TEXAS A&M UNIVERSITY GALVESTON CAMPUS

PORT OPERATIONS, ADMINISTRATION AND ECONOMICS

8. Port Terminals

MARA 416

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MANAGEMENT OF PORT FACILITIES AND INFRASTRUCTURE

A. Types of Port Terminals

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Port Terminals

- Ports as multifunctional entities
  - Combined activities of a number of specialized terminals.
  - Each terminal deals with specific goods and commodities (containers, grain, oil, or iron ore).
  - Each terminal developed for a specific function.
  - Single-user terminals (e.g., petrochemical plant).
  - Multi-user terminals (e.g., container terminal).

Types of Port Terminals

- Break-bulk terminals
  - Cargo carried in drums, bags, pallets, or boxes.
  - General-purpose facilities that combine open storage space and warehouses.
  - Most port terminals were built as multipurpose facilities.
  - Most commercial cargo was carried in break-bulk form.

General Cargo Terminal, Houston 1950's

General Cargo Terminal, Houston 1950's

General Cargo Terminal, Houston 1950's

Types of Port Terminals

- Neo Bulk and Ro-Ro terminals
  - Neo bulk terminals handle unitized cargo that is large in size (heavy equipment, project cargo or lumber), with specialized equipment.
  - Ro-Ro terminals handle vehicles such as cars and trucks rolled on and off a vehicle carrier.
  - The most important footprint of a Ro-Ro terminal is the parking space used to store vehicles.
  - Ferry terminals can handle a combination of passengers and freight (in vehicles).

Vehicles Boarding a RORO Ferry, Horten, Norway

Types of Port Terminals

- Containers terminals
  - Facilities are designed only to handle a single break-bulk standard transport unit.
  - Dominate the port terminal landscape because of the wide variety of goods that can be carried in containers.
  - Due to the storage requirement of containers; capital-intensive and require a large footprint.
  - Composed or large paved surfaces.
- Liquid bulk terminals
  - Commodities transported in liquid form require specialized transshipment equipment and storage facilities.
  - Common liquid bulk terminal facilities are designed to handle oil and petroleum products.

Types of Port Terminals

- Dry bulk terminals
  - Cargo that is not packaged.
  - Transported in large quantities that are limited by ship size or existing demand.
  - Coal, iron ore, and grain, which require specialized equipment and storage facilities.
  - Terminal cannot handle bulk products other than those it was designed and equipped to handle.
- Passenger terminals
  - Used to be handled at multipurpose facilities as liner ships also carried freight.
  - Ferry terminals are a specialized component (Greece and Japan).
  - The cruise industry has been associated with the setting up of cruise passenger terminals that can be extensive at turn port facilities (Miami and Barcelona).

Types of Port Terminals

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PORTS

GENERAL CARGO

Unitized Cargo

BULK CARGO

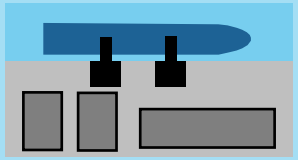
Loose Cargo

PASSENGERS

People and Vehicles

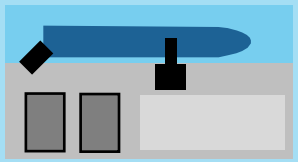
TERMINALS

Break Bulk



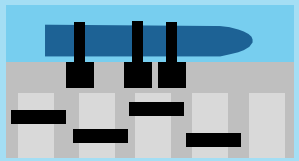
- General warehouses (Drums, bags, pallets, boxes)
- Lift-on/lift-off (1.0 day average port time)
- 7% of tonnage

Neo Bulk



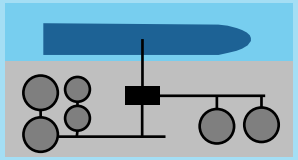
- Parking spaces and warehouses (Lumber, paper, steel, vehicles)
- Lift-on/lift-off, roll-on/roll-off (1.0 day average port time)
- 5% of tonnage

Containerized



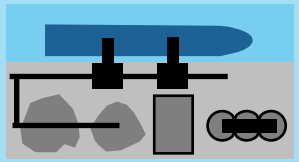
- Paved yards (Containers)
- Lift-on/lift-off (0.9 days average port time)
- 13% of tonnage

Liquid Bulk



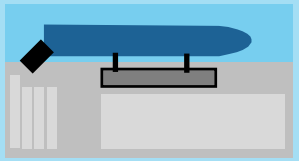
- Storage facilities (Petroleum, LNG, chemicals, vegetal oils)
- Pumps and pipelines (1.1 to 1.3 days average port time)
- 35% of tonnage

Dry Bulk



- Open or covered stacks (Coal, iron ore, grains, bauxite, sand)
- Grabs / suction and conveyors (2.7 days average port time)
- 40% of tonnage

Ferry & Cruise



- Parking spaces, waiting queues, and terminals
- Roll-on/roll-off, gangways (Less than 0.5 days average port time)

Port Terminal Design Fundamentals

- General cargo
  - Unitized cargo that can be carried in batches.
  - Designed around the lift-on/lift-off principle, requiring cranes and storage areas (covered and uncovered).
  - Vehicle terminals, a type of neo bulk terminals, are operated on the roll-on/roll-off principle and are dominated by parking areas.
  - General cargo terminals is a balance between the average throughput and the related storage requirements.

Port Terminal Design Fundamentals

- Bulk cargo
  - Loose cargo carried in loads that are limited only by demand, ship size, and storage capacity.
  - Synchronized at the bulk terminal (buffer between supply and demand).
  - Liquid bulk and dry bulk depend on different transshipment and storage techniques.
  - Two distinct categories of bulk terminals with design considerations.
  - Bulk terminals tend to specialize in handling a single commodity (coal, grain, iron ore, natural gas, or petroleum).
  - Commodities have unique equipment, storage, and design considerations.

Import-Oriented Dry Bulk Terminal: EMO Rotterdam

Read this content

Port Terminal Design Fundamentals

- Passengers
  - Ferry and cruise terminals are a small segment of port terminals.
  - Mainly roll-on/roll-off facilities with direct connectivity to the road system.
  - Larger facilities require significant parking areas, but infrastructures and equipment are simple, with mooring areas and ramps.
  - The growth of the cruise industry has led to the emergence of specialized cruise terminals.
  - Passenger handling facilities and parking areas that bear several similarities with airport terminals.
  - Cruise terminals might also be involved in freight activities related to the procurement of cruise ships.
  - May require separate terminal access and storage facilities, including cold storage.

