CHAPTER 6

Transport Terminals

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• The Function of Transport Terminals
• Transport Terminals and Hinterlands
• Port Terminals
• Rail Terminals
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The Function of Transport Terminals
Containerization and the Changing Operational Characteristics of Transport Terminals

**Conventional**
- Small terminal surface
- Direct transshipment possible
- Limited mechanization and automation
- Improvisation in terminal operations

**Container**
- Large terminal surface
- Indirect transshipment (modal separation in time and space)
- Advanced mechanization and automation
- Organization and planning
The Functions of Transport Terminals

- **Connectivity**
- **Interface**
- **Buffer**
Types of Intermodal Terminals

Port Terminals
- Container sea terminal
- Intermediate hub
- Barge terminal

Rail Terminals
- On-dock and near dock
- Transmodal terminal
- Load center
- Satellite terminal

Distribution Centers
- Transloading
- Cross-docking
- Warehousing
Integration between Port and Airport Terminals

Substitution

Complementarity

Maritime Transport
Air Transport
Road transport

Port
Airport
Transloading / stuffing
Logistics zone
# Main Characteristics of Intermodal Transport Terminals

<table>
<thead>
<tr>
<th>Core (Operations)</th>
<th>Ancillary (Added Value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure</td>
<td>Modal access (dock, siding, road), unloading areas</td>
</tr>
<tr>
<td>Equipment</td>
<td>Intermodal lifting equipment, storing equipment</td>
</tr>
<tr>
<td>Storage</td>
<td>Yard for empty and loaded containers</td>
</tr>
<tr>
<td>Management</td>
<td>Administration, maintenance, access (gates), information systems</td>
</tr>
<tr>
<td>Trade facilitation</td>
<td>Free trade zone, logistical services</td>
</tr>
<tr>
<td>Distribution centers</td>
<td>Transloading, cross-docking, warehousing, light manufacturing, temperature controlled facilities (cold chain)</td>
</tr>
<tr>
<td>Storage depot</td>
<td>Container depot, bulk storage</td>
</tr>
<tr>
<td>Container services</td>
<td>Washing, preparation, repair, worthiness certification</td>
</tr>
<tr>
<td>Function</td>
<td>Overview</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Processing</td>
<td>Operations on the goods. Includes sorting, packaging, testing, assembling.</td>
</tr>
<tr>
<td>Distribution</td>
<td>Operations on the cargo. Consolidation, deconsolidation, transloading or cross-docking. Assembling LTL shipments.</td>
</tr>
<tr>
<td>Customs clearance</td>
<td>Releasing and/or inspecting inbound cargo. Assumed by a national customs authority.</td>
</tr>
<tr>
<td>Free trade zone</td>
<td>A sanctioned site where foreign and domestic goods are considered to be outside of the customs territory. Requires bounded transport and bounded warehousing.</td>
</tr>
<tr>
<td>Container depot</td>
<td>Handle containers (leased or carrier owned). Transfer custody of containers between shippers. Storing and servicing/repairing containers.</td>
</tr>
</tbody>
</table>
Freight Terminal Hierarchy and Added Value

- Transshipment Hub
- Gateway
- Intermodal Terminal
- Inland Port
- Port-centric
- Logistics Zone
- Freight Village
- Satellite Terminal

Size

Added Value
Physical Separation between Modes and Passengers / Cargo at Terminals
Freight Terminal Automation

Blockchain

Foreland
- Automated trains
- Automated ships/barges?

Terminal
- Automated Guided Vehicles
- Automated Stacking Cranes
- Container Position Determination
- Automated Mooring Systems
- Automated Ship to Shore Cranes
- Automated Intermodal Cranes
- Automated Gate Systems

Hinterland
- Automated Trucks
- Automated Warehouses

Port terminal related
- Intermodal terminal related
## Container Transloading

<table>
<thead>
<tr>
<th>Cause</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Consolidation</strong></td>
<td>Transferring the contents of smaller containers into larger containers (e.g. three maritime 40 foot containers into two 53 foot domestic containers). Cost savings (number of lifts). Time delays.</td>
</tr>
<tr>
<td><strong>Weight issues</strong></td>
<td>Transferring the contents of heavy containers into loads meeting national or regional road weight limits (compliance). Remove the weight of the container (2.4 tons for a 20 TEU box and 4.3 tons for a 40 TEU box) and shift to a lighter load unit.</td>
</tr>
<tr>
<td><strong>Palletizing</strong></td>
<td>Placing loose (floor loaded) containerized cargo unto pallets. Adapting to local load units (e.g. europallet).</td>
</tr>
<tr>
<td><strong>Demurrage</strong></td>
<td>Handing back containers to owner (maritime shipping or leasing company) by transferring its contents into another load unit (e.g. domestic container).</td>
</tr>
<tr>
<td><strong>Equipment availability</strong></td>
<td>Making maritime containers available for exports and domestic containers available for imports. Trade facilitation.</td>
</tr>
<tr>
<td><strong>Supply chain management</strong></td>
<td>Terminal and transloading facility as a buffer. Delay decision to route freight to better fulfill regional demands. Perform some added value activities (packaging, labeling, final assembly, etc.)</td>
</tr>
</tbody>
</table>
Consolidation
Transferring the contents of ISO containers into domestic containers. Trade-off between less lifts and consolidation costs.

