

The Geography of Transport Systems

Jean-Paul Rodrigue

Sixth Edition



Transport Terminals

CHAPTER 6

Copyright © 1998-2024, Jean-Paul Rodrigue, Dept. of Maritime Business Administration, Texas A&M University - Galveston.

ecojpr@gmail.com

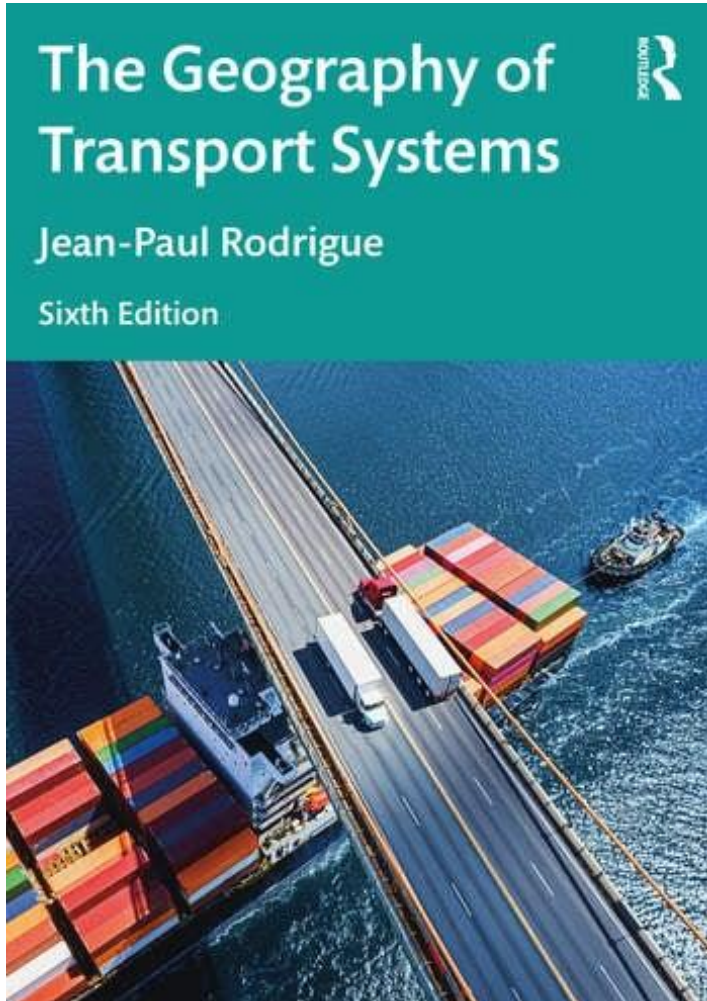
You may use the figures within for educational purposes only. No modification or redistribution permitted.
For more information: <https://transportgeography.org/>

Usage Conditions

- DO NOT COPY, TRANSLATE OR REDISTRIBUTE THIS DOCUMENT.
- The contents of this document can be freely used for personal or classroom use ONLY.
- Although the material contained in this document is freely available, it is not public domain. Its contents, in whole or in part (including graphics and datasets), cannot be copied and published in ANY form (printed or electronic) without consent.
- If you have accessed this document through a third party (such as a content farm), keep in mind that this party is illegally redistributing this content. Please refer to the true source (<https://transportgeography.org/>) instead of the third party.
- Permission to use any graphic material herein in any form of publication, such as an article, a book or a conference presentation, on any media must be requested prior to use.
- Information cited from this document should be referred as: Rodrigue, J-P et al. (2024) The Geography of Transport Systems, Texas A&M University, Department of Maritime Business Administration, <https://transportgeography.org/>.

Table of Contents

- The Function of Transport Terminals
- Transport Terminals and Hinterlands
- Port Terminals
- Rail Terminals
- Airport Terminals



The Function of Transport Terminals

Chapter 6.1

Containerization and the Operational Characteristics of Transport Terminals

CONVENTIONAL PORT



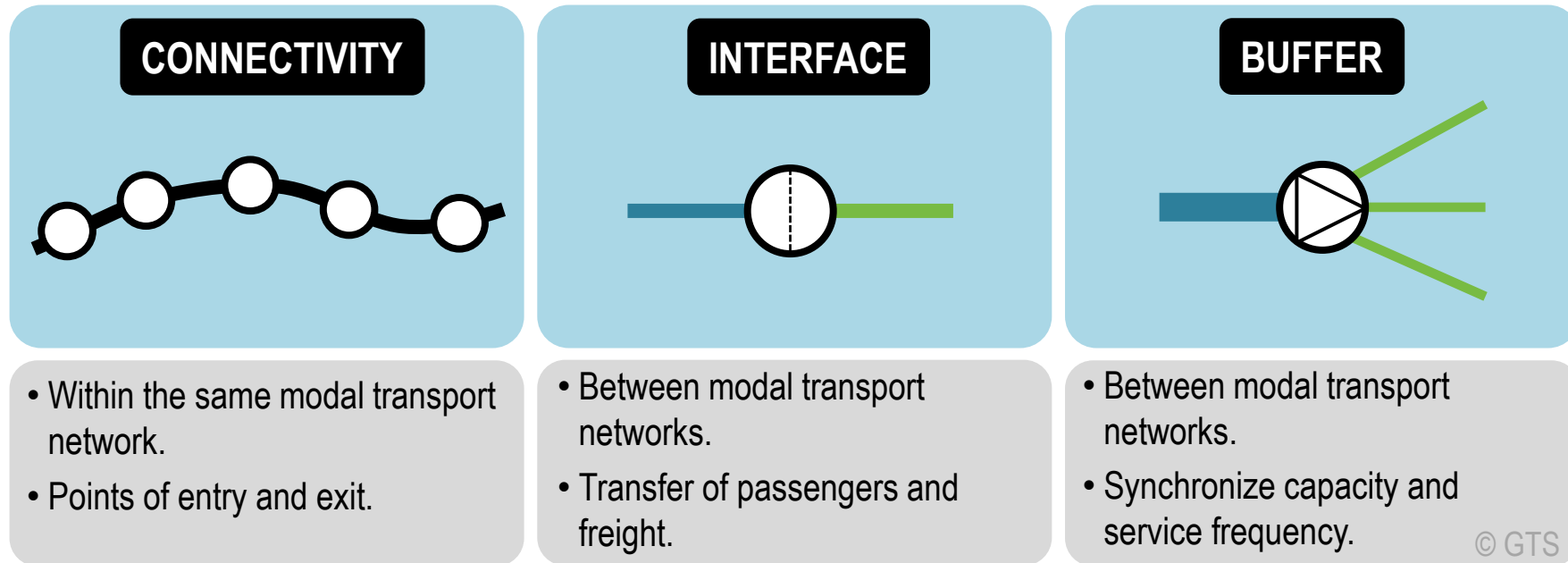
- Small terminal surface
- Dockside warehousing
- Direct transshipment possible
- Limited mechanization
- Improvised terminal operations
- Long dwell time (days or weeks)

CONTAINER PORT



- Large terminal surface
- Indirect transshipment (modal separation in time and space)
- Advanced mechanization and automation
- Organization and planning
- Short dwell time (hours or days)

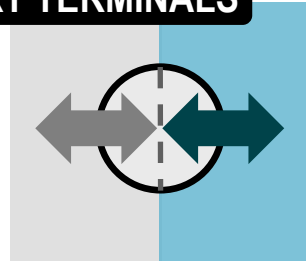
The Functions of Transport Terminals



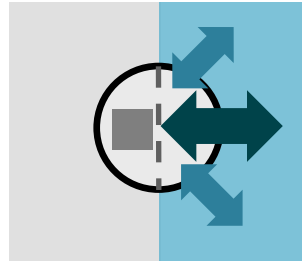
© GTS

Types of Intermodal Terminals

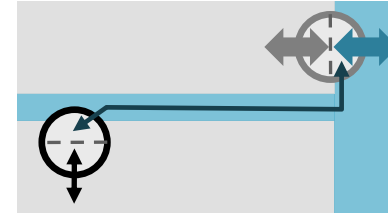
PORT TERMINALS



Gateway

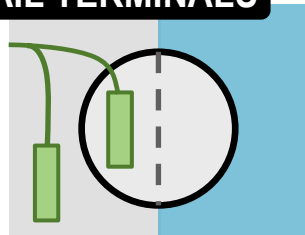


Intermediate hub

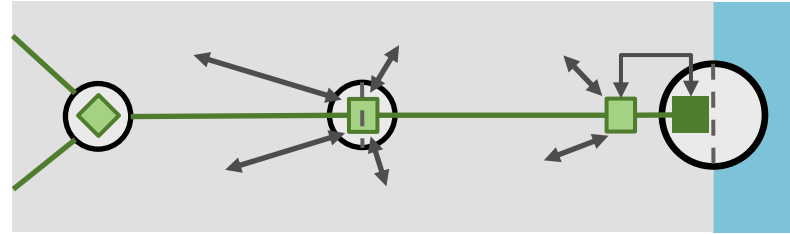


Barge terminal

RAIL TERMINALS



On-dock and near dock

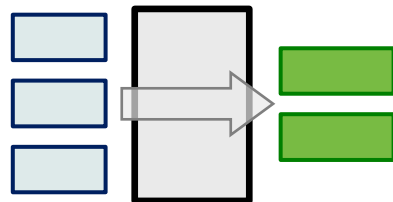


Transmodal terminal

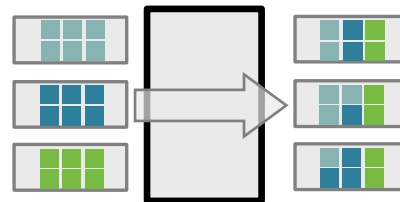
Load center

Satellite terminal

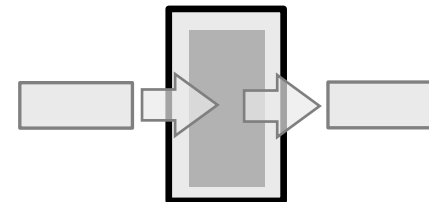
DISTRIBUTION CENTERS



Transloading

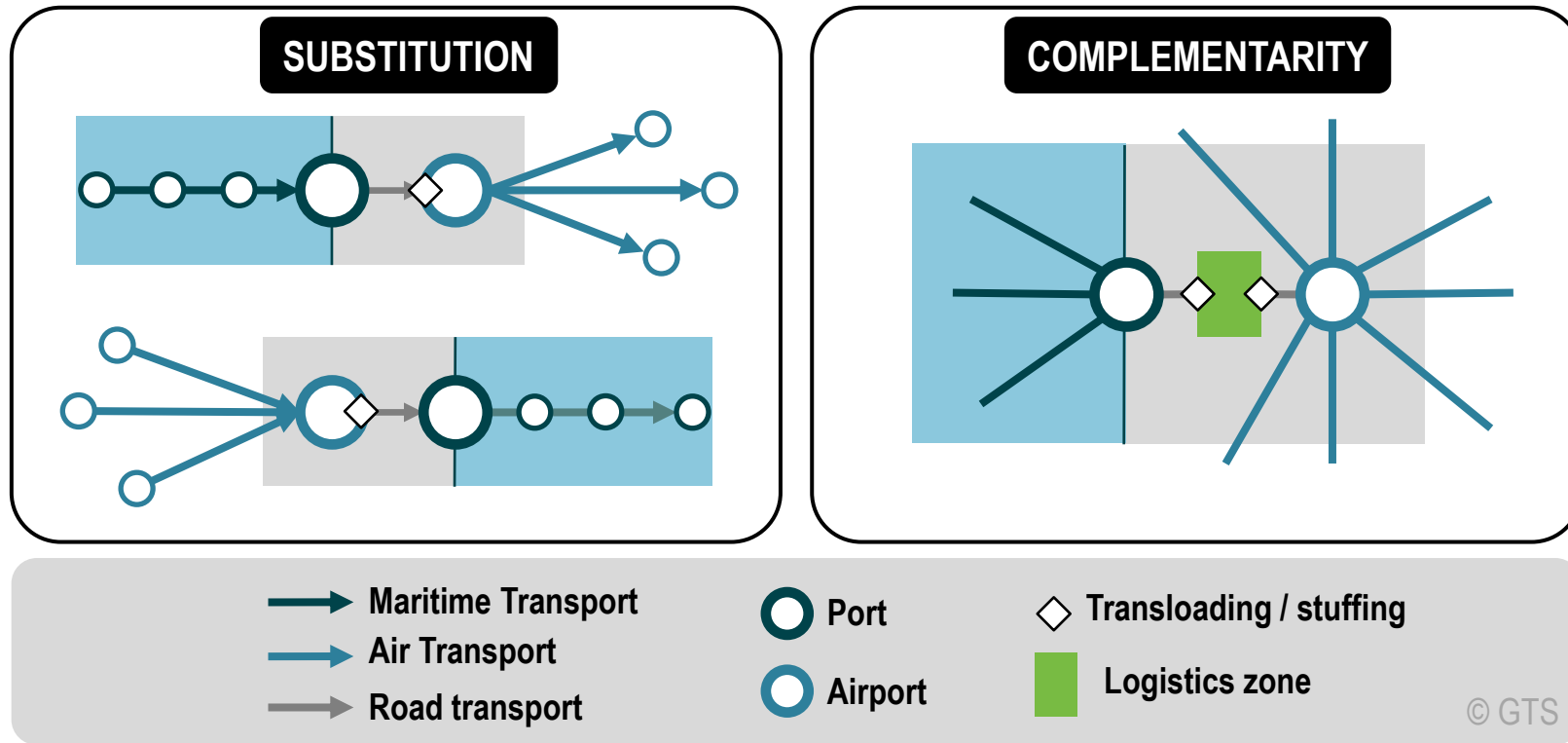


Cross-docking



Warehousing






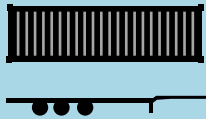
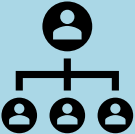

Integration between Port and Airport Terminals



Main Characteristics of Intermodal Transport Terminals

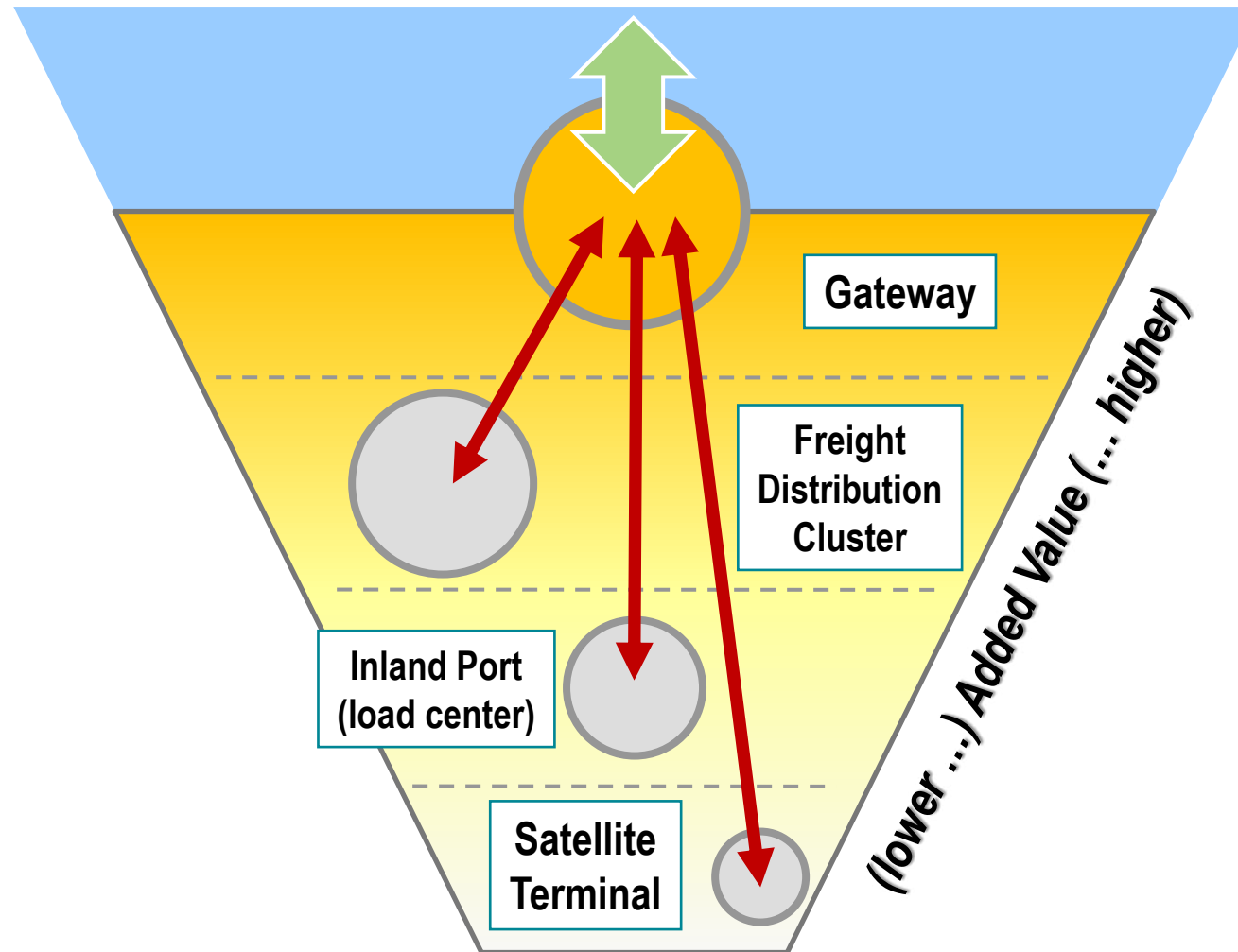
Core (Operations)	Infrastructure	Modal access (dock, siding, road), unloading areas
	Equipment	Intermodal lifting equipment, storing equipment
	Storage	Yard for empty and loaded containers
	Management	Administration, maintenance, access (gates), information systems
Ancillary (Added Value)	Trade facilitation	Free trade zone, logistical services
	Distribution centers	Transloading, cross-docking, warehousing, light manufacturing, temperature controlled facilities (cold chain)
	Storage depot	Container depot, chassis storage, bulk storage
	Container services	Washing, preparation, repair, worthiness certification

Main Characteristics of Intermodal Transport Terminals

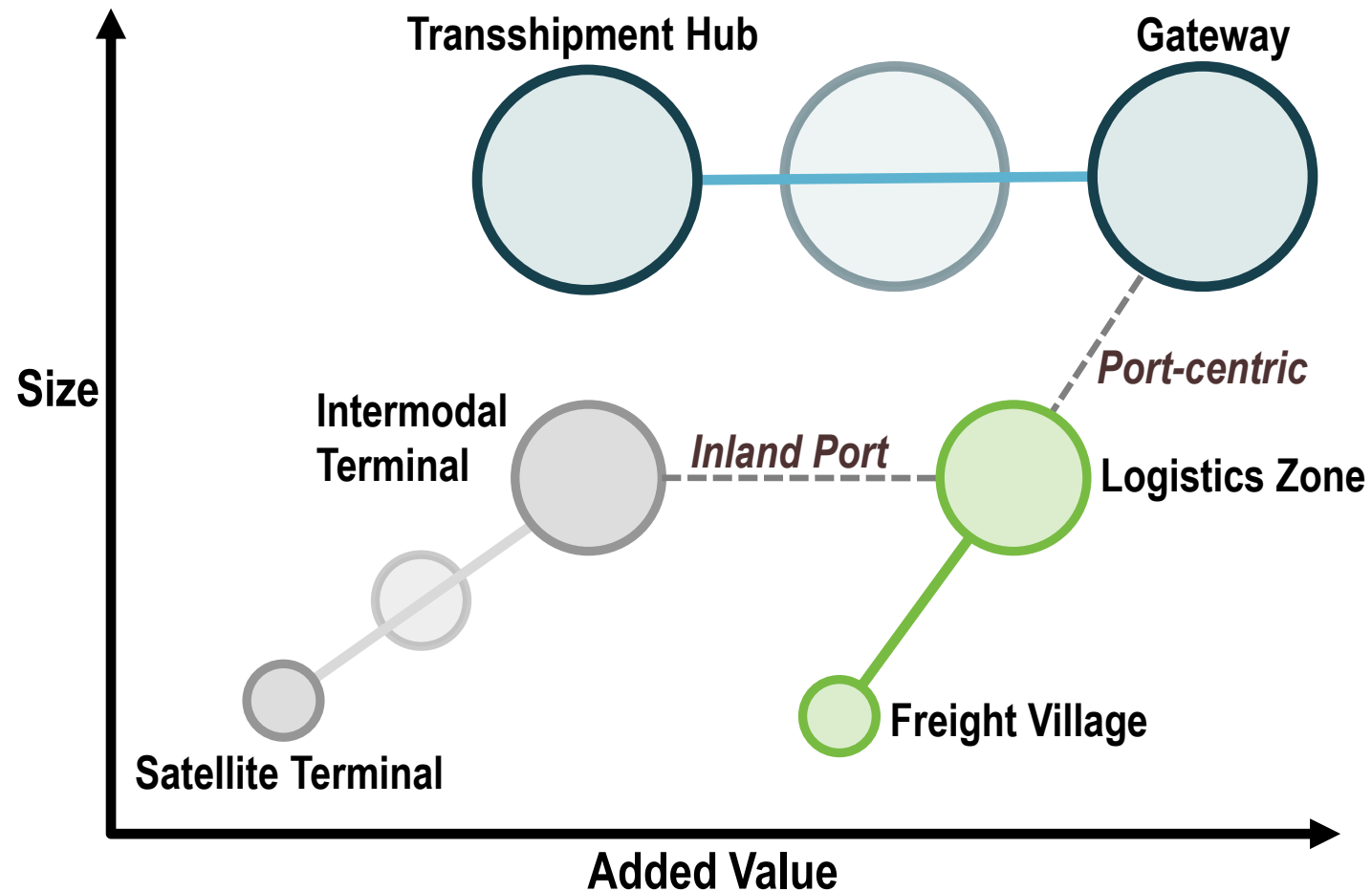
CORE (OPERATIONS)		ANCILLARY (ADDED VALUE)	
	INFRASTRUCTURE Modal access (dock, siding, road), unloading areas		TRADE FACILITATION Free trade zone, logistical services
	EQUIPMENT Intermodal lifting equipment, storing equipment		DISTRIBUTION CENTERS Transloading, cross-docking, warehousing, light manufacturing, temperature-controlled facilities
	STORAGE Yard for empty and loaded containers		STORAGE DEPOT Container depot, chassis storage, bulk storage
	MANAGEMENT Administration, maintenance, access (gates), information systems		CONTAINER SERVICES Washing, preparation, repair, worthiness certification

© GTS

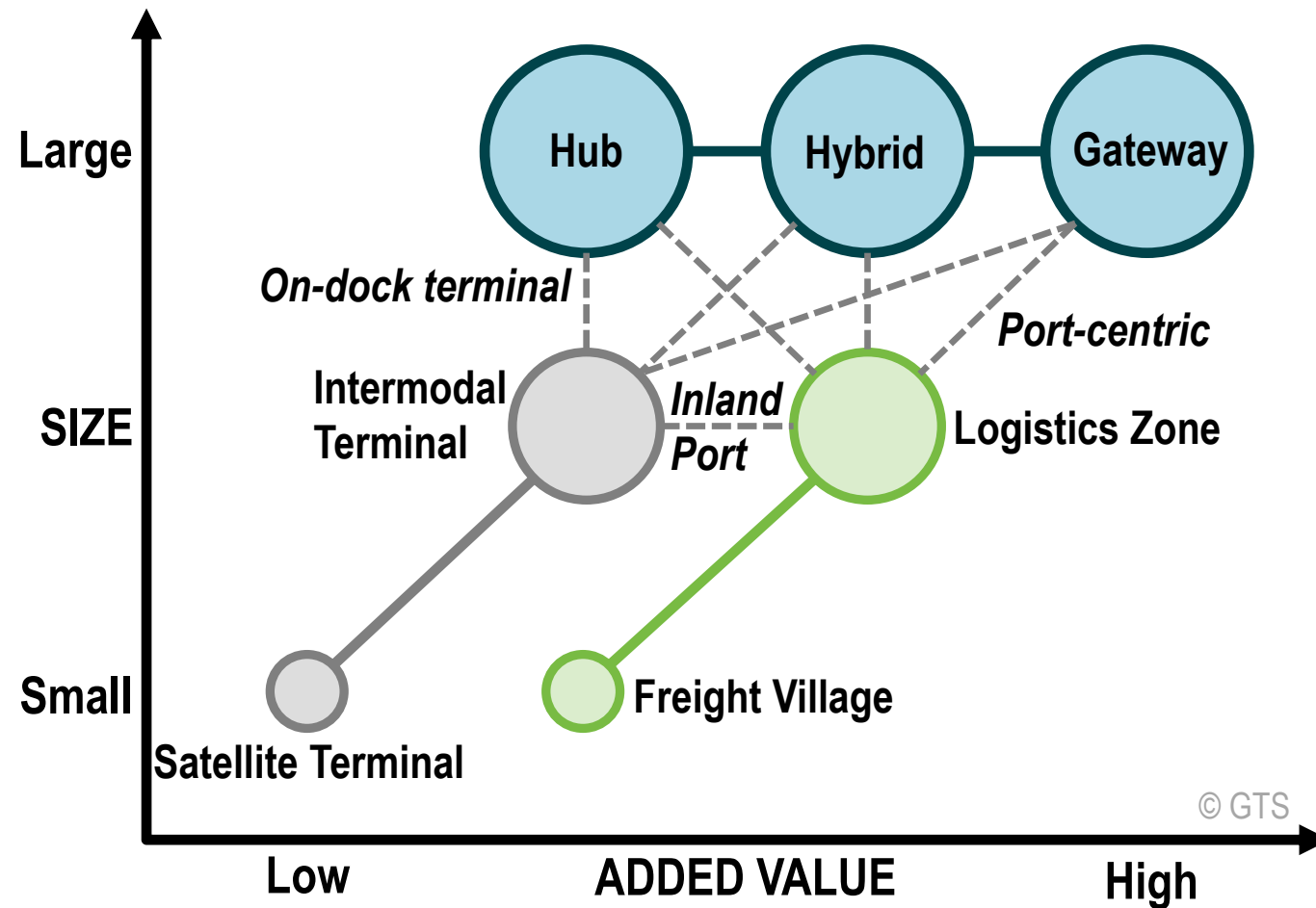
Freight Terminal Hierarchy and Added Value



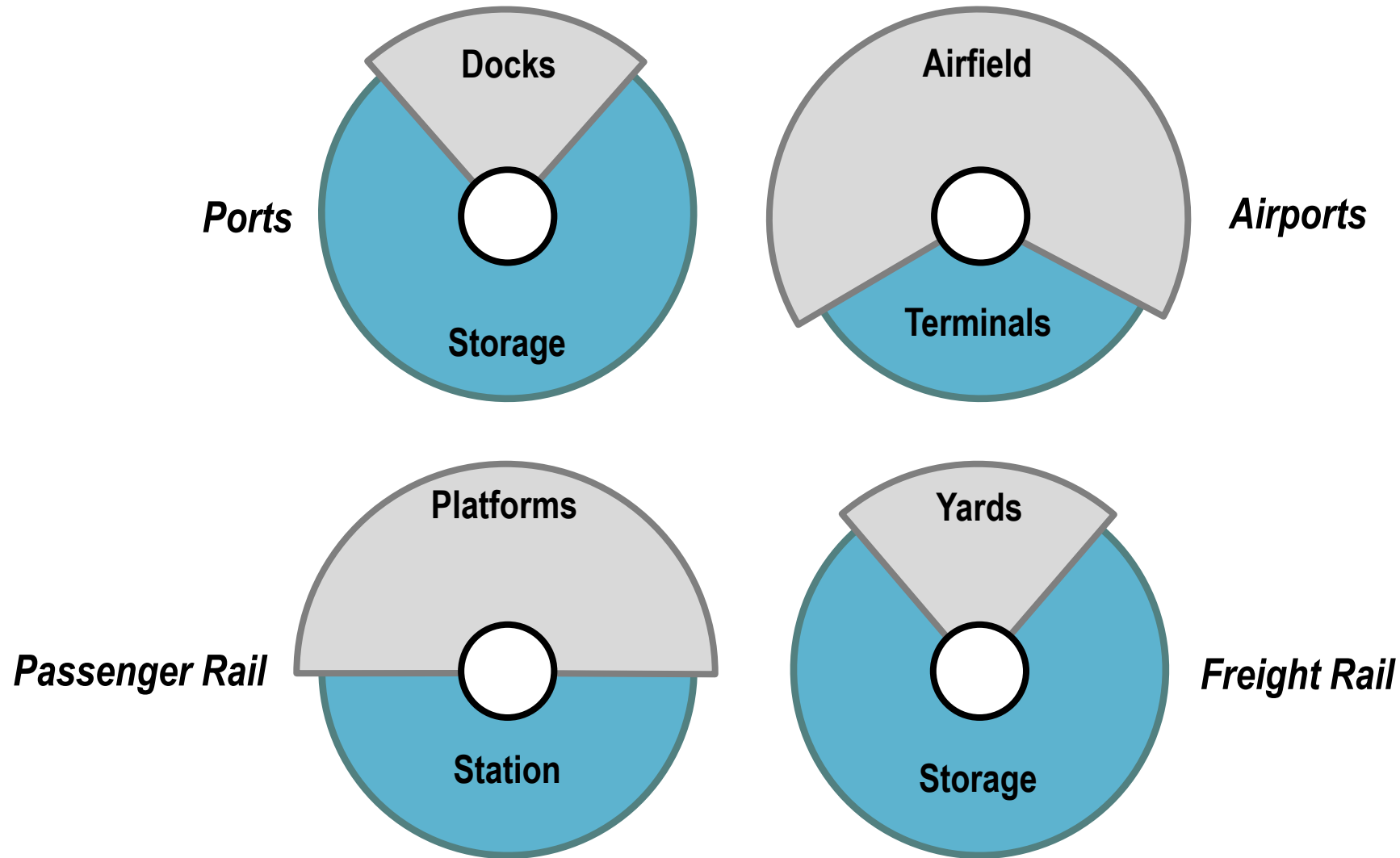
Freight Terminal Hierarchy and Added Value



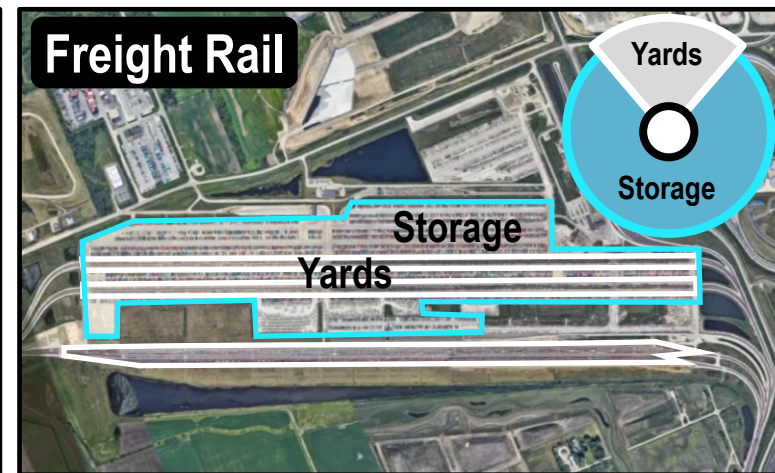
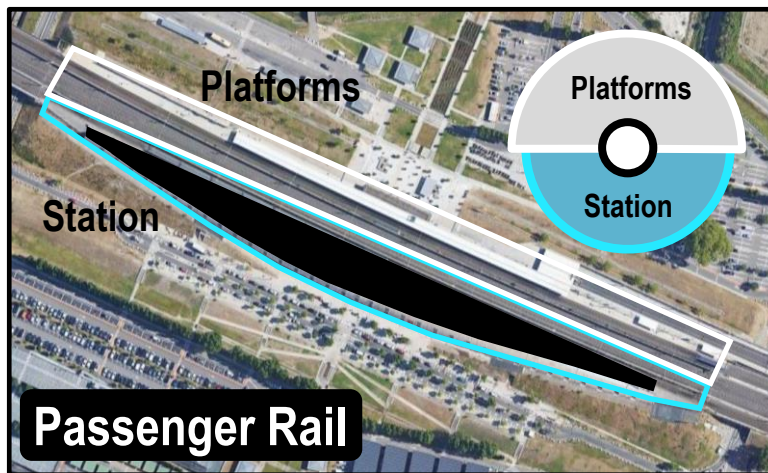
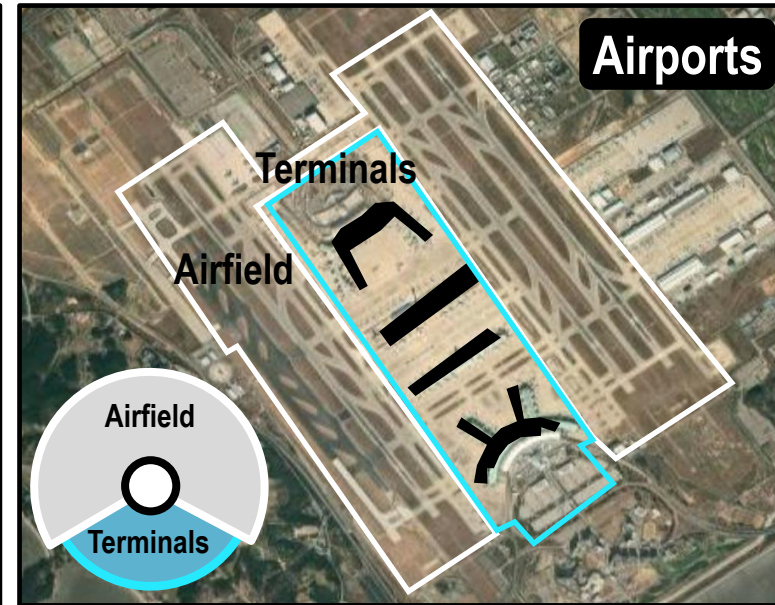
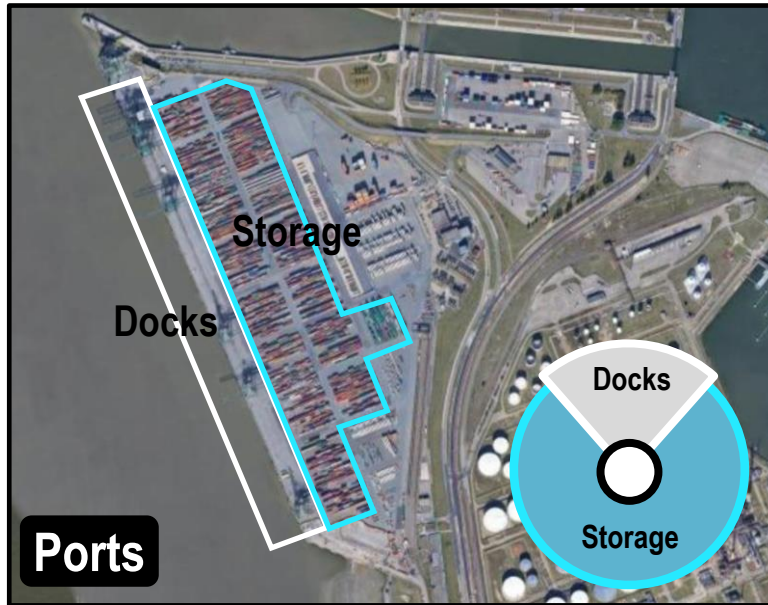
Freight Terminal Hierarchy and Added Value



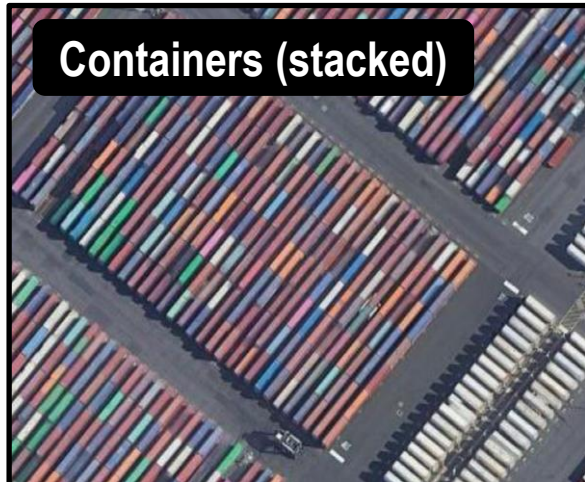
Physical Separation between Modes and Passengers / Cargo at Terminals



Physical Separation between Modes and Passengers / Cargo at Terminals



Inventory in Transit at Freight Terminals



Containers (stacked)



Vehicles



Liquid bulk



Containers (chassis)

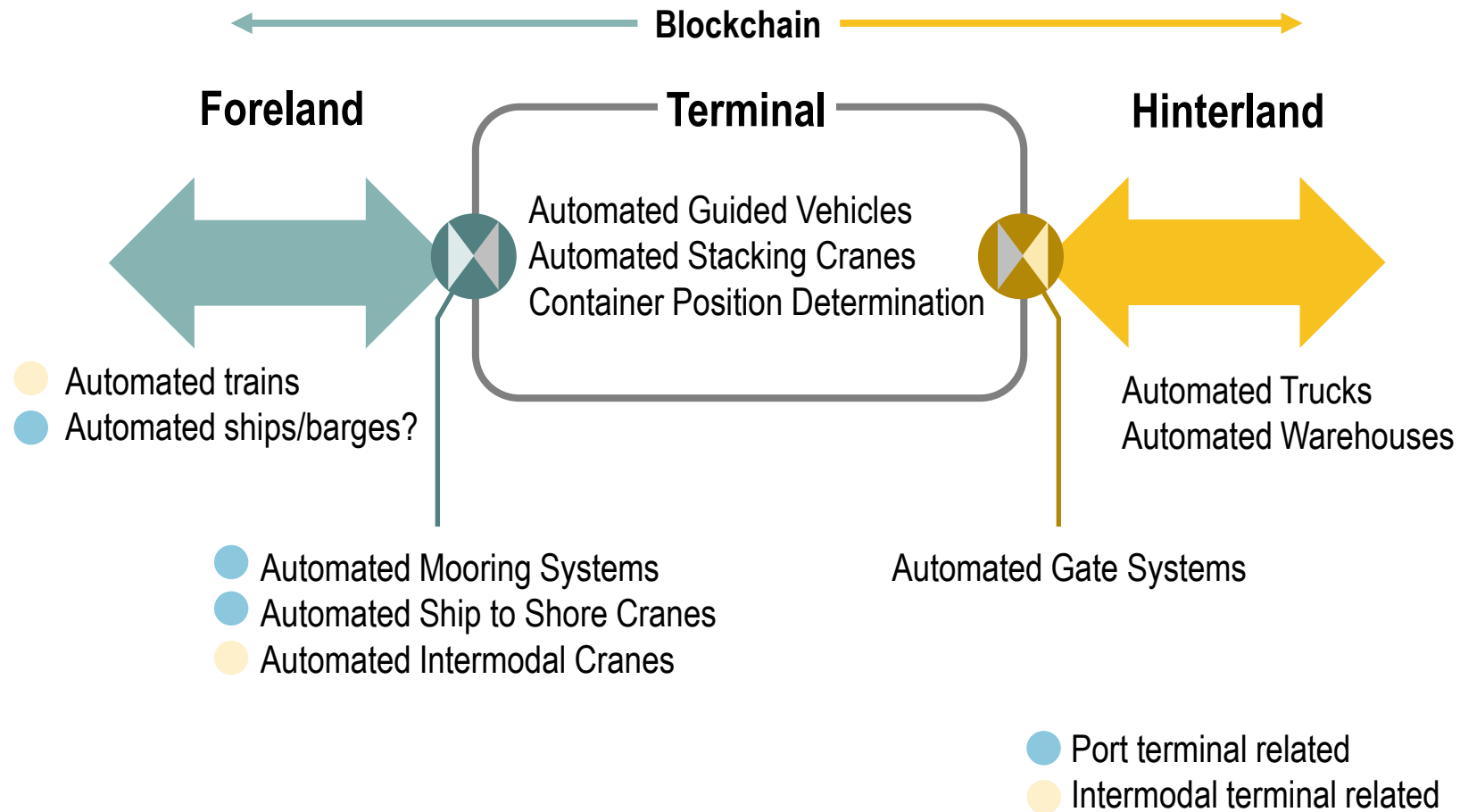


Dry bulk

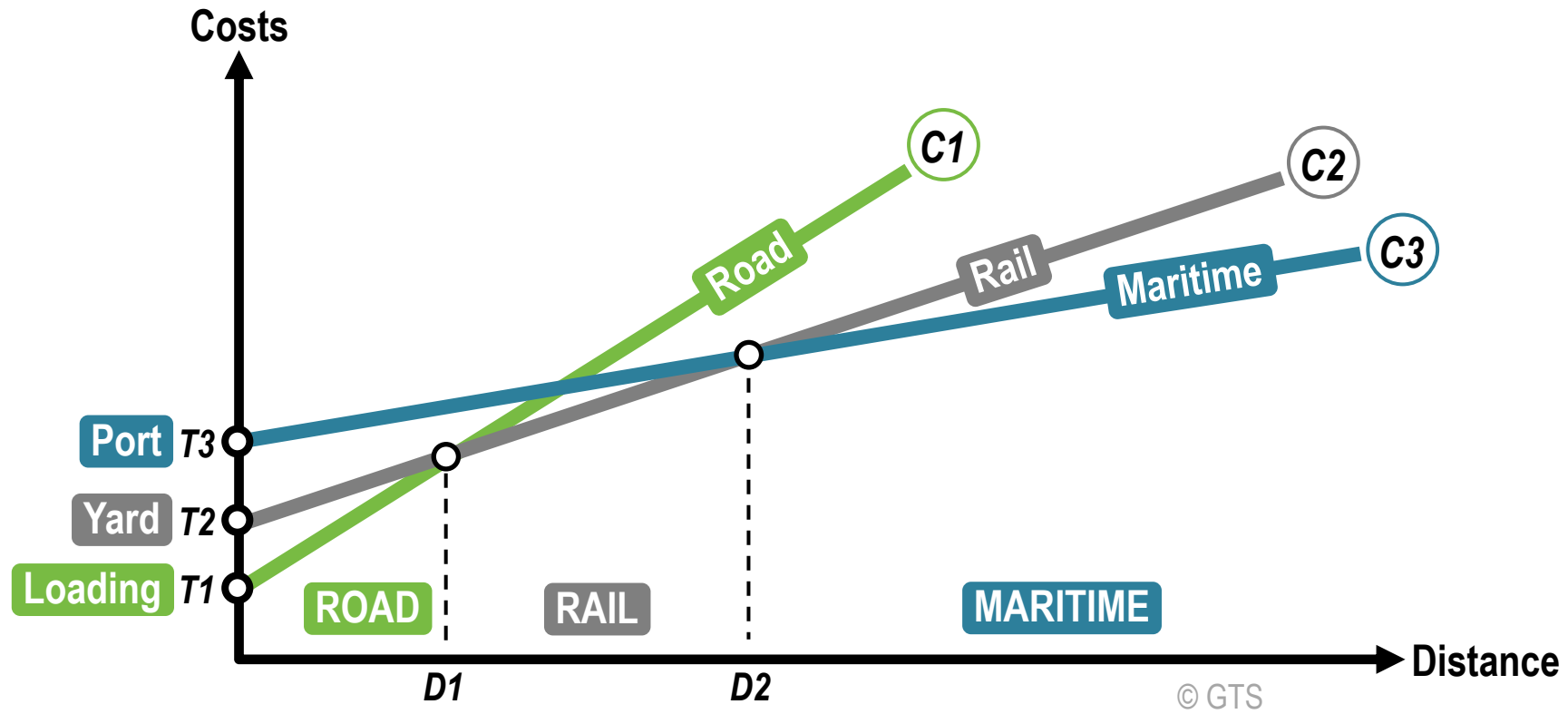


Neo bulk

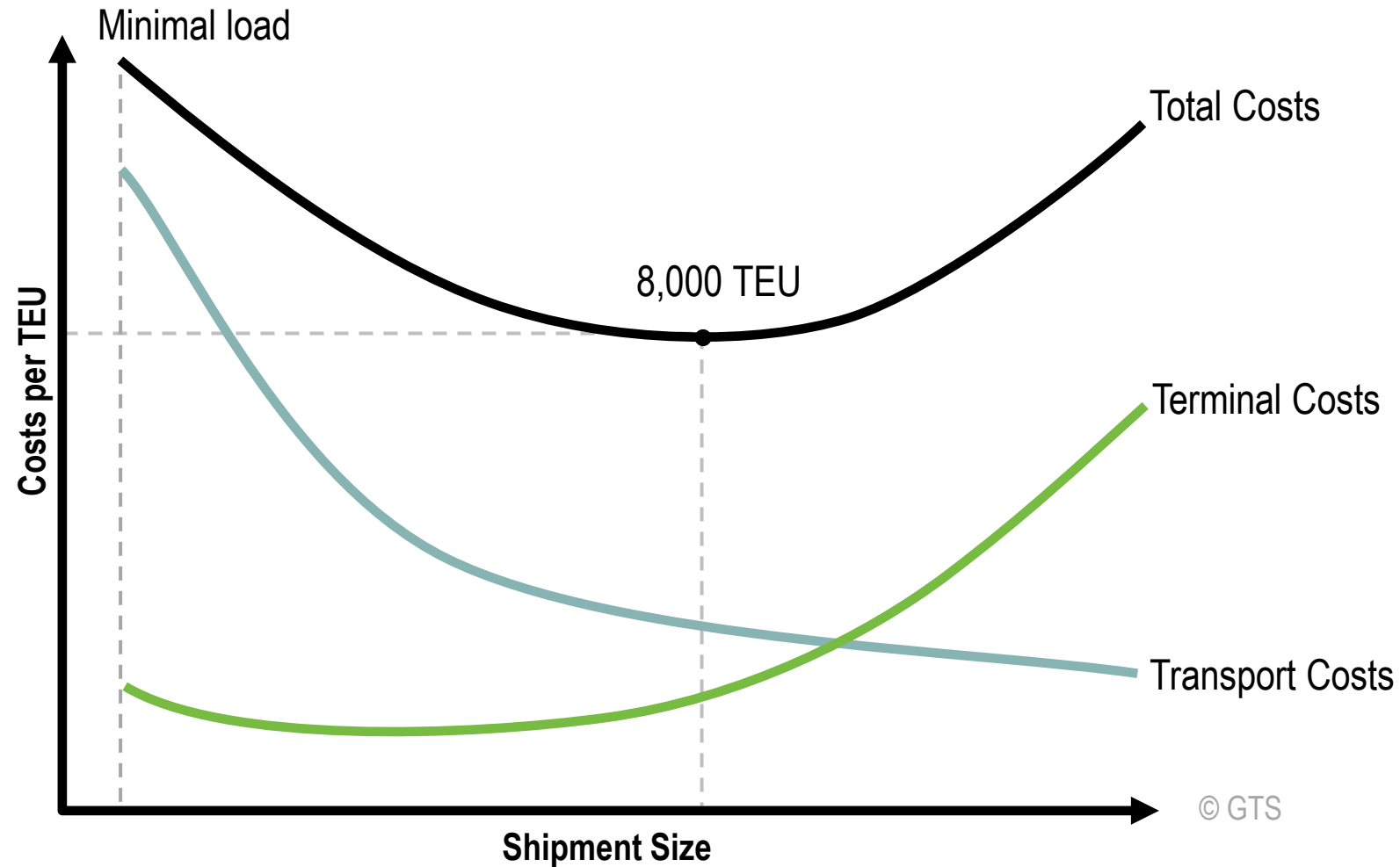
Freight Terminal Automation

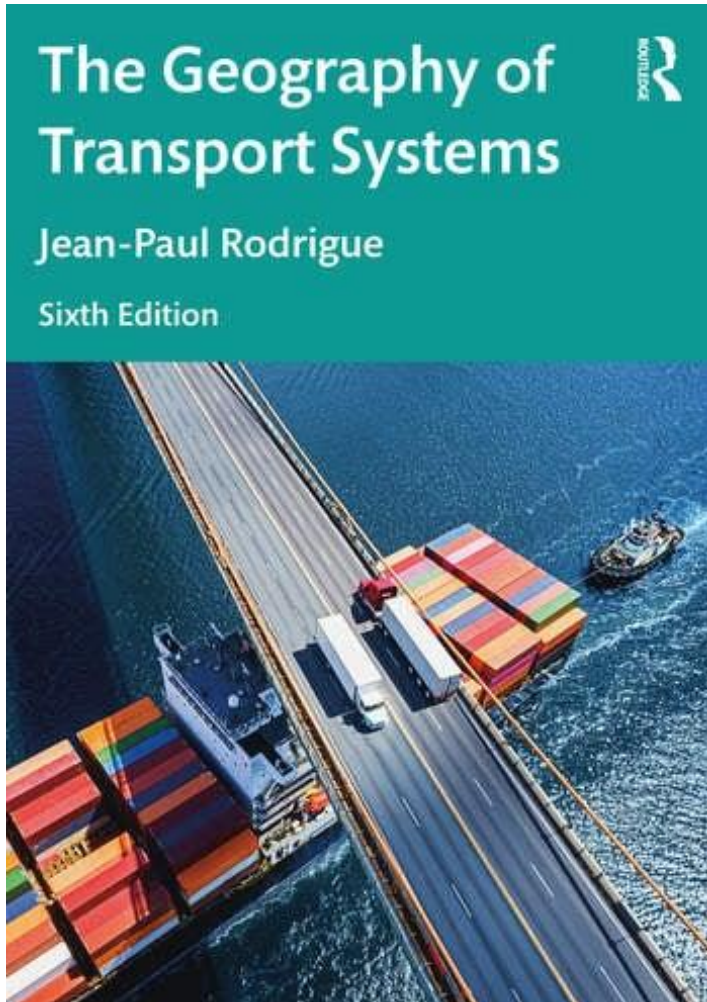


Terminal Costs



Transport and Terminal Costs Tradeoff in a Maritime Transport Chain

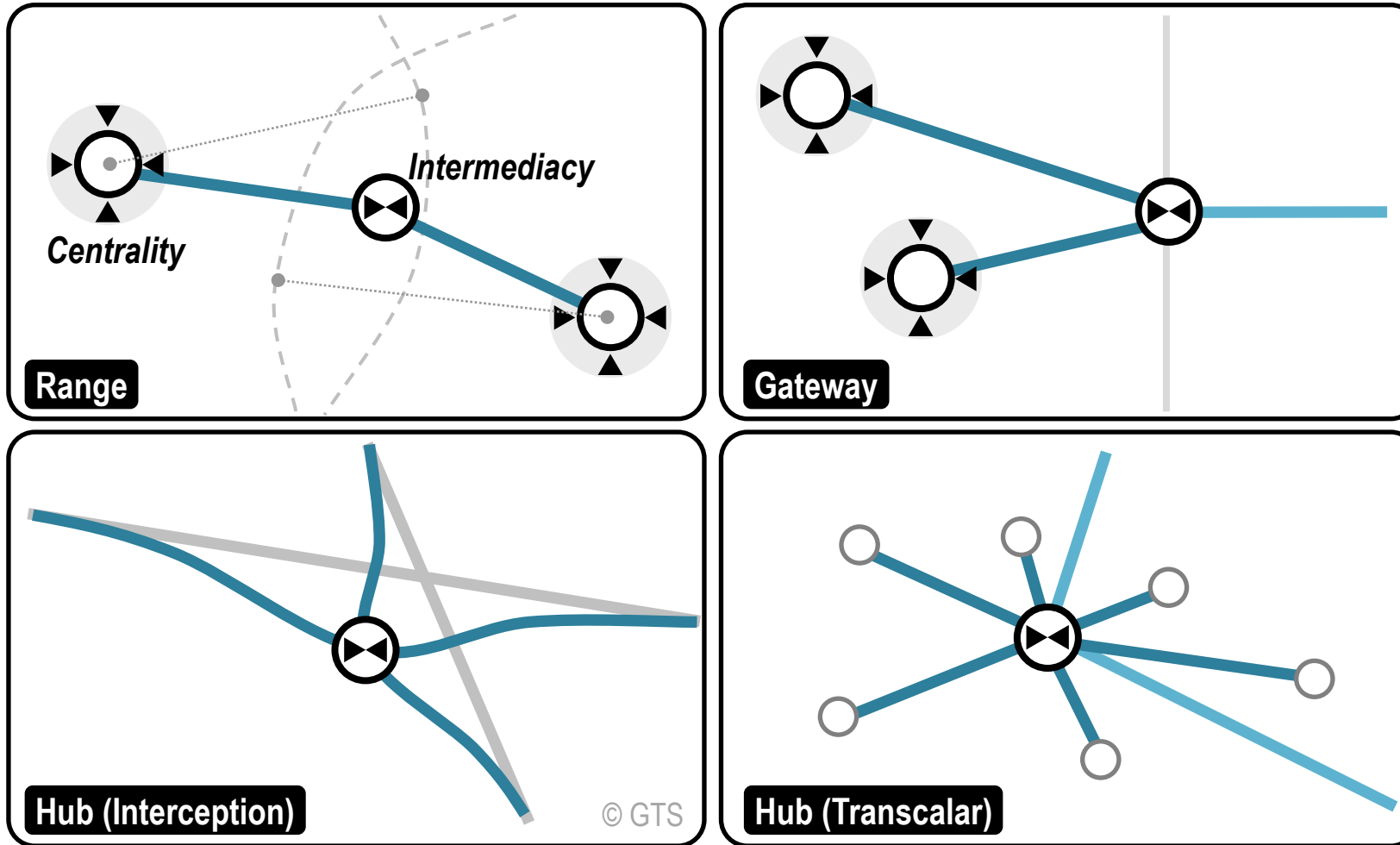




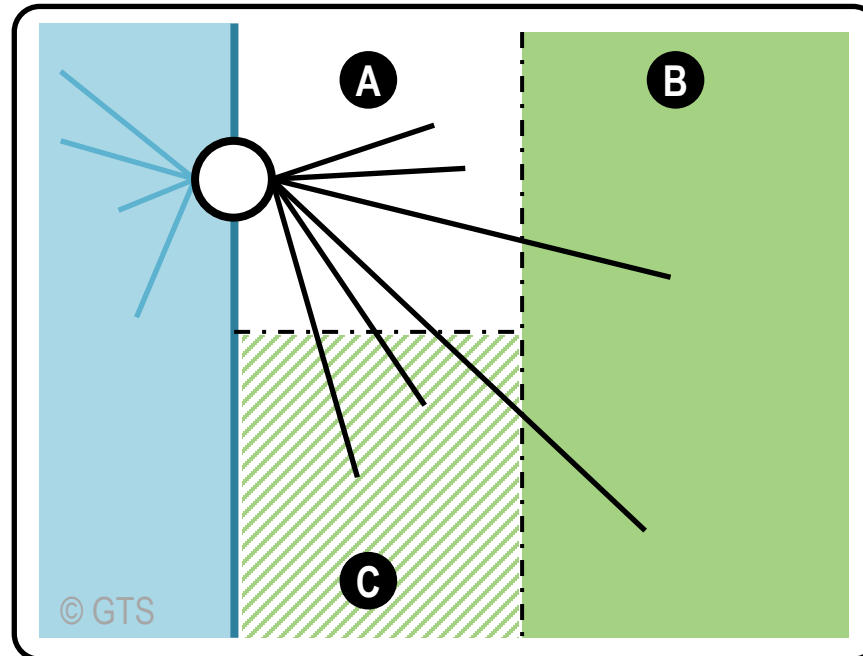
Transport Terminals and Hinterlands

Chapter 6.2

Centrality and Intermediacy



Coastal, Landlocked and Relatively Landlocked Markets



A. Coastal

- Direct connectivity to maritime shipping.
- Part of the same national jurisdiction.