Royal Caribbean Galveston Cruise Terminal (Pier Terminal)

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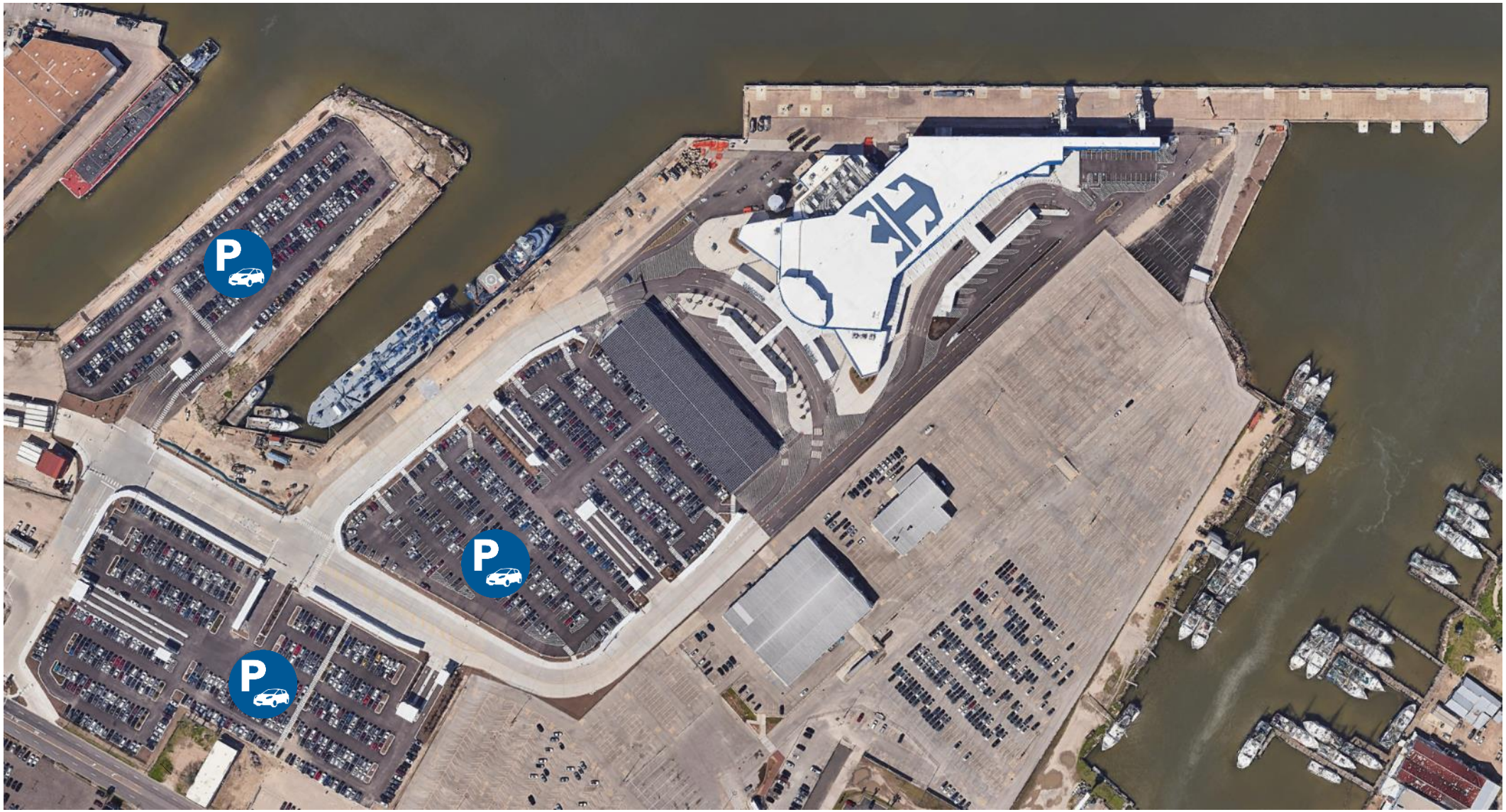


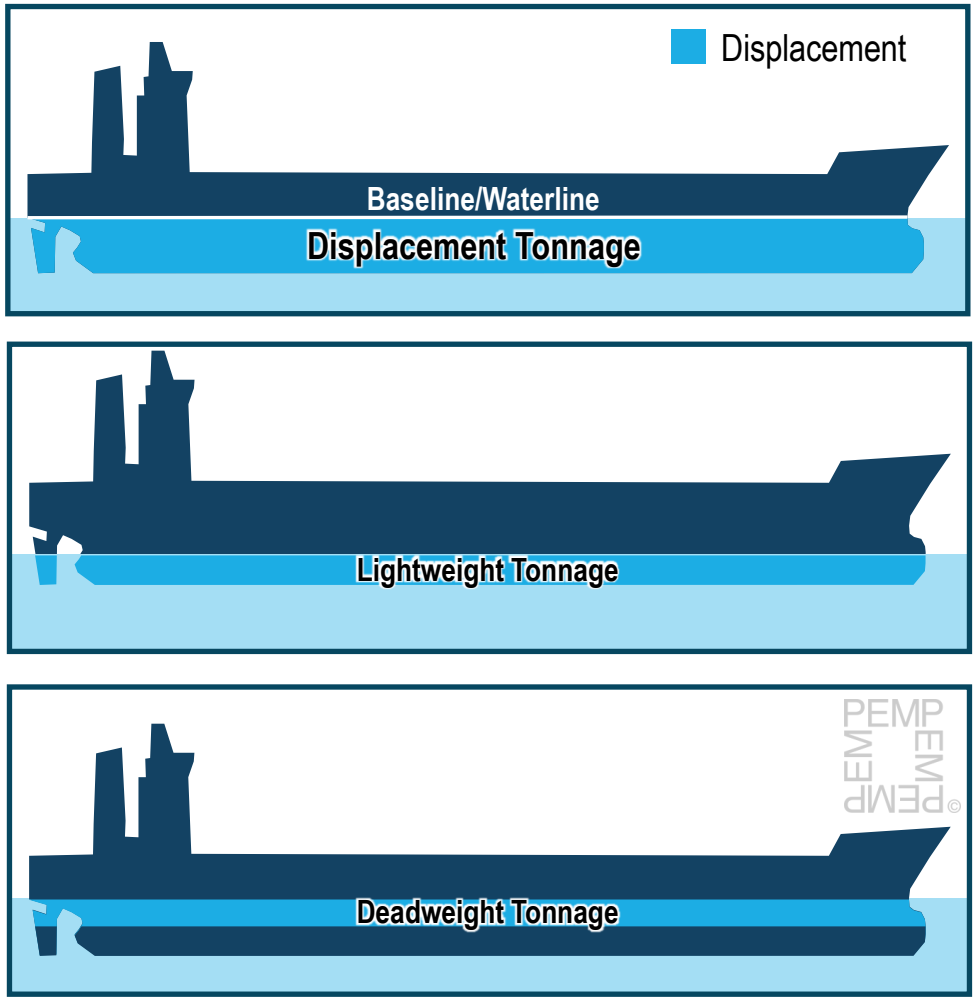
Port Terminal Design Fundamentals

- Level of port integration
  - Even if in the same port terminals may have no particular commonality in the supply chains they are servicing.
  - A multi-terminal port may not be an integrated entity.
  - Share common maritime and inland infrastructure.
  - Relationship between port and terminal design and the characteristics of ships.
- Panamax standard
  - Substantially influenced terminal design.
  - Draft and length, around which infrastructure was built.
- Increase in ship size
  - Consideration of push factors in terminal design and equipment for new terminals.
  - Incentives for existing terminals to expand their technical capabilities.

