CAPACITY PLANNING IN CONTAINER HANDLING FACILITY

Elnora Lucero
Technical Consultant, ETL Technical Consultancy Services, Manila, Philippines
E-mail: etcs.consultancy@yahoo.com

ABSTRACT
Purpose: Uncover unmet plans (underutilized resources) and the met/realized plans (undervalued capacity) fuelled by work methods mediation and establish basis for Ideal Capacity.

Design/Methodology/Approach: To test the Equipment Efficiency and Work Methods, Productivity Standards, Existing Capacity; and Ideal Capacity by Sampling of historical data, current operations reports, performance reports before and after mediation of methods; and Observational Research (naturalistic and participant modes). T-test, ANOVA, and F-Test were used where deemed applicable.

Findings: Improving Equipment Efficiency and Work Methods does improve Productivity Standards at a certain efficiency level not exceeding the equipment's allowable capability; Productivity Standards does not directly affect Existing Capacity; while Productivity Standards, if updated and dependable, is a better basis of Ideal Capacity. But Existing Capacity is a sure yardstick of Productivity Standards' relevance and operational performance.

Research Limitations/implications: Sensitivity of internal information and confidentiality clause delimit the presentation of the detailed computation and efficiency of variable equipment attributes is no longer itemized. Between operator's speed and equipment's speed, the latter prevails and test is no longer necessary.

Practical implications: Negative variance of Ideal Capacity against projected Demand necessitates resource balancing and provision options. Positive variance provokes added marketing efforts or productivity programs. No variance means status quo.

Social implications: Reliable Productivity Standards are beneficial when considering reaction to changes in Gross Domestic Product (trade influx) and in the overall growth of this logistics network.

Originality/Value: In container handling where ideal capacity is based on traditional experience (existing capacity), this study objectively views the ideal capacity through buoyant and dependable Productivity Standards setting.

Keywords: equipment efficiency, existing capacity, container handling, ideal capacity, productivity standards, work methods

Paper type: Case Study

Introduction
Capacity is basically the measure of volume of liquid/solid or space available for a certain container or storage area. For humans, capacity is in the form of aptitude, ability, skill, competence or function. For operations, capacity is the output produced within the number and availability of machines, workers and workers' skill, allowable delays/defects/scrap/errors, other resources and supply factors, and surrounding regulations.

A more usable definition of capacity would be the volume of output per elapsed time and the production capability of a facility (www.zarate-consult.de, 2012).

Container handling facility, the gateway of goods situated at ports, serve as logistics platform coordinating a node for network of parties that Nair and Huynh (2011) identified as shippers, ocean carriers, terminal operators, and forwarding companies. Ports fulfil three key functions—the regulatory function, the landowner function, and the operator function. These functions are detailed in the succeeding scenario:

If docking does not necessitate vessels to wait at a nearby anchorage at the port of call, they are promptly guided by expert pilots (proficient on the unique local seabed contours and safer navigation) as stowage brings them to designated berth, After ports authorities' and customs' formalities, stevedoring services of port terminal operators commence. Gang complement for unlashing is mandatory for containerized vessels prior to discharging of containers by means of quay cranes and the support of trucks transporting the containers from the quay side to the yard. After containers from the yard to the berth are loaded, lashing of loads then seals the stevedoring operations. As arrival and departure cycle is completed, port and customs formalities recur prior to stowage back to anchorage area as the ocean liner is finally released and sails to the next port of call.

However, based on this caselet, in-between discharging and loading or prior to loading, the vessel may opt to have temporary hiatus at the anchorage. A number of reasons for vessel waiting time at the anchorage may be due to: (1) full berth occupancy; (2) terminal handling limitations; (3) freight and load delay; (4) vessel-related or crew-related circumstances; (5) statutory regulations and port state control or compliance; and (6) weather-imposed.

The 3rd to 7th probable reasons for anchorage waiting time are uncontrollable and externally driven. The 1st, and 2nd probable causes may be manageable at the quay-side, terminal operator's end. Thus, a rundown focus is on full berth occupancy, and terminal handling limitations that include pilotage and stowage.