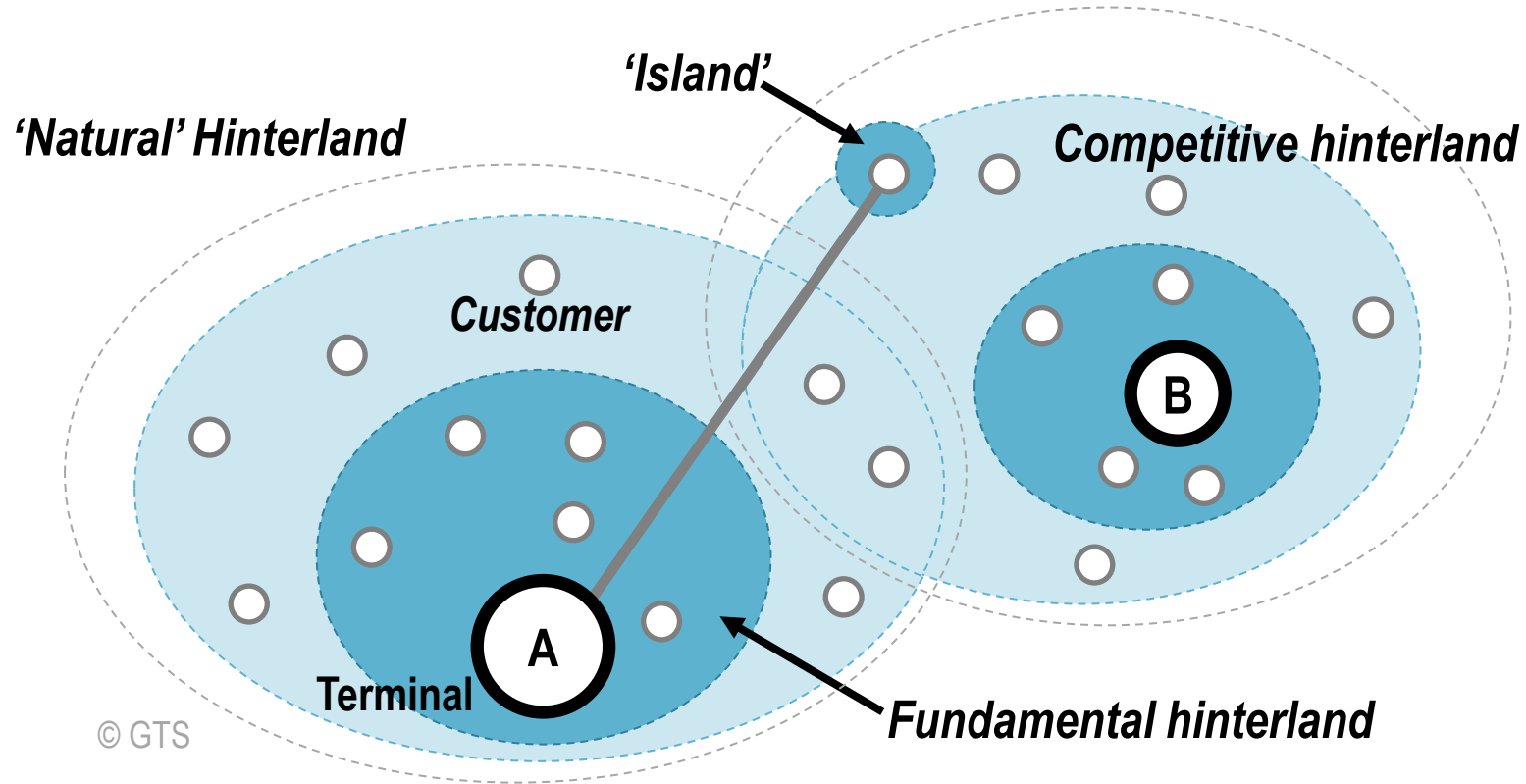
B. Landlocked

- Indirect connectivity to maritime shipping.
- Part of a different national jurisdiction.

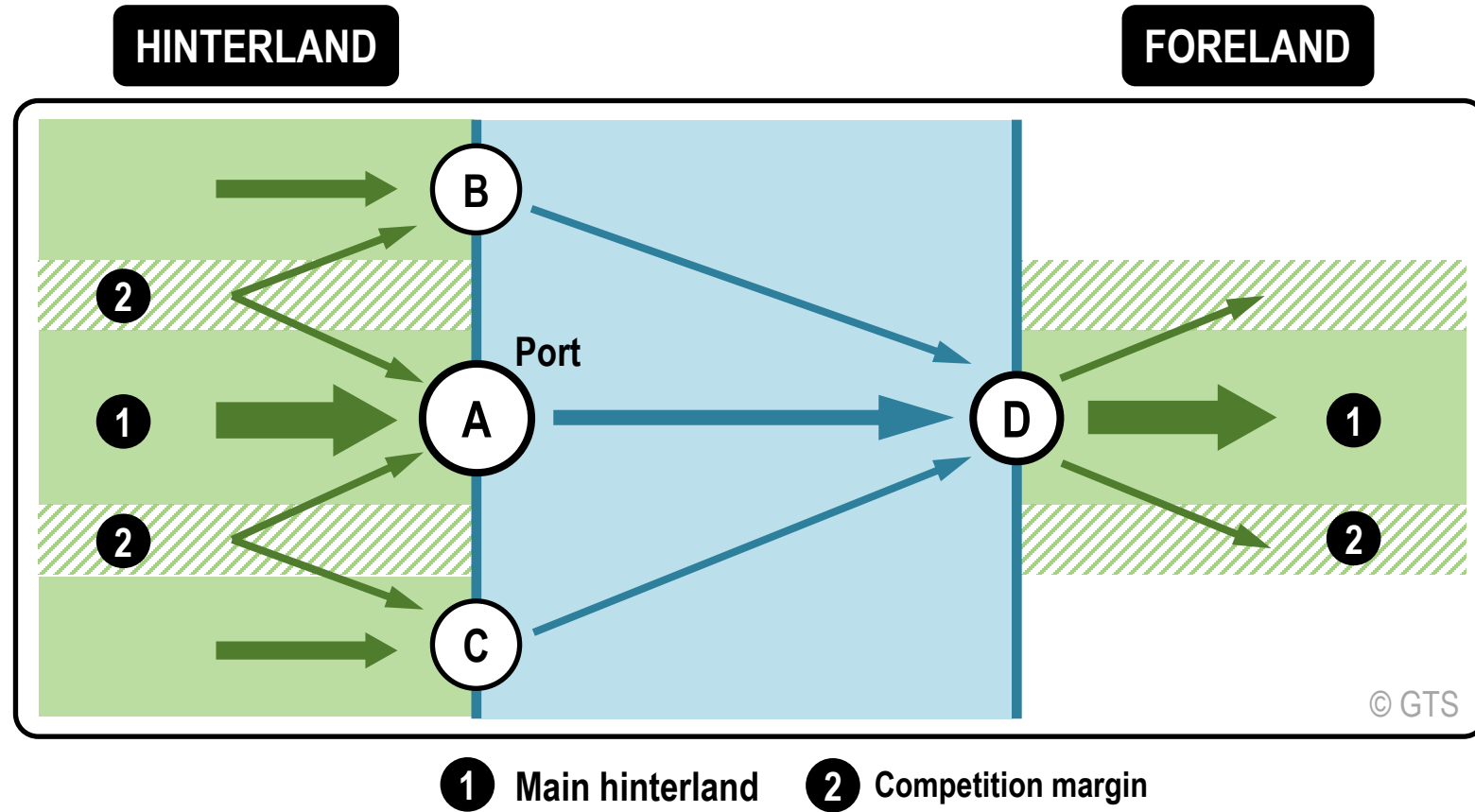
C. Relatively landlocked

- Indirect connectivity to maritime shipping.
- Part of a different national jurisdiction.
- Potential for direct connectivity.

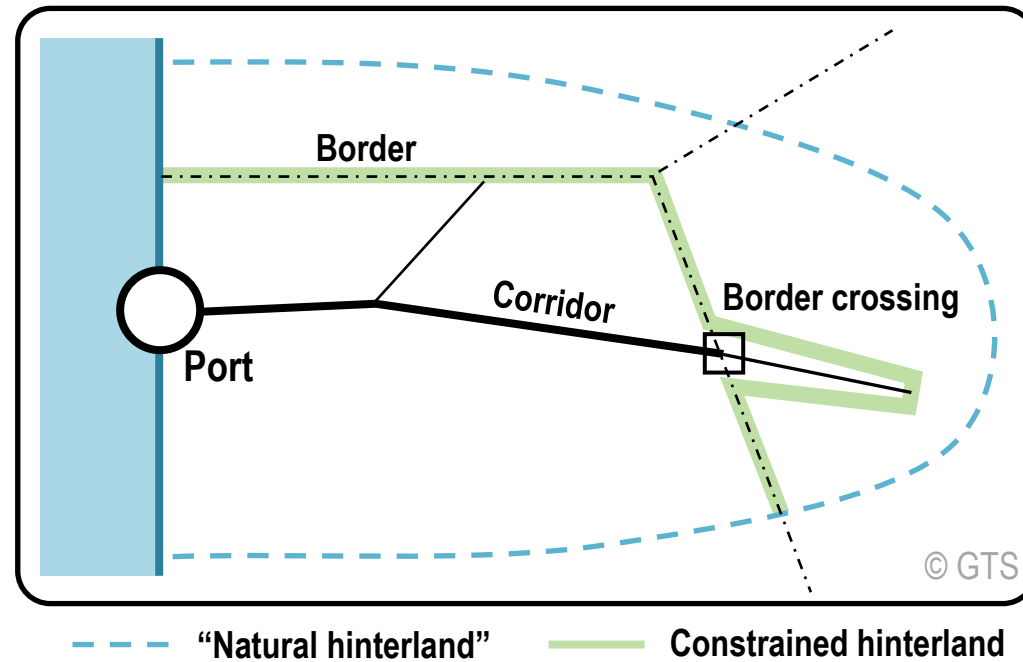
The Hinterland of a Transport Terminal



Port Foreland and Hinterland



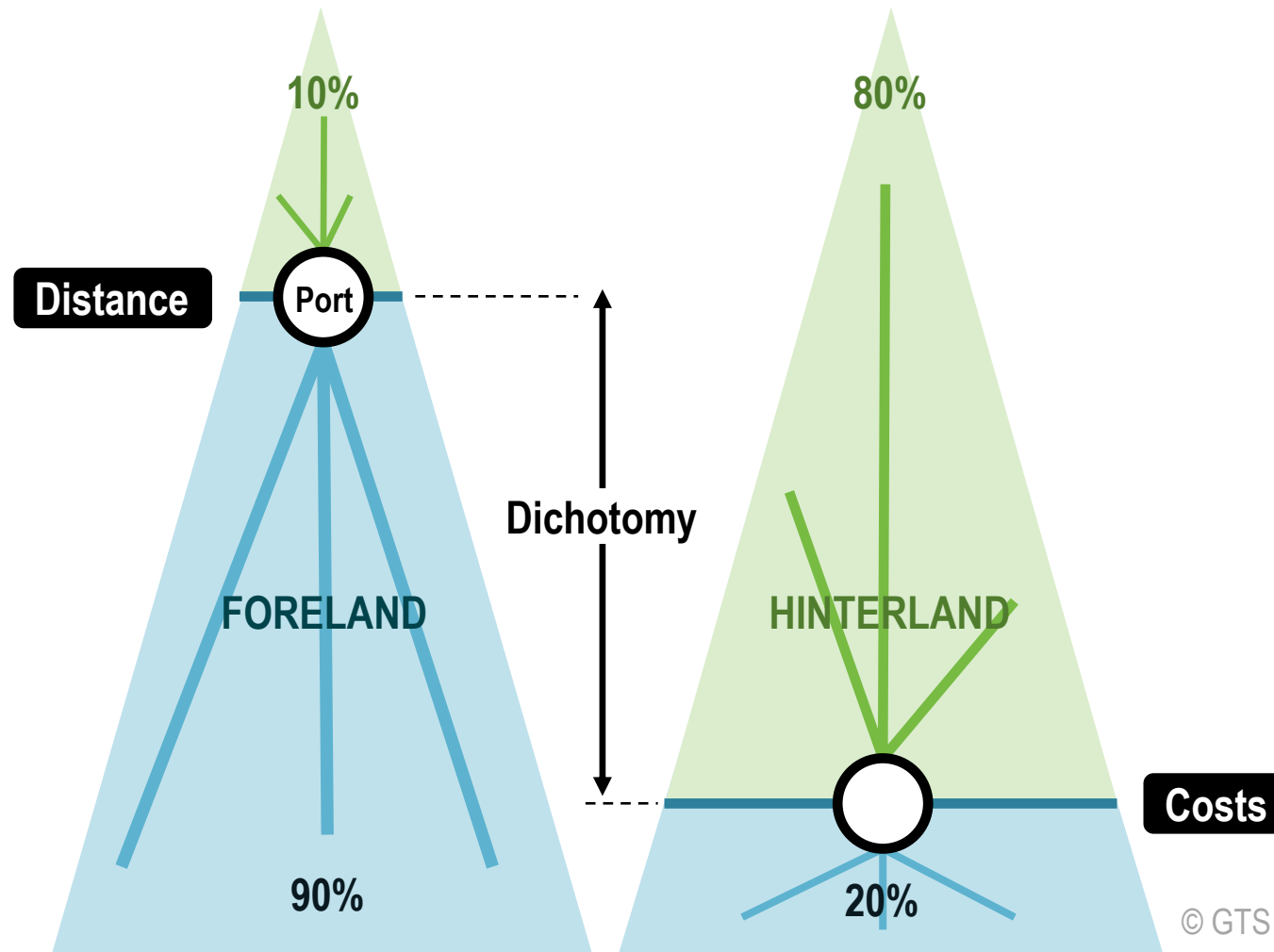
The “Boxed In” Hinterland



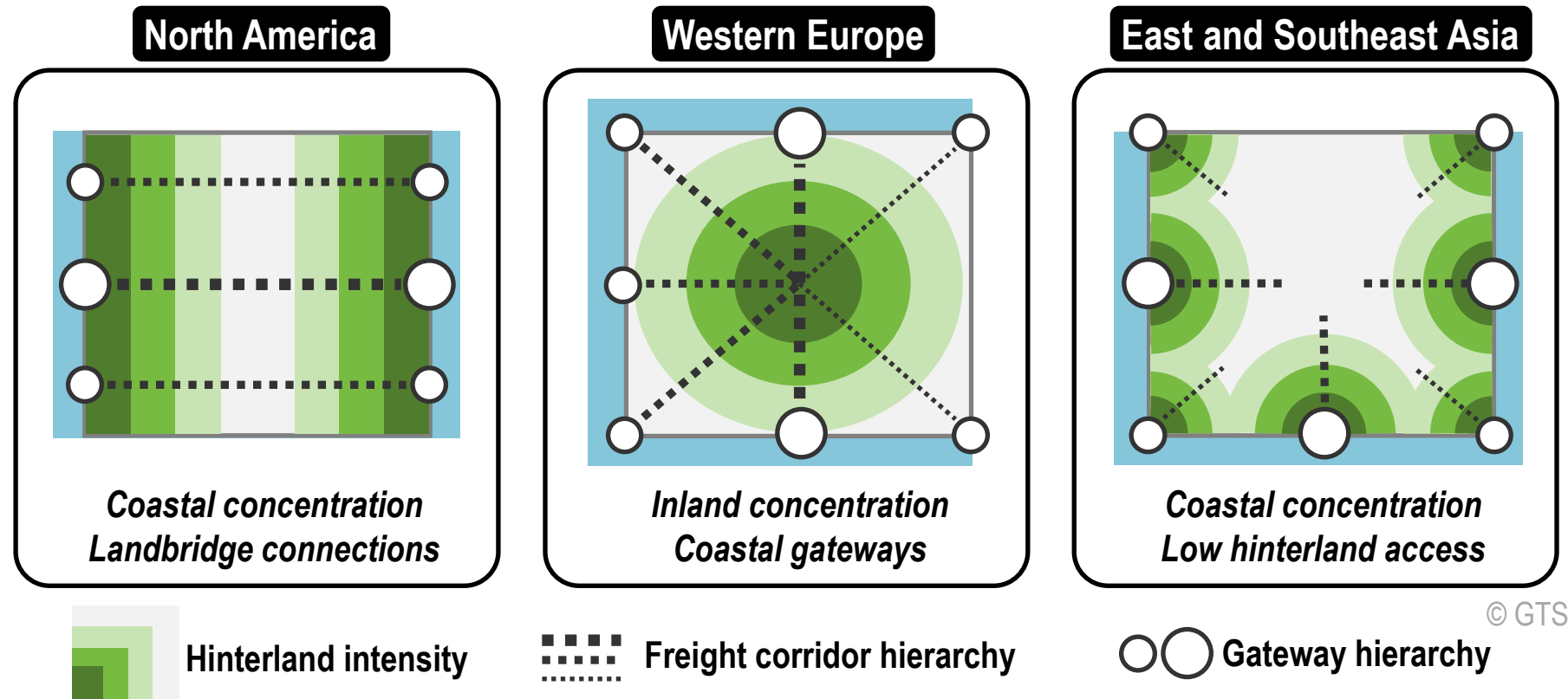
Maritime Enclaves (Landlocked Countries)



The Space / Cost Dichotomy of Forelands and Hinterlands



Hinterland Setting and Major Economic Regions



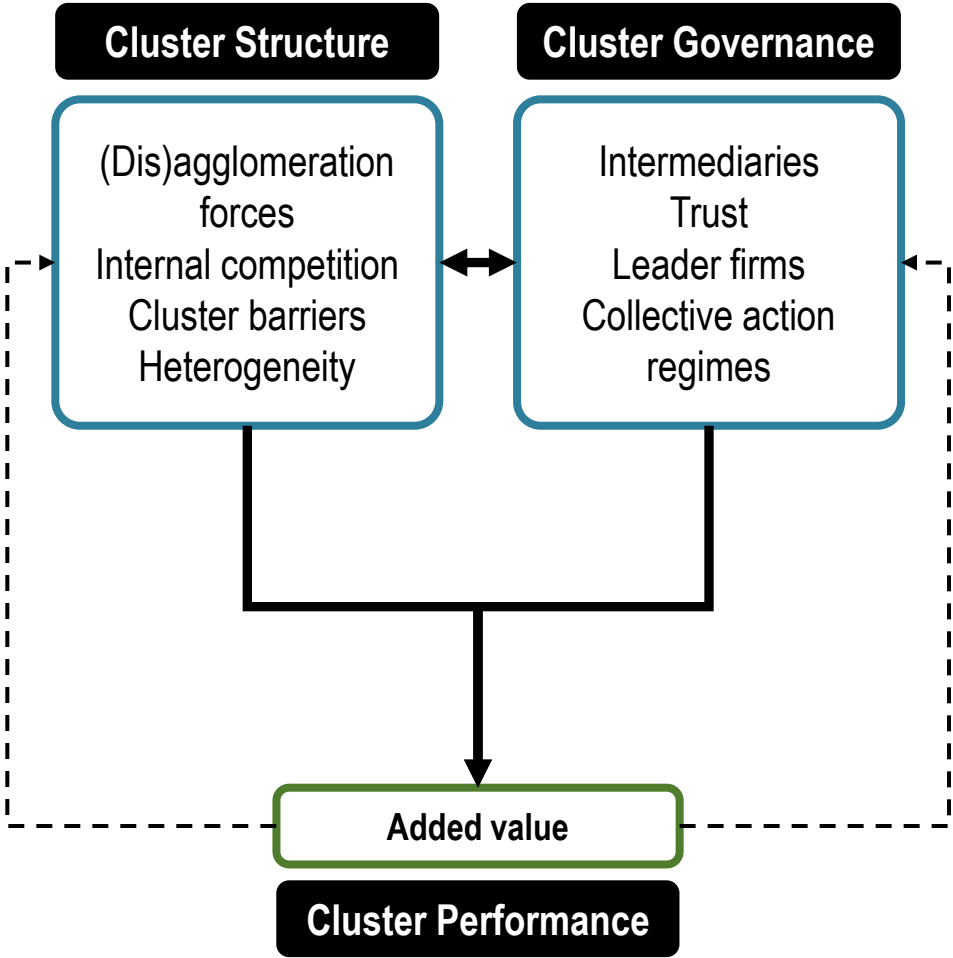
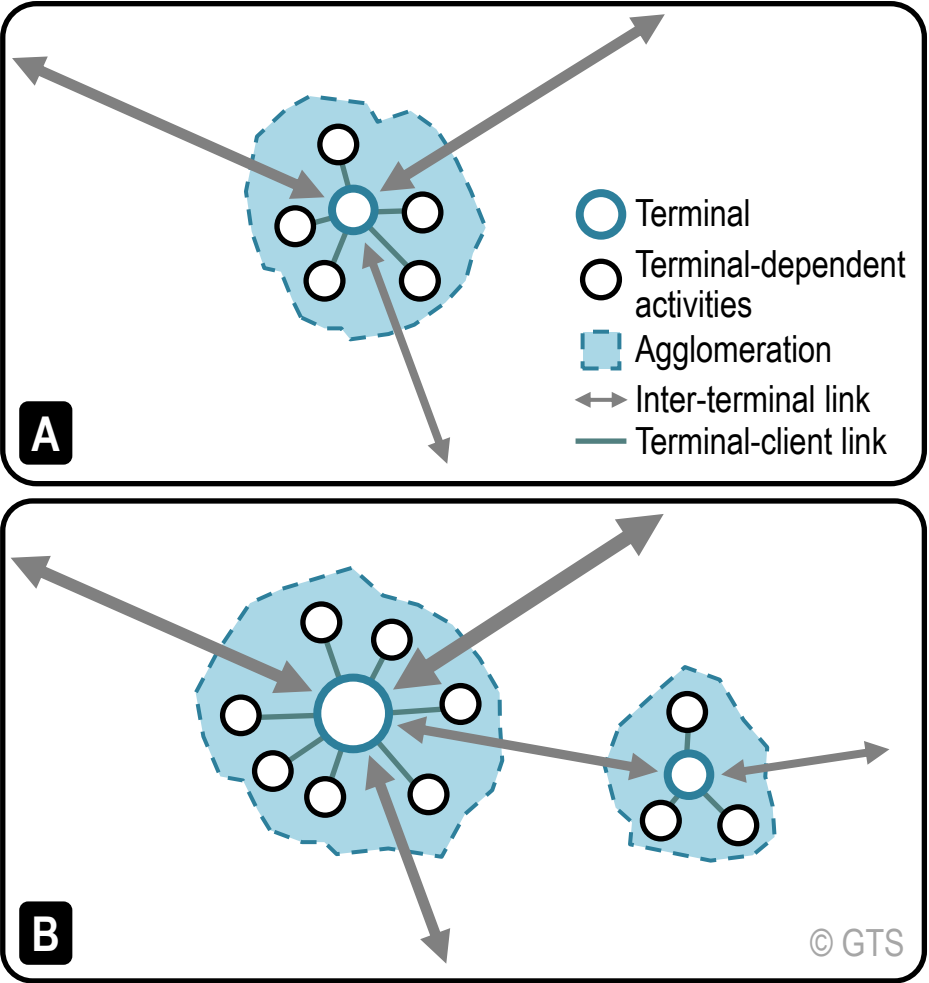
Types of Hinterland

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

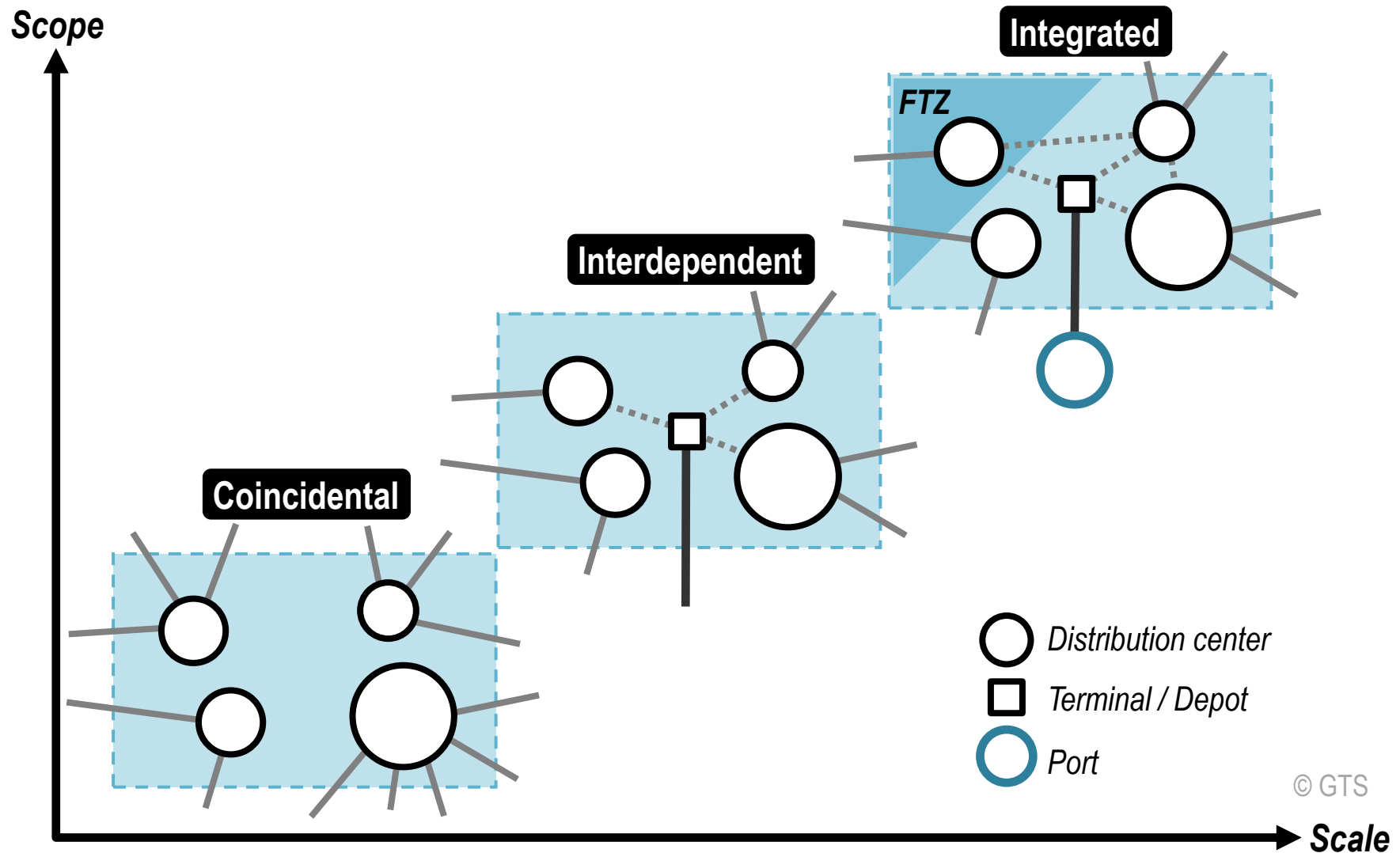
Strategies Used by Port Authorities to Coordinate their Hinterland

Usage of incentives	Coordinate operations of freight actors. Optimal usage of transport chains.
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.