Displacement and Tonnage

Read this content

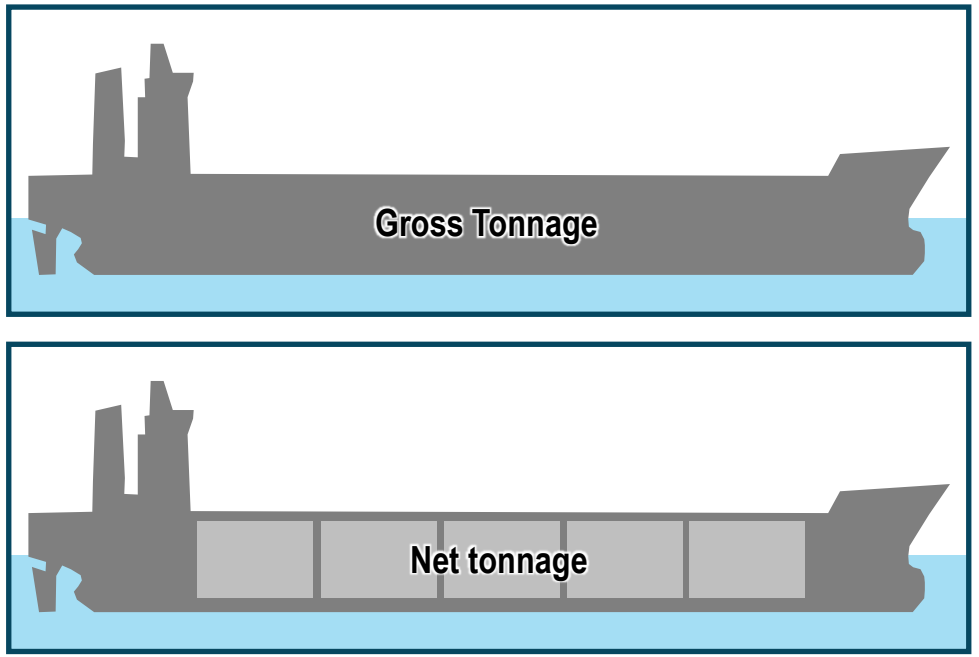
- Displacement tonnage (D)
  - Total weight of the ship when fully loaded.
  - Measured by using the weight of the water being displaced, expressed in metric tons.
- Lightweight tonnage (L)
  - The total weight of the ship when empty.
  - Measured by using the weight of the water being displaced, expressed in metric tons.
- Deadweight tonnage (DWT)
  - Maximum weight that a ship can carry.
  - DWT=D-L.
  - Expressed in metric tons and includes bunker and stores.



Displacement and Tonnage

Read this content

- Gross tonnage (GT)
  - Total volume of a ship converted into tonnage.
  - Measured as volumes of all enclosed spaces and expressed in cubic meters.
  - To determine the fees that a ship will pay to use a canal (Panama GRT, or Suez GRT) or a port.
- Net tonnage (NT)
  - Subtracting the volume occupied by the engine room and the space necessary for the operation of the ship (crew quarters, bridge, etc.) from the gross tonnage.



Displacement and Tonnage

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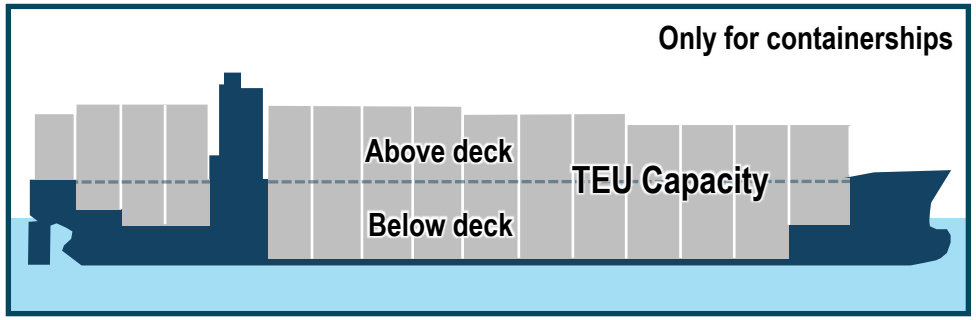
- TEU Capacity
  - Only for containerships or ships able to carry containers.
  - Estimate of the volume in Twenty-Foot Equivalent Units that can be carried without impairing visibility or exceeding the baseline (waterline).
  - Slot capacity (fixed): Total number of containers that can be put in the carried slots.
  - Loadable capacity (variable): Total number of containers that can be loaded on a ship, based on its weight and stability limits.

