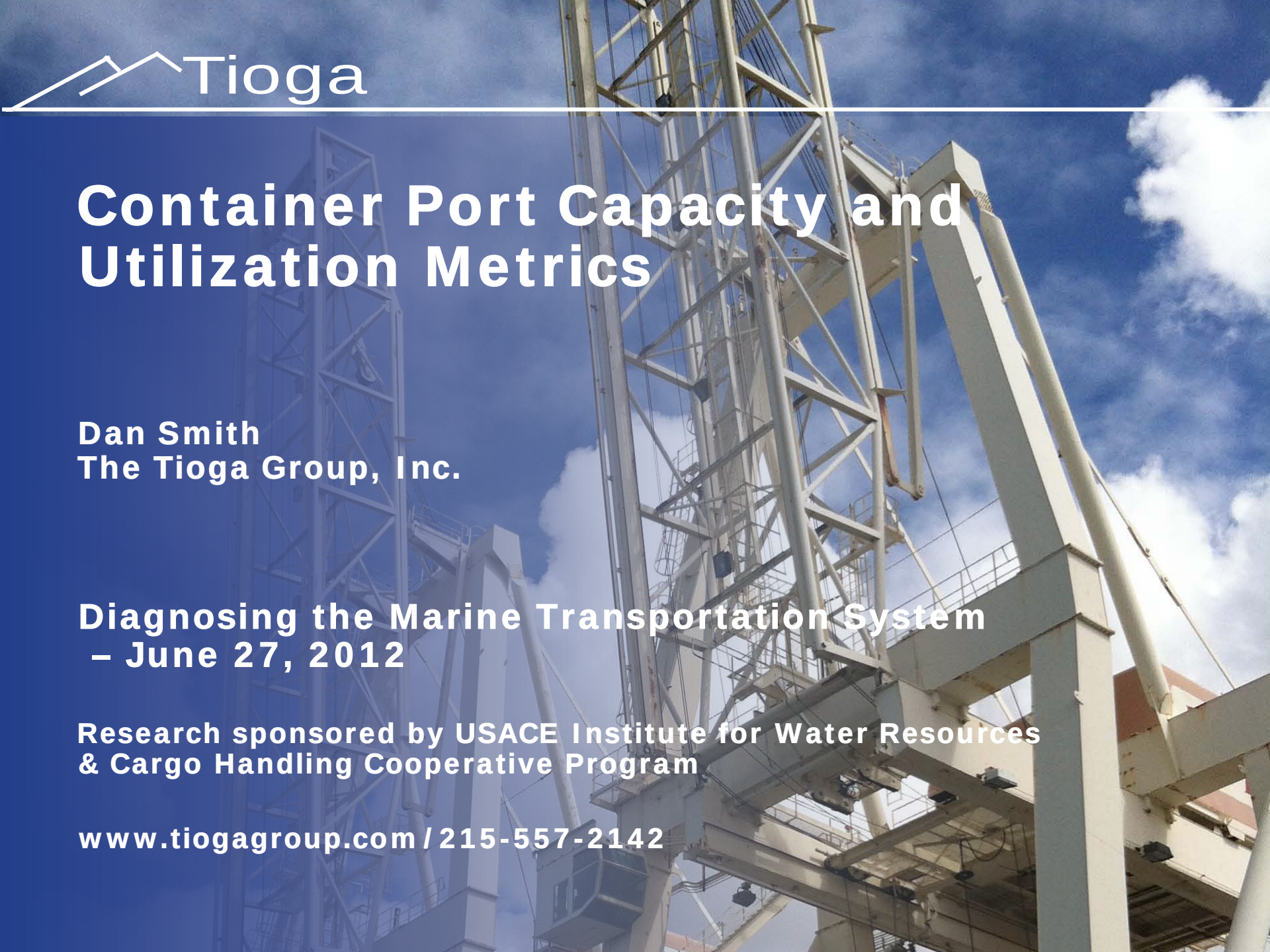

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Container Port Capacity and Utilization Metrics

Dan Smith
The Tioga Group, Inc.

Diagnosing the Marine Transportation System – June 27, 2012

Research sponsored by USACE Institute for Water Resources & Cargo Handling Cooperative Program

www.tiogagroup.com / 215-557-2142

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Key questions

- How do we measure port capacity?
- How do we measure utilization and productivity?
- What do the metrics mean for port development?

Answers

- Port capacity is a function of draft, berth length, CY acreage, CY density, and operating hours
- Most U.S. ports are operating at well below their inherent capacity
- Individual ports and terminals face specific capacity bottlenecks, especially draft

Available Data and Metrics

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What can we do with publicly available data?

- Infrastructure and operating measures are accessible
- Labor and financial measures are not

Available Port Data	Yield	Available Port Metrics	
Always		**Land Use**	
Channel & Berth Depth		TEU/Gross Acre	Gross/Net CY Acres
Berth Length		TEU Slots/CY Acre (Density)	Net/Gross Ratio
Berths		TEU Slots/Gross Acre	CY Utilization
Cranes & Types		TEU/Slot (Turns)	Moves/Container
Gross Acres		TEU/CY Acre	Avg. Dwell Time
Port TEU		**Crane Use**	
Avg. Vessel TEU		Number of Cranes	Avg./Max Moves per hour
Vessel Calls		TEU/Crane	TEU/Available Crane Hour
Sometimes		Vessel Calls/Crane	TEU/Working Crane Hour
Avg. Crane Moves/hr		Crane Utilization	TEU/Man-Hour
CY & Rail Acres		**Berth Use**	
TEU Slots		Number of Berths	Max Vessel DWT and TEU
Estimated		Length of Berths	TEU/Vessel TEU
Max Vessel TEU		Depth of Berth & Channel	Vessel TEU/Max Vessel TEU
Confidential		TEU/Berth	Berth Utilization - TEU
Costs		Vessels/Berth	Berth Utilization - Vessels
Man-hours		**Balance & Tradeoffs**	
Vessel Turn Time		Cranes/Berth	Net Acres/Berth
Rates		Gross Acres/Berth	Cost/TEU
Avg. Dwell Time		CY Acres/Berth	Man-Hours/TEU
Working Crane Hours		CY Acres/Crane	Man-Hours/Vessel

TEU per Acre is a Misleading Metric

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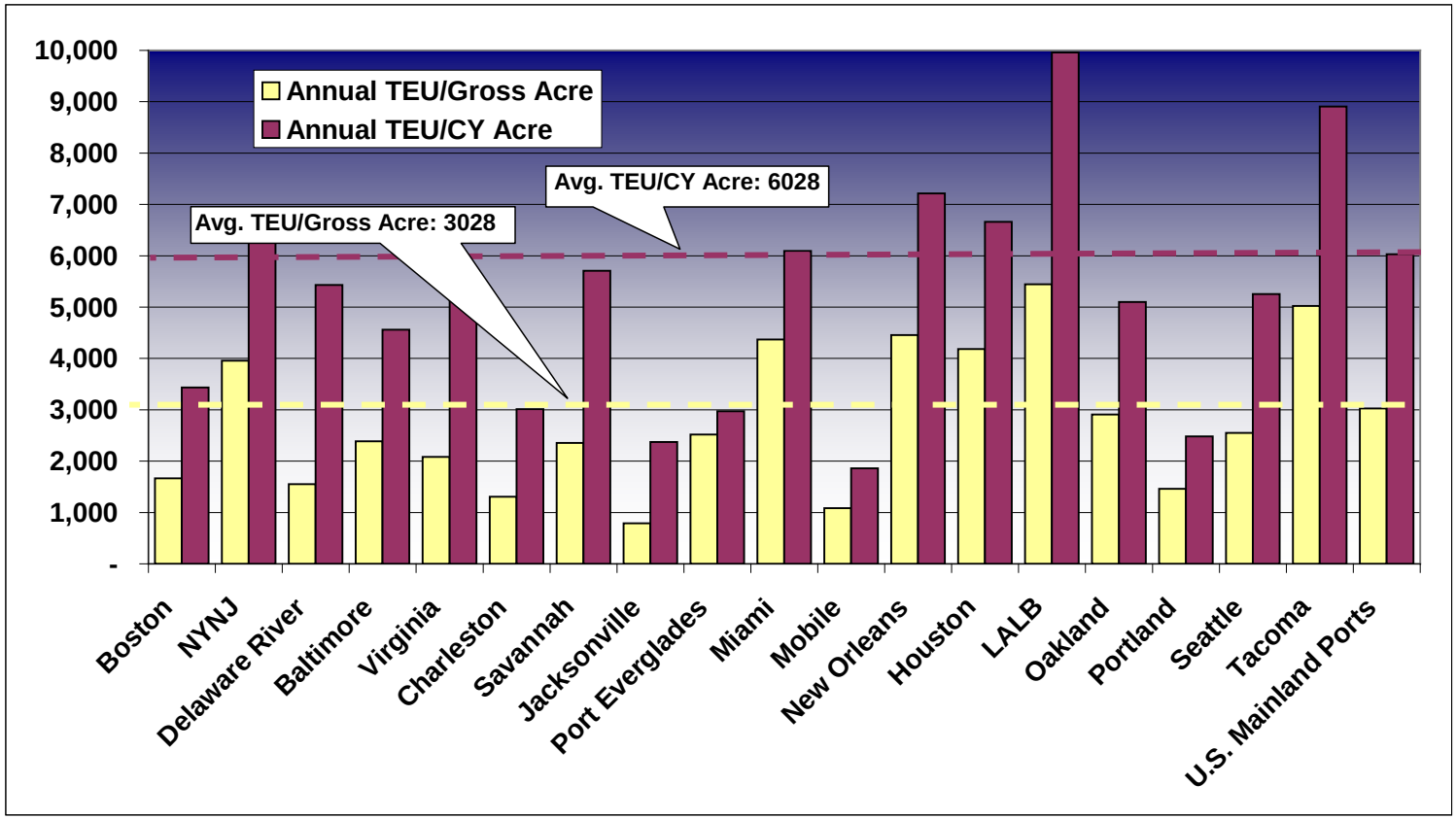
U.S. (and foreign) terminals vary greatly in their land use patterns – land is the cheapest U.S. input