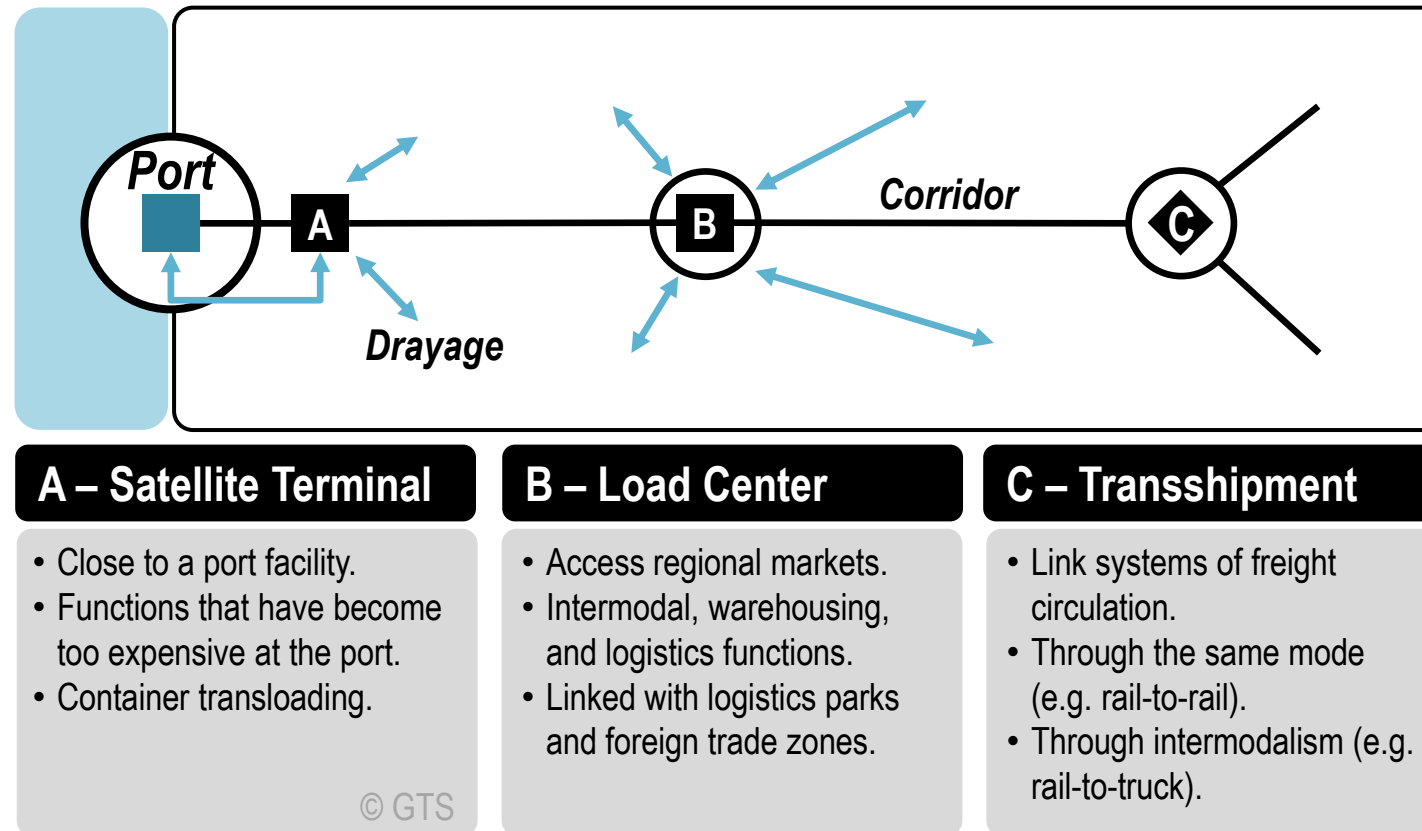
Terminals as Clusters and Growth Poles

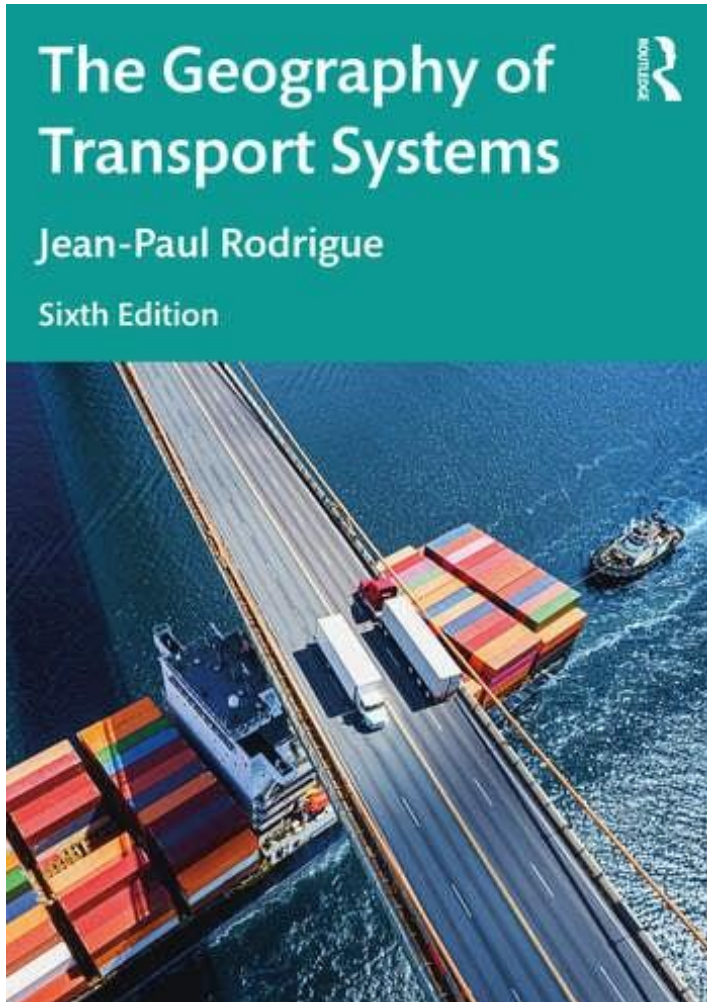


Functional Integration of Freight Clusters



Functions of Inland Terminals

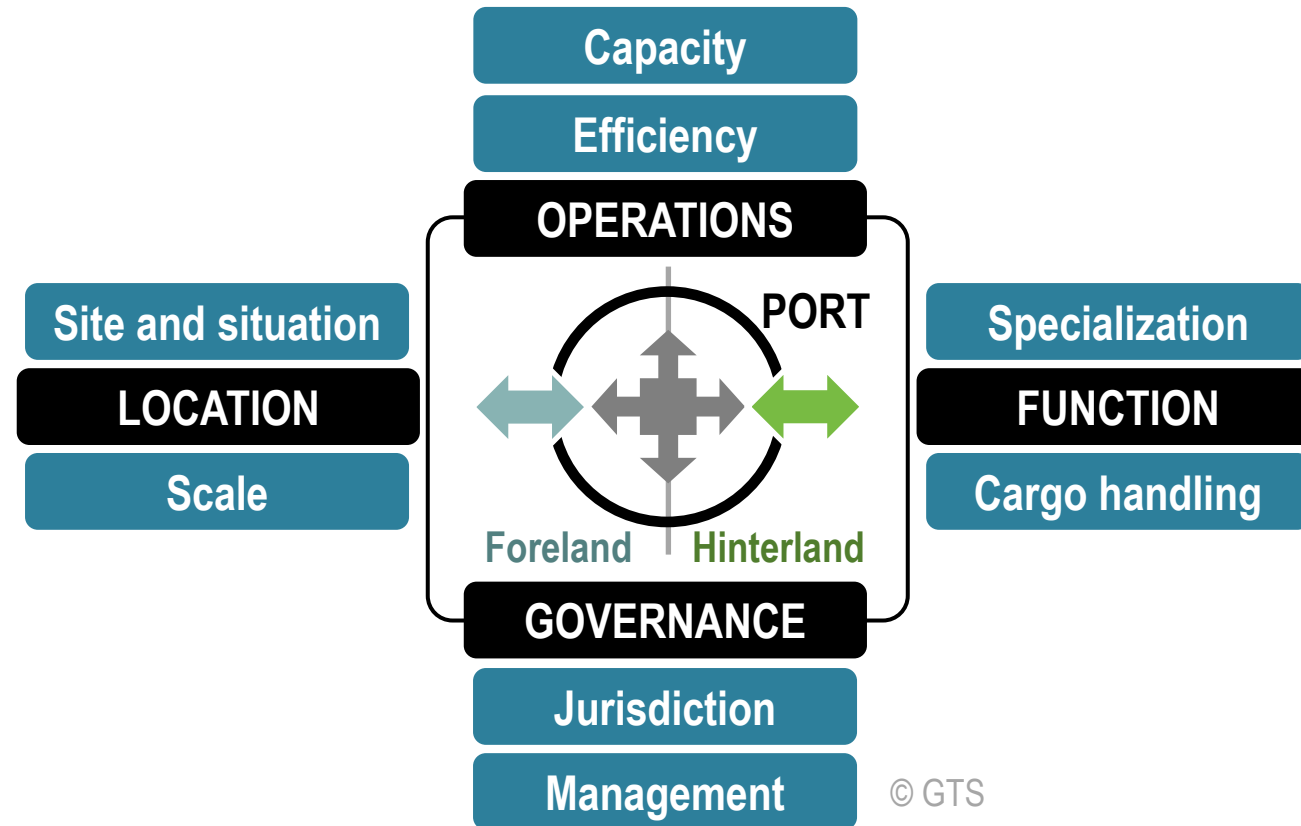




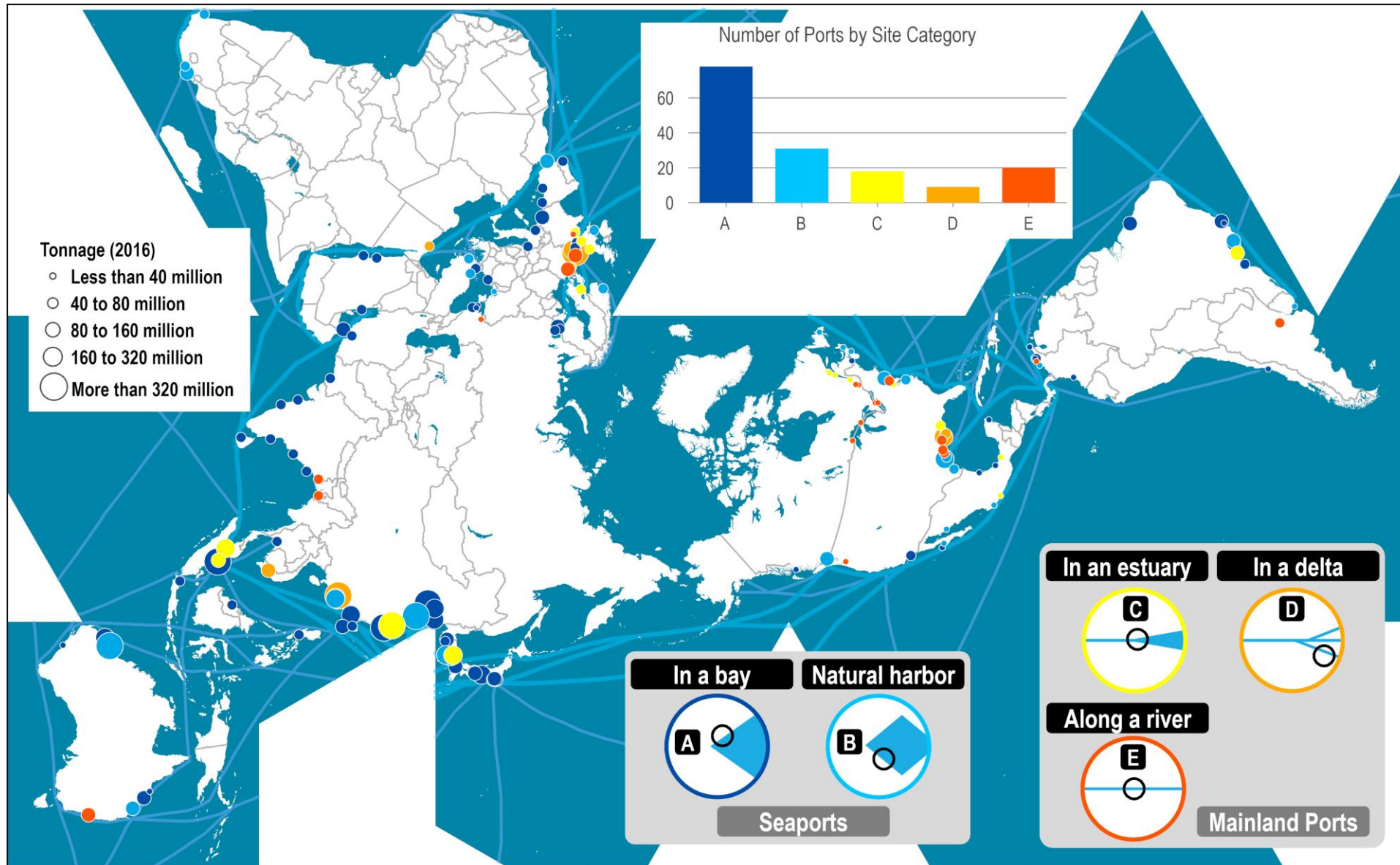
Port Terminals

Chapter 6.3

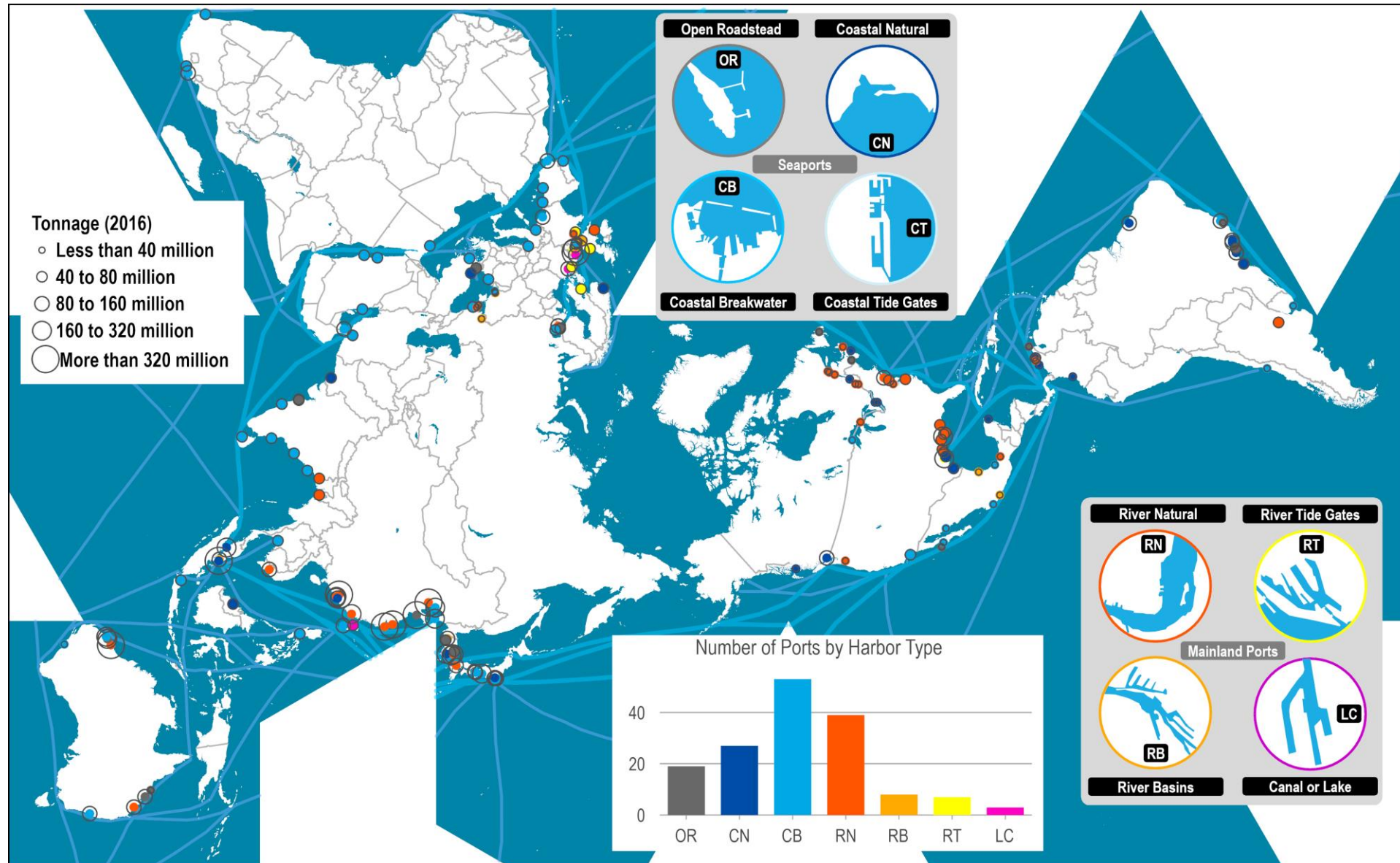
The Main Dimensions of Port Geography



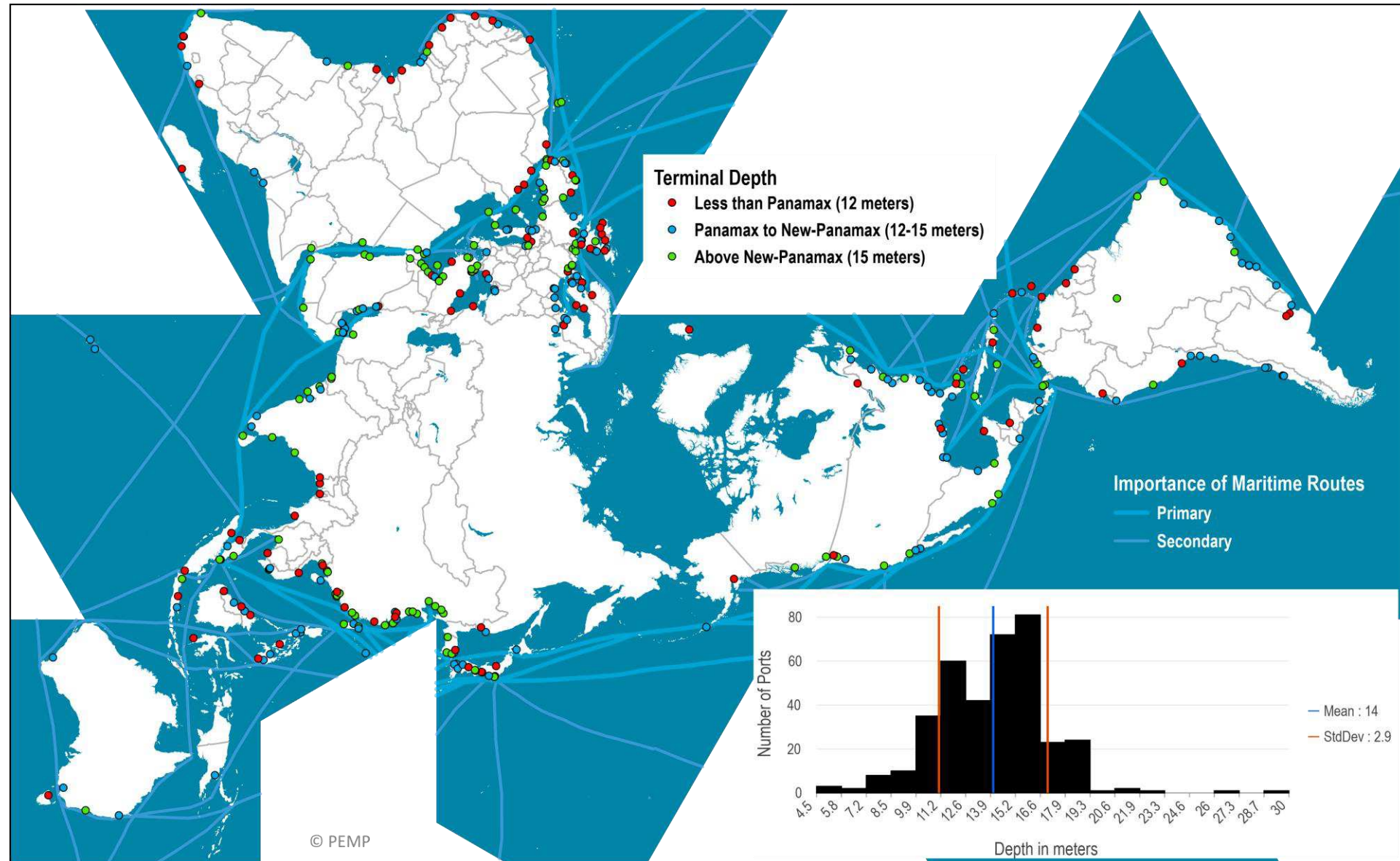
Port Sites



Harbor Types



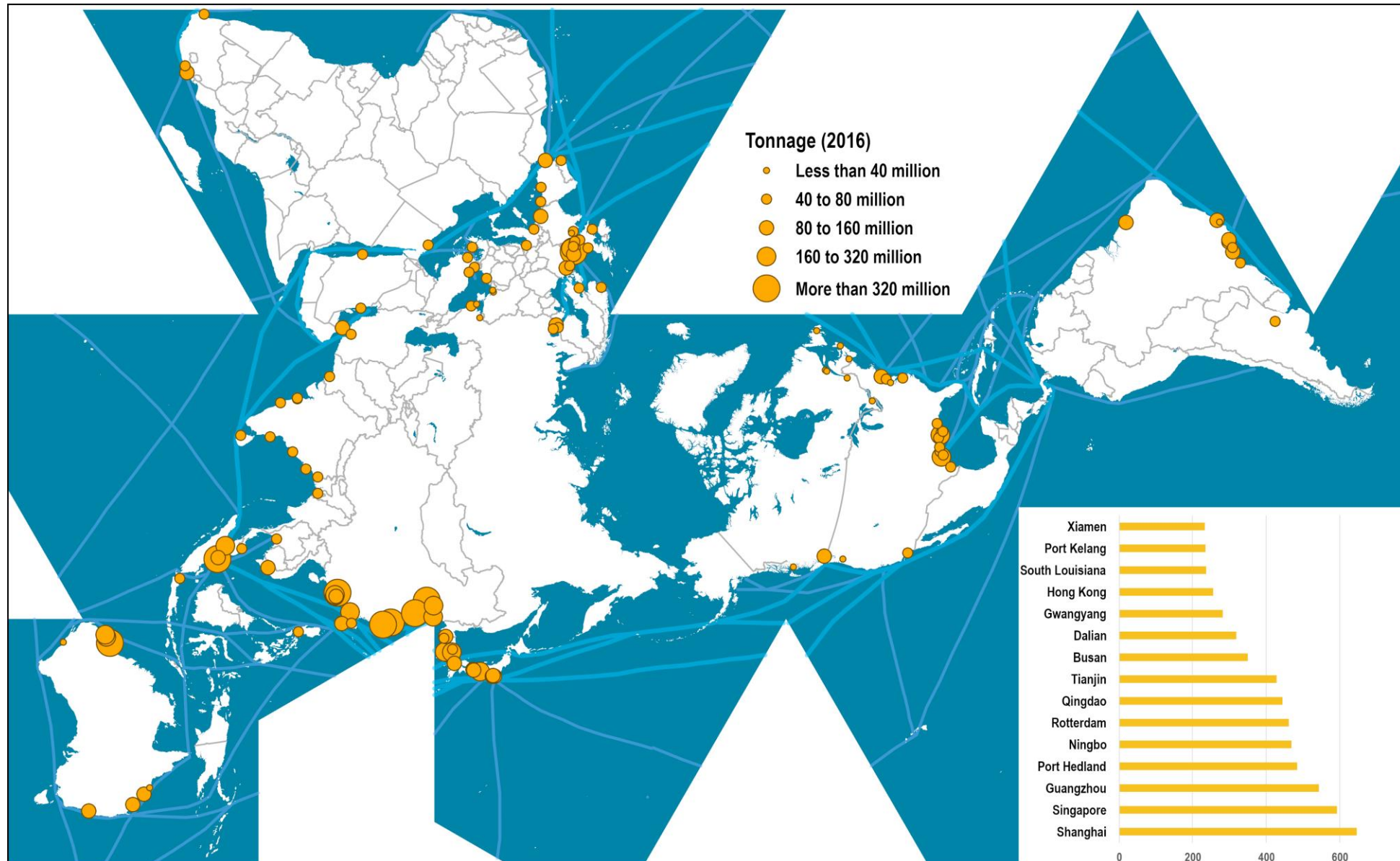
Terminal Depth at Selected Ports



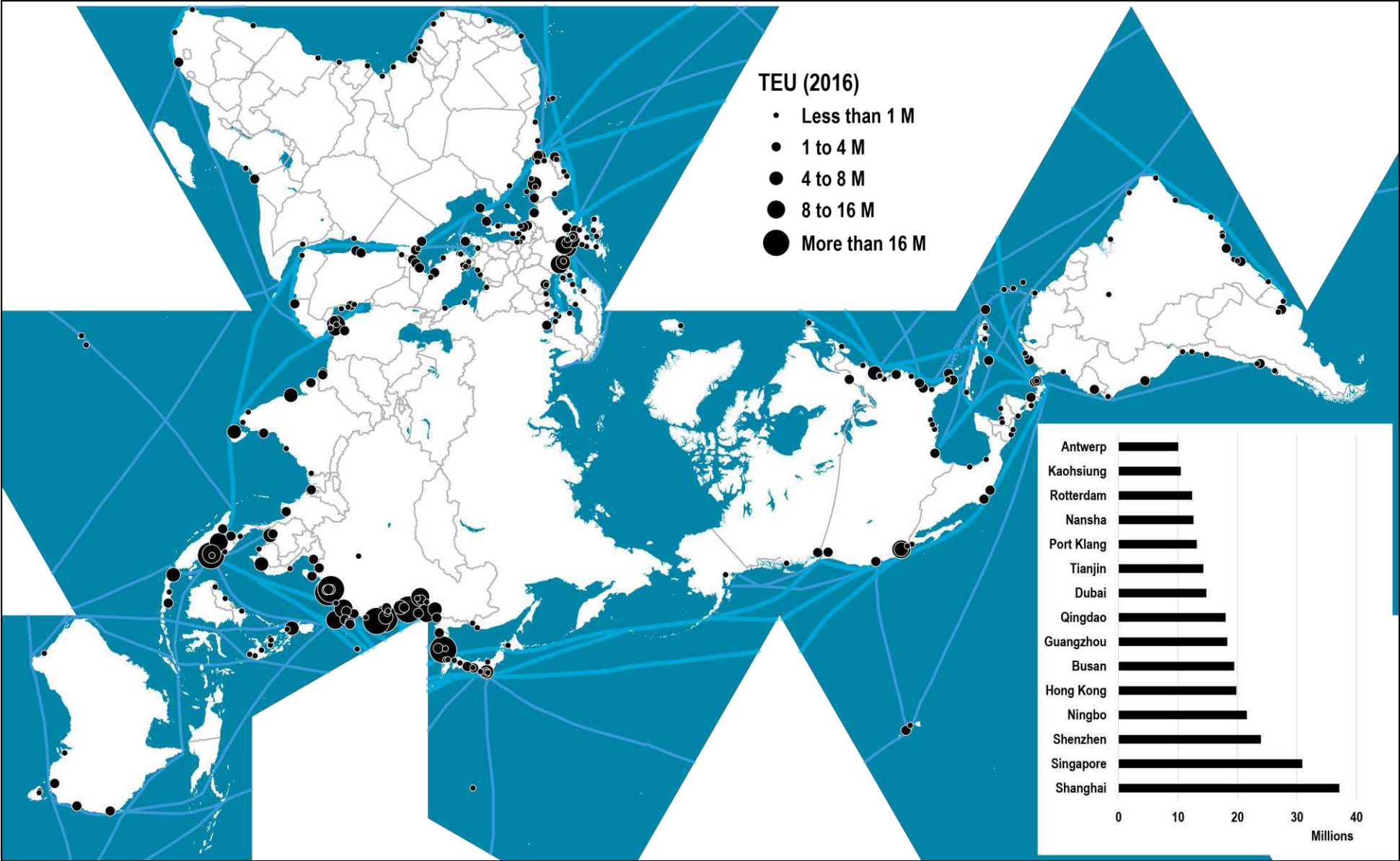
World Harbor Types and Sizes

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

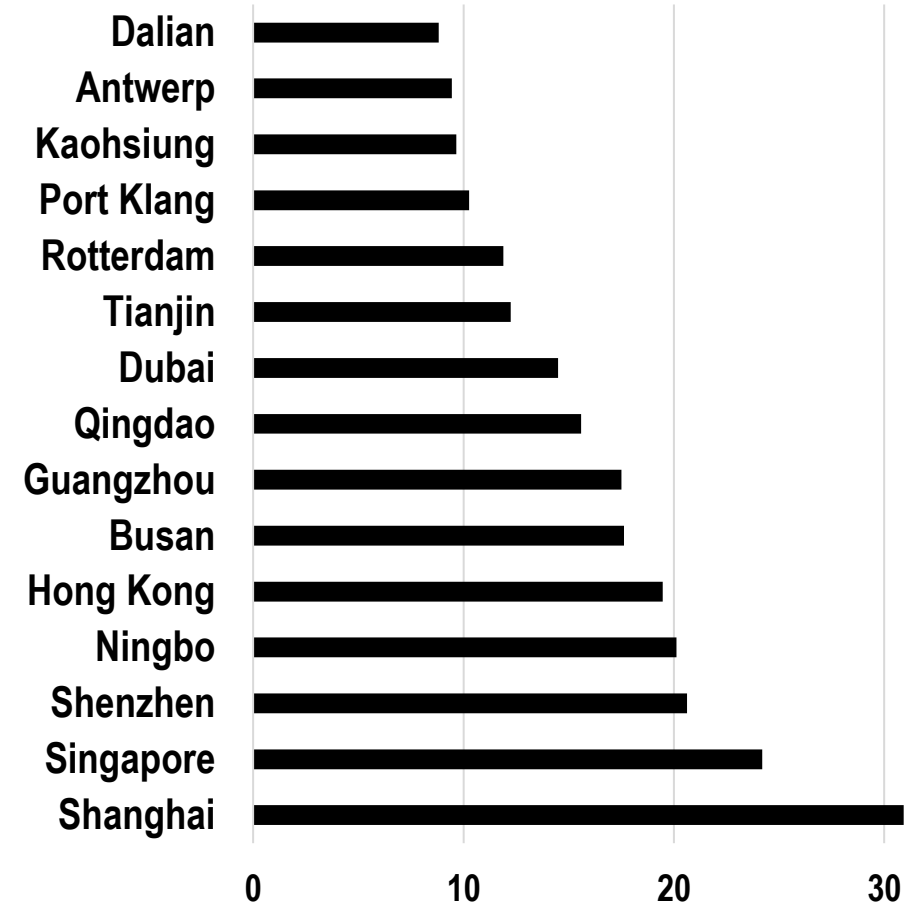
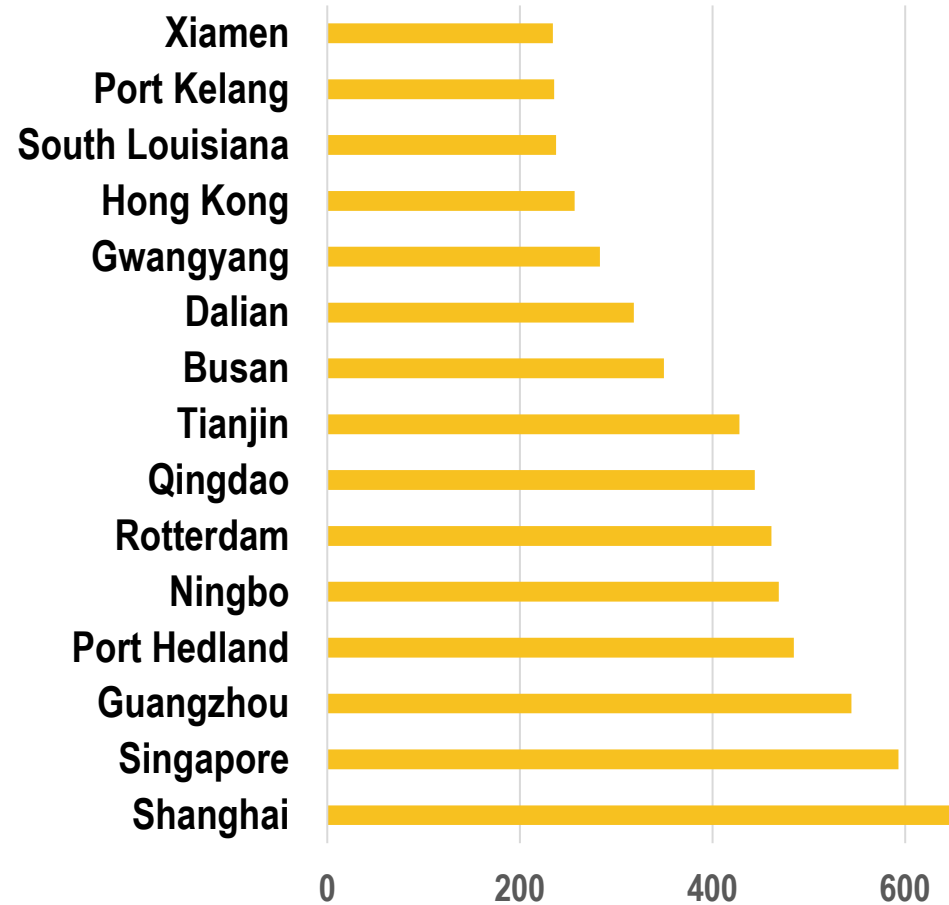
Tonnage Handled by the World's Major Ports, 2016



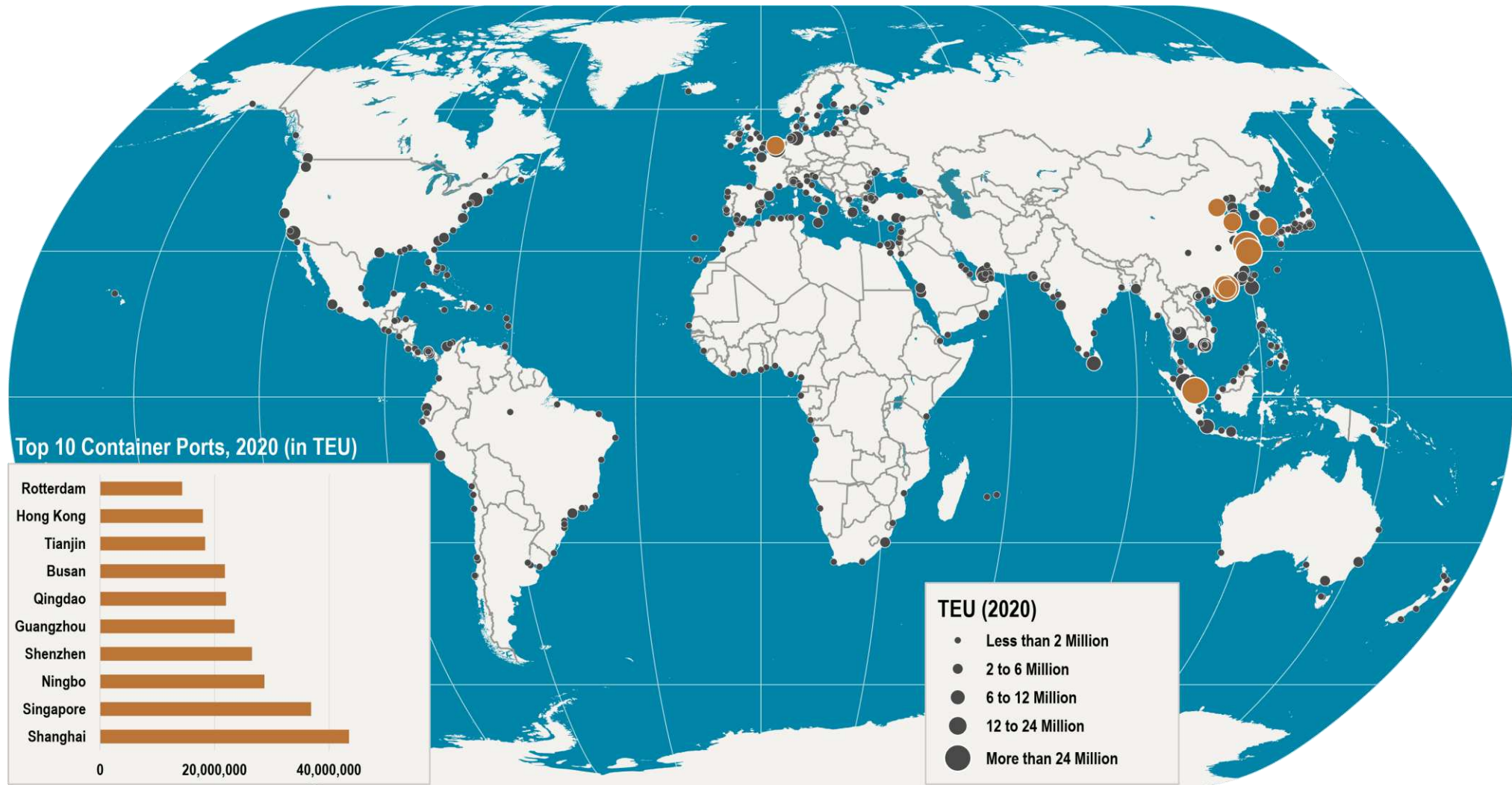
World's Major Container Ports, 2016



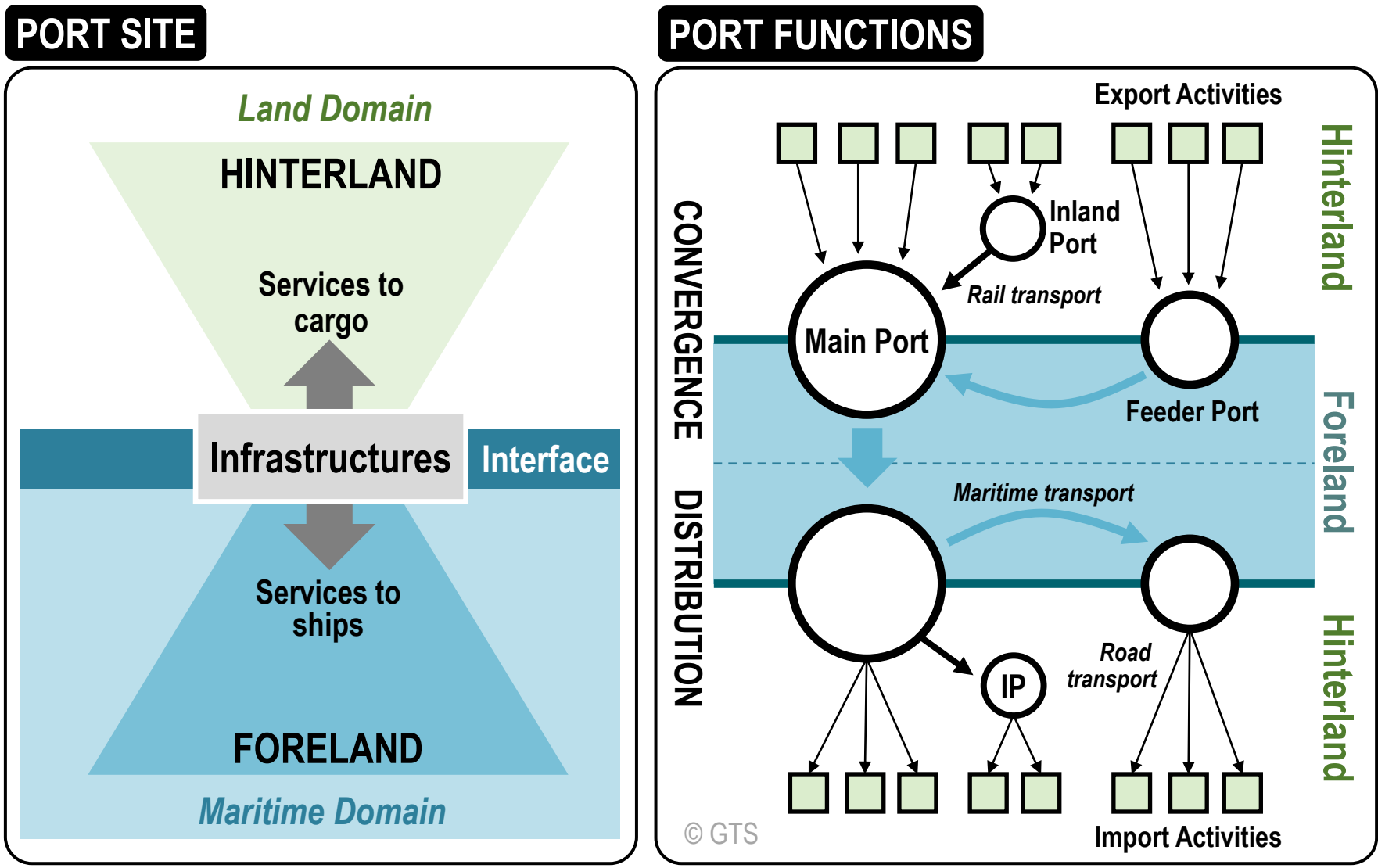
The World's 15 Largest Ports, 2015 (Millions of tons and TEUs)



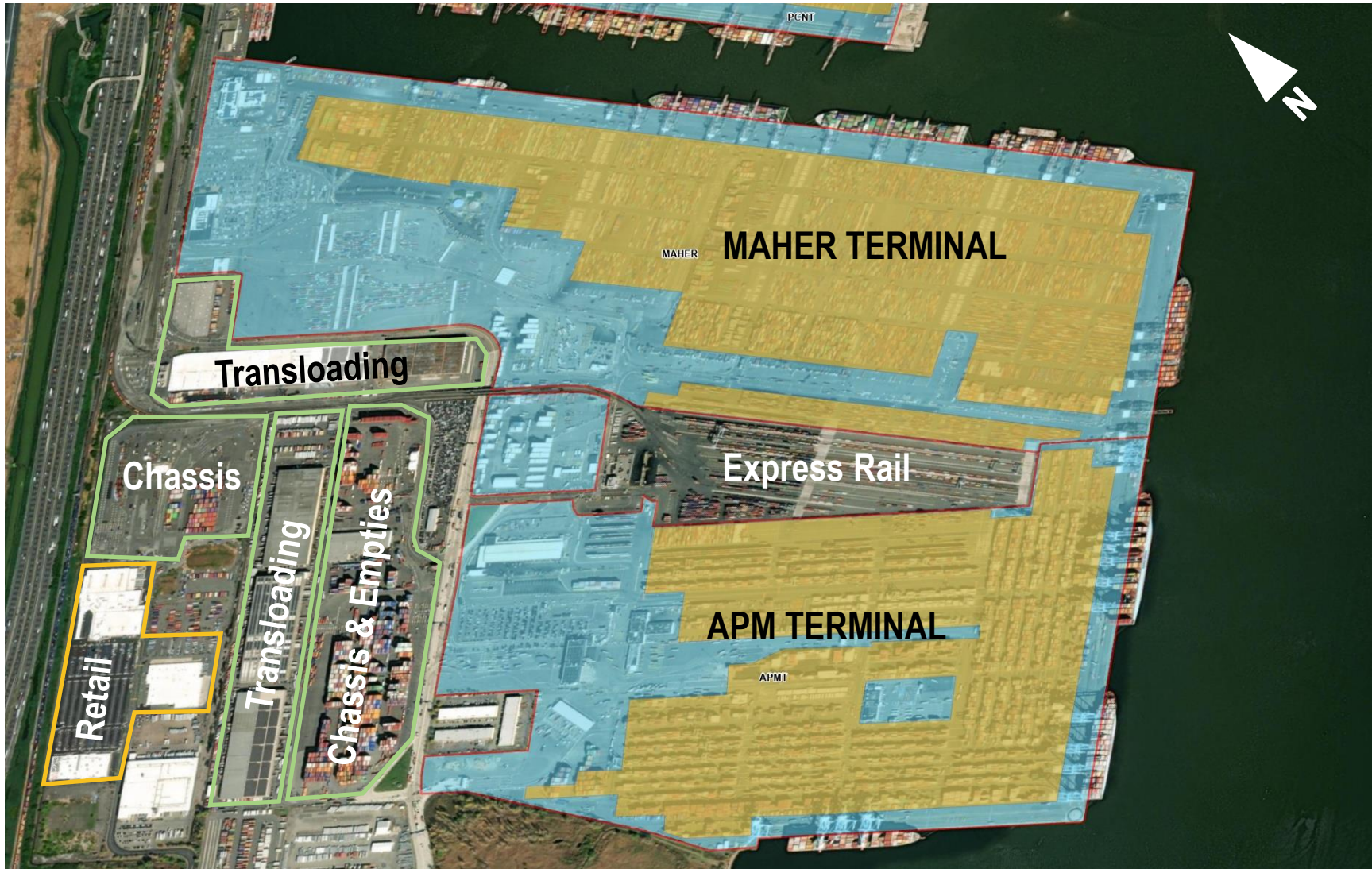
World's Major Container Ports, 2020



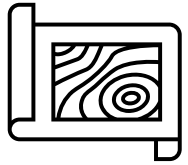
Port Sites and Functions



Port Elizabeth Intermodal Complex, Port of New York / New Jersey



Range of Activities Performed by Ports



Land

- Land acquisition (purchase or lease)
- Land reclamation projects



Infrastructure links

- Railways, roads, canals, tunnels and bridges within the port area



Maritime access

- Access channel dredging
- Sea locks & breakwaters
- Vessel traffic service & ship movement information networks
- Light buoys & navigational aids



Port maintenance

- Maintenance dredging; infra and superstructure



Port infrastructure

- Internal locks; docks, quays, jetties, piers, berths
- Harbor basin dredging



Port services

- Cargo handling (stevedoring, storage, stowage)
- Nautical services (pilotage, towage, mooring)
- Other services (firefighting, water & electricity supply, security, bunkering, pollution control)



Port superstructure

- Pavement
- Cranes and gantries and other mobile/semi-mobile equipment
- Warehouses, shops, sheds, and office buildings
- Public utilities (sewage, water supply, electricity)

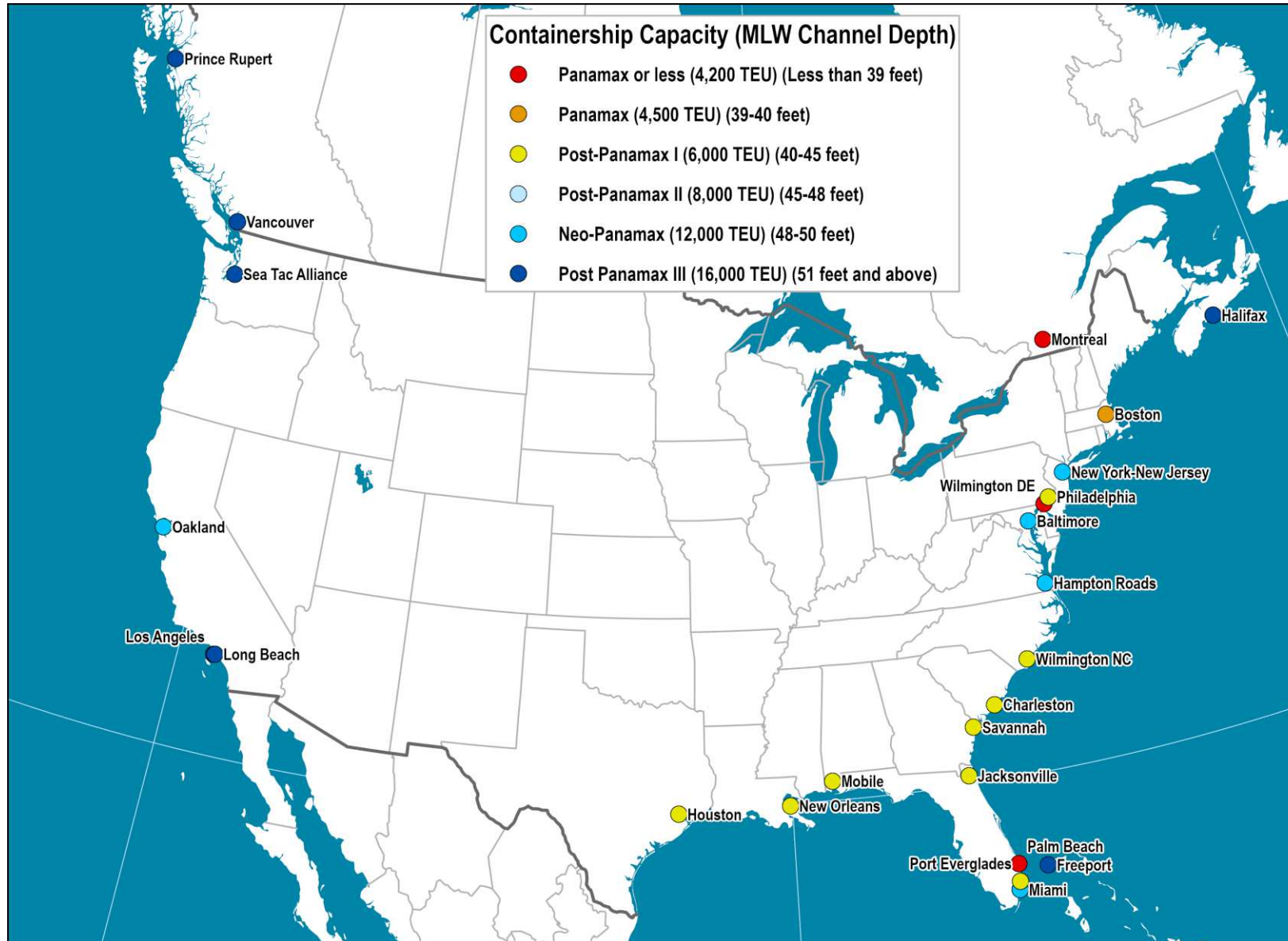
© GTS



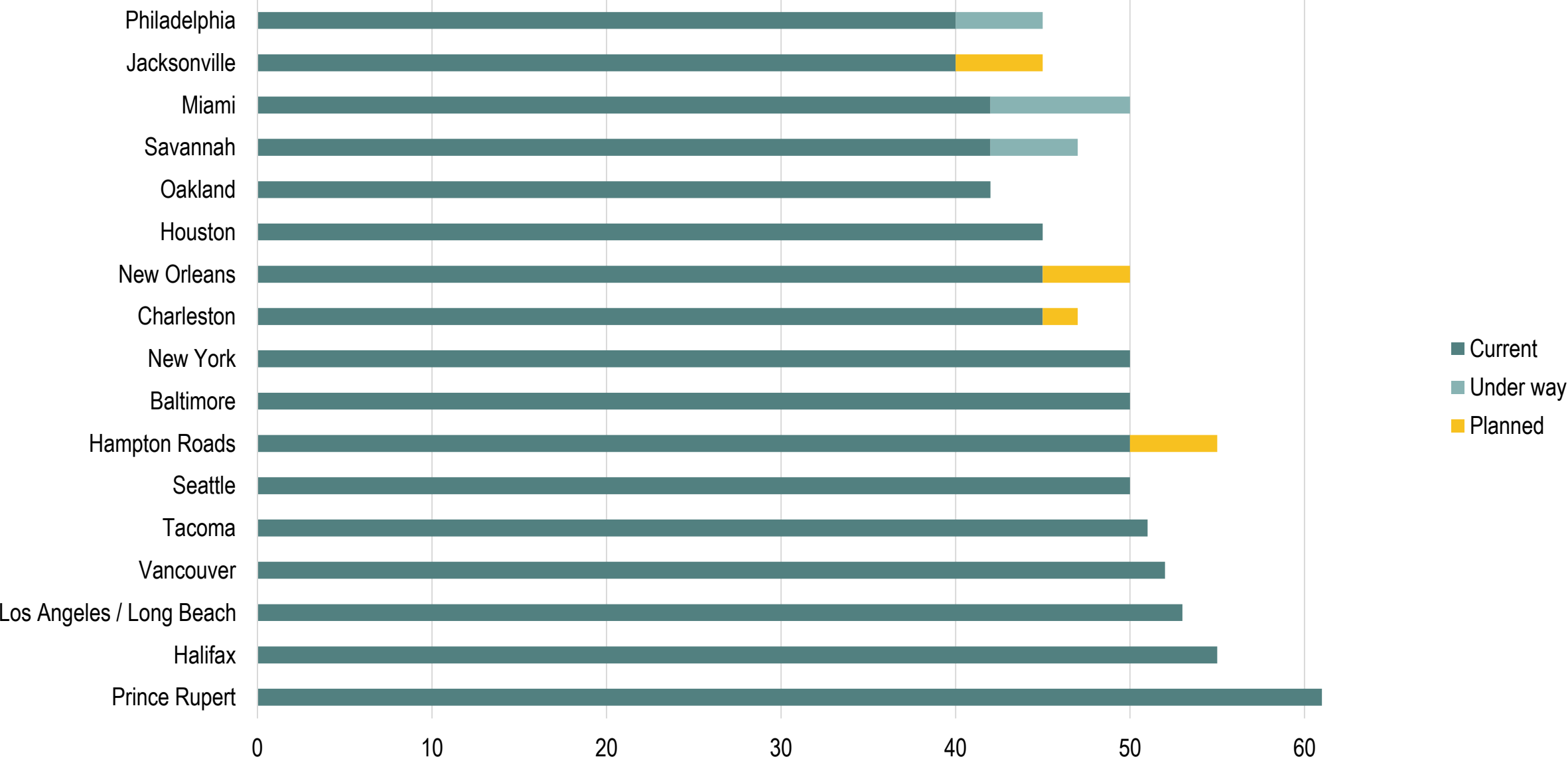
Port planning

- Promoting logistics and industrial areas
- Marketing to existing and potential users
- Planning of infrastructure and superstructure developments

Channel Depth at Major North American Container Ports



Channel Depth at Selected North American Ports (in feet)



Public and Private Roles in Port Management

	Public service port	Tool port	Landlord port	Corporatized port	Private service port
Ownership	Public responsibility				
Port administration				Private responsibility	
Nautical management					
Port infrastructure					
Superstructure					
Cargo handling					
Pilotage					
Towage					
Mooring services					
Dredging			© GTS		

The Main Activities of Landlord Port Authorities

Traffic Management

Vessel traffic management (fast turnaround, security, reliability).
Management of inbound and outbound inland traffic.
Partnership with barge, rail and truck operators for inland distribution.

Area Management

Develop transport infrastructures.
Provide space for port related activities (expansion or reconversion).
Rationalize the land use.

Customer Management

Attract new customers.
Retain existing customers (satisfaction).
Find new added value activities.

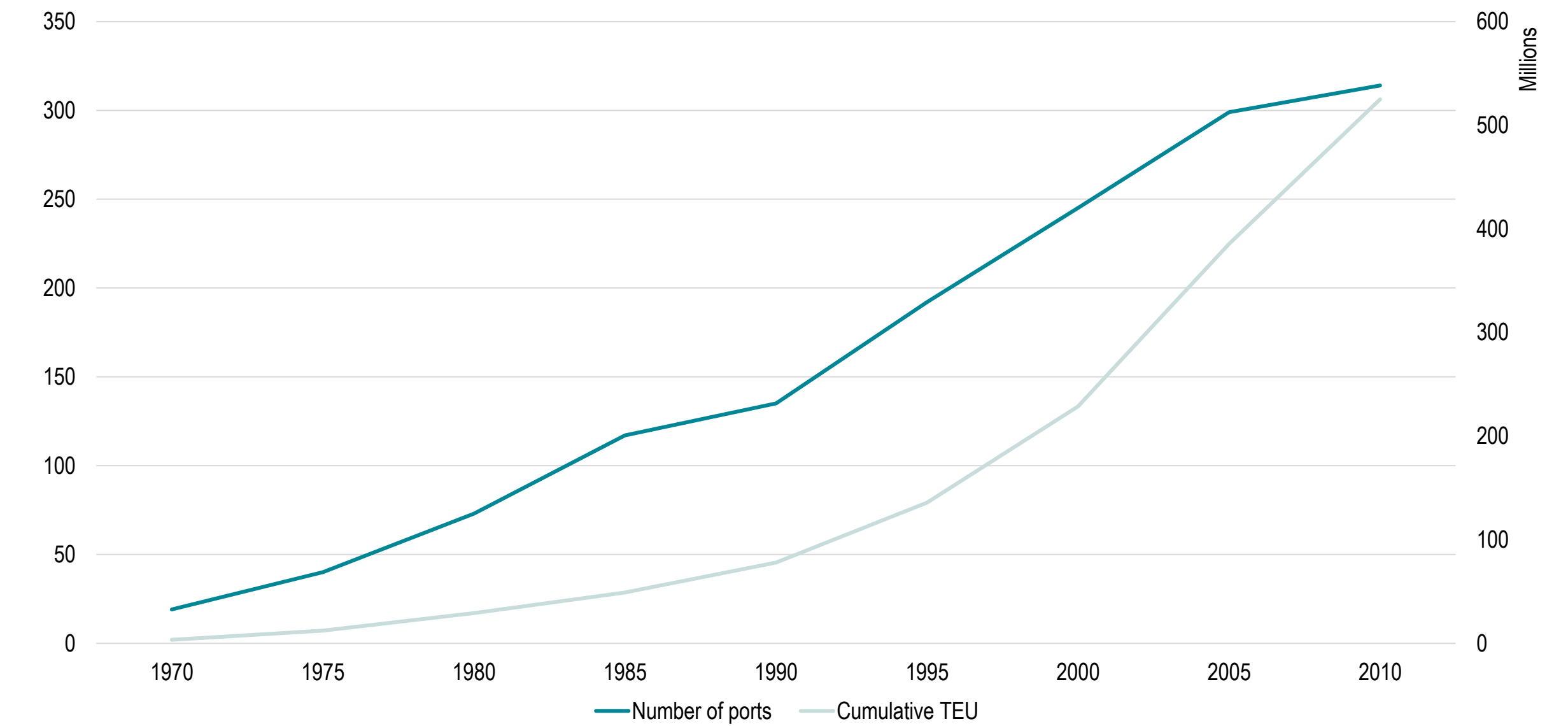
Stakeholder Management

Influence regulation.
Relations with local, regional and national public agencies.

Contextual Evolution of the Dimensions Covered by Port Authorities

	Conventional Port Authority	Expanded Port Authority
Economic	Port infrastructure management and operations. Transport chain.	Concession agreements. Logistical chain. Hinterland access.
Institutional	Centralized entity (node). Financial dependency.	Decentralized entity (cluster). Financial autonomy.
Environmental	Environmental impact assessment.	Environmental management systems. Port-city relationships.

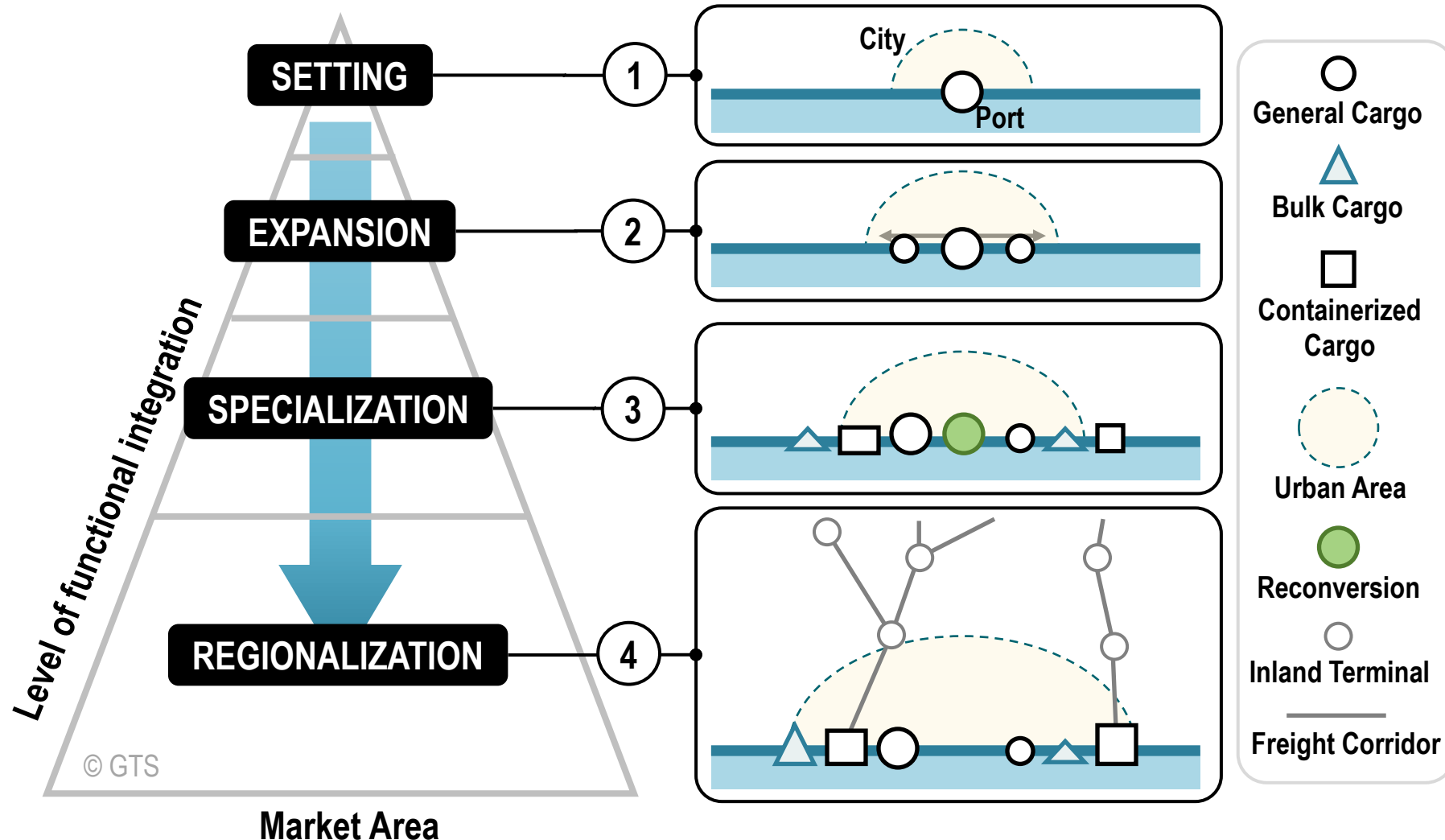
Number of Container Ports of more than 100,000 TEU and Cumulative Traffic, 1970-2010



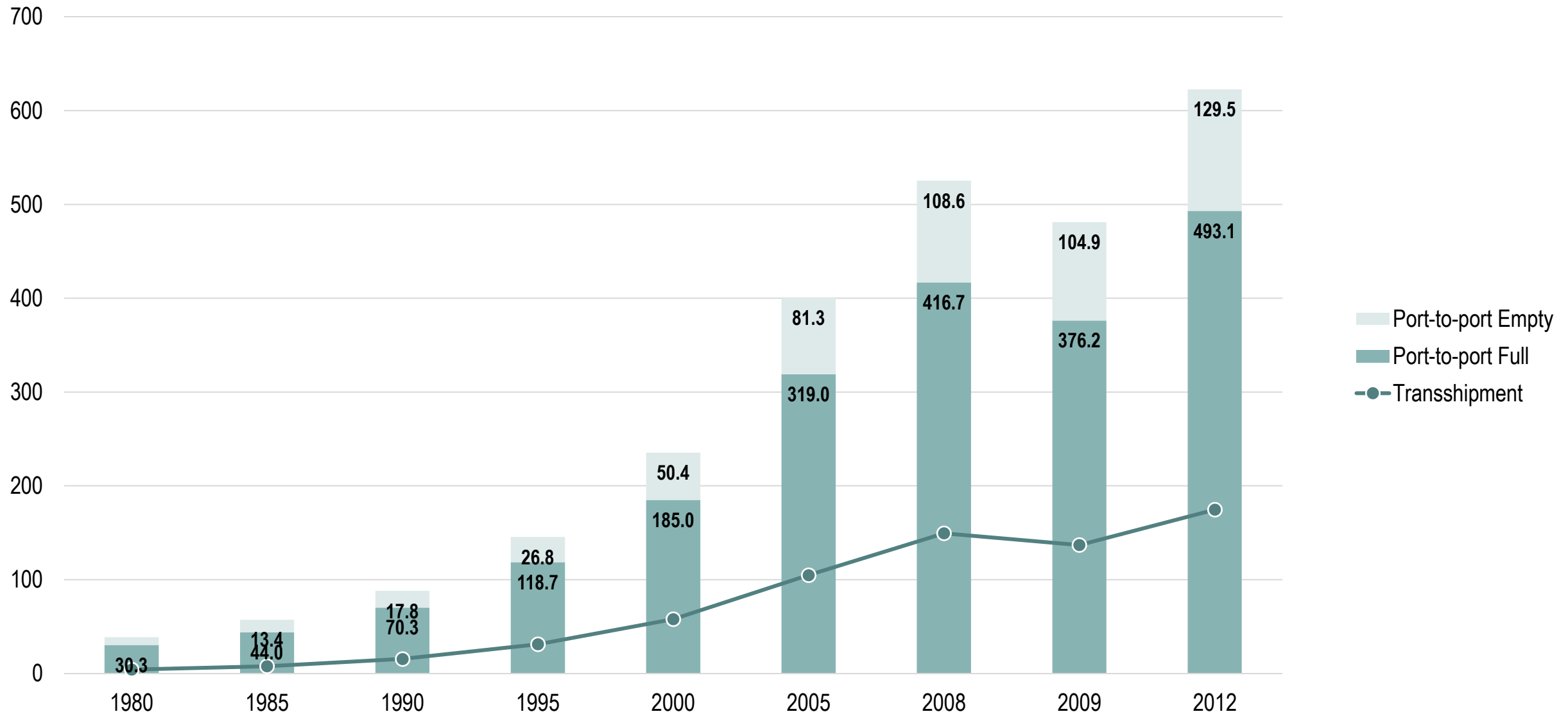
Stages in Port Development

	Stage 1	Stage 2	Stage 3	Stage 4
Period	Up to the mid 19th century	Mid 19th century to mid 20th century	Late 20th century	Late 20th century, early 21st century
Development rationale	Rise in trade	Industrialization	Globalization	Logistics
Main port function	Cargo handling Storage Trade	Cargo handling Storage Trade Industrial manufacturing	Cargo handling Storage Trade Industrial manufacturing Container distribution	Cargo handling Storage Trade Industrial manufacturing Container distribution Logistics control
Dominant cargo	General cargo	Bulk cargo	Containers	Containers and information flows (supply chain)
Spatial scale	Port city	Port area	Port region	Port network
Role of port authority	Nautical services	Nautical services Land and infrastructure	Nautical services Land and infrastructure Port marketing	Nautical services Land and infrastructure Port marketing Network management

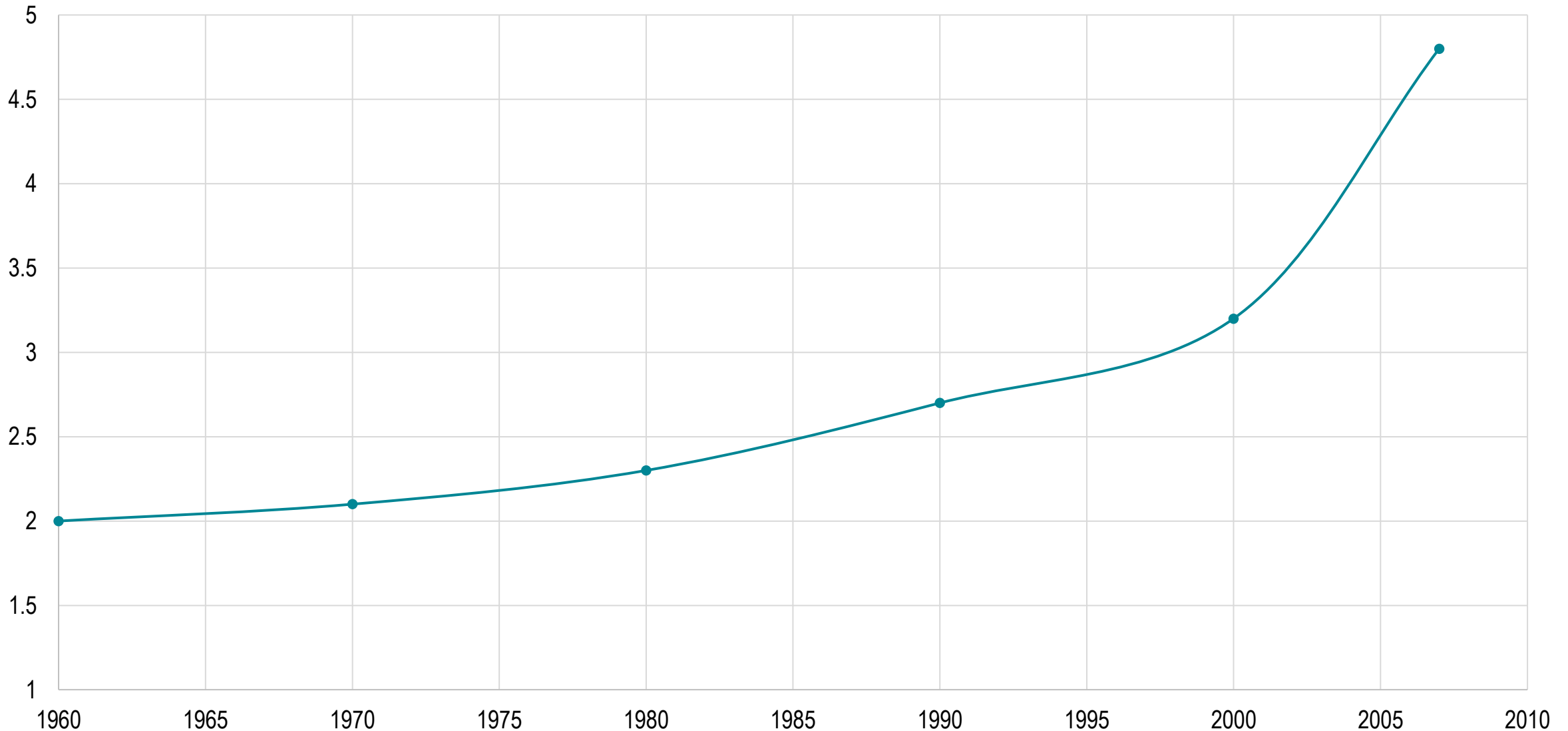
Port Regionalization



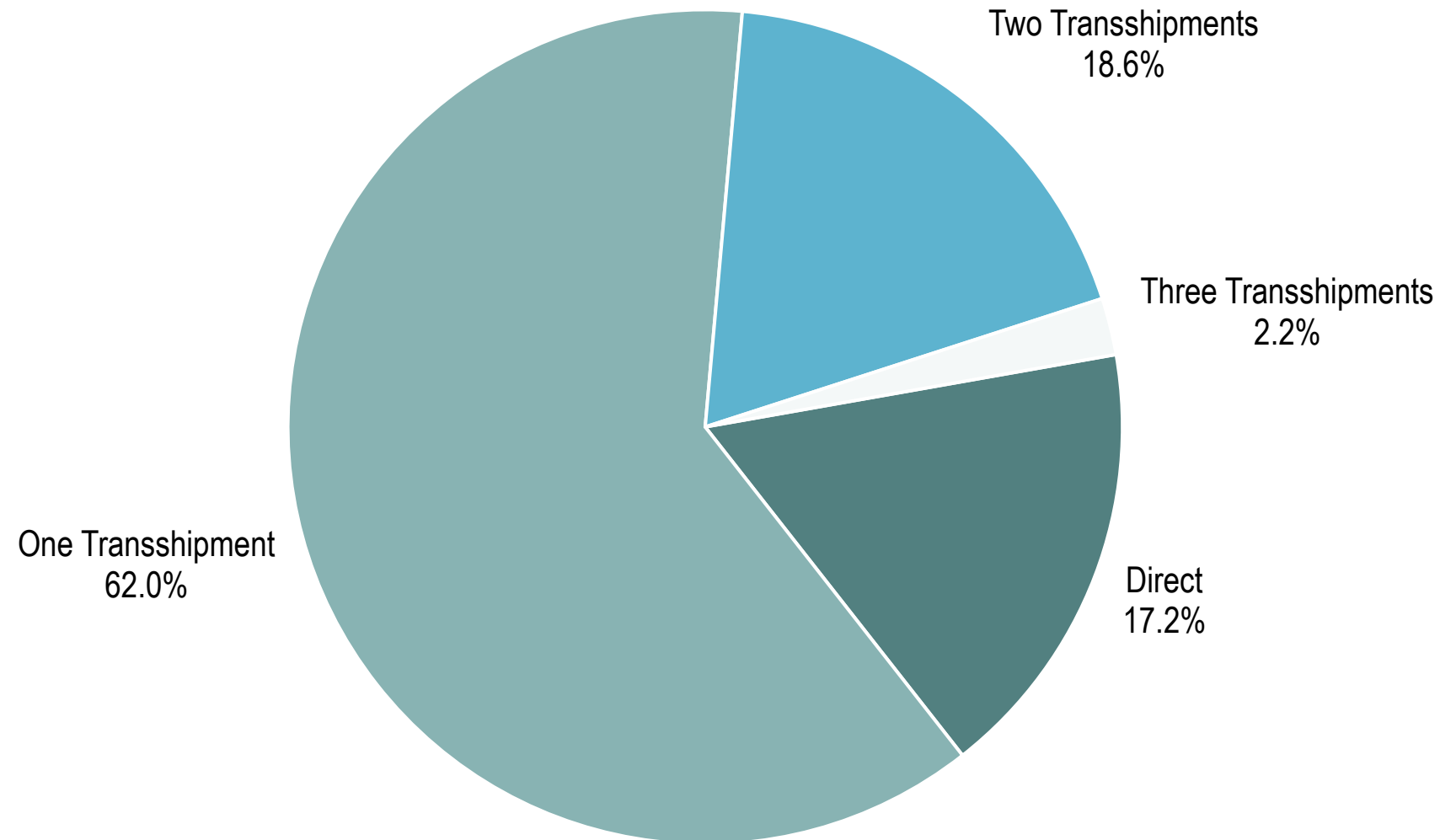
Port TEU Movements, 1980-2012 (millions of TEU)



