container yard utilization

strategies to enhance terminal productivity

by Larry Nye, P.E.
moffatt & nichol engineers

Moffatt & Nichol Engineers

"A Firm Focused on the Waterfront"

- Over 60 Years
- Offices in Major North American Port Cities
- Port & Intermodal Planning
- Terminal Planning & Analysis
- Freight Forecasting
- Port Financial Analysis
- Port Infrastructure Design
- Dredging & Reclamation
- Marinas
- Environmental
- Urban Waterfronts
- Bridge & Highway Design

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Strategies to Enhance Terminal Productivity

Change

Change is exciting

This is the most exciting time ever for ports

"The problem with our time is that the future is not what it used to be..."

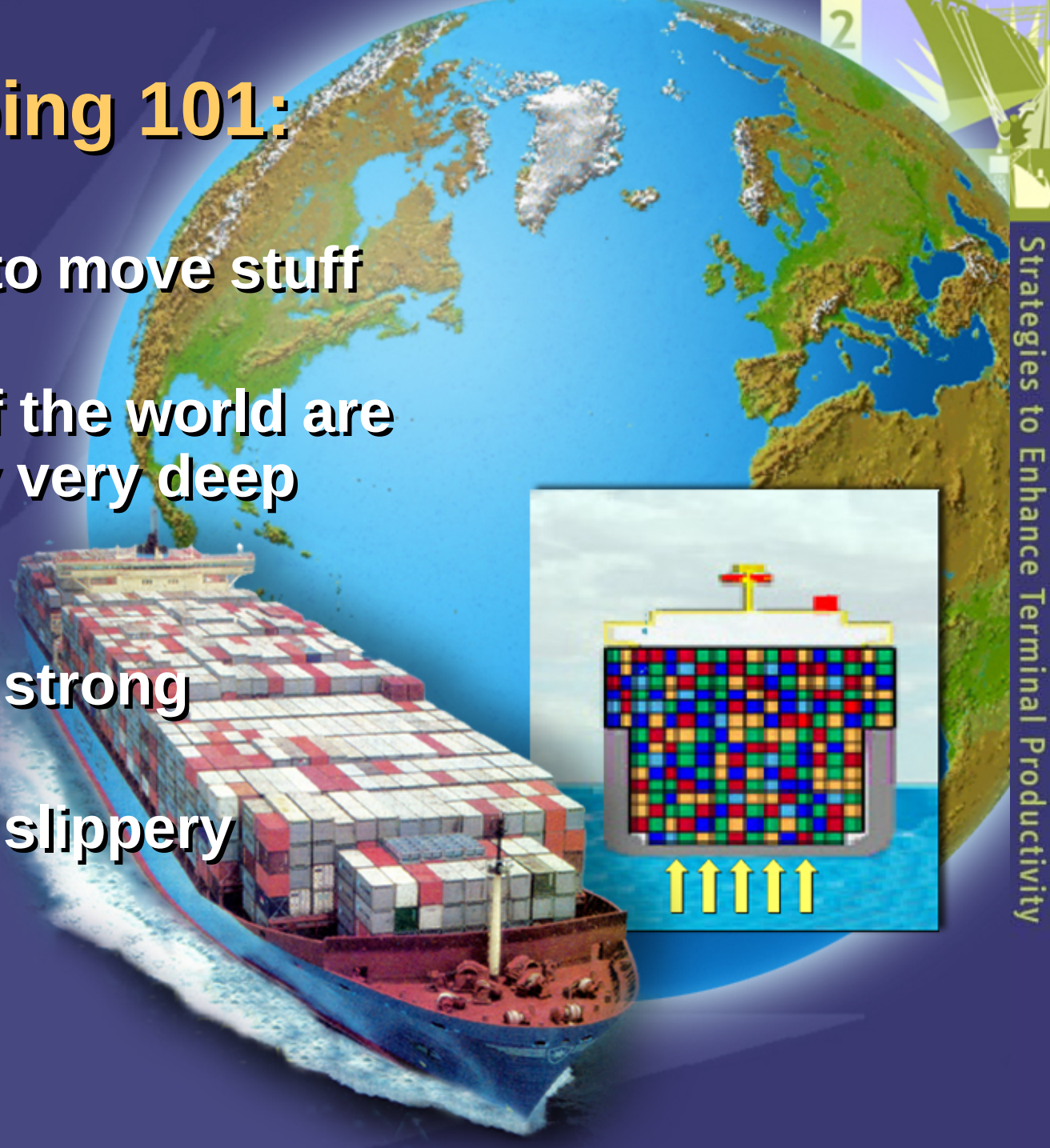
(Unknown author)

"I have no need for ports...I get everything I need from the internet..."

(Unidentified "CAVE" person)

Ocean Shipping 101:

- People need to move stuff
- The people of the world are connected by very deep water
- Water is very strong
- Water is very slippery



- **Floatation is, always & forever, the best way to move stuff on this planet**
  - **Ships have never stopped growing & changing**
    - **We will continue to build *better* ships**
      - **If bigger is better, then ships will grow**
        - **Ports and terminals will adapt to serve them**

- **Compared to ships, trains and trucks are a silly way to move stuff;**

One Ship = 8,000+ TEU
$0.10 per ton mile

And the gap is widening!

One Truck = 2 TEU
$1.00-2.00 per ton mile

One Train = 560 TEU
$.50 per ton mile

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Strategies to Enhance Terminal Productivity

Ocean Shipping 101

“It is only recently, … and cautiously, that we have moved far from the oceans, to places like Siberia or Nebraska, and it is by no means clear that places so far removed from the sea are viable in the long term.”

John Szarkowski; Author, Director Emeritus, Museum of Modern Art, NY

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Strategies to Enhance Terminal Productivity

Green Ports

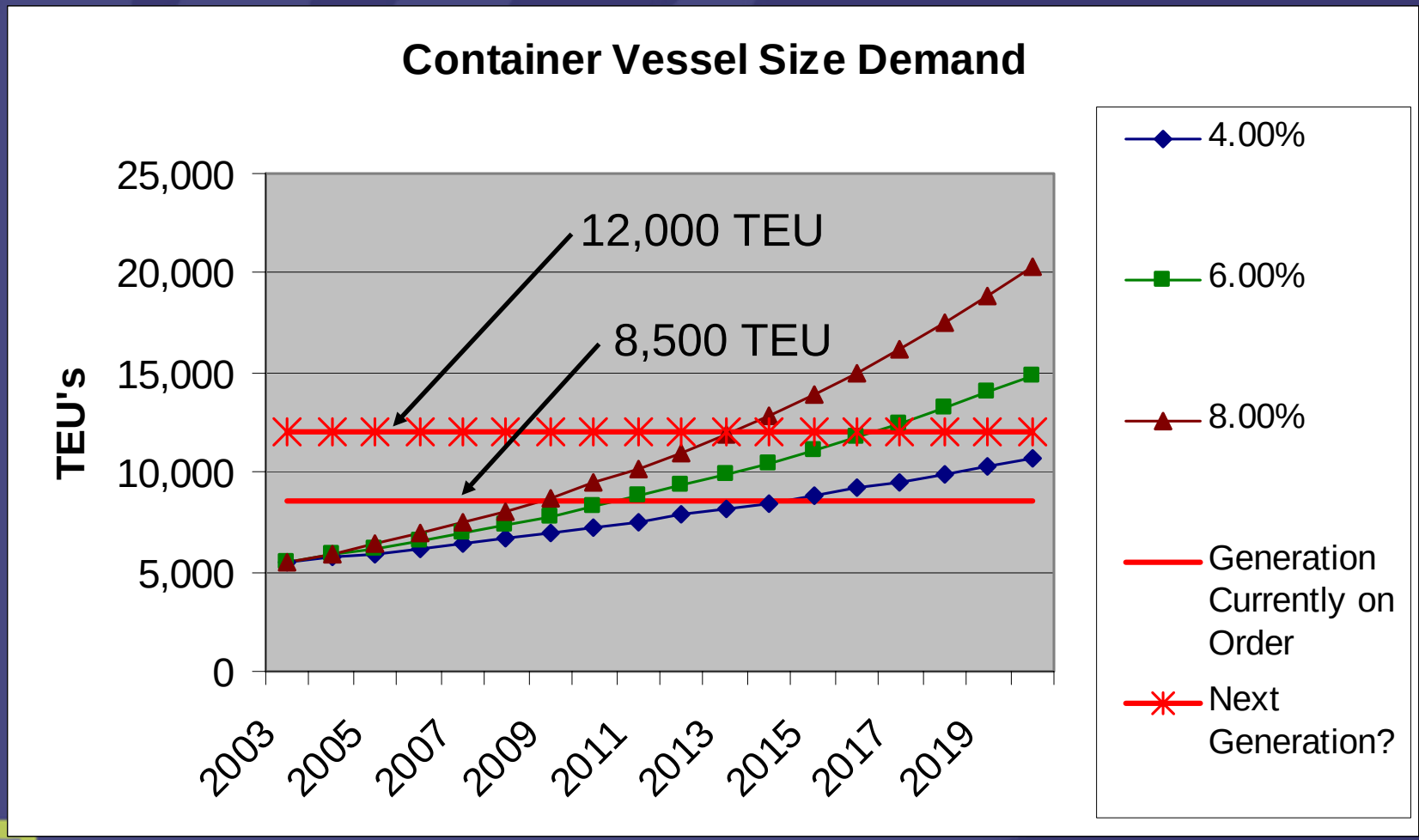
- How do we continue to grow our ports and minimize the impacts on their communities?
- Balance:
  - Growth in trade
  - Wildlife habitat
  - Traffic
  - Emissions / human health
  - Quality of life

Next Generation 1 TEU "Green" Vessel and Agile Port Concept

- No dredging
- No landfill
- No emissions
- Nothing on the shelves at Walmart
- No jobs
- Etc.

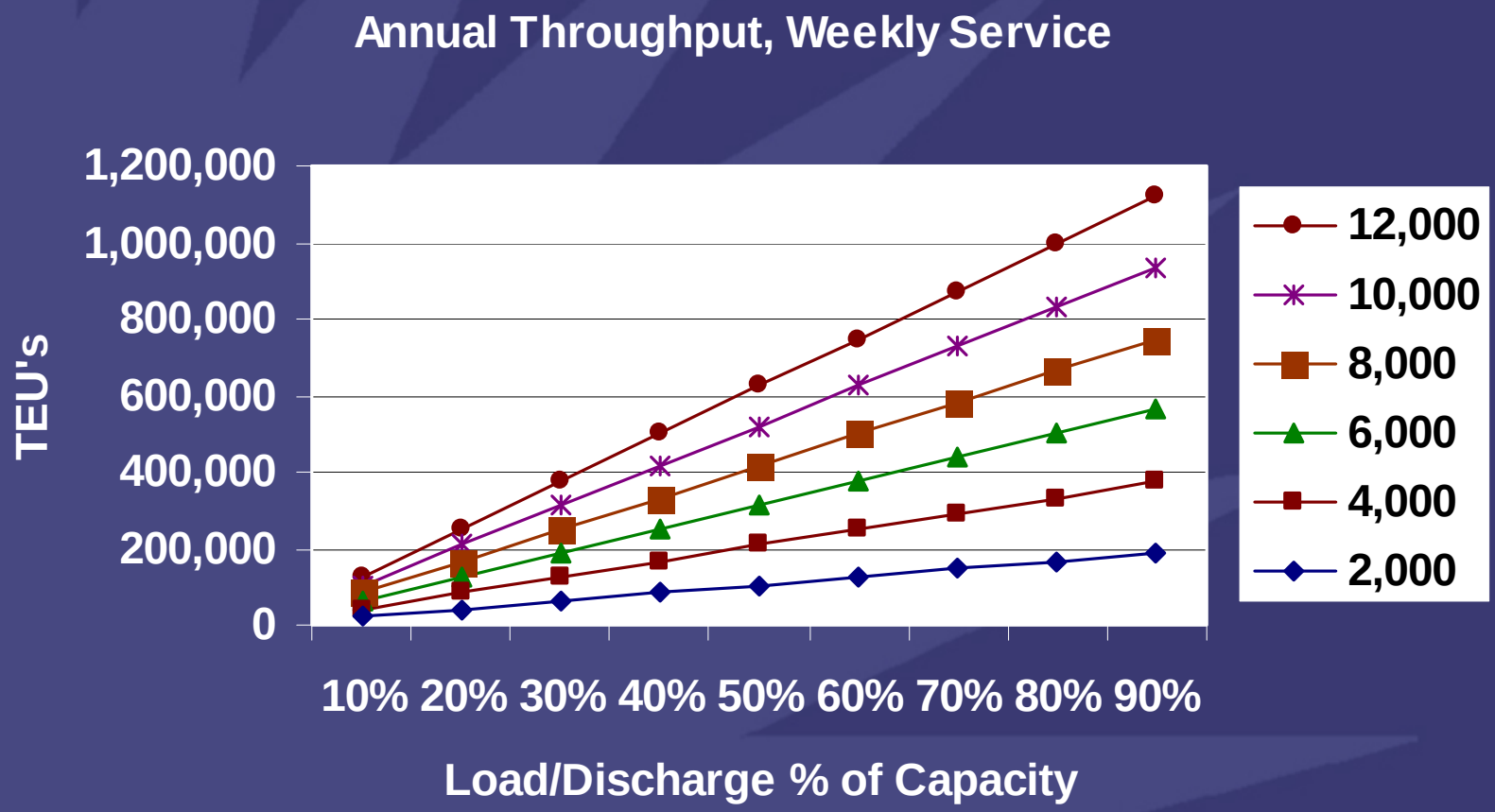
Most Economical Vessel Size

- Equals the capture rate on the service frequency



Impact of Large Vessels – Port Throughput

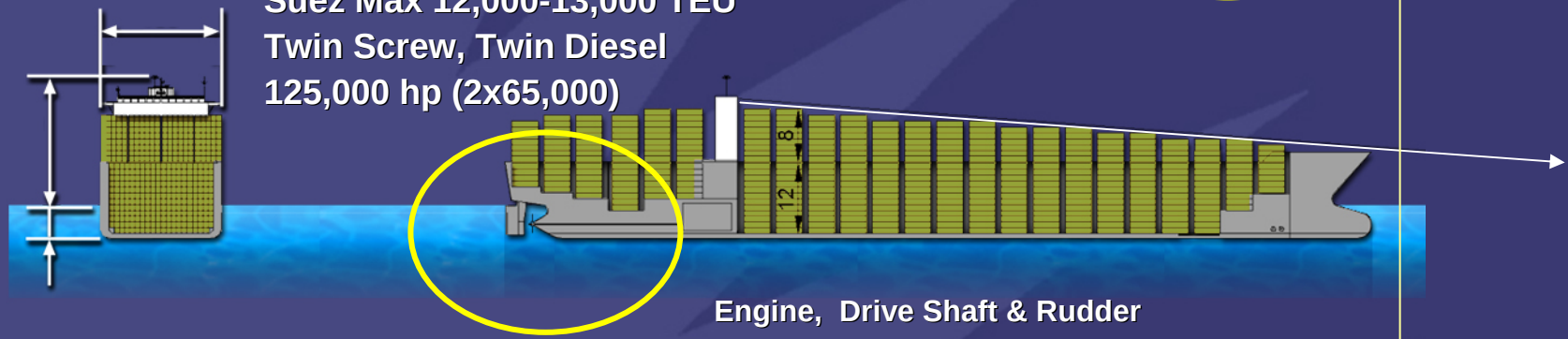
- 10,000 TEU Vessels in a Weekly Service
- Loading & Discharging 50% of Capacity per Call
- Generate Port Throughput of 500,000 TEU's per year