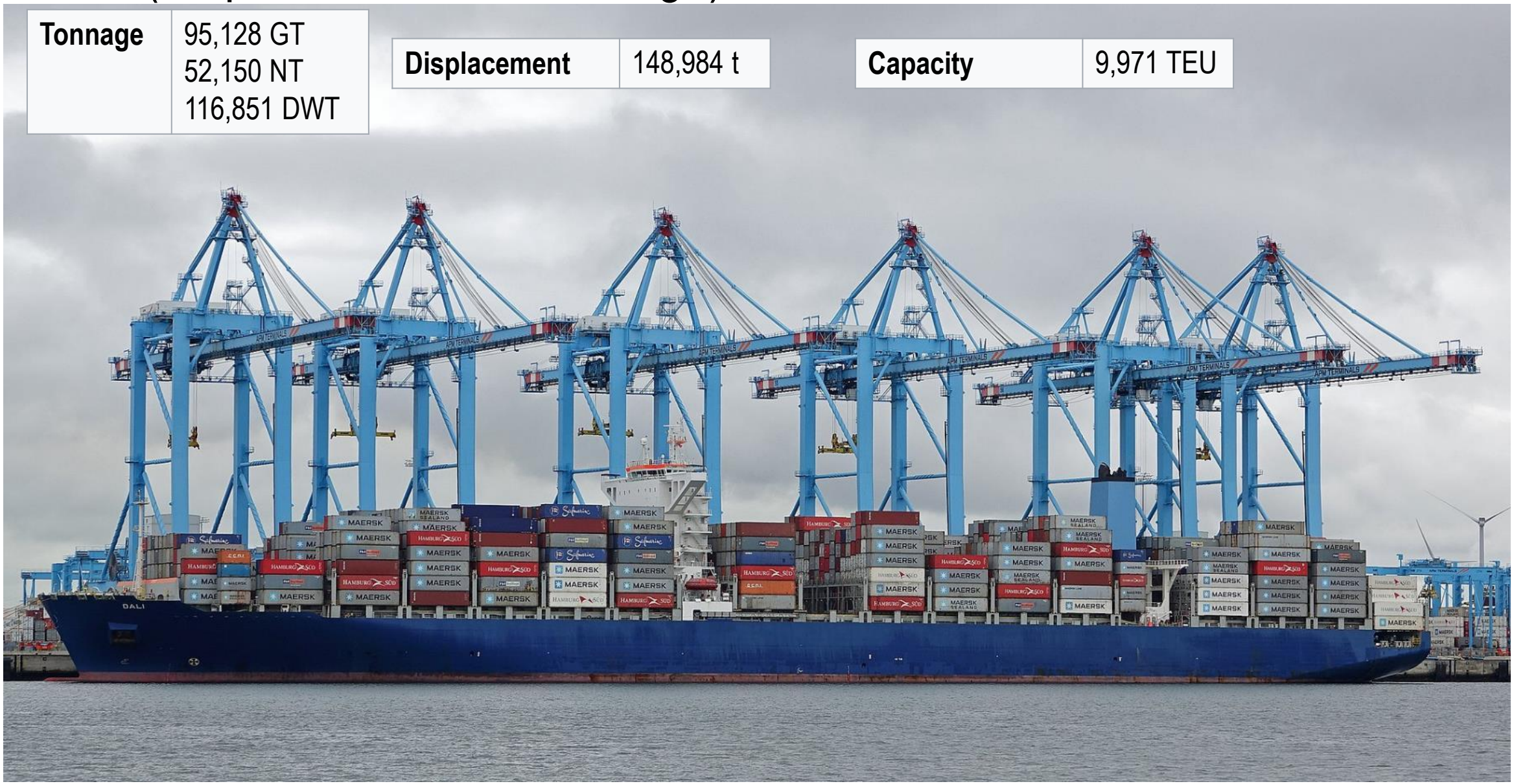


MV Dali (Displacement and Tonnage)

Tonnage	95,128 GT 52,150 NT 116,851 DWT

Displacement	148,984 t

Capacity	9,971 TEU



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MANAGEMENT OF PORT FACILITIES AND INFRASTRUCTURE

B. Terminal Operators

Read this section

Private Involvement in Port Terminal Operations

- Context
  - Late 1980s, public ownership and operation were dominant models.
  - Forms of port governance differed greatly (municipally-owned to state-owned ports), but publicly managed port operations were prevalent.
  - High institutional entry barriers and limited to specific services.
  - Contrast with the shipping industry (private ownership almost universal).
  - Containerization:
    - Underlined how operationally deficient were public port authorities.
    - Difficulty to adapt to growing time and performance requirements imposed on intermodal transport chains.

Private Involvement in Port Terminal Operations

- Rationale for private involvement
  - Promote competition:
    - Belief that the transport industry as a whole should be divested.
    - Ports were among the many sectors targeted by economic liberalization policies.
  - Deregulation:
    - Free highly controlled port industry.
    - Allowing new entrants.
- Port devolution
  - The public sector relinquishing its role.
  - Consideration of various forms of privatization.

Typology of Port Holdings

- Concessions as a dominant form of port terminal management
  - Privatization has sparked a trend toward awarding port operational concessions.
  - Rapid growth of international trade required massive and rapid capital investments.
  - Most governments could not readily provide.
  - Rise in the number of companies seeking concessions.
- Port holding
  - An entity, commonly private, that owns or leases port terminals in several locations.
  - Also known as a port terminal operator.
  - Three main categories:
    - Pure stevedores.
    - Maritime shipping companies.
    - Financial holdings.

Typology of Port Holdings

- Pure stevedores
  - Operators expanded into new markets to replicate their terminal operations expertise and diversify revenue.
  - Horizontal integration.
  - Stevedores account for about 50% of the hectares controlled by terminal operators worldwide.
  - Moved beyond terminal operations by investing in (inland) logistics service provision.
  - PSA International
    - Headquarters in Singapore.
    - Largest global terminal operator coming from a stevedore background
  - Hutchison Ports
    - Headquarters in Hong Kong.

Typology of Port Holdings

- Maritime shipping companies
  - To help support their core maritime shipping business.
  - Vertical integration.
  - Hybrid structures are formed with separate business units or sister companies active in liner shipping or terminal operations.
  - Terminal facilities can be operated on a single-user dedicated base or be open to third-party shipping lines.
  - Shipping lines account for about 31% of the hectares controlled by terminal operators worldwide.
  - APM Terminals
    - Maersk Line sister company.
    - One of the largest global terminal operators from a maritime shipping background.

Typology of Port Holdings

- Financial holdings
  - Financial interests ranging from investment banks and retirement funds to sovereign wealth funds.
  - Attracted by the port terminal sector as an asset class and with revenue generation potential.
  - Asset diversification.
  - Indirect management approach:
    - Acquiring an asset stake and leaving the existing operator to take care of the operations.
  - Others will directly manage the terminal assets through a parent company.
  - Interested because of high-value proposition.
  - Holdings account for about 19% of the hectares controlled by terminal operators worldwide.

Typology of Global Terminal Operators

Read this content

A. STEVEDORES

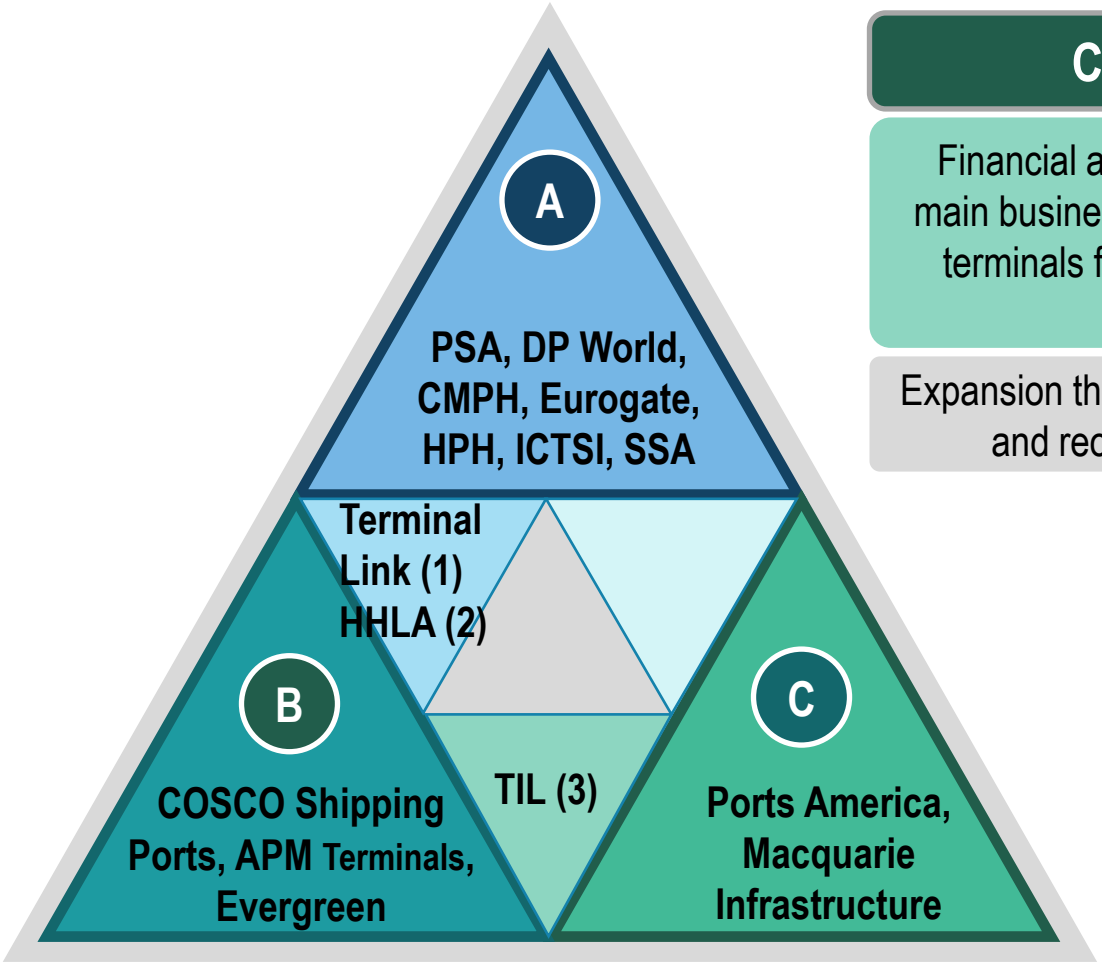
Terminal operation is a key activity but often delivered as part of wider (inland) logistics services.

