

Port Performance Metrics

July 15, 2016



Key questions

- How do we choose **useful, fair, and consistent** port metrics?
- How do we address the **diversity** of port types and operations?
- How to we use the opportunity to provide **insight** and tell the **port industry story**?



U.S. Port Examples

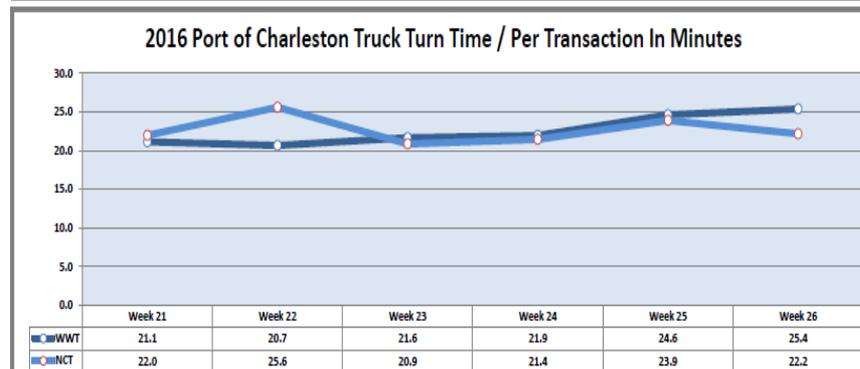
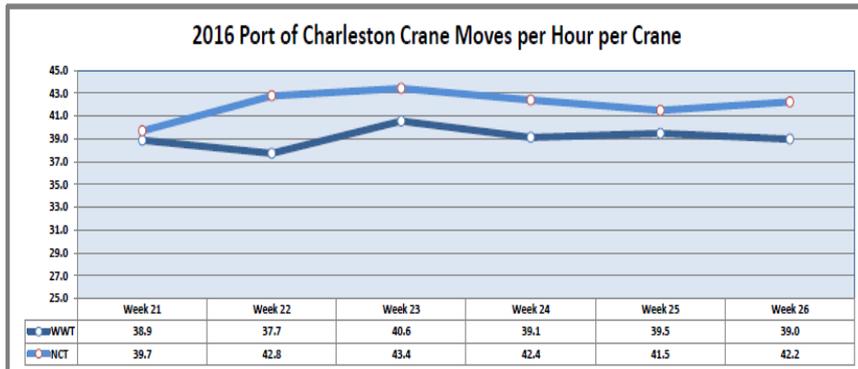
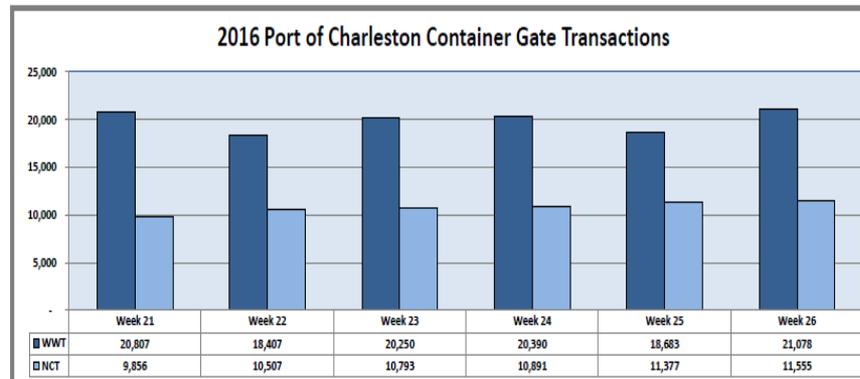
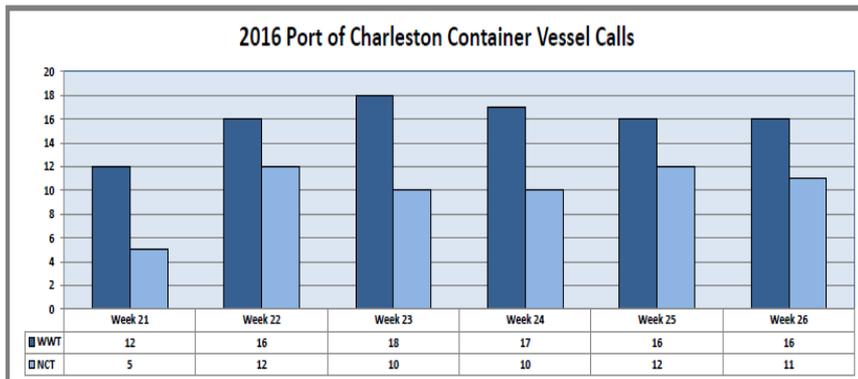
- Port of Charleston – selected metrics
- Port of Virginia – selected metrics
- Port of Oakland – performance metrics initiative

Foreign Examples

- Transport Canada Gateways & Trade Corridors Fluidity Indicator
- PPRISM ESPO Dashboard Pilot (through 2013)
- EU PORTOPIA program

Port of Charleston Website Metrics

Port of Charleston publishes selected weekly metrics



Port of Virginia Website Metrics

The Port of Virginia provides selected weekly metrics



Oakland's Port Efficiency Task Force has identified selected performance metrics of interest to customers and stakeholders:

- Truck wait-time outside terminal gates (street time)
- Truck turn-time within the marine terminal
- On-time vessel arrival
- Import dwell time (average time from vessel discharge to out-gate)
- Average rail transit time
- Percent of import shipments placed on Customs hold
- Average Customs hold time
- Chassis availability (inventory, out-of-service units/%, # units idle over 60-days)