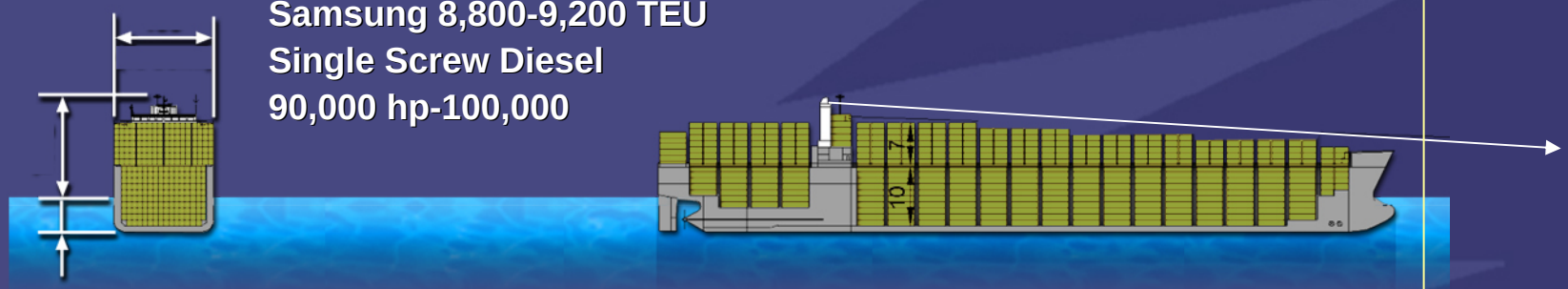
“Next” Generation Container Ships

Suez Max 12,000-13,000 TEU
Azimuthing Drives
125,000 hp (2x65,000)

Suez Max 12,000-13,000 TEU
Twin Screw, Twin Diesel
125,000 hp (2x65,000)

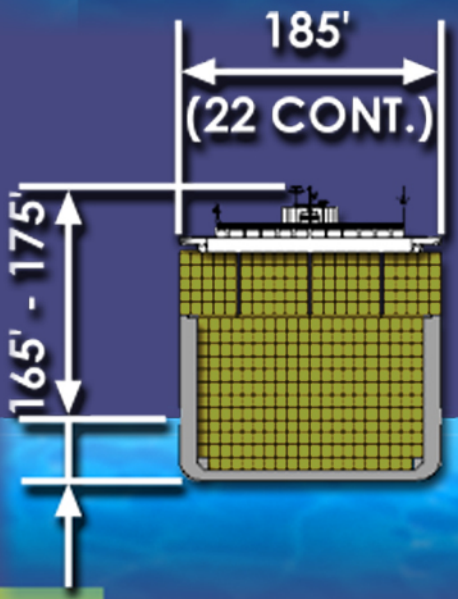


Samsung 8,800-9,200 TEU
Single Screw Diesel
90,000 hp-100,000



13,000 TEU Vessel Suezmax / “New Panamax”, Azimuthing Drives?

“Suez / New Panamax” 12,000 - 13,000 TEU



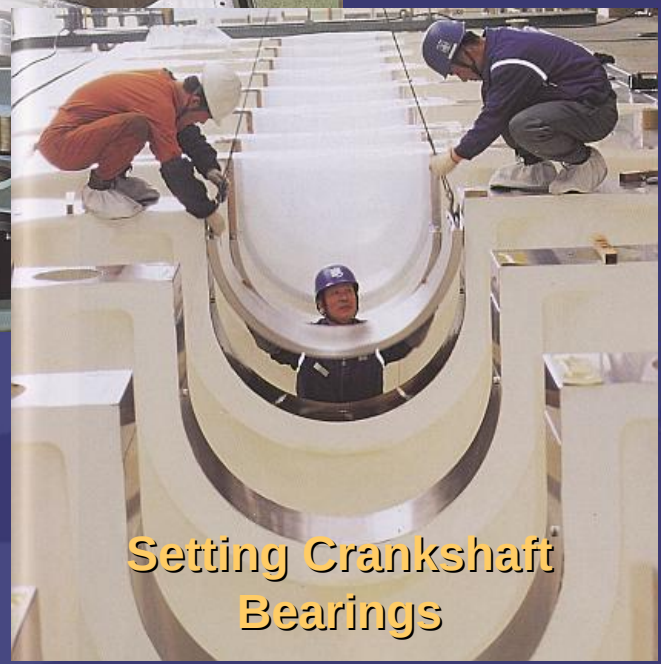
- Multiple Diesel-Electric Azimuthing Pod Drives
- 1300 feet long overall
- 185 foot beam (20 - 22 containers)
- 45 - 48 foot draft
- 165 - 185 foot airdraft
- Optimum hull design
- High maneuverability

Sulzer Marine Engine

- 14 Cylinder Inline Diesel 108,000 hp
- 10,000 TEU Vessel at 25 knots
- 5,000,000 pounds
- 90 feet long, 45 feet high
- Largest single-screw possible?

Laying the 300 ton Crankshaft

Building the Cylinder Deck



Setting Crankshaft Bearings

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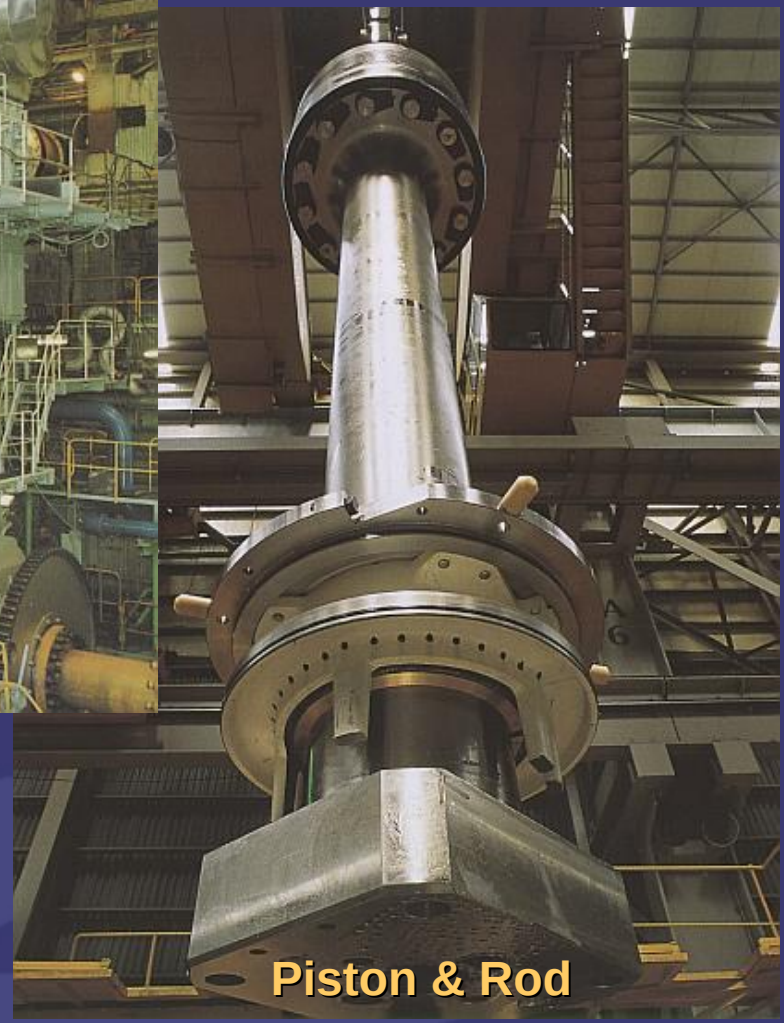
Strategies to Enhance Terminal Productivity

Sulzer Marine Engine

12 Cylinder Version


Piston & Rod

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10,000 TEU Vessel Carrying Capacity

1
10,000 TEU
Container
Ship

=

18
8,000 Foot
Double-Stack
Trains
(27 Miles)
(50 Acres)

=

5,800
Trucks
(60 Miles)
(95 Acres)

=

570
Boeing 747
Cargo Liners

DISCHARGE *OR* LOAD ONLY !

Strategies to Enhance Terminal Productivity

Impact of Large Vessels - Port Traffic - West Coast

10,000 TEU Vessel
85% Discharge / 85%Load
50% Local / 50% Intermodal

8 - 8,000 Foot Double-Stack Trains

8 - 8,000 Foot Double-Stack Trains

Total Traffic Generated;
16, 8,000 Foot Trains
8,000 Local Truck Trips

2,500 Truck Loads
(4,000 Local Truck Trips)

2,500 Truck Loads
(4,000 Local Truck Trips)

DISCHARGE

LOAD

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Strategies to Enhance Terminal Productivity

Impact of Large Vessels – Port Traffic – East Coast

10,000 TEU Vessel
25% Discharge / 25% Load
50% Local / 50% Intermodal

3, 6,000 Foot Double-Stack Trains

3, 6,000 Foot Double-Stack Trains

Total Traffic Generated;
6, 6,000 Foot Trains
2,200 Local Truck Trips

750 Trucks (1,100 Trips)

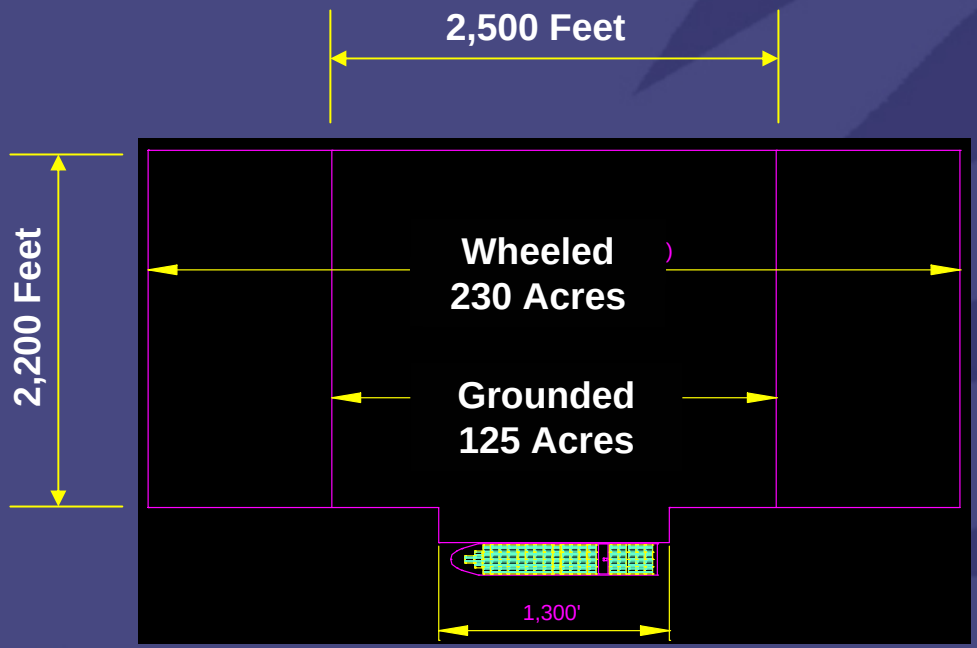
750 Trucks (1,100 Trips)

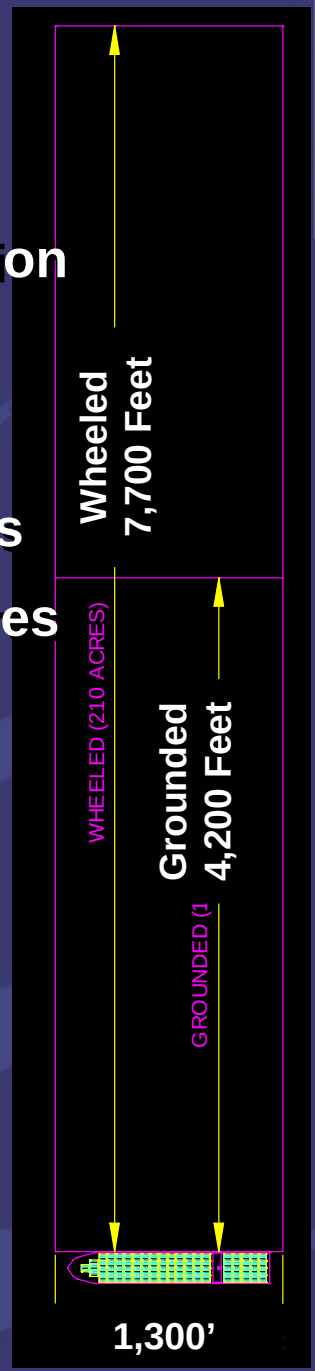
DISCHARGE

LOAD

Impact of Large Vessels – Terminal Size - West Coast

- 10,000 TEU Container Ships in a Weekly Rotation
- 85% Average Discharge / Load
- 880,000 TEU's / Year
- Wheeled: 3,800 TEU's / Acre / Year = 230 Acres
- Grounded: 7,000 TEU's / Acre / Year = 125 Acres



