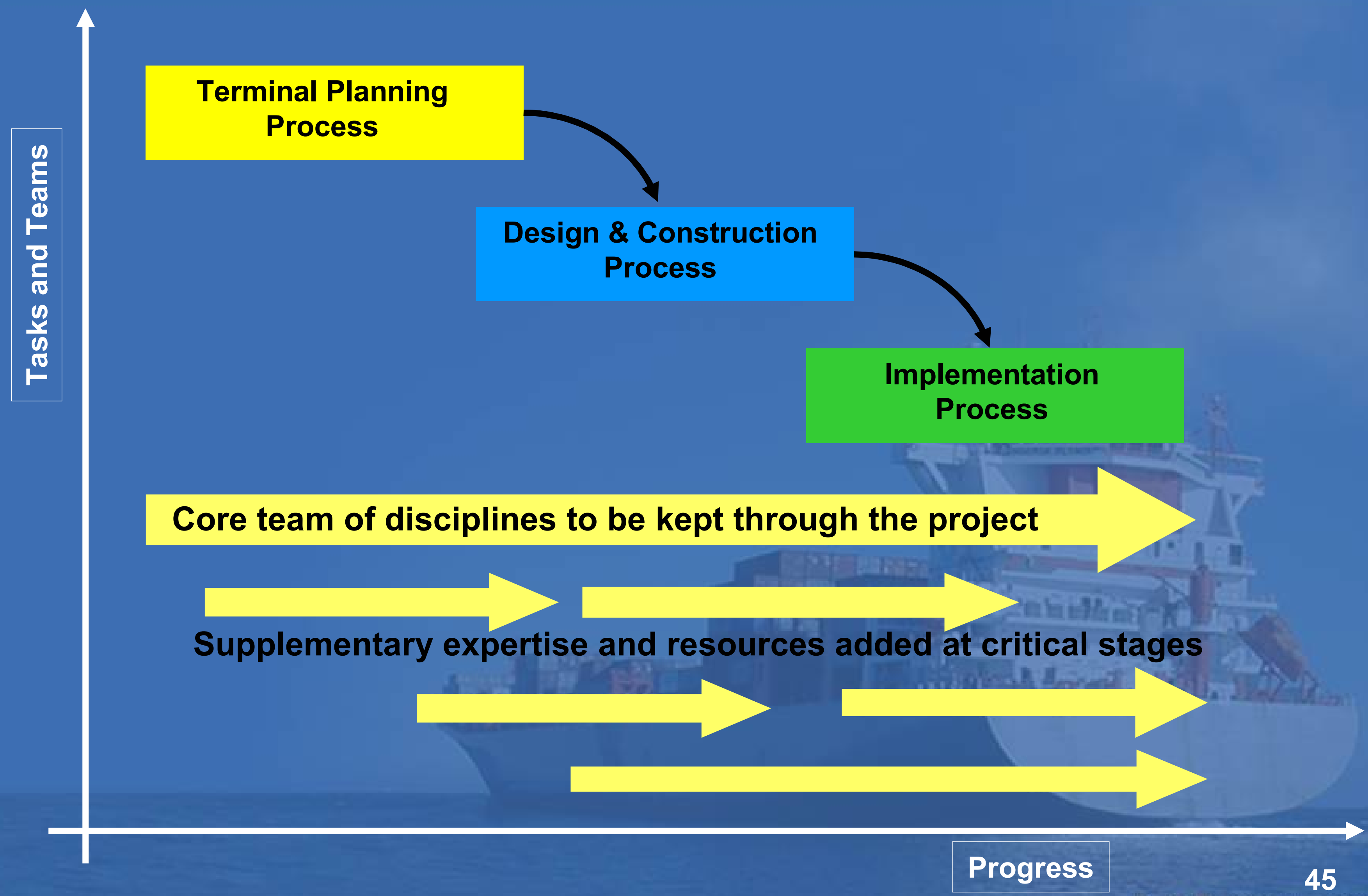
Integrated Terminal Design

- Integrated design of an automated terminal includes achieving the best balance of the clients;
  - Capacity goals
  - Performance goals
  - Financial goals
    - Infrastructure
    - Equipment
    - Labor
    - Maintenance
    - Operating systems

Integrated Terminal Design

- In fact, the design of a successful automated terminal requires the cooperative effort of a core team of experts from each discipline;
  – Management
  – Finance
  – Operations
  – IT Systems
  – Equipment (specification)
  – Civil / infrastructure
  – Maintenance

Integrated Terminal Design



Conclusions

- The container shipping and port business constantly strives to reduce the cost of goods movement through efficiency
- Automated container handling is a way to increase efficiency
- Terminal automation technology has reached a level of maturity that makes it a viable option for any major project
- No two terminals are the same, so a variety of solutions are seen

Thank You