Data are being compiled from multiple sources for publication on the Port website

Transport Canada collects and publishes data on transit time and reliability as well as port performance indicators



Port Utilization Indicators

Monthly Intermodal Indicators (5 partner ports)

| | | |
|-----|---------------------------------|-------------------------------|
| 1. | Average Truck Turnaround Time | [Min.] |
| 2. | Berth Utilization | [TEU/meter of workable berth] |
| 3. | Average Vessel Turnaround Time | [Sec./TEU] |
| 4. | Average Vessel Turnaround Time | [Hours] |
| 5. | Average Container Dwell Time | [Days] |
| 6. | Dwell Target - % under 72 Hours | [%] |
| 7. | Port Productivity | [TEU/Gross Ha] |
| 8. | Vessel On-Time Performance | [%] |
| 9. | Crane Productivity | [Lifts per hour] |
| 10. | Number of Vessel Calls | [Number/month] |
| 11. | Average TEU per Vessel Call | [Number/month] |
| 12. | Container Throughput | [Number/month] |

PORTOPIA: EU Terminal Productivity Indicator

PORTOPIA objectives:

- To support the European Port Industry with meaningful performance data to increase individual port and port transport system performance
- To support policy formulation and monitor policy implementation

| Data | Publicly available? |
|-------------------------------------|--|
| Throughput volume at port level | Yes, for most ports, available in PORTOPIA. |
| Throughput volume at terminal level | No, terminals do not disclose their volumes. |
| Total ship calls per port | Yes but imperfectly, not all ports report this publicly |
| Volume loaded and unloaded per ship | No, this is proprietary to shipping lines (& terminals) |
| Ship's time at berth | No, even though for ships with AIS such data can be generated. |
| Size (m ²) of terminal | Imperfectly, for some terminals this is available, based on satellite images from Google, for others not, given the absence of visible 'boundaries' between terminals. |
| Quay length | Yes, based on satellite images from Google. |

How do we measure port capacity?

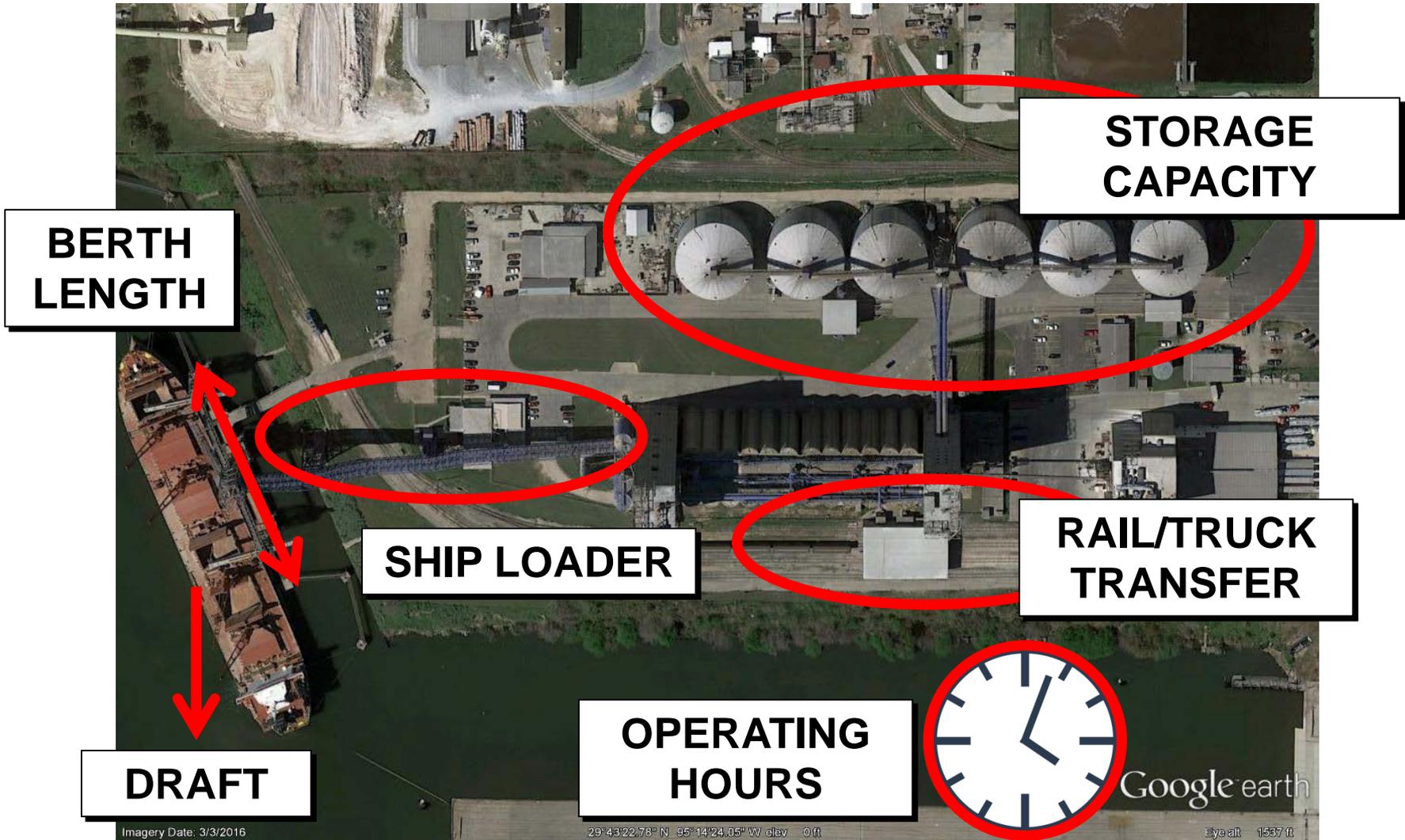
Capacity may be based on port/terminal estimates, third-party estimates, or engineering studies