Terminal Handling Limitations may be the ability of the operator to manage resources, comply with regulations, adapt to market mechanism, and other positioning strategies. Even the Stowage and Pilotage Availability may just be a minimal portion of the delay if two vessels arrive at the same time or due to pilot contracts/shifting/scheduling issues only.

Yet, the Full Berth occupancy may reflect two opposing manifestations. Firstly, this circumstance may represent that everything occurs as planned. Secondly, this may be a resultant of unmet plan dragging some slight, prolonged stay of vessels at dockside. Slight because if substantial berthing time extensions are needed, they are better sent back to anchorage to allow other vessels on queue. However, unmet allocated berthing time may again be caused by terminal operations or the shipping lines/shippers/forwarders. The latter, may only be imposed by terminal operator in the form of lead time cut-off or policy sanctions but the former, must be traced back to the planning assumptions used or unproductive execution of plan.

Unmet plan due to planning inaccuracy with supposed terminal standards is considered an operational inefficiency. Throughput is measured in terms of twenty-foot equivalent units or TEUs as what Nair and Huynh (2011) mentioned as a standard maritime industry measurement used when counting cargo containers of varying lengths.

On the surface, realized plan that is consistent with terminal standards and verifiable assumptions established by operations, is already claimed as productive port performance. It is neither an aspect to be complacent with because as UK Parliament's Committee on Transport (2003) puts it: Throughput is only one indicator of port performance. It does not necessarily reflect efficiency. However, there is no simple relationship between efficiency and capacity. *High utilization can lead to a reduction in operational efficiency, increased congestion and reduced service levels on both shipside and landside*.

Growing Capacity is always apparent in global logistics. The Port Technology Organization (2011) for instance cited the following at the shipbuilding's point of view: (a) Global boxship deliveries to increase TEU capacity by 5%; (b) Total global capacity is expected to reach 16.8M TEUs in 2012 based on Braemar Seascope's Containership Fleet Statistics; (c) 59 of the 230 containership expected to be delivered in 2012 will have a total capacity of 10,000 TEUs or more; (d) Vast majority of ultra-large containerships are currently deployed on *Asia-Europe services*; (e) The 2012 delivery influx would be sufficient tonnage to create another *5 loops deploying 10 x 13,000 TEU vessels*; (f) Orders of smaller capacity ships of 5,100 TEU is up by *2.9% in 2011* and *3% in 2012*; and (g) By 2011, the *10,000 TEU capacity vessels* constitute *49% of the global orderbook* while the *5,100 TEU capacity vessels* has the *20% share* of the global orderbook.

Not only in shipbuilding but in port expansion as well in 2011 that: (a) *India* is to increase its annual capacity to more than 3B tons by 2020 according to its Minister of Shipping. Seaborne trade represents 80% of India's total exports; (b) *Jebel Ali Port in UAE* is to expand as DP World contractor announced the US$850M project to reach a capacity of 19M TEU by 2014, a 4M TEUs per annum rise. In 2011, the growth was 11% and over a million TEU per month being handled in the port; (c) Expansion plans for *Dublin Port* may double trade in 20 years or by 2040 starting 2011. For the past 30 years, volume of goods going through Dublin Port had quadrupled; (d) *New Zealand Port of Tauranga* has started in 2011 the expansion worth NZD30M. Trade volume increased by 18% in 2011; (e) *Saudi Arabia* to spend $613M on port expansion in *Dammam, Yanbu, and Jubail Ports*. Dammam is set to double its capacity within the next 3 years; (f) China is planning $7.1B expansion of Dandong Port which is to increase the port's annual capacity from 60M to 100M tons; (g) While the UK's economic outlook remains uncertain, the economy's ability to return to growth will only be possible if the UK has the necessary infrastructure. Berths 8&9 of *Felixstowe* will ensure the country has the port capacity to enable this growth, creating an additional one million TEU capacity per annum; and (h) Container traffic through *Canada's Pacific Gateway* is expected to double over the next 10 to 15 years, and nearly triple by 2030. Current projections indicate approximately four million TEUs (twenty-foot equivalent units) of additional capacity will be needed to meet West Coast container demand by 2030 (Nightingale, 2011).