Weight Compliance
Transferring the contents of heavy containers into loads meeting national or regional road weight limits. Remove the weight of the container and shift to a lighter load unit.

Palletizing
Placing loose (floor loaded) containerized cargo unto pallets. Adapting to local load units (e.g. europallet).

Demurrage and Equipment Availability
Handing back containers to owning companies by transferring cargo into another load unit. Making maritime containers available for exports and domestic containers available for imports.

Supply Chain Management
Terminal and transloading facility as a buffer. Delay decision to route freight to better fulfill regional demands. Perform added value activities (packaging, labeling, final assembly, etc.)
### Advantages and Disadvantages of Transloading

<table>
<thead>
<tr>
<th></th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
</table>
| **Importers**        | Reduction of unit transport costs (three maritime 40 footer containers into two domestic 53 footers).  
                       | Added-value activities (sorting, packing, labeling, etc.).  
                       | Routing flexibility through postponement.                                  | Transloading costs.  
                       |                                                                              | Loss of at least one day of inland transit time.  
                       |                                                                              | Possible shortage of domestic containers.  
                       |                                                                              | Not all cargo suitable.  
                       |                                                                              | Reconciling different container loads (additional delays).  
                       |                                                                              | Risk of damage or theft of cargo during transloading.                      |
| **Maritime Shipping**| Limit repositioning of empty containers.  
                       | Higher asset utilization (faster container turnover).                      | Risk of container damage.  
                       |                                                                              | Less equipment available inland for exports.                                |
Terminal Costs

The diagram illustrates the relationship between distance and terminal costs for three different modes of transportation: Road (C1), Rail (C2), and Maritime (C3). The costs are plotted against distance on the graph, with each mode showing a distinct trend line.

- **Road (C1)**: Shows a moderate increase in costs as distance increases, indicated by the green line.
- **Rail (C2)**: Exhibits a steep increase in costs with distance, represented by the orange line.
- **Maritime (C3)**: Displays the lowest increase in costs with distance, depicted by the blue line.

The graph highlights the varying costs associated with different modes of transportation, with each mode's cost structure changing as the distance increases (D1, D2, D3).
Transport and Terminal Costs Tradeoff in a Maritime Transport Chain

Costs per TEU vs. Shipment Size

- **Minimal load**
- **Total Costs**
- **Terminal Costs**
- **Transport Costs**

Data for Shipment Size:

- 8,000 TEU
Transport Terminals and Hinterlands
Centrality and Intermediacy

- **Centrality**
- **Intermediacy**
- **Range**
- **Gateway**
- **Hub (Interception)**
- **Hub (Transcalar)**
The Hinterland of a Transport Terminal

- **‘Natural’ Hinterland**
- **Fundamental hinterland**
- **Competitive hinterland**
- **‘Island’**

A

B

Customer

Terminal

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Port Foreland and Hinterland

HINTERLAND  FORELAND

Main hinterland

Competition margin

A

B

C

D
Continuous and Discontinuous Port Hinterlands

- Main hinterland
- Maritime load centre
- Inland terminal
- Competition margin

- Continuous hinterland of Port A
- Continuous hinterland of Port B
- Discontinuous hinterland of Port A
- Discontinuous hinterland of Port B

Port A

Port B

"Island" formation
The “Boxed In” Hinterland

[Diagram showing a port connected to a border with a corridor. The diagram illustrates two types of hinterland: “Natural hinterland” and “Constrained hinterland.”]
Coastal, Landlocked and Relatively Landlocked Markets
The Space / Cost Dichotomy of Forelands and Hinterlands
Hinterland Setting and Major Economic Regions

North America

- Coastal concentration
- Landbridge connections
- Hinterland intensity

Western Europe

- Inland concentration
- Coastal gateways
- Freight corridor hierarchy

East and Southeast Asia

- Coastal concentration
- Low hinterland access
- Gateway hierarchy
## Types of Hinterland