- Low TEU/acre = excess capacity or low-cost, low-density operations
- High TEU/acre = tight capacity or higher-cost operations



Container Terminal Capacity Dimensions

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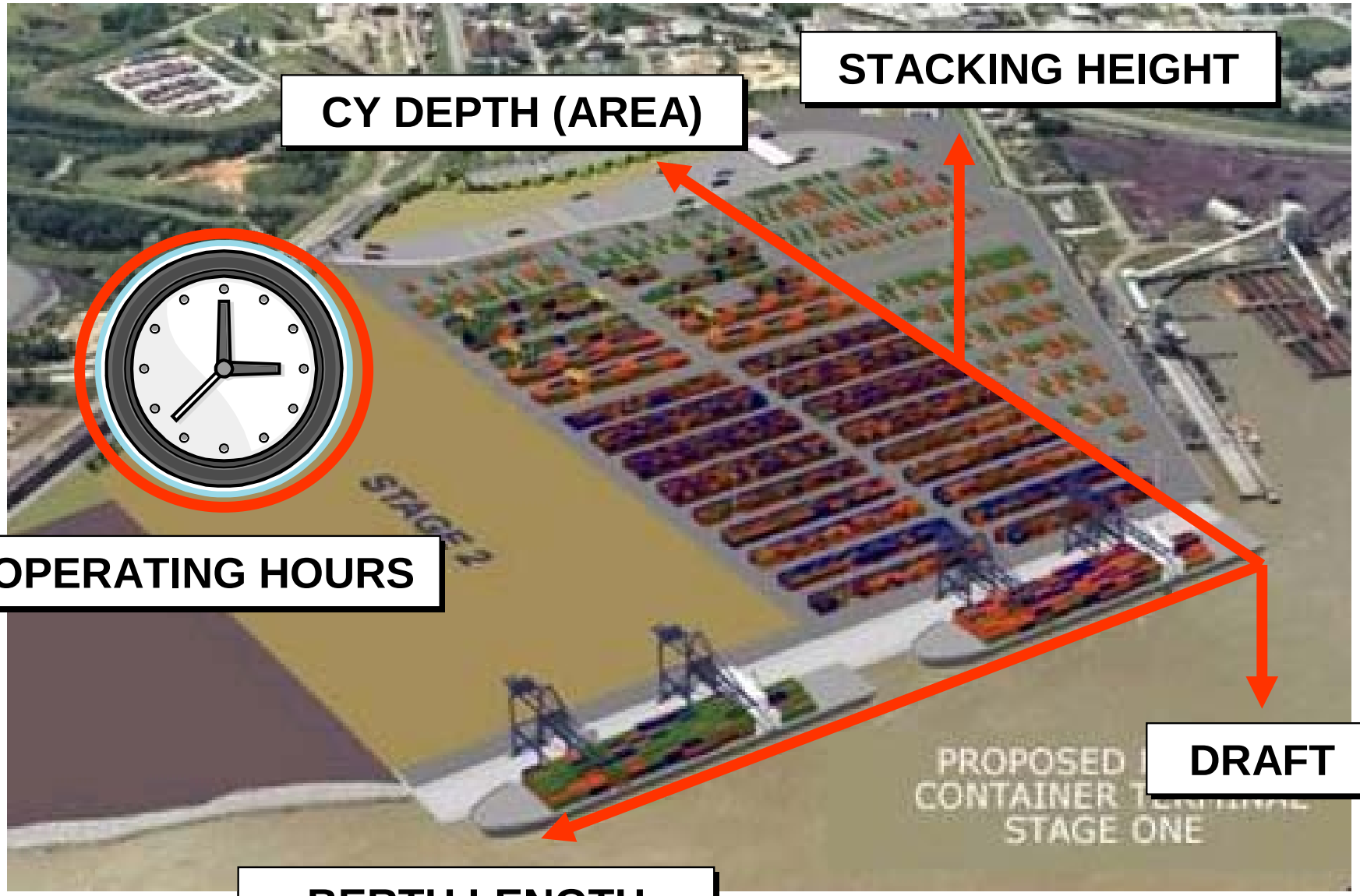

Marine Container Terminal Characteristics

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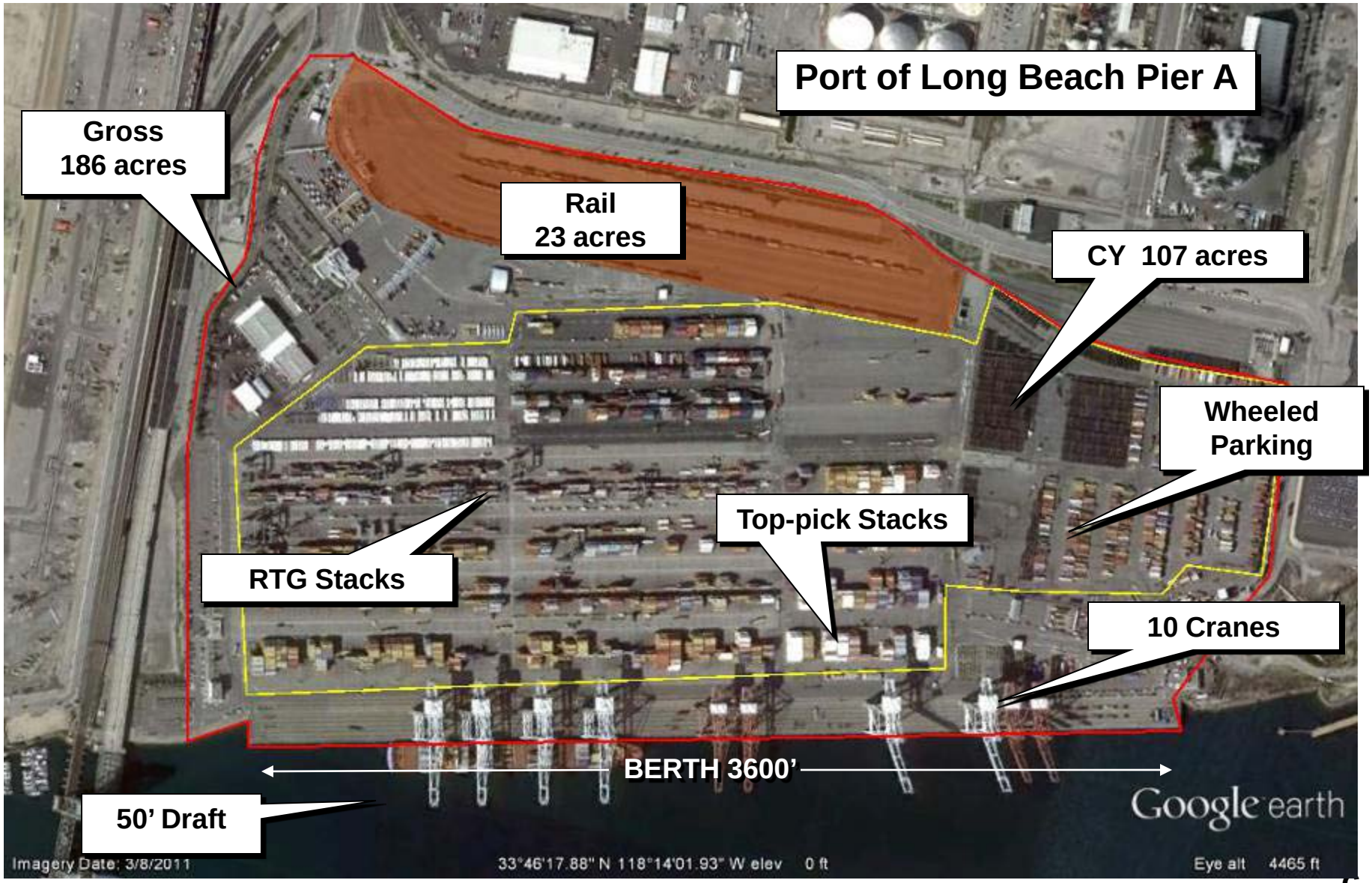

