DETACHING LANDSIDE FROM WATERSIDE OPERATIONS IN BIG-SHIP CONTAINER TERMINALS

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This paper is a sequel to my previous Port Technology paper "Big Ships and Densification of Container Terminals" (June 2019). Both papers are concerned with big-ship terminals' need to expand capacity while facing shortage of waterfront land. The container yard (CY) takes most of the waterfront area and therefore its capacity is the main constraint on overall terminal capacity. The previous paper focused on measures to increase CY capacity without expanding its area, using technology to increase storage density, including a novel High Bay System and high-density versions of present yard cranes. The previous paper intentionally ignored berth capacity, since for most terminals it far exceeds CY capacity. Yet, since the berth is the most essential and costly terminal component a brief discussion of its capacity is warranted.

Berth capacity is usually expressed by the formula:

Berth Throughput Capacity (TEUs/Year) = Number of Cranes per Berth x Crane Productivity (TEUs/hour) x Berth Utilization (%)

The first argument, the number of ship-to-shore (STS) cranes per berth, or crane density, depends on the design ship's length and configuration. Since STSs can only be positioned every other bay, up to 13 STSs can be deployed to handle a 24-bay, big ship of 24,000 TEUs. In reality, due to operational and financial considerations, the average number of STSs handling big ships is around 6. The second argument, crane productivity, depends on crane technology. Newer STSs, equipped with dual trolley, automated conning/deconning and tandem lift capability, already reach 40+ moves/crane-hour (e.g., Barcelona's BEST, Spain; Charleston, USA; Qingdao's QQCTN, China; Moody's recent report). Accordingly, productivity of 240 moves/berth-hour (6 x 40) is already within reach for big-ship terminals. Assuming 80% berth utilization, 1.7 TEUs/move and 10 days/year downtime, berth throughput capacity can reach 2.78 million TEUs/year (240 x 355 x 24 x 0.8 x 1.7) which, for a 400-m design ship is equivalent to 6,000 TEUs/m (2.78 / 460 x 1.000), compared with 2,000 TEUs/m currently achieved by most productive terminals. Future technologies are aimed at doubling crane density, among them: (a) STSs mounted on elevated runways similar to APMT's Fastnet, and (b) indented, 2-sided berths, similar to Amsterdam Container Terminal. A novel version of the indented berth, Konecrane's COFASTRANS, based on double-girder bridge cranes with four trolleys each, is planned to reach productivity of about 400 moves/berth-hour . Incidentally, 400 moves/berth-hour also is the current world's record, as recently