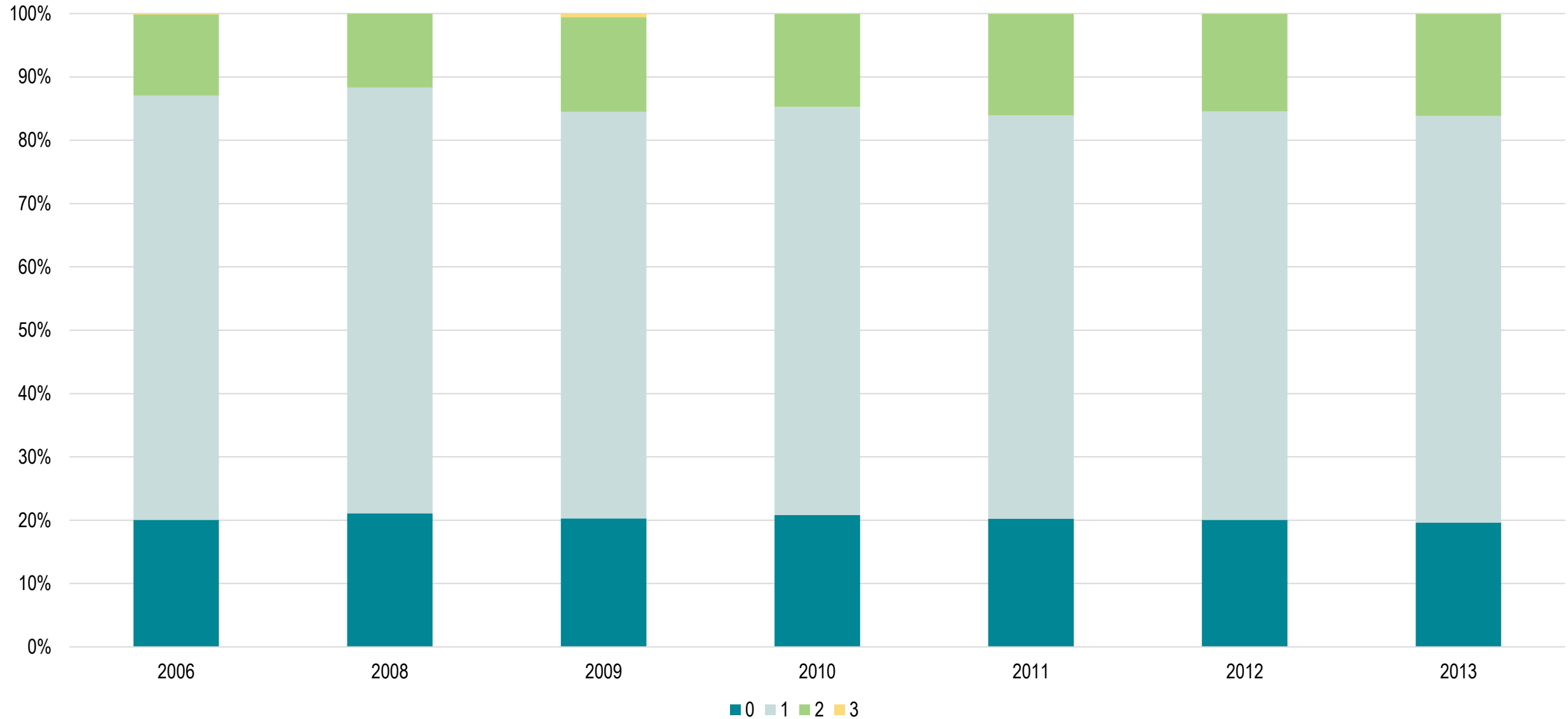
Number of Transfers per Container between Ship and Shore



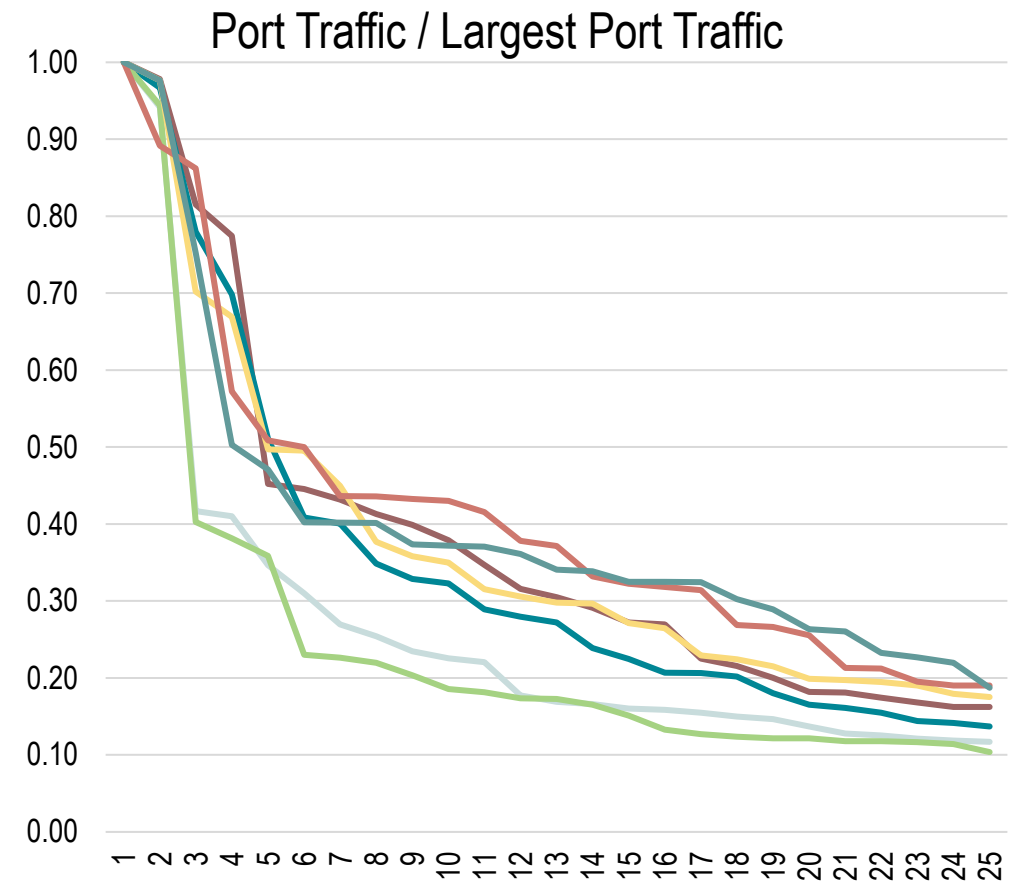
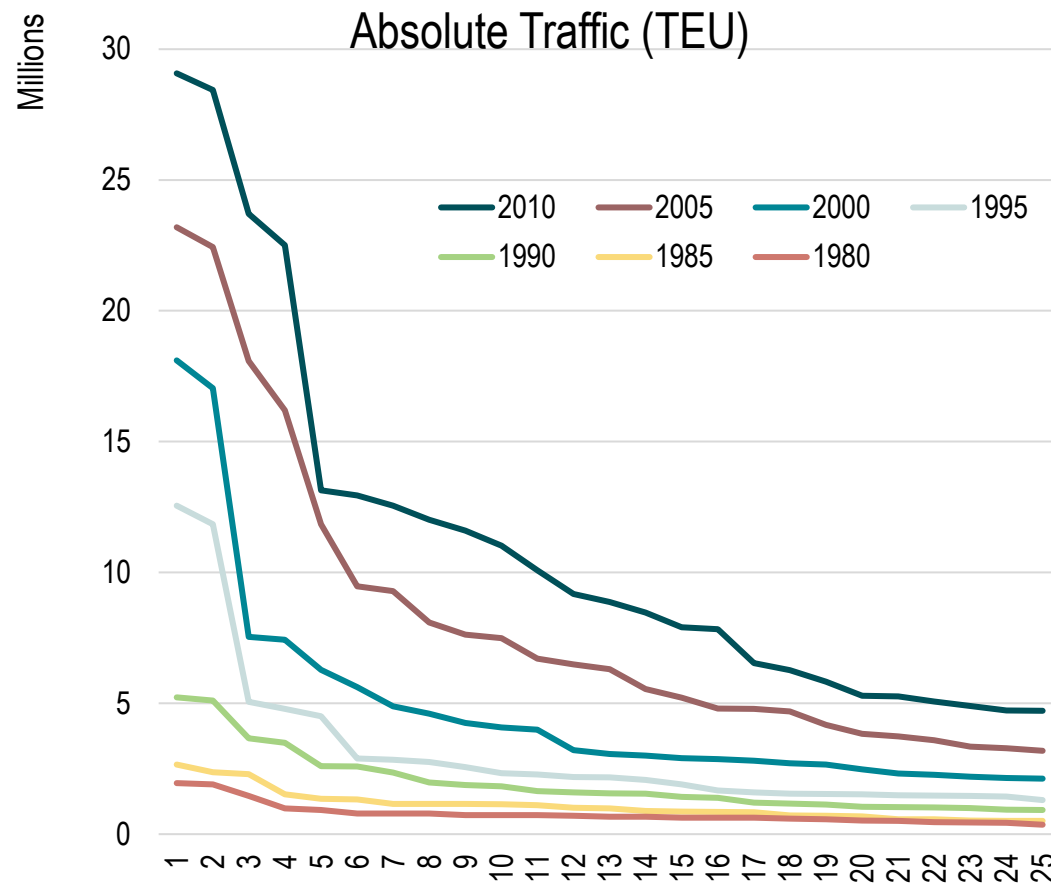
Transshipment Requirements for Liner Shipping Connections between Country Pairs, 2009



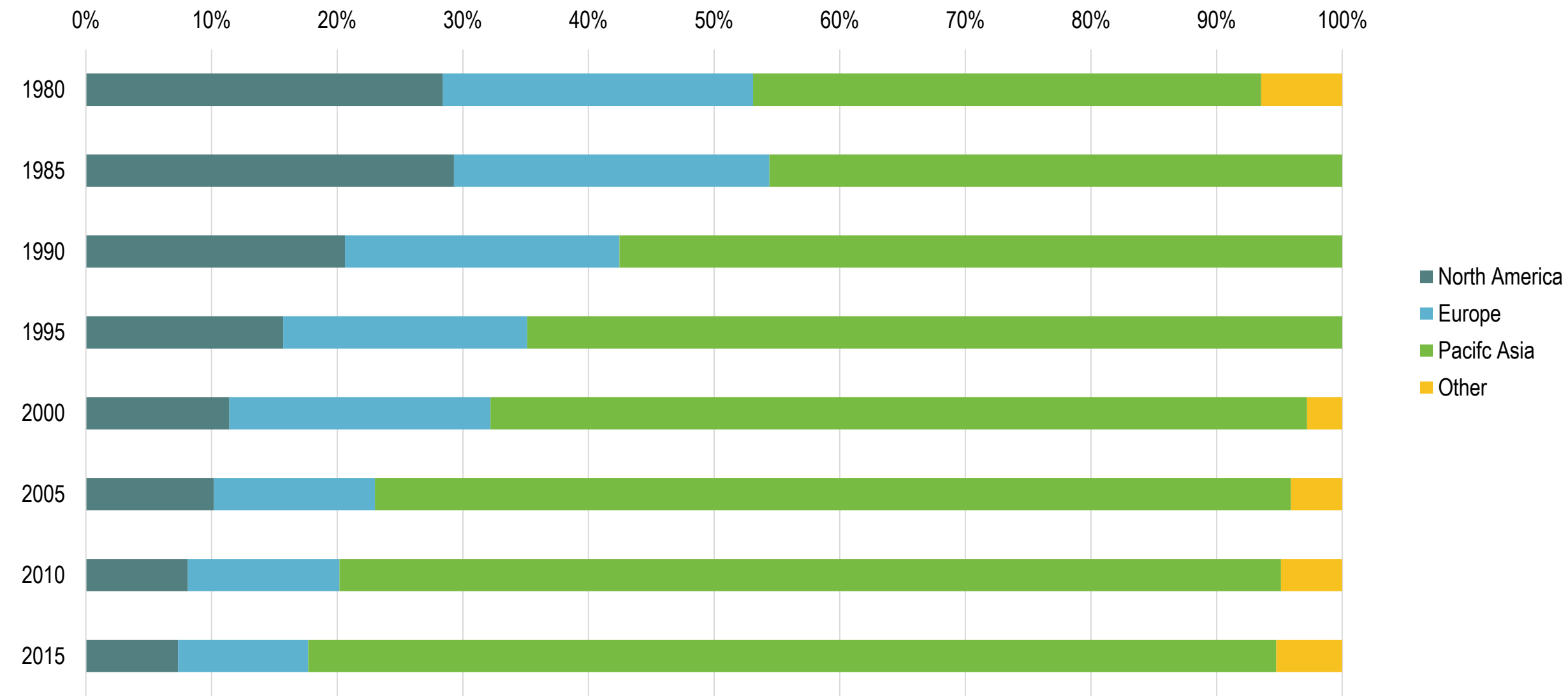
Transshipment Requirements for Liner Shipping Connections between Country Pairs



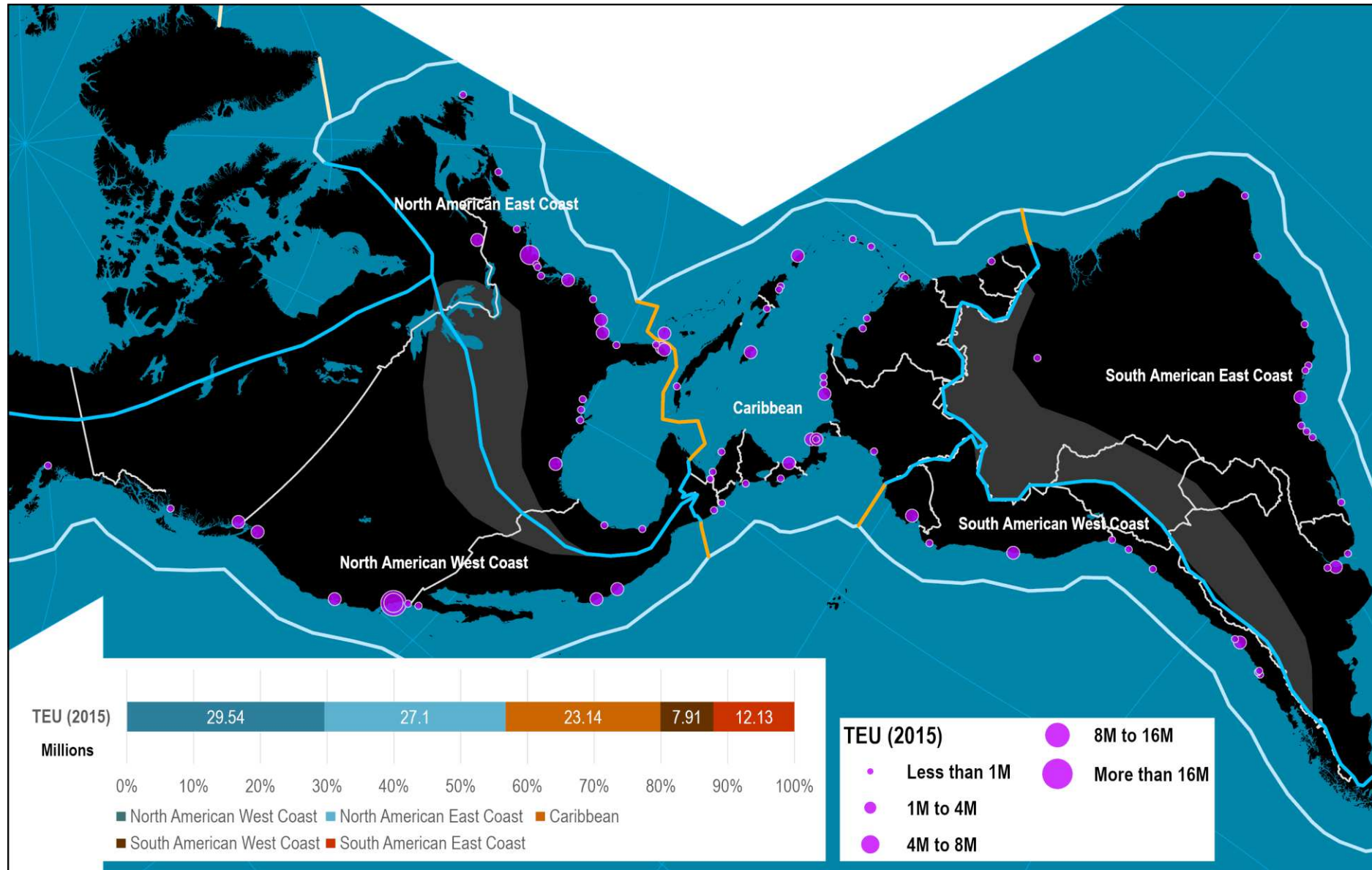
Rank / Size of the 25 Largest Container Ports, 1980-2010 (TEUs)



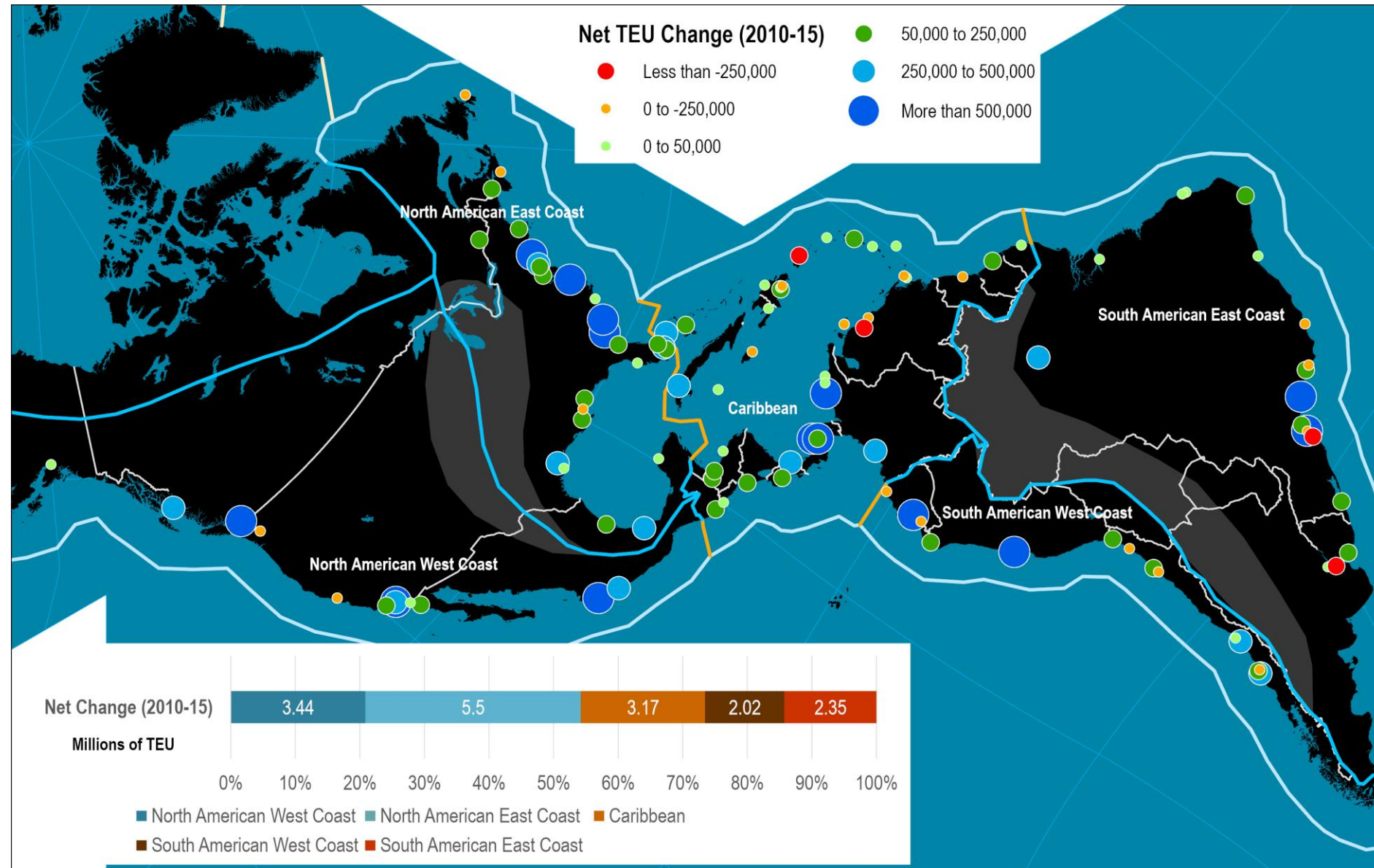
Container Traffic of the World's 20 Most Important Ports, 1980-2015



Container Ports and Main Maritime Ranges of the Americas, 2015



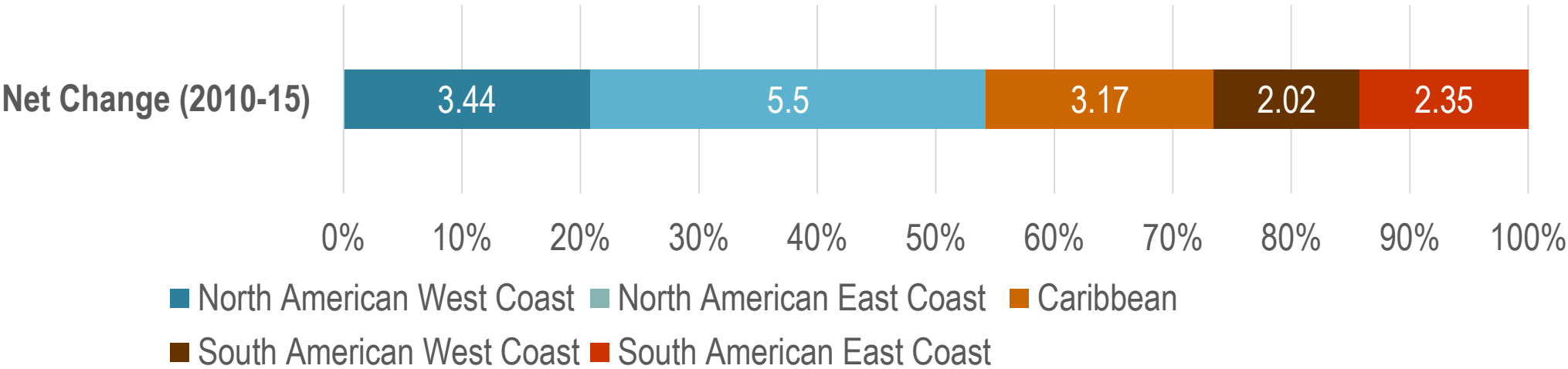
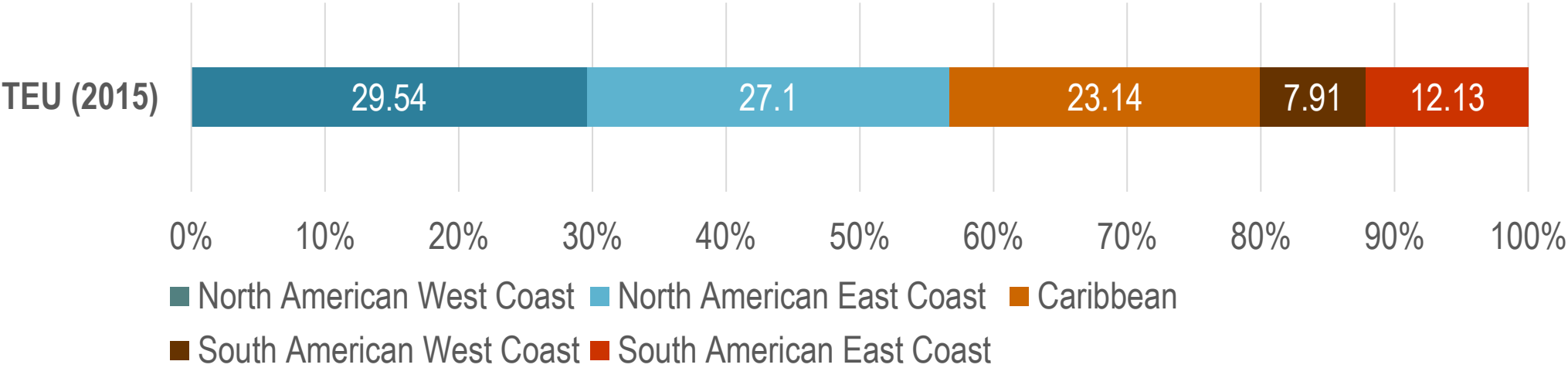
Net Container Volume Changes in the Americas, 2010 / 2015



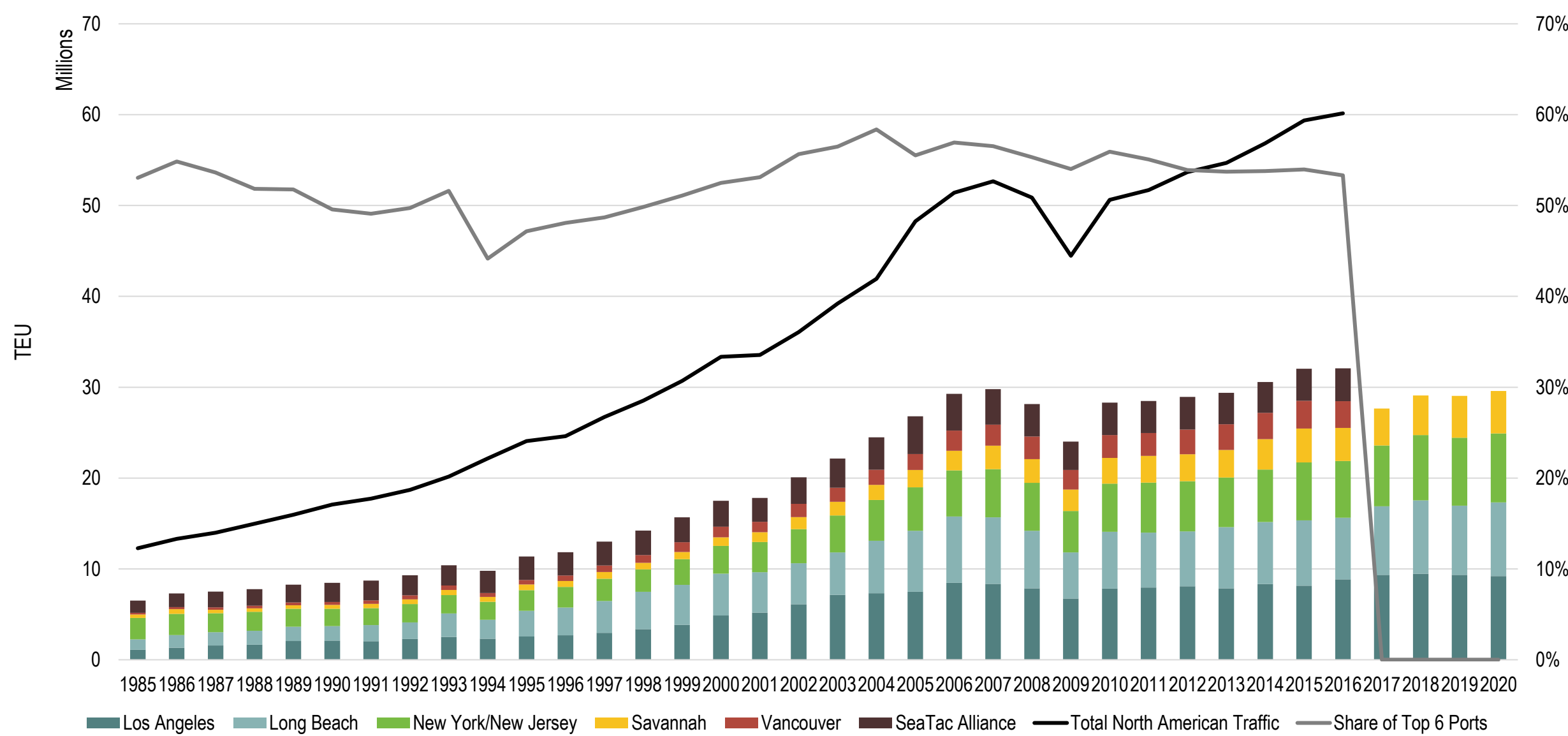
Share of the Maritime Ranges of the Americas in Total Container Volumes, 1990-2015



Share of the Maritime Ranges of the Americas in Total Container Volumes, 1990-2015

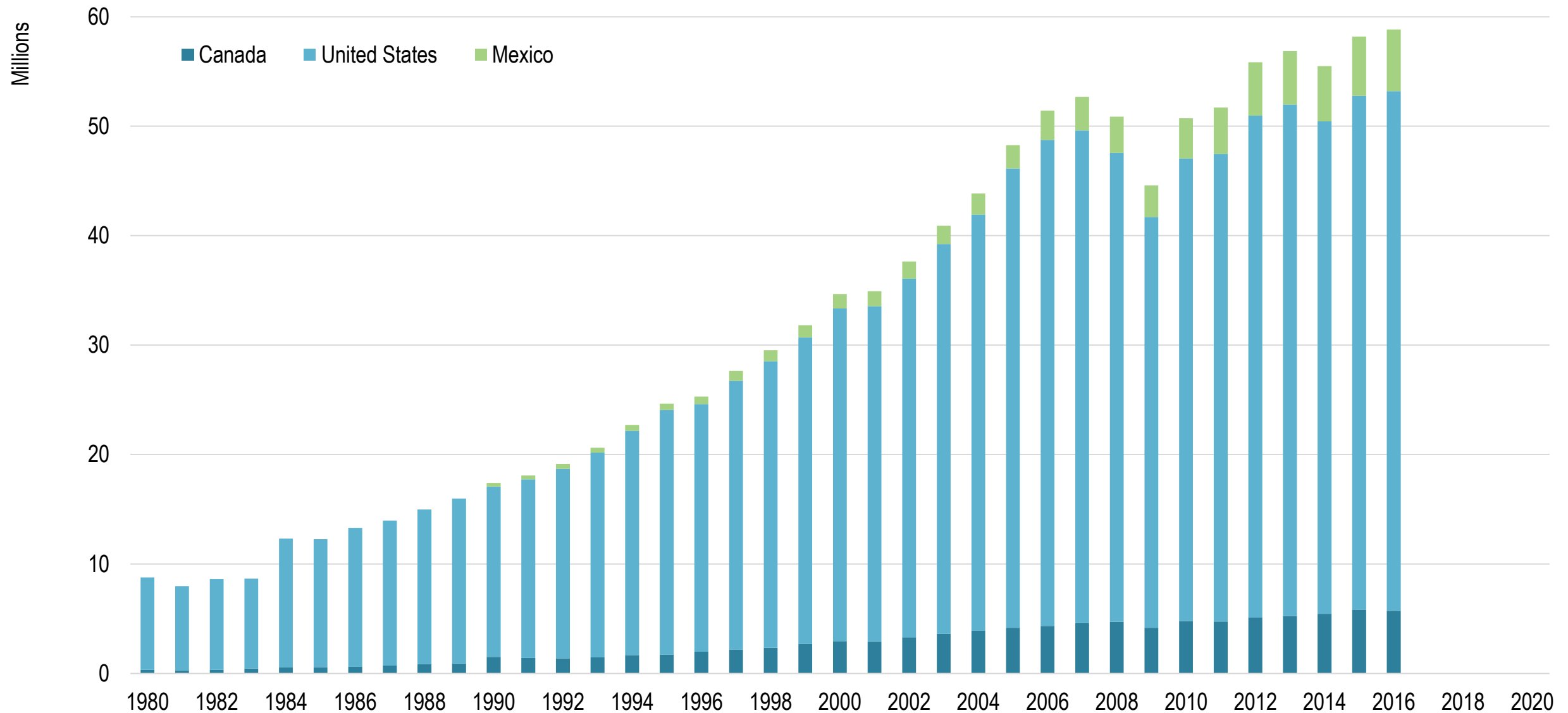


Cargo Handled by the Top 6 North American Container Ports, 1985-2016 (in TEUs)

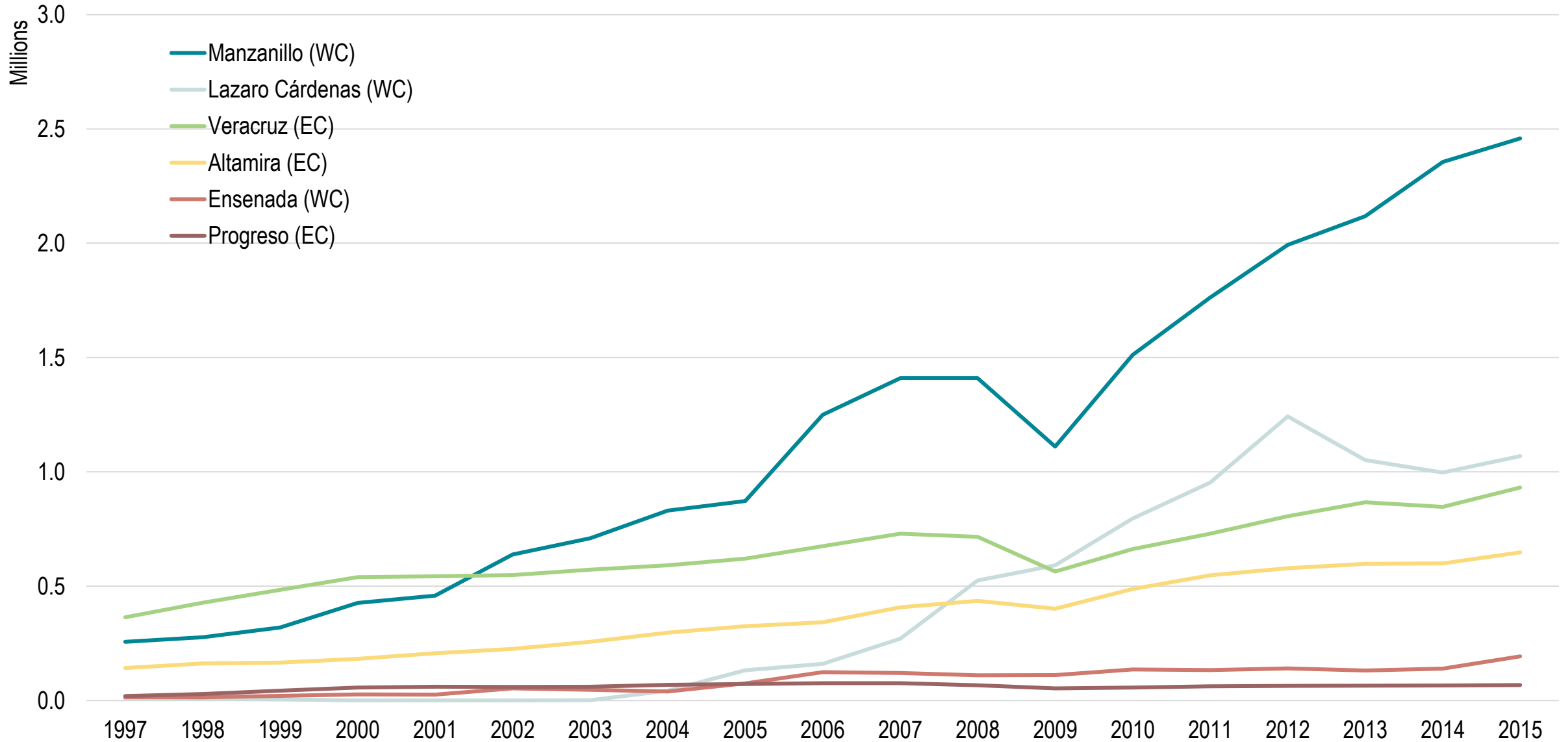


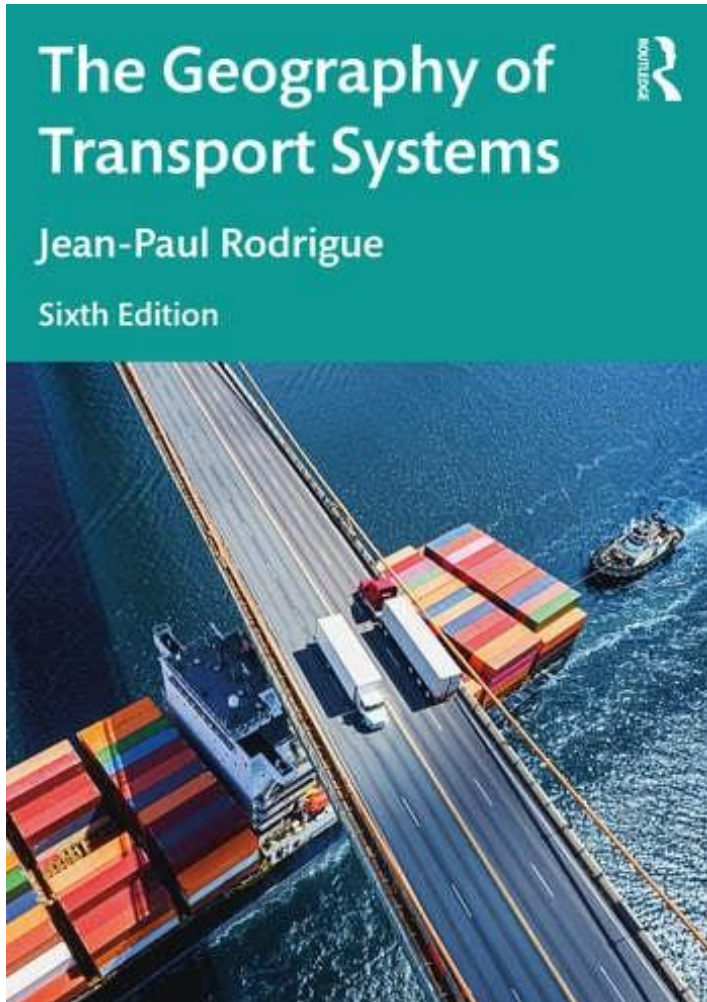
Copyright © 1998-2024, Dr. Jean-Paul Rodrigue, Dept. of Maritime Business Administration, Texas A&M University. For personal or classroom use ONLY. This material (including graphics) is not public domain and cannot be published, in whole or in part, in ANY form (printed or electronic) and on any media without consent. This includes conference presentations. Permission MUST be requested prior to use.

Container Traffic at North American Ports, 1980-2016 (TEUs)



Traffic at the Main Container Ports of Mexico, 1997-2015 (TEUs)

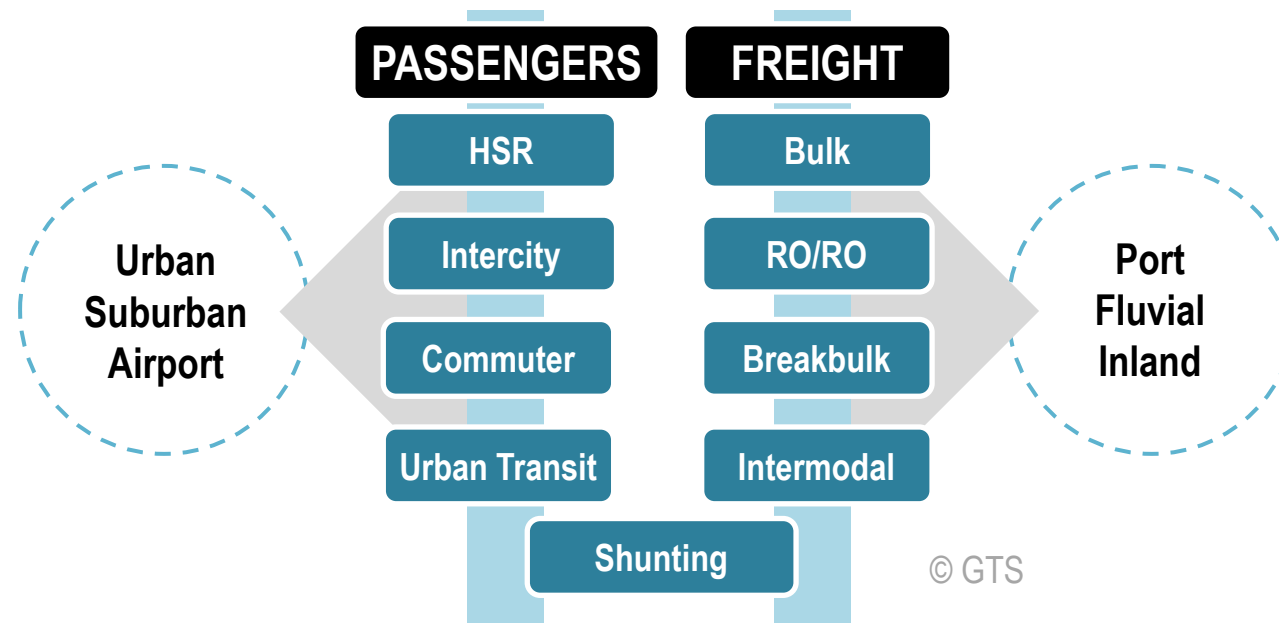




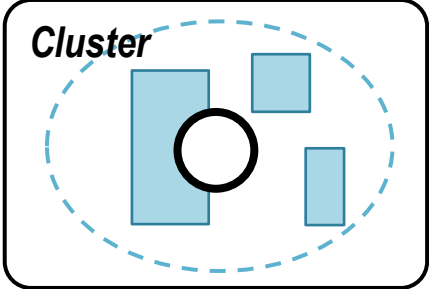
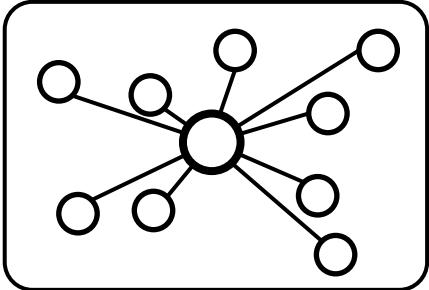
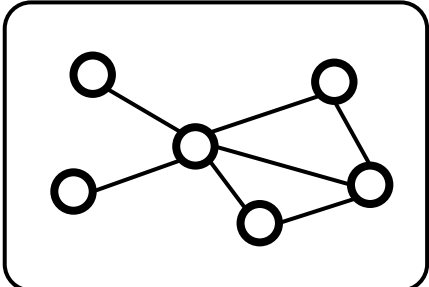
Rail Terminals

Chapter 6.4

Types of Rail Terminals

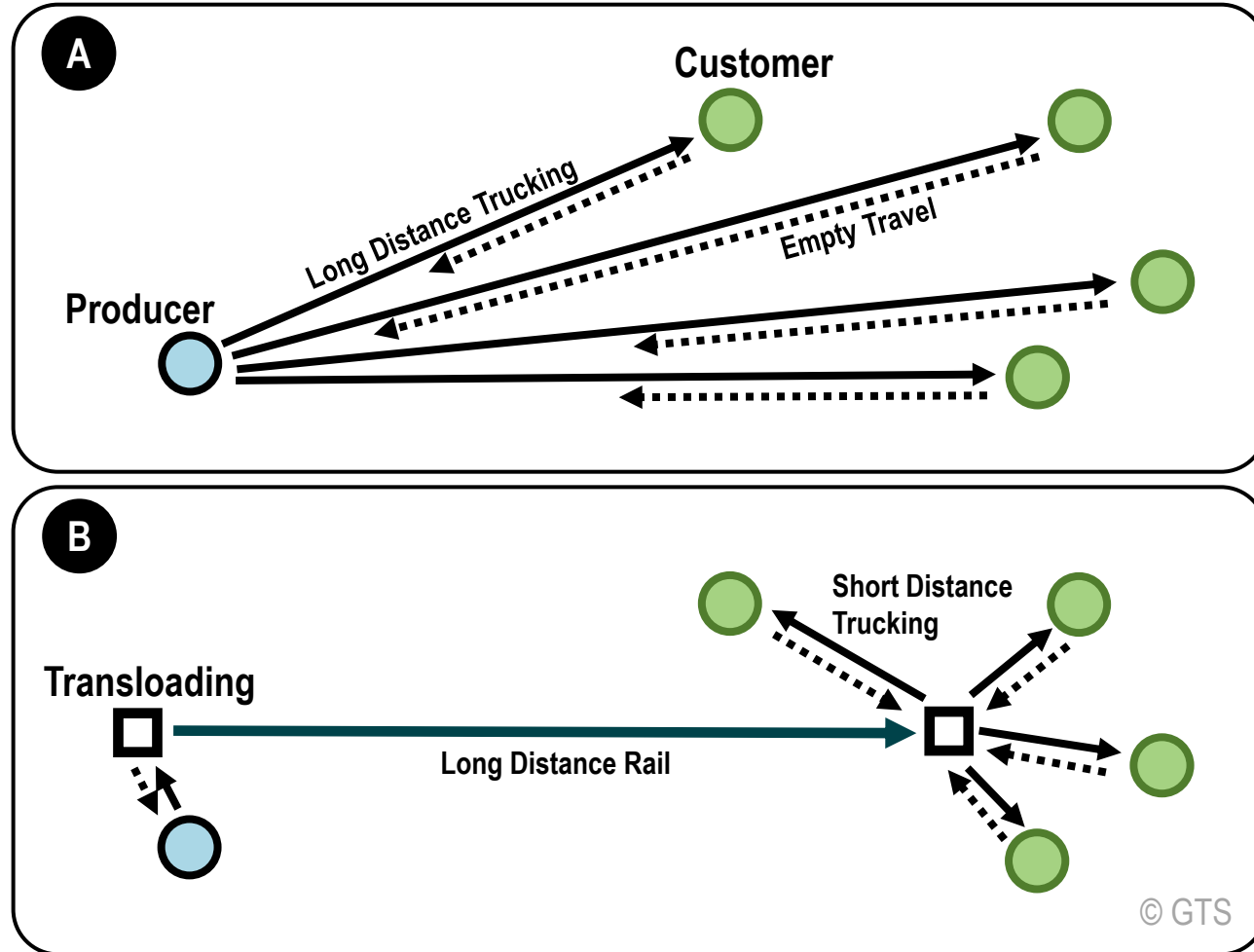


Structuring Effects of Rail Terminals

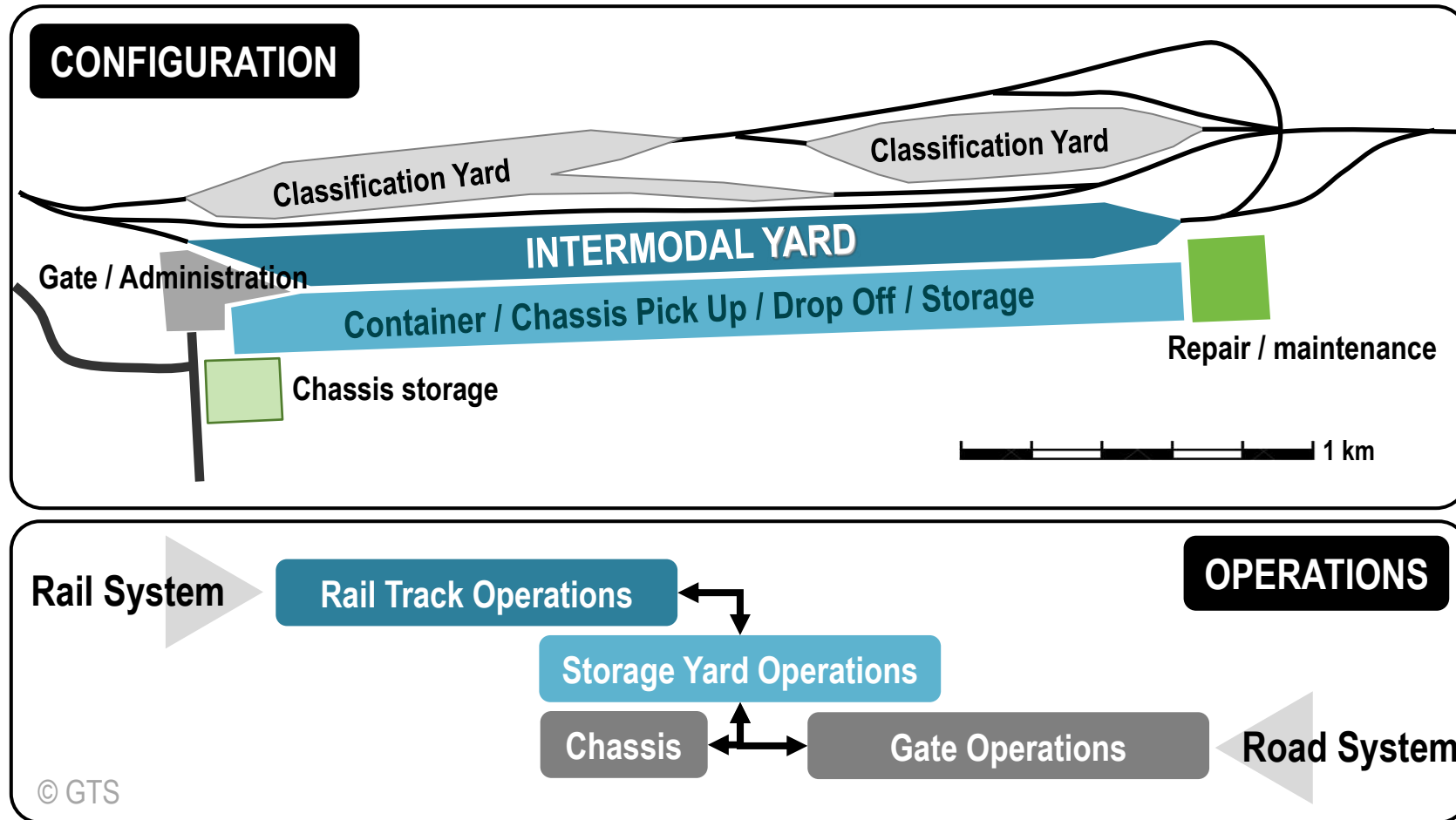
		PASSENGERS	FREIGHT
Adjacency		<ul style="list-style-type: none">• Hotels, retail and restoration.• Office parks.	<ul style="list-style-type: none">• Specialized storage (grain, minerals, chemicals).• Heavy industries.• Logistics zones.
Accessibility		<ul style="list-style-type: none">• User base.• Distance decay.• Road and transit systems.	<ul style="list-style-type: none">• Customer base.• Drayage distance.• Highway system.
Network		<ul style="list-style-type: none">• Urban system.• Commercial and social interactions.	<ul style="list-style-type: none">• Economic specialization and interdependency.• Hinterland access.