<table>
<thead>
<tr>
<th>Concept</th>
<th>Macro-economic</th>
<th>Physical</th>
<th>Logistical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elements</td>
<td>Transport demand</td>
<td>Transport supply</td>
<td>Flows</td>
</tr>
<tr>
<td>Logistical sites (production and consumption) as part of commodity chains</td>
<td>Transport links and terminals</td>
<td>Mode, Timing, punctuality and frequency of services</td>
<td></td>
</tr>
<tr>
<td>Attributes</td>
<td>Interest rates, exchange rates, prices, savings, production, debt</td>
<td>Capacity, corridors, terminals, physical assets (fixed and mobile)</td>
<td>Added value, tons-km, TEU, Value of time, ICT</td>
</tr>
<tr>
<td>Challenge</td>
<td>International division of production and consumption</td>
<td>Additional capacity (modal and intermodal)</td>
<td>Supply chain management</td>
</tr>
</tbody>
</table>

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## Strategies Used by Port Authorities to Coordinate their Hinterland

| Usage of incentives | Coordinate operations of freight actors.  
<table>
<thead>
<tr>
<th></th>
<th>Optimal usage of transport chains.</th>
</tr>
</thead>
</table>
| Inter-firm alliances| Vertical integration (along transport chains).  
|                     | Horizontal integration (between competitors).  
|                     | Alliance between a maritime shipping company and a terminal operator (vertical).  
|                     | Equipment / container pools (horizontal). |
| Organisational scope| Vertical integration where an actor decides to penetrate a new market. |
|                     | A maritime shipping company involved in port terminal operations. |
|                     | A port authority developing an inland port. |
| Collective actions  | Public / private partnerships to create logistics parks. |
|                     | Each actor contributes within its realm of expertise. |
|                     | Development of port community systems. |
Terminals as Clusters and Growth Poles

Cluster Structure
- (Dis)agglomeration forces
- Internal competition
- Cluster barriers
- Heterogeneity

Cluster Governance
- Intermediaries
- Trust
- Leader firms
- Collective action regimes

Cluster Performance

Added value

Diagram:
A: Terminal dependent activities
B: Terminal client link

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Functional Integration of Freight Clusters

Scope

Scale

- Integrated
- Interdependent
- Coincidental

- Distribution center
- Terminal / Depot
- Port
Functions of Inland Terminals

A – Satellite Terminal
- Close to a port facility.
- Functions that have become too expensive at the port.
- Container transloading.

B – Load Center
- Access regional markets.
- Intermodal, warehousing, and logistics functions.
- Linked with logistics parks and foreign trade zones.

C – Transshipment
- Link systems of freight circulation.
- Through the same mode (e.g. rail-to-rail).
- Through intermodalism (e.g. rail-to-truck).
### Major Public and Private Actors in the Maritime / Land Interface

<table>
<thead>
<tr>
<th>Waterside</th>
<th>Port Complex</th>
<th>Inland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maritime shipping companies (Private)</td>
<td>Terminal operators (Private)</td>
<td>On-dock rail (Port Authority and terminal operators)</td>
</tr>
<tr>
<td>Waterways and navigation channels (Public)</td>
<td>Port operations (Port Authority)</td>
<td>Near-dock rail (rail companies; main, regional, short line)</td>
</tr>
<tr>
<td>Land ownership (Public and Private)</td>
<td>Trucking and barging (private)</td>
<td>Local roads (Public; municipal, county)</td>
</tr>
</tbody>
</table>
Port Terminals
Terminal Depth at Selected Ports

Terminal Depth
- Less than Panamax (12 meters)
- Panamax to New-Panamax (12-15 meters)
- Above New-Panamax (15 meters)

Importance of Maritime Routes
- Primary
- Secondary

Number of Ports

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## World Harbor Types and Sizes