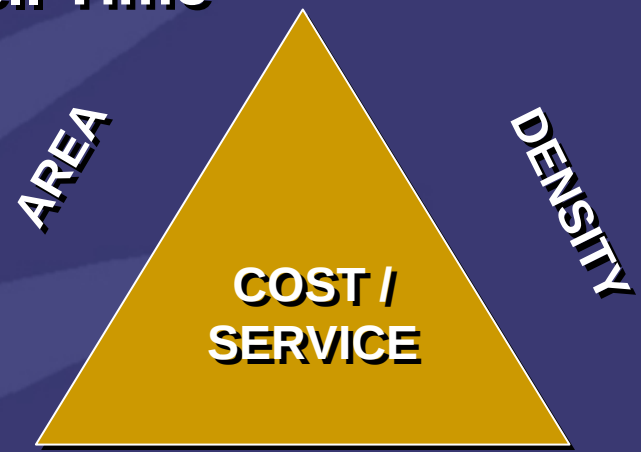


The Goal of Terminal Productivity

- Highest Throughput at Lowest Cost
- Port Throughput Capacity is Limited by Storage Capacity (almost always)
- The Container Yard is the Key

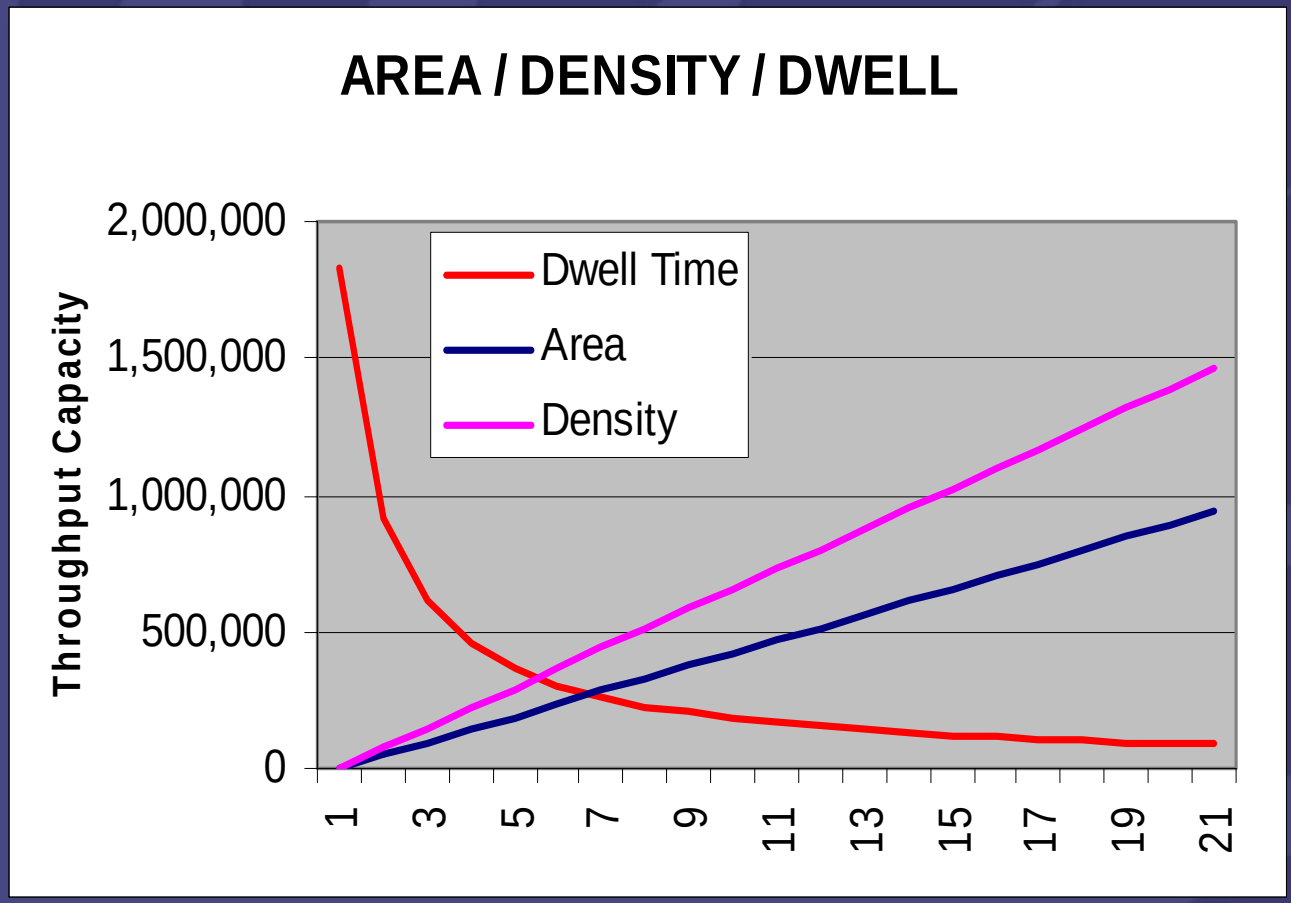
Area - Density – Dwell Time

- The Three Elements of C.Y. Capacity
  - Area, Density, Dwell Time
- Static Capacity = Area x Density
- Throughput Capacity = A x D / Dwell Time
- The Modifying Elements
  - Cost
  - Service



Interrelated & Inseparable

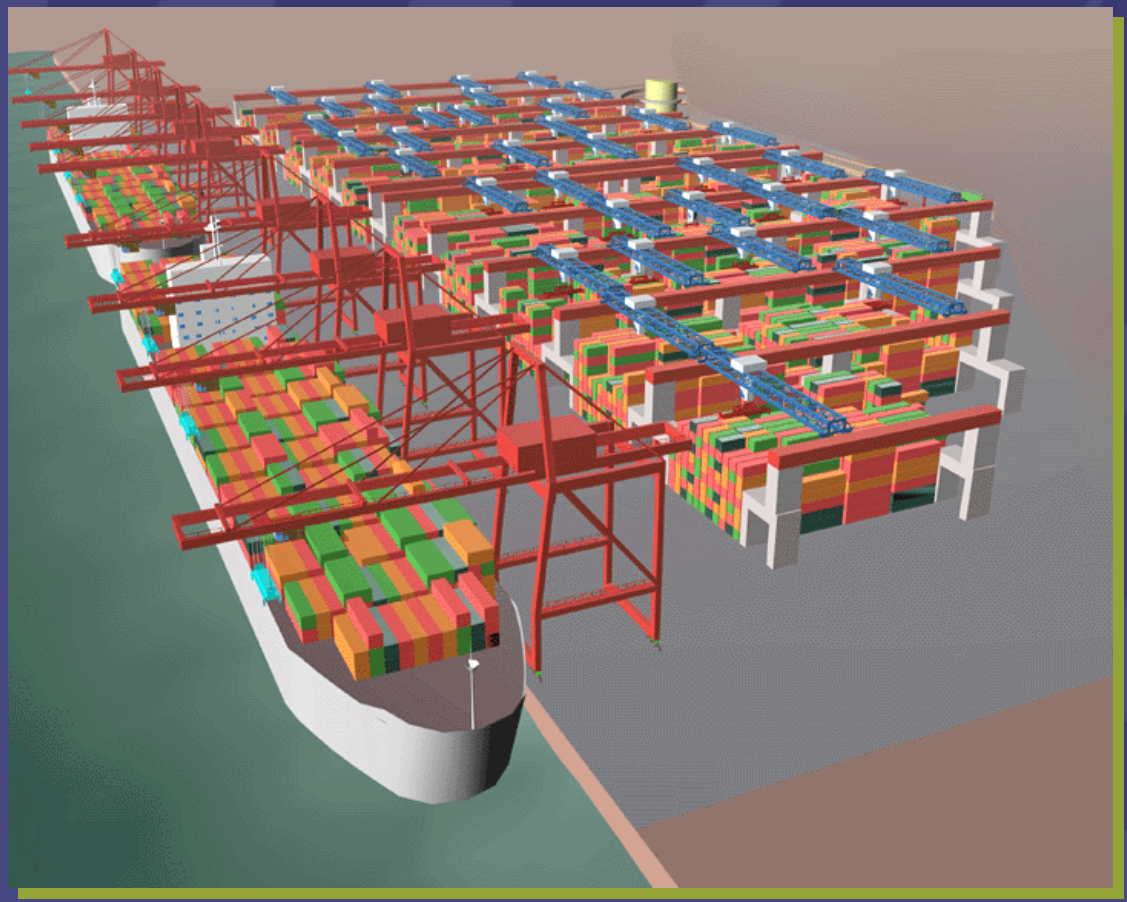
Terminal Capacity



High Dwell Time is Devastating to Capacity!

High Dwell Time is Devastating to Capacity!

Effective Storage Density



= Gross Density Less Efficiency Factors

- Sorting Factors
- Digging Space
- Vessel Peaking Factors
- Seasonal Peaking Factors

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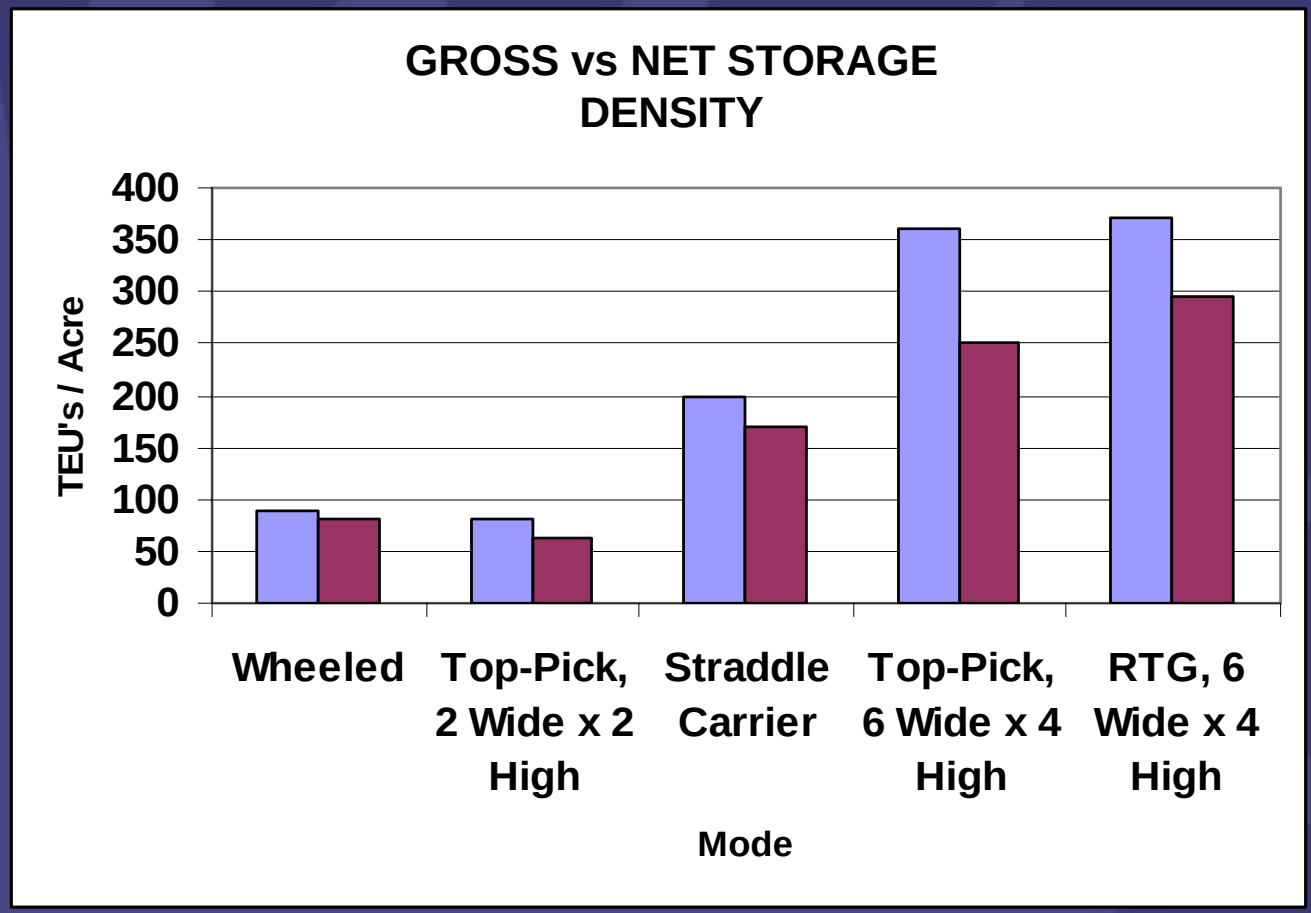
Strategies to Enhance Terminal Productivity

Gross / Net Density of Storage Mode



Container Dwell Time

- Typical U. S. container dwell times
  - Imports 4 - 6 days
  - Exports 5 - 7 days
  - Empties 10 - 40 days
    - Enforce allocations
    - Move off terminal
- As awareness increases, dwell time is being reduced
- Longer dwell dictates higher density