Container Terminal Profiles

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- Tioga completed profiles for each U.S. container terminal
- The main info sources were port and terminal websites
- *Sources do not always agree, and conditions can change quickly*

CONTAINER TERMINAL PROFILE			
Profle date:	Sept. 27, 2009	**2010 TEU:**	610,918
Port:	Maryland	**Total Acres:**	256
Terminal:	**Seagirt Marine, Baltimore**	**CY Acres:**	134
Terminal Type:	Container Terminal	**On-Dock Rail Acres:**	66
Address:	2600 Broening Highway Baltimore, MD 21224	**Other Non-CY Acres:** **Net Terminal Acres:**	56 190
Operator (Stevedore):	Ports America (410-288-8602)	**Berths:**	3
Contact Name:		**Total Berth Length:**	3,127
Telephone Number:	410-288-8602	**Channel Depth (MLLW):**	50
Fax Number:	410-288-8649	**Berth Depth (MLLW):**	42
E-Mail Address:		**Panamax Container Cranes:**	
Port Website:	www.marylandports.com	**Post-Panamax Container Cranes:**	7
Terminal Website:	www.portsamerica.com	**CY Rail-Mounted Gantries:**	
Inbound Gates:	9	**CY Rubber-Tired Gantries:**	12
Outbound Gates:	5	**CY Side or Top Loaders:**	
Reversible Gates:		**CY Straddle Carriers:**	
Total Gates:	14	**CY Reach Stackers:**	
On-Line Access System:	eModal & Navis	**Total CY Lift Machines**	12
Appointment System:	no	**On-site M&R (yes/no):**	no
Reefer Plugs/Slots:	192	**On-dock Rail (yes/no):**	yes
Terminal Hours:	Mon – Fri 0700-1700		
Gate Hours:			
Notes: Seagirt near dock terminal operated by CSX is contiguous to the marine terminal, Norfolk Southern Baltimore terminal is 3-4 miles from the Port. Dundalk and Seagirt terminals are connected by an internal connector bridge.			

Critical Assumptions

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Assumptions and rules of thumb

- Maximum annual TEU slot turnover = 70 turns (5 day dwell, 350 days/yr)
- Crane available 16 hours/day (two shifts), 250 days/yr
- Modern crane maximum = 35 moves/hr
- Vessel spacing at berth = vessel beam
- Maximum of 260 annual calls per berth (5 per week)
- Working draft = channel/berth draft – 3 feet
- Maximum vessel sailing draft = 92% of design draft
- **Sustainable capacity = 80% of maximum capacity**

Example:

- **7 cranes** @ max of 4,000 hrs/yr = 28,000 crane hours
- 80% = 22,400 sustainable crane hours
- Maximum crane productivity of 35 containers per hour
- 80% = 28 cont./hr x 1.54 TEU/container = 43 TEU/hr
- Sustainable crane capacity = 43x22,400 = **965,888 TEU/yr**

Terminal Handling Methods

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Container yard capacity depends on acreage and storage density

- Lower storage densities usually mean less handling and lower cost
- Terminal designers and managers increase density to accommodate rising volume

DENSITY	TYPE	COMMENT
VERY LOW DENSITY 80 TEU/acre	Ro/Ro or Ship's Gear Wheeled Combination Dedicated Wheeled	Very small, barge, specialized Small, mixed, legacy Older terminals when new
LOW DENSITY 80 TEU/acre	Wheeled/Top-pick Top-pick/Wheeled	Transition terminals
MID DENSITY 100-200 TEU/acre	Straddle/Top-pick/Wheeled RTG/Top-pick/Wheeled	"Hybrid" terminal Dominant "hybrid" type
HIGH DENSITY 160-300 TEU/acre	Straddle Carrier RTG	NIT Virginia, Maher NYNJ No US example
VERY HIGH DENSITY 360 TEU/acre	RMG	APM Portsmouth

Container Yard Handling Equipment

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TOP-PICK EMPTY HANDLER

REACH STACKER

SIDE LOADER

STRADDLE CARRIER

RUBBER-TIRED GANTRY (RTG)

RAIL-MOUNTED GANTRY (RMG)