© GTS

Road / Rail Transloading



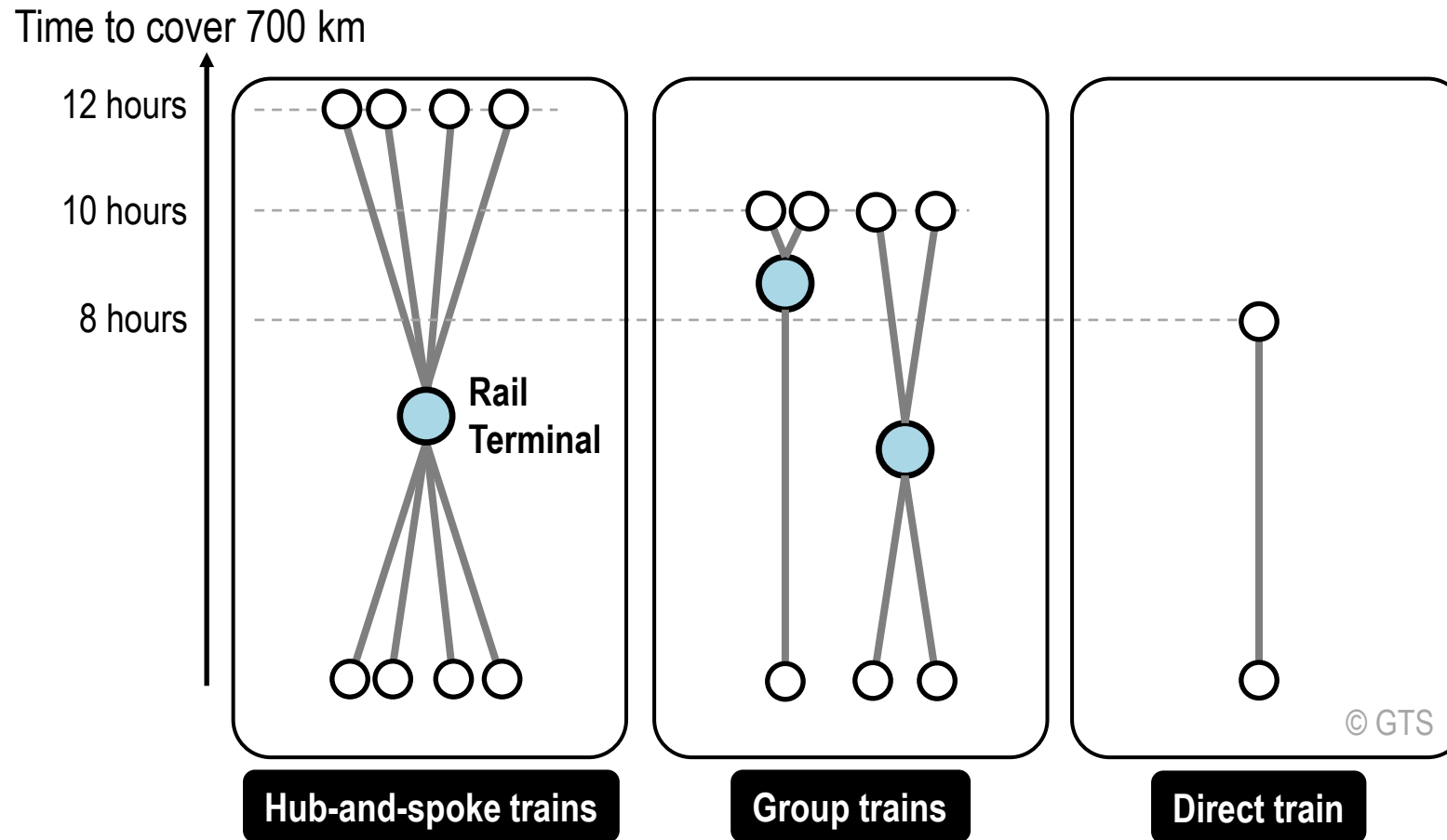
Configuration of an Intermodal Rail Terminal



BNSF Logistics Park Terminal, Joliet, Illinois



Rail Bundling Strategies and Operational Time



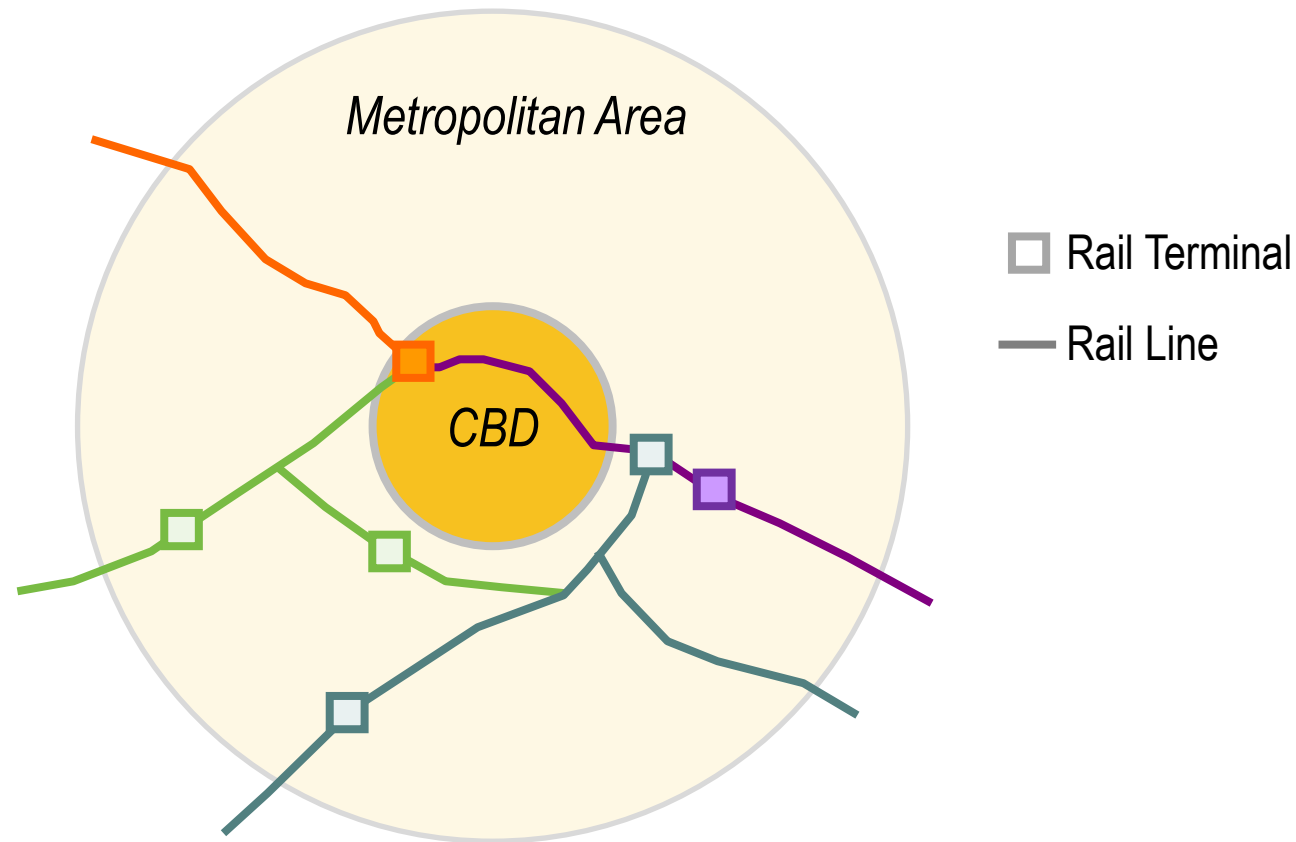
Main Infrastructure Components of an Intermodal Rail Terminal Facility

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

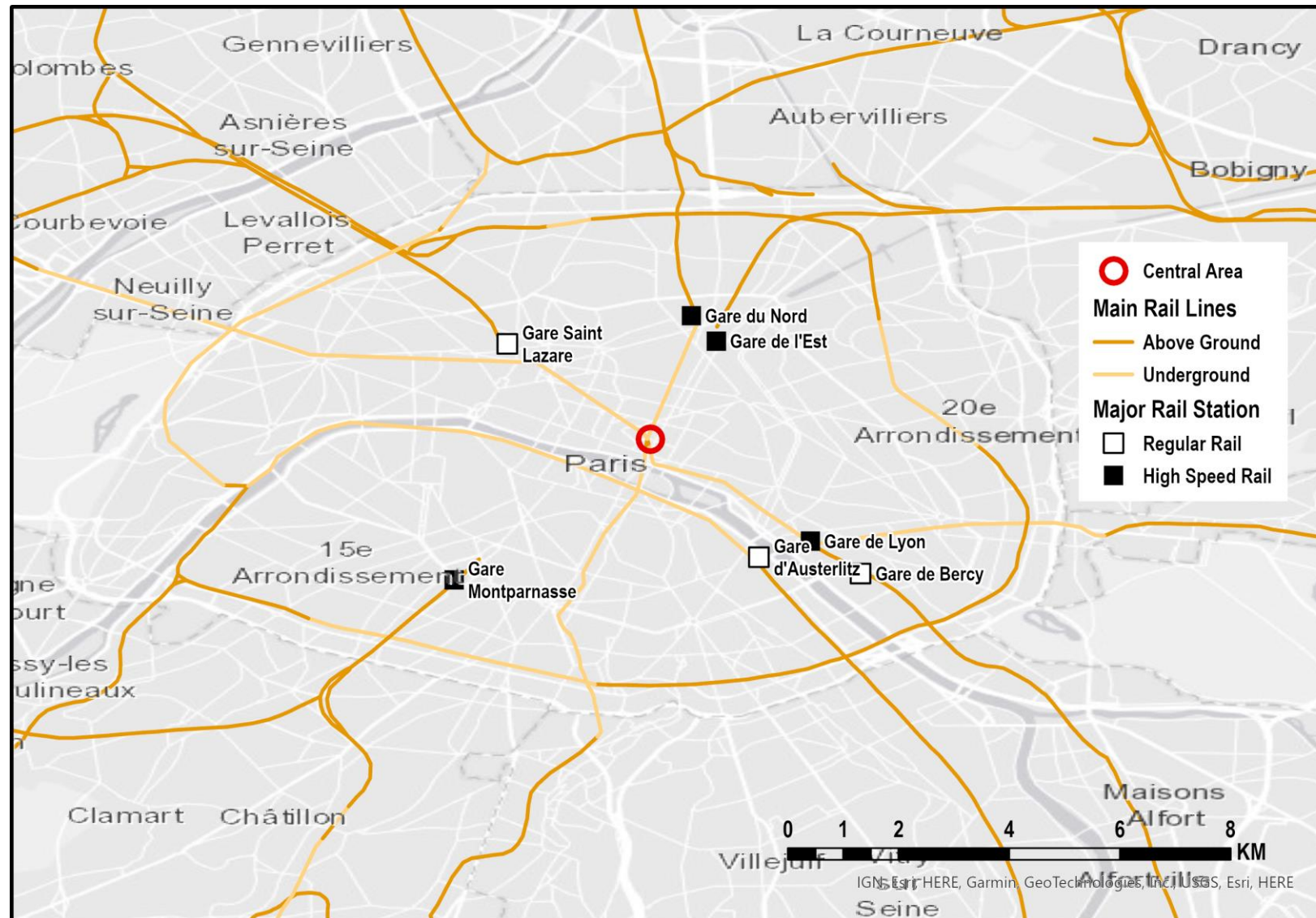
Three Generations of Intermodal Rail Terminals

	Intermodal Equipment	Storage
1 st Generation	Side loaders	Chassis or grounded
2 nd Generation	RTGs	Chassis with some grounded (empties) or grounded
3 rd Generation	Wide span gantry cranes	Grounded

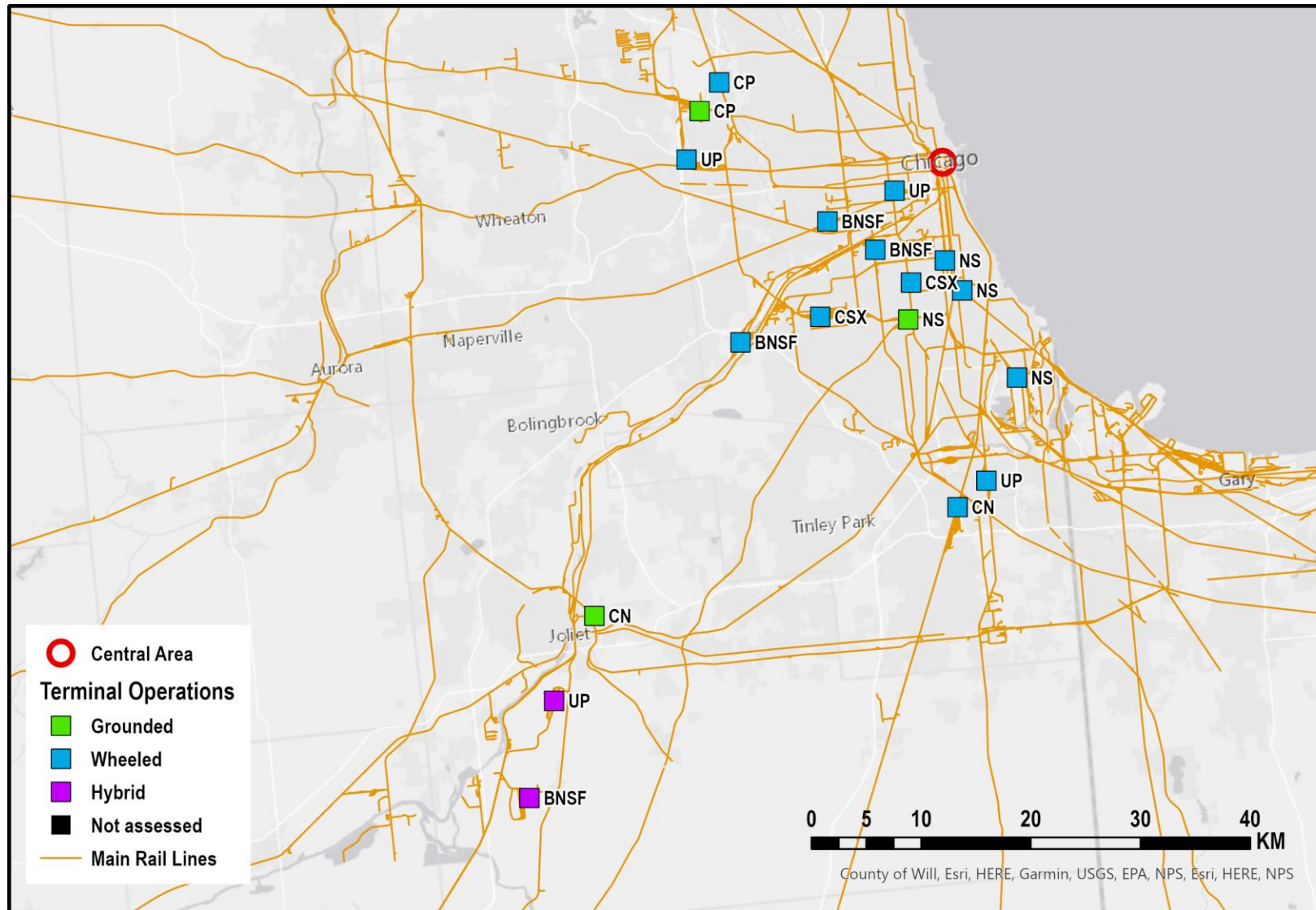
Transmodal Rail Transportation and Ownership Fragmentation



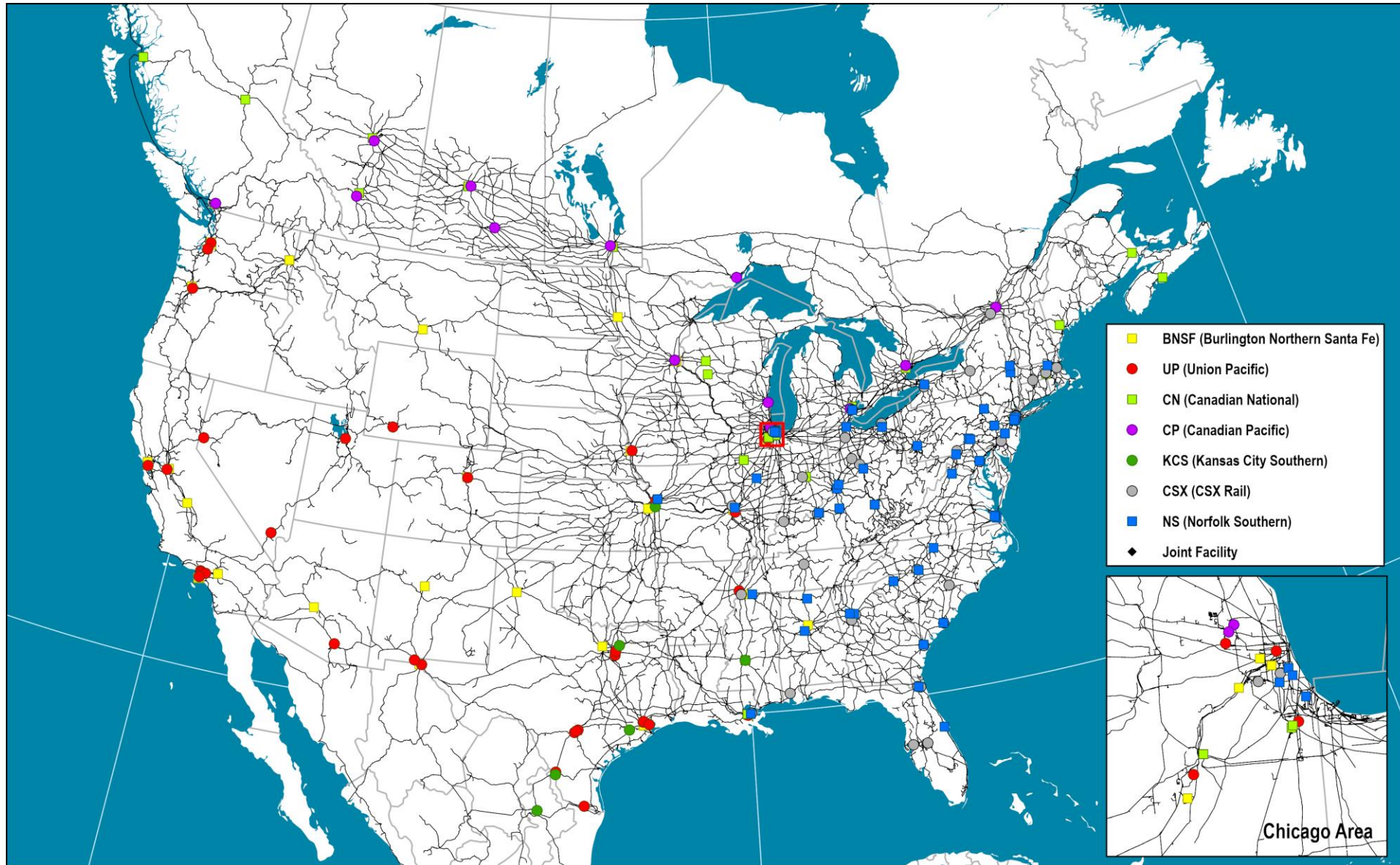
Major Rail Stations and Rail Lines in the Paris Metropolitan Area



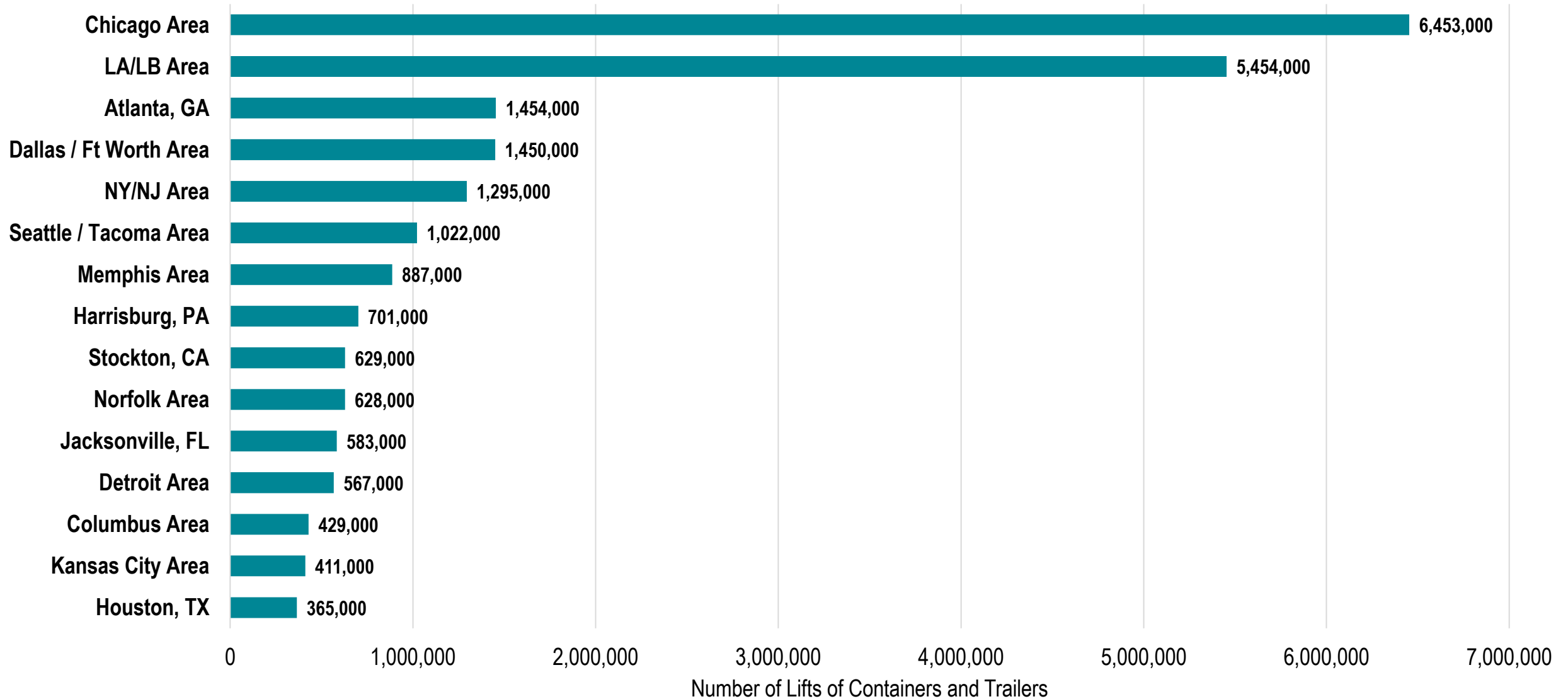
Intermodal Rail Yards in the Chicago Metropolitan Area



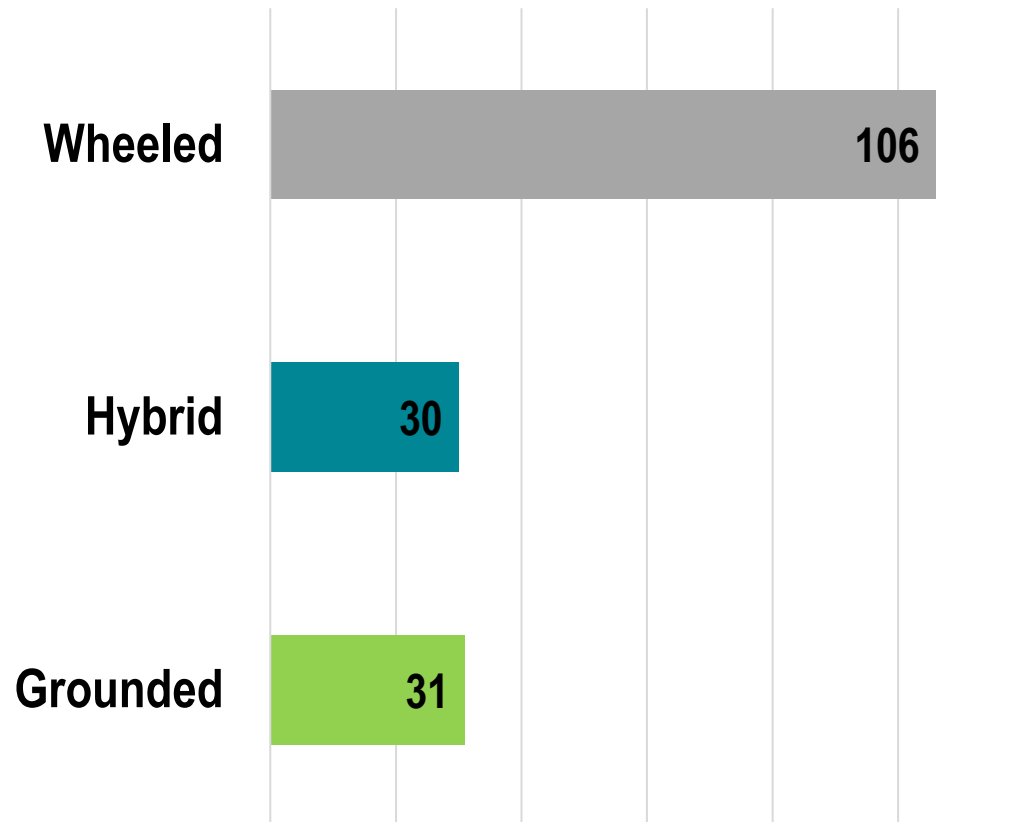
Ownership of North American Intermodal Rail Terminals, 2015



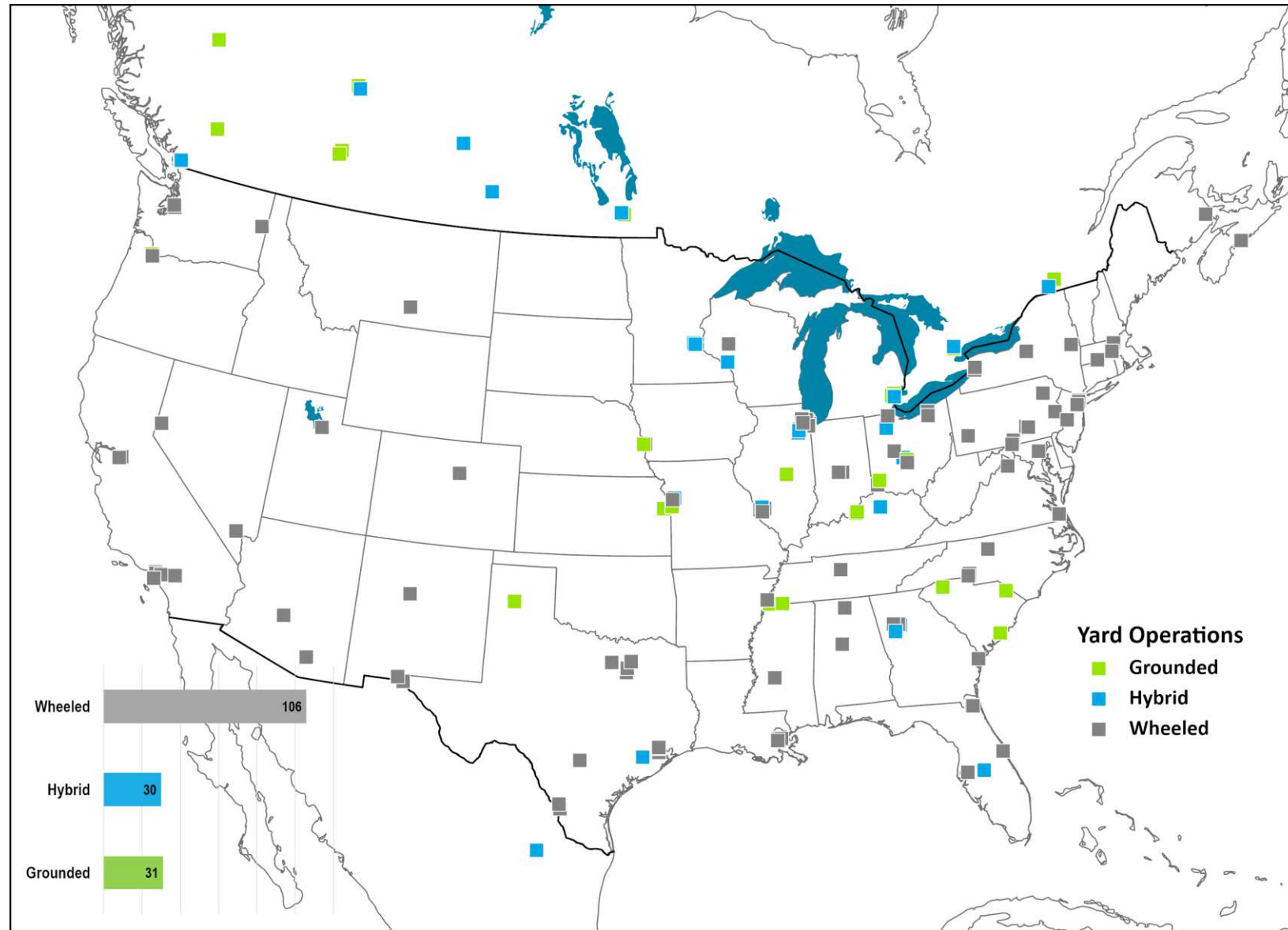
Major Intermodal Rail Markets in the United States, 2018



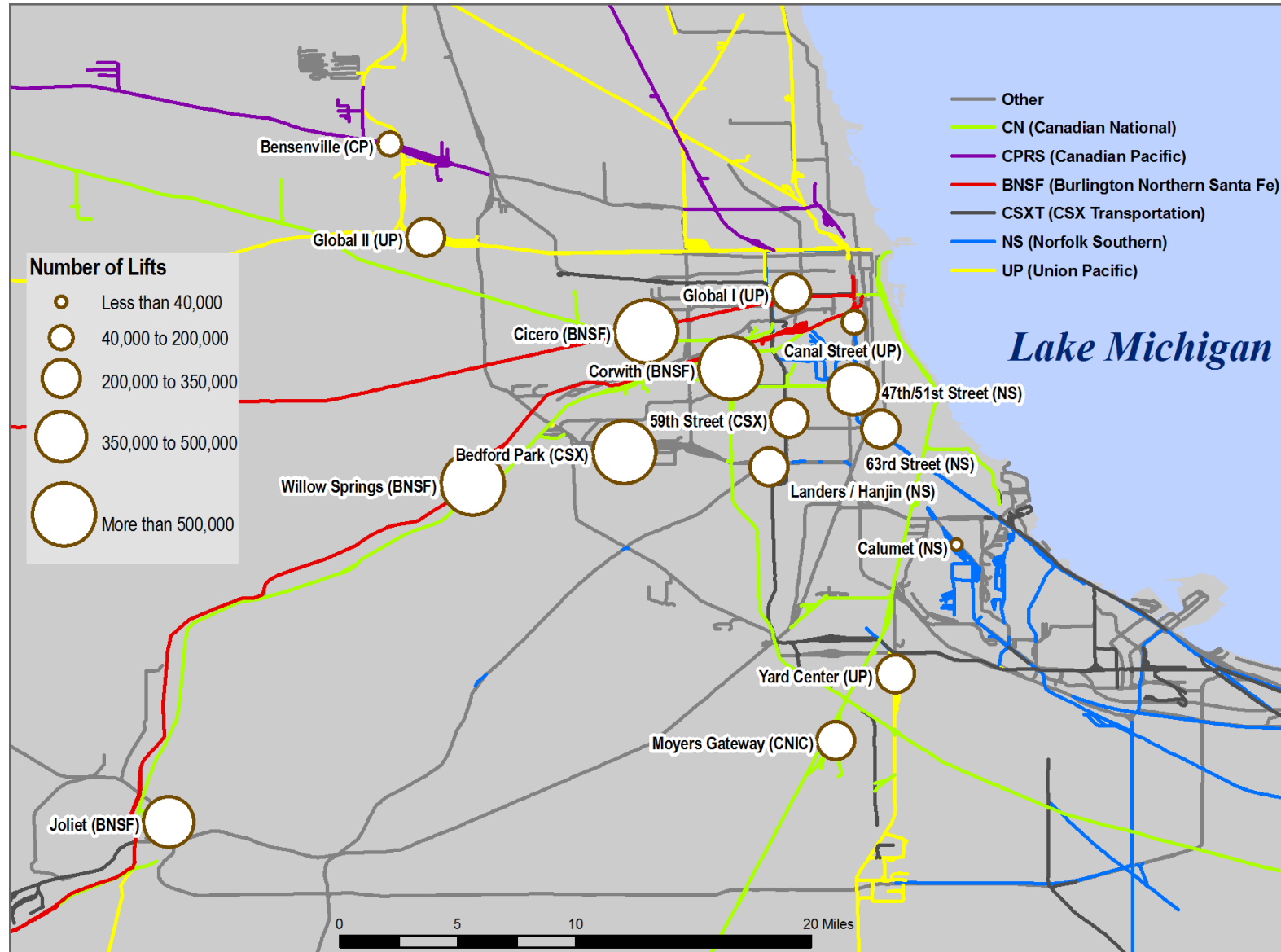
Number of Intermodal Rail Terminals by Type of Yard Operation, Class I Railroads



Intermodal Rail Terminals by Type of Yard Operation Serviced by Class I Rail Carriers

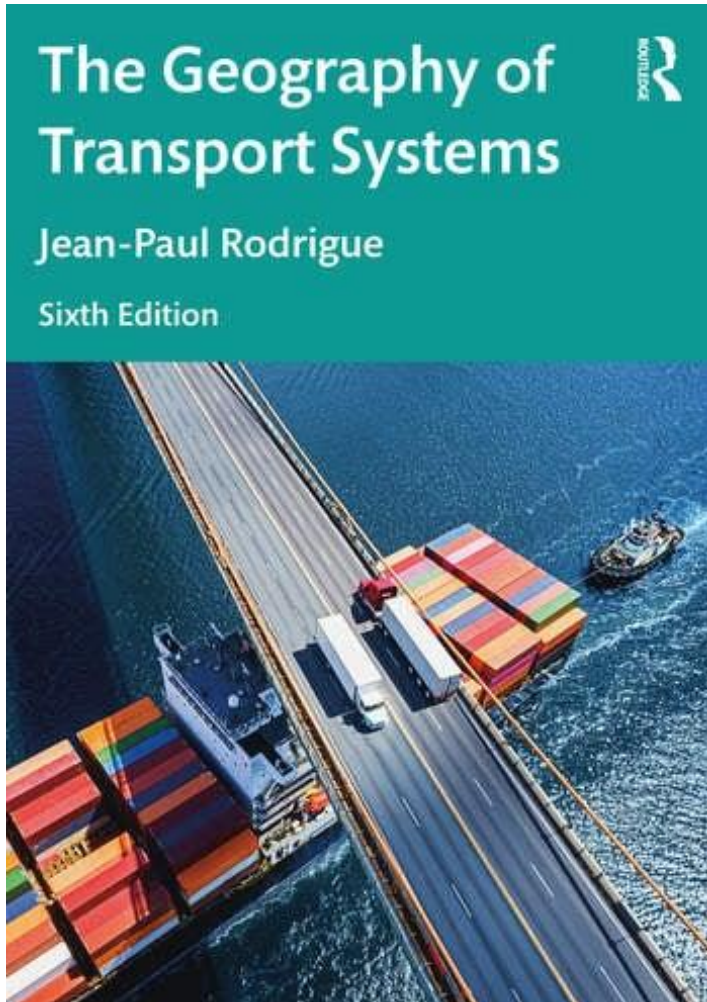


Lifts at Intermodal Rail Terminals, Chicago, 2005



“Triple Crown” Intermodal Network

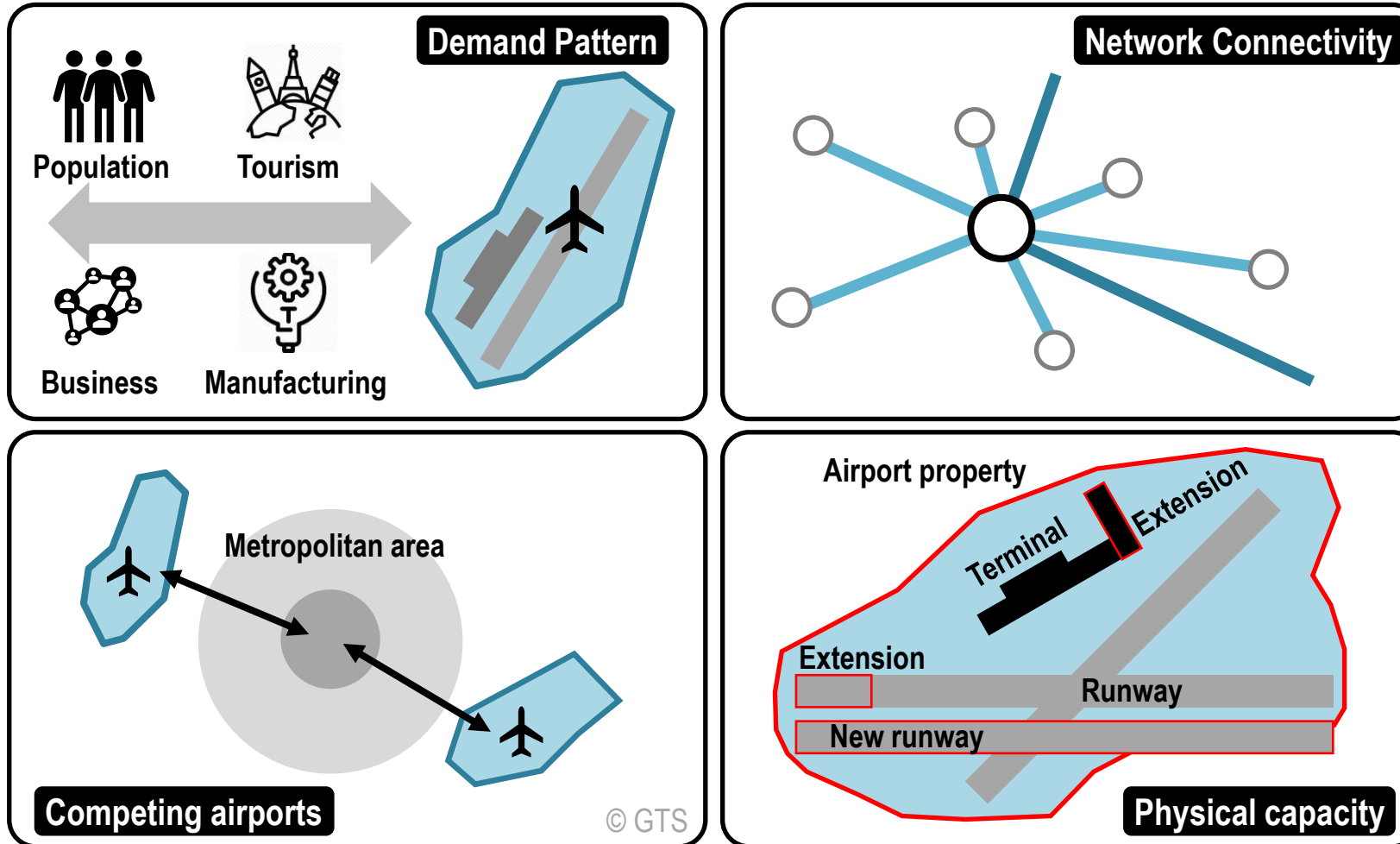




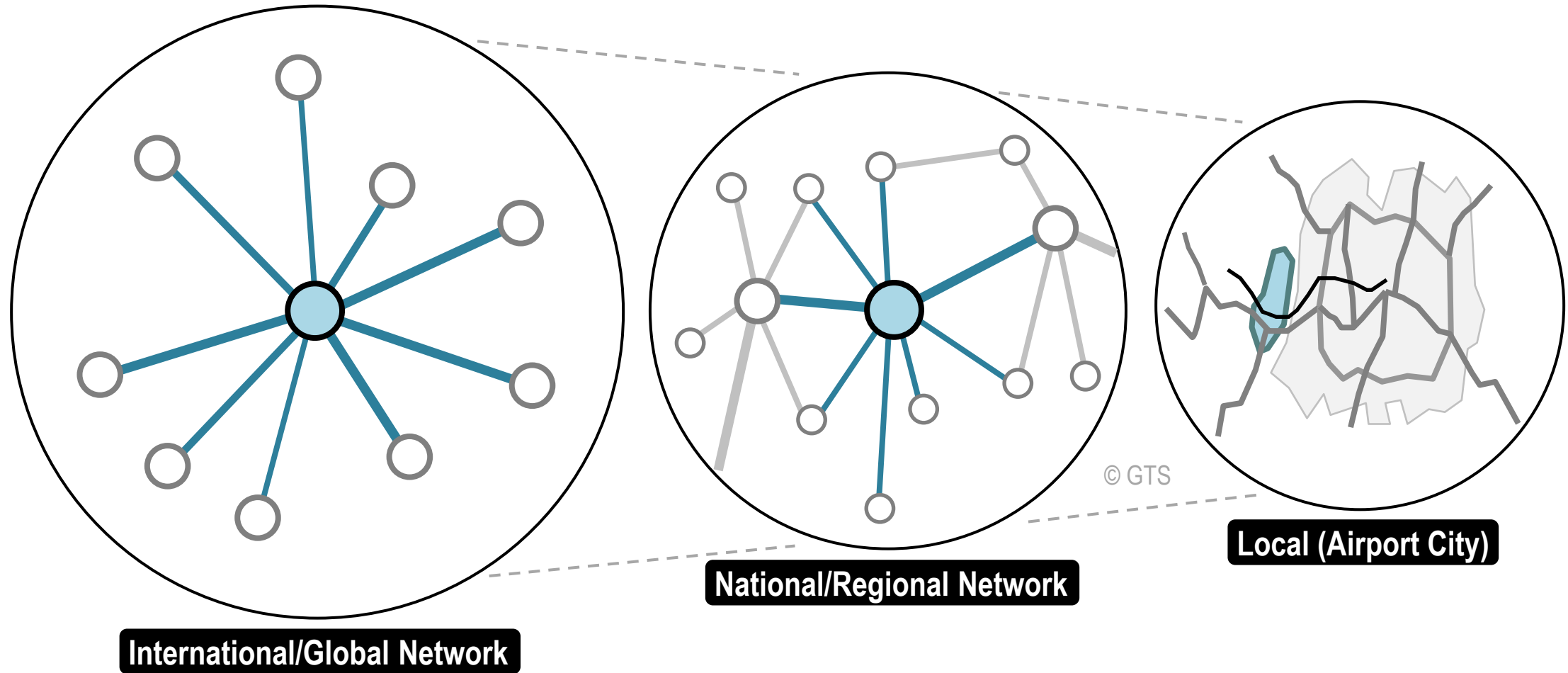
Airport Terminals

Chapter 6.5

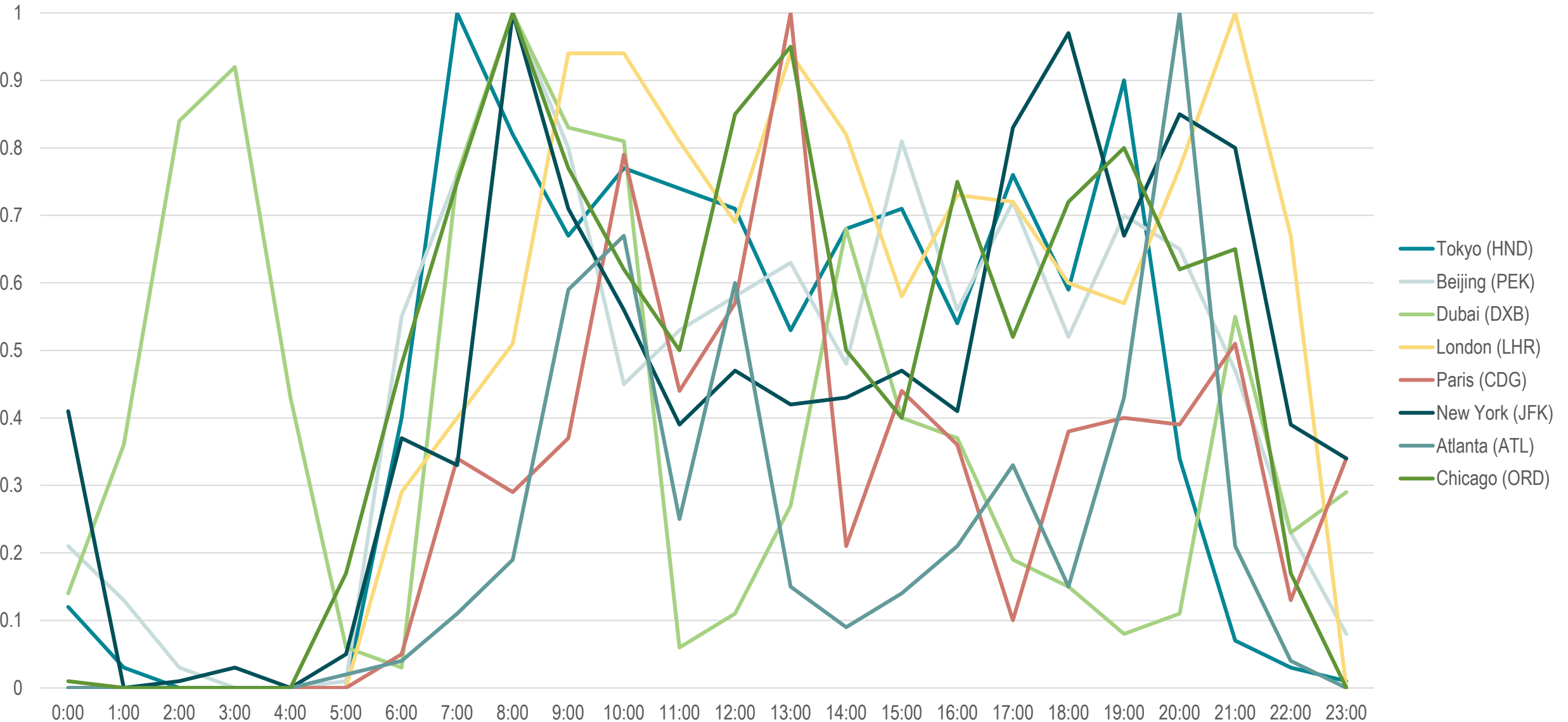
Factors Impacting Airport Traffic



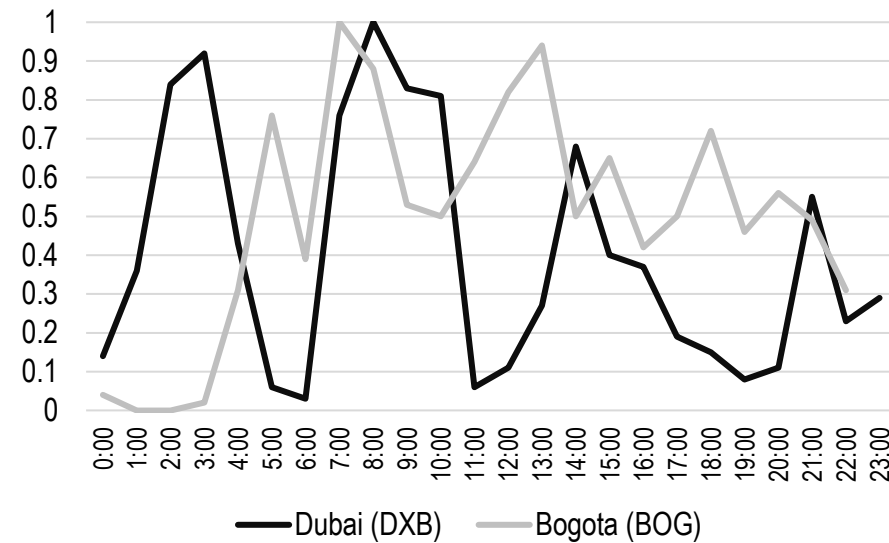
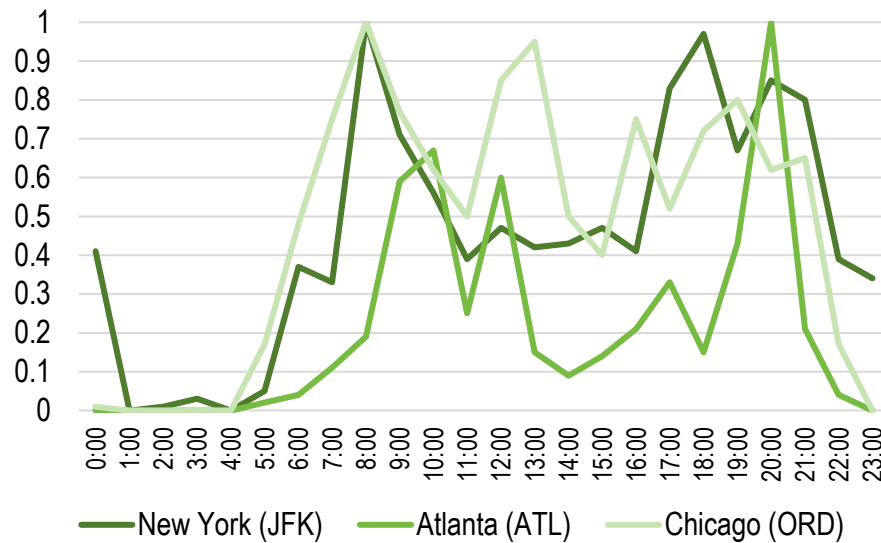
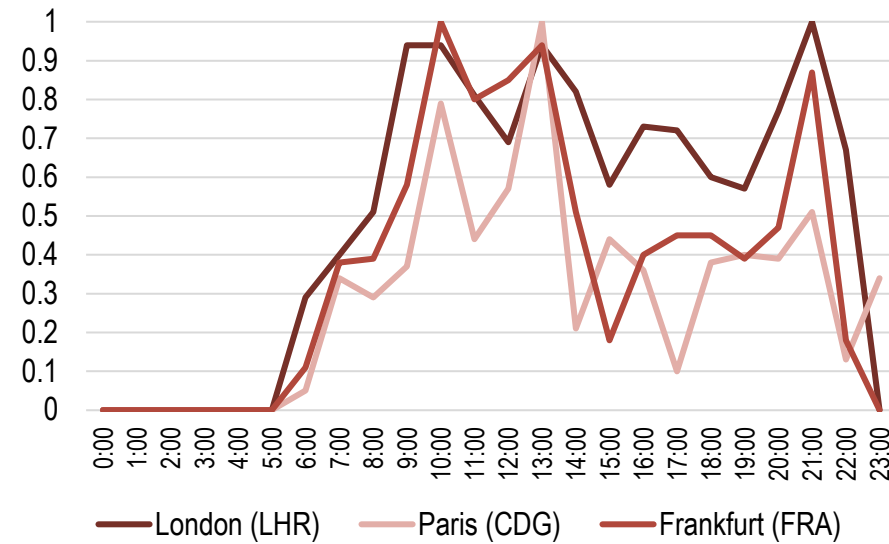
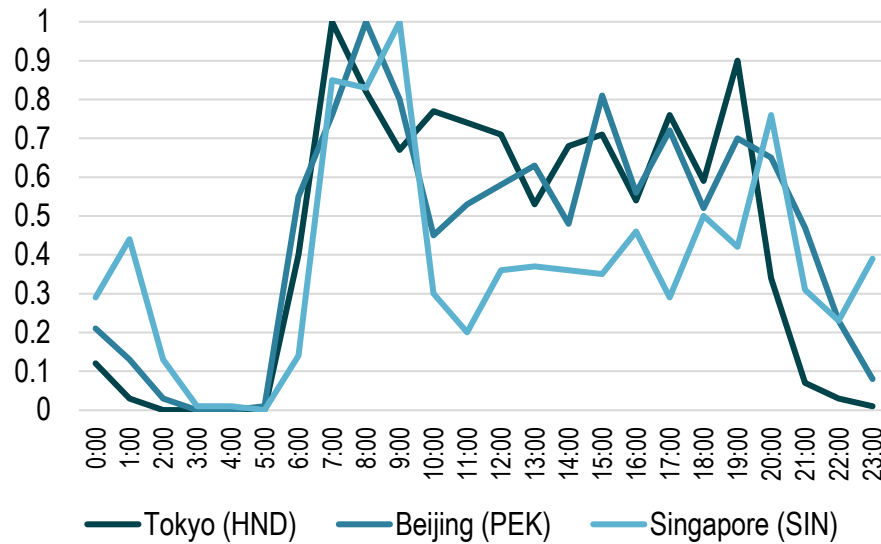
Geographical Scales of Airport Location



