TEXAS A&M UNIVERSITY GALVESTON CAMPUS

PORT OPERATIONS, ADMINISTRATION AND ECONOMICS

6. The Evolution of Ports

MARA 416

Professor: Dr. Jean-Paul Rodrigue

Table of Contents

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PORT OPERATIONS, ADMINISTRATION AND ECONOMICS

A. The Geography of Ports

Read this section

Geographical Considerations

- Site and situation considerations
  - Site is fixed, but the situation changes.
- Port centrality
  - How a port is connected to its hinterland and to the economic density of its market.
  - A port with high centrality has a dense, well-connected hinterland.
  - A port with low centrality has a low-density hinterland with limited connections.
  - A more stable component of port geography, since economic conditions and the resource density of a hinterland change slowly.

Geographical Considerations

- Port intermediacy
  - How a port is connected to the global maritime shipping network.
  - Deviation from the main shipping lines.
  - A port with a high deviation (low intermediacy):
    - Requires a substantial deviation.
    - Commonly acts as a feeder.
  - Port with a low deviation (high intermediacy):
    - Does not require a deviation.
    - Can act as a hub (intermediary) port.
  - An unstable component of port geography as shipping networks and trade flows can change.

Geographical Considerations

- Gateways
  - A port with high centrality (strong hinterland access). A “go through” port.
  - Low to medium intermediacy.
- Feeders
  - A port with low to medium centrality.
  - High deviation.
- Port nexus
  - A port characterized by high centrality and intermediacy.
  - Considered the best maritime location in the world
  - Shanghai, Hong Kong, Busan, Tokyo, Los Angeles, New York, and Rotterdam.
- Pure hub ports
  - High maritime connectivity but poor hinterlands.
  - There are also pure hub ports, such as Panama, Freeport, Colombo, and Gioia Tauro.

Port Centrality and Intermediacy

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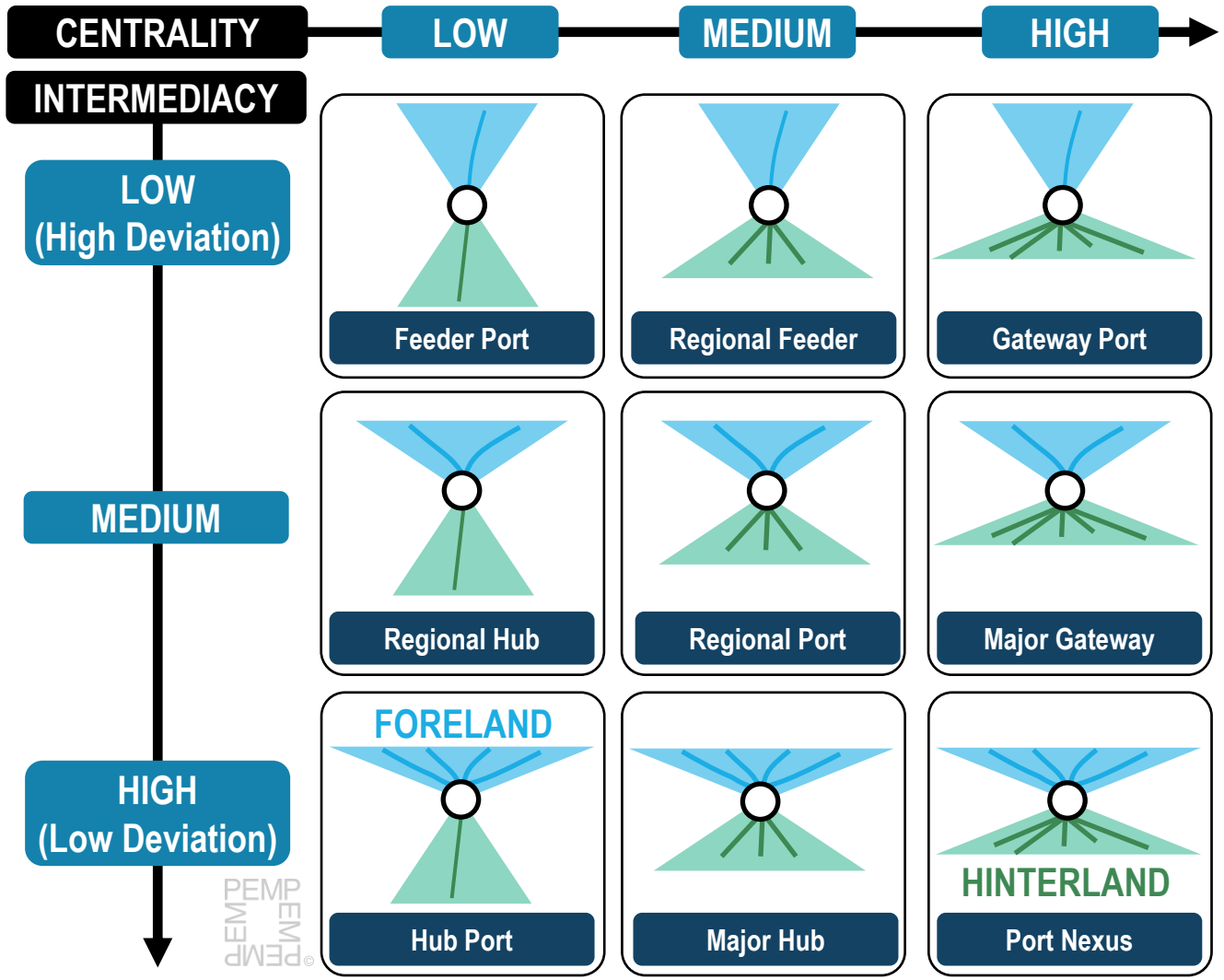

Historical Considerations

- Low maritime costs compared with hinterland costs
- Location of port cities
  - Reflected the nautical advantages of the site.
  - Enhanced by opportunities in the hinterland.
  - Uncertainties of sailing and the vulnerability of ships.
  - A protected harbor and a promontory were important factors in port site selection.
- The provision of a suitable harbor
  - Early issue in port development.
  - Ships spent a significant amount of time at harbors.
  - Need for protection from physical risks, such as wind and tides.
  - Ships carried valuable cargo; security risks, including piracy.
  - Requirements remained relatively unchanged through the ages.