In 2012 updates of Port Technology news, the following are the expansion plans: (a) French Firm, Bollore Group, to double capacity of *Ivorian container facility* by 2015 with $79M infrastructure upgrade at Abidjan Port, Africa; (b) APM Terminals to invest over $100M to boost capacity at *Port Poti, Georgia* to increase Poti's capacity over the next 3 years by a further 50% from the 178,000 TEU in 2011; and (c) a 568-meter quay capable of serving 2 sea-going vessels and 3 barges simultaneously shall increase the capacity of *Antwerp Port* by 18%.

In 2000-2008, US container port traffic grew by an astounding 42.56% (Nair and Huynh, 2011).

There is no indication of slowing down of container handling demand and port capacities as consumption is set to increase as population increases.

Capacity Planning issues at the port can result in various forms of operational inefficiencies such as ship delays, missed feeders, extra manpower, yard congestion, re-handling, increased idle times for trucks and emission (environmental concern), and longer lead times for shipper. Approximately 55% of port-related costs can be reduced by improving ship turn-around times and cargo handling needs (Nair and Huynh, 2011) although 5.3% of delays is said to be caused by worse climactic conditions (Varbanova, 2011).

The purpose of this study is to uncover unmet plans (underutilized resources) and the met/realized plans (undervalued capacity). Thus, assess the declared, existing capacity of a certain port (with variable equipment efficiency ratings) if it is indeed the ideal capacity by looking at the operational inefficiencies that may serve as areas for improvement.

Literature Review

The selected, succeeding literature were valuable citations by which analysis and direction of the study outcome were anchored. Some also fuelled the arguments and clarification to challenge the usual practice or gave credence to known theories and uncommon facts. .

Capacity further means as the maximum amount of work that an organization is capable of completing in a given period of time. In a simple model (www.zarate-consult.de, 2012), it might be calculated as [*number of machines and/or workers*] x [*number of shifts*] x [*utilization*] x [*efficiency*].

An optimal berth utilization as per the world standard, defined by United Nations Conference on Trade and Development (UNCATD) is about *65% to 70%*. The world's benchmark for Throughput per day is about *30 to 40,000* tonnes. The *turn-around time* for high productivity ports is in the range of *1.8 to 2.4 days*. The *parcel size is about 120,000 tonnes*. (Australian Port Association and other bulk Ports in the world in TransCare Logistics India, 2007).

In Bulgaria, as cited in Varbanova (2011), the main reasons for lack of schedules integrity on container feeder lines in the region are due to the following: port utilization/congestions and delayed berthing

(65.5%); delay during cargo operations due to port equipment (20.6%); delays due to worse climactic conditions (5.3%); delays due to time lost for waiting of pilots, tugs (4.7%); and a total of 3.9% for accidental delays at ports, delays in supplies of fuels, channel passages, etc.

In other parts of the globe where productivity rates are simply crane productivity, berth utilization rate and turn-around times, in UK Parliament's Commitee on Transport Ninth Report (2003), the measures of productivity are broader and proportional to other costs of operation. The Ports Comparative Terminal Productivity is measured in terms of Port, Quay Length (m), Terminal Area (Ha), Throughput of a given period or year, TEU per meter of Quay, and TEU per Hectare.

Edullantes (2007) said that an era of opportunities and challenges in port operations is plausible because Asian and world economies continue to expand by which port operators and shipping lines eventually face tougher shipping demands. In Makassar Terminal Services alone, the annual growth is more than 10% annually at a high productivity rate of over 25 TEUs per hour per crane. Yet, major ports in Indonesia deal with shortage of capacity, resulting in longer vessel waiting time and turnaround time. There are over 2,000 ports in an archipelago of over 13,000 islands.

It is difficult to see progress in container handling equipment - methods of handling containers are essentially unchanged since the dawn of containerisation. There are two underlying factors to consider. Firstly, port planning and operational research and studies should be interdisciplinary in that they straddle the border lines of different engineering disciplines. Planning of ports and harbours usually comes within the bounds of civil engineers working for administrative authorities such as national or municipal governments or port authorities Secondly, planning and design of container terminals have always depended mainly on empirical experience, while a corpus of theoretical knowledge, which could help inform this experience and in turn be verified or modified by it, has been lacking. At the onset of containerisation, it was indispensable for terminal operators to build up experience. It was relatively easy to perform daily operations based only on what that **experience** indicated was the storage capacity of the terminal (Watanabe, 2001).