Expansion through direct investment.

B. CARRIER-LINKED

Maritime shipping is the main business; Investment in container terminals as part of carrier's logistics integration.

Expansion through direct investment or parent companies.



C. HOLDINGS

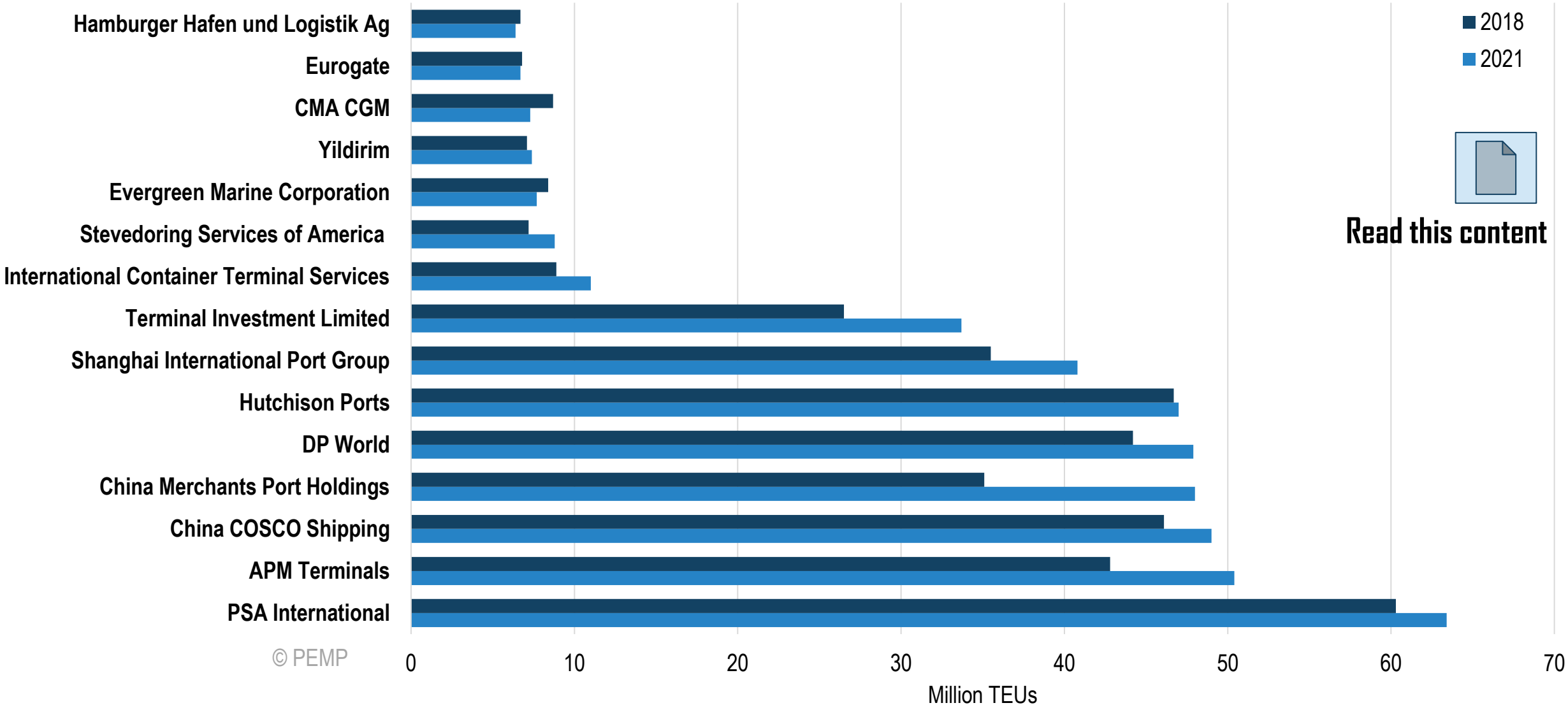
Financial assets management is the main business; Investment in container terminals for valuation and revenue generation.

Expansion through acquisitions, mergers and reorganization of assets.