Daily Operations vs. Terminal Design

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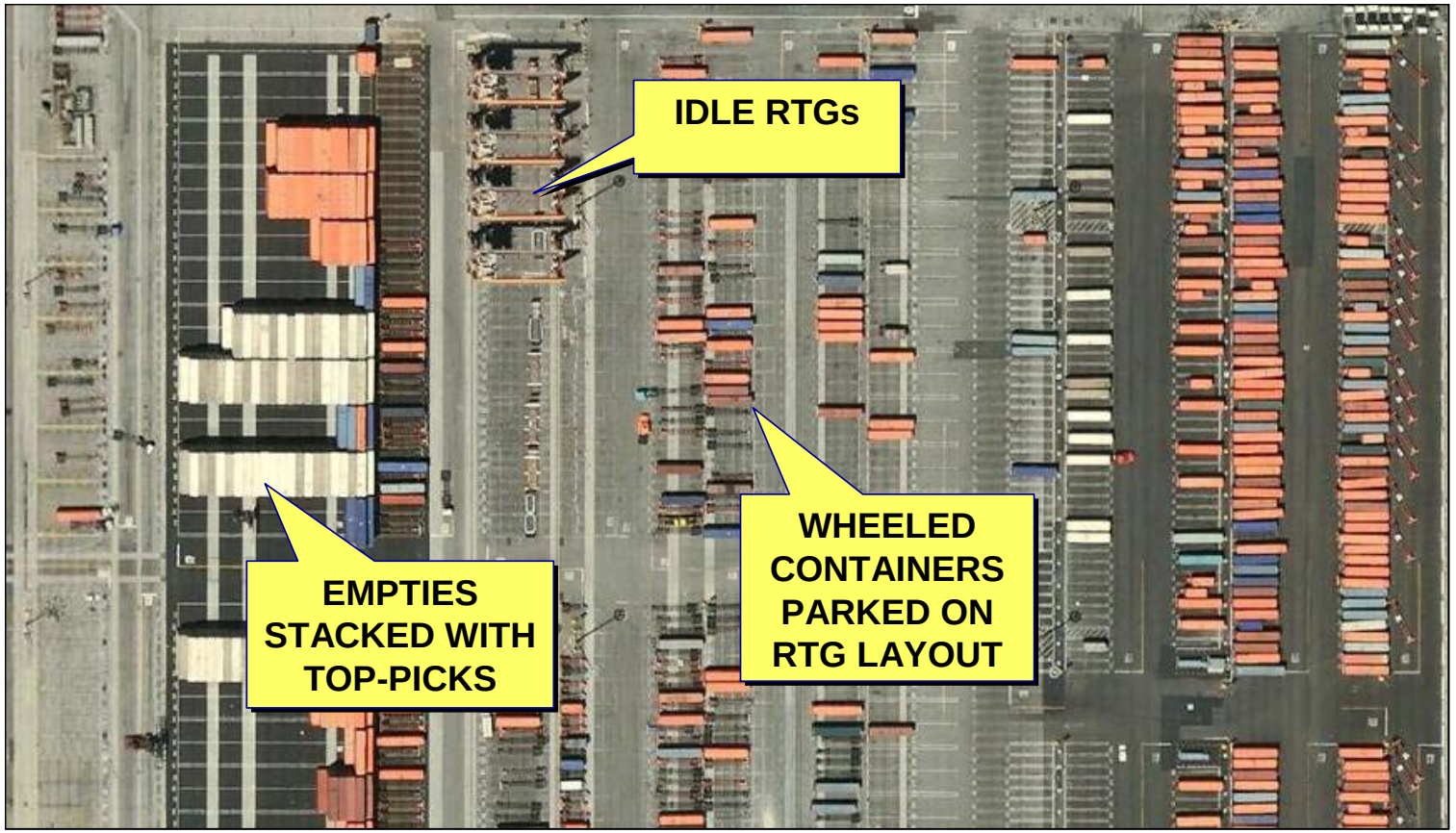
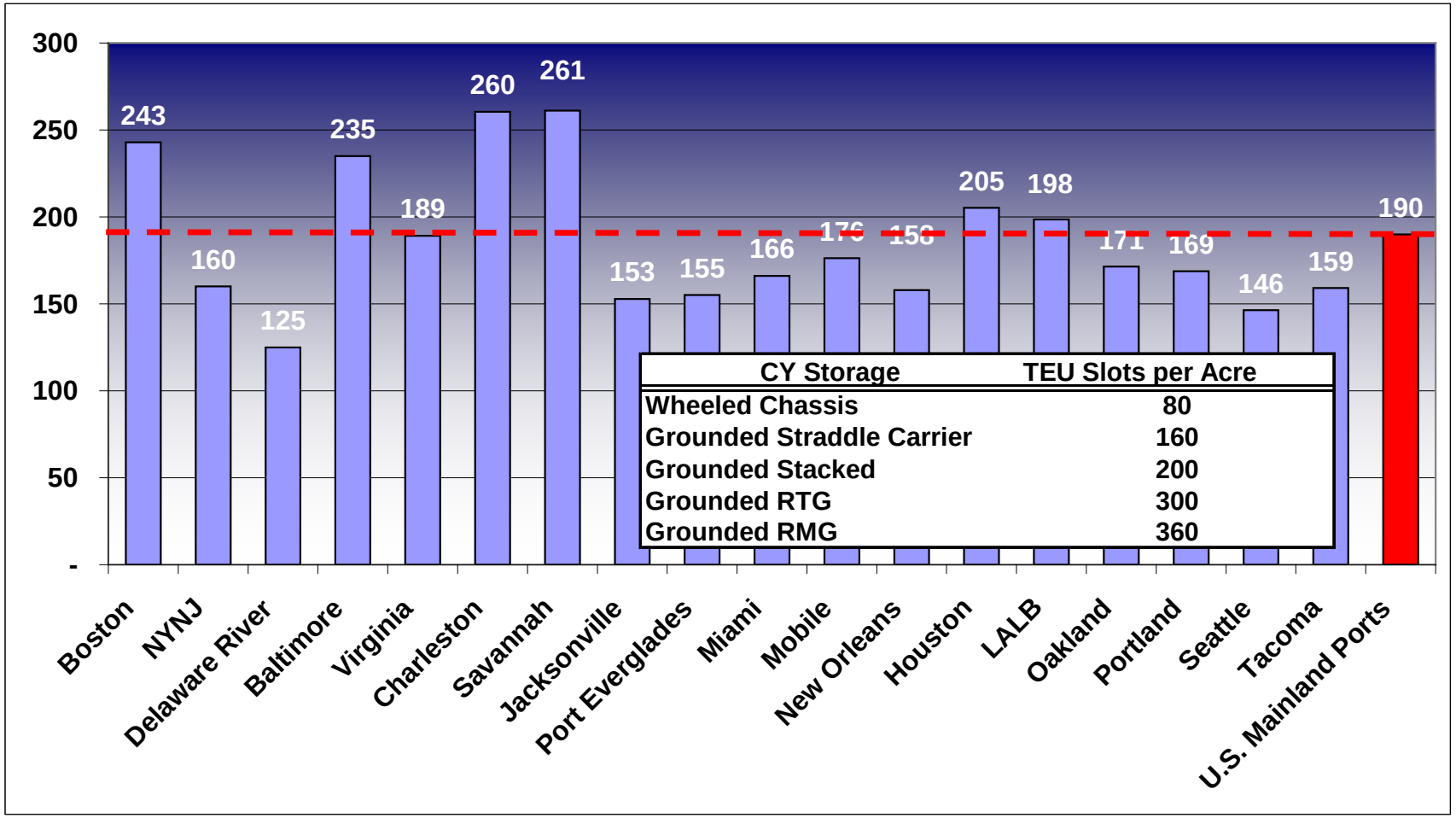
- Terminal managers adjust operations to minimize cost at each volume
- Terminals revert to wheeled operations where possible when business is slow (e.g. 2009)



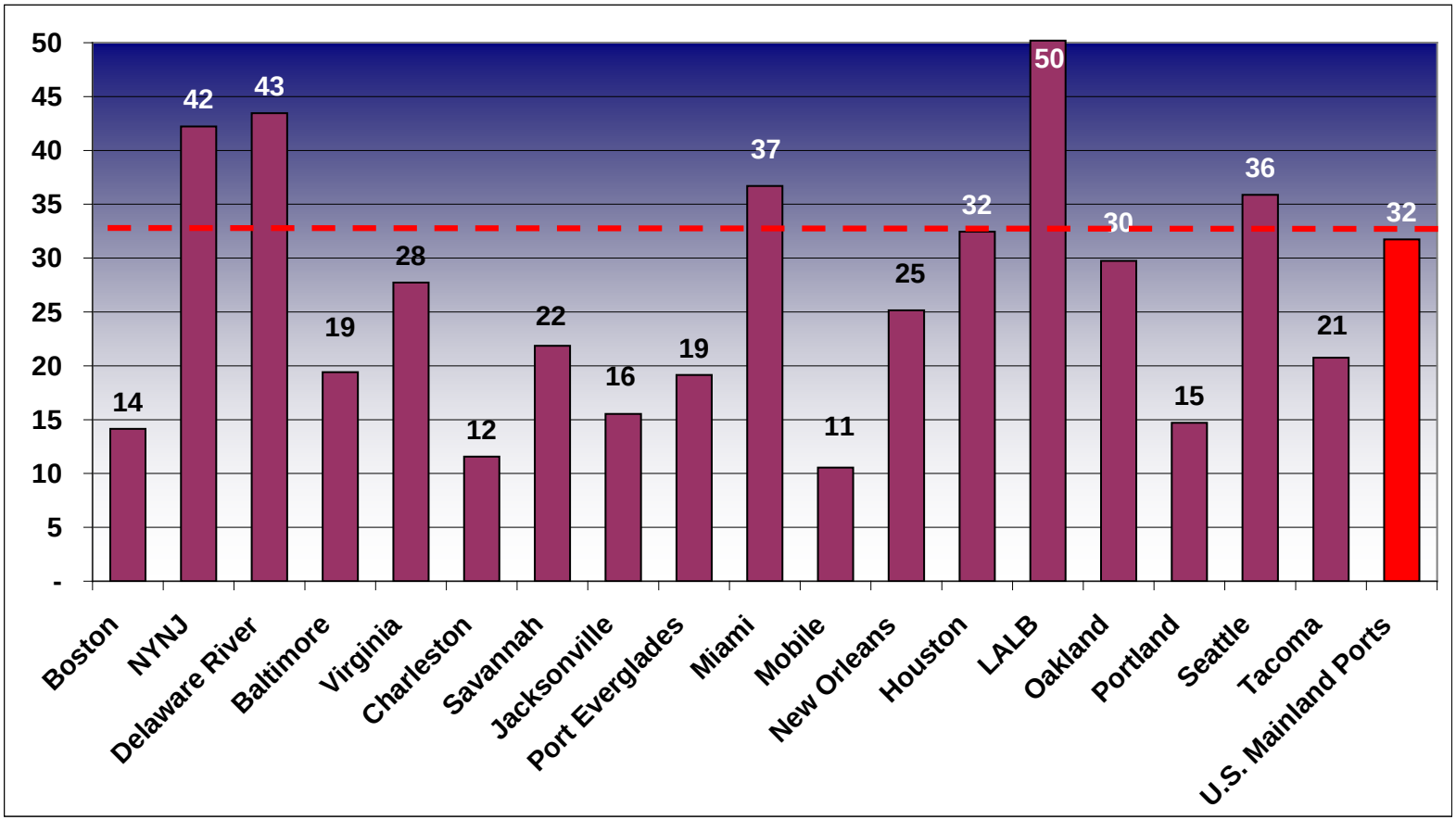
Average TEU Slots per CY Acre

- U.S. ports average about 190 TEU slots per CY acre
- Averages are due to port and terminal storage type mixes