An Operations Analyst once argued that Productivity Standards depend on government regulations. A justification for not updating the productivity rates of the quay cranes by which the capacity plans and port stay or berthing time are estimated and based. Estimated Time of Completion (**ETC**) and eventually, Estimated Time of Departure (**ETD**) of the Vessel calling at the port are dependent on usual productivity rate assumption. From the time the quay cranes were acquired, the productivity rates may have only updated once or twice for a span of 8 years. The basis of which was, in fact, the final stevedoring reports with mere figures without remarks on the nature of operations that transpired.

SGV & Co/Ernst and Young Principal, Washington Roqueza (1993) clarified to the author that Work Standards are based on three aspects: *Product-Based*, *Equipment/Machine-based*, and *Methods-Based*. As to how often should standards be updated, he further stressed that the need is as often as there is change among (or in any of) the three aspects.

Ahmad, Idris, and Kader, (2007) wrote that container terminal capacity should be periodically reviewed. It has to be audited against demand and current performance.

On Capacity Planning and Expansion, a seasoned terminal manager who is adept with technology's significance said: "You don't open a terminal to try and steal some business from the existing market. You open a terminal because there's a pent-up demand for capacity. As that capacity is brought online, you obviously look at the demand side to make sure you're not OVER providing, and at the same time, that you're not UNDER providing" (Milliken, 2007).

There is a growing realization that simply producing large quantities of a standard product does not necessarily mean one is productive. Organizations must produce what the marketplace needs, when it needs it, and at a competitive price. The ideal of meeting customer needs and expectations without error or waste has now entered the vocabulary. So the output side of the calculation is more complex now. When considering labor productivity, the input is simply the quantity of labor expended. In a more sophisticated analysis, the industrial engineer will also consider things such as how effective the labor is by measuring performance, utilization, and method levels (Smith, 2001 in Rao, 2012).

The key to the strategic success of planning and scheduling as partly mentioned in Lockamy III and Cox III (1994) are quality, delivery and lead time. Measurements monitored within this area are: (1) *Conformance to Daily Production Schedules* (2) *Planning Customer Service*; (3) *Operations cycle time*; (4) *Scrap/Delay/Lost Time cost*; (5) *Customer Service*; (6) *Inventory Performance*; and (7) *Departmental budget*.

Research Methods

As primary data source, the two types of Observational Research, naturalistic and participant as Mitchell and Jolley (1996) mentioned, were adapted. In gathering sample of actual work methods and performance of equipment, the naturalistic observation, was extremely helpful. In the case of the work methods improvement mediation, after discussion with and approval from the section head, a pilot trial of the enhancement in methods was applied which is known as participant observation.

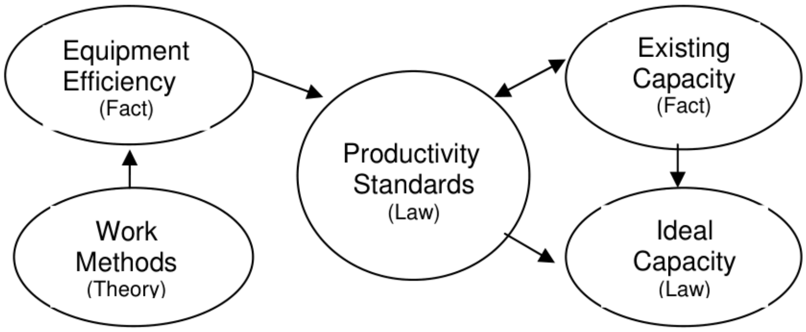

Figure 1. Capacity Planning Research Framework

Validation and further sampling on the secondary data (planned and actual performance reports and other documentation pertaining to subject workers and equipment) were scanned and analyzed.

Figure 1 illustrates the variables tested in this capacity planning framework study.