<table>
<thead>
<tr>
<th>Type</th>
<th>Large</th>
<th>Medium</th>
<th>Small</th>
<th>Very Small</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal Breakwater</td>
<td>39 (29.8%)</td>
<td>105 (33.2%)</td>
<td>281 (23.8%)</td>
<td>388 (13.0%)</td>
</tr>
<tr>
<td>Coastal Natural</td>
<td>26 (19.8%)</td>
<td>89 (28.2%)</td>
<td>474 (40.1%)</td>
<td>1529 (51.4%)</td>
</tr>
<tr>
<td>Coastal Tide gates</td>
<td>5 (3.8%)</td>
<td>5 (1.6%)</td>
<td>18 (1.5%)</td>
<td>11 (0.4%)</td>
</tr>
<tr>
<td>Lake or Canal</td>
<td>3 (2.3%)</td>
<td>6 (1.9%)</td>
<td>26 (2.2%)</td>
<td>32 (1.1%)</td>
</tr>
<tr>
<td>Open Roadstead</td>
<td>18 (13.7%)</td>
<td>17 (5.4%)</td>
<td>97 (8.2%)</td>
<td>450 (15.1%)</td>
</tr>
<tr>
<td>River Basins</td>
<td>7 (5.3%)</td>
<td>20 (6.3%)</td>
<td>23 (1.9%)</td>
<td>27 (0.9%)</td>
</tr>
<tr>
<td>River Natural</td>
<td>25 (19.1%)</td>
<td>59 (18.7%)</td>
<td>248 (21.0%)</td>
<td>518 (17.4%)</td>
</tr>
<tr>
<td>River Tide gates</td>
<td>7 (5.3%)</td>
<td>14 (4.4%)</td>
<td>12 (1.0%)</td>
<td>14 (0.5%)</td>
</tr>
<tr>
<td>Total</td>
<td>131 (100%)</td>
<td>316 (100%)</td>
<td>1181 (100%)</td>
<td>2875 (100%)</td>
</tr>
</tbody>
</table>
Footprint of Container Port Terminals

Terminal hectares (#)
- ≤20 (257)
- ≤40 (220)
- ≤60 (107)
- ≤100 (117)
- ≤200 (52)
- ≤486 (13)
Port Sites and Functions

Port Site

Land Domain

Hinterland

Services to merchandises

Foreland

Maritime Domain

Infrastructures

Interface

Services to ships

Port Functions

Export Activities

Main Port

Inland Port

Rail transport

Feeder Port

Maritime transport

IP transport

Import Activities

Foreland

Hinterland

CONVERGENCE

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## Port Activities (to be updated)

<table>
<thead>
<tr>
<th>Category</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Land</strong></td>
<td>Land acquisition (purchase or lease)</td>
</tr>
<tr>
<td></td>
<td>Land reclamation projects</td>
</tr>
<tr>
<td><strong>Maritime Access</strong></td>
<td>Access channel dredging</td>
</tr>
<tr>
<td></td>
<td>Sea locks &amp; breakwaters</td>
</tr>
<tr>
<td></td>
<td>Vessel traffic service &amp; ship movement information networks</td>
</tr>
<tr>
<td></td>
<td>Light buoys &amp; navigational aids</td>
</tr>
<tr>
<td><strong>Port Infrastructure</strong></td>
<td>Internal locks; docks, quays, jetties, piers, berths</td>
</tr>
<tr>
<td></td>
<td>Harbor basin dredging</td>
</tr>
<tr>
<td><strong>Port Superstructure</strong></td>
<td>Pavement</td>
</tr>
<tr>
<td></td>
<td>Warehouses, sheds</td>
</tr>
<tr>
<td></td>
<td>Cranes and gantries and other mobile/semi-mobile equipment</td>
</tr>
<tr>
<td></td>
<td>Terminal and office buildings</td>
</tr>
<tr>
<td></td>
<td>Public utilities (sewage, water supply, electricity)</td>
</tr>
<tr>
<td><strong>Infrastructure Links</strong></td>
<td>Railways, roads, canals, tunnels and bridges within the port area</td>
</tr>
<tr>
<td><strong>Port Maintenance</strong></td>
<td>Maintenance dredging; infra and superstructure</td>
</tr>
<tr>
<td><strong>Port Services</strong></td>
<td>Cargo handling (stevedoring, storage, stowage)</td>
</tr>
<tr>
<td></td>
<td>Nautical services (pilotage, towage, mooring)</td>
</tr>
<tr>
<td></td>
<td>Other services (firefighting, water &amp; electricity supply, security, bunkering, pollution control, etc.)</td>
</tr>
<tr>
<td><strong>Port Planning</strong></td>
<td>Promoting logistics and industrial areas</td>
</tr>
<tr>
<td></td>
<td>Marketing to existing and potential users</td>
</tr>
<tr>
<td></td>
<td>Planning of infrastructure and superstructure developments</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Range of Activities Performed by Ports</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Land</strong></td>
</tr>
<tr>
<td>• Land acquisition (purchase or lease)</td>
</tr>
<tr>
<td>• Land reclamation projects</td>
</tr>
<tr>
<td><strong>Maritime access</strong></td>
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<td>• Sea locks &amp; breakwaters</td>
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<tr>
<td>• Light buoys &amp; navigational aids</td>
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<tr>
<td><strong>Port infrastructure</strong></td>
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<tr>
<td>• Internal locks; docks, quays, jetties, piers, berths</td>
</tr>
<tr>
<td>• Harbor basin dredging</td>
</tr>
<tr>
<td><strong>Port superstructure</strong></td>
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<tr>
<td>• Pavement</td>
</tr>
<tr>
<td>• Cranes and gantries and other mobile/semi-mobile equipment</td>
</tr>
<tr>
<td>• Warehouses, shops, sheds, and office buildings</td>
</tr>
<tr>
<td>• Public utilities (sewage, water supply, electricity)</td>
</tr>
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<td><strong>Infrastructure links</strong></td>
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<tr>
<td>• Railways, roads, canals, tunnels and bridges within the port area</td>
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<td>• Maintenance dredging; infra and superstructure</td>
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<tr>
<td>• Other services (firefighting, water &amp; electricity supply, security, bunkering, pollution control)</td>
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<tr>
<td><strong>Port planning</strong></td>
</tr>
<tr>
<td>• Promoting logistics and industrial areas</td>
</tr>
<tr>
<td>• Marketing to existing and potential users</td>
</tr>
<tr>
<td>• Planning of infrastructure and superstructure developments</td>
</tr>
</tbody>
</table>
Channel Depth at Major North American Container Ports