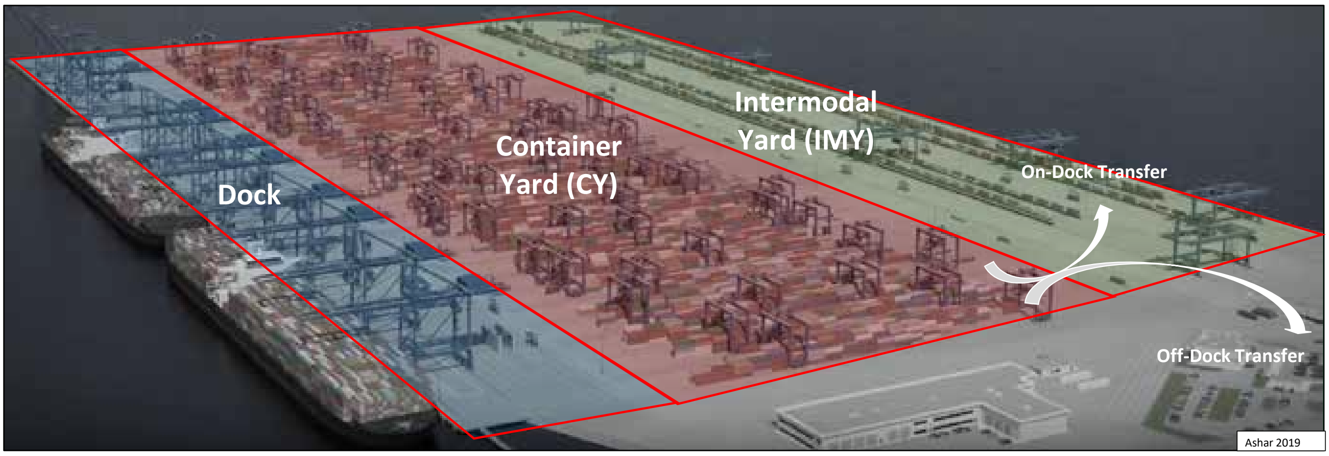


Figure 1: Roberts Bank 2 Planned Layout

reported by Salalah, Oman . It seems that in the near future, berth productivity of 280 moves/berth, declared "revolutionary" by Drewry, quoting Maersk Line , will be the norm for handling big ships. Altogether, berth capacity has the potential to grow 3 folds or more from its current level – if not constrained by CY capacity.

INCREASING CY CAPACITY TO MATCH BERTH CAPACITY

Achieving a similar, 3-fold increase in CY capacity is unattainable solely by densifying storage, even with the above-noted technologies. It requires much more radical measures:

- **Removing Non-Essential Functions** – Continue past trends of relocating outside the marine terminal storage sheds, CFS, and chassis parking to include administrative buildings, empty container yard, and intermodal railyard, using the area to increase the CY's area; and
- **Changing the Function of the CY** – Transfer the container storage and gate processing to off-dock CYs, resulting in reducing containers' dwell time at the marine terminal from the current 4–5 days to 1 day (or less).

The second measure is, in effect, a rearrangement of the entire port system: detaching landside operations from waterside operations – the subject of this paper. Before that, the following is a short discussion of the first measure, removing non-essential facilities, focusing on on-dock intermodal yards (IMY).

REMOVING ON-DOCK INTERMODAL YARDS

Most modern container terminals incorporate on-dock intermodal yards (IMY), occupying waterfront areas that could otherwise be used as CYs. For example, Figure 1 shows the planned layout of the future 2.5-million TEU Roberts Bank 2 (RB2) container terminal in Vancouver BC, Canada, to be constructed on an artificial island in deep water, connected to the mainland by a long and narrow causeway. The terminal area taken by the on-dock IMY is about half that of the CY's. Also, the on-dock rail-handling operation is cumbersome; it requires "shoving" long trains back & forth through the causeway, a costly maneuver which interferes with terminal operations. Alternatively, RB2's railbound traffic could be trucked to an IMY located at a near-dock location on the mainland, or, preferably, to the adjacent IMY of Deltaport's GCT, which can be expanded to serve both terminals. The expanded IMY will be operationally more efficient and the larger railbound traffic volume will provide for better rail services. Despite the longer trucking distance, the cost difference between on-dock and off-dock transfers should be insignificant, if conducted by self-driving trucks using a port-dedicated road (see below discussion on the "devaluation of drayage"). The pay-off for removing RB2's IMY and dedicating the entire island's area to a CY would be dramatic -- increasing the CY's capacity, as well as that of the entire terminal, by 50%. Another possibility is to substantially reduce the size of the island and save on the costly deep-water reclamation, or use the area to support another dock on the opposite side of the island.