Main Ports of the Roman Empire, c125 CE

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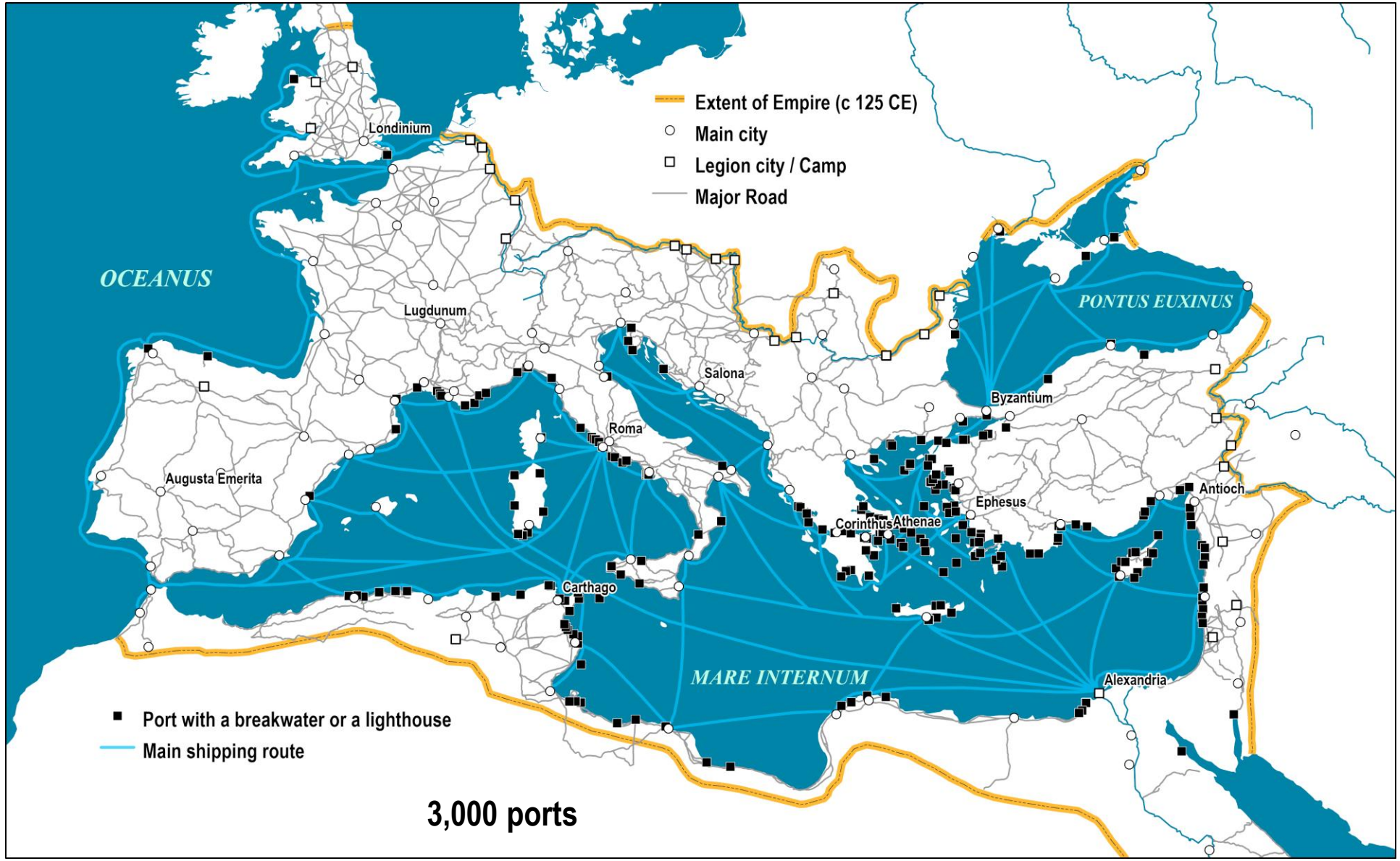

The Port of Portus, Ancient Rome

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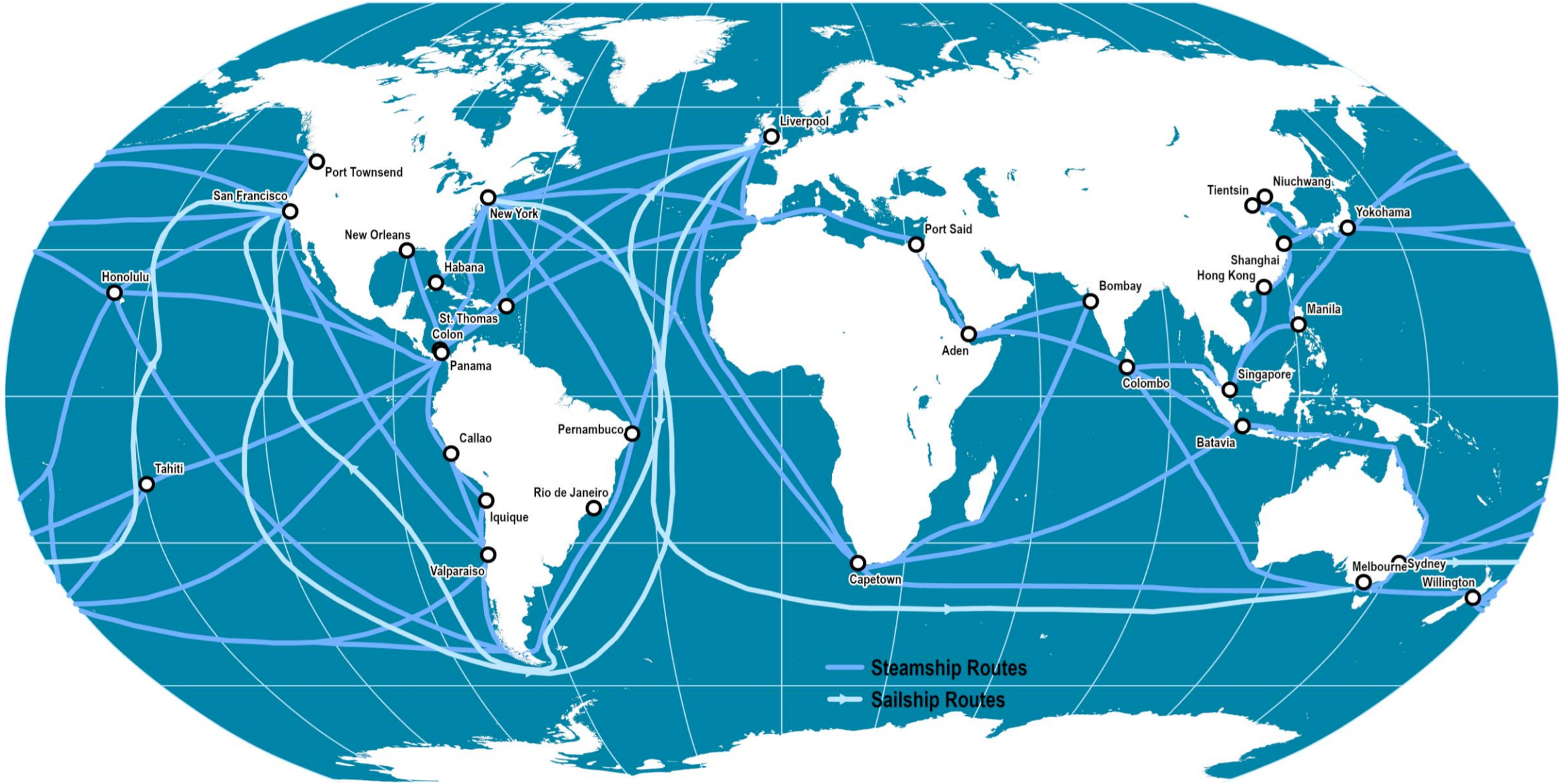
Historical Considerations

- Enduring problem of siltation
  - Ports along rivers and at the heads of river deltas.
  - Dependent on wood as a fuel and a source of construction materials.
  - Forested areas surrounding rivers subject to deforestation.
  - Increased runoff and silt being carried downstream.
  - Over decades, ports such could cease to be commercially relevant.
  - Harbor and access channels became clogged by accumulating sediments carried by rivers.
  - Remedial work could be expensive.
  - A port site could be abandoned in favor of a more suitable alternative for security and economic reasons, as well as due to specific environmental factors.