Containership Capacity (MLW Channel Depth)

- Panamax or less (4,200 TEU) (Less than 39 feet)
- Panamax (4,500 TEU) (39-40 feet)
- Post-Panamax I (6,000 TEU) (40-45 feet)
- Post-Panamax II (8,000 TEU) (45-48 feet)
- Neo-Panamax (12,000 TEU) (48-50 feet)
- Post Panamax III (16,000 TEU) (51 feet and above)
<table>
<thead>
<tr>
<th>Traffic Management</th>
<th>Vessel traffic management (fast turnaround, security, reliability). Management of inbound and outbound inland traffic. Partnership with barge, rail and truck operators for inland distribution.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area Management</td>
<td>Develop transport infrastructures. Provide space for port related activities (expansion or reconversion). Rationalize the land use.</td>
</tr>
<tr>
<td>Customer Management</td>
<td>Attract new customers. Retain existing customers (satisfaction). Find new added value activities.</td>
</tr>
<tr>
<td>Stakeholder Management</td>
<td>Influence regulation. Relations with local, regional and national public agencies.</td>
</tr>
</tbody>
</table>
## Contextual Evolution of the Dimensions Covered by Port Authorities

<table>
<thead>
<tr>
<th></th>
<th>Conventional Port Authority</th>
<th>Expanded Port Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Economic</strong></td>
<td>Port infrastructure management and operations.</td>
<td>Concession agreements.</td>
</tr>
<tr>
<td></td>
<td>Transport chain.</td>
<td>Logistical chain.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hinterland access.</td>
</tr>
<tr>
<td><strong>Institutional</strong></td>
<td>Centralized entity (node).</td>
<td>Decentralized entity (cluster).</td>
</tr>
<tr>
<td><strong>Environmental</strong></td>
<td>Environmental impact assessment.</td>
<td>Environmental management systems.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Port-city relationships.</td>
</tr>
<tr>
<td>Stages in Port Development</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Stage 1</strong></td>
<td><strong>Stage 2</strong></td>
<td><strong>Stage 3</strong></td>
</tr>
<tr>
<td><strong>Period</strong></td>
<td>Up to the mid 19th century</td>
<td>Mid 19th century to mid 20th century</td>
</tr>
<tr>
<td><strong>Development rationale</strong></td>
<td>Rise in trade</td>
<td>Industrialization</td>
</tr>
<tr>
<td><strong>Main port function</strong></td>
<td>Cargo handling</td>
<td>Cargo handling</td>
</tr>
<tr>
<td></td>
<td>Storage</td>
<td>Storage</td>
</tr>
<tr>
<td></td>
<td>Trade</td>
<td>Industrial manufacturing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dominant cargo</strong></td>
<td>General cargo</td>
<td>Bulk cargo</td>
</tr>
<tr>
<td><strong>Spatial scale</strong></td>
<td>Port city</td>
<td>Port area</td>
</tr>
<tr>
<td><strong>Role of port authority</strong></td>
<td>Nautical services</td>
<td>Nautical services</td>
</tr>
<tr>
<td></td>
<td>Land and infrastructure</td>
<td>Land and infrastructure</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Disadvantages of Scale

Maritime / Port Operations
- Less ports able to accommodate larger ships.
- Reduction in ship call frequency.
- Longer intra-port navigation.
- Longer berth space and berth time.
- Reduction in crane productivity.

Yard Operations
- Surges in yard haulage.
- Surges in yard storage.
- Surges in reefer slots usage.
- Security and customs inspection issues.