Bulk, container, and inland ports may have different capacity metrics and concerns

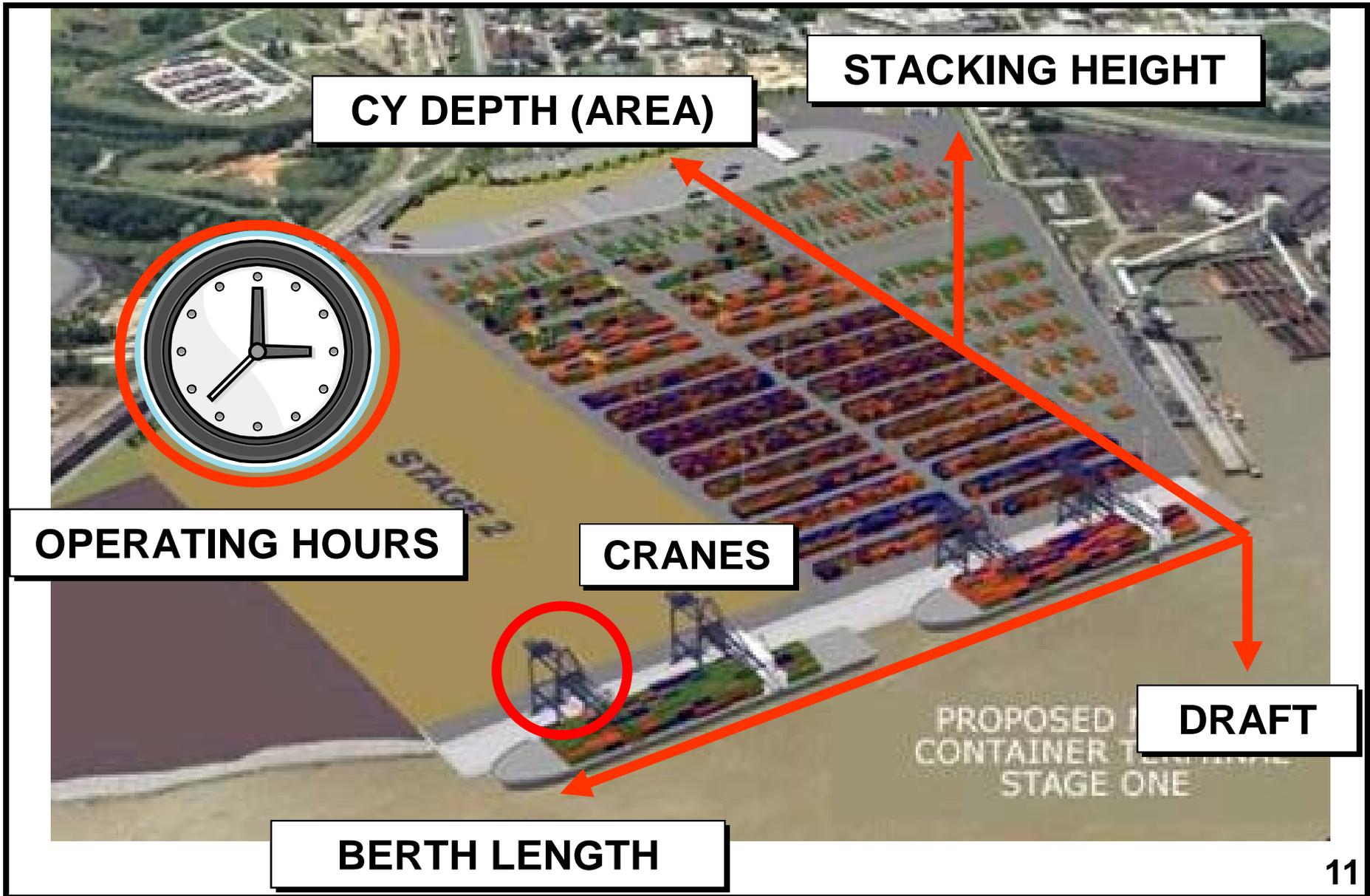
Near-term throughput capacity may be limited by one or more factors, including:

- Terminal/yard storage capacity
- Berth length
- Berth/channel draft
- Handling equipment/crane capacity
- Operating hours
- Inland transport capacity

