Section II

LEGAL REGULATION OF INTERNATIONAL TRANSPORTATION

Topic 10. International legal regulation of maritime and river transportation

1. Maritime Transportation
2. Shipping Services and Networks
3. Strategic Maritime Passages
4. Port Terminals
5. Inland Ports / Dry Ports

1. Maritime Transportation

Maritime Geography and Routes From its modest origins as Egyptian coastal and river sailships around 3,200 BCE, maritime transportation has always been the dominant support of global trade. By 1,200 BCE Egyptian ships traded as far as Sumatra, representing one of the longest maritime route of that time. By the 10th century, Chinese merchants frequented the South China Sea and the Indian Ocean, establishing regional trade networks. In the early 15th century, Admiral Zheng He led a large fleet of 317 vessels manned by 28,000 crewmen to conduct seven major expeditions, one which reached the east African coast. However, China's attempt at asserting a regional maritime dominance was short lived and such expeditions were not permitted to continue. European colonial powers, mainly Spain, Portugal, England, the Netherland and France, would be the first to establish a true global maritime trade network from the 16th century. Most of the maritime shipping activity focused around the Mediterranean, the northern Indian Ocean, Pacific Asia and the North Atlantic, including the Caribbean. Thus, access to trade commodities remains historically and contemporarily the main driver in the setting of maritime networks. With the development of the steam engine in the mid 19th century, trade networks expanded considerably as ships were no longer subject to dominant wind patterns. Accordingly and in conjunction with the opening of the Suez Canal, the second half of the 19th century will see an intensification of maritime trade to and across the Pacific. In the 20th century, maritime transport grew exponentially as changes in international trade and seaborne trade became interrelated. Maritime transportation, like all transportation, is a derived demand that exists to support trade relations. These trade relations are also influenced by the existing maritime shipping capacity. There is thus a level of reciprocity between trade and maritime shipping capabilities. As of 2006, seaborne trade accounted for 89.6% of global trade in terms of volume and 70.1% in terms of value. Maritime shipping is one of the most globalized industries in terms of ownership and operations. Maritime transportation, similar to land and air modes, operates on its own space, which is at the same time geographical by its physical attributes, strategic by its control and commercial by its usage. While geographical considerations tend to be constant in time (with the exception of the seasonality of weather patterns), strategic and especially commercial considerations are much more dynamic. The physiography of maritime transportation is composed of two major elements, which are rivers and oceans. Although they are connected, each represents a specific domain of maritime circulation. The notion of maritime transportation rests on the existence of regular itineraries, better known as maritime routes.

Maritime routes. Corridors of a few kilometers in width trying to avoid the discontinuities of land transport by linking ports, the main elements of the maritime / land interface. Maritime routes are a function of obligatory points of passage, which are strategic places, of physical constraints (coasts, winds, marine currents, depth, reefs, ice) and of political borders. As a result, maritime routes draw arcs on the earth water surface as intercontinental maritime transportation tries to follow the great circle distance. Maritime routes are linking maritime ranges representing main commercial areas between and within which maritime shipping services are established.