Gate / Hinterland Operations
- Surges in gate access.
- Increased local congestion.
- Supply chain adjustments (more lead time and inventory).
- Cargo risks (insurance).
<table>
<thead>
<tr>
<th>Ownership</th>
<th>Port admin.</th>
<th>Nautical management</th>
<th>Port infrastructure</th>
<th>Superstructure</th>
<th>Cargo handling</th>
<th>Pilotage</th>
<th>Towage</th>
<th>Mooring services</th>
<th>Dredging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public service port</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tool port</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Landlord port</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corporatized port</td>
<td>Public Responsibility</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private service port</td>
<td>Private Responsibility</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Public and Private Roles in Port Management
Transshipment Requirements for Liner Shipping Connections between Country Pairs, 2009

- One Transshipment: 62.0%
- Two Transshipments: 18.6%
- Three Transshipments: 2.2%
- Direct: 17.2%
Transshipment Requirements for Liner Shipping Connections between Country Pairs

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Rank / Size of the 25 Largest Container Ports, 1980-2010 (TEUs)

Absolute Traffic (TEU)

Port Traffic / Largest Port Traffic

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>North American West Coast</td>
<td>29.54</td>
<td>3.44</td>
</tr>
<tr>
<td>North American East Coast</td>
<td>27.1</td>
<td>5.5</td>
</tr>
<tr>
<td>Caribbean</td>
<td>23.14</td>
<td>3.17</td>
</tr>
<tr>
<td>South American West Coast</td>
<td>7.91</td>
<td>2.02</td>
</tr>
<tr>
<td>South American East Coast</td>
<td>12.13</td>
<td>2.35</td>
</tr>
</tbody>
</table>

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Rail Terminals
Types of Rail Terminals

Urban
Suburban
Airport

Passengers
- HSR
- Intercity
- Commuter
- Urban Transit

Freight
- Bulk
- RO/RO
- Breakbulk
- Intermodal

Port
Fluvial
Inland

Shunting
## Structuring Effects of Rail Terminals

<table>
<thead>
<tr>
<th>Adjacency</th>
<th>Passengers</th>
<th>Freight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster</td>
<td>Hotels, retail and restoration. Office parks.</td>
<td>Specialized storage (grain, minerals, chemicals). Heavy industries. Logistics zones.</td>
</tr>
</tbody>
</table>
Time to cover 700 km

- Hub-and-spoke trains: 12 hours
- Group trains: 8 hours
- Direct train: 10 hours

Rail Terminal
### Main Infrastructure Components of an Intermodal Rail Terminal Facility

<table>
<thead>
<tr>
<th>Component</th>
<th>Infrastructures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land</td>
<td>Loading/unloading area.</td>
</tr>
<tr>
<td></td>
<td>Stacking area (storage).</td>
</tr>
<tr>
<td></td>
<td>Gate access.</td>
</tr>
<tr>
<td></td>
<td>Potential for expansion.</td>
</tr>
<tr>
<td>Rail access</td>
<td>Spur (small terminal) or a through rail line (larger terminal).</td>
</tr>
<tr>
<td>Utilities</td>
<td>Lighting, drainage, sewage.</td>
</tr>
<tr>
<td>Operating facilities</td>
<td>Buildings (administration, maintenance, warehousing), scale.</td>
</tr>
<tr>
<td>Security</td>
<td>Gate, fence, surveillance.</td>
</tr>
</tbody>
</table>

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# Three Generations of Intermodal Rail Terminals

<table>
<thead>
<tr>
<th>Generation</th>
<th>Intermodal Equipment</th>
<th>Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>Side loaders</td>
<td>Chassis or grounded</td>
</tr>
<tr>
<td>2nd</td>
<td>RTGs</td>
<td>Chassis with some grounded (empties) or grounded</td>
</tr>
<tr>
<td>3rd</td>
<td>Wide span gantry cranes</td>
<td>Grounded</td>
</tr>
</tbody>
</table>
Airport Terminals
Factors Impacting Airport Traffic

- Demand Pattern:
  - Population
  - Tourism
  - Business
  - Manufacturing

- Network Connectivity:

- Competing airports

- Metropolitan area

- Airport property
  - Terminal
  - Extension
  - Runway
  - New runway

- Physical capacity
Geographical Scales of Airport Location

International/Global Network

National/Regional Network

Local (Airport City)
Hourly Level of Activity at Selected Airports, 2015

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Hourly Level of Activity at Selected Airports, 2015