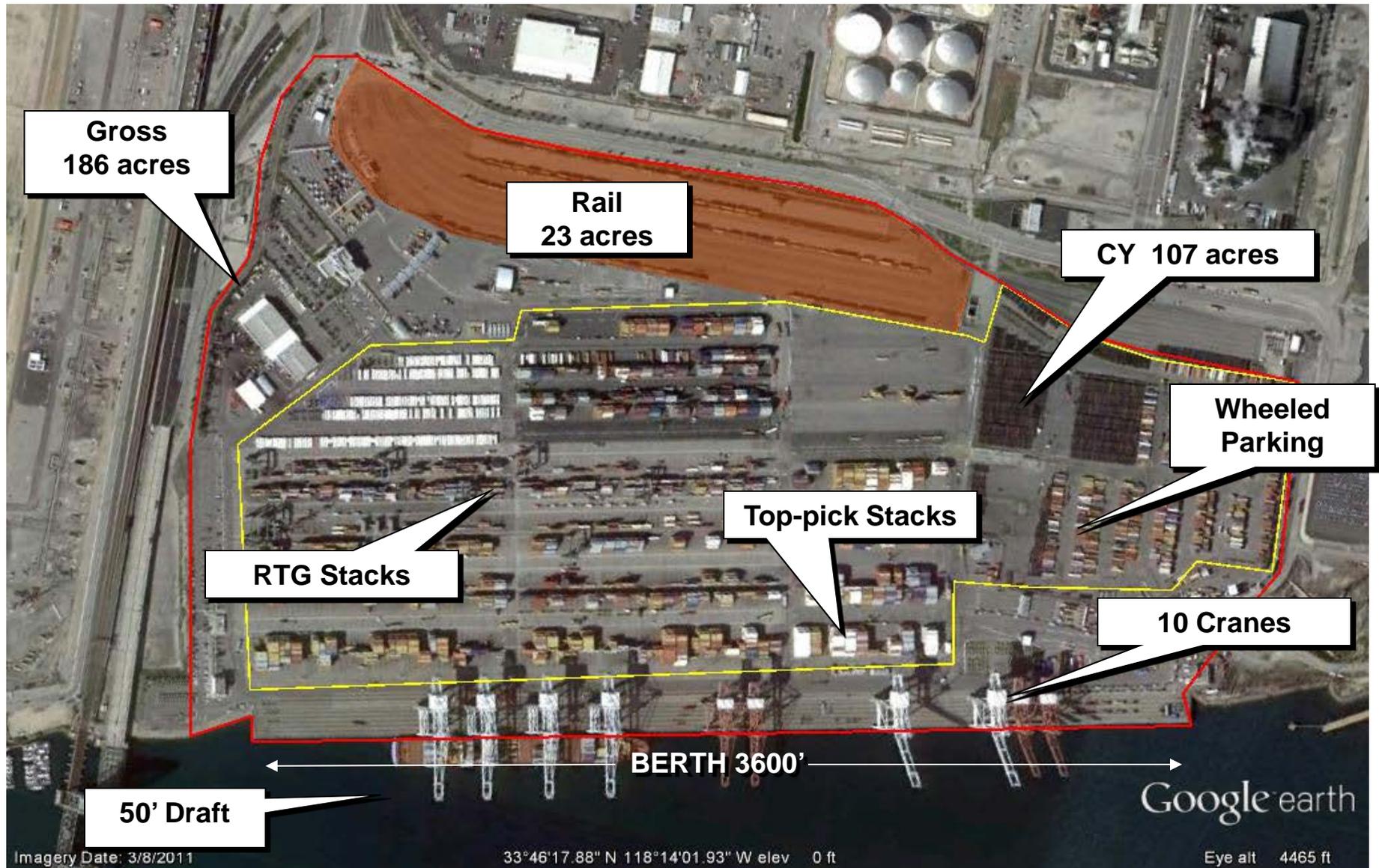
Bulk Terminal Capacity Factors



Container Terminal Capacity Factors



Marine Container Terminal Characteristics



Container Yard Capacity

Container yard capacity depends on acreage and storage density

- Lower storage densities usually mean less handling and lower cost
- Terminal designers and managers “densify” 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 |

Critical Capacity Assumptions: Example

Assumptions and rules of thumb

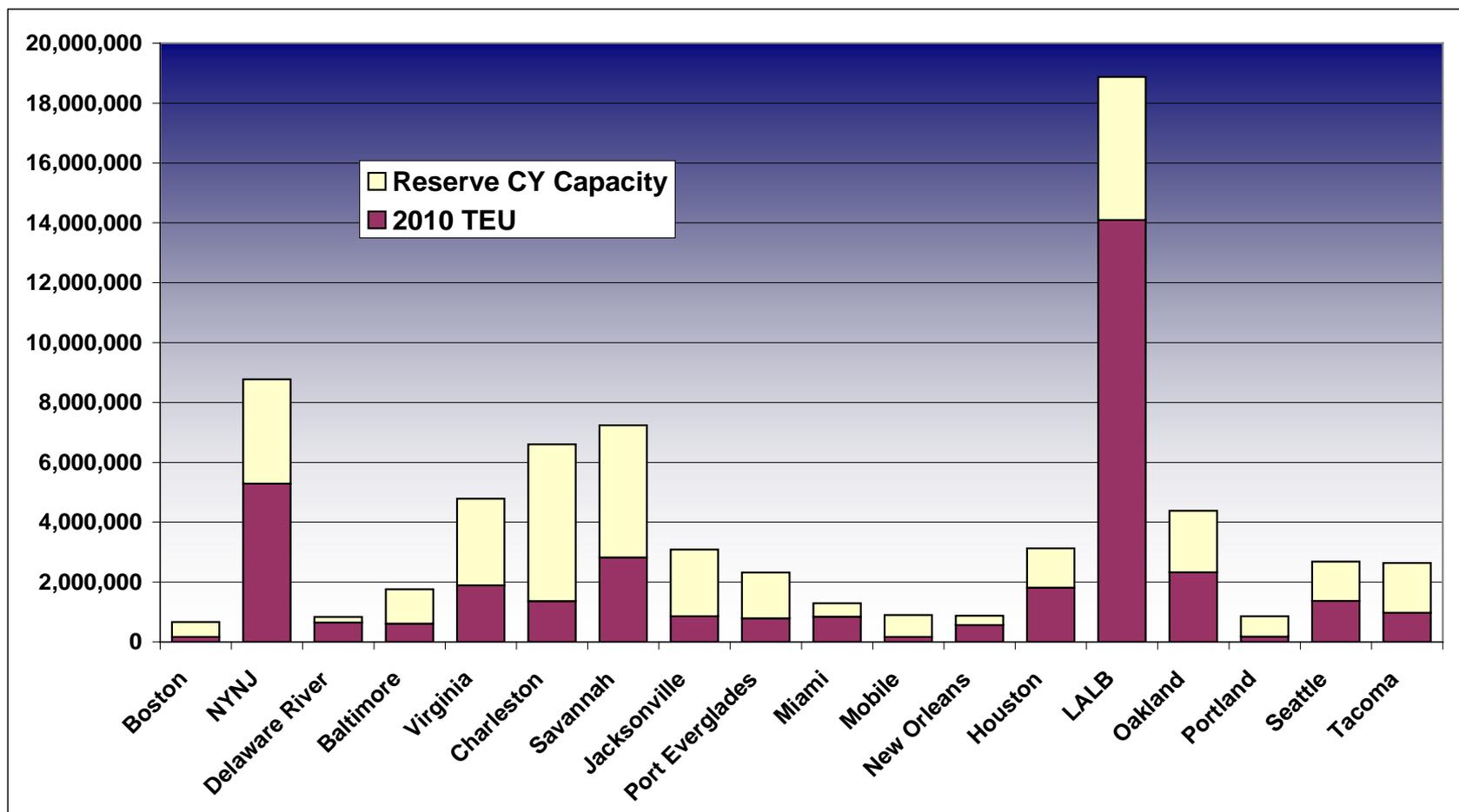
- Maximum annual TEU slot turnover = 70 turns (5 day dwell, 350 days/yr)
- Crane available 16 hours/day (two shifts), 250 days/yr
- Modern crane maximum = 35 moves/hr
- Vessel spacing at berth = vessel beam
- Maximum of 260 annual calls per berth (5 per week)
- Working draft = channel/berth draft – 3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