Average Annual Slot Turns

- On average, U.S. ports turn over CY slots 32 times annually
- Ports with more reserve CY capacity have lower turnovers – tighter CYs have higher averages



2010 TEU and CY TEU Capacity

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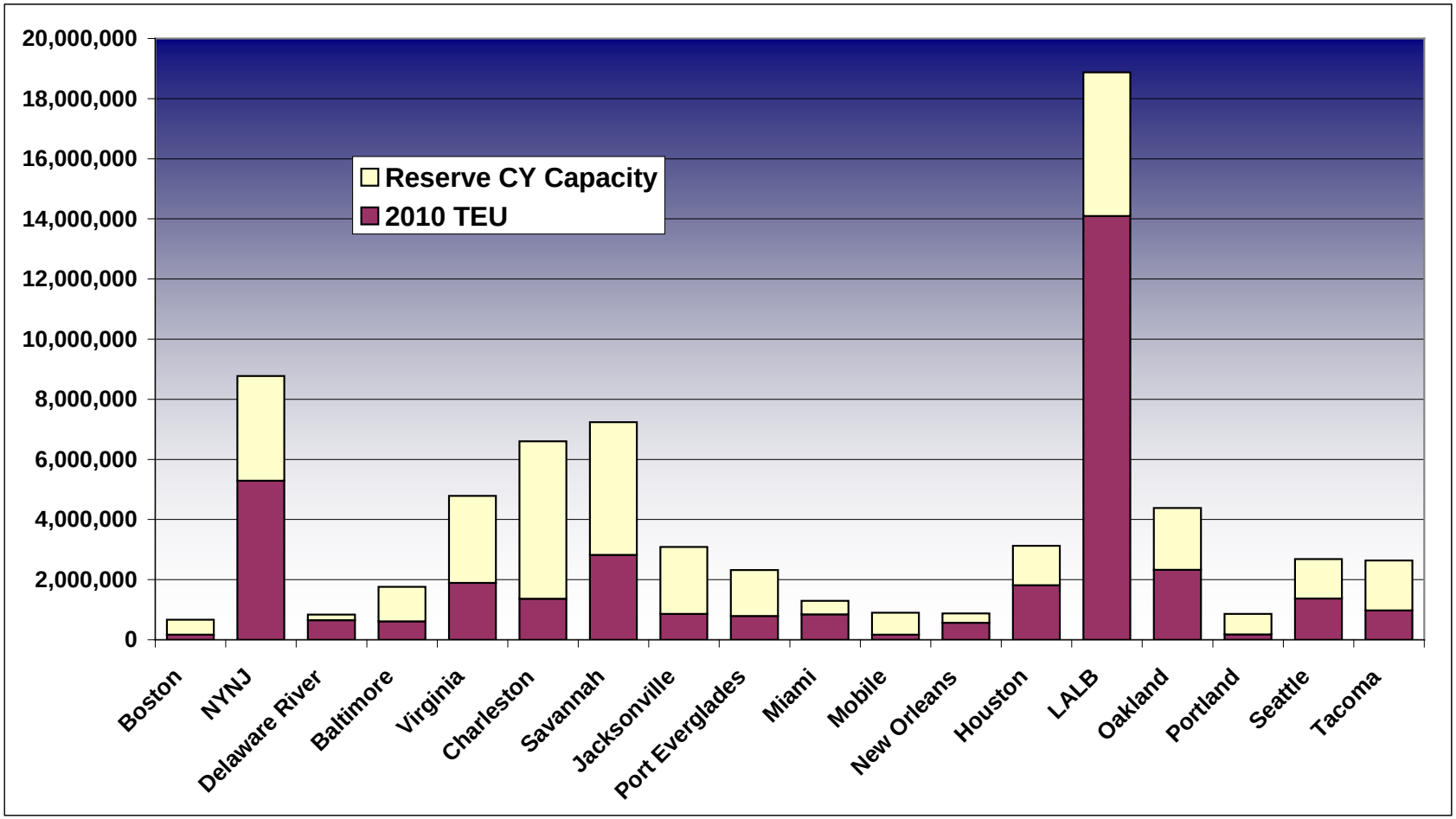
With existing terminal layouts and handling densities, U.S. container ports have substantial reserve CY capacity



Crane Utilization

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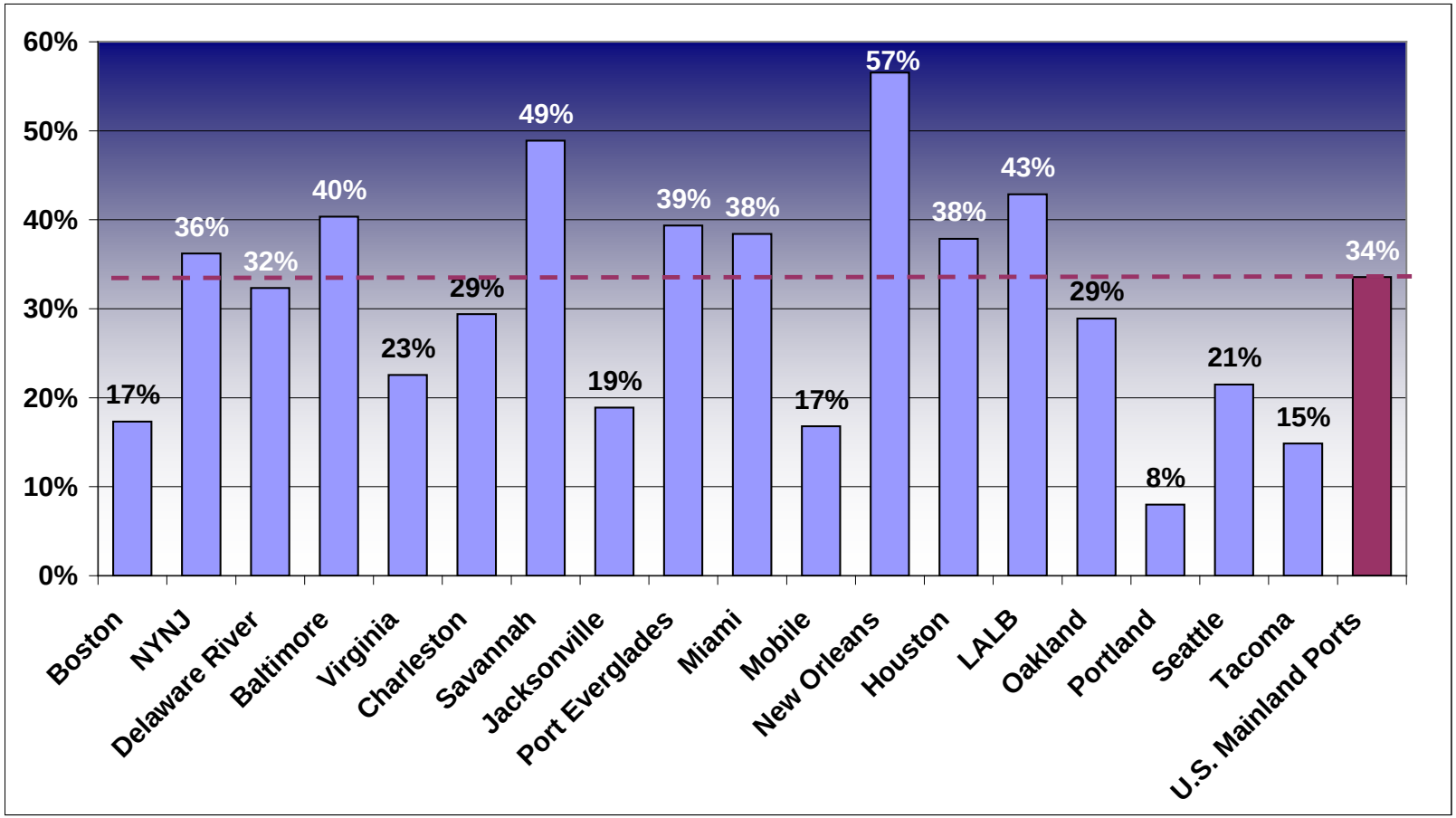
Crane utilization is sacrificed to turn vessels quickly