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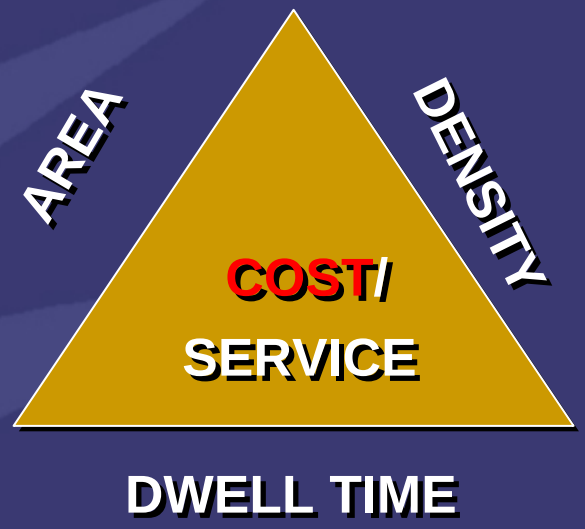
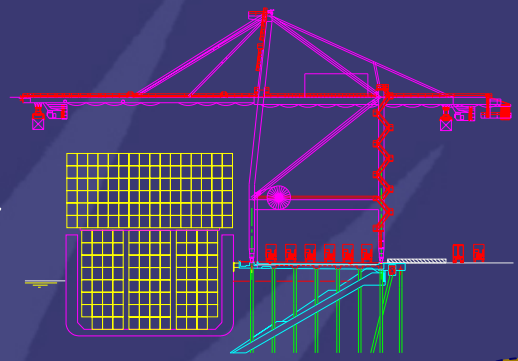
Strategies to Enhance Terminal Productivity

Storage Density / Cost

- **Land Cost**
  - Higher Density = Lower Cost (+)
- **Civil Development Cost**
  - Higher Density = Higher Cost (-)
- **Labor Cost**
  - Higher Density = Higher Cost (-)
- **Equipment Cost**
  - Higher Density = Higher Cost (-)



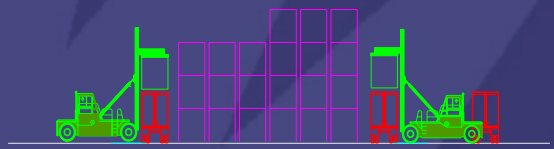
Grounded Costs
(California Costs)



VESSEL

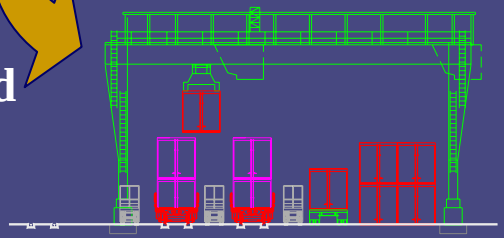
1. Discharge
$75

2. Receive
$15



INTERMODAL BUFFER

3. Deliver
$15



TRAIN

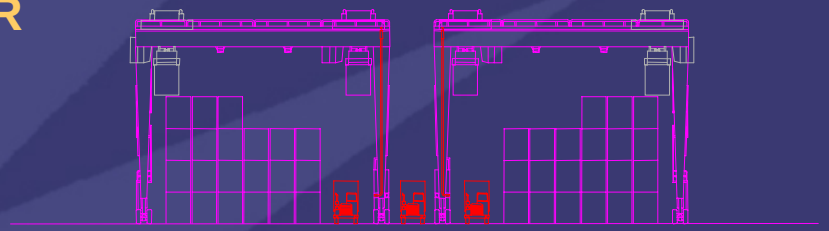
4. Load
$25

Total Intermodal $130

1. Discharge
$120

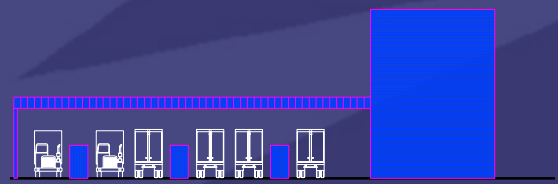
2. Receive
$20

5. Shuffle
$65



YARD

3. Deliver
$38



GATE

4. Gate
$10

Total Local $180-$250

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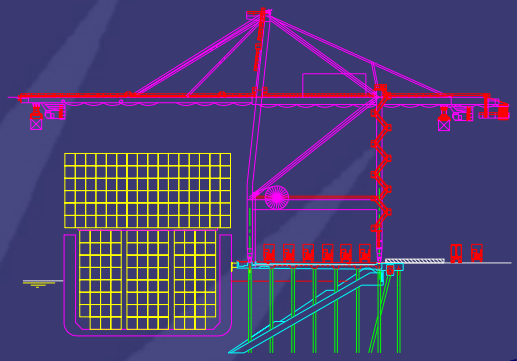
Strategies to Enhance Terminal Productivity

Wheeled Costs
(California Costs)



VESSEL

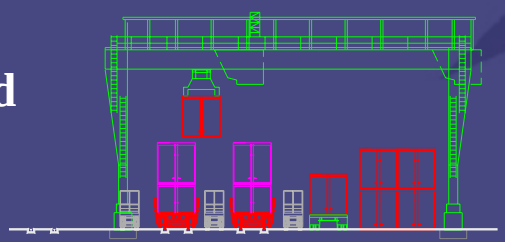
1. Discharge
$75

2. Receive
$0

3. Deliver
$10

INTERMODAL BUFFER

4. Load
$25



TRAIN

Total Intermodal $110
($20 Savings)

1. Discharge
$75

5. Shuffle
$10

2. Receive
$0

YARD

3. Deliver
$0

GATE

4. Gate
$10

Total Local $85-$100
($90-$150 Savings)

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Strategies to Enhance Terminal Productivity

Effect of Sorting

Front-End Loader Access

One Sort =
32 Boxes

Gross Capacity

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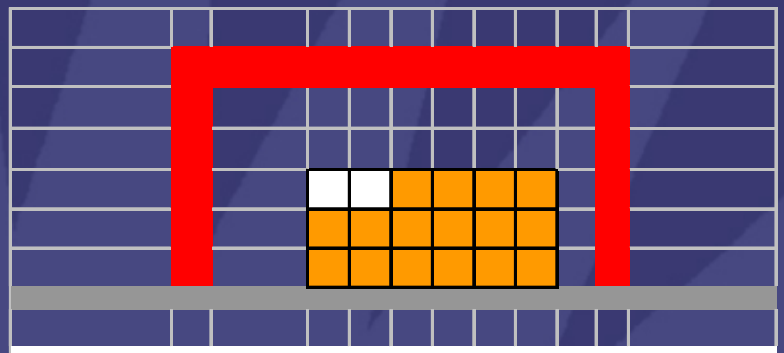
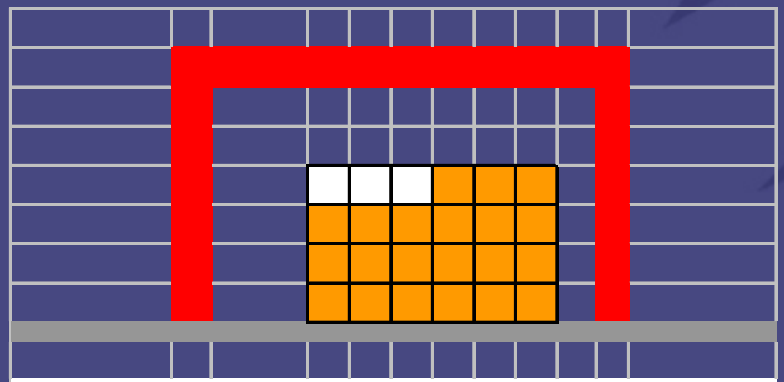
Strategies to Enhance Terminal Productivity

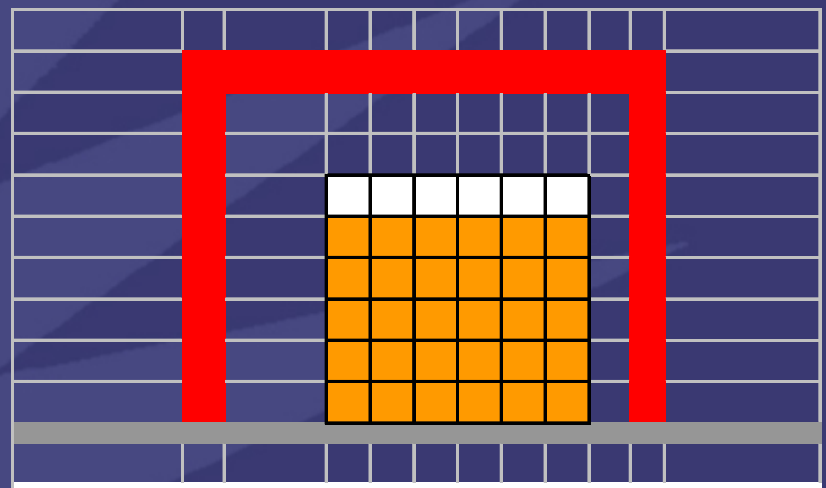
Effect of Digging



6-wide, 1 over 3 RTG
Gross Cross-Section, 18 Boxes
Effective Height, 2.67

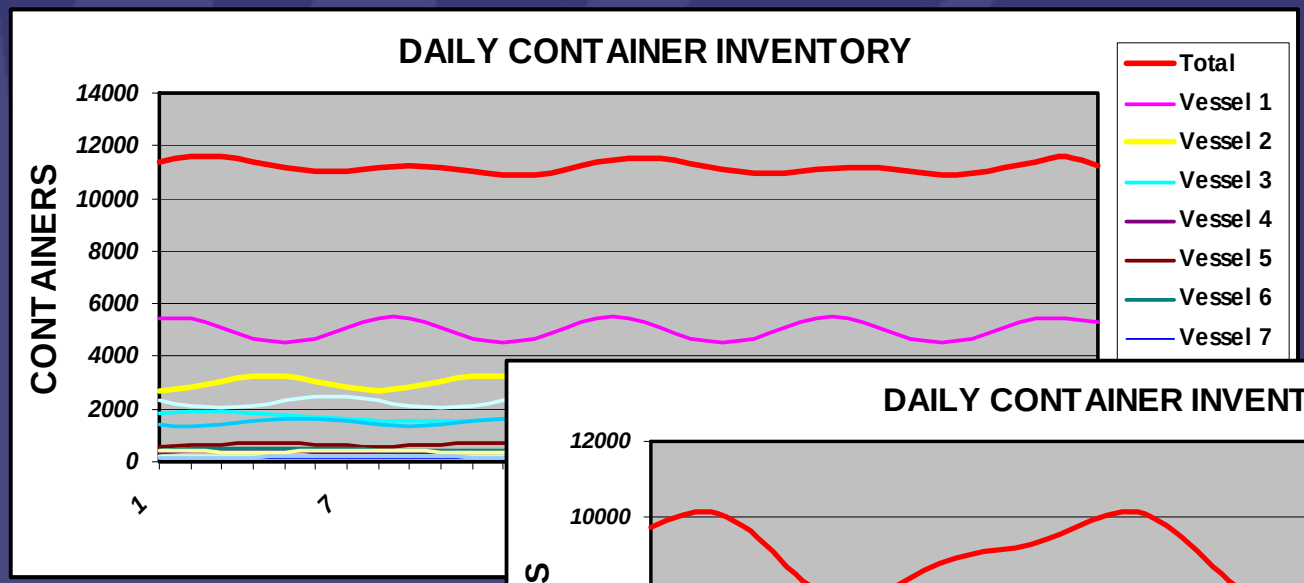


6-wide, 1 over 4 RTG
Gross Cross-Section, 24 Boxes
Effective Height, 3.5



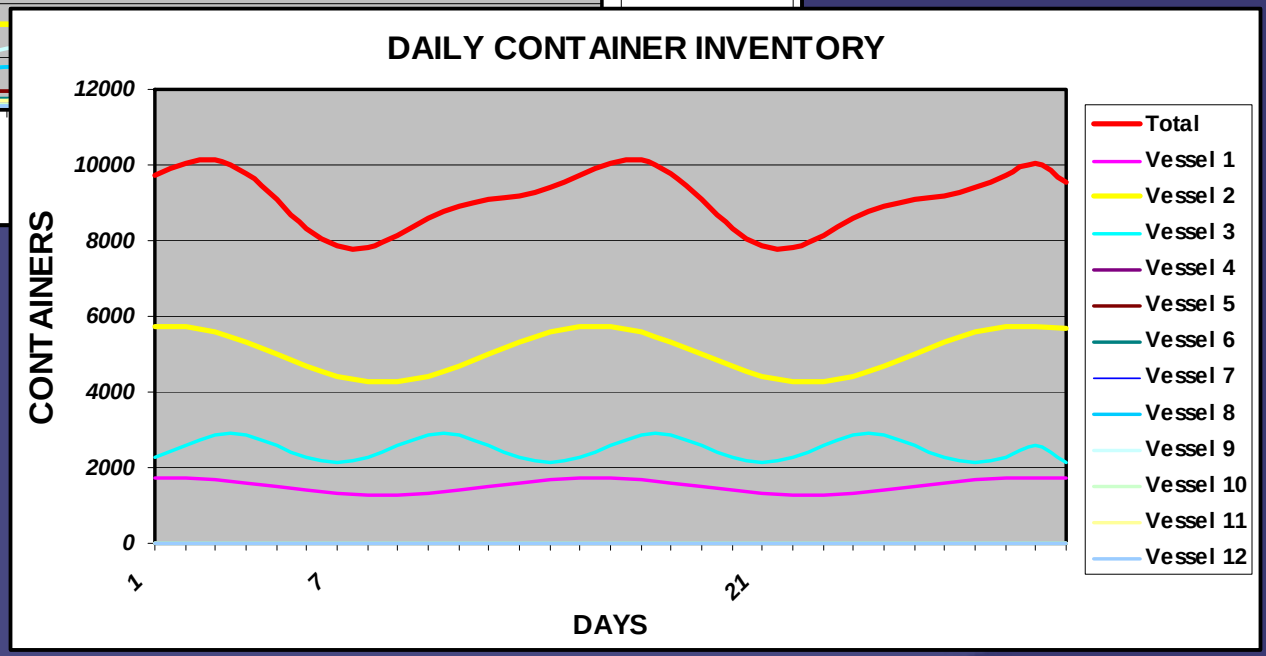
6-wide, 1 over 6 RTG
Gross Cross-Section, 36 Boxes
Effective Height, 5