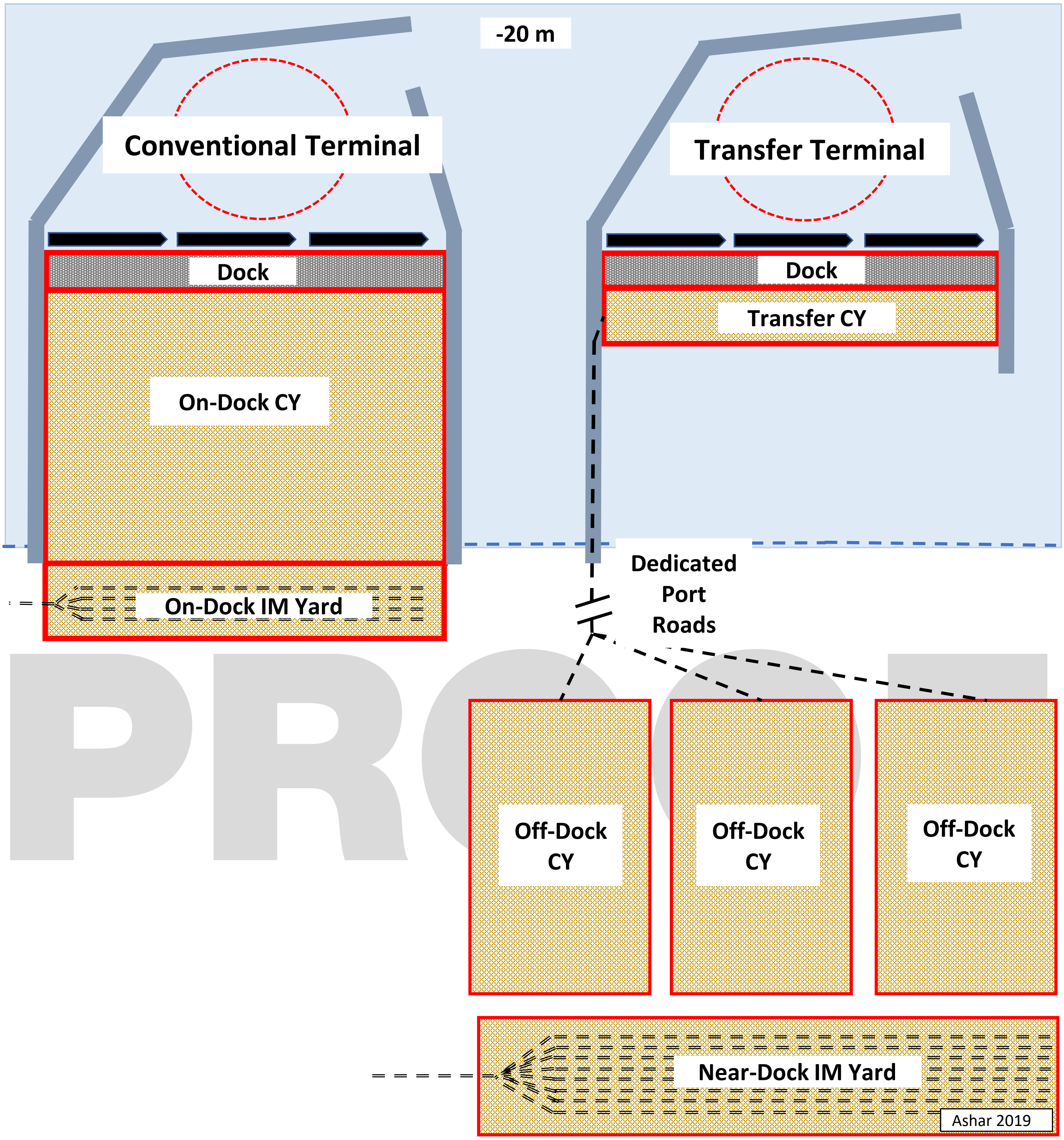
My studies of US on/off-dock IMYs suggest that allocating a scarce waterfront land to IMYs is economically justified only when the share of railbound traffic that can be efficiently handled on-dock approaches 30%. This indeed is the case with many US ports on both coasts (e.g., Los Angeles 35%, Norfolk 37%). Still, there are quite a few ports with relatively small railbound traffic, but with large on-dock IMYs (e.g. New York 15%, Rotterdam 11%). For these ports, the impact of railbound traffic on the local economy is limited, since it is usually destined/originated to/from far-away hinterlands. Also, since this railbound traffic is mostly discretionary, it can be better served by neighboring ports with ample waterfront lands. In conclusion, although it may border heresy, ports with a small percentage of railbound traffic and limited waterfront area should consider removing their on-dock IMYs, using the area to enlarge CYs and increase their CYs' and overall terminal capacity.

PURE PEEL-OFF TERMINALS

The previous paper discussed the growing trend among US West Coast ports of "peel-off" operations: storing import boxes upon their discharge from ship in unsorted "blocks" and, after a short stay, trucking them "en-block" to nearby, off-dock CYs. For example, in Los Angeles, SSA presently operates 3 off-dock CYs, transferring up to 2,000 boxes/day, mostly at night; the planned Harbor Performance Enhancement Center's off-dock CY is expected to transfer 4,000 boxes/day(!). In Long Beach, NEXT Trucking has recently inaugurated an off-dock CY; in Oakland there are already several operators offering peel-off services (also called "dray off" or "drop yard"). While currently applicable mainly to import boxes, off-dock CYs could also handle export boxes, saving on the drayage cost by facilitating dual-cycling.