Hypotheses

1. Improving Equipment Efficiency and Work Methods will improve the Productivity Standards
2. Increasing Productivity Standards will directly increase Existing Capacity
3. Productivity Standards and Existing Capacity are reliable bases of Ideal Capacity

Research Design

To test hypothesis No.1: Discharging and loading processes were observed and areas for improvement were noted. Actual Observation (Control Set-up) was conducted against the Mediation of Proposed Methods (Experimental Set-up) which was coordinated with the section head concerned. Worker skill and methods and his intervention with machine shall be randomly verified in actual and other samples shall be based on performance reports. Prior and Post Experimental data on trial of proposed or improvements in work methods were analyzed.

For Hypothesis No. 2: Productivity Rates of past periods were tested with the sampling period's Existing Capacity based on reported performance. Equipment Logsheet, working time, downtime, idle time, set-up time, and maintenance time were verified. Utilization rate was compared against the productivity rate set-out for equipment. Between man and machine, the efficiency rating of the machine shall override the efficiency rating of man or machine/equipment operator.

For Hypothesis No.3: Planned discharging and loading for a certain vessel, the ETC and ETD, equipment and worker complements were traced with the actual performance reports. The Plan against Performance Reports and against Overall Available or Ideal Capacity (Assigned and Unassigned Berthing Time) were compared.

The sampling period shall cover two weeks, one week day-shift observation and one week night-shift observation. The berthing schedule, discharging and loading sequence, the gang complement and quay crane as well as truck allocation shall be secured and compared with the performance reports for the same production schedule of 2 weeks. The quay crane acquisition date, the existing efficiency rating, the utilization rate for the past 2 weeks prior to sampling period, the current deployment times, the model and brand were noted.

There is no more test needed for increasing Equipment Efficiency against Productivity Standards or against Capacity since *High utilization can lead to a reduction in operational efficiency, increased congestion and reduced service levels on both shipside and landside (UK Parliament's Committee on Transport, 2003)*. T-Test, Analysis of Variance and F-Test for analyzing Multiple Group Experiment were utilized where deemed applicable among the 3 hypotheses.

Findings
The overall results are presented in Table 1 wherein Hypothesis 1 is True, Hypothesis 2 is Not Always Applicable while Hypothesis 3 favors Productivity Standards more than Existing Capacity on certain circumstances.

Hypothesis 1	Hypothesis 2	Hypothesis 3
YES, True	NOT ALWAYS	Only with Updated Standards; Existing Capacity applicable if matches the Standards but at times underperformed

Table 1. Overall Results Summary

The comparative results of the observation, report scanning, work methods mediation, and records analyses are summarized in Table 2.

Tests on Hypothesis / Area Observed	Hypothesis 1 (Improving Equipment Efficiency and Work Methods will improve Productivity Standards)	Hypothesis 2 (Increasing Productivity Standards will directly increase Existing Capacity)	Hypothesis 3 (Productivity Standards and Existing Capacity are reliable bases for Ideal Capacity)
On Board Job	Gang composition is too much. Reduction not easy. Contract and protection from the labor union	N.A. – Deployment Negotiated and Dictated by the Collective Bargaining Agreement (labor)	Yes because of previously accepted agreement between terminal operator and labor union
Dockside	Quay crane operator works at normal pace as planned using schematic diagram. Delays during positioning and releasing of containers atop the yard trucks just situated below the crane. Both are unique and dependent to each other; Variable condition per equipment	Not consistent; quay cranes have reach constraint due to built; if r seasonal weather not considered during standard setting; or quay crane preventive maintenance and set-up time are not inclusively established in the Performance Report (basis of Existing Capacity).	NO because equipment operational history of Existing Capacity is not in the performance report; thus, Existing Capacity is Independent is not affected by Productivity Standards. It is reactive. Fluctuating productivity rates of equipment; sometimes have notation of repair but mostly, no remarks.
Dockside/Landside Interface	Yard trucks not consistently parked on a convenient position. Drivers position the trucks off-lane, The crane has to tilt the cable to fit the locks of the container on the chassis. Delay is 1.5	Truck's productivity rate (planned assumptions) matches with existing capacity if quay crane performance has no unpredictable interruptions and	No, because what is assumed standard during dry season and rainy season when records were scanned, were just the same. Maintenance standards were not on a per machine basis when considered by Planning.