Example: Terminal with 7 Cranes

- 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 = 54 TEU/hr
- Sustainable crane capacity = 54x22,400 = 1,209,600 TEU/yr

2010 TEU and CY TEU Capacity

With existing terminal layouts and handling densities, U.S. container ports had reserve CY capacity in 2010



How do we measure utilization and productivity?

Utilization is throughput/capacity expressed as a percentage

- Utilization is strongly affected by the timing of capacity additions versus demand growth
- Low utilization may signal low productivity, loss of demand, or reserve capacity
- High utilization may signal high productivity, demand spikes, or capacity constraints

Productivity is typically a ratio of throughput per asset unit

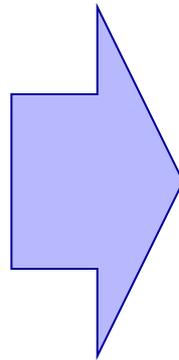
- TEU or tons per acre
- Vessel or barge calls per berth
- Crane moves per hour

Averages summarize key characteristics and “smooth out” differences between terminals and over time

- Average truck turn time
- Average tons per vessel or barge call
- Average cranes per berth

Common Accessible Port Data

- Cargo Tonnage
- Terminal Acres
- Berths & Length
- Vessel/Barge Calls & Sizes
- Vessel/Barge Dwell Time



Potential Common Port Metrics

- Tons per Acre
- Tons per Berth/Berth Foot
- Tons per Vessel/Barge Call
- Vessel Calls per Berth
- Average Vessel/Barge Size
- Average Vessel/Barge Dwell Time
- Tons per Vessel/Barge Hour

Container Port Data and Metrics

| Port Metric | Data Needs | Availability? |
|--|--|-------------------------------|
| Overall Port Metrics | | |
| Annual TEU | Port TEU | Yes |
| Port TEU Capacity | Terminal Capacities | From terminals - definitions? |
| Excess/Reserve Capacity | Port TEU, Terminal Capacities | From terminals - definitions? |
| Land and CY Productivity | | |
| TEU/Gross Acre | Port TEU, Gross Acres | Yes |
| TEU/Net Acre | Port TEU, Net Acres | Estimate Net Acres |
| TEU/CY Acre | Port TEU, CY Acres | Estimate CY Acres |
| Net/Gross Ratio | Gross Acres, Net Acres | Estimate Net Acres |
| CY Slot Turns | Port TEU, CY Slots | Estimate Slots |
| Container Dwell Time | Container Dwell time (by type?) | From terminals |
| Container Crane Productivity | | |
| Annual TEU or Moves/Crane | Port TEU or moves, Cranes | Yes |
| Annual TEU or Moves/Available Crane Hour | Port TEU or moves, Cranes, Port hours | Yes |
| Avg. TEU or moves/Vessel Dwell Hour | Port TEU or moves, Vessel Dwell Time | Yes |
| Avg. TEU or moves/Working Crane Hour | Port TEU or moves, Working Crane Hours | From terminals - definitions? |
| Berth Productivity | | |
| Cranes/Berth | Cranes, Berths | Yes |
| Gross acres/Berth | Acres, Berths | Yes |
| Net, CY acres/Berth | Acres, Berths | Estimate Net/CY Acres |
| Annual TEU or moves/Berth | Port TEU/moves, Berths | Yes |
| Annual TEU or moves/Foot | Port TEU/moves, Feet | Yes |
| Annual Vessel Calls/Berth | Vessel calls, Berths | Yes |
| Average Vessel Dwell Time | Vessel Calls, Vessel Dwell Time | Yes |
| Annual TEU or moves/Vessel call | Port TEU, Vessel calls | Yes |