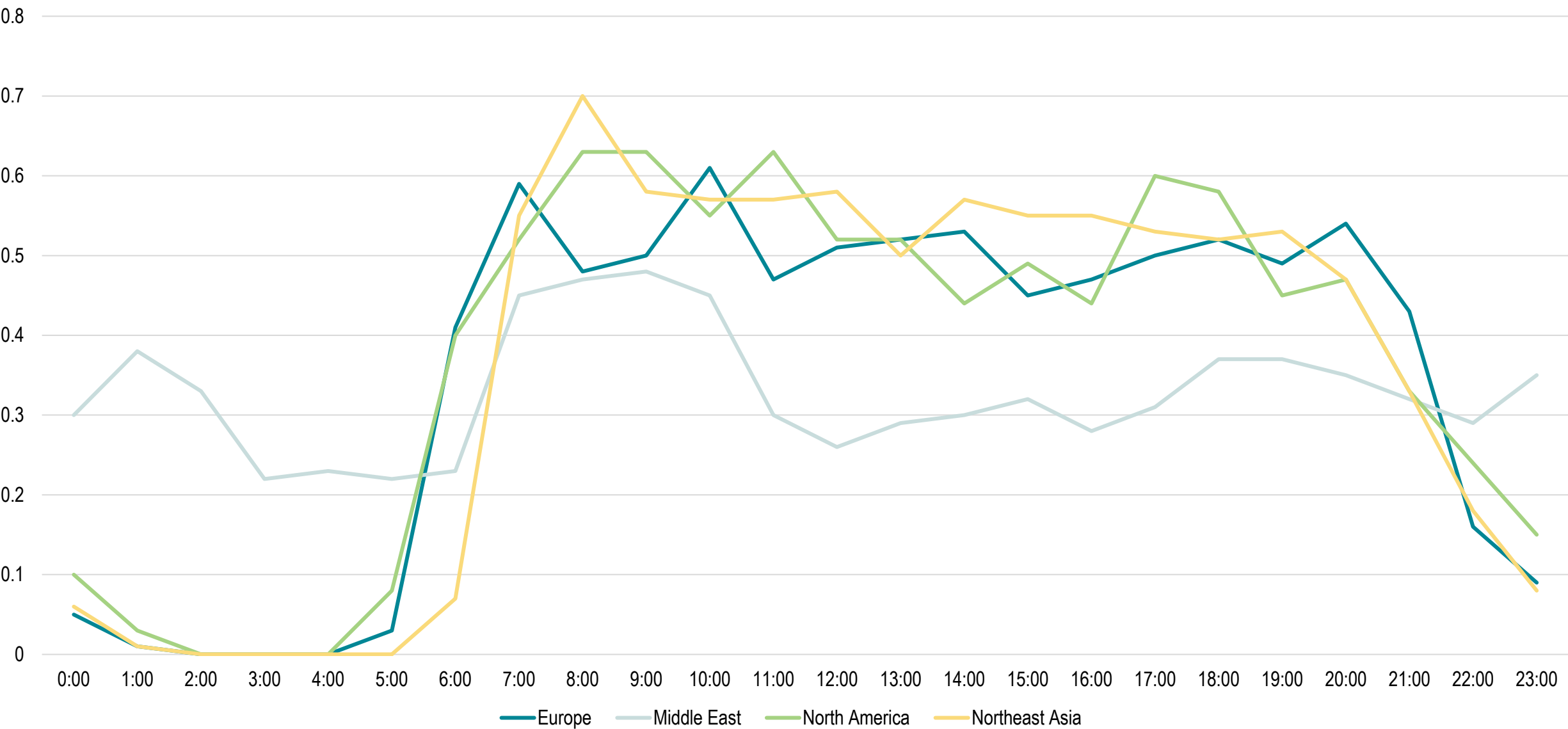
Hourly Level of Activity at Selected Airports, 2015



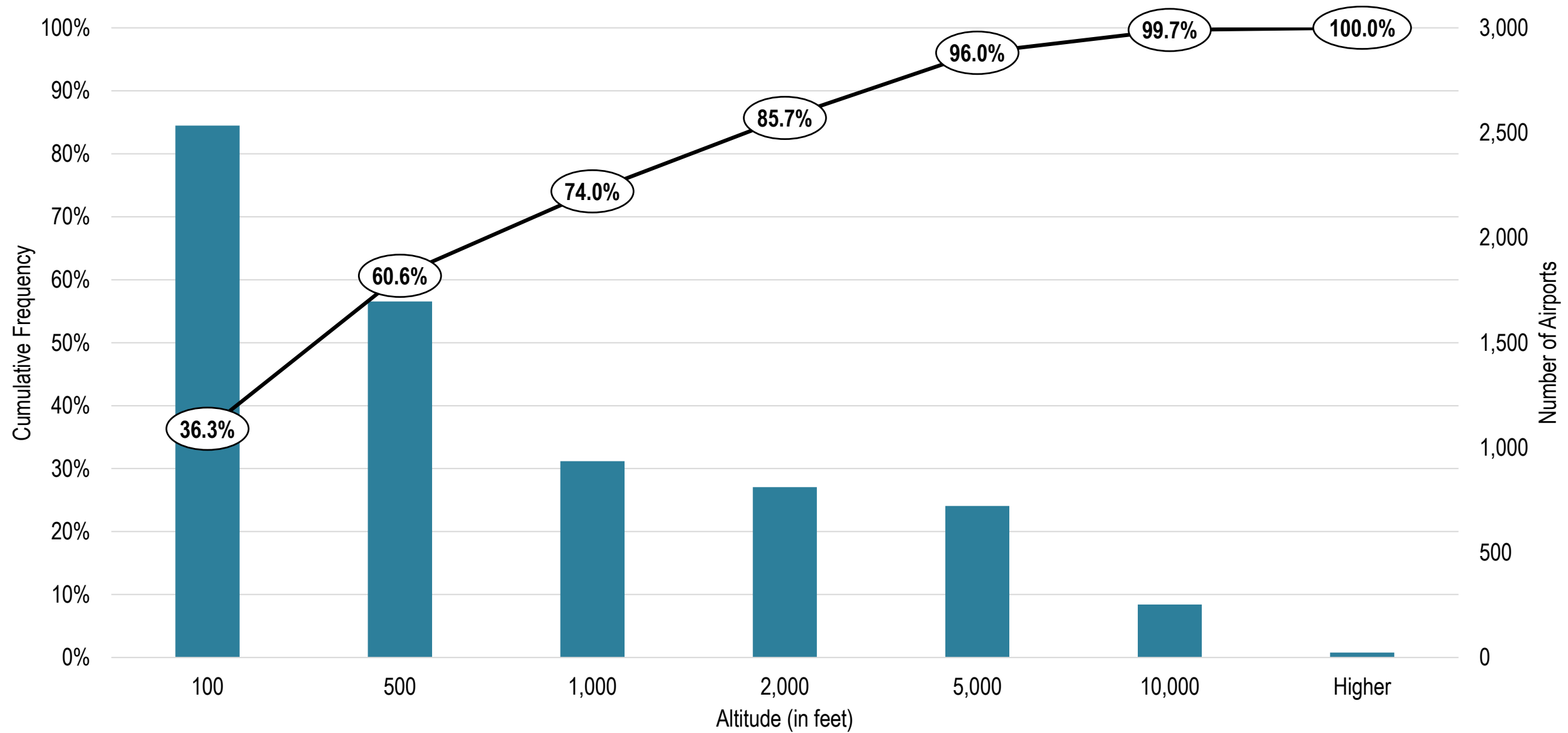
Hourly Level of Activity at Selected Airports, 2015



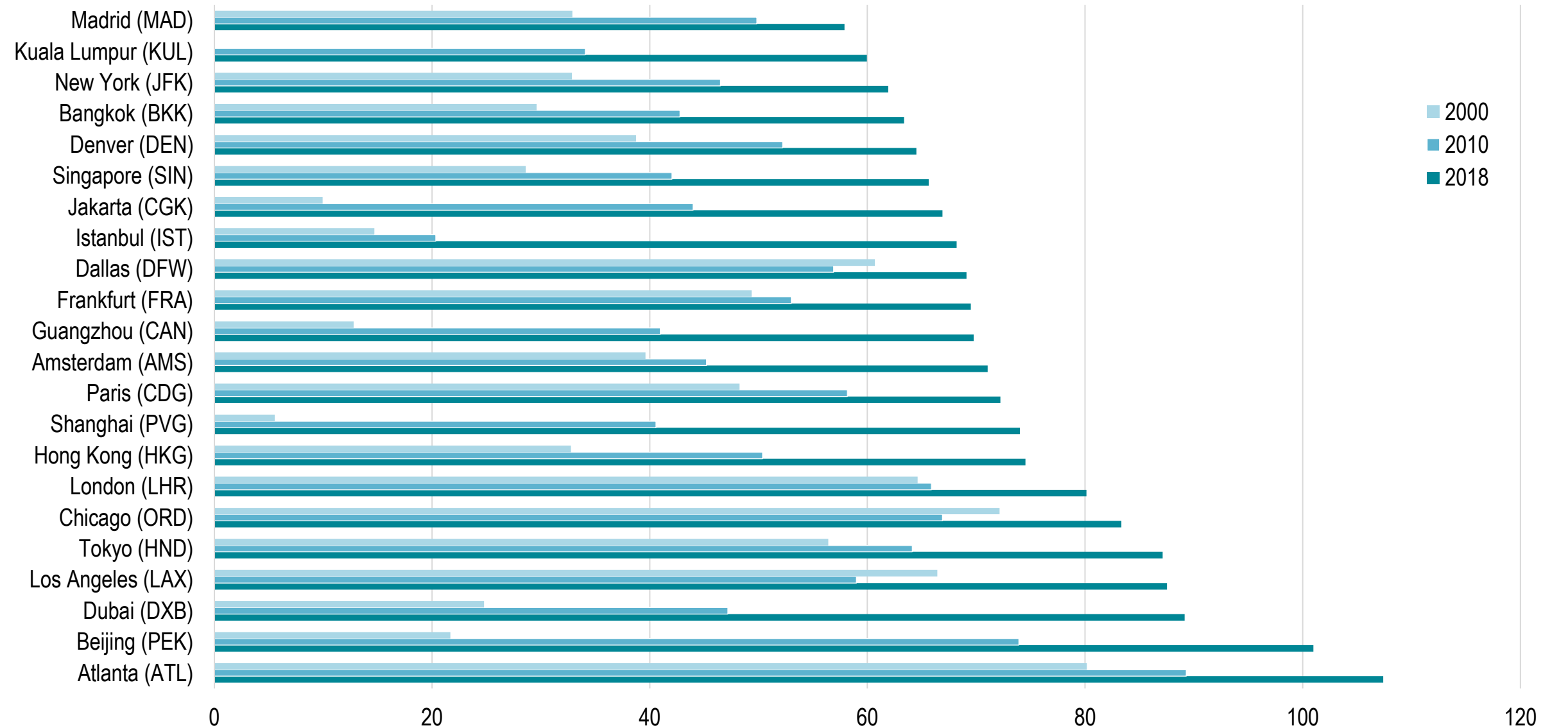
Average Hourly Airport Activity Level by Region, 2015



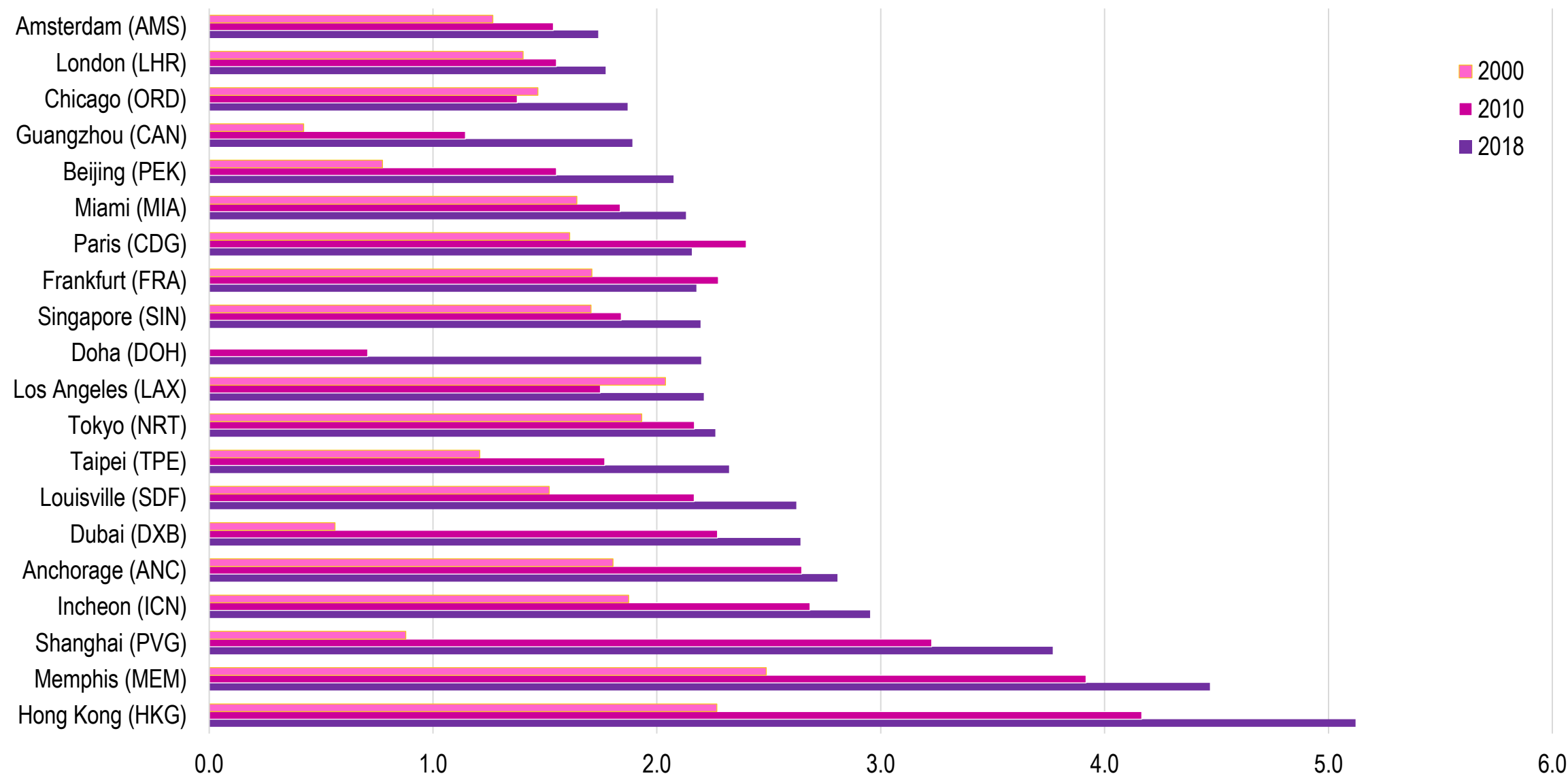
Distribution of Airports by Altitude



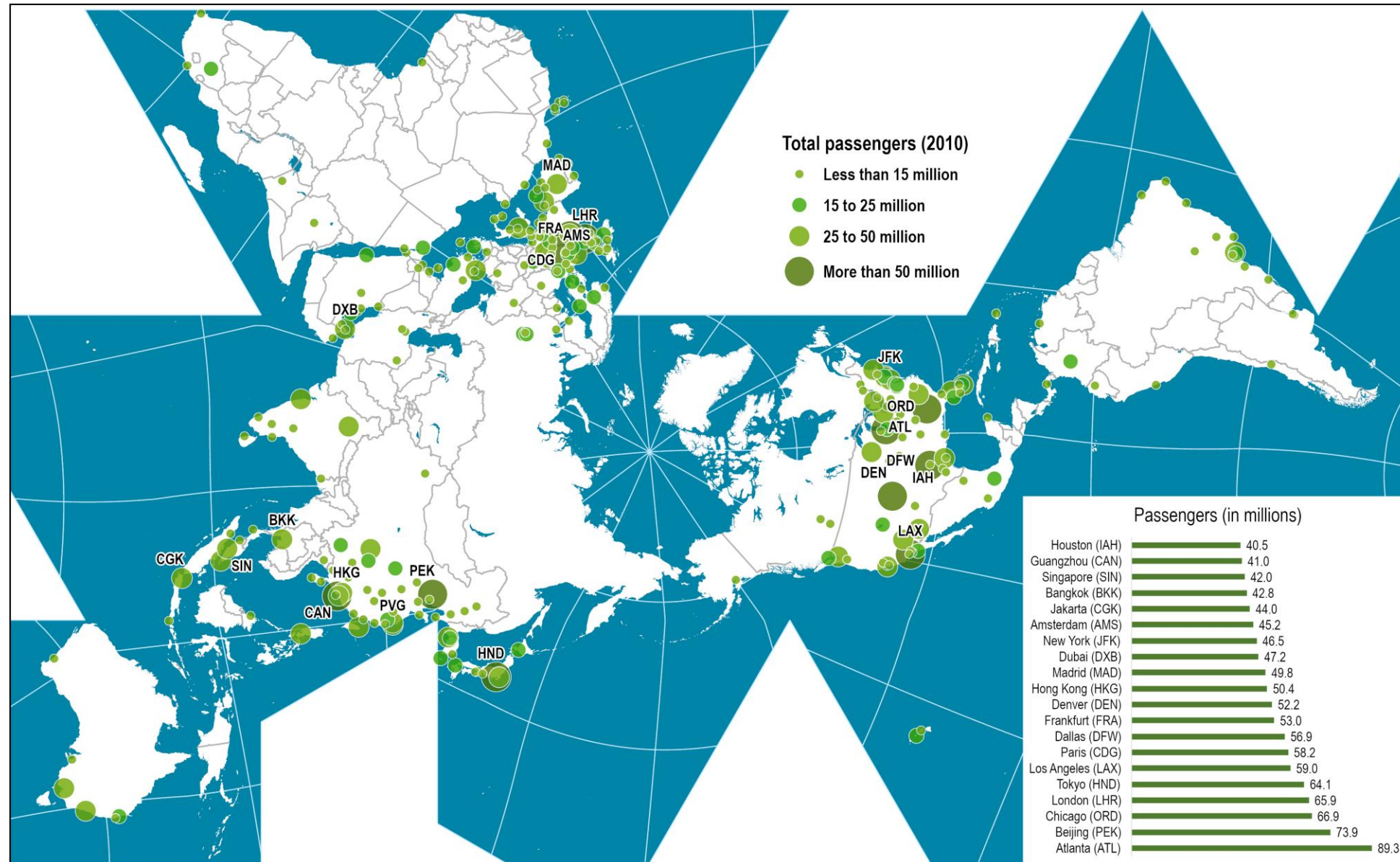
World's 20 Largest Airports (Millions of Passengers)



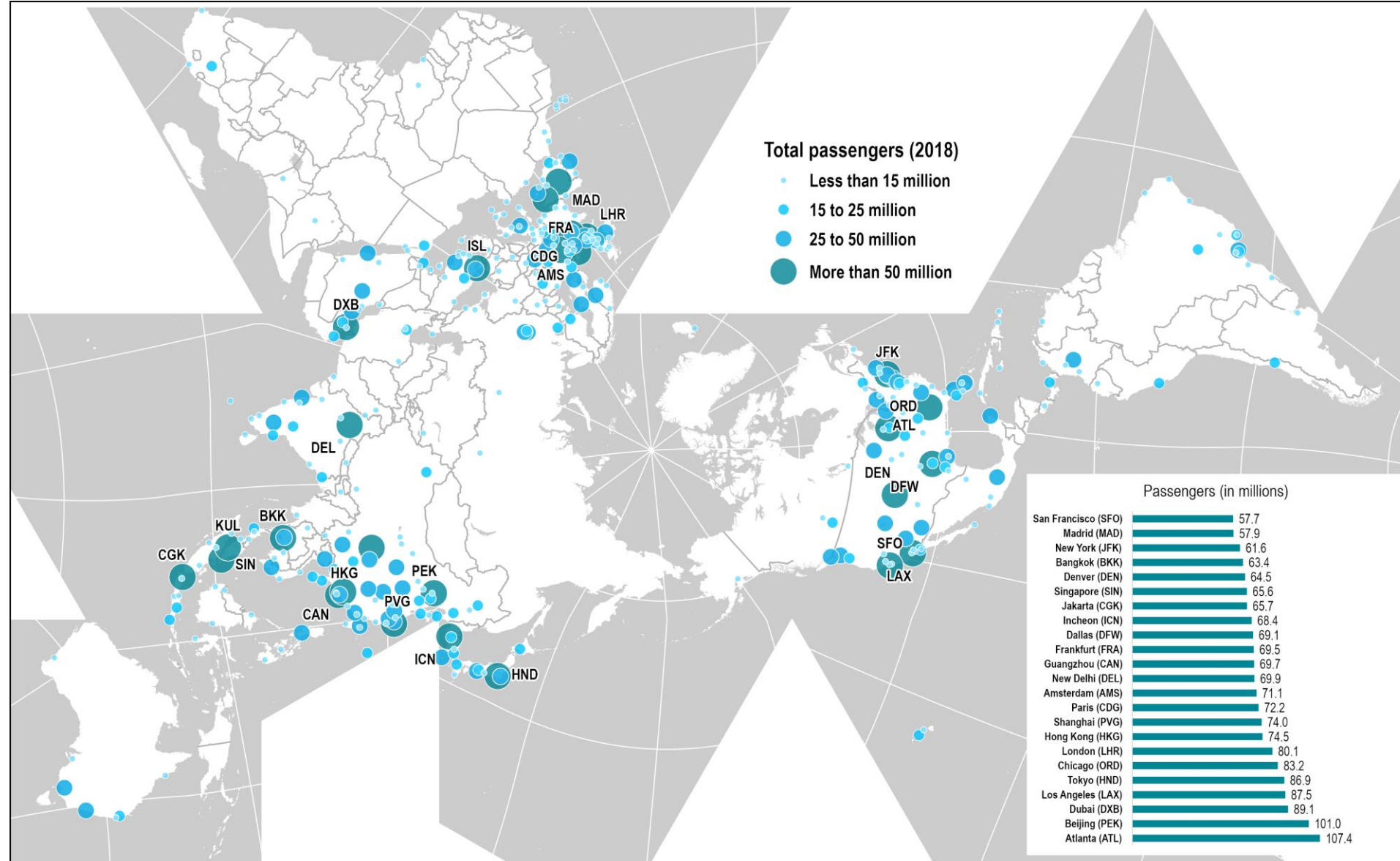
World's 20 Largest Freight Airports (in Millions of Metric Tons)



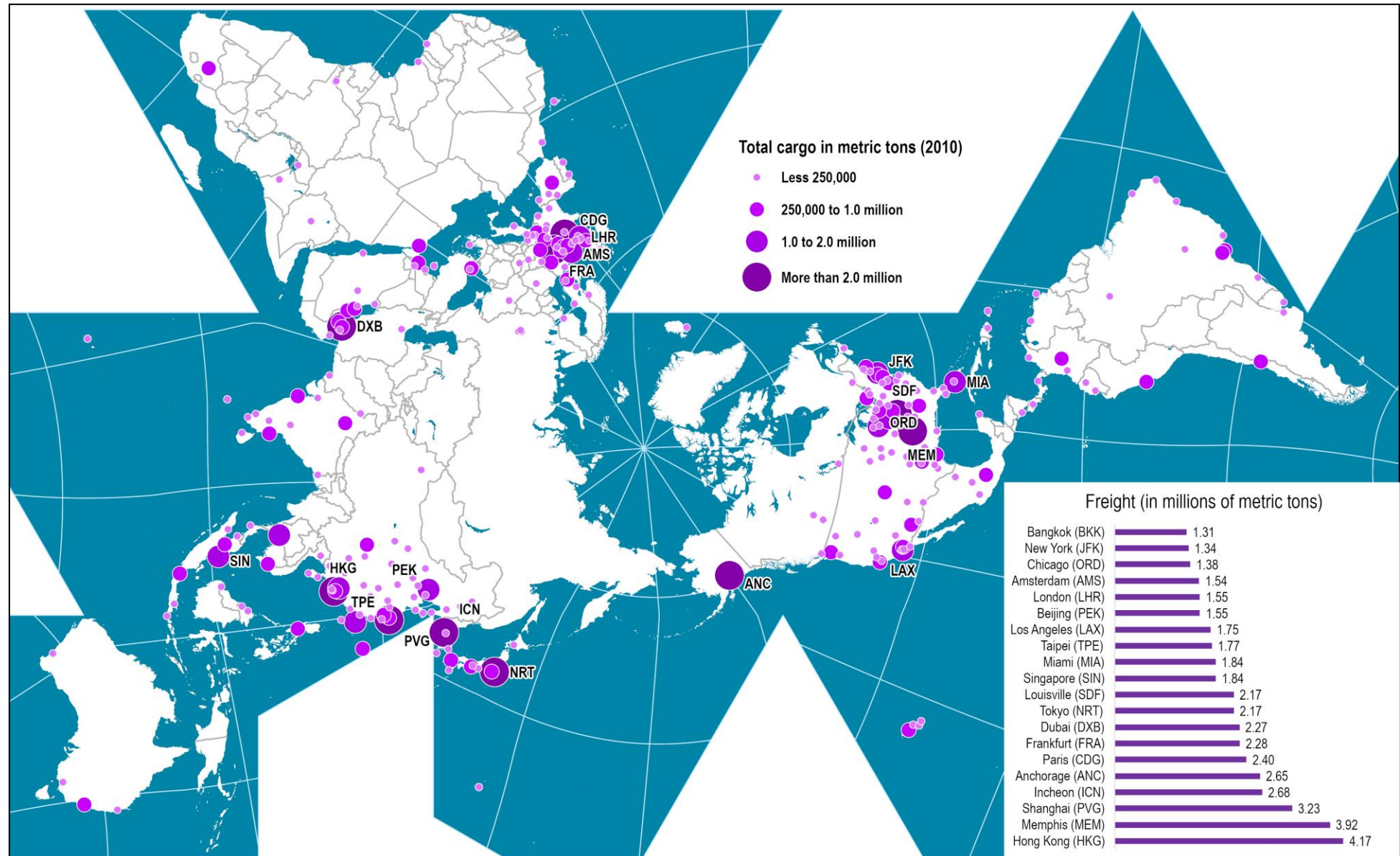
Passenger Traffic at the World's Largest Airports, 2010



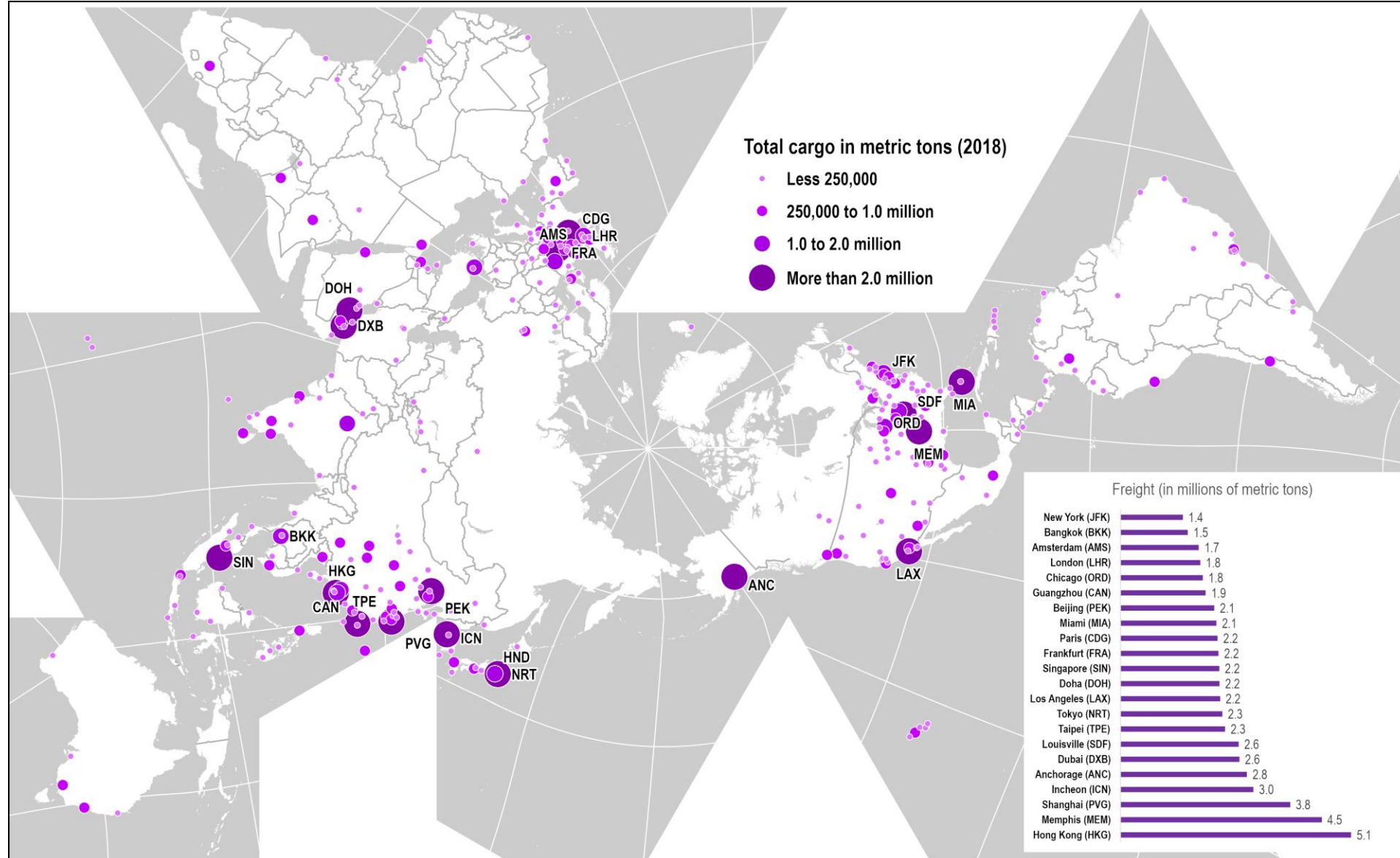
Passenger Traffic at the World's Largest Airports, 2018



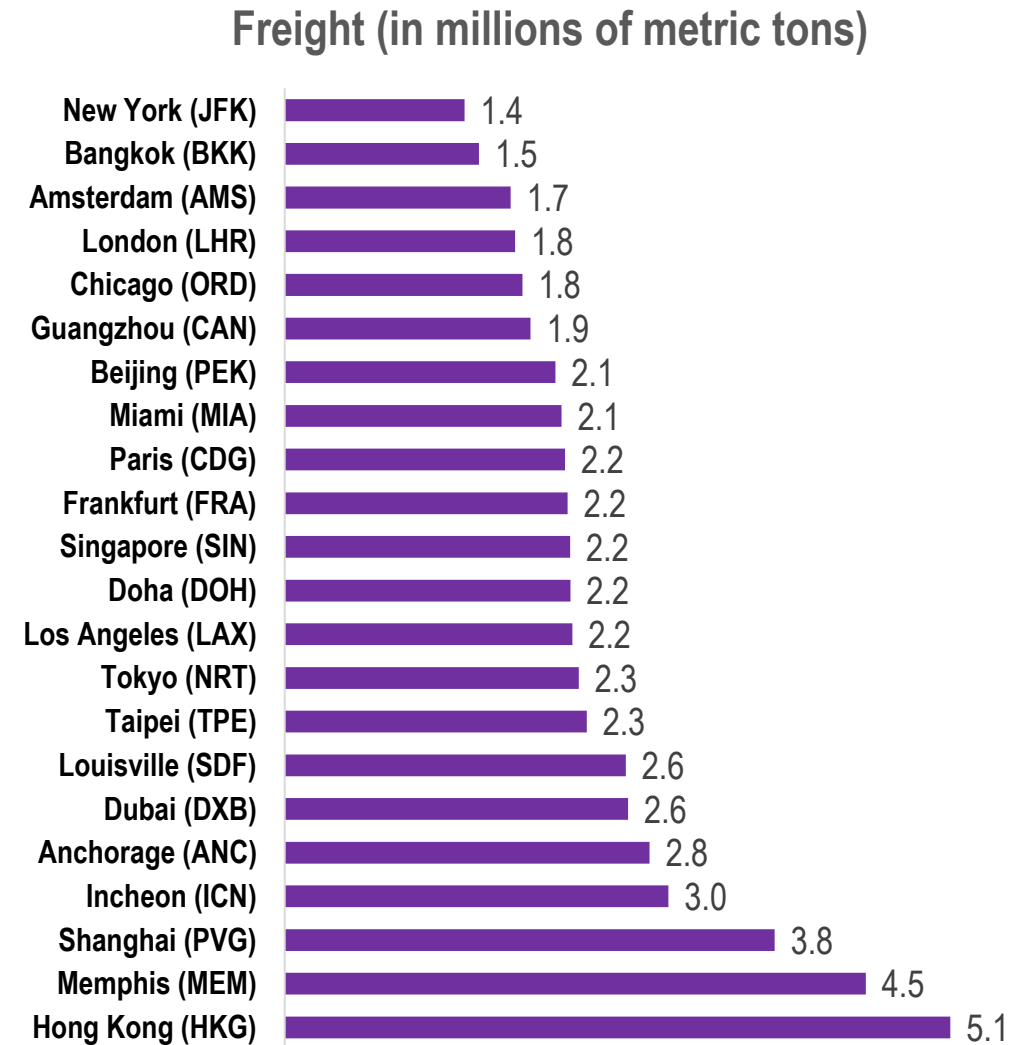
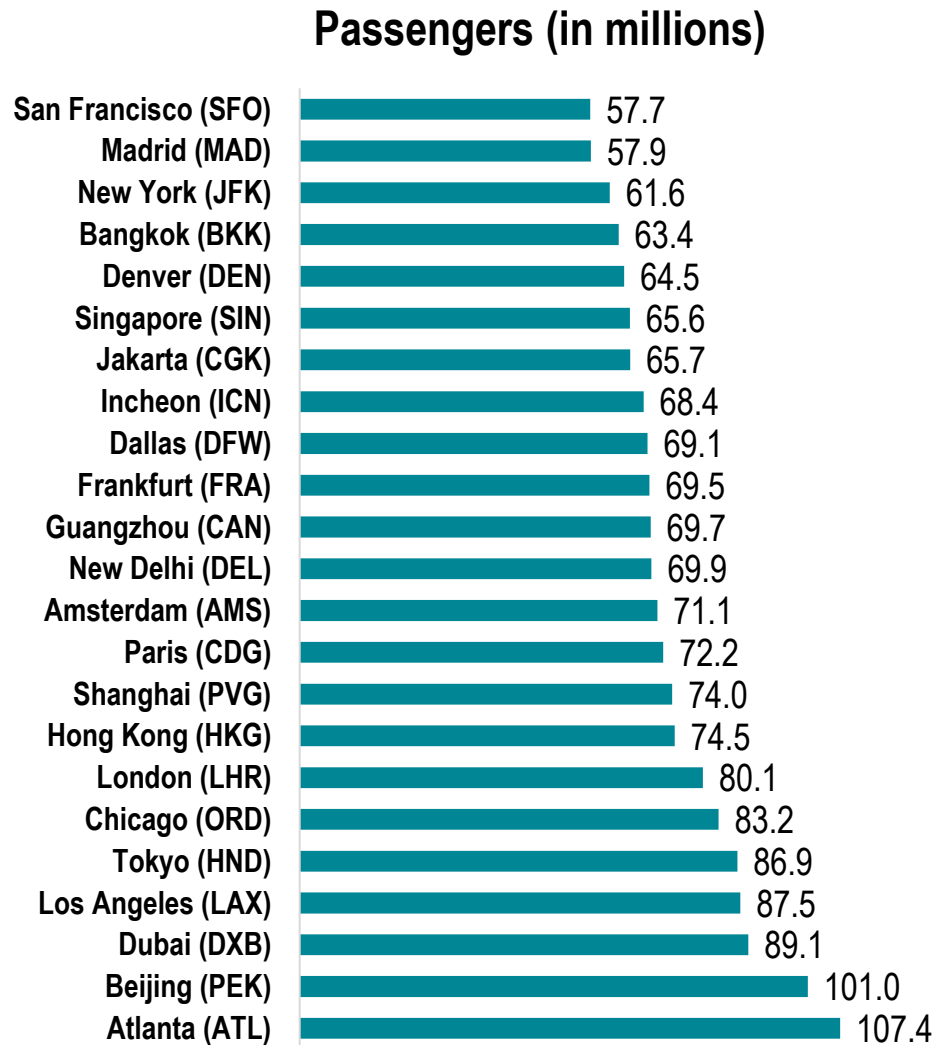
Freight Traffic at the World's Largest Airports, 2010



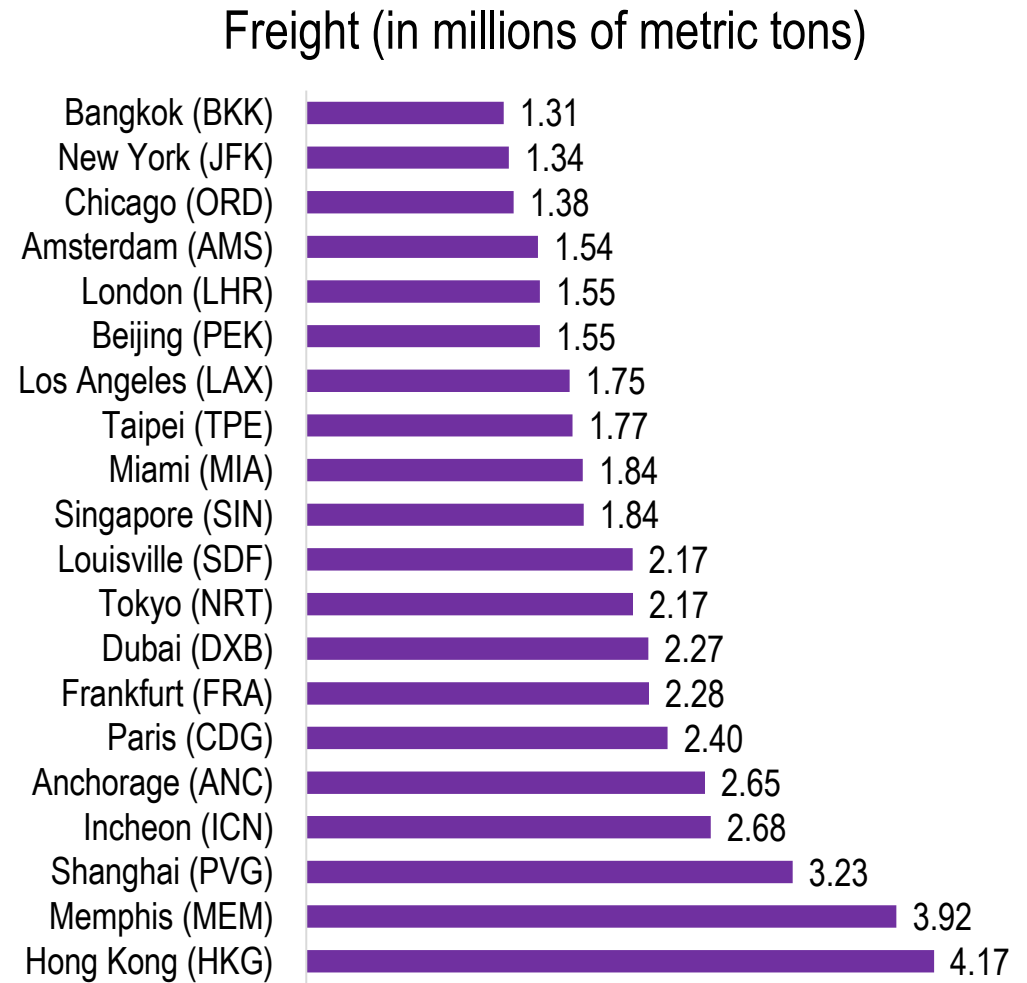
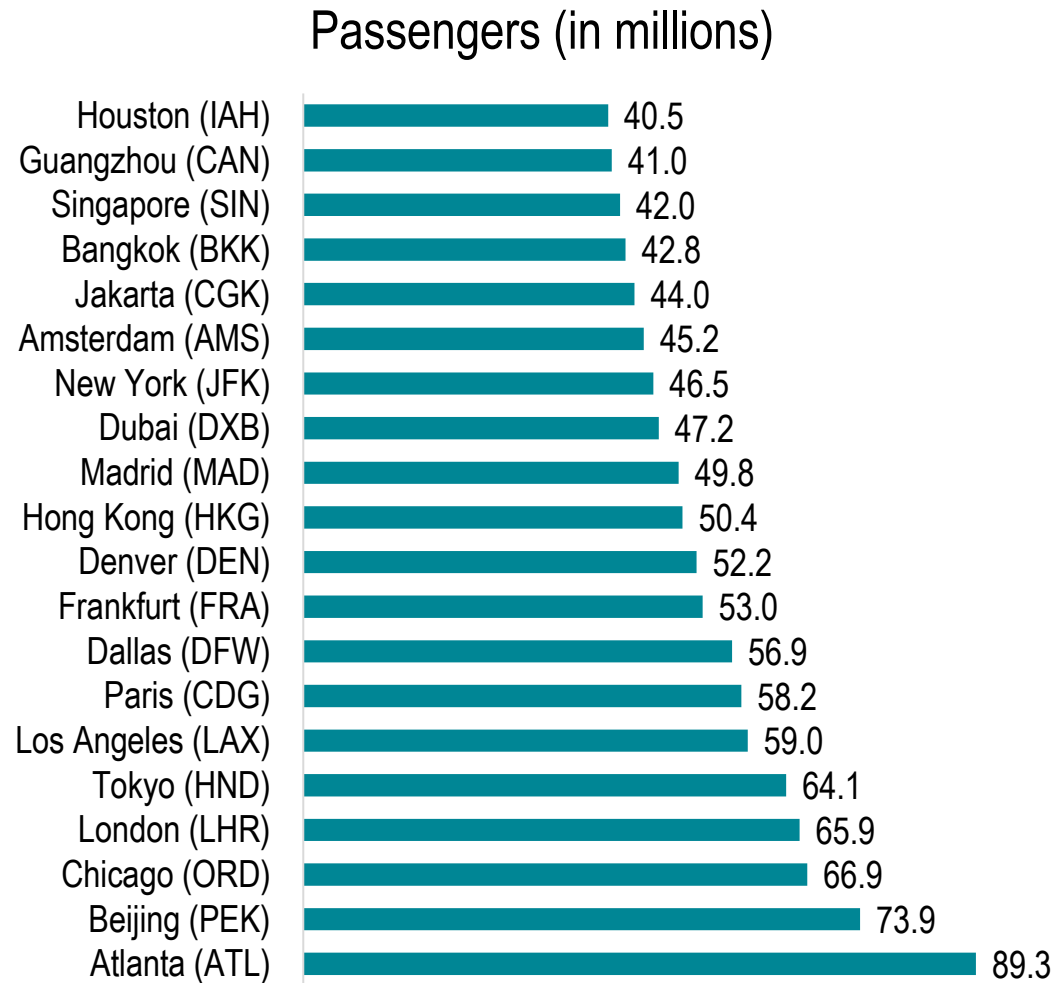
Freight Traffic at the World's Largest Airports, 2018