Effect of Vessel (Inventory) Peaking



12 Vessels, Peak/Average Ratio = 1.1

Max. Util. = 91%



3 Vessels, Peak/Average Ratio = 1.25

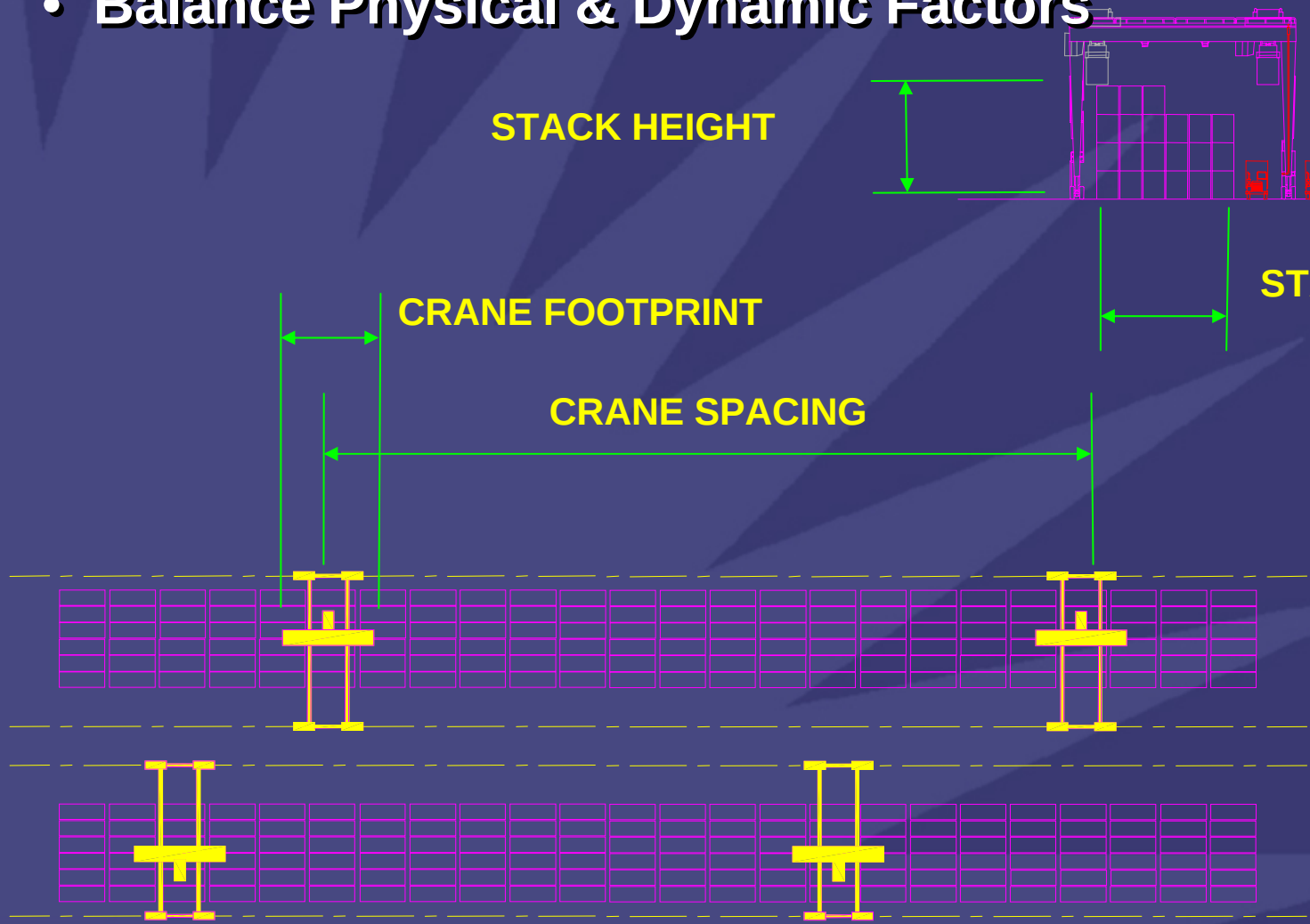
Max. Util. = 80%

Yard Productivity - Crane (Hook) Density

- The ratio of yard cranes to TEU's of storage capacity
- Yard cranes must meet total service demand
- Required hook density is a function of;
  - Peak demand
    - Vessel
    - Gate
    - Train
  - Dwell Time (Turnover Rate)
- Solution varies considerably
  - Port to port
  - Day to day

Yard Productivity – Crane (Hook) Density

- TEU's of Storage per Hook
- Balance Physical & Dynamic Factors



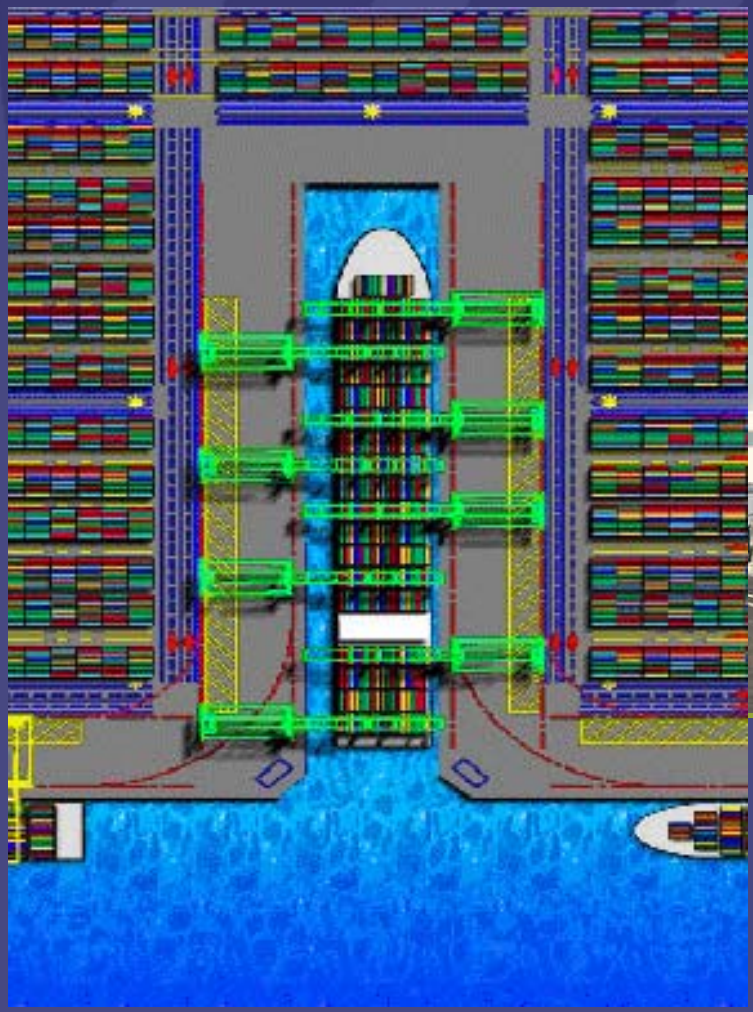
Yard Productivity - Crane (Hook) Density

- Example HIT, Hong Kong
- Need for high density (125 Yard cranes in 80 Acres)
- Semi-Automated RMG's
  - 12 wide x 6 high
  - High degree of automation
  - 1,100 TEU's / crane
  - 300 foot spacing
  - 80 feet bumper-bumper
- Insufficient hooks to meet peak demand
- Vessel priority/poor gate service
  - Even with 24 hr gate & appointments

Density / Service

- Higher Density = Lower Service
- More Digging
- Higher Hook Density
- Extended Hours of Operation
- Appointments

Service Definition



- Vessel Productivity
- Gate Turn Times

Changing Definition of Service

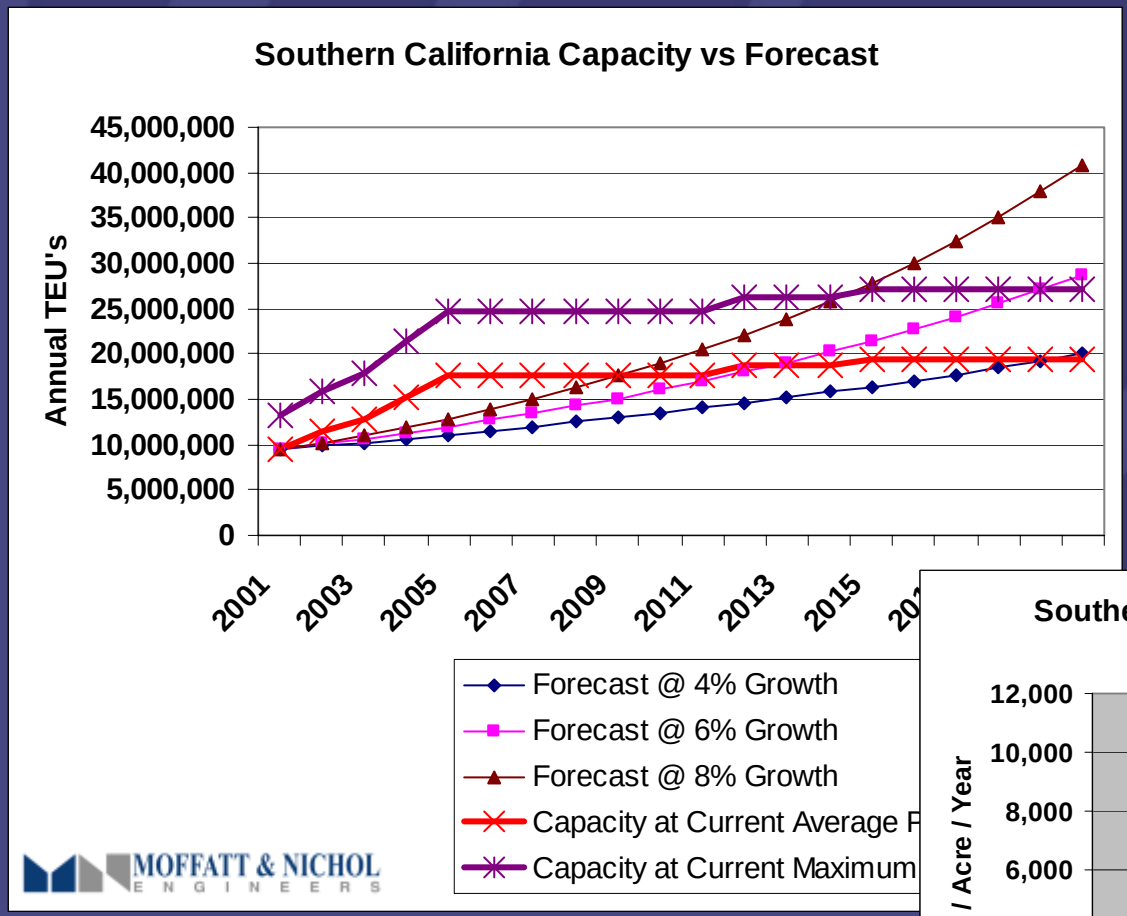
- Ports, Terminal Operators, and Shipping Companies are not driving the train anymore
  - Large Retailers
  - Manufacturers
  - Shippers
  - Logistics Providers Say:

"What" "When" "How"

- The ports neighbors say:

"Minimize the Impacts"
or
"Get Out of Town"

LA/LB Growth



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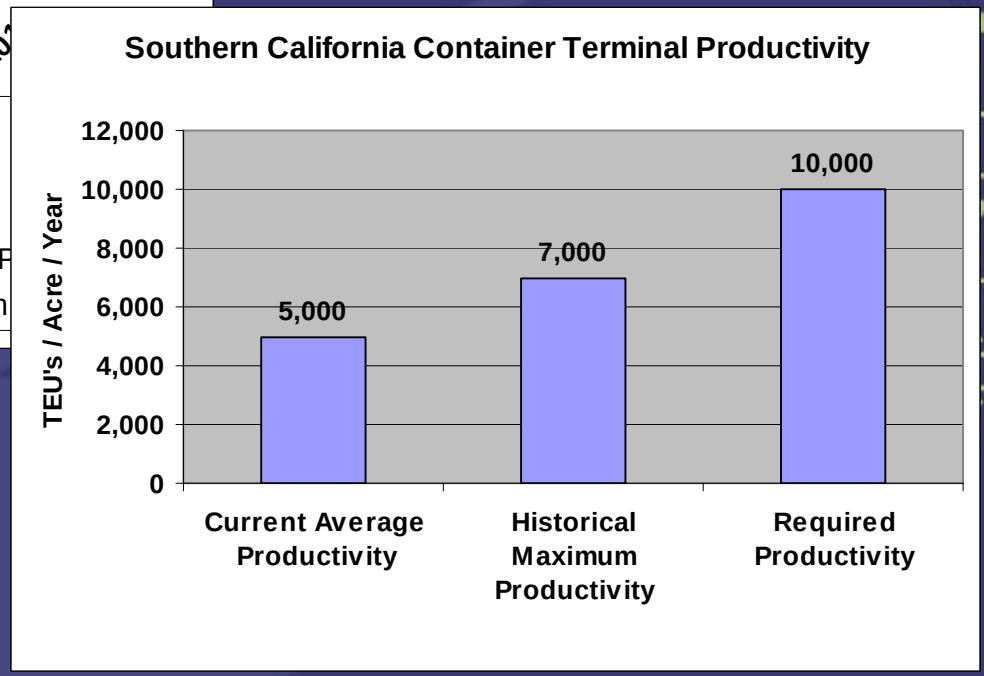