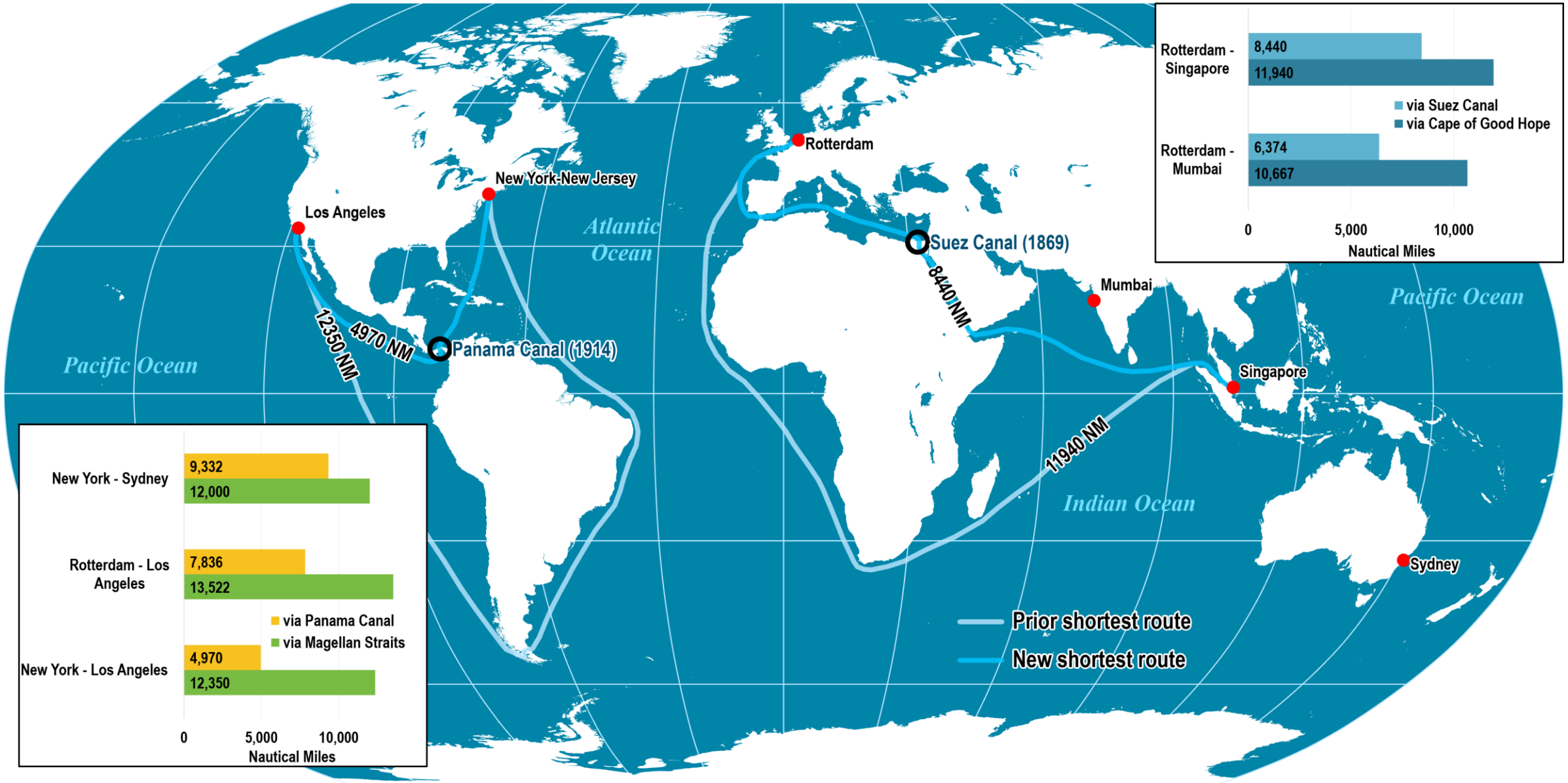
Historical Considerations

- City rank a function of port rank
  - Cities gained prominence due to their ports, and at times, lost their prominence because of commercial and technological changes that undermined their ports.
  - Ports remained the most connected and commercially active locations.
- Industrial revolution
  - Steamships in the 19th century: capacity and steering limitations removed.
  - Change in network structure with more direct and quicker connections.
  - Specialization of port functions within the port area, including industrial and energy generation.
  - Transfer of bulk cargo could be undertaken with new systems of cranes and conveyor belts.
  - Break-bulk cargo still needed to be handled manually.

World Maritime Trade Routes, 1912



Geographical Impacts of the Suez and Panama Canals



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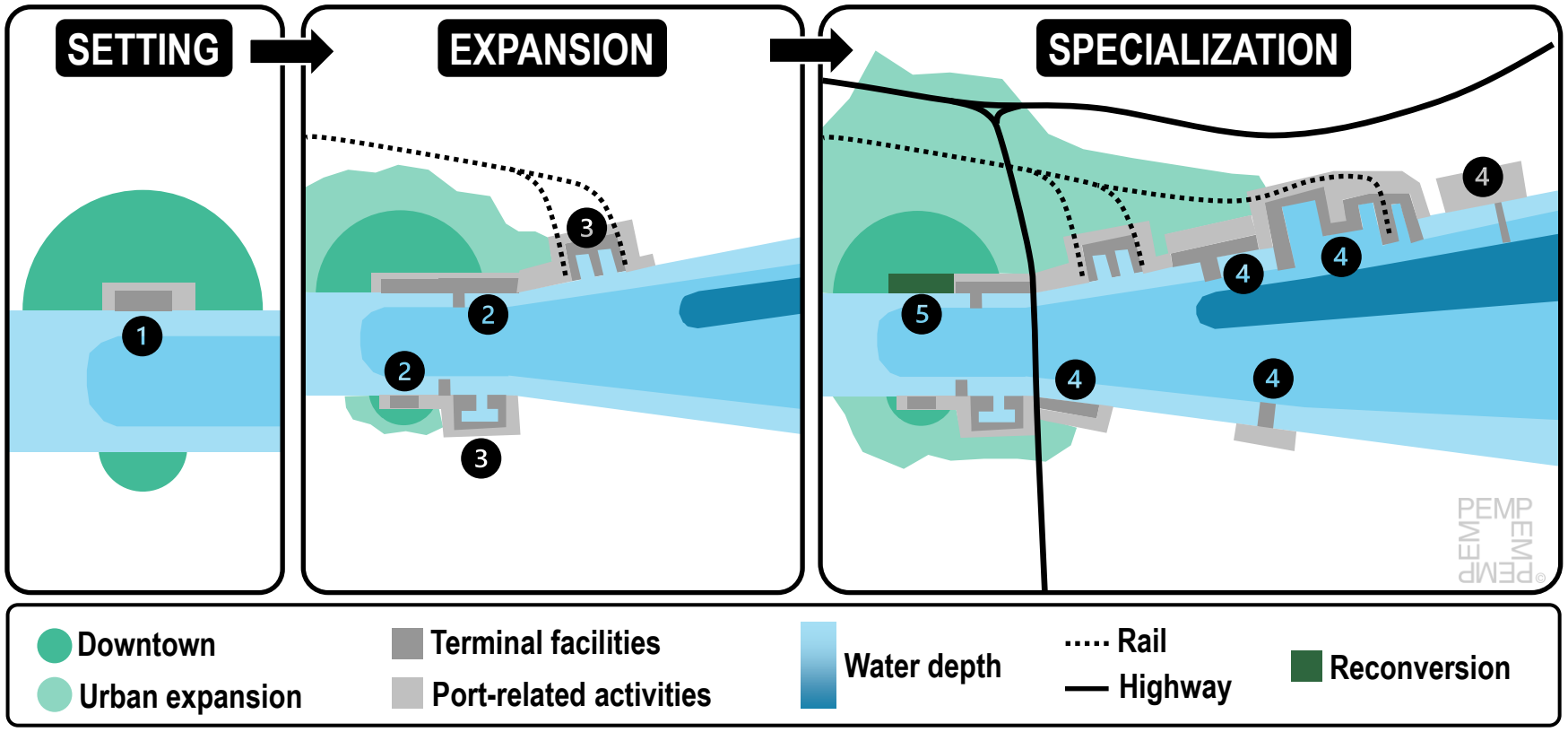
PORT OPERATIONS, ADMINISTRATION AND ECONOMICS