There is nothing new in the concept of diverting some of the port's operations away from the waterfront. One example, Inland Container Depot (ICD) is designed mainly to avoid port congestion. ICDs are popular especially in developing countries (e.g., Nigeria, Ghana, Kenya, India, Bangladesh). Another example is the dry (inland, satellite) port, located in remote, hinterland area, is designed to save on trucking cost by providing connection via rail and barge. Interestingly, dry ports, which have been in operations for many years worldwide, have recently gained popularity with US East Coast ports (e.g., Norfolk, Charleston).

Thus far, peel-off operation has only been applied to some of the traffic at marine terminals. Why not apply it to all the traffic? In such a pure peel-off marine terminal, all boxes will be transferred en-block to/



from off-dock CYs immediately after/before ship arrival. These off-dock CYs will be providing storage and gate processing for all boxes; the on-dock CY will only serve as an operational buffer in support of ship-handling. Accordingly, in a pure peel-off terminal, the dwell time of boxes will be slashed from the current average of 4-5 days to 1 day or less. The reduction in dwell time will result in a proportionate increase in the CY's throughput capacity— allowing it to keep pace with berth capacity. Altogether, in the envisioned pure peel-off terminal, the landside operations will be "detached" from the waterside operations which, in effect, amounts to rearrangement of the entire port system.

Moreover, the envisioned pure peel-off terminal will only be dealing with a few "wholesale" customers, off-dock CY operators handling blocks of containers; there will be no dealing with myriad "retail" customers, individual shippers attempting to retrieve a specific container, which might be buried at the bottom of the pile. A close cooperation between on-dock and off-dock CYs will simplify the inter-CY transfer. Special "speed gates" with cameras and automated barriers will eliminate the need for paper documents and physical survey of equipment and testing of road-ability. Accordingly, in a pure peel-off terminal there will be no need for elaborate gate facilities, including pre-gate parking, entry kiosks, multi-lane canopies, trouble lanes, administrative buildings, etc. And, since all handlings will be en-block, selectivity-oriented, high-density storage technologies such as High Bay System, will be of no use.

OFF-DOCK CYS' COSTS AND SAVINGS

Adding off-dock CYs to the port system entails additional costs due to double handling and, especially, inter-CY trucking (drayage). Ideally, the inter-CY drayage traffic should use dedicated port roads or, at least, special lanes where non-port traffic is prohibited (e.g., at night). The drayage should be conducted by electrified, self-driving trucks, platooning, and rubber-wheel trains (multi-trailer systems, MTS). As a result, the cost of drayage to/from off-dock CYs (and air pollution) will be radically reduced, substantially enhancing the economics of off-dock CYs. The envisioned "devaluation of drayage" will have a profound impact on the port system, similar to that of the "devaluation of selectivity" discussed in my previous densification paper; both devaluations are made possible by the combination of block operations and automation.

The savings generated by off-dock CYs will stem first from providing low cost storage, gate processing and related terminal services. Second, distributing the marine gate processing over several off-dock CYs will diffuse the traffic concentration and congestion around it and reduce trucking costs. If, in the future, off-dock CYs add logistic functions, there will be additional savings in trucking costs, since off-dock CYs will become final origin/destination points for the containerized cargo. Still, the main saving will be the substantial increase in the capacity of the on-dock CY along with that of the entire marine terminal.

CONVENTIONAL VS. TRANSFER TERMINALS

Figure 2 illustrates the envisioned re-arrangement of the port system, using a hypothetical case-study of a port authority considering building a new terminal for big ships, based on a massive, deep-water reclamation. The Figure's left side shows a conventional layout, with all terminal components located on-dock, including a large CY required to fully support the berth capacity. The Figure's right side presents an alternative layout, defined as Transfer Terminal, with a small on-dock CY, serving as an operational buffer. The storage and gate processing of containers are relocated to off-dock CYs, with the inter-CY connection provided by a dedicated network of port roads. The small on-dock IMY of the conventional layout is replaced here by a much larger, near-dock IMY. The near-dock IMY can also serve domestic containers and trailers, resulting in more frequent rail services to more destinations.