Truck, Rail, and Chassis Metrics

| Port Metric | Data Needs | Availability? |
|---------------------------------------|----------------------------------|---|
| Truck Productivity | | |
| Average Total Truck Turn Time | Total Truck Turn Time | Needs New Data Sources |
| Average Terminal Turn Time | Terminal Turn Time | From terminals |
| Average Queue Time | Truck Queue Time | Needs New Data Sources |
| Trouble Ticket Frequency | Trouble Ticket Records | From terminals - definitions? |
| Rail Productivity | | |
| Average Rail Container Dwell Time | Rail Container Dwell Time | From terminals - definitions? |
| Annual TEU/Moves per Rail Acre | Rail TEU. Rail Acres | Yes |
| Chassis Productivity | | |
| Chassis Out of Service Ratio | Chassis fleet & OSS records | From Chassis Providers - Confidentiality? |
| Container per Chassis Ratio | Chassis availability by terminal | From Chassis Providers - Confidentiality? |

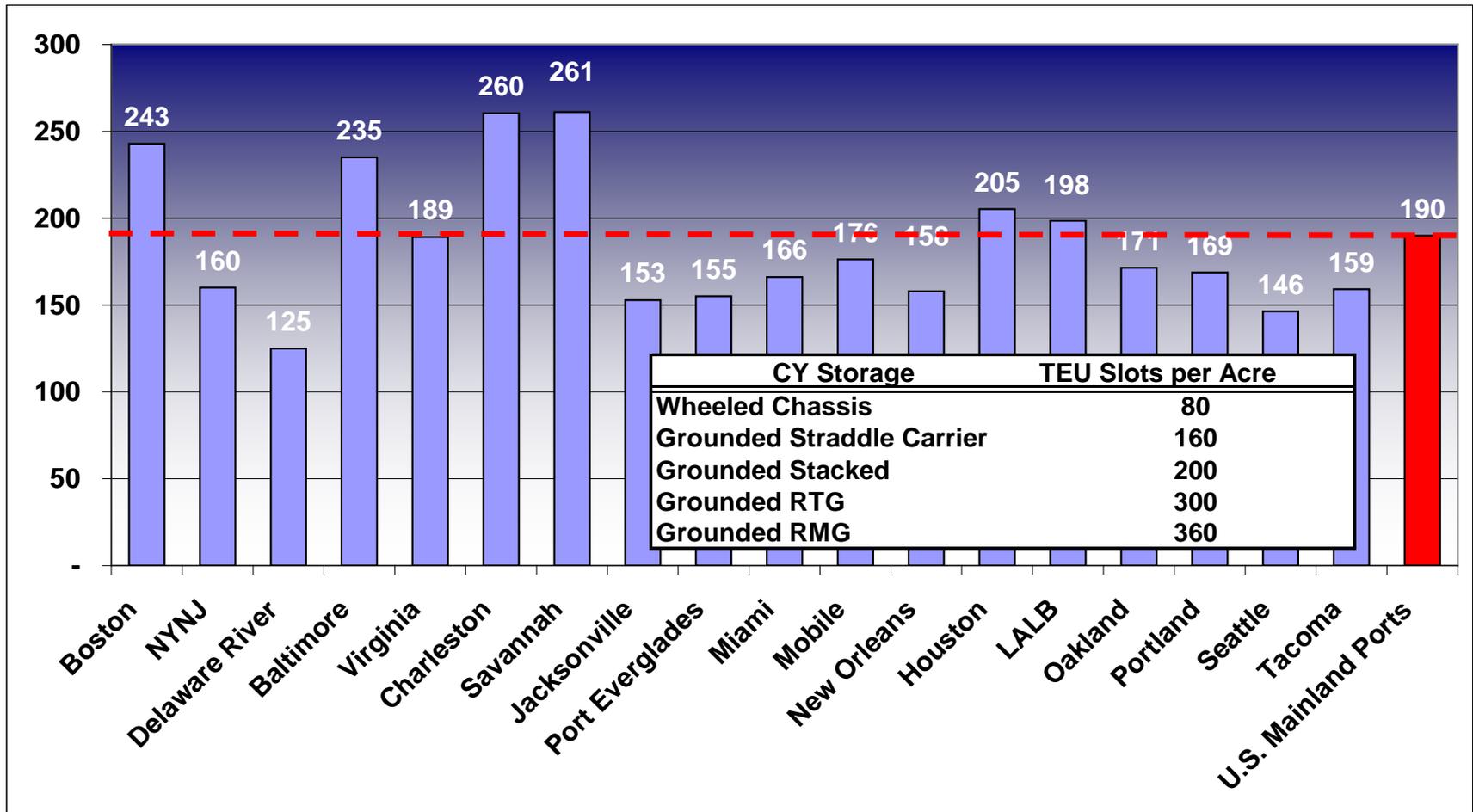
Annual TEU per Acre has been used to compare U.S. container ports with each other and (often unfavorably) with foreign ports

Annual TEU per acre can be a misleading metric.