B. The Evolution of Contemporary Ports

Read this section

The Evolution of a Port



Read this content

The Evolution of a Port

- Setting
  - Initial setup of a port site strongly depends on geographical considerations.
  - A standard evolution of a port starts from the original port, commonly a fishing port with trading and shipbuilding activities, which includes several quays.
  - Before the Industrial Revolution, ports had relatively rudimentary terminal facilities.
  - Mainly focused on warehousing and wholesaling, located on sites directly adjacent to the port.
  - Port district key element of urban centrality with adjacent retailing, wholesaling, and financial activities.

The Evolution of a Port

- Expansion
  - The Industrial Revolution triggered several changes that impacted port activities.
  - Quays expanded.
  - Jetties constructed to handle growing freight and passenger traffic.
  - Size of ships expanded.
  - Shipbuilding became an activity that required the construction of docks.
  - Integrating rail lines with port terminals granted access to vast hinterlands.
  - Port-related activities also expanded to include industrial activities.
  - This expansion mainly occurred downstream towards deeper draft areas.

The Evolution of a Port

- Specialization
  - Constructing specialized piers.
  - Handle bulk and breakbulk freight, such as containers, ores, grain, petroleum, and coal.
  - Expanded warehousing needs.
  - Larger ships required dredging or the construction of long jetties granting access to greater depths.
  - Migration of their activities away from their original setup and increased handling capacities.
  - Original port sites became obsolete and were abandoned.
  - Numerous reconversion opportunities for port facilities to other uses (waterfront parks, housing, and commercial developments).

The Evolution of a Port

- Closure
  - Facility is abandoned due to inadequate site or operating conditions.
  - Terminal has lost its market relevance.
  - Abandoned brownfield site that can be subject to redevelopment.
- Expansion
  - Operating conditions require the footprint of an existing site to be extended or modified.
  - Additional yard areas and the lengthening of berths.
- Addition
  - New berths in response to demand for deeper water or improved operating facilities.
- Consolidation
  - Several existing berths are combined to provide expanded facilities.
- Reconversion/Redevelopment
  - Functional reassessment of existing facilities that are repurposed, often to non-port uses.

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PORT OPERATIONS, ADMINISTRATION AND ECONOMICS

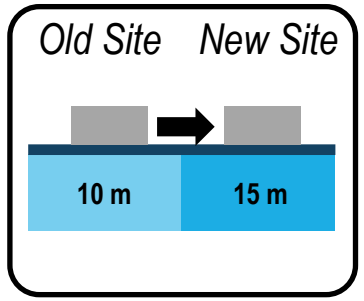
3. Port Migration

Read this section

Migration versus Relocation

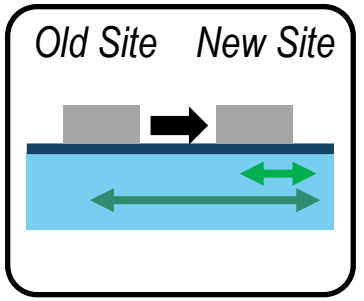
- Port terminals can be subject to migration and relocation.
- Terminal relocation
  - Closing the old terminal facility once the terminal has relocated to a new site.
- Terminal migration
  - Using a new terminal site in addition to the existing site.
  - Development from obsolete facilities near the urban core to peripheral locations with ample space and better nautical accessibility.
  - Downstream on a river, laterally along a coastline, or outward into the sea through land reclamation.
  - May prompt changes in its governance structure, as the existing port authority may not have jurisdiction over the locations where the facilities have migrated.

Drivers of Port Terminal Migration and Relocation



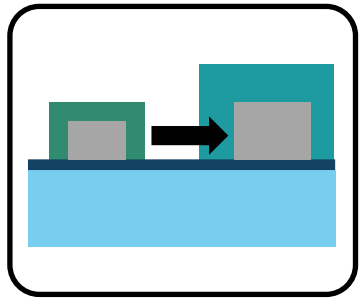
DRAFT LIMITATIONS

- Need for deep water access.
- Allows for larger ships.



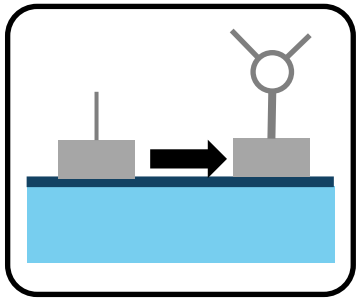
LINER CONNECTIVITY

- Better connectivity to liner shipping networks.
- Less harbor navigation time.



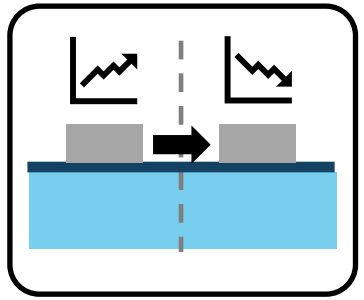
LAND AVAILABILITY

- Real estate for terminal operations and logistics.
- Urban development and zoning changes.



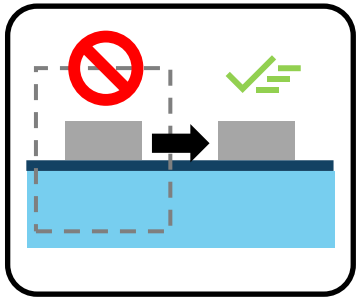
INLAND CONNECTIVITY

- Inland capacity.
- Intermodal accessibility.