- Cranes are much cheaper than vessels
- Ports can add cranes relatively quickly



Annual Vessel Capacity

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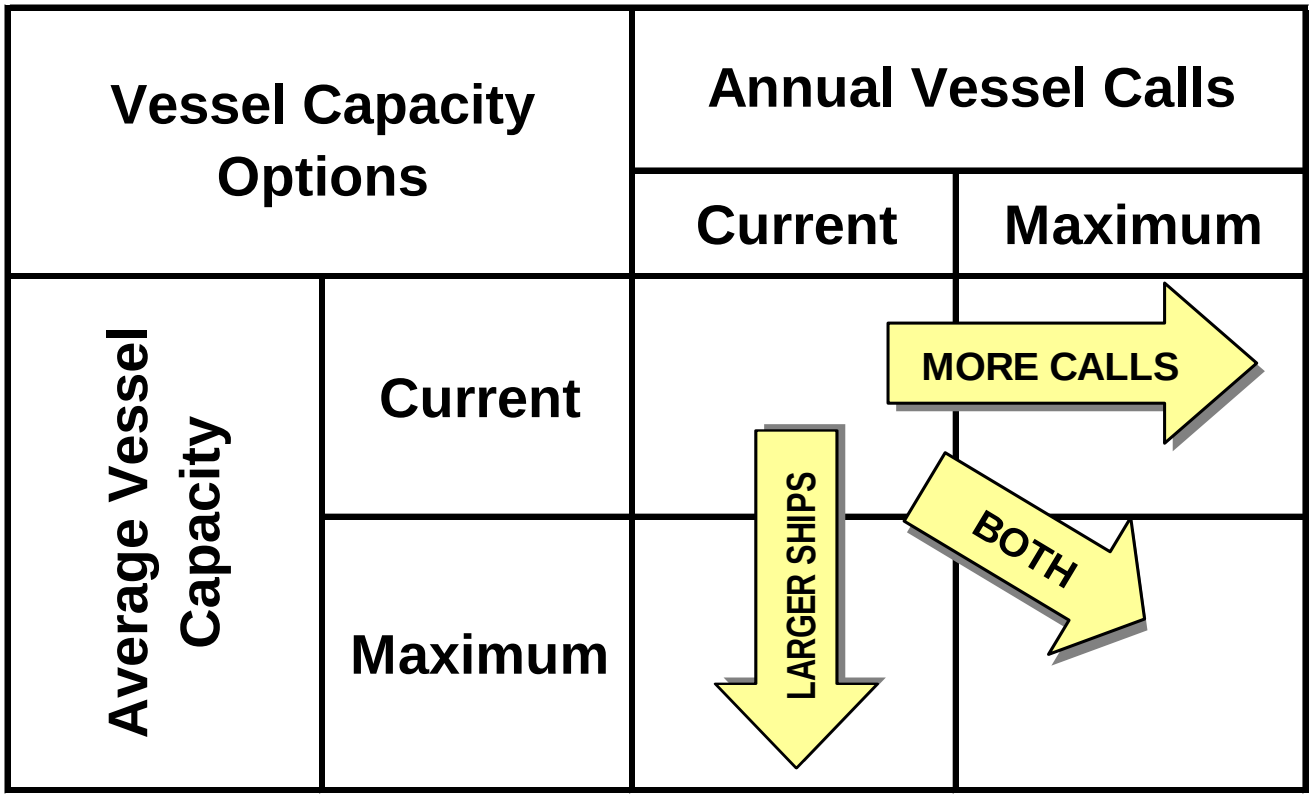
Aggregate vessel capacity is a function of vessel size and service frequency

- Vessel Size is limited by draft (and berth length)
- Vessel call frequency is determined by the number of carrier services (most services are weekly)



Vessel TEU vs. Design Draft

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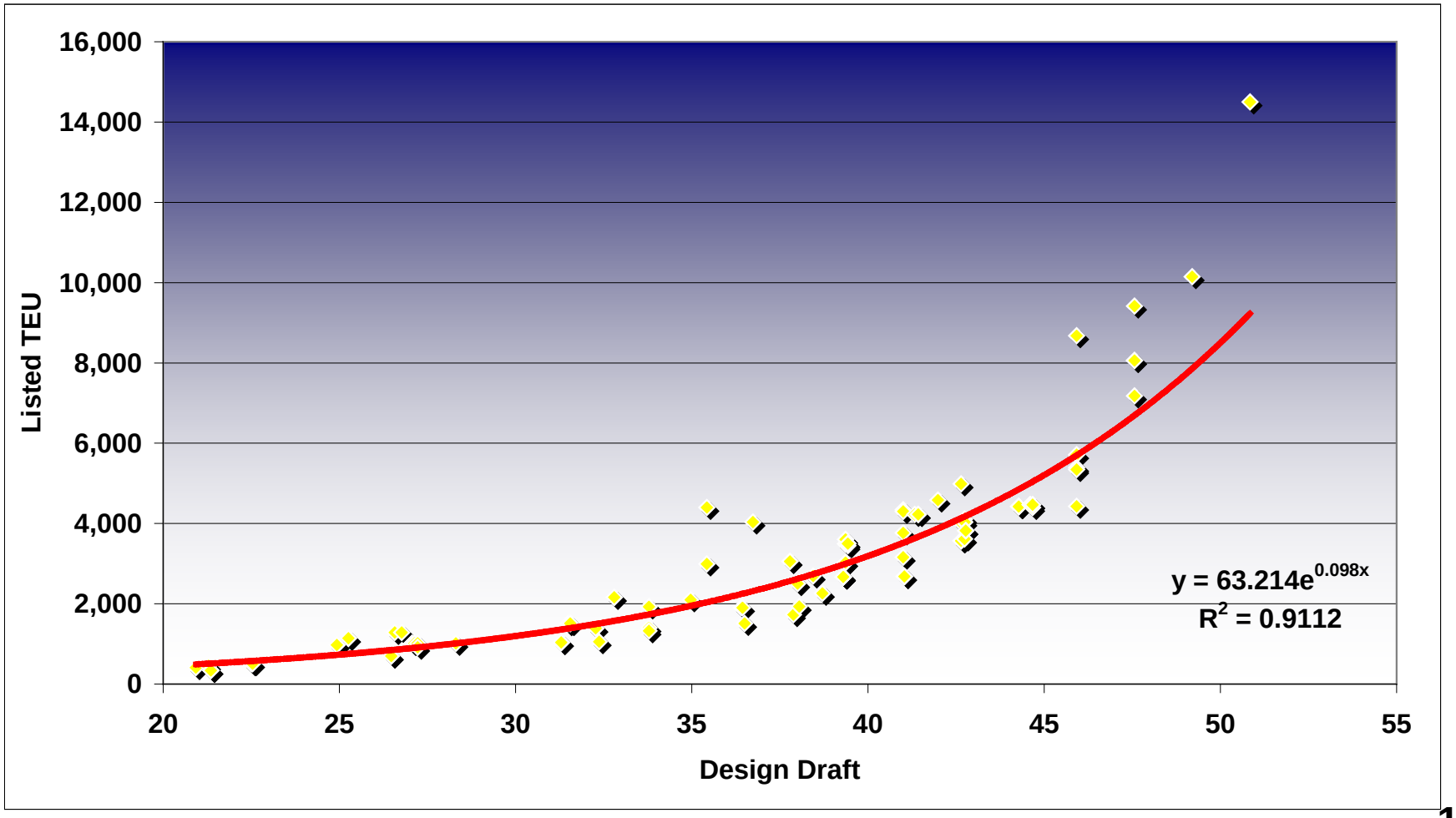
Recent “mega-ship” designs depart from past practice by limiting draft to 50-51 feet