The most recent technological transformations affecting water transport have focused on modifying water channels (such as dredging port channels to higher depths), on increasing the size, the automation and the specialization of vessels (e.g. container ships, tanker, bulk carrier) and developing massive port terminal facilities to support the technical requirements of maritime transportation. These transformations partially explain the development of a maritime traffic that has been adapting to increasing energy demand (mainly fossil fuels), the movements of raw materials, the location of major grain markets and not least to the growth of the trade of parts and finished goods. Yet, this process is not uniform and various levels of connectivity to global shipping networks are being observed. This massification of transport into regular flows over long distances is not without consequences when accidents affecting oil tankers can lead to major ecological disasters (e.g. Amoco Cadiz, Exxon Valdez). Fluvial transportation, even if slow and inflexible, offers a high capacity and a continuous flow. The fluvial / land interface often relies less on transshipment infrastructures and is thus more permissive for the location of dependent activities. Ports are less relevant to fluvial transportation but fluvial hub centers experiences a growing integration with maritime and land transportation, notably with containerization. The degree of integration for fluvial transportation varies from totally isolated distribution systems to well integrated ones. In regions well supplied by hydrographic networks, fluvial transportation can be a privileged mode of shipment between economic activities. In fact, several industrial regions have emerged in along major fluvial axis as this mode was initially an important vector of industrialization. More recently, river-sea navigation is also providing a new dimension to fluvial transportation by establishing a direct interface between fluvial and maritime systems. The majority of maritime circulation takes place along coastlines and three continents have limited fluvial trade; Africa, Australia and Asia (with the exception of China). There are however large fluvial waterway systems in North America, Europe and China over which significant fluvial circulation takes place. Fluvial-maritime ships enable to go directly from the fluvial to the oceanic maritime network. Despite regular services on selected fluvial arteries, such as the Yangtze, the potential of waterways for passenger transport remains limited to fluvial tourism (river cruises). Most major maritime infrastructures involve maintaining or modifying waterways to establish more direct routes (navigation channels and canals). This strategy is however very expensive and undertaken only when absolutely necessary. Significant investments have been made in expanding transshipment capacities of ports, which is also very expensive as ports are heavy consumers of space. Not every region has a direct access to the ocean and maritime transport. As opposed to coastal countries, maritime enclaves (landlocked countries) are such countries that have difficulties to undertake maritime trade since they are not directly part of an oceanic domain of maritime circulation. This requires agreements with neighboring countries to have access to a port facility through a highway, a rail line or through a river. However, being landlocked does not necessarily imply an exclusion from international trade, but substantially higher transport costs which may impair economic development. Further, the concept of being landlocked can be at time relative since a coastal country could be considered as relatively landlocked if its port infrastructures were not sufficient to handle its maritime trade or if its importers or exporters were using a port in a third country. For instance, France has significant nautical accessibility, but the main port handling it containerized traffic is Antwerp in Belgium. The importance and configuration of maritime routes has changed with economic development and technical improvements. Among those, containerization changed the configuration of freight routes with innovative services. Prior to containerization, loading or unloading a ship was a very expensive and time consuming task and a cargo ship typically spent more time docked than at sea. With faster and cheaper port operations, pendulum routes have emerged as a dominant configuration of containerized maritime networks.

Pendulum service. Involves a set of sequential port calls from at least two maritime ranges, commonly including a transoceanic service and structured as a continuous loop. They are almost exclusively used for container transportation with the purpose of servicing a market by balancing the number of port calls and the frequency of services. The term pendulum refers to the back and forth movements between the maritime ranges.

The main advantage of pendulum services is the ability to call several ports and therefore increase the ship load factor. This sequence of ports tends to be highly flexible in terms of which ports are serviced to maximize the market potential. There is however the risk of empty trips (particularly backhauls) and longer service times between distant port pairs along the route. The first pendulum route was set in 1962 by Sea-Land between the ports of New York (Newark facilities), Los Angeles and Oakland by using the Panama Canal. The return trip also included a stop in San Juan

(Puerto Rico) The most extensive pendulum services are known as "round-the-world" routes as major maritime ranges of the world are services along a continuous loop. Another recent trend has been the integration and specialization of several routes with feeder ships converging at major maritime intermediate hubs. This is notably the case for Europe (Mediterranean, North Sea and the Baltic) in light of the negative impacts of deviations from main maritime shipping routes in terms of service length and frequency of port calls

Maritime Traffic

Maritime transportation is dominantly focused on freight since there are no other effective alternative to the long distance transportation of large amounts of freight. Before the era of intercontinental air transportation, transcontinental passenger services were assumed by liner passenger ships, dominantly over the North Atlantic. Long distance passenger movements are now a marginal leisure function solely serviced by cruise shipping. Still, several oceanic ferry services are also in operation over short distances, namely in Europe (English Channel, Baltic Sea, Agean), Japan and Southeast Asia (Indonesia and the Philippines). The systematic growth of maritime freight traffic has been fueled by:

- **Absolute advantages.** Linked with the geographical distribution of resources, implying that the places of production are usually different from the places of consumption. Large quantities of cargo therefore need to be carried over long distances. The growth in mineral and energy trades, the dominant cargoes carried by maritime shipping, is the outcome of both conventional demands from developed countries as well as new demands from developing economies. For instance, coal is mainly used for energy generation and steel-making, activities that grew substantially in the developing world.
- **Comparative advantages.** Concerns cargoes that under ideal circumstances would likely not be carried, but because of cost and capabilities differentials, substantial shipping flows are generated. The international division of production and trade liberalization, commonly referred as globalization, incited a large amount of parts and finished goods to be carried over long distances, which has supported growth

in container shipping. Therefore, such cargoes can be temporary and subject to changes in their origins and destinations.