COST DIFFERENCES

- Land (rent), labor and capital costs.
- Taxation and subsidies.



REGULATIONS

- Environmental restrictions.
- Governance and jurisdictional issues.

Drivers of Port Terminal Migration

- Draft limitations
  - Push towards economies of scale.
  - Larger ships with more stringent technical requirements in terms of draft and pier length.
  - 10-12 meters was considered suitable for terminal operations in the 1990s (Panamax standard)
  - 15 meters is now considered the standard.
  - Migration to a site with more favorable nautical attributes.
- Liner connectivity
  - Locations involving lower port turnaround times offer better connectivity to liner shipping networks.
  - Downstream terminals have less harbor navigation time.

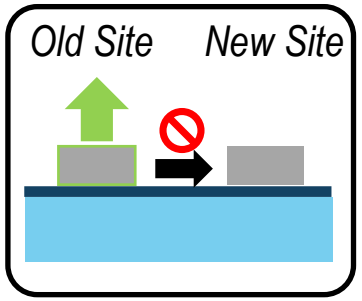
Drivers of Port Terminal Migration

- Land availability
  - Terminal stacking yard functions as a buffer and temporary storage area.
  - Space consumed by container terminals increases substantially with traffic growth.
  - Reshape the geography of ports and drive the migration of terminals to new peripheral sites.
- Inland connectivity
  - Migration to a new terminal facility can lead to improved access to regional transportation networks.
  - Peripheral sites typically have less inland congestion.

Drivers of Port Terminal Migration and Relocation

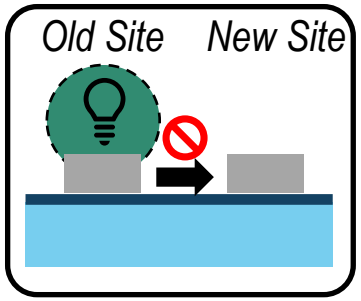
- Cost differences
  - High costs of production factors, such as land, labor, and capital, at an existing terminal site.
  - Lead to migration to peripheral sites where these costs are lower.
  - Near urban core areas; rent pressures are intense due to competing activities, such as commercial and residential uses.
- Regulations
  - Increasing environmental regulations.
  - Constraints such as opening hours and circulation bans.
  - Negatively impact terminal operations and could be mitigated by migration to a new site.

Impediments and Delaying Factors of Port Terminal Migration and Relocation



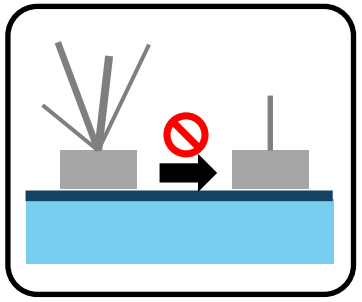
LAND PRODUCTIVITY LEAPS

- Equipment.
- Automation.
- Inland terminal development.



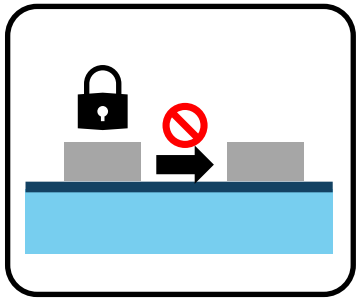
URBAN ENVIRONMENT

- Intangible advantages of urban environments (knowledge, innovation).



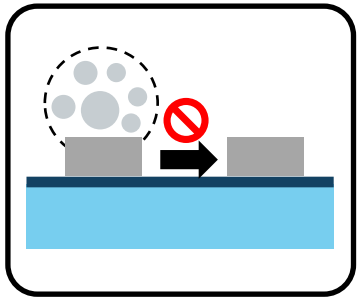
MARKET CONNECTIVITY

- Proximity, access, and connectivity to markets.



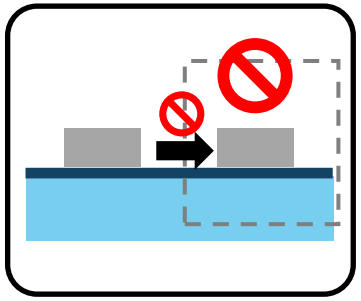
PATH DEPENDENCY

- Mechanism of preferential attachment



CLUSTER AND SCALE EFFECTS

- Cargo generation.
- Economies of agglomeration and co-location.



POLITICS AND COLLECTIVE ACTIONS

- Dynamics of NIMBYism in alternative locations

Impediments of Port Terminal Migration and Relocation

- Land productivity leaps
  - Improvements at the existing port facilities.
  - Can mitigate congestion and create room for further growth.
  - Reducing the need to seek new locations through port migration.
  - E.g. better equipment and automation.
- Market connectivity
  - Market players value certain supply chain-related characteristics of existing ports.
  - Proximity and better connectivity to inland markets via road, rail, or barge networks.
- Cluster and scale effects
  - Cluster and scale effects in cargo generation.
  - Prevent new ports from emerging as a result of port migration processes.

Impediments of Port Terminal Migration and Relocation

- Urban environment
  - Superior infrastructure, knowledge, innovation, and decision-making capacities.
  - Congestion and environmental challenges disproportionately affect urban ports.
  - Significant incentive for innovation that improves competitiveness.
  - Environmental innovation can occur in ports under severe pressure to improve environmental performance from lead firms, local communities, organizations, and governments.
- Path dependence
  - Retention mechanisms can reinforce the existing hierarchy in a port system.
  - Ports with many ties are more likely to receive new ties in the future.
- Power, politics, and collective action
  - Local political forces in existing ports.
  - Joint efforts of various actors in port communities.

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PORT OPERATIONS, ADMINISTRATION AND ECONOMICS

4. Mega Port Facilities

Read this section

The Emergence of Mega Ports

- Exceptional sites and situations
  - Commercial opportunities and strategic locations within the maritime shipping network.
  - Only the most commercially important locations with high maritime and hinterland connectivity can generate traffic levels sufficient and stable enough.
  - Many ports, such as Rotterdam and Antwerp, are larger in area than the cities they serve.
  - The expansion of large Chinese ports, such as Shanghai, has necessitated the development of entirely new sites outside central areas.
  - Modern port infrastructures are capital-intensive.
  - Several port authorities struggle to meet the substantial investment requirements for large-scale infrastructure projects.
  - Economic and strategic importance of mega ports is such that capital investment can be found from public and private sources.