Vessel Draft and Capacity Estimates

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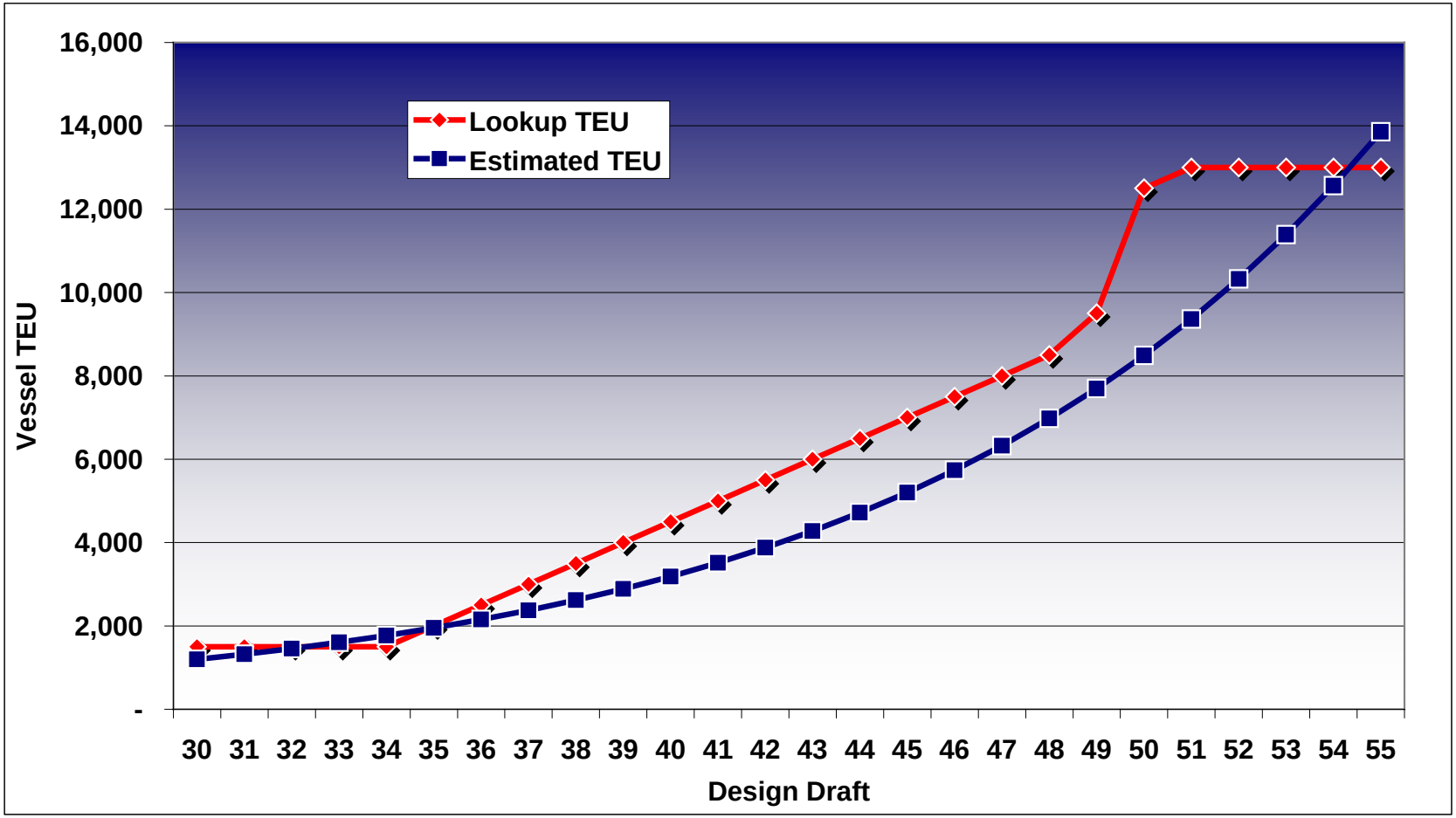
Vessel capacity estimates use a modified TEU/Draft relationship to account for emerging design practice



Maximum vs. Average Vessel Capacity

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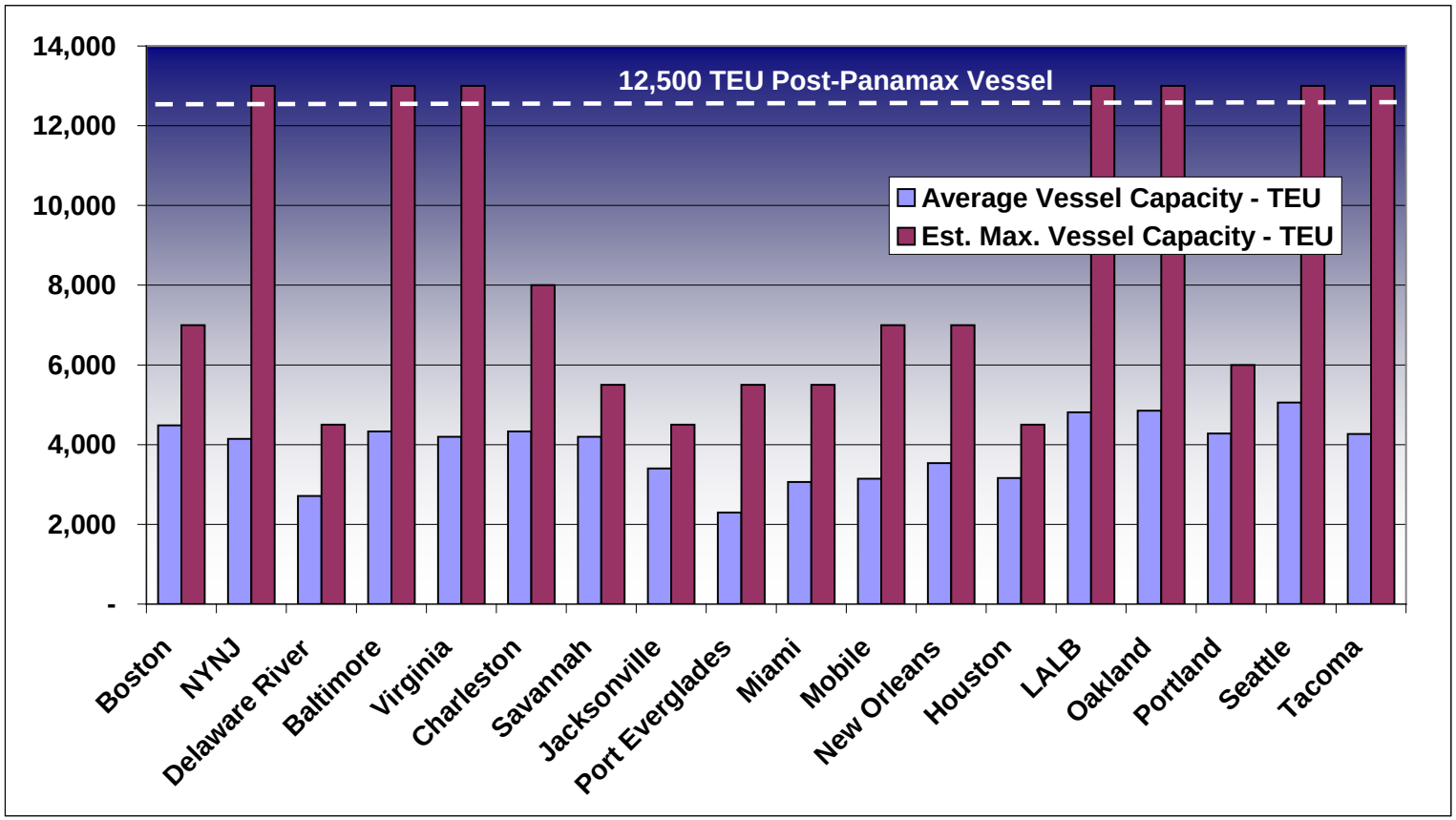
Trade volumes and drafts on the whole service rotation dictate vessel size

- U.S. average is 4,233 TEU
- Average sizes range from 32-76% of the maximum size