- **Technical improvements.** Ships and maritime terminals have become more efficient in terms of their throughput and their ability to handle several types of cargoes (e.g. containers, natural gas, refrigerated goods), enabling to support long distance trade.

- **Economies of scale.** The growth in the size of ships permitted maritime transportation to become increasingly cost effective, a trend which has been strengthened by containerization.

Maritime traffic is commonly measured in **deadweight tons**, which refers to the amount of cargo that can be loaded on an "empty" ship, without exceeding its operational design limits. This limit is often identified as a loadline, which is the maximal draft of the ship and does not account for the weight of the ship itself but includes fuel and ballast water. Maritime freight is conventionally considered in two main markets:

Bulk cargo. Refers to freight, both dry and liquid, that is not packaged such as minerals (oil, coal, iron ore, bauxite) and grains. It often requires the use of specialized ships such as oil tankers as well as specialized transshipment and storage facilities. Conventionally, this cargo has a single origin, destination and client and prone to economies of scale. Services tend to be irregular, except for energy trades, and part of vertically integrated production processes (e.g. oil field to port to refinery). The dynamics of the bulk market are mainly attributed to industrialization and economic development creating additional demand for resources and energy.

Break-bulk cargo. Refers to general cargo that has been packaged in some way with the use of bags, boxes, drums and particularly containers. This cargo tends to have numerous origins, destinations and clients. Before containerization, economies of scale were difficult to achieve with break-bulk cargo as the loading and unloading process was very labor and time consuming. The dynamics of the break bulk market are related to manufacturing and consumption.

Technical improvements tend to blur the distinction between bulk and break-bulk cargo, as both can be **unitized** on pallets and increasingly in **containers**. For instance, it is possible, and increasingly common, to ship grain and oil, both bulk cargoes, in a container. Consequently, the amount of containerized freight has grown substantially, from 23% of all non-bulk cargo in 1980, to 40% in 1990 and to 70% in 2000. Geographically, maritime traffic has evolved considerably over the last decades especially through growth in of Asia-Europe and transpacific trade. By establishing commercial linkages between continents, maritime transport supports a considerable traffic. The advantage of maritime transport does not rest on its speed, but on its capacity and on the continuity of its services. Railway and road transportation are simply not able to support a traffic at such a geographical scale and intensity. Heavy industrial activities that use bulk raw materials are generally adjacent to port sites, benefiting from load breaks. The average haul length was about 4,200 miles. The global maritime shipping industry is serviced by about 100,000 commercial vessels of more than 100 tons falling into four broad categories:

- **Passenger vessels** historically played an important role since they were the only mode available for long distance transportation. In a contemporary setting, passenger vessels can be divided into two categories: passenger ferries, where people are carried across relatively short bodies of water (such as a river or a strait) in a shuttle-type service, and cruise ships, where passengers are taken on vacation trips of various durations, usually over several days. The former tend to be smaller and faster vessels, the latter are usually very large capacity ships having a full range of amenities. In 2014, about 21.5 million passengers were serviced by cruise ships, underlining an industry with much growth potential since it services several seasonal markets where the fleet is redeployed to during the year.
- **Bulk carriers** are ships designed to carry specific commodities, and are differentiated into liquid bulk and dry bulk vessels. They include the largest vessels afloat. The largest tankers, the Ultra Large Crude Carriers (ULCC) are up to 500,000 deadweight tons (dwt), with the more typical size being between 250,000 and 350,000 dwt; the largest dry bulk carriers are around 400,000 dwt, while the more typical size

is between 100,000 and 150,000 dwt. The emergence of liquefied natural gas (LNG) technology enabled the maritime trade of natural gas with specialized ships.