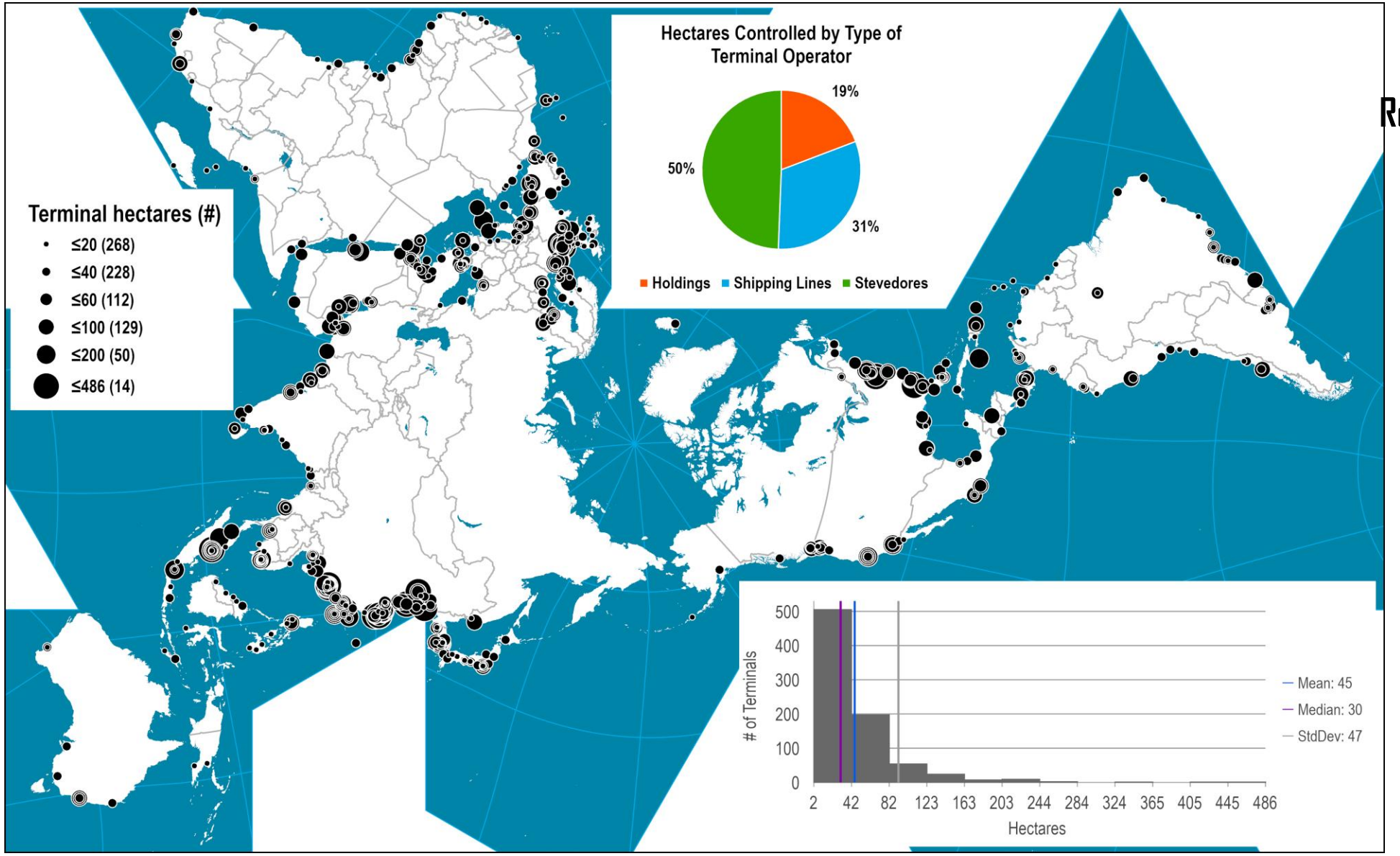
PEMP ©

(1) CMA CGM (51%); China Merchants Port Holdings (CMPH) (49%)
(2) Free and Hanseatic City of Hamburg (50.1%); MSC (49.9%)
(3) MSC (60%); GIP Global Infrastructure Partners (30%); GIC Government of Singapore Investment Corporation (10%)

Largest Global Container Terminal Operators by Equity-Based Throughput, 2018-21



Footprint of Container Terminal of the World's Major Terminal Operators, 2024



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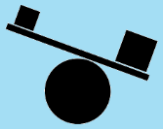
Typology of Port Holdings

- Freight transport companies
  - Shipping agents, freight forwarders, road and rail transport companies, and third-party logistics service providers.
  - Bollore (France), Arkas (Turkey), Wilson (Brazil), Kuwait Gulf Link, Rennies (South Africa), Korea Express (South Korea), Nippon Express (Japan), Severstahltrans (Russia), and Kontena Nasional (Malaysia).
- Construction companies
  - Engineering firms involved in container terminal concessions through private finance initiatives or attempts to secure terminal construction contracts.
  - Acciona (Spain), Gammon (India), Tribasa (Mexico), Tucuman (Brazil), Samsung Corporation, and Hyundai Development (South Korea).

Typology of Port Holdings

- Equipment manufacturers
  - Specialist companies that have moved into concessions from their original base in equipment servicing.
  - Could be perceived as an unfair competitive practice since they would be providing equipment to competing operators.
  - Portek (Singapore), ABG Heavy Industries (India), and Mi-Jack (USA).
- Property developers
  - Diversified from commercial and residential developments into the provision of concessioned infrastructure.
- Industrial conglomerates
  - Diversified holding companies or large manufacturers (steel or automobile companies).

The Strategies of Terminal Operators

FINANCIAL ASSETS		• Large financial assets and the capacity to tap global financial markets. • Terminals as equity generating returns.
MANAGERIAL EXPERTISE		• Experience in the management of containerized operations. • IT and compliance with a variety of procedures.
GATEWAY ACCESS		• Creation of a “stronghold”. • Provides a stable flow of containerized shipments. • Development of related inland logistics activities.
LEVERAGE		• Negotiate with freight transport providers favorable conditions. • Some are subsidiaries of maritime shipping companies.
TRAFFIC CAPTURE		• Capture and maintain traffic for their terminals.
GLOBAL PERSPECTIVE		• Comprehensive view of the state of the industry. • Anticipate developments and opportunities.

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MANAGEMENT OF PORT FACILITIES AND INFRASTRUCTURE

C. Port Terminal Construction

Read this section

Types of Port Site Developments

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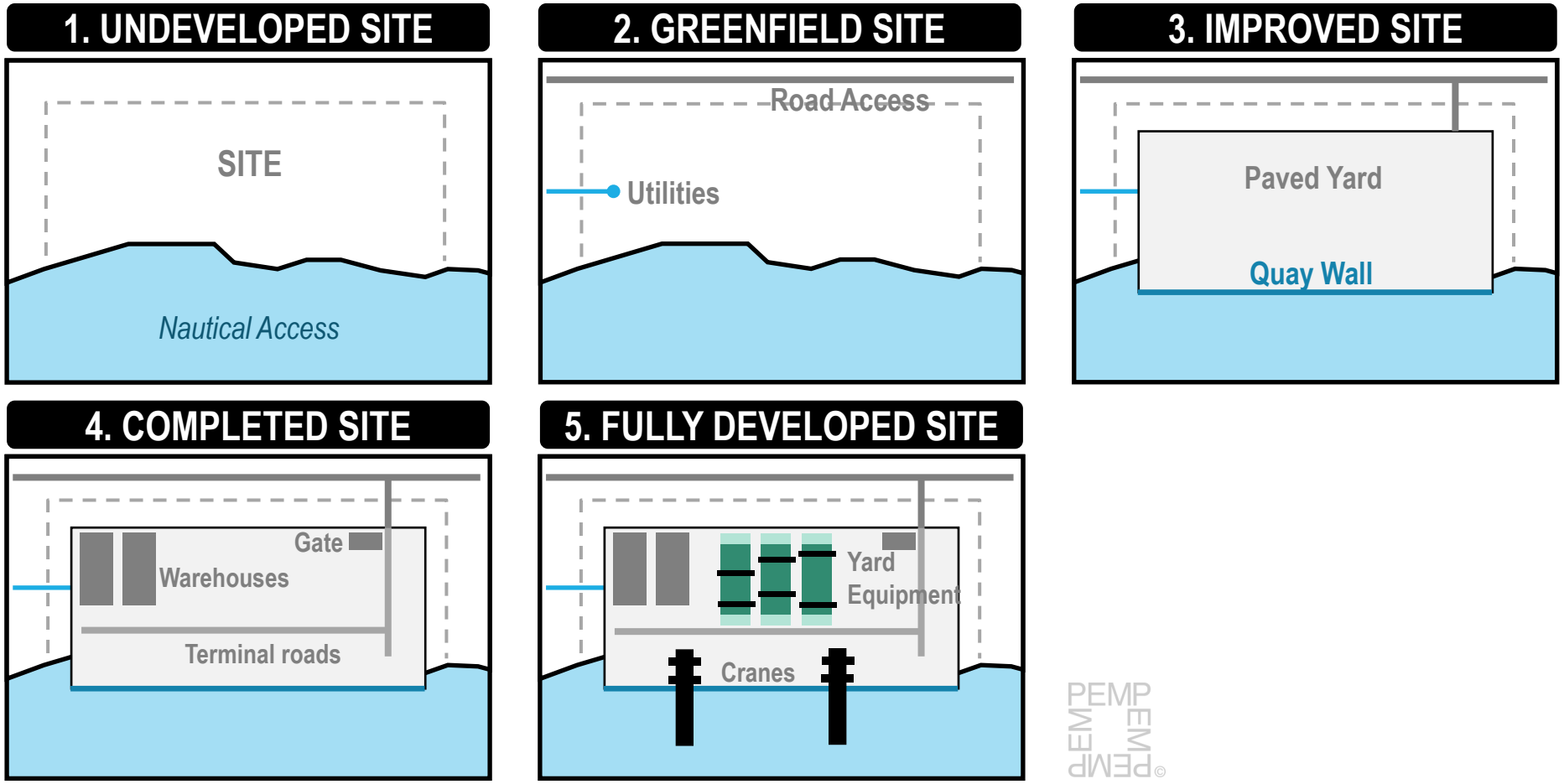