Evolution of the Port of Rotterdam

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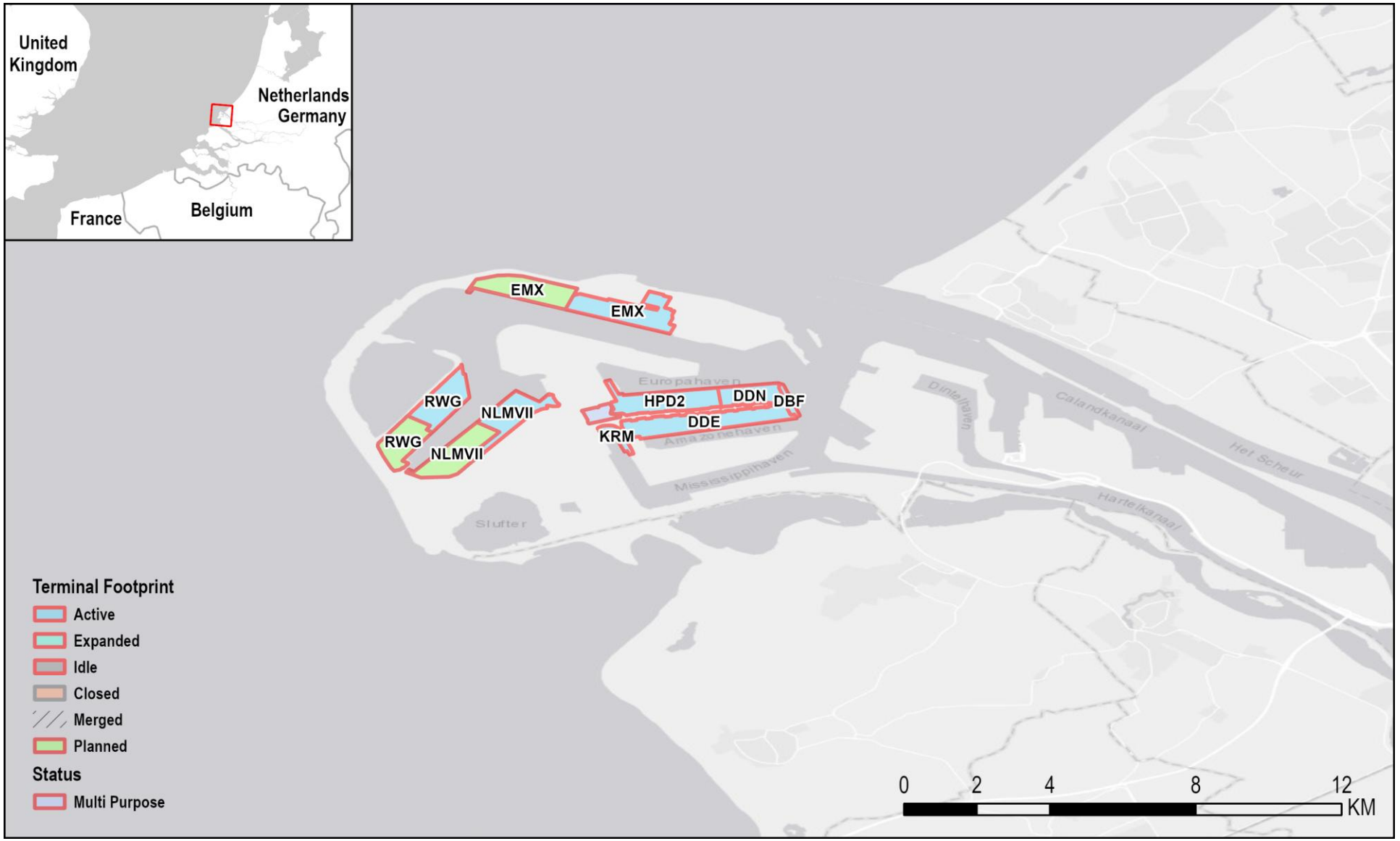
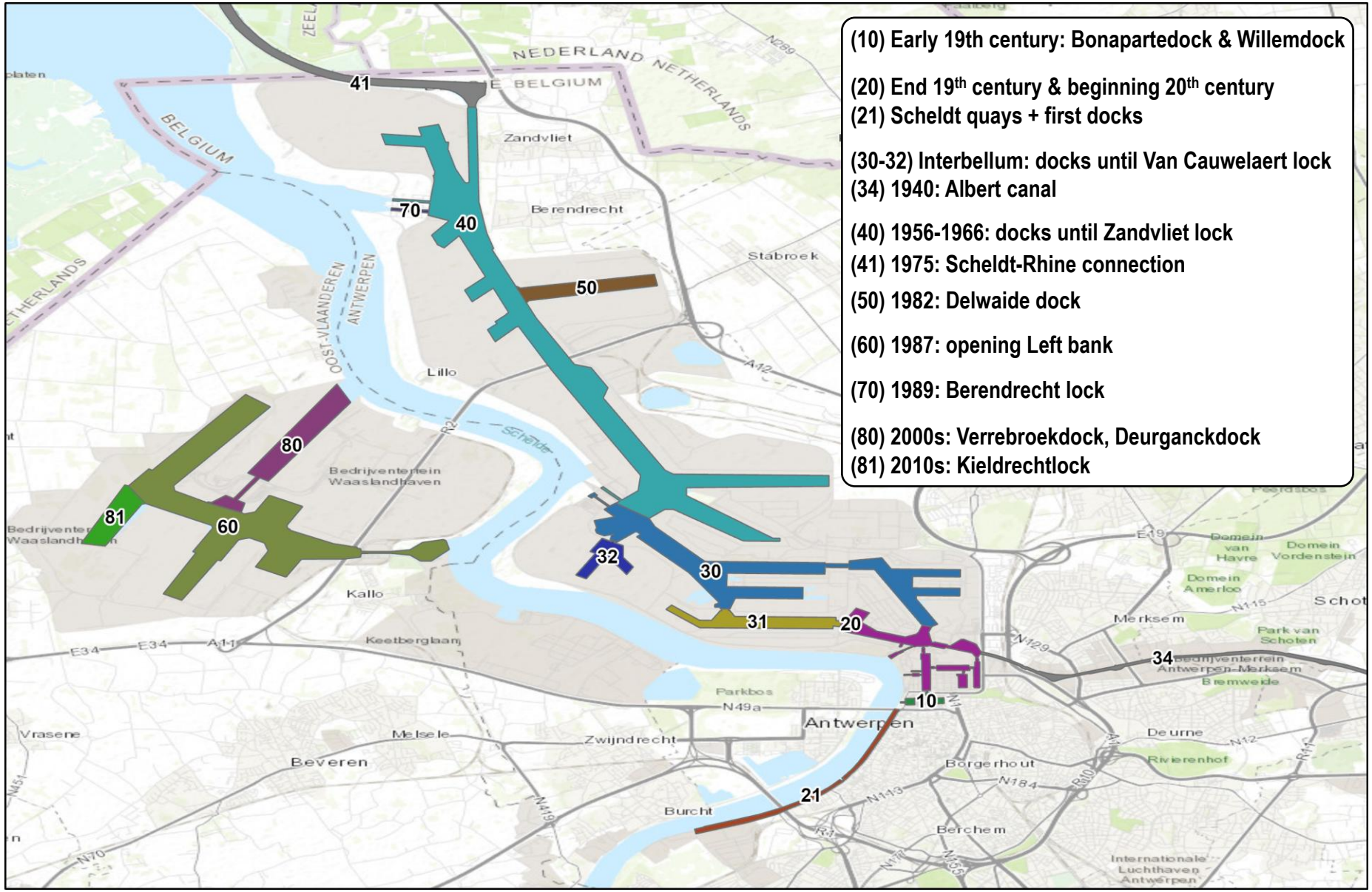
Rotterdam Maasvlatke Port Expansion Project (Container Terminals)



Mega Ports

- Rotterdam
  - Europe’s largest port expanded downstream.
  - Expansion in the North Sea.
  - Construction of an entirely new facility on reclaimed land at Maasvlakte in the 1980s.
  - Subsequent traffic growth in the 1990s led the port authority to propose a new facility further out in the North Sea: Maasvlakte II.
  - Construction in 2008 and began operations in 2013.
  - Full completion anticipated by 2030.
  - Port navigation time is significantly reduced, resulting in faster port turnaround times.