- **General cargo** ships are vessels designed to carry non-bulk cargoes. The traditional ships were less than 10,000 dwt, because of extremely slow loading and off-loading. Since the 1960s these vessels have been replaced by container ships because they can be loaded more rapidly and efficiently, permitting a better application of the principle of economies of scale. Like any other ship class, larger containerships require larger drafts with the current largest ships requiring a draft of 15.5 meters.
- **Roll on-Roll off** (RORO) vessels, which are designed to allow cars, trucks and trains to be loaded directly on board. Originally appearing as ferries, these vessels are used on deep-sea trades and are much larger than the typical a ferry. The largest are the car carriers that transport vehicles from assembly plants to the main markets. Their capacity is measured in the amount of parking space they are able to offer to the vehicles they carry, mostly measured in lane meters.

The distinctions in vessel types are further differentiated by the **kind of services** on which they are deployed. Bulk ships tend to operate both on a regular schedule between two ports or on voyage basis to reflect fluctuations in the demand. This demand may be seasonal, as for grain transport, of niche, such as for project cargo (e.g. carrying construction material). General cargo vessels operate on liner services, in which the vessels are employed on a regular scheduled service between fixed ports of call, or as tramp ships, where the vessels have no schedule and move between ports based on cargo availability.

Maritime shipping is dominated by bulk cargo, which roughly accounted for 69.6% of all the ton-miles shipped in 2005. However, the share of break-bulk cargo is increasing steadily, a trend mainly attributed to containerization. Maritime shipping has traditionally faced two drawbacks in relation to other modes. First, it is **slow**, with speeds at sea averaging 15 knots for bulk ships (26 km/hr), although container ships are designed to sail at speeds above 20 knots (37 km/hr). Secondly, **delays** are encountered in ports where loading and unloading takes place. The latter may involve several days of handling when break-bulk cargo was concerned. These drawbacks are particularly constraining where goods have to be moved over short distances or where shippers require rapid deliveries. Maritime shipping has seen several major technical innovations aiming at improving the performance of ships or their access to port facilities, notably in the 20th century. They include:

- **Size**. The last century has seen a growth of the number of ships as well as their average size. Size if a common denominator for ships is it expresses type as well as capacity. Each time the size of a ship is doubled, its capacity is cubed (tripled). Although the minimum size for cost effective bulk handling is estimated to be around 1,000 deadweight tons, economies of scale have pushed for larger ship sizes to service transportation demand. For ship owners, the rationale for larger ships implies reduced crew, fuel, berthing, insurance and maintenance costs. The largest tankers (ULCC) are around 500,000 dwt (dominant size between 250,000 and 350,000 dwt), while the largest dry bulk carriers are around 350,000 dwt (dominant size between 100,000 and 150,000 dwt). The only remaining constraints on ship size are the capacity of ports, harbors and canals to accommodate them.
- **Speed**. The average speed of ships is about 15 knots (1 knot = 1 marine mile = 1,853 meters), which is 28 km per hour. Under such circumstances, a ship would travel about 575 km per day. More recent ships can travel at speeds between 25 to 30 knots (45 to 55 km per hour), but it is uncommon that a commercial ship will travel faster than 25 knots due to energy requirements. To cope with speed requirements, the propulsion and engine technology has improved from sailing to steam, to diesel, to gas turbines and to nuclear (only for military ships; civilian attempts were abandoned in the early 1980s). Since the invention of the helix, propulsion has improved considerably, notably by the usage of double helixes, but peaks were reached by the 1970s. Reaching higher maritime speeds remains a challenge which is excessively costly to overcome. As a result, limited improvements in commercial maritime speeds are foreseen. An emerging commercial practice, particularly in container shipping, concerns "slow steaming" where the operating speed is reduced to about 19-20 knots to reduce energy consumption. By 2011, about 50% of the world's container shipping capacity was operating under slow steaming.

- **Specialization of ships**. Economies of scales are often linked with specialization since many ships are designed to carry only one type of cargo. Both processes have considerably modified maritime transportation. In time, ships became increasingly specialized to include general cargo ships, tankers, grain carriers, barges, mineral carriers, bulk carriers, Liquefied Natural Gas (LNG) carriers, RO-RO ships (roll-on roll off; for vehicles) and container ships.
- **Ship design**. Ship design has significantly improved from wood hulls, to wood hulls with steel armatures, to steel hulls (the first were warships) and to steel, aluminum and composite materials hulls. The hulls of today's ships are the result of considerable efforts to minimize energy consumption, construction costs and improve safety. Depending on its complexity, a ship can take between 4 months (container and crude carriers) and 1 year to build (cruise ship).
- **Automation**. Different automation technologies are possible including self-unloading ships, computer assisted navigation (crew needs are reduced and safety is increased) and global positioning systems. The general outcome of automation has been smaller crews being required to operate larger ships.