World's Largest Air Passenger and Freight Airports, 2018

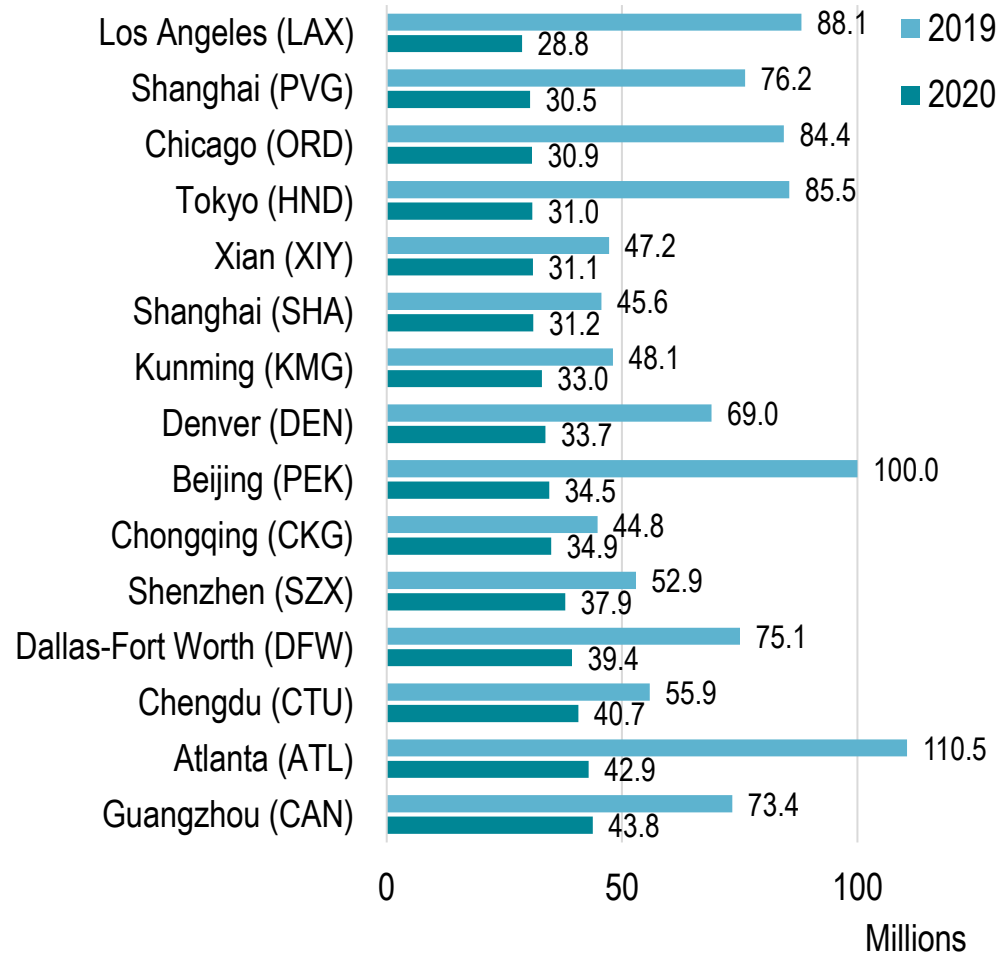


World's Largest Air Passenger and Freight Airports, 2010

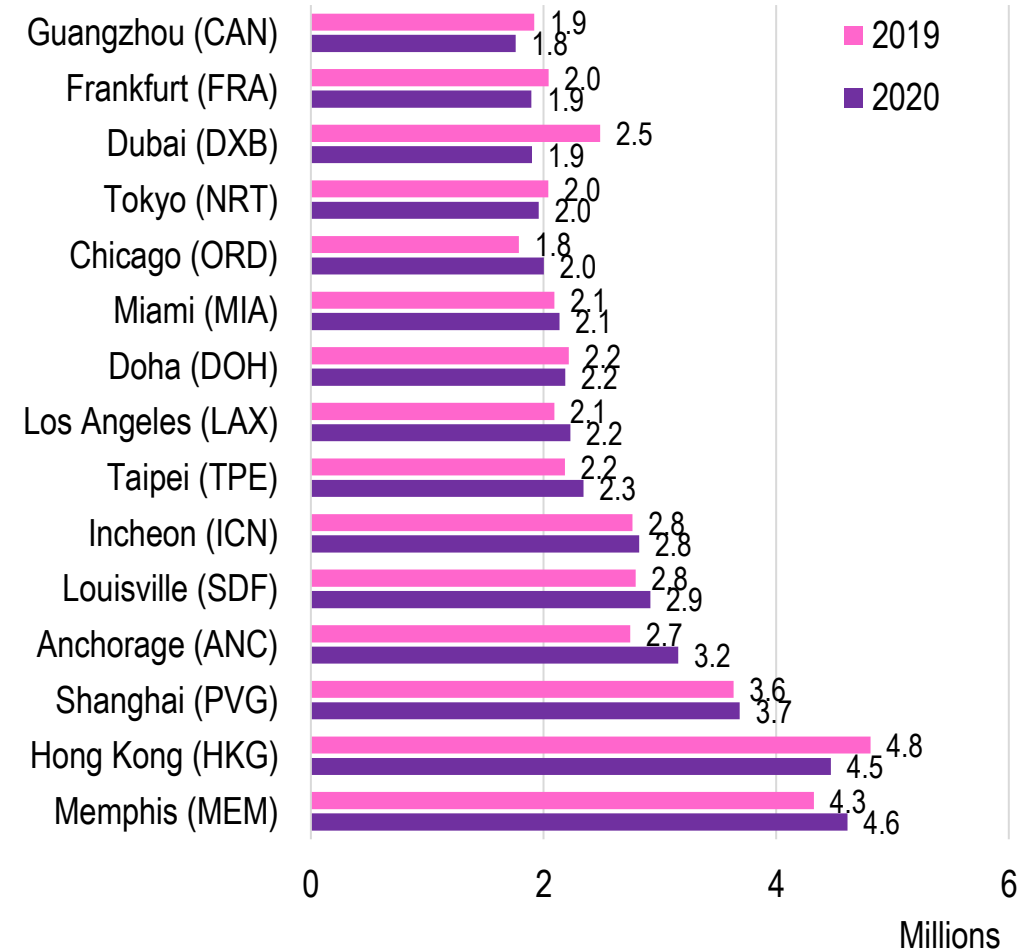


Impacts of COVID-19 on Airport Passenger and Freight Activity, 2019-2020

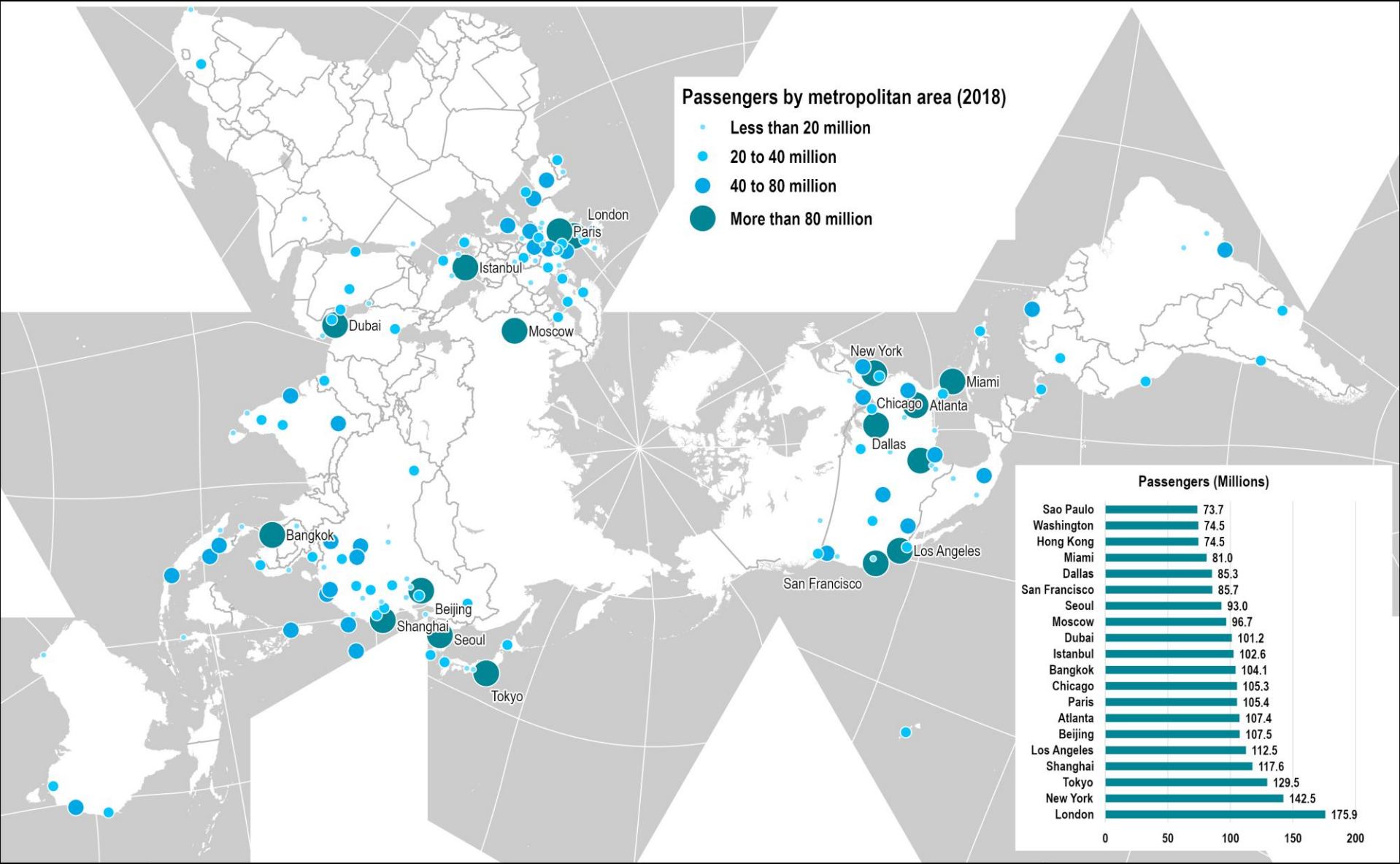
Passengers



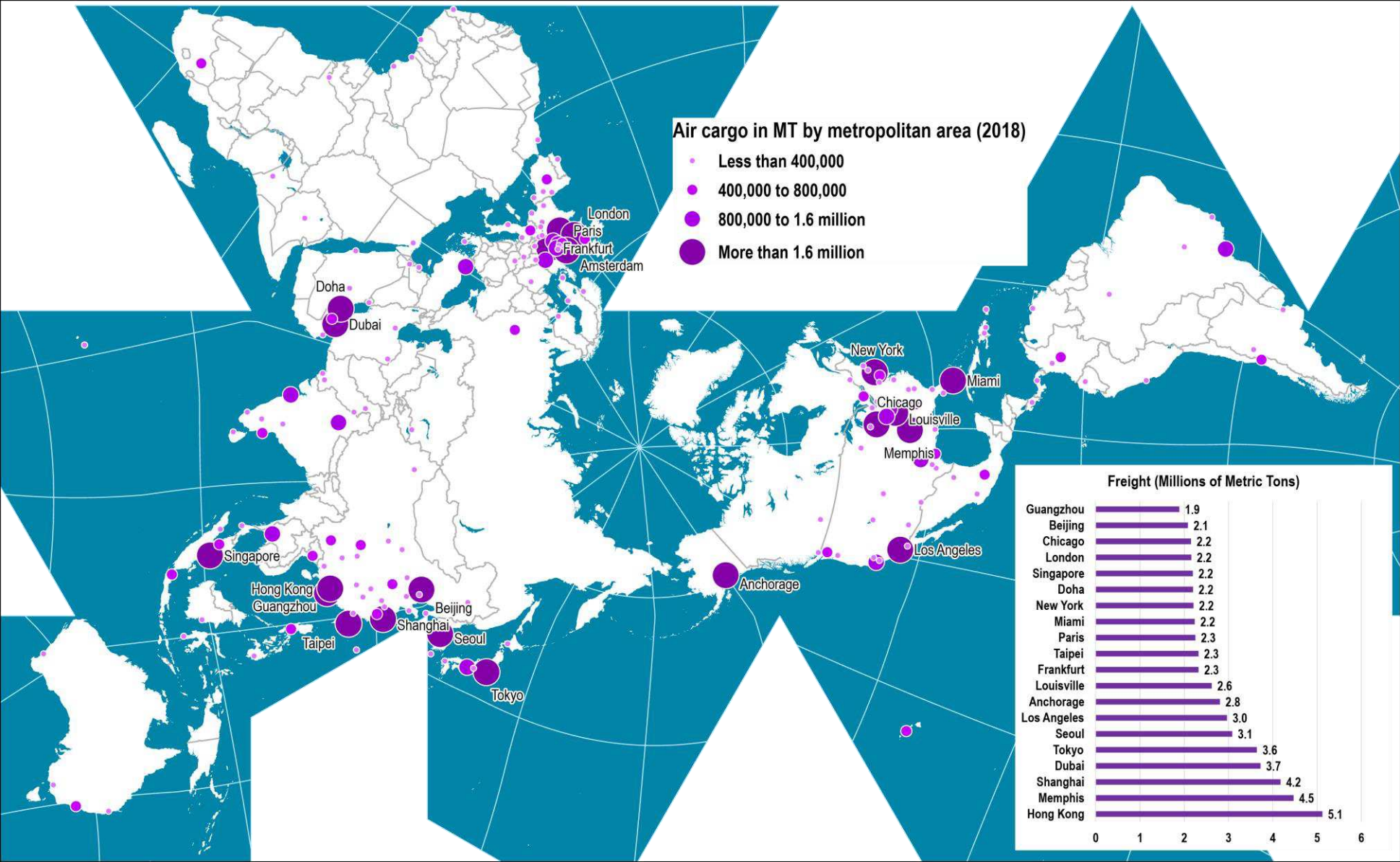
Freight (tons)



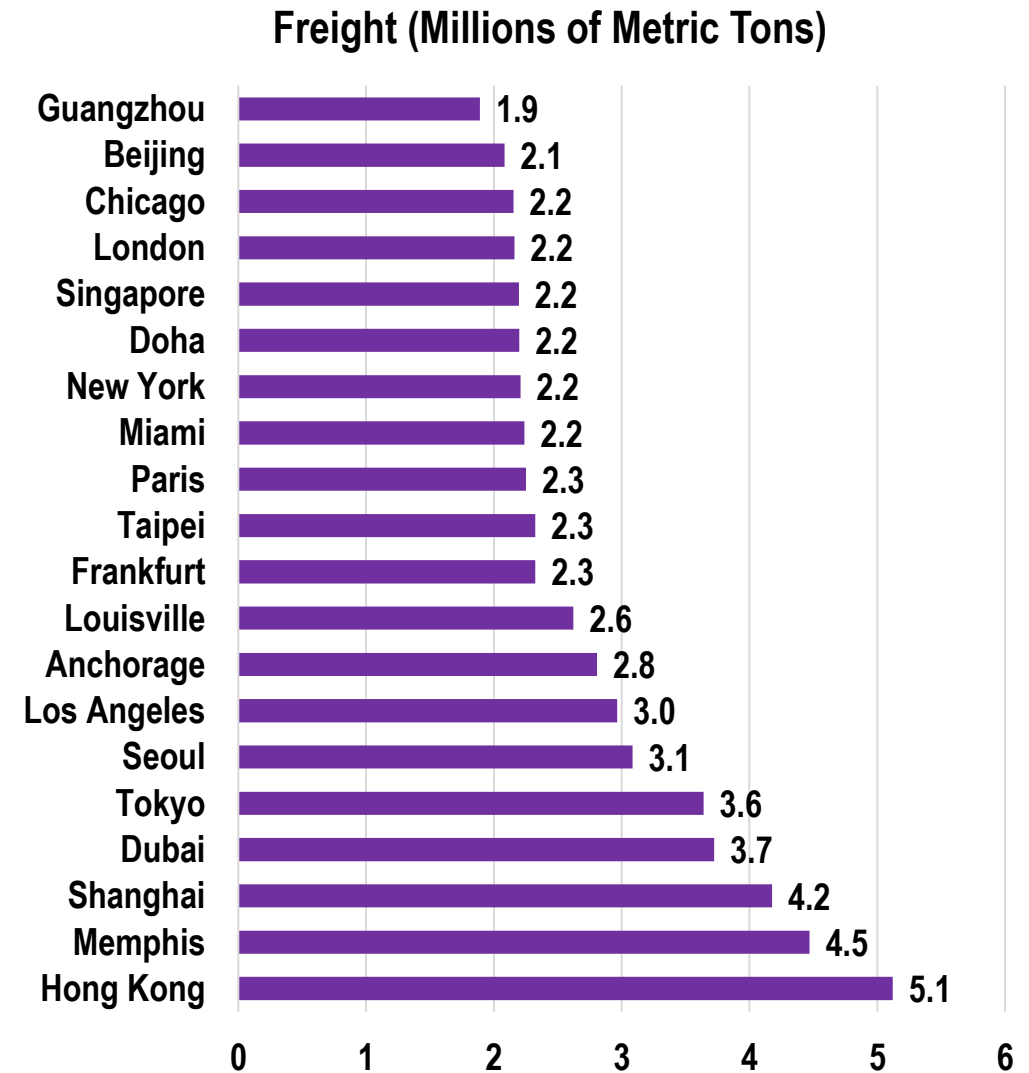
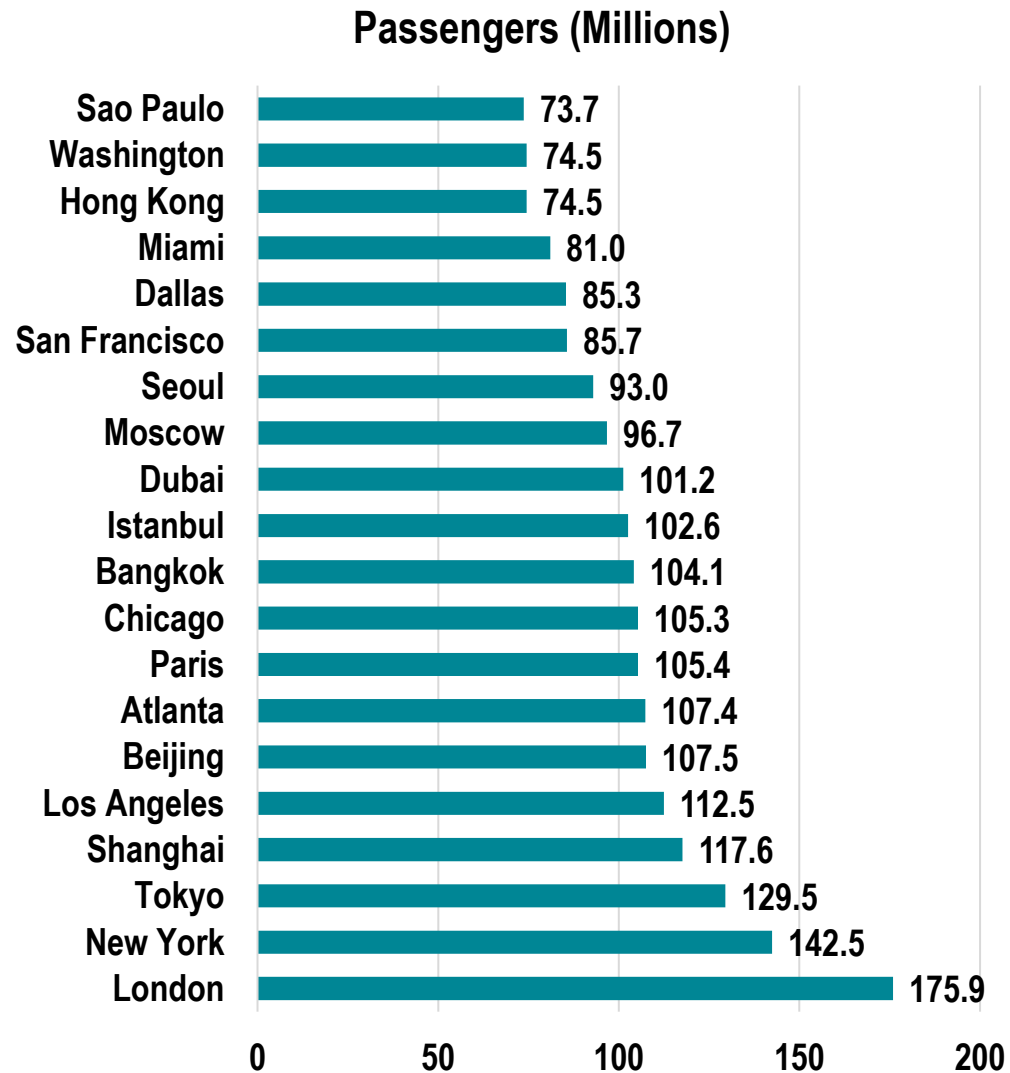
Airport Passenger Traffic by Metropolitan Area, 2018



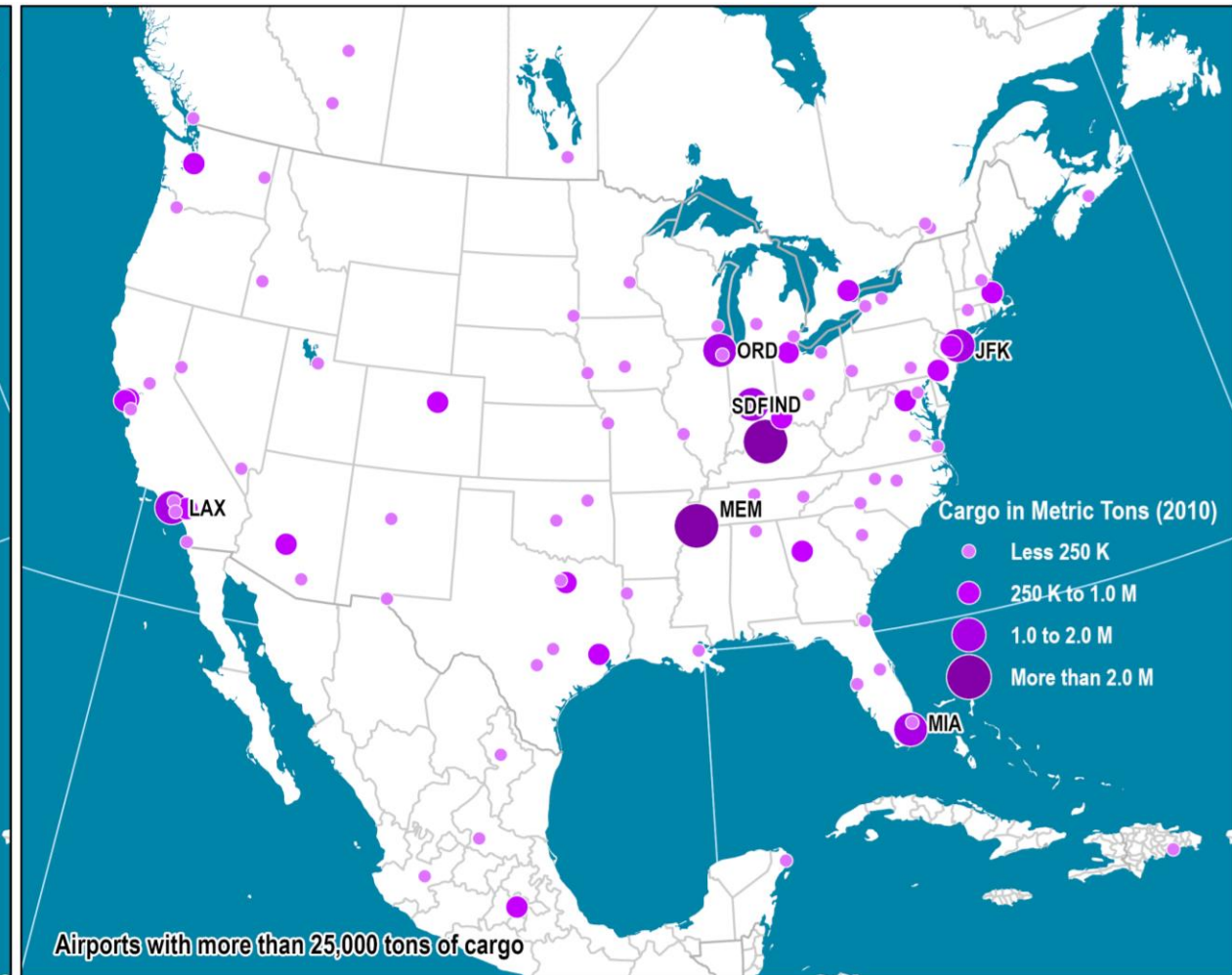
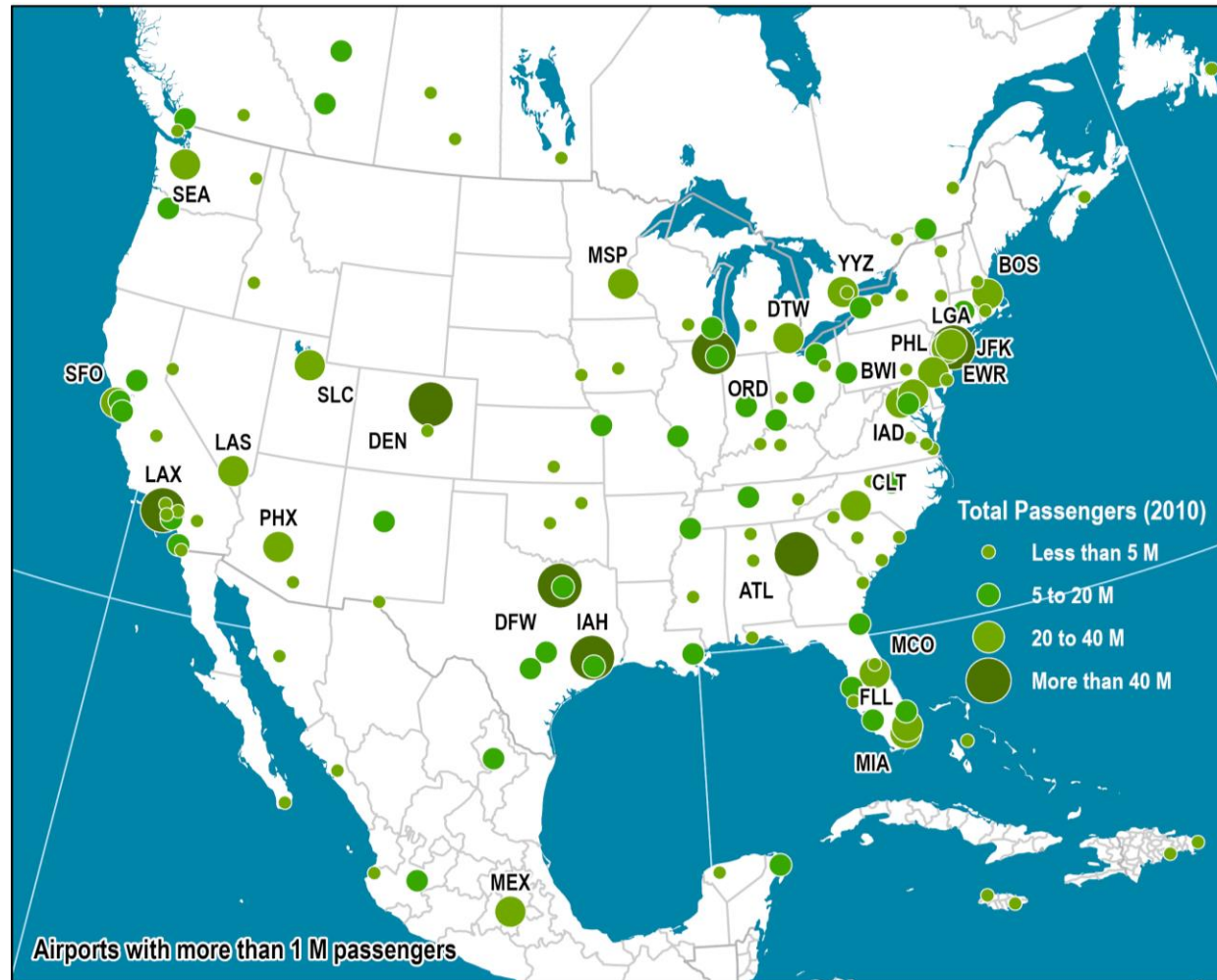
Air Cargo Traffic by Metropolitan Area, 2018



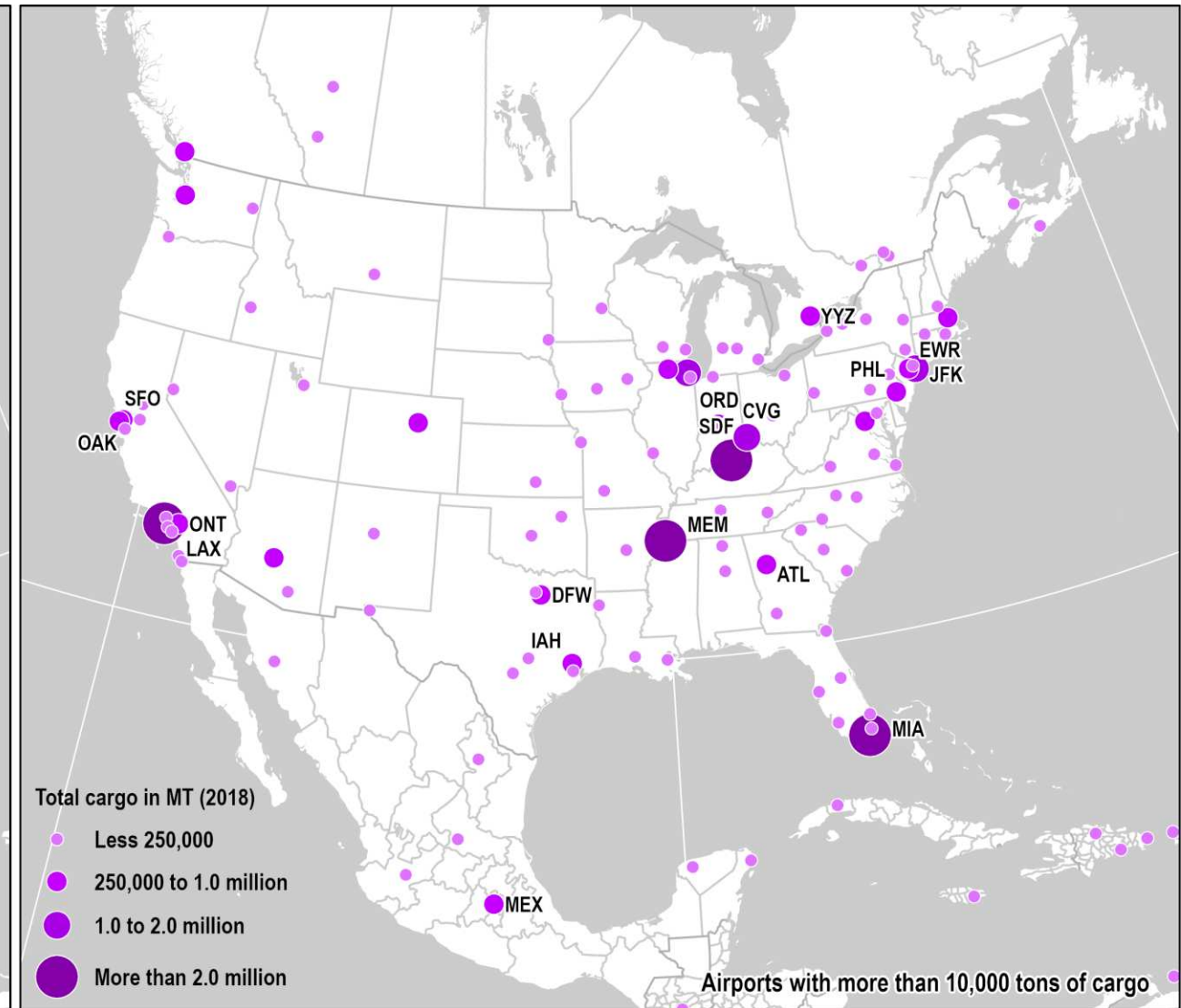
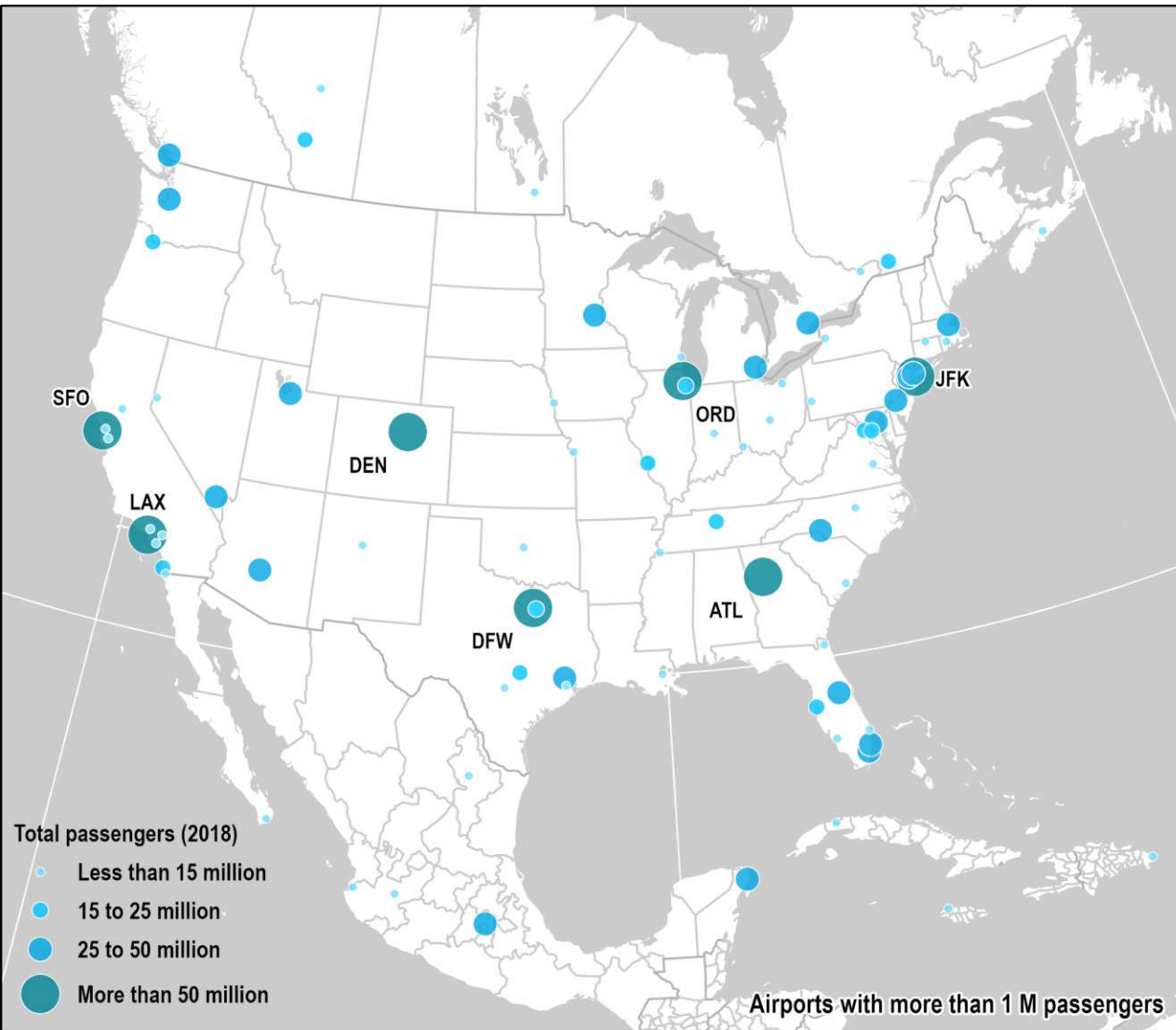
World's Largest Air Passenger and Freight Traffic by Metropolitan Area, 2018



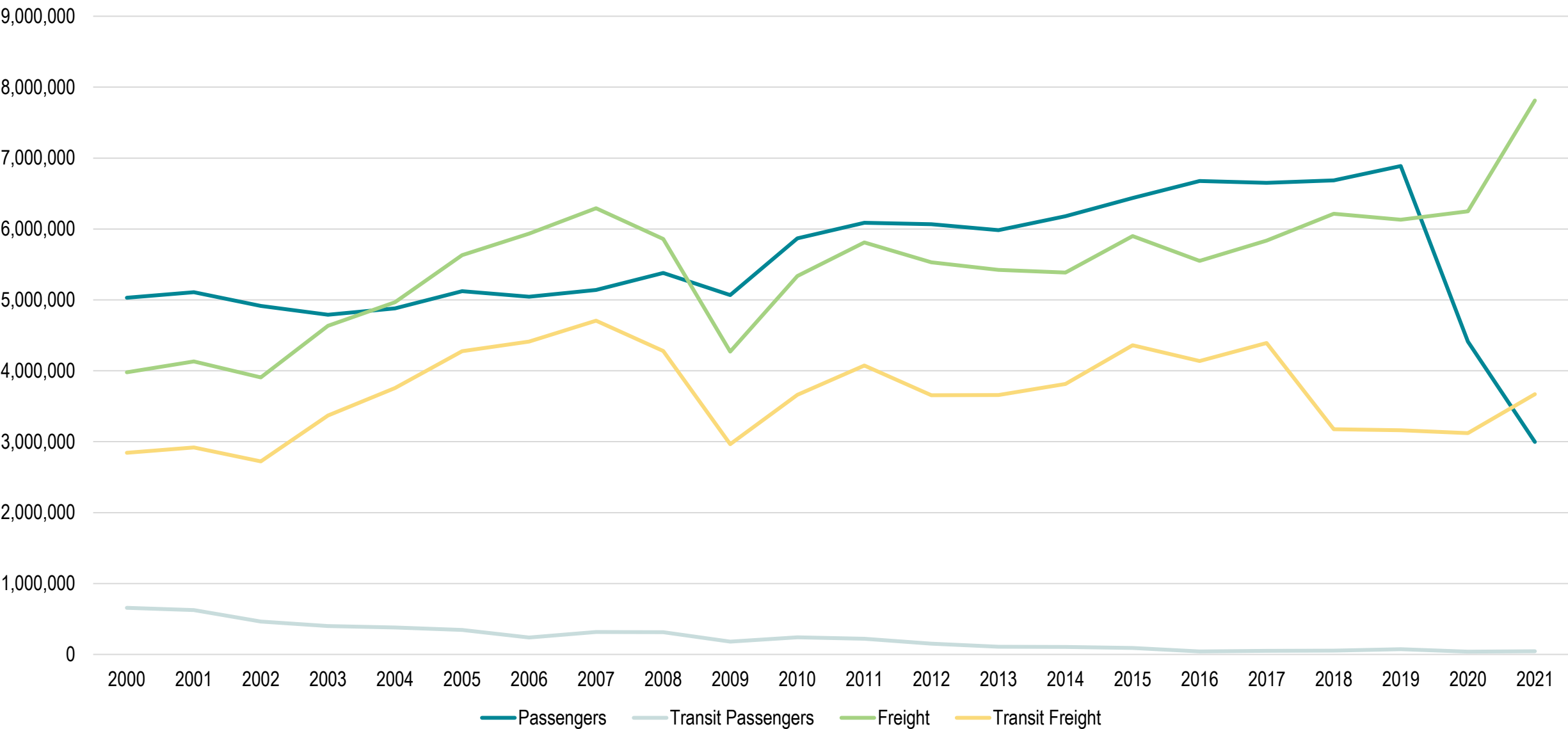
Passenger and Freight Traffic at North American Airports, 2010



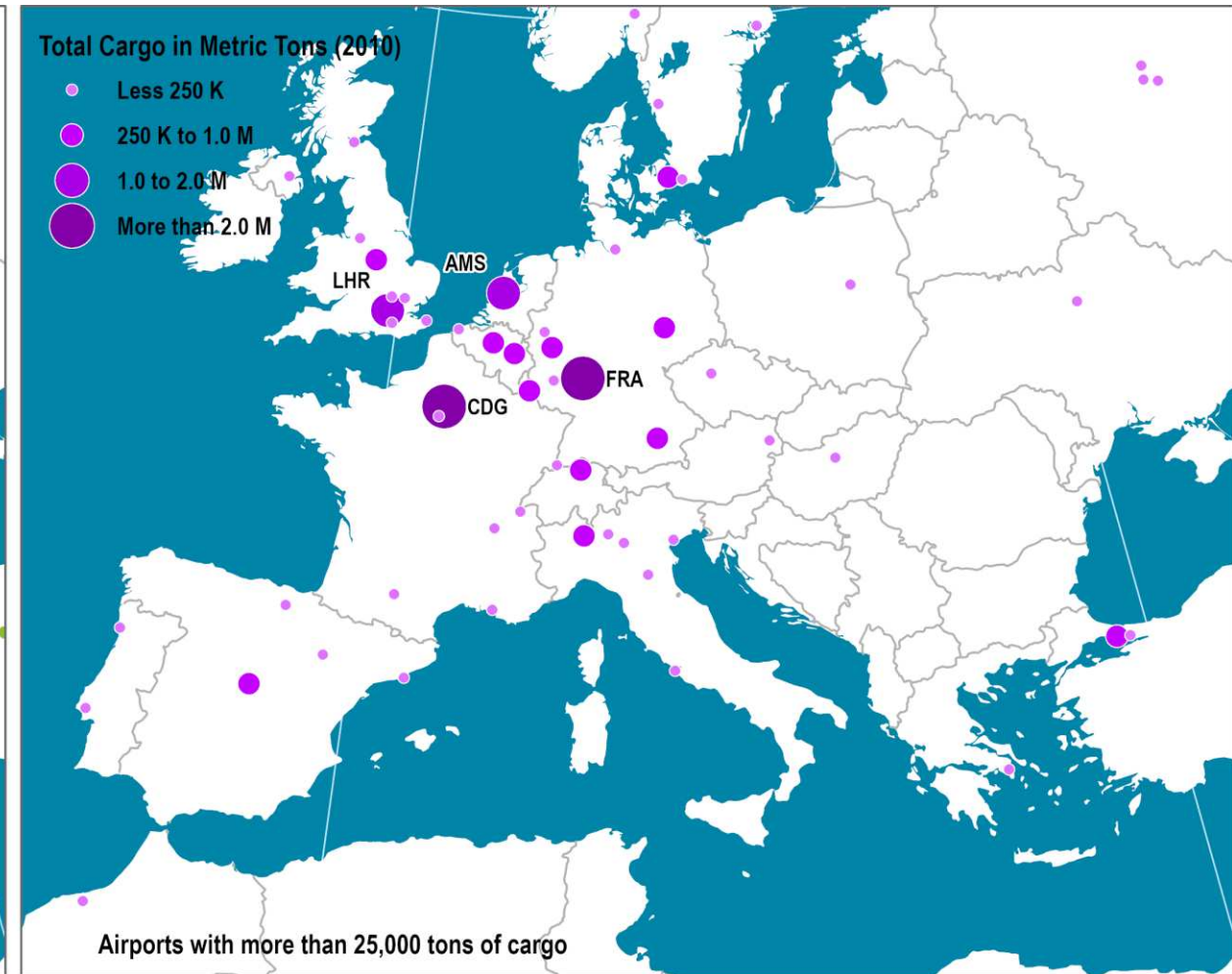
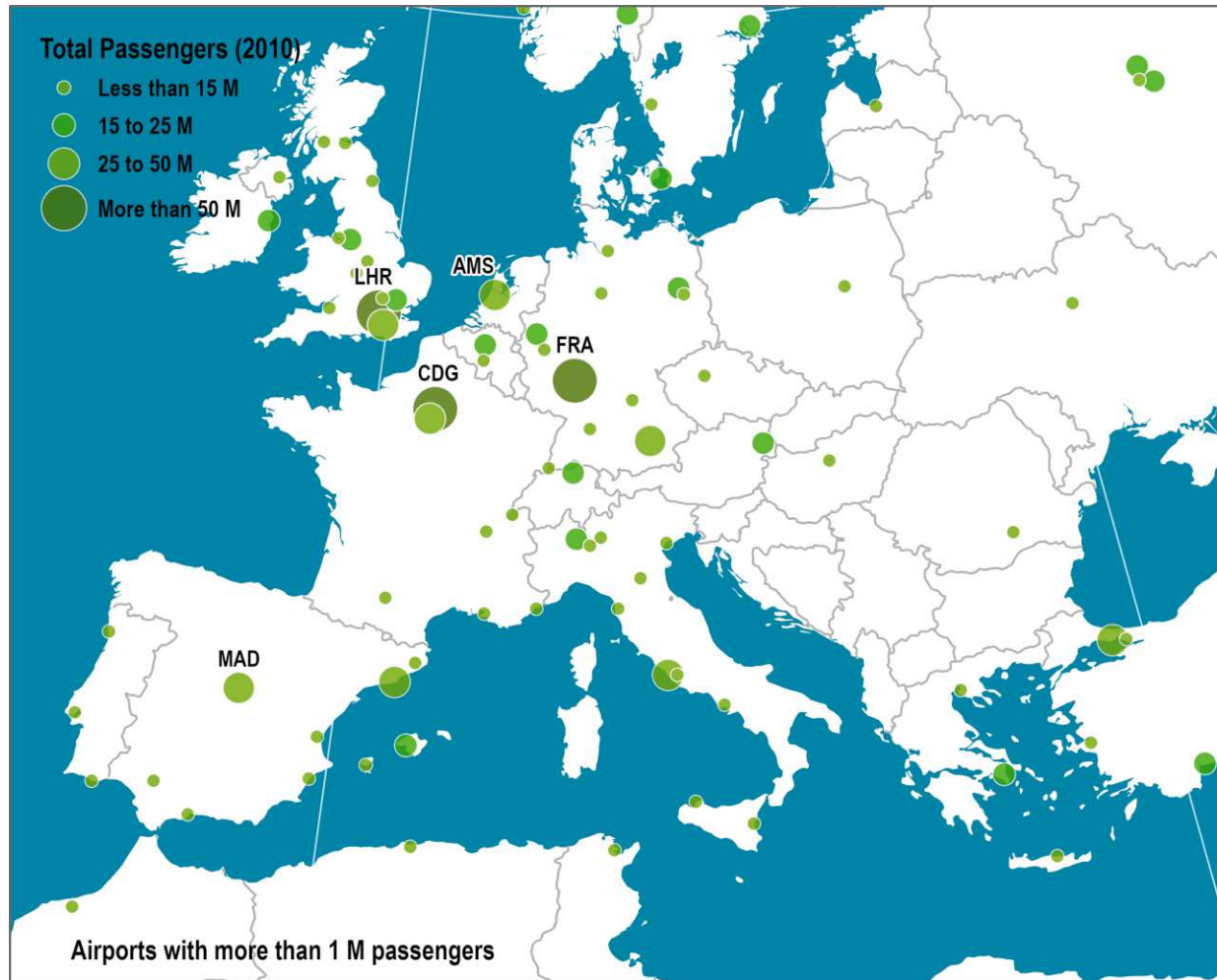
Passenger and Freight Traffic at North American Airports, 2018



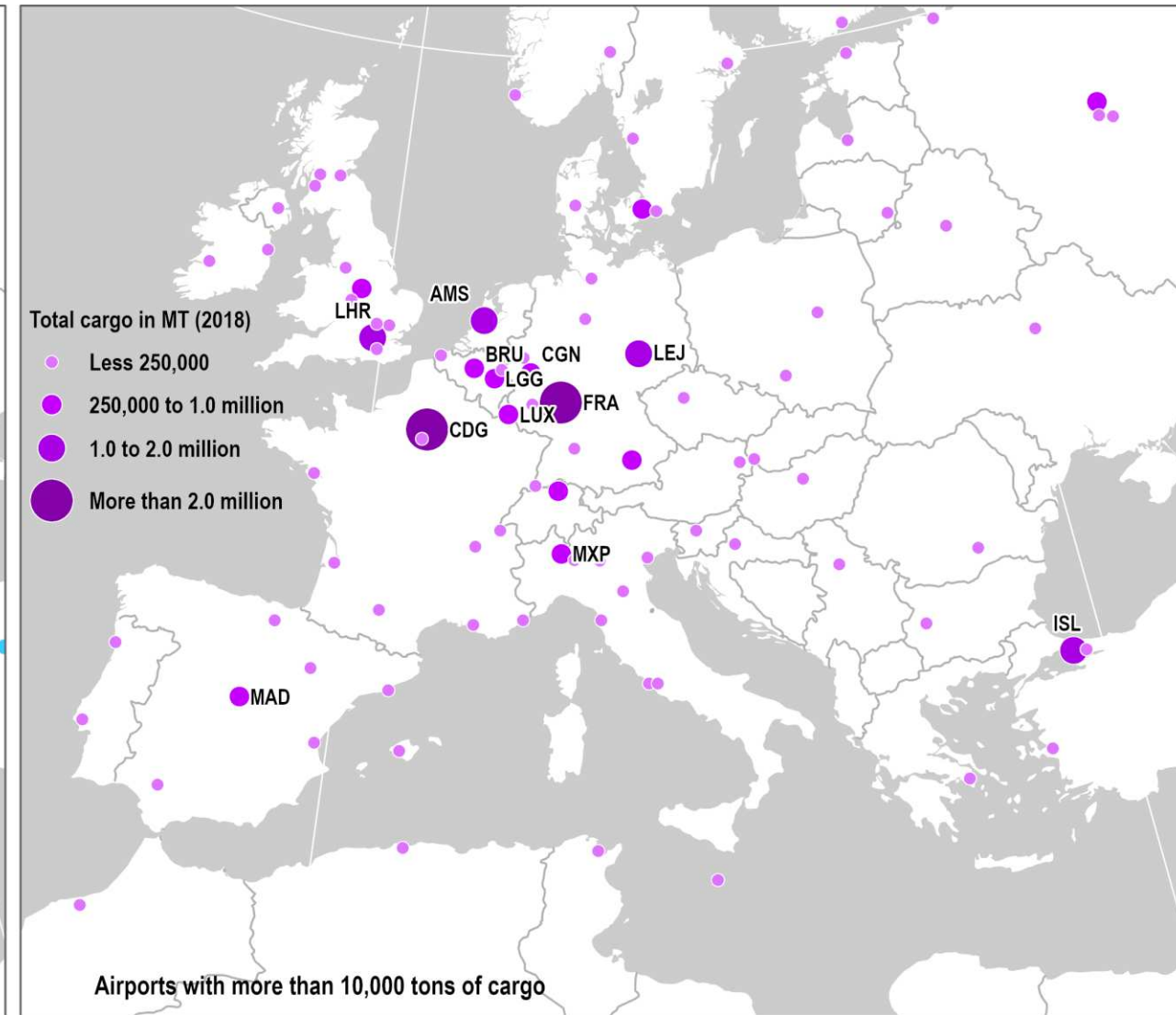
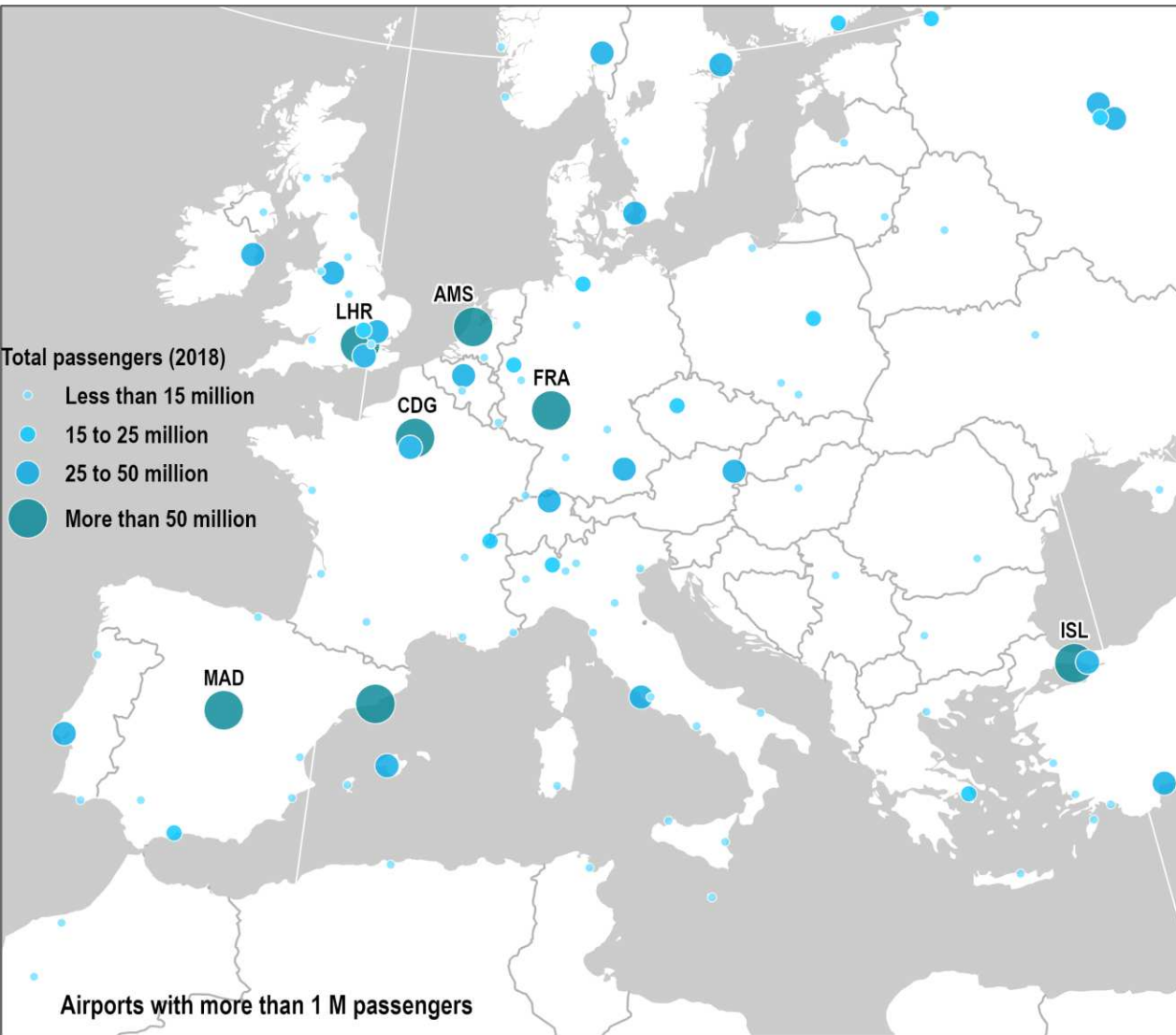
Passenger and Freight Traffic at Anchorage Airport