Risk and Site Characteristics

- Undeveloped site
  - The operator must develop infrastructure and superstructure, including the terminal, road connectors, and utilities.
  - Nautical access is usually provided by the port authority.
- Greenfield site
  - Infrastructure, such as roads and utilities, is reaching the site boundary.
  - The operator develops the terminal infrastructure and superstructure.
- Improved site
  - A quay line and paved yard but without buildings or handling equipment.
- Completed site
  - Civil works completed, but the operator supplies quay cranes and yard handling equipment.
- Fully developed site
  - A site that included quay cranes but the operator supplies yard handling equipment.

Technical Risks in Port Financing

- Source of cost overruns and delays
  - The application of innovative techniques and technologies (automation).
  - Design changes, including terminal function.
  - Land acquisition and availability.
  - Delays in project approvals and permits (red tape).
  - Changes in construction legislation (safety) and default by the contractor (materials).
  - Archaeological findings.
  - Construction contract variations or default from one of the contractors.
  - Availability of finance (cash flow) and force majeure such as a natural disaster.

Market Risks in Port Financing

- Source of incorrect assessment of the demand
  - No established regional trade with projections based on unproven market expectations, such as those associated with a new free trade zone.
  - Established regional trade with substantial transshipment.
  - Established hinterland general cargo trade but with a low market penetration factor.
  - Established regional and national trade but open to competition from other terminal operators within the same or a nearby port.
  - Established container trade and need for facilities upgrade.

Funding and Financing of Terminal Development

- Funding
  - Provision of capital at no interest for developing the port project (e.g. state grants, internal reserves).
  - The capital is not necessarily expected to be recovered.
- Financing
  - Capital lent is regarded as an investment.
  - Comes with an interest rate (e.g. commercial and investment banks, bond financing) or required rate of return for the investor.
  - The capital is expected to be recovered.

Port Terminal Infrastructure and Superstructure

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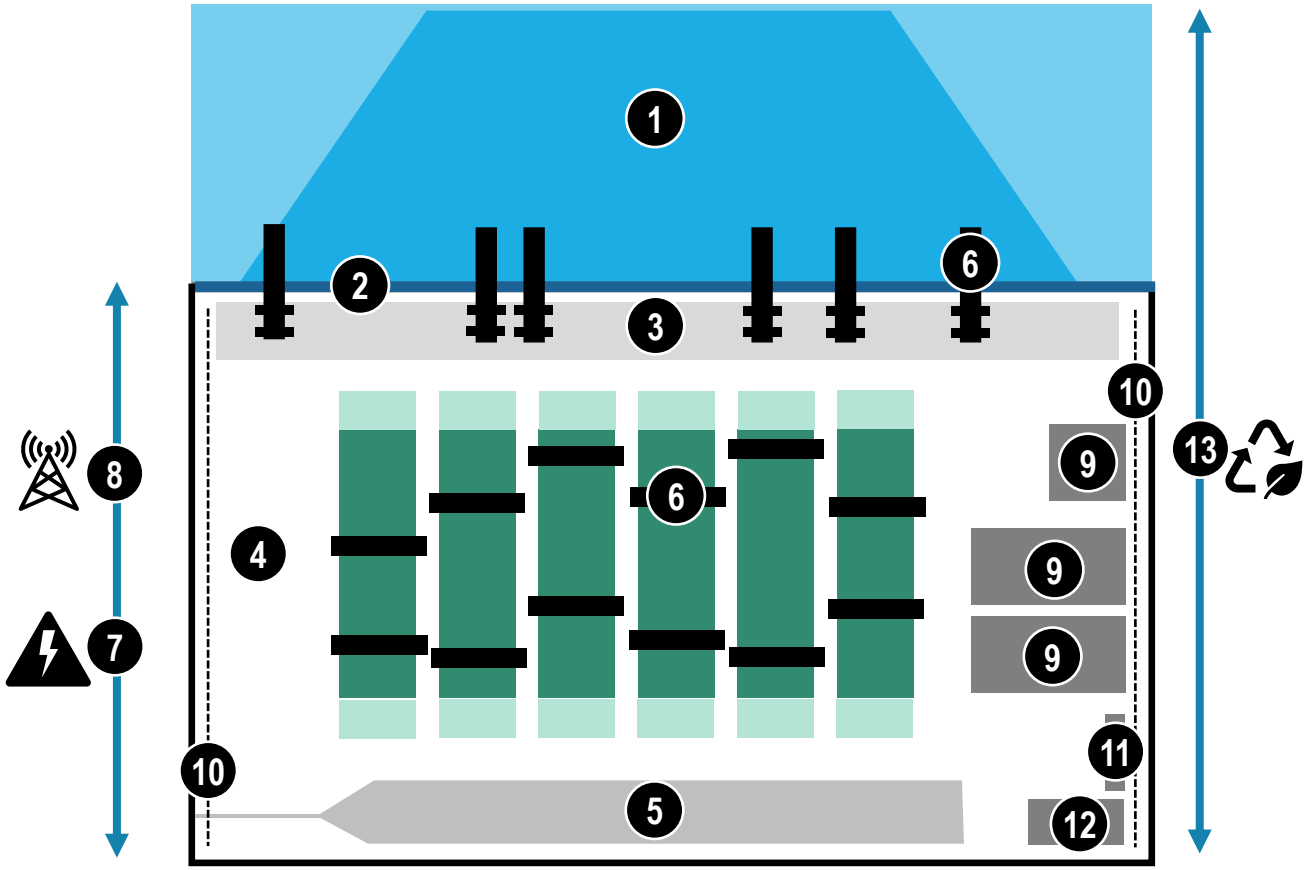


INFRASTRUCTURE

1. Land reclamation works, capital dredging and maintenance dredging.
2. Quay-wall construction and maintenance.
3. Apron, mooring equipment and fenders.
4. Paving and roads on the terminal.
5. On-dock rail facilities.