2. Shipping Services and Networks

The shipping industry has a very international character, particularly in terms of ownership and flagging. The ownership of ships is very broad. While a ship may be owned by a Greek family or a Japanese corporation, it may be flagged under another nationality. There are two types of registers, national registers and open registers, which are often labeled as "flags of convenience". The use of flags of convenience is a mean by which ship owners can obtain lower registration fees, lower operating costs and fewer restrictions. The maritime industry is now more deregulated than before because of technical changes, mainly containerization and open registry ships operating under fiscal shelters. As of 2013, about 73% of the global tonnage was registered under a flag of convenience, with Panama and Liberia being the most prevalent. The maritime shipping industry offers two major types of services:

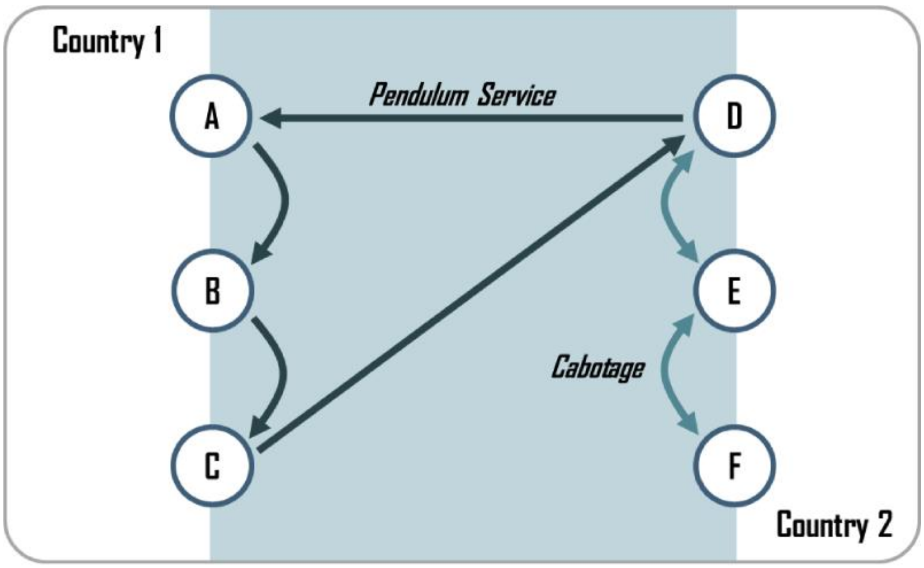
- **Charter services** (also known as Tramp). In this form of service a maritime company rents a ship for a specific purpose, commonly between a specific port of origin and destination. This type of shipping service is notably used in the case of bulk cargo, such as petroleum, iron ore, grain or coal, often requiring specialized cargo ships that become the load unit (the whole contents of the ship are usually traded).
- **Liner shipping services**. Involves a regular scheduled shipping service often calling several ports along a pendulum route. The emergence of post-panamax containerships has favored the setting of pendulum services since the maritime landbridge of Panama is no longer accessible to this new class of ships. To insure schedule reliability, which rarely exceeds 50%, frequency and a specific level of service (in terms of port calls), many ships can be allocated to a single route, which can take different shapes. For instance, to insure a weekly port call, 8 vessels must be allocated for a pendulum service between Europe and Pacific Asia and about 5 vessels for a trans-Atlantic service. These maritime shipping services are available to any freight importer of exporter, implying that the cargo being carried on any given ship belongs to different interests. A growing share of liner services is containerized.