	minutes per TEU. If 23 TEU/hr/crane, then that is **50% more**: 23x1.5=34.5 minutes extension for a supposed 1 hr work	truck drivers do not cause any delay; Truck and quay crane performance is supposedly complementary and no lost time or waiting time for both.	Machines are variable and when actual allocation of machine, the net productivity rate sometimes are assumed instead of the per machine or equipment rate. Standards are not comprehensively considered in what Varbanova (2011) cited.
Landside	Turnaround time of trucks delayed; Outgoing containers, prioritized. Yard congestion or lane choking	Overall quayside and landside performance (ETC) is more than **30%** unmet	No; utilization not optimized with congestion or movement obstruction in the yard, predetermined yard location, distances, and transport times

Table 2: Comparative Summary of Naturalistic and Participant Observation

If quay side manner of movement of containers is improved, trucks aligned and positioned orderly under the quay crane, not tilted, the productivity rate may even reach 34 to 35 TEUs per hour per crane which is still attainable in other ports. Some ports even reach around 50 TEUs. ETC is also bound to have minimized deviation from actual time of completion of discharging/loading.

Conclusions and Recommendations

Improving Equipment Efficiency (Quay Cranes and Yard Trucks) and Work Methods (flow and manner of equipment operation) correspondingly improved the Productivity Rates by 50% more. Improvements are on the elimination of unwanted moves, process slowdown, misuse of equipment or awareness of its capabilities/limitations, and dependable information systems (diagrams and reports).

Increasing Productivity Standards does not directly increase Existing Capacity especially if the constraints considerations are not at explicit precision and predetermined interruptions are not allocated in the planning stage. Existing Capacity may also exceed Productivity Standards if Plan assumptions were understated but most of the time, missed the Productivity Standard as manifestation of non-updated productivity rates and uncalculated delays translate to more than 30% unmet ETC. Planning and standards setting lose its essence if unmet plans persist.

Productivity Standards and Existing Capacity are NOT reliable bases of Ideal Capacity. They are if normal condition and assumptions (standards) are up-to-date; and if berths are fully utilized without lost times and unacceptable delays (not selective equipment-related or formalities/weather/tug-related); But in the analyses of the variances between the three variables, Productivity Standards, if dependable and realistic (proactive), are better basis of Ideal Capacity. Existing Capacity is Reactionary but a sure yardstick of Standards applicability and operational performance.

Lastly, with Work Methods enhancement, with skilled and enlightened personnel, efficient equipment at optimal, not maximum utilization, with updated and dependable assumptions/Productivity Standards, and with corrective/reflective Existing Capacity execution and documentation, the ultimate outcome, Ideal Capacity, may be computed. It is on the basis of a per variable equipment productivity with respect to total working time available (number of shifts) for work, factored in with the utilization rate as delays, interruption and interface anticipated plus the differentiation in trends of vessels size and built.

Such computed capacity may therefore be used as comparison to the projected demand. If negative variance (pent-up demand), at some periods, then a decision for either berth or both berth and quay crane and other complementary support services be acquired or provided. Positive variance provokes added marketing efforts or energy consumption and other preventive measures. If no variance at all, maintain status quo.

Reliable Productivity Standards assumed in Ideal Capacity are beneficial when considering reaction to changes in Gross Domestic Product (trade influx of imports and exports) and in the overall growth of this logistics network (terminal operators, shippers, shipbuilders, ocean liners, and forwarders).

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Author Biography
Industrial Engineering degree earned at Adamson University, Manila with units in teaching program at Philippine Normal University and in masteral program at the University of the Philippines. She is currently a Consultant on Feasibility Studies (New Entrant or Substitute Venture/Product Innovation, or in Curriculum Design), Management Services, and on Technical Communications. A presenter, trainer, and engineering project defense panelist.

She had worked as Corporate Researcher, Industry Lecturer for Engineering and Logistics Management, Special Projects Manager of a Travel Company, Systems Analyst and Program Logic Designer of Industry and Local Government Information Systems, Executive Assistant to SVP-Operations, Operations Auditor, Retail and Trading Methods Analyst, and Reengineering Consultant in some industries in Metro Manila.

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