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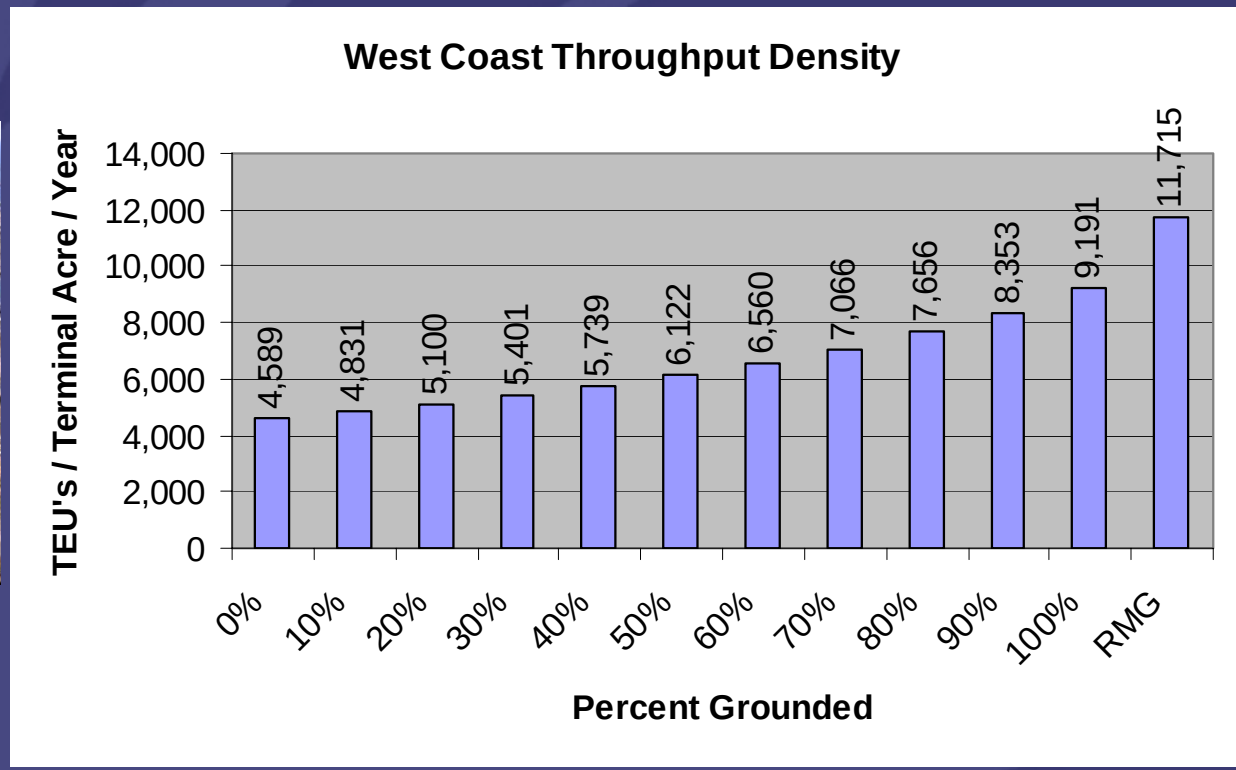
Strategies to Enhance

West Coast Terminal Productivity

- Priority Imports Wheeled
- Imports RTG's
- Exports Top-Picks
- Empties Side Picks

- So. Calif. average = 4,800 TEU/ac/yr
- Recent maximum = 7,000 TEU/ac/yr
- Reasonably achievable = 6,500 TEU/ac/yr



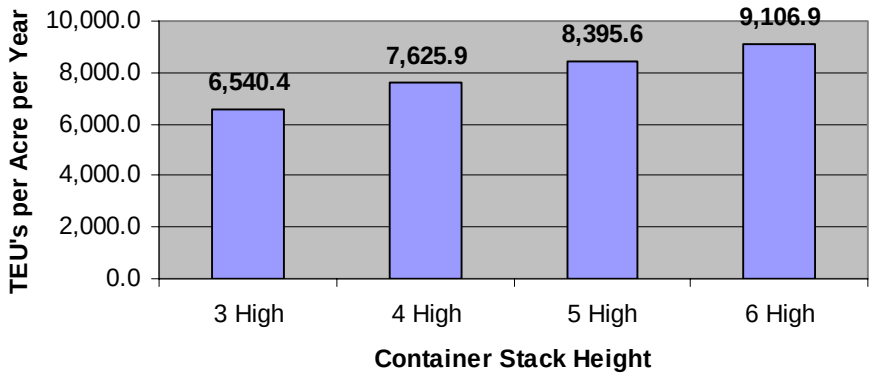
Port Land Productivity & Capacity

- West Coast Container Terminal Area = 4,860 Acres
- 2004 Throughput = 19,860,000 TEU's
- 2004 WC Average Terminal Productivity = 4,088 T/Acre
- Capacity of Exist. Terminals @ 6,500 T/Acre = 31,577,000 TEU's
- Latent Capacity @ 6,500 T/Acre = 11,715,800 TEU's
- Latent Capacity of MP Land = 24,286,800 TEU's
- Assumes even distribution to WC ports

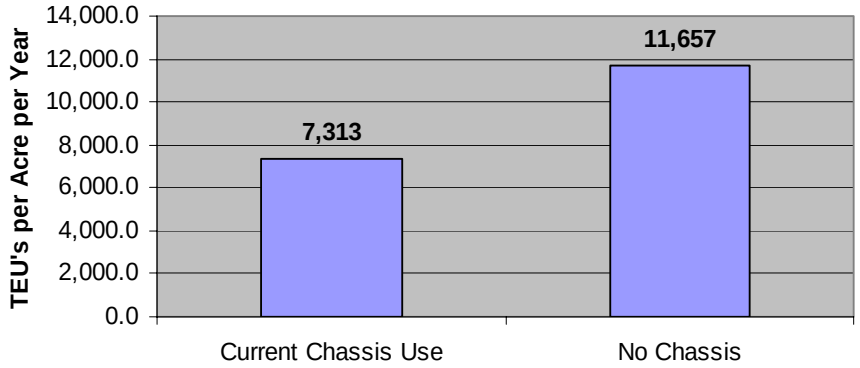
Port	Current Area	Master Plan Area	2004 Throughput	2004 Productivity (TEU's / Acre)	Capacity at 2004 Productivity		Capacity at 6,500 TEU/Ac		Latent Capacity at 6,500 TEU/Ac	
					Current Land	Masterplan Land	Current Land	Masterplan Land	Current Land	Masterplan Land
Vancouver	325	710	1,539,058	4,736	1,539,058	3,362,250	2,112,500	4,615,000	573,442	3,075,942
Seattle	464	464	1,775,858	3,827	1,775,858	1,775,858	3,016,000	3,016,000	1,240,142	1,240,142
Tacoma	456	828	1,127,261	2,472	1,127,261	2,046,869	2,964,000	5,382,000	1,836,739	4,254,739
Portland	200	200	274,609	1,373	274,609	274,609	1,300,000	1,300,000	1,025,391	1,025,391
Oakland	674	764	2,043,122	3,031	2,043,122	2,315,942	4,381,000	4,966,000	2,337,878	2,922,878
Long Beach	1,262	1,885	5,779,852	4,580	5,779,852	8,633,139	8,203,000	12,252,500	2,423,148	6,472,648
Los Angeles	1,477	1,941	7,321,440	4,957	7,321,440	9,621,473	9,600,500	12,616,500	2,279,060	5,295,060
Total	**4,858**	**6,792**	**19,861,200**	**4,088**	**19,861,200**	**27,768,067**	**31,577,000**	**44,148,000**	**11,715,800**	**24,286,800**