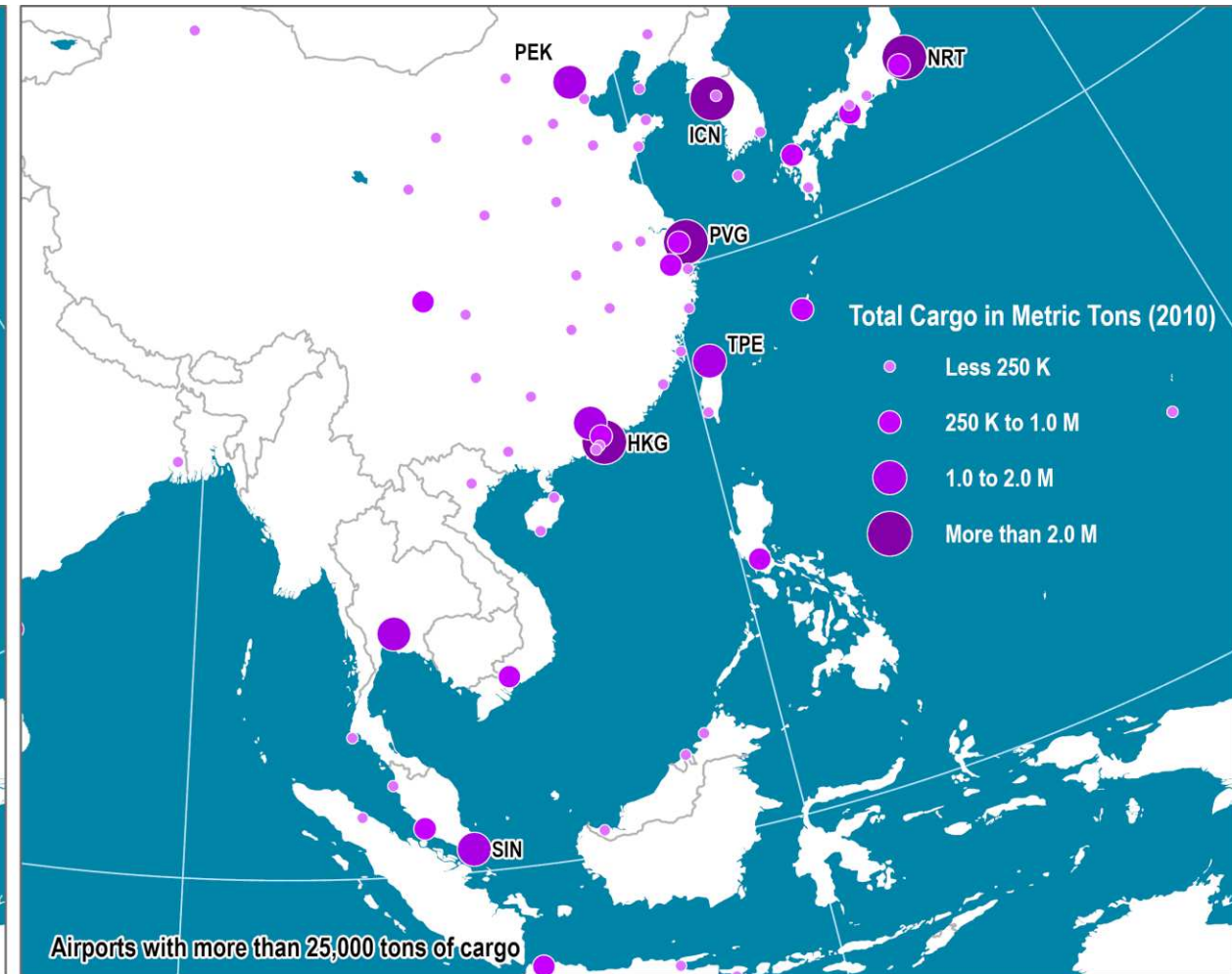
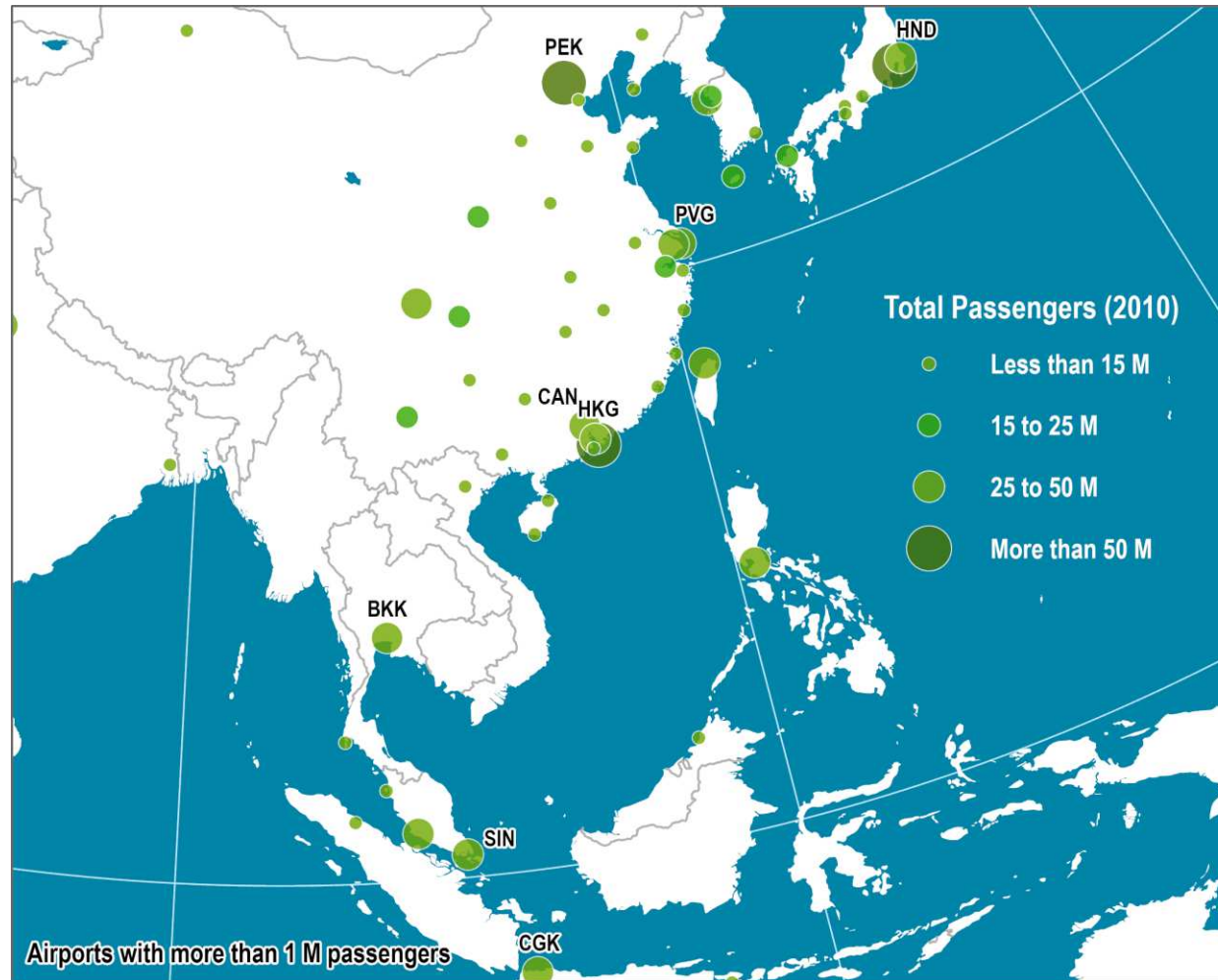
Passenger and Freight Traffic at European Airports, 2010



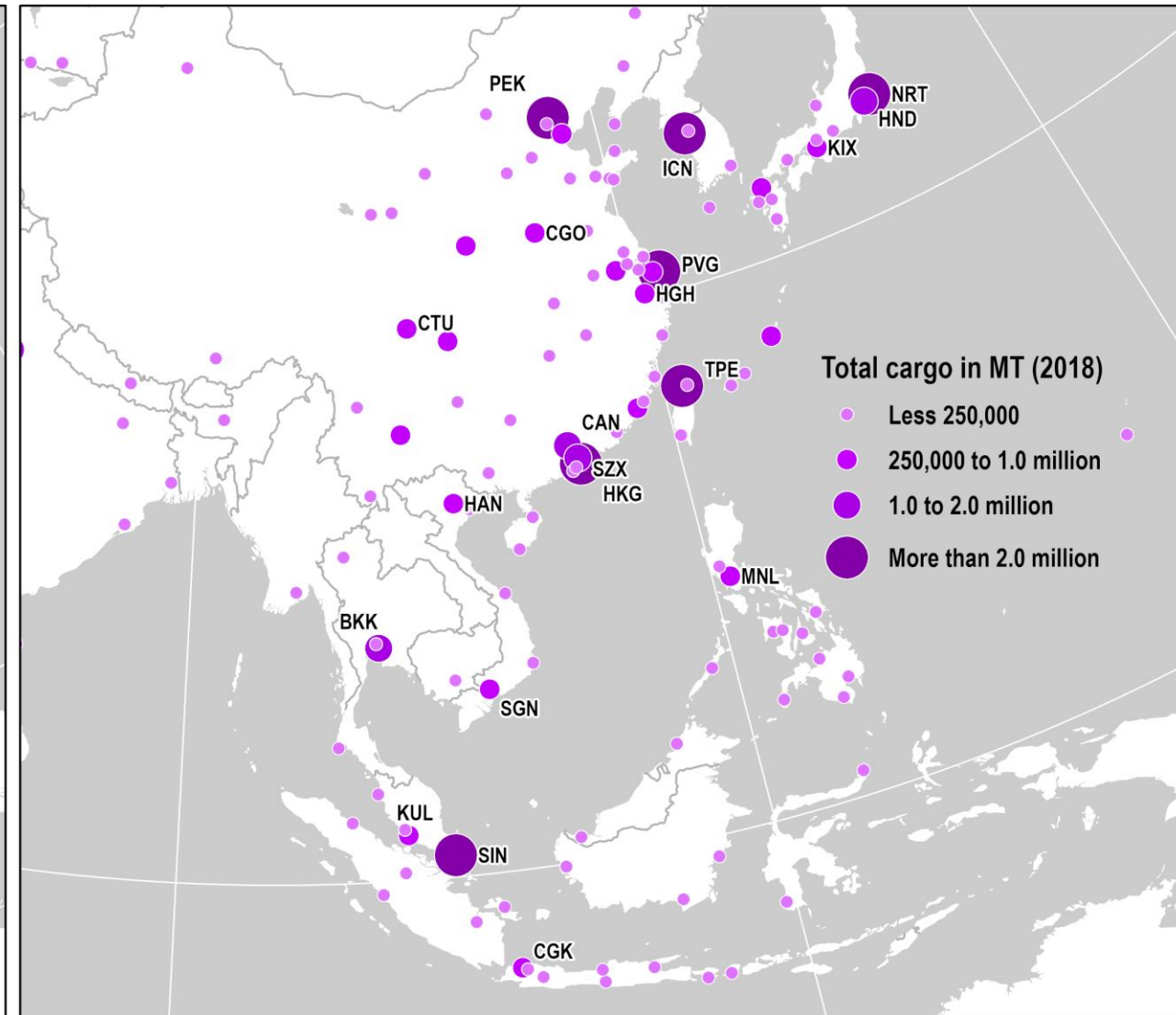
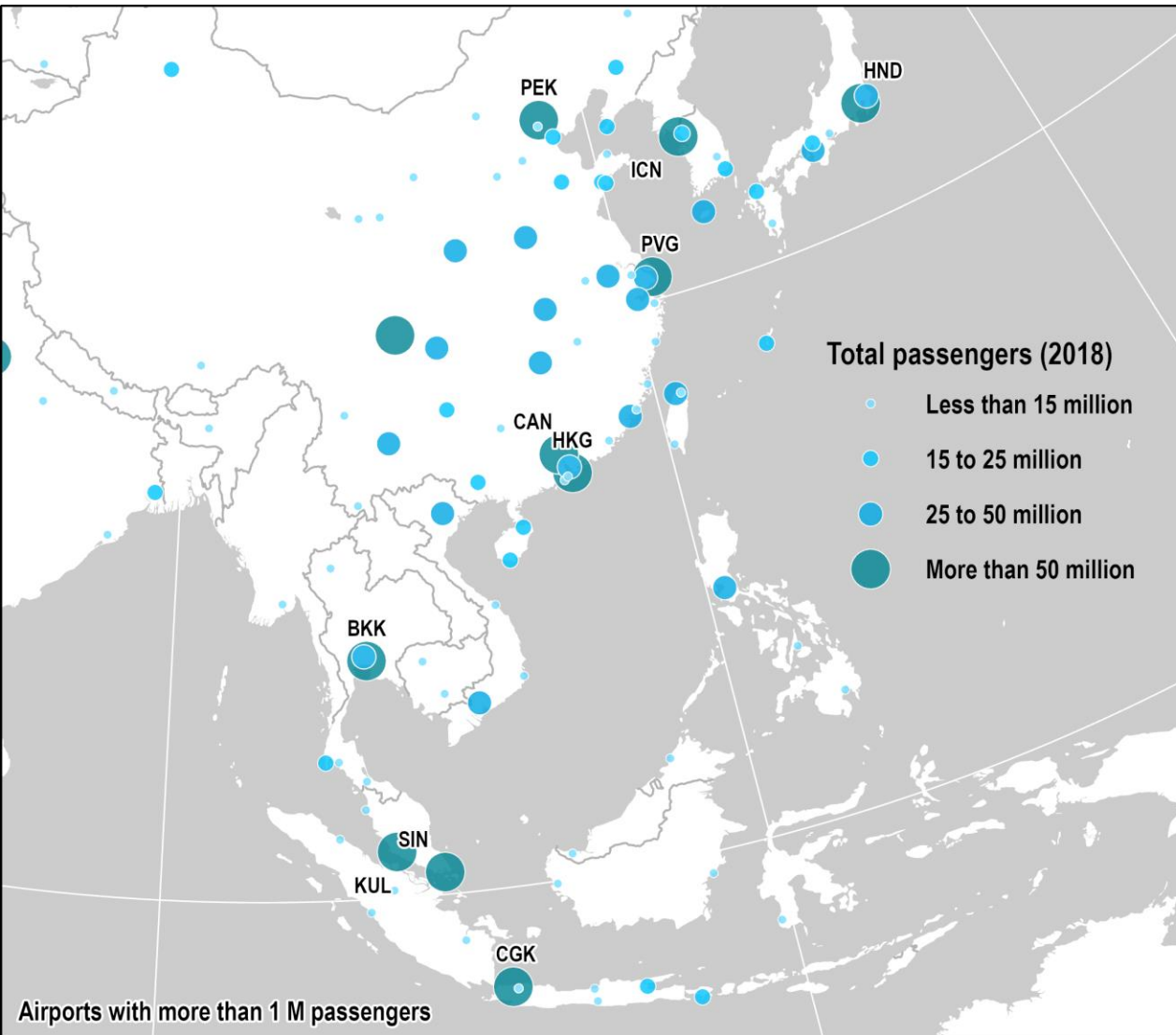
Passenger and Freight Traffic at European Airports, 2018



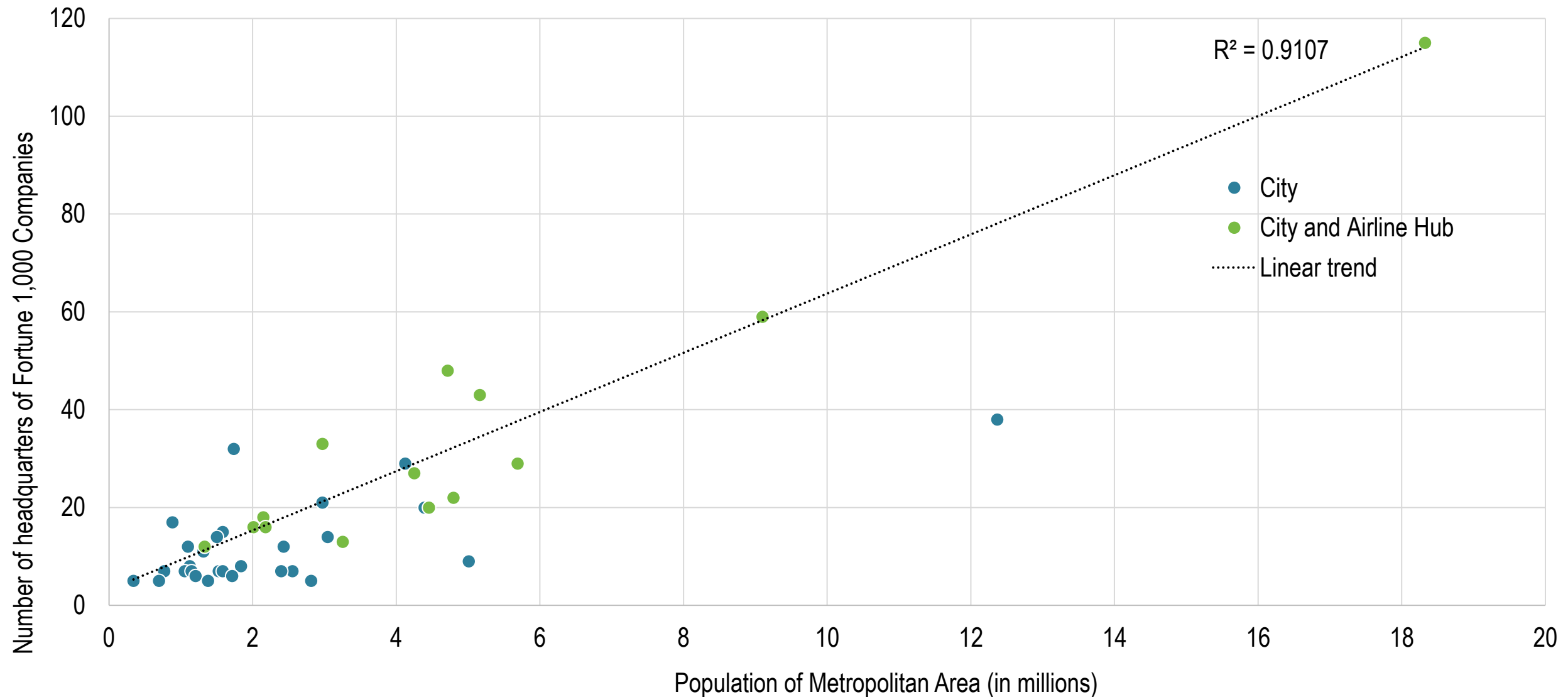
Passenger and Freight Traffic at East and Southeast Asian Airports, 2010



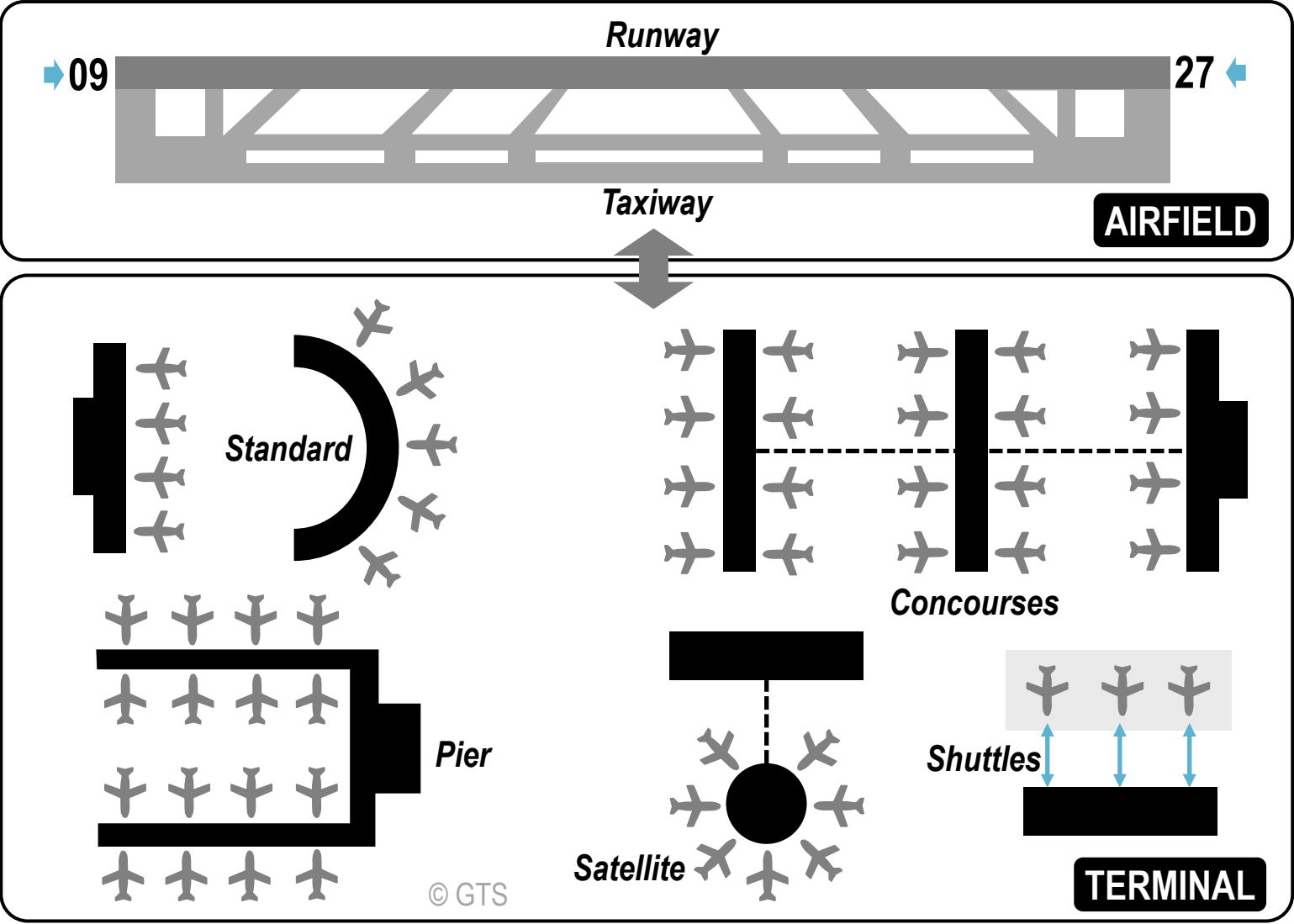
Passenger and Freight Traffic at East and Southeast Asian Airports, 2018



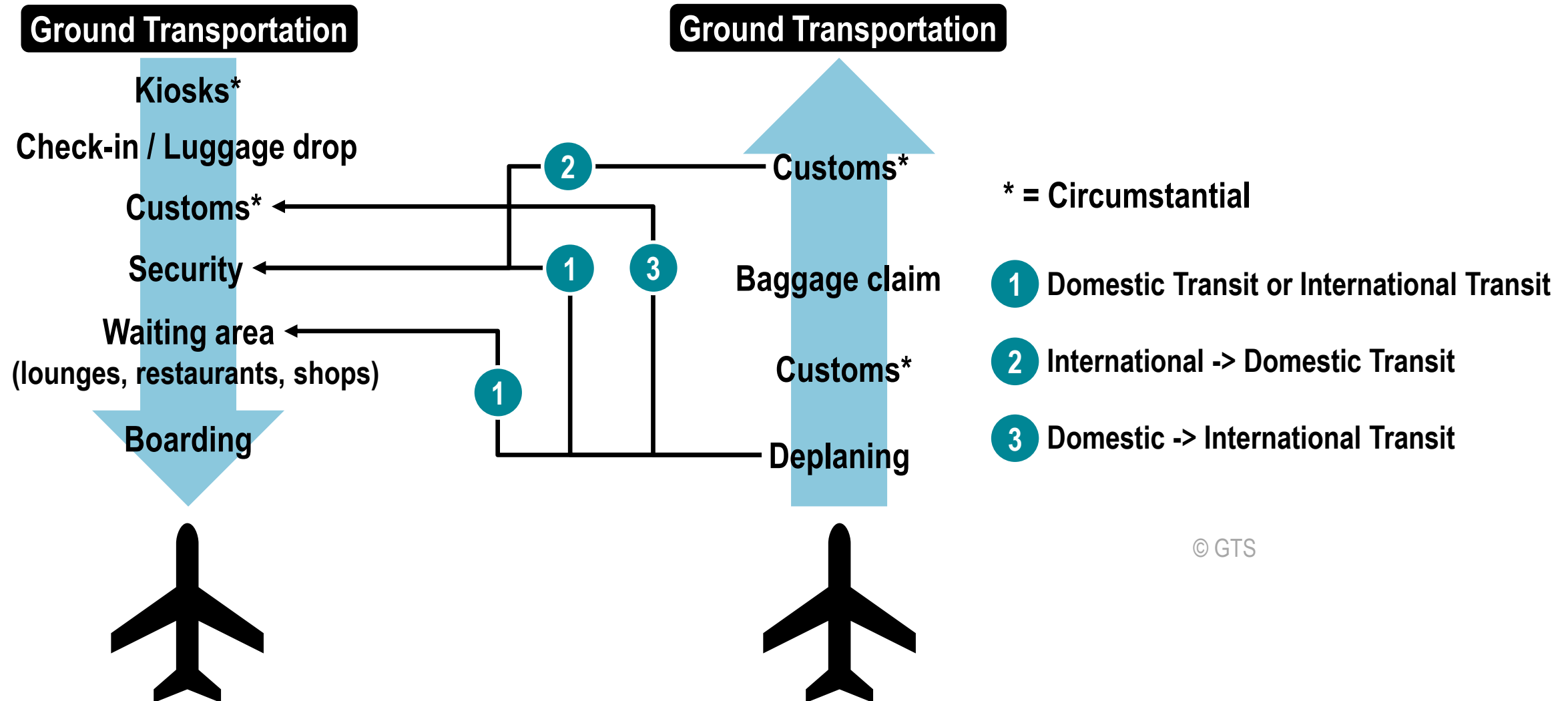
Corporate Headquarters and Metropolitan Population, United States



Airport Components and Terminal Configurations



Vertical and Lateral Passenger Flows in at Airport Terminal

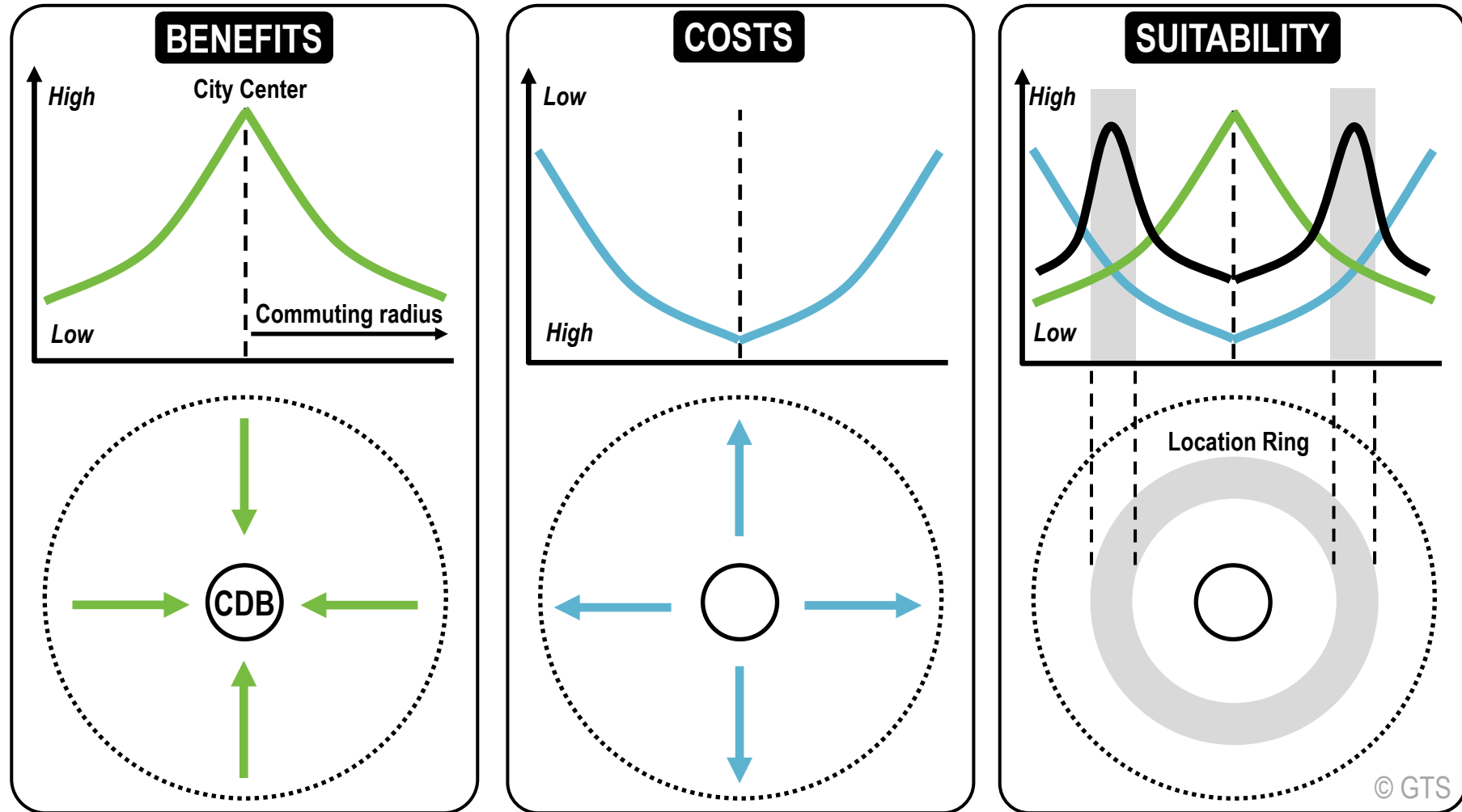


© GTS

Economics of Airport Terminals

Activity	Revenues	Costs
Airside	Landing fees; Gate fees.	Ground navigation; Emergency services; Airside maintenance; Security.
Passenger processing	Service fees; Security fees	Terminal maintenance; Security; Luggage handling; Information systems
Concessions	Rent revenues; Profit share.	Terminal maintenance; Security.
Real estate	Rent revenues; Utilities; Maintenance.	Facility maintenance; Security.

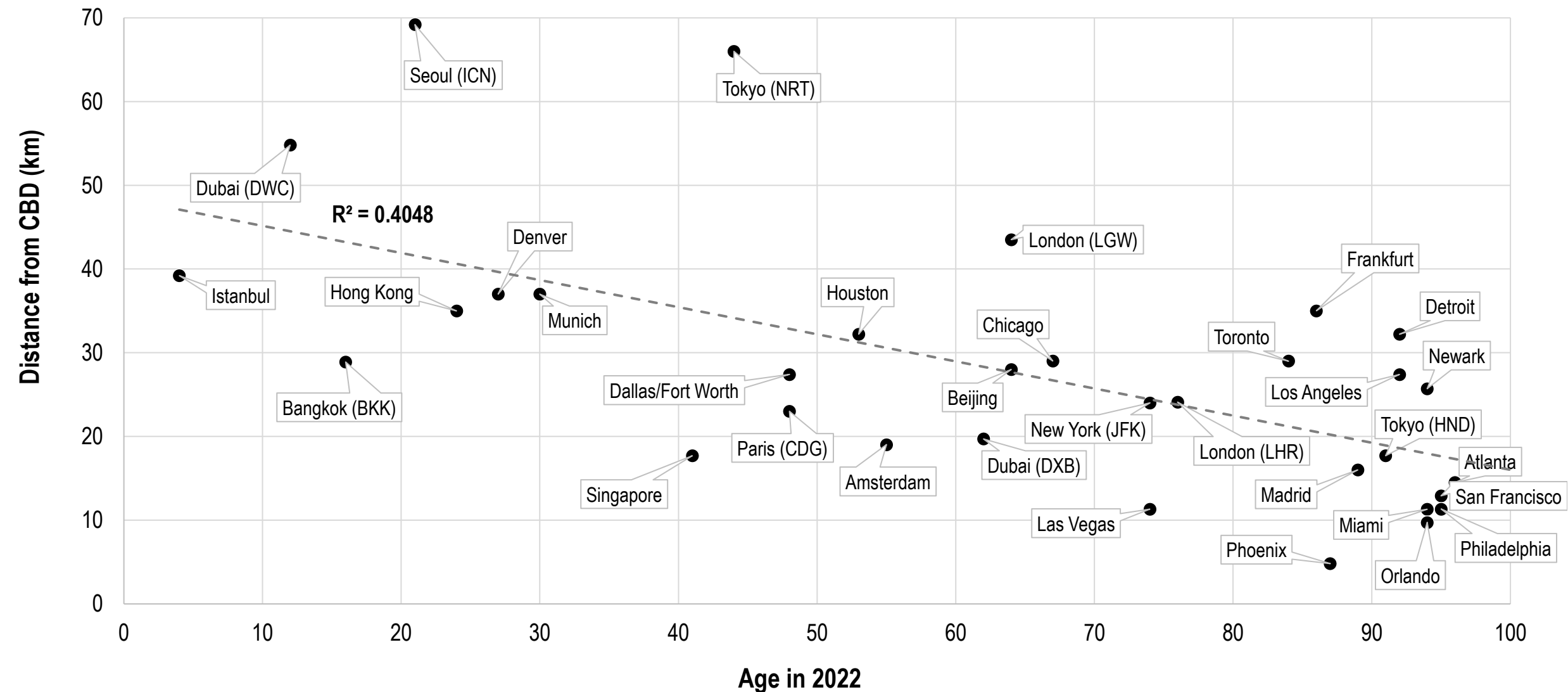
Basic Airport Location Factors



Hong Kong Chek Lap Kok Terminal



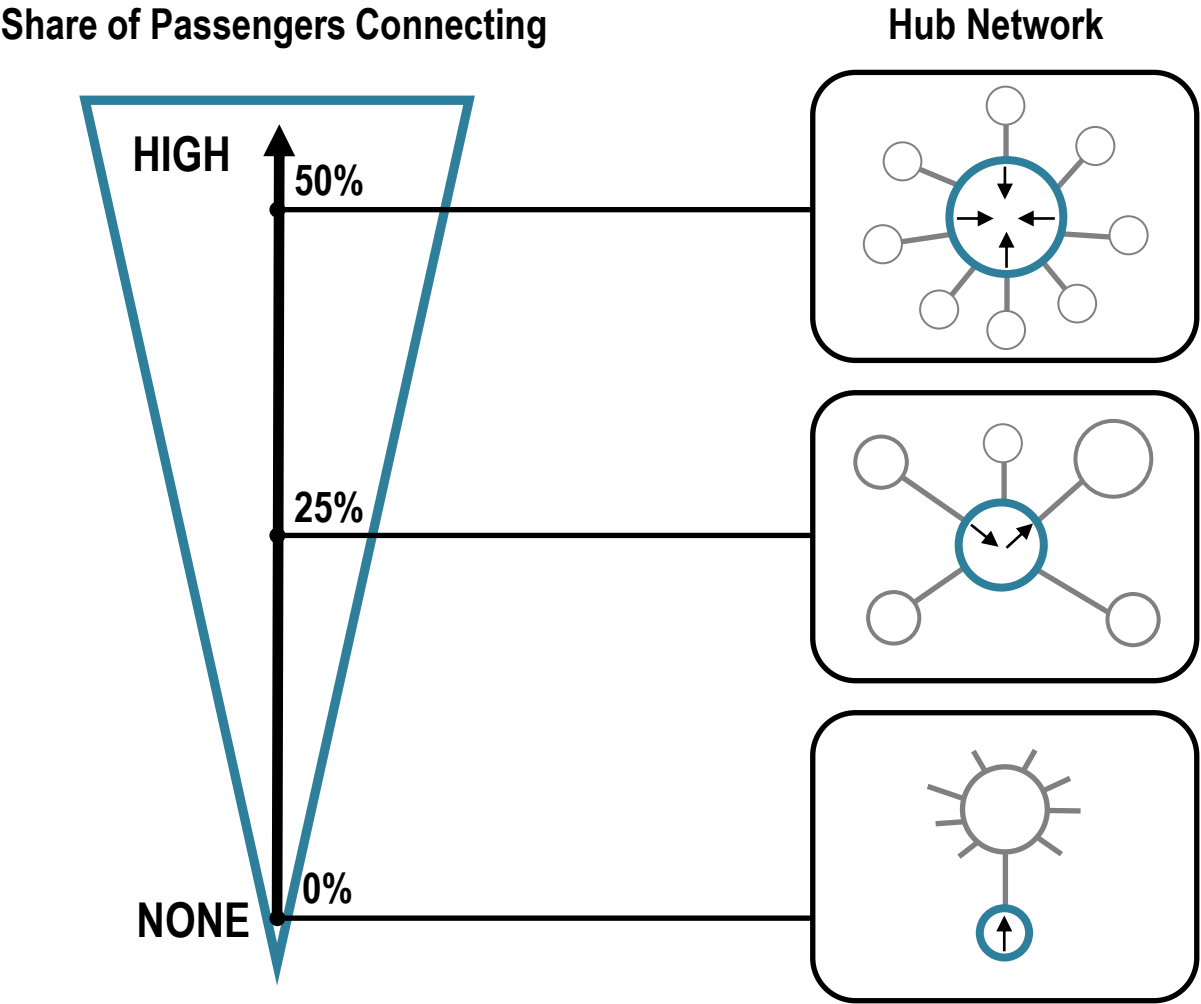
Distance from CBD and Age of the World's Largest Airports



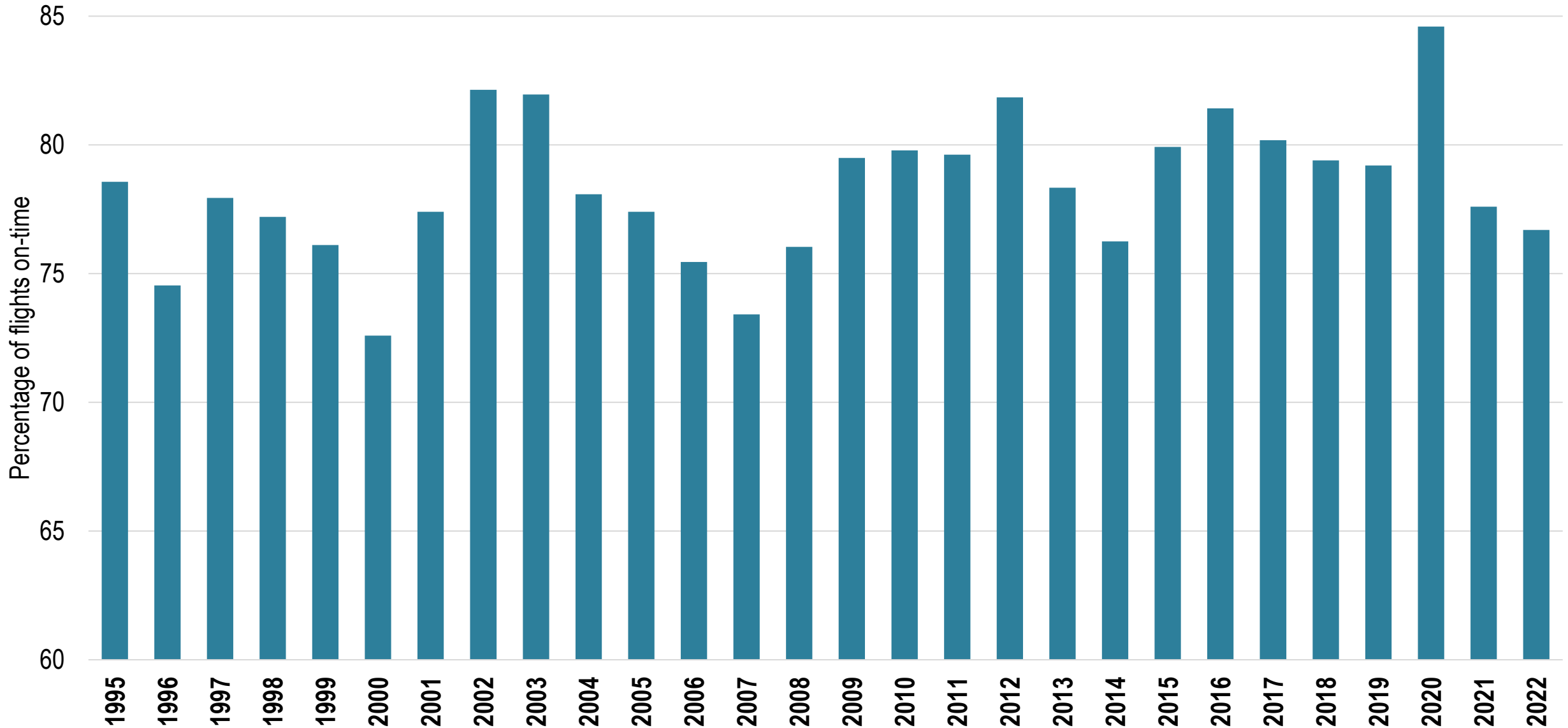
Recently Completed Airports by Cost

Country	Airport	Year Opened	Cost (USD Billions)
Dubai	Al Maktoum International Airport	2010	8.0
China	Hong Kong (Chek Lap Kok)	1998	20.1
Japan	Osaka (Kansai International)	1994	14.4
Japan	Nagoya (Centrair)	2005	7.3
South Korea	Seoul (Incheon International)	2001	5.8
Germany	Munich (Franz Strauss)	1992	5.3
USA	Denver International	1995	4.2
China	Beijing (Terminal 3)	2008	3.5
Malaysia	Kuala Lumpur International	1998	3.2
Thailand	Bangkok (Suvarnabhumi)	2006	3.3
China	Guangzhou (Baiyun)	2004	2.5
China	Shanghai (Pudong)	1999	1.4
Turkey	Istanbul (Istanbul Airport)	2019	12.0

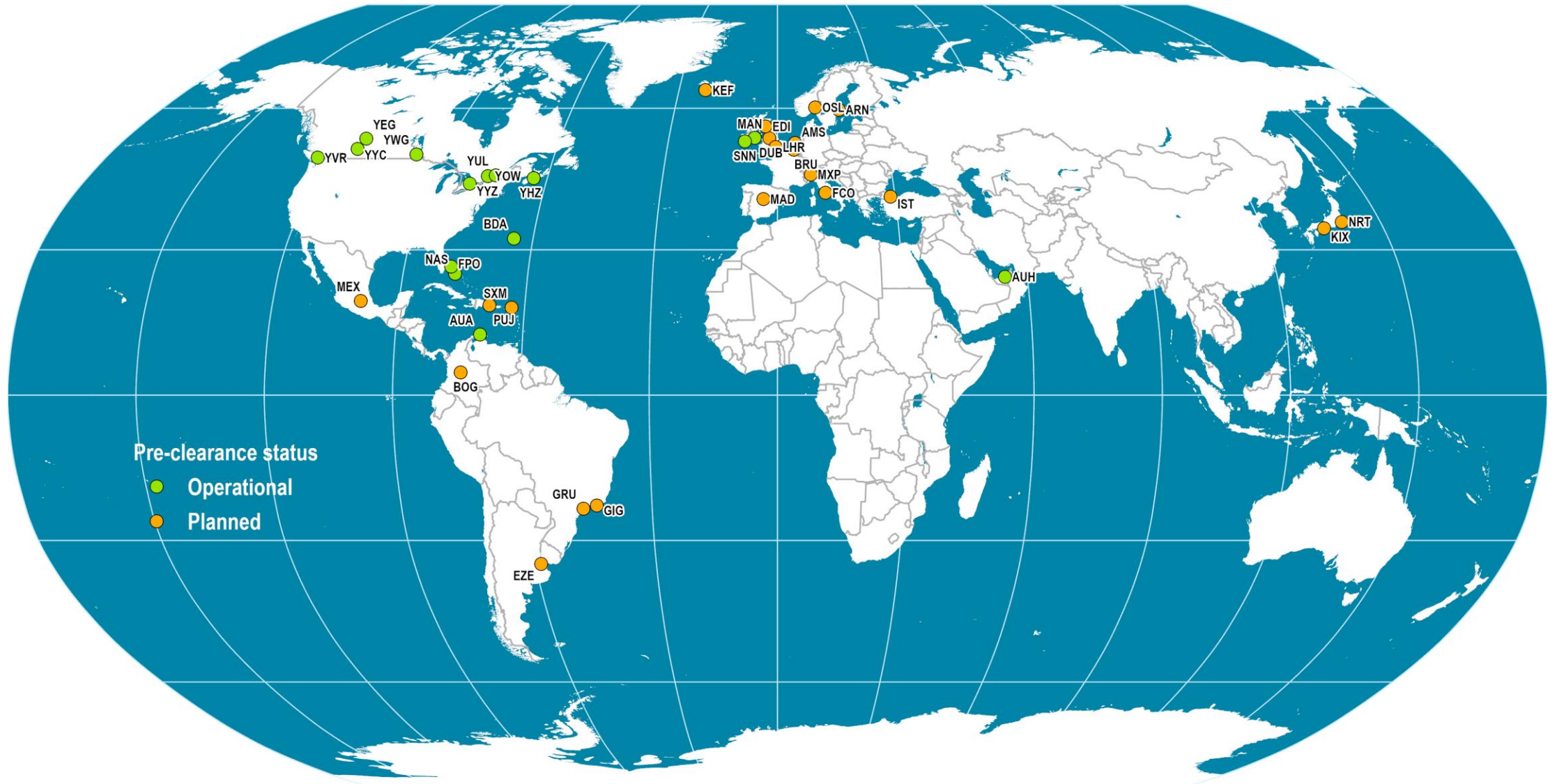
Airport Hubbing Level



On-Time Arrivals in the United States, 1995-2022



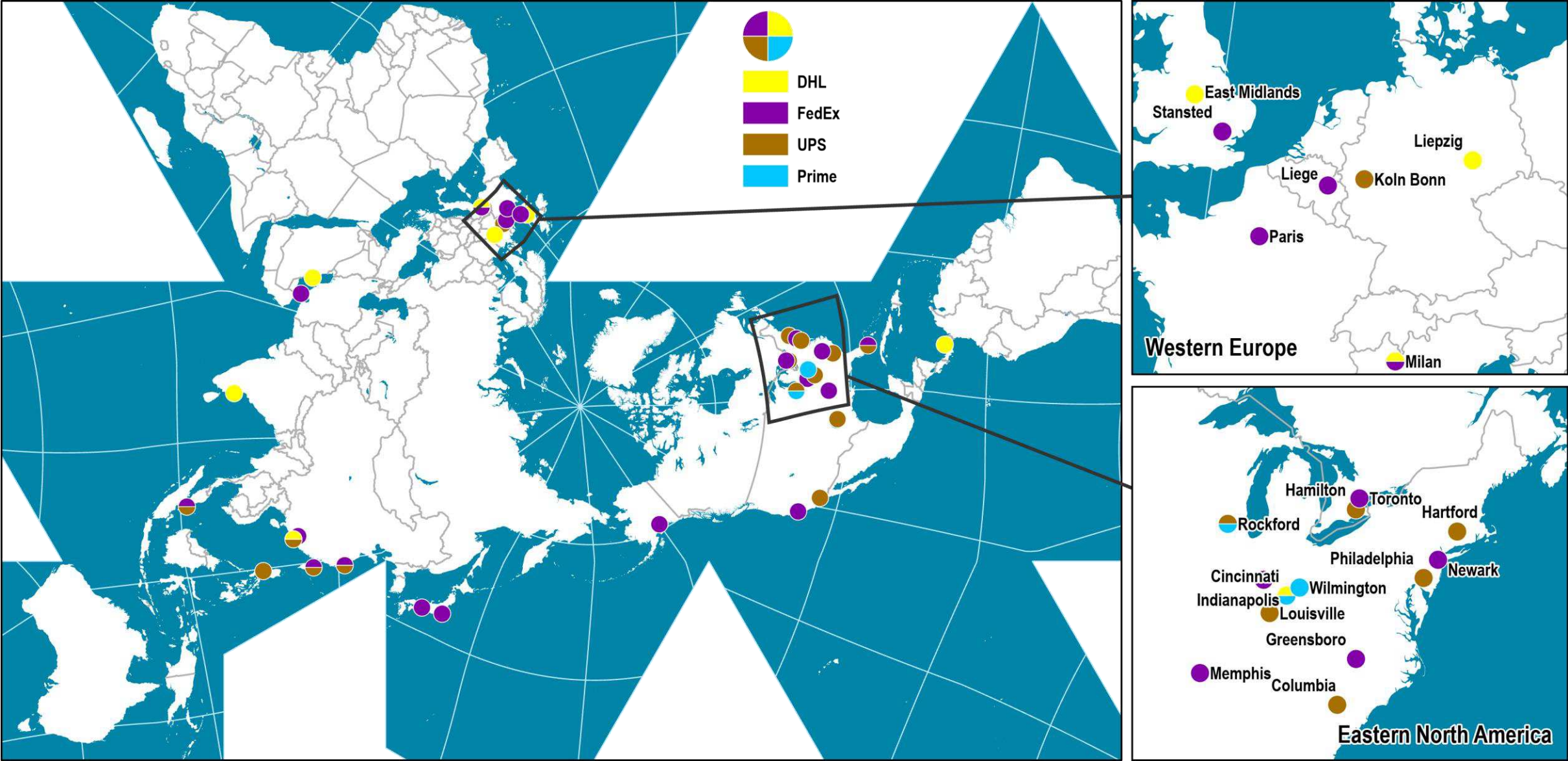
Customs Pre-Clearance Airports for the United States



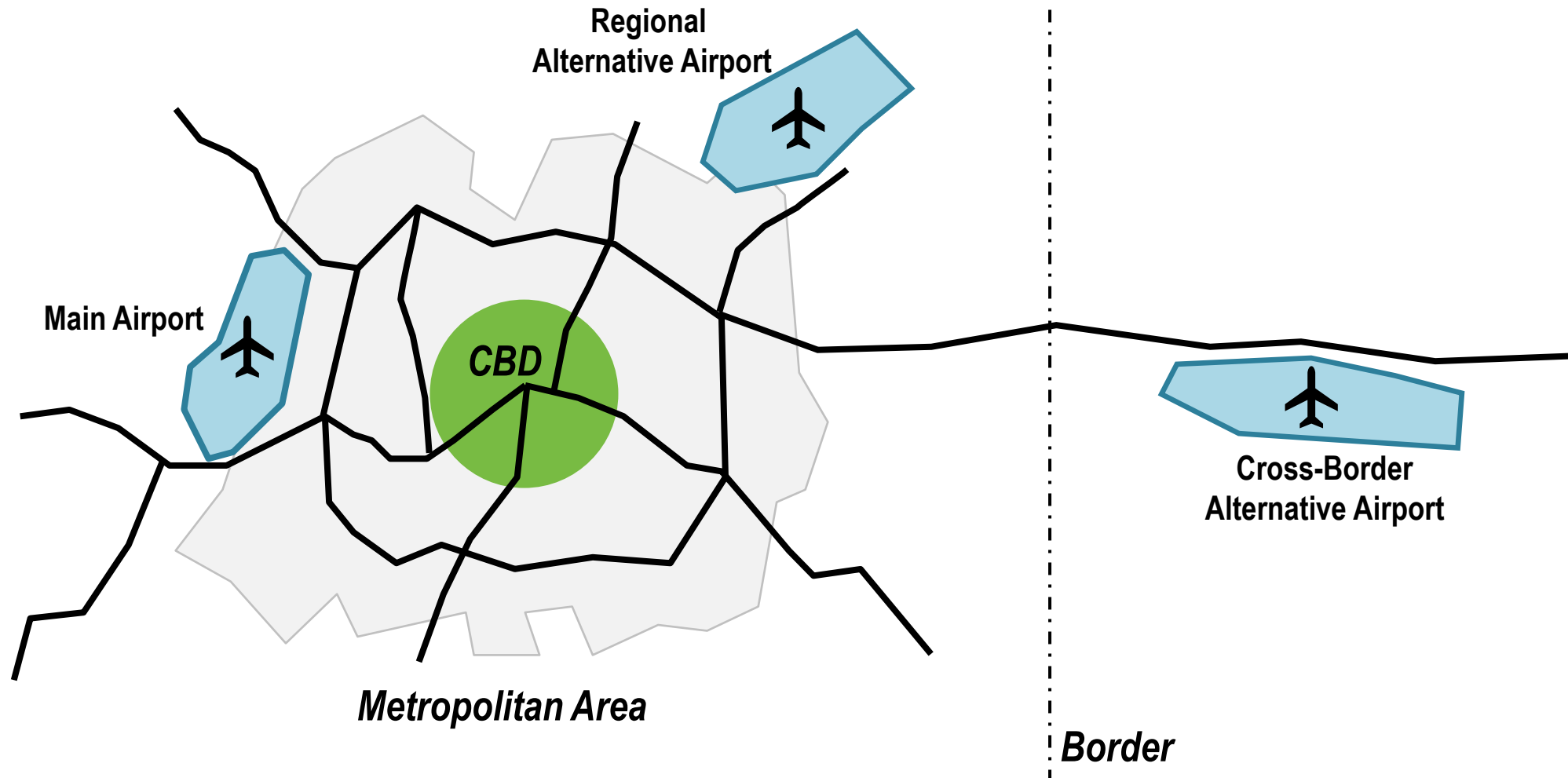
Aerotropolis Developments



Hubs of Major Air Freight Integrators



Alternative Airports



Amazon Air Hub at Cincinnati/Northern Kentucky International Airport