An important historic feature of oceanic liner transport is the operation of "conferences". These are formal agreements between companies engaged on particular trading routes. They fix the rates charged by the individual lines, operating for example between Northern Europe and the East Coast of North America, or eastbound between Northern Asia and the West Coast of North America. Over the years in excess of 100 such conference arrangements have been established. While they may be seen as anti-competitive, the conference system has always escaped prosecution from national anti-trust agencies. This is because they are seen as a mechanism to stabilize rates in an industry that is inherently unstable, with significant variations in supply of ship capacity and market demand. By fixing rates exporters are given protection from swings in prices, and are guaranteed a regular level of service provision. Firms compete on the basis of service provision rather than price. A new form of inter-firm organization has emerged in the container shipping industry since the mid-1990s. Because of the costs of providing ship capacity to more and more markets are escalating beyond the means of many carriers, many of the largest shipping lines have come together by forming strategic alliances with former competitors. They offer joint services by pooling vessels on the main commercial routes. In this way they are each able to commit fewer ships to a particular service route, and deploy the extra ships on other routes that are maintained outside the alliance. The alliance services are marketed separately, but operationally involve close cooperation in selecting ports of call and in establishing schedules. The alliance structure has led to significant developments in route alignments and the economies of scale of container shipping. The consequences have been a concentration of ownership, particularly in container shipping.The 20 largest carriers controlled 26% of the world slot capacity in 1980, 42% in 1992, 58% in 2003 and 81% in 2013. The level of concentration is causing concerns among various national regulatory bodies that see such developments as potentially unfair competitive practices. For instance, in 2013 a large alliance dubbed P3 was being planned between the world's three largest carriers, Maersk, MSC and CMA CGM, to help mitigate overcapacity along several major trade routes, particularly between Asia and Europe. However, in 2014 the Chinese government rejected the alliance with the rationale that it was creating an undue level of concentration and the possibility of unfair competition with its own carriers. Therefore, Maersk and MSC decided to form a smaller alliance called M2 that began operations in 2015. Further CMA CGM, China Shipping Container Lines and United Arab Shipping Company (UASC) formed their own alliance called Ocean Three.Carriers have the responsibility to establish and maintain profitable routes in a competitive environment. This involves three major decisions about how such a maritime network takes shape:

- **Frequency of service**. Frequency is linked with more timely services since the same port will be called at more often. A weekly call is considered to be the minimum level of service but since a growing share of production is time dependent, there is a pressure from customers to have a higher frequency of service. A trade-off between the frequency and the capacity of service is commonly observed. This trade-off is often mitigated on routes that service significant markets since larger ships can be used with the benefits of economies of scale.

- **Fleet and vessel size**. Due the basic maritime economics, large ships, such as post-panamax containerships, offer significant advantages over long distances. Shipping lines will obviously try to use this advantage over their long distance routes, keeping smaller ships for feeder services. In addition, a large enough number of ships must be allocated to insure a good frequency of service. To keep their operations consistent, shippers also try to have ships a similar size along their long distance pendulum routes. This is not an easy undertaking since economies of scale force the introduction of ever larger ships which cannot be added all at once due to extensive financial requirements and the capacity of shipbuilders to provide them. So each time a bigger ship is introduced on a regular route, the distribution system must adapt to this change in capacity.
- **Number of port calls**. A route that involves less port calls is likely to have lower average transit times in addition to requiring a lower number of ships. Conversely, to few port calls could involve difficulties for the cargo to reach inland destinations remote from the serviced ports. This implies additional delays and potentially the loss of customers. An appropriate selection of port calls along a maritime facade will help insure access to a vast commercial hinterland.

Since many container shipping services have a pendulum structure, cabotage imposes some restrictions on these services.



Pendulum Services and CabotagePendulum services must be specifically structured in order not to infringe national cabotage laws (such as the Jones Act in the United States) preventing a foreign maritime company to carry freight between domestic ports. For instance, for a pendulum service D-A-B-C-D, a maritime shipping company registered in country 2 has the right to unload or load freight at ports A, B or C in country 1 as long as this freight is coming from or bound to a foreign port (port D in this case). Moving freight from port A to port B or C would not be permitted since it would be considered as cabotage. That same maritime shipping company would however be able to carry freight between ports D, E and F (cabotage) since it is registered in country 2.