- TEU per acre measures land productivity, but land may be the least costly terminal asset
- On-dock rail intermodal facilities add to acreage and distort comparisons
- Terminal expansion adds capacity but reduces TEU per acre
- Some terminals have moved chassis and empty container storage to off-dock sites, effectively increasing acreage
- Higher CY storage densities increase TEU per acre but also increase costs and truck turn times

Average TEU Slots per CY Acre

- U.S. ports averaged about 190 TEU slots per CY acre in 2010
- Averages are due to port and terminal storage type mixes



TEU per CY Acre

Wheeled container yard means:

- Low storage density and no CY lift equipment
- Two longshore moves, one trucker move



Vessel dwell time is a function of:

- The number of containers or tonnage to be loaded and unloaded
- Terminal resources available (e.g. cranes per berth and vessel)
- The efficiency with which those resources are employed

Vessel dwell time is not a linear function of cargo volume, since each vessel typically requires:

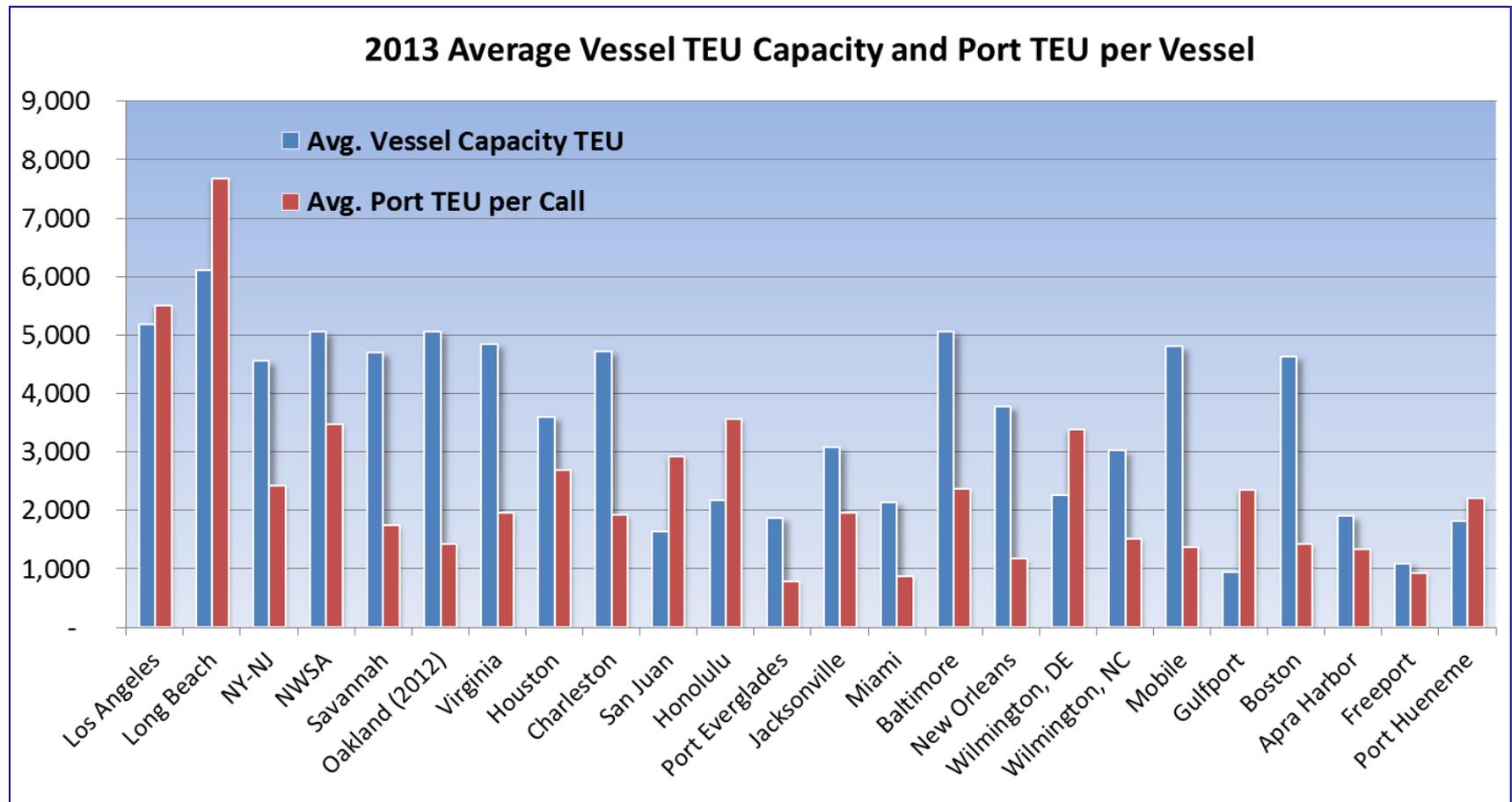
- 2-4 hours to be tied up and readied for cargo operations
- 2-4 hours to be readied for departure after cargo operations

Vessel dwell time also varies with the timing of arrival and departure.

- Late vessels may result in overlapping calls and delays
- A vessel that arrives in mid-shift may not be worked until the start of the next full shift

Vessel TEU/TEU per Vessel

AAPA and MARAD data can provide average vessel capacity and average TEU per vessel call