Spatial Development of the Port of Antwerp



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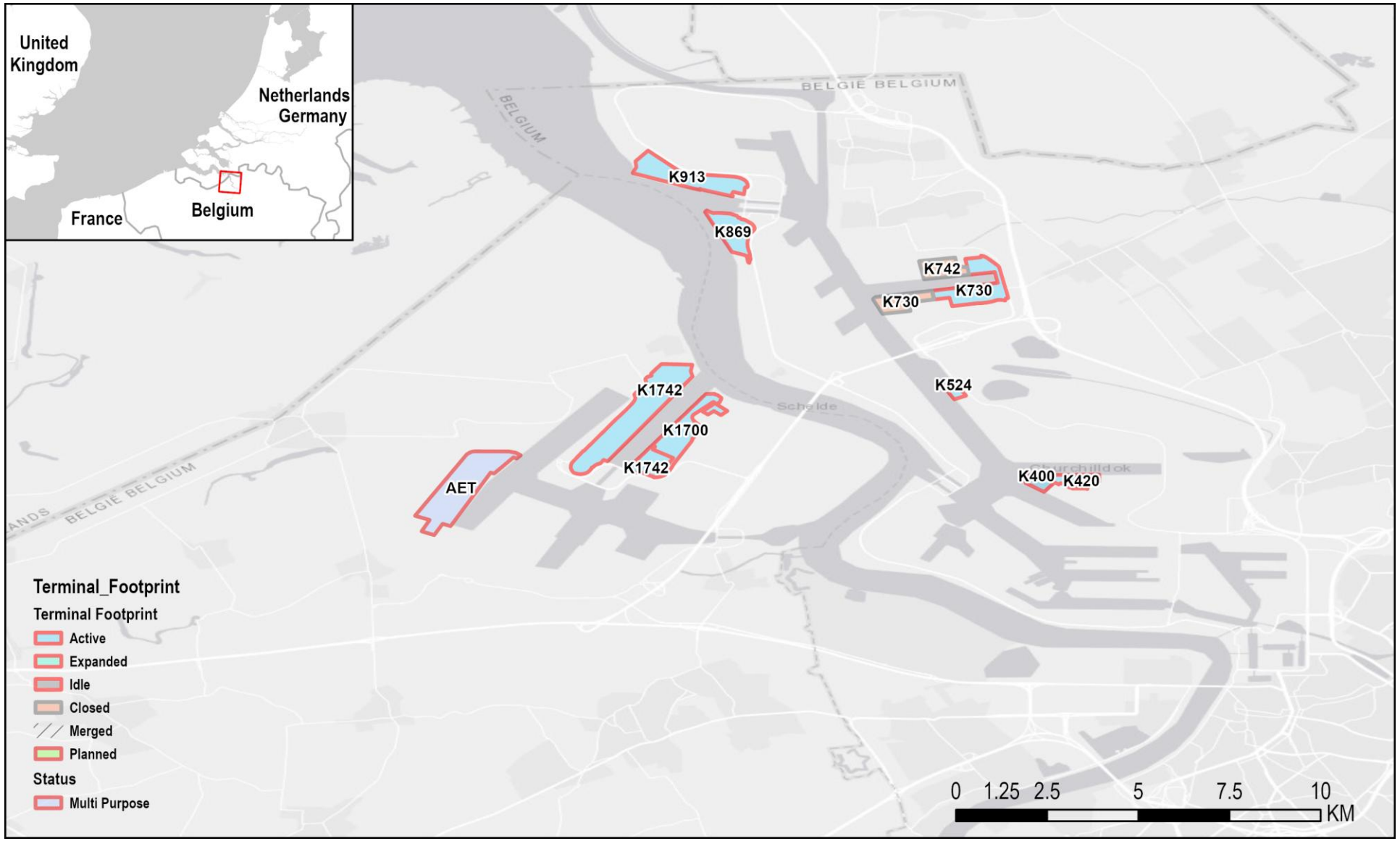
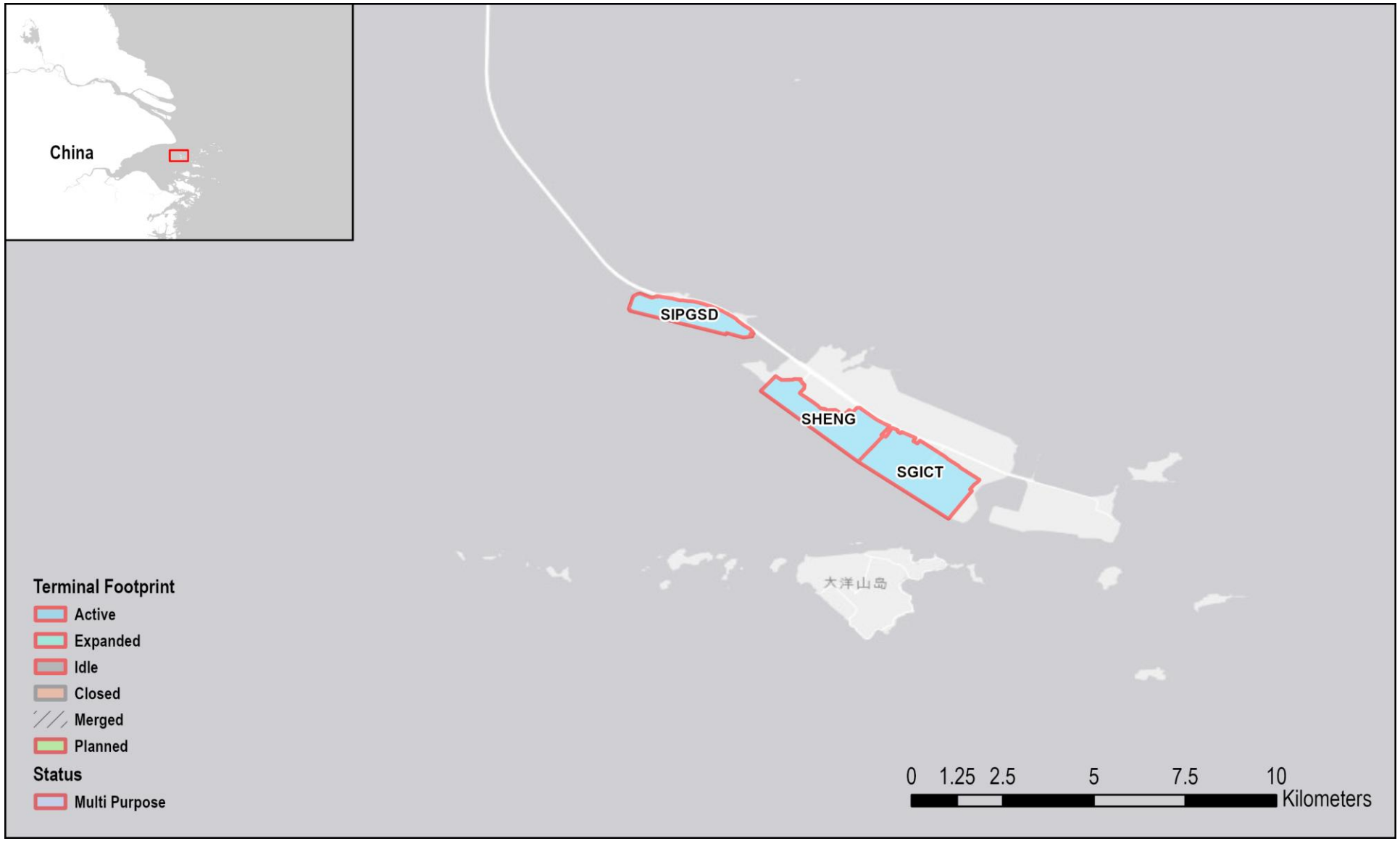
Antwerp Deurganckdock Port Expansion Project (Container Terminals)