Capacity Enhancement Strategy Comparison

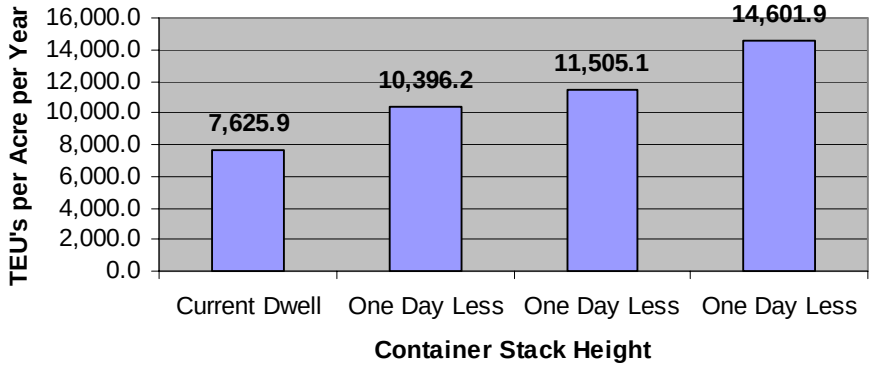
Effect of Stacking Height Alone + 40%



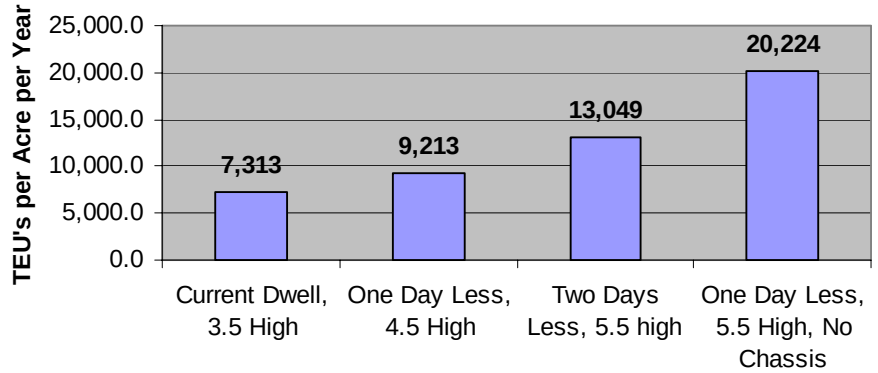
Effect of Chassis + 50%



Effect of Dwell Time Alone + 50-90%



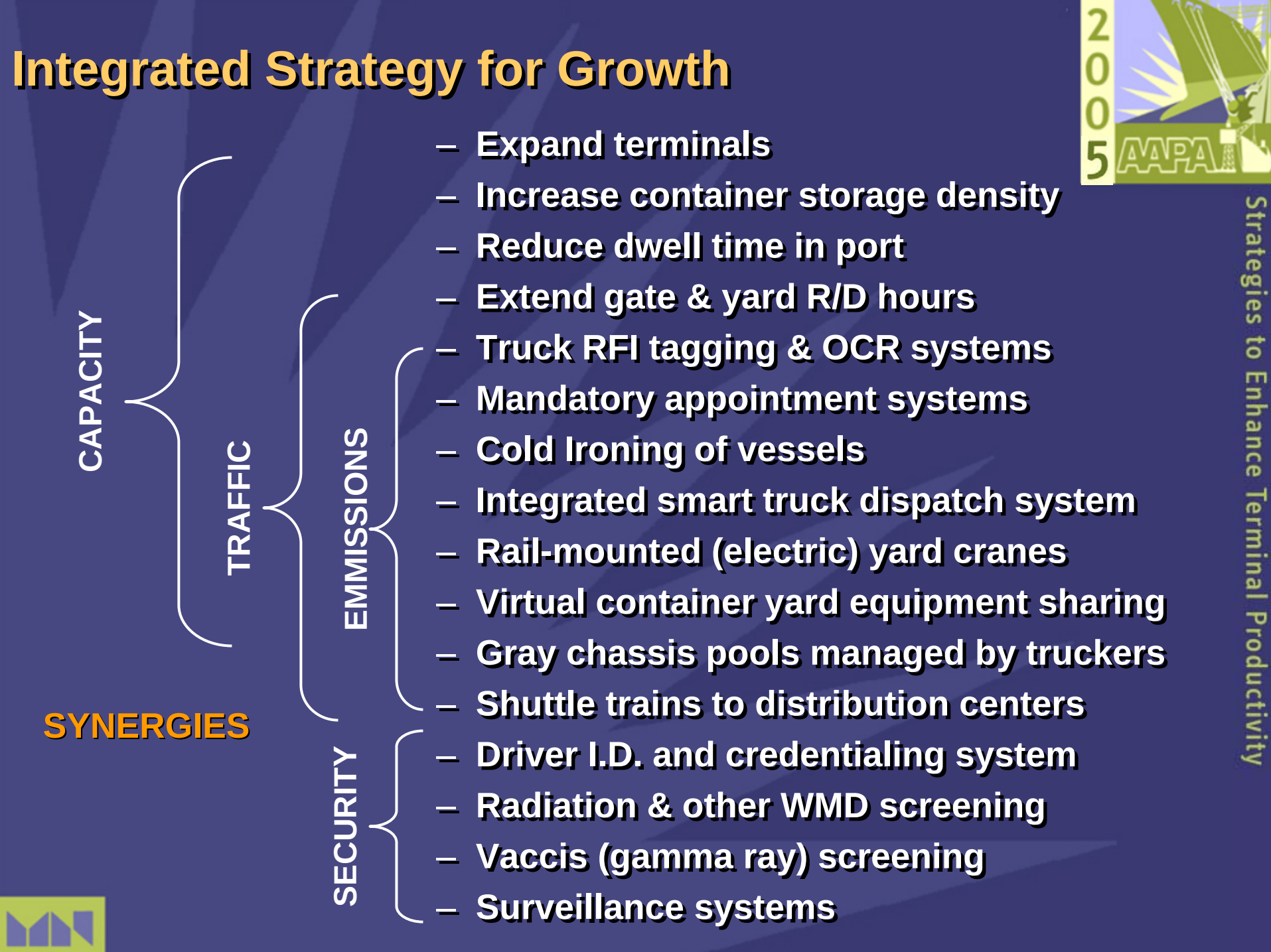
Effect of All + 275%



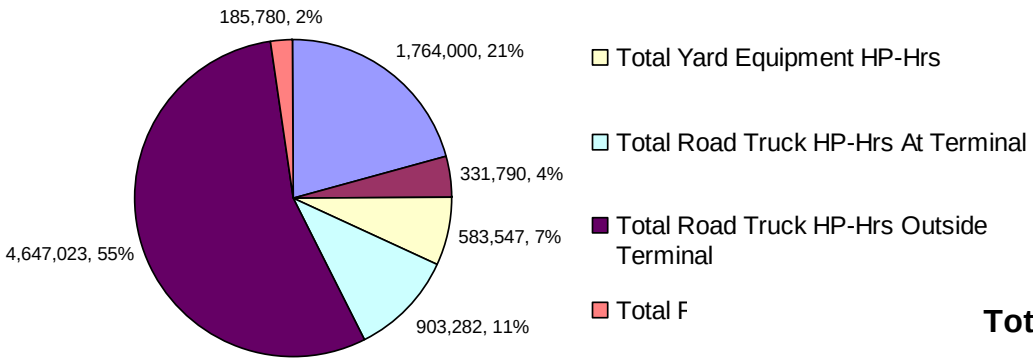
Growth Issues

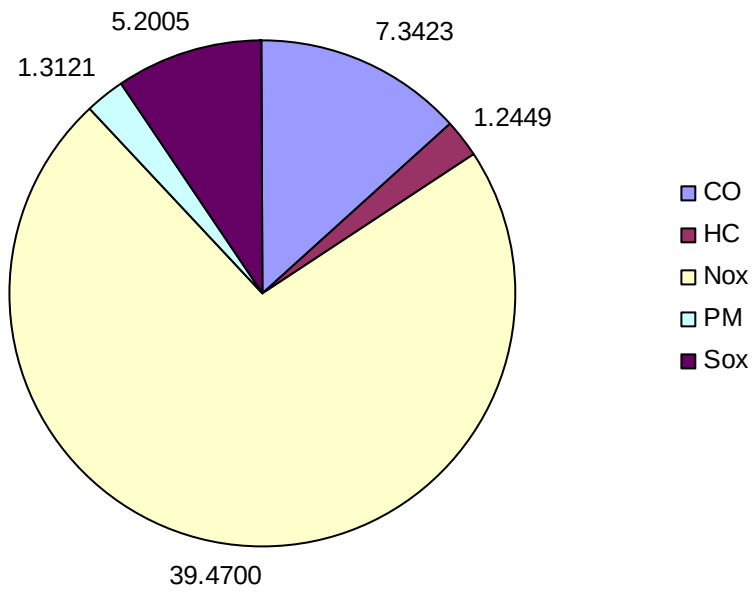
- Growth & Capacity
  - Port
  - Landside Infrastructure
- Labor & Technology
- Impacts
  - Traffic
  - Emissions
- Security

Integrated Strategy for Growth

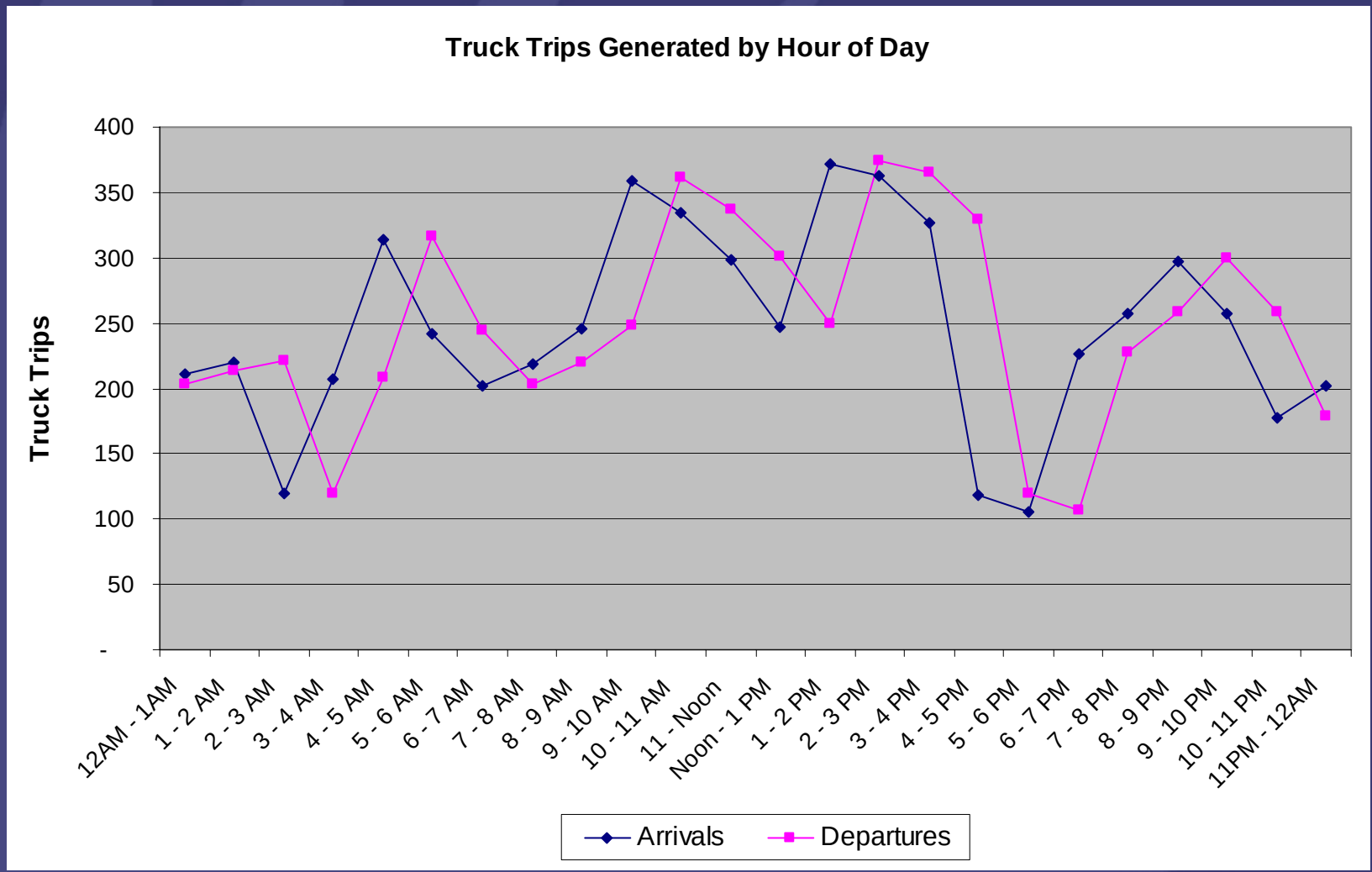


Emissions Modeling





Traffic Generation Modeling



Conclusions

- The “Area / Density / Dwell / Service / Cost” Equation Varies from Port to Port
- The “Best Solution” Varies with Location ***&*** ***Time***
  - Hence Maximum Operational Flexibility is Always Highly Desirable
  - Higher Density Reduces Flexibility

Conclusions

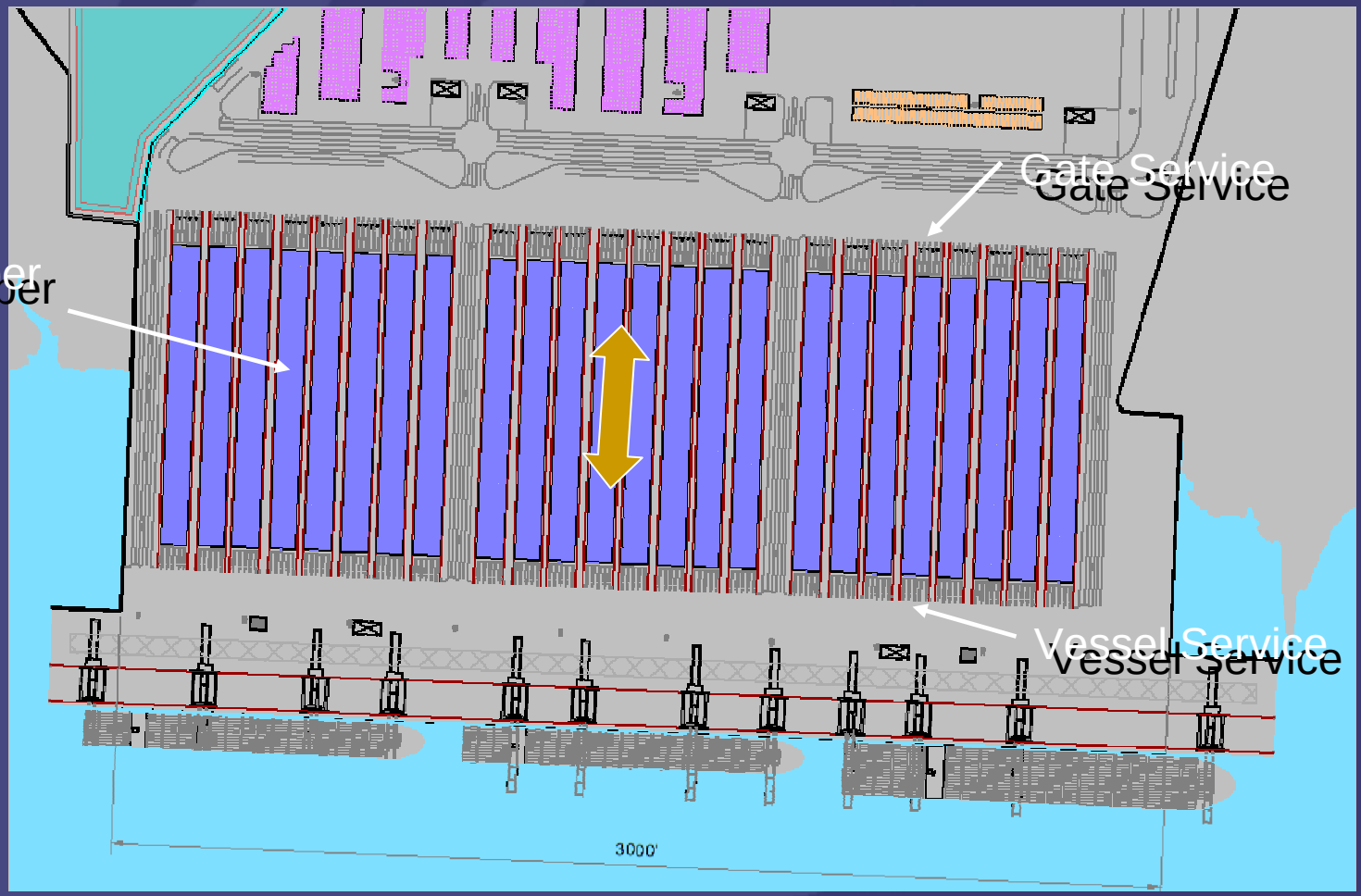
- The Problems Will Not Be Solved by Technology Alone
- An Integrated Approach is Needed
  - Automation Generally Addresses (Labor) Cost Only
  - C.Y. Automation Usually Precludes Operational Flexibility
  - Automation Does Not Currently Co-Exist with Density & Service
  - But Higher Levels of Automation are Required in U.S. Terminals

The U. S. Terminal of the (Near) Future

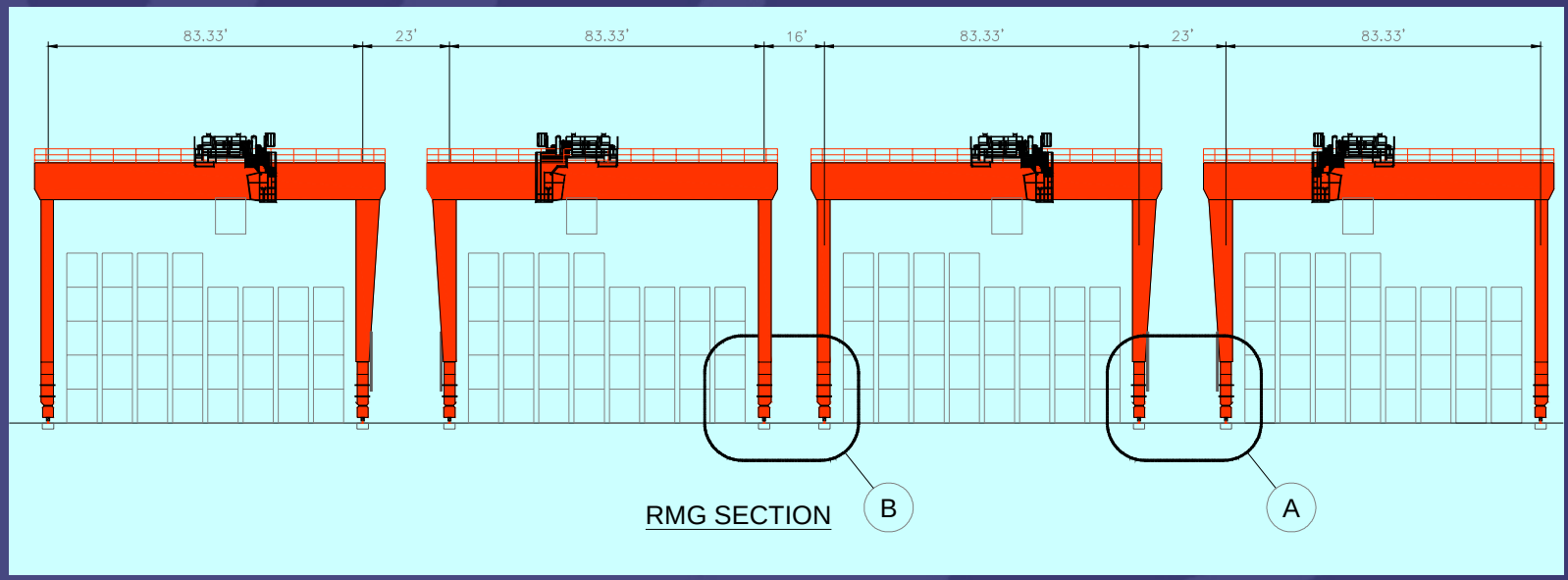
- Virtually all grounded up to 6 high
- Rail-mounted yard cranes (semi-automated)
- Significantly automated gates
  - RF Tagging of tractors & chassis
  - OCR
  - Paperless
- 24 hour “steady-state” terminal operations
  - 50% Day – 35% Night – 15% Hoot
  - R&D, pre-mounting
  - Stack grooming
- Appointment systems
- Integrated truck dispatch system
- Chassis stored outside terminals
- Empty yards / depots off terminal
- All local drivers registered & documented
- Maximum use of on-dock / near-dock intermodal
- Shared local shuttle trains serving distribution centers