- Tokyo (HND)
- Beijing (PEK)
- Singapore (SIN)
- London (LHR)
- Paris (CDG)
- Frankfurt (FRA)
- New York (JFK)
- Atlanta (ATL)
- Chicago (ORD)
- Dubai (DXB)
- Bogota (BOG)
Passenger Traffic at the World’s Largest Airports, 2018
Freight Traffic at the World’s Largest Airports, 2018

Total cargo in metric tons (2018)
- Less 250,000
- 250,000 to 1.0 million
- 1.0 to 2.0 million
- More than 2.0 million

Freight (in millions of metric tons)

New York (JFK): 1.4
Bangkok (BKK): 1.5
Amsterdam (AMS): 1.7
London (LHR): 1.8
Chicago (ORD): 1.8
Guangzhou (CAN): 1.9
Beijing (PEK): 2.1
Miami (MIA): 2.1
Paris (CDG): 2.2
Frankfurt (FRA): 2.2
Singapore (SIN): 2.2
Dubai (DXB): 2.2
Los Angeles (LAX): 2.2
Tokyo (NRT): 2.3
Taipei (TPE): 2.3
Louisville (OSF): 2.6
Dubai (DXB): 2.6
Anchorage (ANC): 2.8
Istanbul (IST): 2.9
Shanghai (PVG): 3.1
Mumbai (BOM): 4.5
Hong Kong (HKG): 5.1

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World’s Largest Air Passenger and Freight Airports, 2018

**Passengers (in millions)**

- San Francisco (SFO): 57.7
- Madrid (MAD): 57.9
- New York (JFK): 61.6
- Bangkok (BKK): 63.4
- Denver (DEN): 64.5
- Singapore (SIN): 65.6
- Jakarta (CGK): 65.7
- Incheon (ICN): 68.4
- Dallas (DFW): 69.1
- Frankfurt (FRA): 69.5
- Guangzhou (CAN): 69.7
- New Delhi (DEL): 69.9
- Amsterdam (AMS): 71.1
- Paris (CDG): 72.2
- Shanghai (PVG): 74.0
- Hong Kong (HKG): 74.5
- London (LHR): 80.1
- Chicago (ORD): 83.2
- Tokyo (HND): 86.9
- Los Angeles (LAX): 87.5
- Dubai (DXB): 89.1
- Beijing (PEK): 101.0
- Atlanta (ATL): 107.4

**Freight (in millions of metric tons)**

- New York (JFK): 1.4
- Bangkok (BKK): 1.5
- Amsterdam (AMS): 1.7
- London (LHR): 1.8
- Chicago (ORD): 1.8
- Guangzhou (CAN): 1.9
- Beijing (PEK): 2.1
- Miami (MIA): 2.1
- Paris (CDG): 2.2
- Frankfurt (FRA): 2.2
- Singapore (SIN): 2.2
- Doha (DOH): 2.2
- Los Angeles (LAX): 2.2
- Tokyo (NRT): 2.3
- Taipei (TPE): 2.3
- Louisville (SDF): 2.6
- Dubai (DXB): 2.6
- Anchorage (ANC): 2.8
- Incheon (ICN): 3.0
- Shanghai (PVG): 3.8
- Memphis (MEM): 4.5
- Hong Kong (HKG): 5.1

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World’s Largest Air Passenger and Freight Traffic by Metropolitan Area, 2018

**Passengers (Millions)**
- Sao Paulo: 73.7
- Washington: 74.5
- Hong Kong: 74.5
- Miami: 81.0
- Dallas: 85.3
- San Francisco: 85.7
- Seoul: 93.0
- Moscow: 96.7
- Dubai: 101.2
- Istanbul: 102.6
- Bangkok: 104.1
- Chicago: 105.3
- Paris: 105.4
- Atlanta: 107.4
- Beijing: 107.5
- Los Angeles: 112.5
- Shanghai: 117.6
- Tokyo: 129.5
- New York: 142.5
- London: 175.9

**Freight (Millions of Metric Tons)**
- Guangzhou: 1.9
- Beijing: 2.1
- Chicago: 2.2
- London: 2.2
- Singapore: 2.2
- Doha: 2.2
- New York: 2.2
- Miami: 2.2
- Paris: 2.3
- Taipei: 2.3
- Frankfurt: 2.3
- Louisville: 2.6
- Anchorage: 2.8
- Los Angeles: 3.0
- Seoul: 3.1
- Tokyo: 3.6
- Dubai: 3.7
- Shanghai: 4.2
- Memphis: 4.5
- Hong Kong: 5.1
Passenger and Freight Traffic at North American Airports, 2010

Airports with more than 1 M passengers

Airports with more than 25,000 tons of cargo

Total Passengers (2010)
- Less than 5 M
- 5 to 20 M
- 20 to 40 M
- More than 40 M