Mega Ports

- Antwerp
  - Expansion options are limited.
  - Significant tidal variations, in the range of 3 to 5 meters.
  - Majority of port facilities have been dredged behind river tide gates.
  - Right bank of the River Scheldt reaching capacity.
  - Deurganck dock opened in 2005:
    - A new dock complex was built on the left bank.
    - Adding about 9 million TEUs to the existing container handling capacity.
  - The port of Antwerp is preparing to further expand its container-handling capacity:
    - Adding more than 7 million TEU through smaller extensions to existing facilities.
    - Creation of a new L-shaped dock connected to the Deurganck dock.

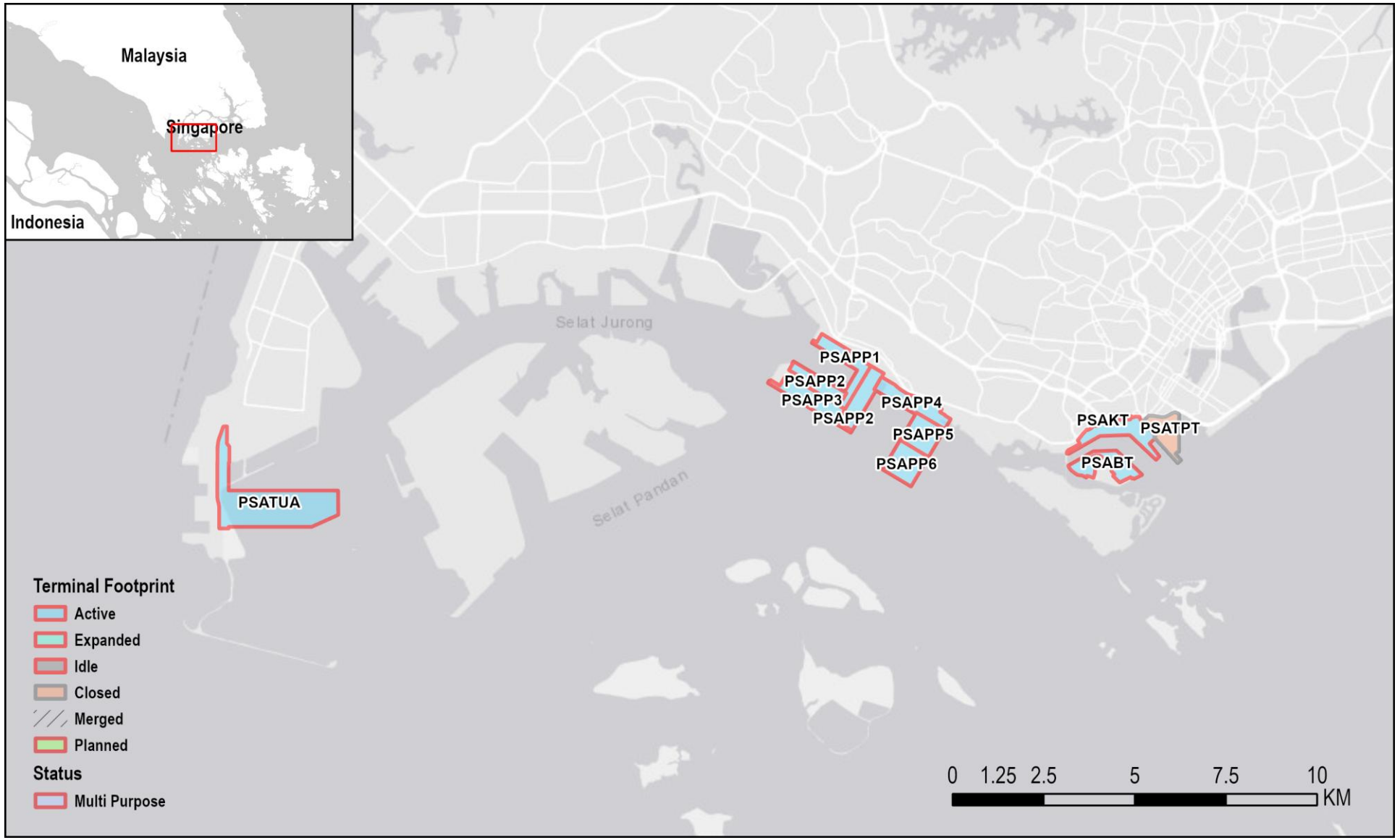
Shanghai Yangshan Port Expansion Project (Container Terminals)



Mega Ports

- Yangshan (Shanghai)
  - Entirely new facility has been built from scratch.
  - Located well outside the existing port facilities in the Changjiang Delta.
  - Facility situated in Hangzhou Bay, 35 km offshore.
  - Opened in 2005 built for two purposes:
    - Overcome the physical limitations of the existing port facilities at the mouth of the Yangtze River.
    - Too shallow to accommodate the latest generation of containerships.
    - Provide additional capacity to meet traffic growth expectations.
    - Expected capacity of 15 million TEUs.
  - World's third-longest bridge, with a length of 32.5 km, built to link the port to the mainland
  - Offshore complex with direct access compared with navigating the Changjiang.

Singapore Tuas Port Expansion Project (Container Terminals)



Mega Ports

- Tuas (Singapore)
  - Singapore is the world's most important transshipment hub.
  - Oldest container terminal facilities (Tanjong Pagar, Keppel, and Brani) are located near the central area.
  - In 1993, construction of the Pasir Panjang 1 project began and was completed in 2009.
  - Tuas port expansion project:
    - Unique case involving a gradual and complete relocation of Singapore's container terminal facilities.
    - Construction began in 2019, and reclamation works for the first phase were completed in November 2021.
    - Expected to be capable of handling 65 million TEU on about 1,337 ha of land.
  - Keppel and Brani facilities will be relocated to Tuas by 2027.
  - By the 2040s, the remaining Pasir Panjang facilities will be consolidated at the Tuas complex.