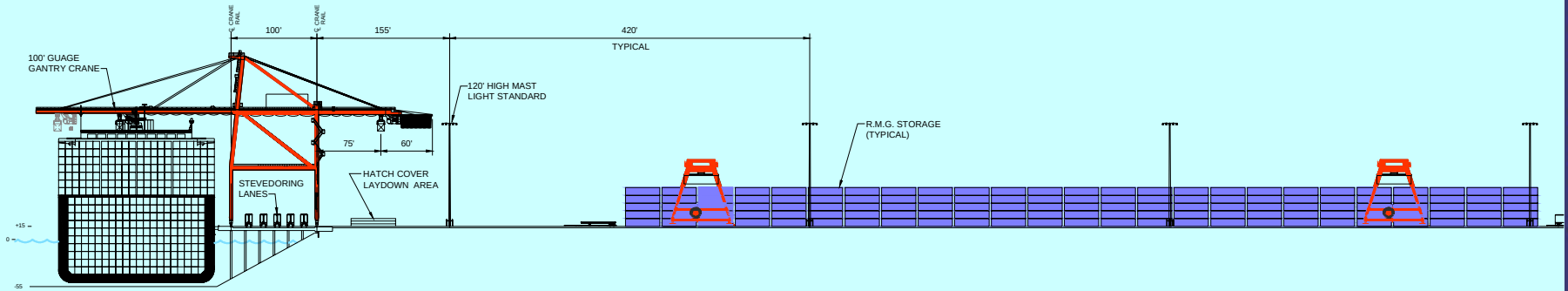
Next Generation U.S. Semi-Automated Terminal

- **Electric Rail Mounted Gantries perpendicular to berth**
  - **Internal stack moves fully automated**
  - **Remote crane operators for vessel / gate service**
- **Dock crane service by bomb carts or strads (shuttle carriers)**



Next Generation U.S. Semi-Automated Terminal

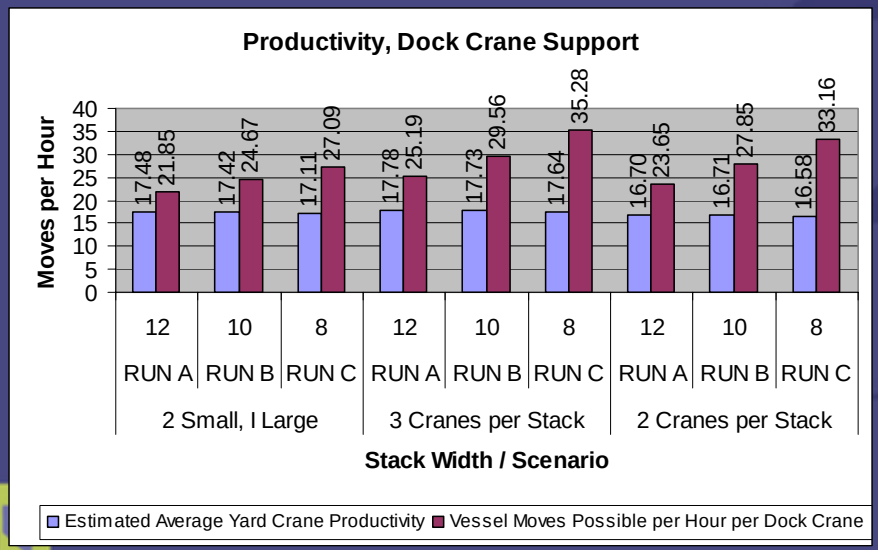


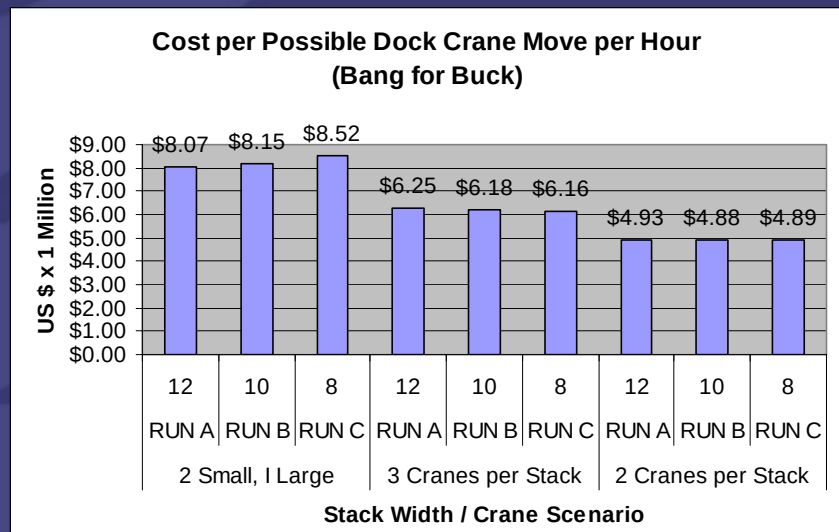


Strategies to Enhance Terminal Productivity

Modeling of Automated Terminals

Crane Configuration per Stack	2 Small, I Large			3 Cranes per Stack			2 Cranes per Stack		
Model Run	RUN A	RUN B	RUN C	RUN A	RUN B	RUN C	RUN A	RUN B	RUN C
Stack Width (Containers)	12	10	8	12	10	8	12	10	8
Cranes per Stack	3			3			2		
Number of stacks/cranes possible across yard	15	17	19	17	20	24	17	20	24
Ratio, yard vessel server cranes to dock cranes	1.25	1.42	1.58	1.42	1.67	2.00	1.42	1.67	2.00
Estimated Average Yard Crane Productivity	17.48	17.42	17.11	17.78	17.73	17.64	16.70	16.71	16.58
Vessel Moves Possible per Hour per Dock Crane	**21.85**	**24.67**	**27.09**	**25.19**	**29.56**	35.28	**23.65**	**27.85**	33.16
Total yard cranes	45	51	57	51	60	72	34	40	48
Hook Density (Static TEU's / Hook)	881	778	696	778	661	551	1,167	992	826
Interior Aisle Width	98	93	125	138	115	96	138	115	96
Stack Length (TEU's)			**52**			**41**			**41**
Stack Length (ft)	939	994	1,112	828	845	880	828	845	880
Feet of Crane Rail Required	68,324	81,194	99,705	34,957	41,789	51,839	34,957	41,789	51,839
Estimated Cost per Yard Crane (mil $)	$2,400,000	$2,350,000	$2,300,000	$2,400,000	$2,350,000	$2,300,000	$2,400,000	$2,350,000	$2,300,000
Total Yard Crane Cost (Mil $)	$108.00	$119.85	$131.10	$122.40	$141.00	$165.60	$81.60	$94.00	$110.40
Estimated Cost of Crane Rails (Mil $)	$68.32	$81.19	$99.71	$34.96	$41.79	$51.84	$34.96	$41.79	$51.84
Total Cost of Yard Cranes & Crane Rails (Mil $)	$176.32	$201.04	$230.81	$157.36	$182.79	$217.44	$116.56	$135.79	$162.24
Cost per Possible Vessel Move per Hour (Mil $)	$8.07	$8.15	$8.52	$6.25	$6.18	$6.16	$4.93	$4.88	$4.89
Net Stack Area (acres)	79.63	83.18	90.76	72.52	73.58	75.85	72.52	73.58	75.85
Net CY Density (TEU/Ac)	498.2	476.9	437.1	547.0	539.1	523.0	547.0	539.1	523.0





Strategies to Enhance Terminal Productivity

Conclusions

- Smarter People: Ports & Terminal Operators
- Understanding: We Must Understand the Problems to Craft the Solutions
- Smarter Ports & Terminal Facilities
- Prudent, Incremental Application of Technologies
- Reasonable Cooperation of Labor
- Environmentally Responsible

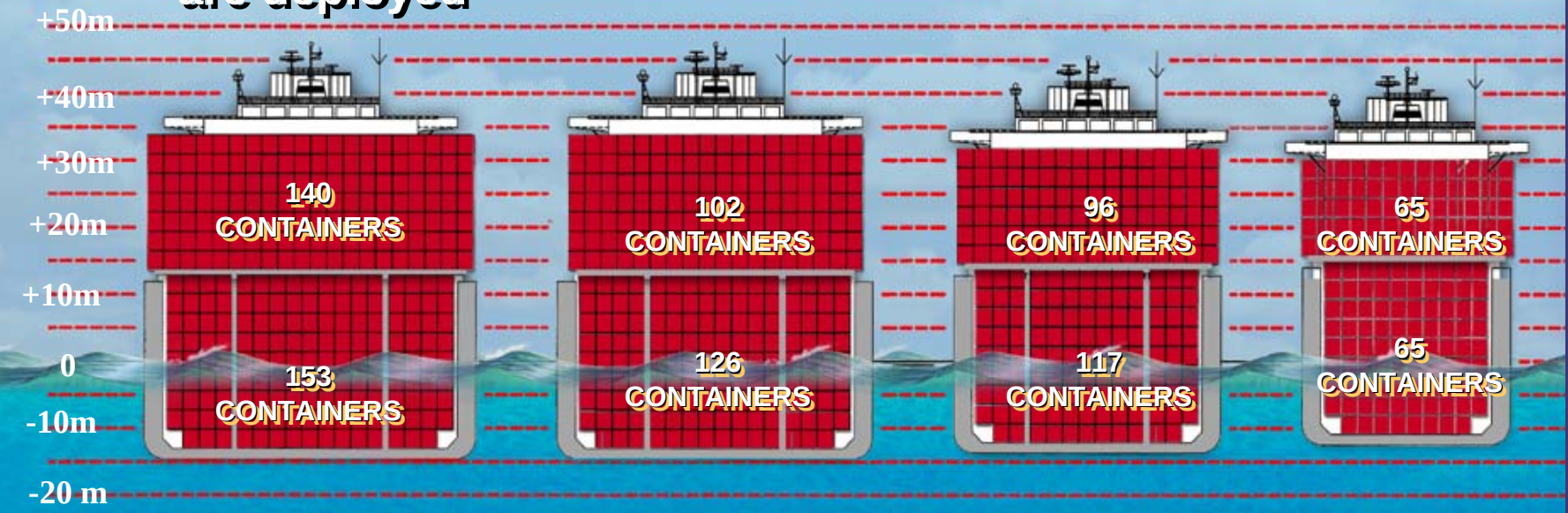
"Good judgment comes for experience and a lot of that comes from bad judgment."

Will Rogers

thank you!

10,000 TEU Vessels

- **Since only one crane per hatch can be deployed, Minimum port time is increased, no matter how many cranes are deployed**



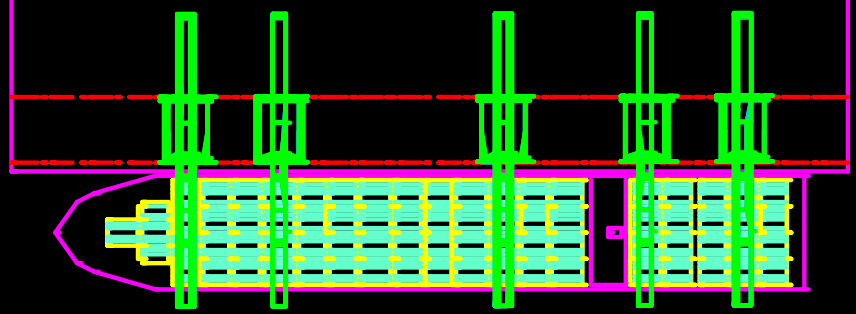
"SUEZ CLASS"	"SUPER POST-PANAMAX"	"POST-PANAMAX"	"PANAMAX"
20 WIDE	17 WIDE	16 WIDE	13 WIDE
10,000 – 12,000 TEU	7,000 TEU	5,500 TEU	4,000 TEU
293 CONTAINERS	220 CONTAINERS	213 CONTAINERS	130 CONTAINERS
22 HOURS @ 27 LPH	16 HOURS @ 27 LPH	16 HOURS @ 27 LPH	10 HOURS @ 27 LPH

Strategies to Enhance Terminal Productivity

10,000 TEU Vessels

West Coast
10,000 TEU Vessel
Discharge/Load 85% of Cap.
9,700 Moves per Call
22-24 Hatch Positions

Conventional Berth
4 - 5 Cranes
@ 27 Moves / Hour
80 Productive Hours, Min. Req.
4 - 5 Days in Port
1,000 Container Initial Discharge
Yard Crane Density 1:850 TEU



Indented Berth
8 - 10 Cranes
@ 27 Moves / Hour
40 Productive Hours, Min. Req.
2 - 2.5 Days in Port
2,000 Container Initial Discharge
Yard Crane Density 1:650 TEU