While Figure 2 refers to new terminals, the concept illustrated there also is applicable to existing terminals attempting to increase capacity while facing a shortage of developable waterfront land. Accordingly, these terminals could transform their operating system to pure peel-off, relocating the on-dock storage, gate and IMY operations outside the marine terminal, to near-port off-dock CYs and IMYs.

SPECIALIZATION: GATEWAY, TRANSSHIPMENT AND RAIL TERMINALS

The discussion above focused on gateway terminals, or terminals mainly handling local traffic via trucks, for which the landside operations of storage and gate processing are relocated to off-dock CYs. For terminals mainly handling transshipment traffic, there is no use for off-dock CYs since (a) the landside operations are quite limited; and (b) inter-ship dwell time is short. This also is the case with terminals mainly handling railbound traffic, which, as already argued above, should be handled by on-dock IMY. Accordingly, I envision an evolutionary process culminating with the emergence of three types of specialized marine terminals: gateway, transshipment, and rail, with each terminal having a different layout and yard system. Still, all three will have three common features – block operations, limited on-dock storage and limited gates.

My previous densification paper discussed the case of Jebel Ali's Terminal 4, arguing that a high-selectivity storage system is not required there, since about half of its traffic was transshipment. The other half, local cargo, is mostly destined/originated to/from the nearby FTZ. Accordingly, a plausible expansion plan for Terminal 4 could be based on splitting its yard system into: (a) for transshipment, on-dock, limited CY based on the existing crane system; and (b) for gateway, en-block trucking to off-dock CYs constructed at the nearby FTZ.

EXPANDING THE ROLE OF PORT AUTHORITIES

Developing a system of off-dock CYs and a road network to connect them to the marine terminals requires active intervention by port authorities in the region surrounding their marine terminals, beyond their traditional area of jurisdiction. Such an intervention mandates close cooperation with regional governments. In most ports, the land surrounding marine terminals is used for port-related activities such as chassis parking, empty box depots, warehouses, and truck terminals, some of which can be relocated farther away from the waterfront to provide land for off-dock CYs. However, some ports are tightly cordoned by residential and commercial areas, which may require re-zoning, buying out tenants and, in difficult cases, condemnations, as demonstrated by the recent land seizure by the City of Newark and the NY/NJ Port Authority. Developing a near-port road system could be mostly based on expanding existing roads with dedicated port-traffic lanes or, if impossible, allocating existing lanes during off-hours. But it may also require constructing new roads, including overpasses/underpasses, which may require heavy investments.

PARADIGM SHIFT: FROM WATERSIDE TO LANDSIDE

To recap, this paper explores a radical concept for increasing the capacity of land-constrained, big-ship container terminals: rearrange the entire port system by detaching the landside from the waterside operations. The rearrangement involves relocating the storage and gate processing from on-dock CYs to off-dock CYs, limiting the role of on-dock CYs' to serve as an operational buffer for ship handling. The rearrangement would allow present marine terminals to fully exploit their berth capacity, resulting in a 3-fold increase in overall terminal capacity.

Although seemingly radical, the proposed concept simply extends long-established (ICDs, dry ports) and recently-introduced (peel-off) trends to their logical end. Nonetheless, its implementation, especially the acquisition/condemnation of near-port land, construction of off-dock CYs and, especially, port roads, is going to be a long and arduous process, mandating close cooperation between port authorities and regional governments. Hence, the time to start thinking and planning for it is right now. The alternative, building new big-ship terminals, is incomparably more difficult and, for some ports, unattainable.

To conclude, this paper is a call for a paradigm shift in the thinking of the port industry in the era of big ships and scarcity of waterfront land: shift your attention from constructing new terminals to better utilizing existing ones – and from the waterside to the landside of port infrastructure.

ABOUT THE AUTHOR

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