SUPERSTRUCTURE

6. Terminal handling equipment (cranes, yard equipment).
7. Electric installations and wiring.
8. Telecommunication installations and wiring.
9. Warehouses and technical buildings.
10. Fencing and video surveillance (port security).
11. Truck gates.
12. Office buildings.

REGULATORY

13. Environmental mitigation.

PEMP

Greenfield and Brownfield Sites

- Greenfield Sites
  - Extending a port on a vacant site along a river, estuary, or coastline.
  - Historically, the majority of port development projects were labeled greenfield, which often goes hand in hand with port migration.
  - The vacant site might be located in a green zone, wetland, or agricultural area.
  - Getting permission for a greenfield development usually takes a long time.
  - Existing spatial planning and environmental rules and regulations.
  - Required extensive project evaluation.

Greenfield and Brownfield Sites

- Brownfield Sites
  - Reconverting an existing (mostly industrial) site for terminal use.
  - Usually involves large-scale clean-up operations of contaminated soil.
  - Renovating and deepening the quay walls.
  - Rehabilitation and reuse of existing port real estate, avoiding lengthy and difficult port extension procedures.
  - Communities can remove dangerous structures and stop or stabilize contamination near waterways.
  - Opportunities for waterfront redevelopment, and it may catalyze revitalization in the broader community.
  - Frees space for various uses and creates more available property for sale or lease, providing ports with additional sources of revenue.
  - Can help alleviate pressure on undeveloped wetlands and coastal areas.

Greenfield and Brownfield Sites

- Land Reclamation
  - Based on hydraulic fill.
  - Sediment or rock excavated by dredgers from the seabed or other borrow areas is transported and placed into the designated reclamation area.
  - Well-graded quartz sands are the preferred material for landfills.
  - Preparatory engineering studies conducted to collect:
    - Bathymetrical (a measurement of the depth of bodies of water).
    - Topographical (physical features of the area)
    - Geological (soil and rock).
    - Geotechnical data (bedrock, soil, and groundwater stability).
  - Landfill quality and ground improvement to support the infrastructure and superstructure.

Nautical Access to Terminals

- Terminal construction
  - Adapting the nautical access to guarantee a minimum nautical draft for seagoing vessels
  - Deepen water depth near the quay wall and capital dredging work on the nautical route (river or sea) from the main shipping lane to the terminal site.
  - Widening channel to allow two-way vessel traffic, widening the breakwater entrance to the port terminal, or widening the turning basin for vessels.
- Capital dredging
  - Deepen and widen existing rivers or nautical access routes or create a new port or terminal.
- Maintenance dredging
  - Maintain an existing waterway or channel.
- Construction and engineering techniques have been standardized

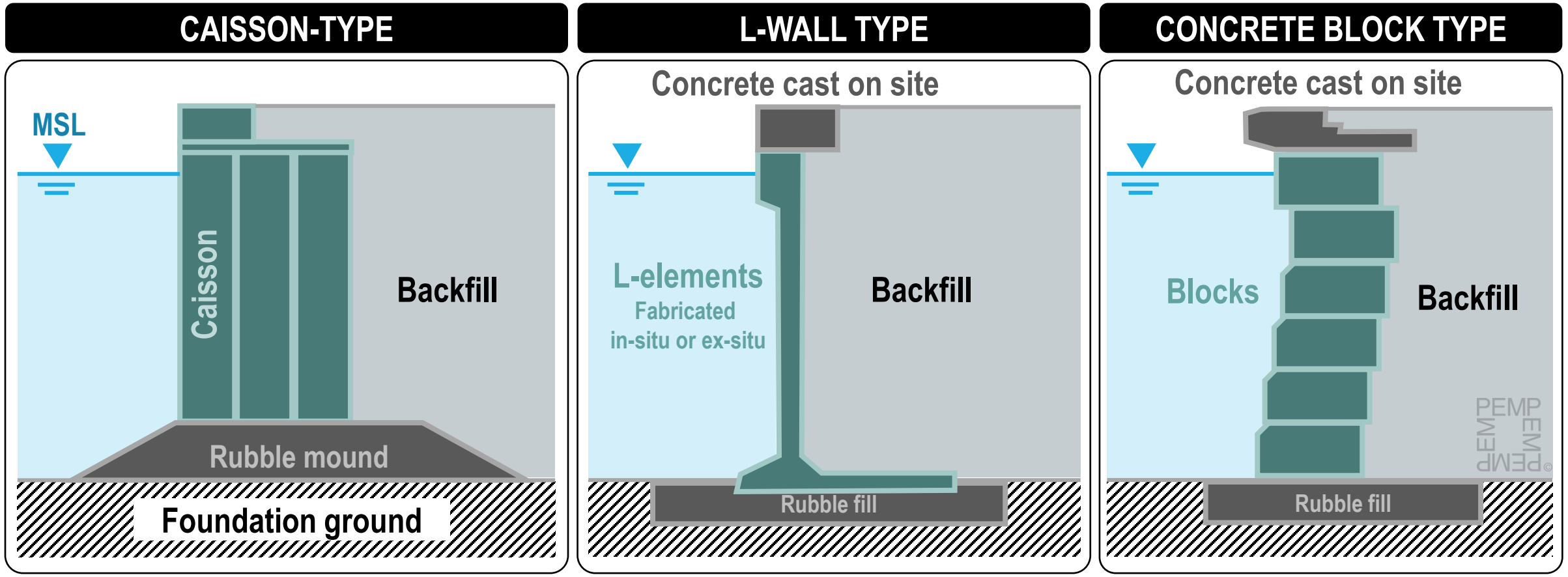
Port Approach Channels and Ship Maneuvering

- Draught-related factors
  - Under-keel clearance, wave-induced motions, and squat.
- Length-related factors
  - Design of navigation channels, berths, and turning basins.
- Air draft for vertical clearance under bridges and overhead electric cables
- Wind effects impacting navigation and the dispersion of dust, pollutants, and odors
- Support craft requirements, such as towage and tugs
- Existing and required aids to navigation
- Environmental factors
  - Protected areas, water pollution, and the disposal of dredging materials.
- Safety risks
  - Navigation (collision risk) and access to port facilities by trucks and rail equipment.

Quay Wall Construction

- Quay wall
  - Soil retaining structure that provides a mooring place for ships.
  - Bearing capacity for crane loads, goods, and storage.
  - Water-retaining function (occasionally).
- Embedded retaining walls
  - Embedded retaining walls are composed of interlocking pile elements and include sheet-pile walls and in-situ concrete pile walls.
- Gravity walls
  - Structures using their own weight for support.
  - Usually built behind a cofferdam in the dry and constructed in situ.
- Suspended deck structures
  - Structures may be made of steel, concrete, timber, or a combination.

Typical Cross-Sections of Gravity Quay Walls



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Caissons Used to Create a Quaywall, Tuas Container Port, Singapore

Block Wall Port Construction in Qatar