Cargo in Metric Tons (2010)
- Less 250 K
- 250 K to 1.0 M
- 1.0 to 2.0 M
- More than 2.0 M
Passenger and Freight Traffic at European Airports, 2010

Total Passengers (2010)
- Less than 15 M
- 15 to 25 M
- 25 to 50 M
- More than 50 M

Total Cargo in Metric Tons (2010)
- Less 250 K
- 250 K to 1.0 M
- 1.0 to 2.0 M
- More than 2.0 M

Airports with more than 1 M passengers
Airports with more than 25,000 tons of cargo
Passenger and Freight Traffic at East and Southeast Asian Airports, 2010

Total Passengers (2010)
- Less than 15 M
- 15 to 25 M
- 25 to 50 M
- More than 50 M

Total Cargo in Metric Tons (2010)
- Less 250 K
- 250 K to 1.0 M
- 1.0 to 2.0 M
- More than 2.0 M

Airports with more than 1 M passengers
- Airports with more than 25,000 tons of cargo

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Airport Components and Terminal Configurations

- Airfield
  - Runway
  - Taxiway

- Terminal
  - Standard
  - Pier
  - Satellite
  - Concourses
  - Shuttles
## Economics of Airport Terminals

<table>
<thead>
<tr>
<th>Activity</th>
<th>Revenues</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airside</td>
<td>Landing fees; Gate fees.</td>
<td>Ground navigation; Emergency services; Airside maintenance; Security.</td>
</tr>
<tr>
<td>Passenger processing</td>
<td>Service fees; Security fees</td>
<td>Terminal maintenance; Security; Luggage handling; Information systems</td>
</tr>
<tr>
<td>Concessions</td>
<td>Rent revenues; Profit share.</td>
<td>Terminal maintenance; Security.</td>
</tr>
<tr>
<td>Real estate</td>
<td>Rent revenues; Utilities; Maintenance.</td>
<td>Facility maintenance; Security.</td>
</tr>
</tbody>
</table>
Basic Airport Location Factors

**Benefits**

- **City Center**
  - **Commuting radius**
  - **High**
  - **Low**

**Costs**

- **High**
- **Low**

**Suitability**

- **High**
- **Low**

Location Ring

CDB
Distance from CBD and Age of the World’s Largest Airports

**R² = 0.4048**
<table>
<thead>
<tr>
<th>Country</th>
<th>Airport</th>
<th>Year Opened</th>
<th>Cost (USD Billions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dubai</td>
<td>Al Maktoum International Airport</td>
<td>2010</td>
<td>8.0</td>
</tr>
<tr>
<td>China</td>
<td>Hong Kong (Chek Lap Kok)</td>
<td>1998</td>
<td>20.1</td>
</tr>
<tr>
<td>Japan</td>
<td>Osaka (Kansai International)</td>
<td>1994</td>
<td>14.4</td>
</tr>
<tr>
<td>Japan</td>
<td>Nagoya (Centrair)</td>
<td>2005</td>
<td>7.3</td>
</tr>
<tr>
<td>South Korea</td>
<td>Seoul (Incheon International)</td>
<td>2001</td>
<td>5.8</td>
</tr>
<tr>
<td>Germany</td>
<td>Munich (Franz Strauss)</td>
<td>1992</td>
<td>5.3</td>
</tr>
<tr>
<td>USA</td>
<td>Denver International</td>
<td>1995</td>
<td>4.2</td>
</tr>
<tr>
<td>China</td>
<td>Beijing (Terminal 3)</td>
<td>2008</td>
<td>3.5</td>
</tr>
<tr>
<td>Malaysia</td>
<td>Kuala Lumpur International</td>
<td>1998</td>
<td>3.2</td>
</tr>
<tr>
<td>Thailand</td>
<td>Bangkok (Suvarnabhumi)</td>
<td>2006</td>
<td>3.3</td>
</tr>
<tr>
<td>China</td>
<td>Guangzhou (Baiyun)</td>
<td>2004</td>
<td>2.5</td>
</tr>
<tr>
<td>China</td>
<td>Shanghai (Pudong)</td>
<td>1999</td>
<td>1.4</td>
</tr>
<tr>
<td>Turkey</td>
<td>Istanbul (Istanbul Airport)</td>
<td>2019</td>
<td>12</td>
</tr>
</tbody>
</table>
Airport Hubbing Level

Share of Passengers Connecting

High

50%

25%

0%

None

Hub Network

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Customs Pre-Clearance Airports for the United States
Hubs of Major Air Freight Integrators