Vessel Size Distribution

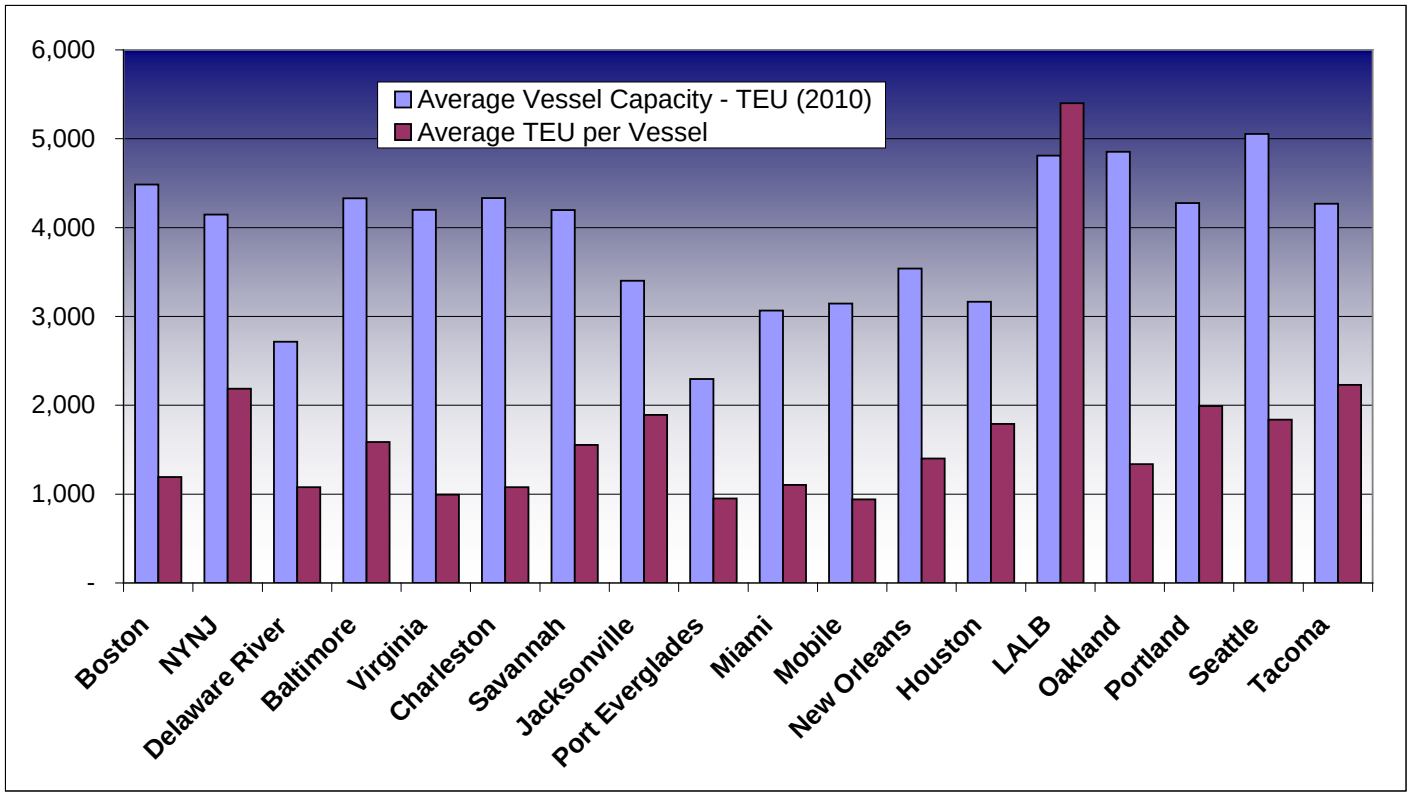
- Actual vessel sizes may be widely distributed
- Vessels can exceed the estimated maximum size by light loading or riding tides

2012 Port Metro Vancouver Vessel Calls			
Service	**Avg DWT**	**Avg TEU**	**Calls**
ANW1	35,433	2,698	52
C-PNW	93,650	7,500	52
H-PNW	68,146	5,506	52
Y-PNW	50,155	4,236	52
K-PNW	70,112	5,832	52
CGM-CMA/Maersk	101,916	8,071	52
EMC UAM	62,441	5,317	52
MPS	37,535	2,659	52
MSC Cal Express	65,794	4,986	52
PNX	100,621	7,889	52
NWX	**105,275**	**8,586**	**52**
WAN	18,339	1,329	26
PNW	72,483	6,280	52
PS1	63,445	5,294	52
Westwood	40,744	2,067	52
Port Average	**65,739**	**5,217**	**50**

Vessel Size and Load Comparison

Theoretically, a port can unload and load 200% of a vessel's capacity (100% off, 100% on)

- Most ports handle only 30-60% of vessel capacity due to multiple calls on each voyage –U.S. average of 2,188 TEU
- LALB loads unloads and loads 112% - 5401 TEU per voyage



Berth Utilization Metrics

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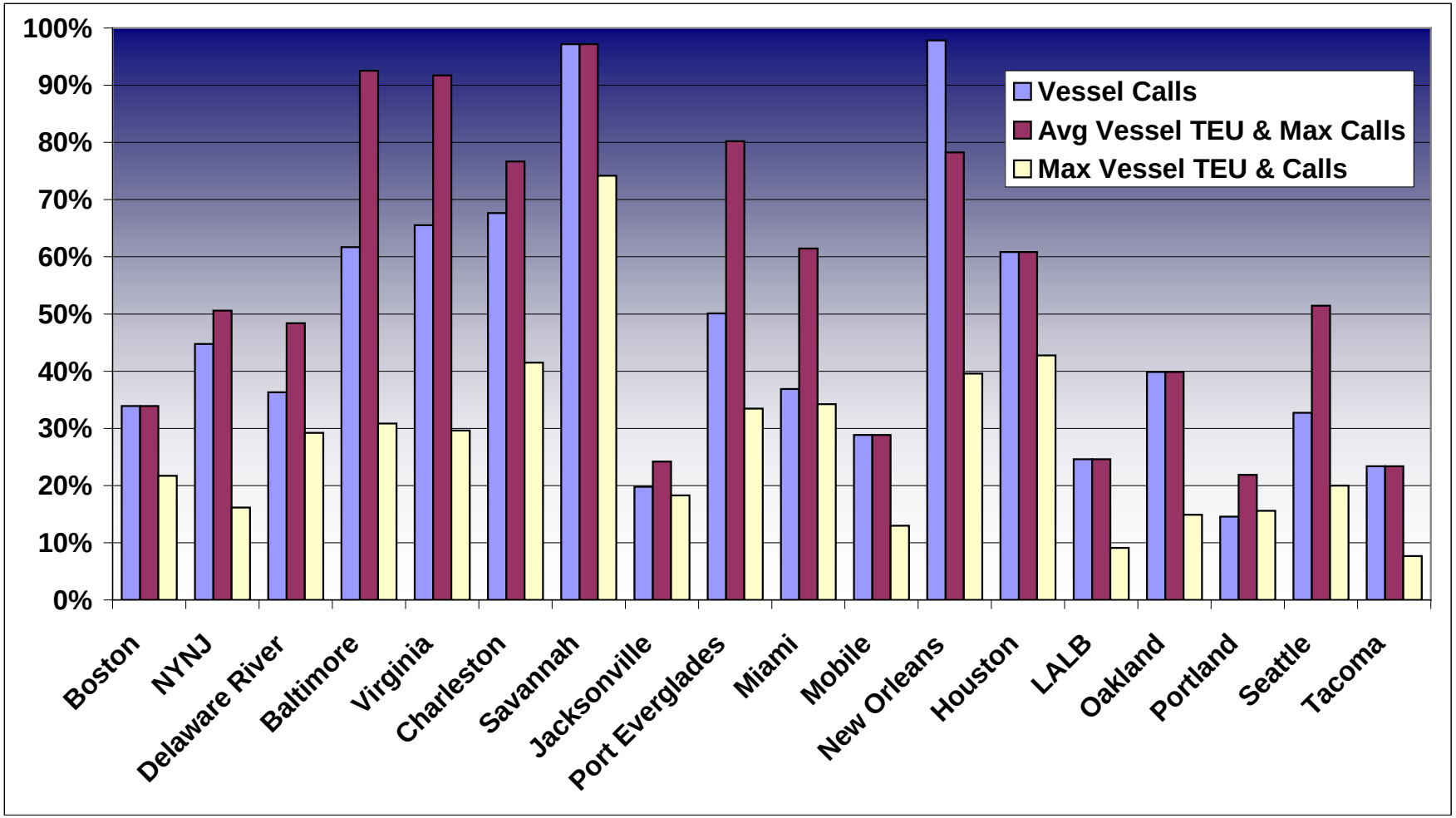
Multiple berth utilization metrics tell unique port stories



Conclusions?

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- Port capacity and utilization assessments require multiple metrics
- Most U.S. ports have substantial unused capacity inherent in their terminal infrastructure
- Terminals combine multiple operating methods and strive to minimize cost
- U.S. ports operate at lower densities than European or Asian terminals – land is cheap here
- Terminal capacity utilization is often constrained by vessel sizes, vessel utilization, and call frequency
- Channel & berth draft are the ”exogenous” constraints
- Every port and terminal is different

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Contacts and Follow-ups

CHCP Productivity Report
http://www.marad.dot.gov/documents/070810_Tioga_CHCP_Productivity_Report.pdf

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