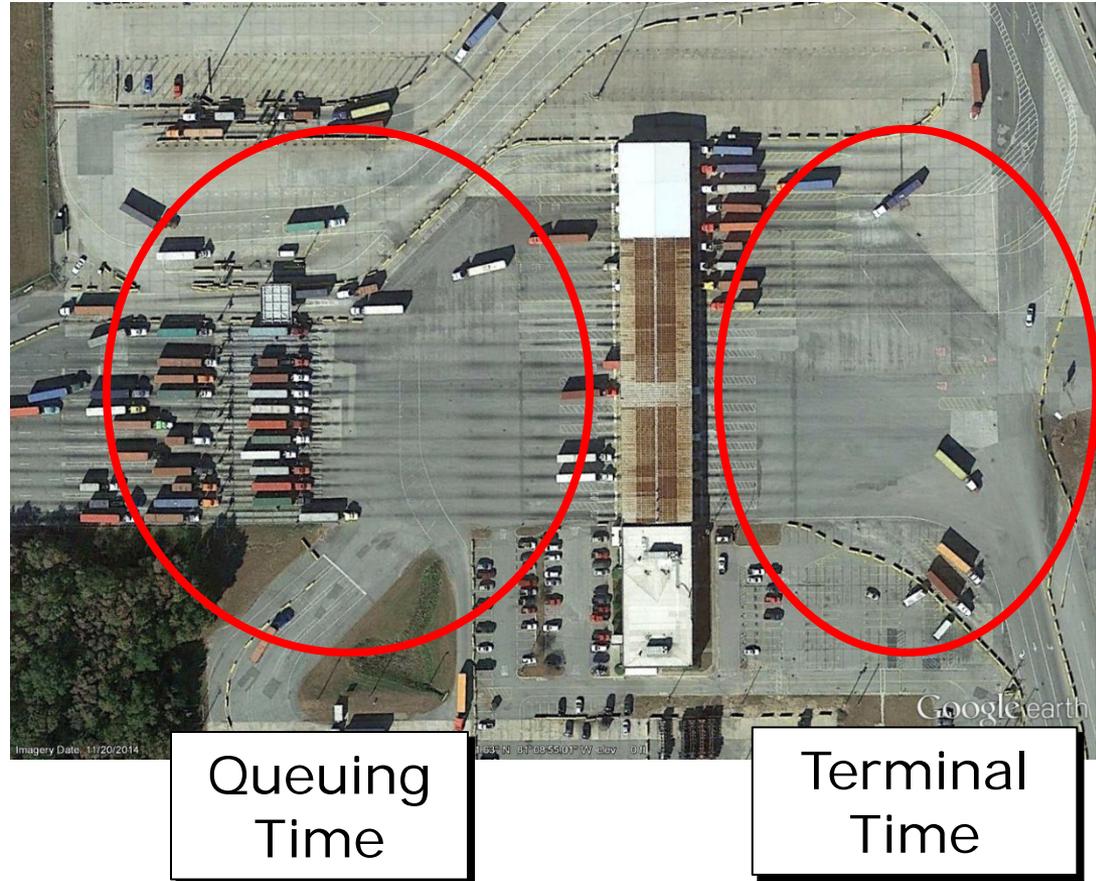
Crane moves per hour as a terminal efficiency metric poses methodological and data collection challenges.

- “Cranes moves” may include handling hatch covers and restowing containers as well as movement of imports and exports
- “Hours” may include or exclude scheduled breaks, yard congestion delays, and other factors depending on data collection practice
- Crane moves per hour can be affected by vessel stowage and adjacent bay constraints, particularly with large alliance vessels.
- The use of additional cranes to shorten vessel dwell time may compromise crane productivity
- Agreements between carriers and terminals sometimes specify the number of cranes to be provided per vessel call

Truck Turn Time

Truck turn time includes waiting/queue time and terminal time.

- Terminal turn times vary by time of day and transaction type
- Port-wide average **terminal** turn times could be compiled from terminal information systems
- Compiling **queueing times** would require new data collection efforts and technology applications.

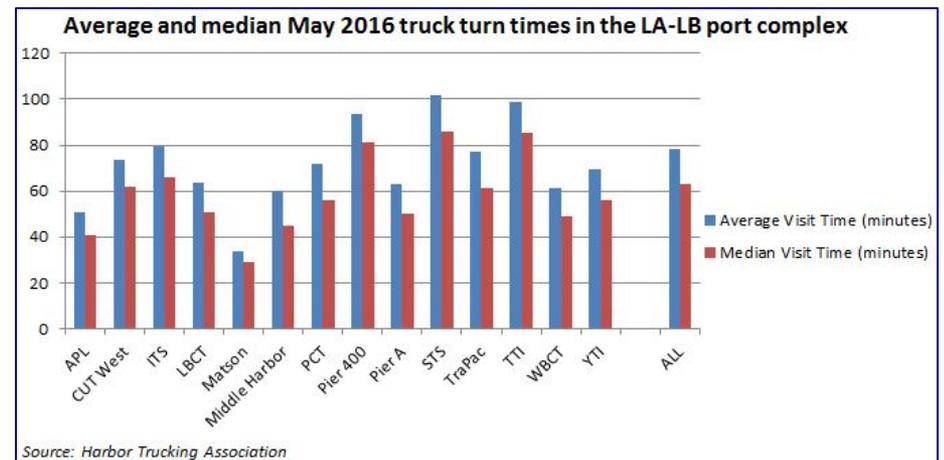


Truck Turn Time

There is limited information on turn times at U.S. ports:

- Port of Oakland sponsors DrayQ with **queue and terminal** times from Bluetooth data
- Southern California Harbor Trucking Association (HTA) publishes monthly **total turn time** averages for LALB terminals from GPS data
- The Ports of Charleston and Virginia post weekly data on **terminal** turn time
- Some marine terminals publish turn times

| Terminals | Street Wait | Terminal Turn | Total Wait | Low Med High |
|--------------------|-------------|---------------|------------|--|
| SSA West Gate | 25m | 47m | 1h 12m | █ █ █ |
| SSA East Gate | 9m | 52m | 1h 1m | █ █ █ |
| SSA East Back Gate | 7m | 33m | 40m | █ █ █ |
| TRAPAC | 51m | 1h 28m | 2h 19m | █ █ █ |
| Everport | 15m | 1h 5m | 1h 20m | █ █ █ |
| MATSON | 5m | 1h 5m | 1h 10m | █ █ █ |
| SSA Roundhouse | - | - | - | █ █ █ |
| TRAPAC B-25 Gate | - | - | - | █ █ █ |



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