3. Strategic Maritime Passages

Global Maritime Routes and Chokepoints

Maritime transportation is the dominant purveyor of international freight distribution and evolves over a **global maritime space**. This space has its own constrains such as the profile of continental masses and the detours and passages it creates. Maritime routes are spaces of a few kilometers wide trying to avoid the discontinuities of land transport. They are a function of obligatory points of passage, which are almost all strategic places, physical constraints such coasts, winds, marine currents, depth, reefs, or ice and political boundaries where sovereignty may impede circulation. The majority of the maritime circulation takes place along coasts and three continents have limited fluvial trade (Africa, Australia and Asia; except China).International maritime routes are thus forced to pass through specific locations corresponding to passages, capes and straits. These routes are generally located between major markets such as Western Europe, North America and East Asia where an active system of commercial containerized trade is in place. The importance of these large markets are structuring the exchanges of semi-finished and finished goods. Also, major routes involve flows of raw materials, namely minerals, grains, food products, and most importantly petroleum. The location of strategic oil and mineral resources shapes maritime routes for bulks since they represent the most transported commodities. For instance, over 30 million barrels of oil per day are being shipped around the world. The most important strategic maritime passages are known as chokepoints (or bottlenecks) due to:

- **Capacity constraints**. Chokepoints tend to be shallow and narrow, impairing navigation and imposing capacity limits on ships. For canals such as Panama and Suez, the capacity must effectively be managed with appointment and pricing systems.
- **Potential for disruptions or closure**. Disruption of trade flows through any of these export routes could have a significant impact on the world economy. Many chokepoints are next to politically unstable countries, increasing the risk of compromising their access and use, such as with piracy. Closures are a rare instance that only took place in situations of war as one proponent prevented another to access and use the chokepoint (e.g. Gibraltar and Suez during World War II). A closure of a maritime chokepoint in the current global economy, even if temporary, would have important economic consequences with the disruption of trade flows and even the interruption of some supply chains (e.g. oil). These potential risks and impacts are commonly used to justify military naval assets to protect sea lanes even if such benefits are difficult to demonstrate.

Changes in the technical and operational characteristics of transoceanic canals and passages can have substantial impacts on global trade patterns. The Panama Canal, the Suez Canal, the Strait of Malacca and the Strait of Hormuz account for the world's four most important strategic maritime passages in part because of the chokepoints they impose on global freight circulation and in part because of the economic activities and resources they grant more efficient access to. Their continuous availability for global maritime circulation is challenging dominantly because the global trade system is highly reliant on their use. Yet, they have shaped global trade with the ongoing setting of rings of circulation, notably in the northern hemisphere. In addition to the transoceanic canals, "dry canals" have also been constructed or under consideration. They are called dry canals because they replicate the role of regular canals, implying that they are relatively short overland corridors of rail, road and pipeline infrastructures connecting two ports where the cargo is transshipped. Several dry canals started as portage routes to be either discontinued as they lost their capability to compete, while others were complemented with a canal, such as for Panama. The main disadvantage of dry canals is the load break at both end, which adds costs and delays, as well as limited economies of scale on the overland route. Still, they represent routing options that can incite national imports and exports and the development of logistical activities. Such imprint on regional development is much less evident in canals, since they are simply points of passage.

The Suez Canal The Suez Canal is an artificial waterway of about 190 km in length running across the Isthmus of Suez in northeastern Egypt which **connects the Mediterranean Sea with the Gulf of Suez**, an arm of the Red Sea. The minimum width of the channel is 60 meters and ships of a draft of 18 meters (62 feet) can make the transit. The canal can accommodate ships as large as 220,000 deadweight tons fully loaded. The Suez Canal has no locks, because the Mediterranean Sea and the Gulf of Suez have roughly the same water level and is thus the world's longest canal without locks. It acts as a shortcut for ships between both European and American ports and ports located in southern Asia, eastern Africa, and Oceania. Because of obvious geographical considerations, the maritime route from Europe to the Indian and Pacific oceans must contour the Cape of Good Hope at the southernmost point of the African continent. There are a number of alternatives to the Suez Canal but they involve either very long detours or have limited capacity. The first canal between the Nile River delta and the Red Sea was excavated around the 13th century BC. Its purpose was to expand trade between the Mediterranean and the Middle East, which became significant by 100 AD. During the next 1,000 years, the canal was neglected, but at different times Egyptian and Roman rulers modified it. Restoration efforts were abandoned in the 8th century AD as the Roman Empire collapsed and Mediterranean trade dropped. Transshipping the goods across the Isthmus was judged more profitable than supporting the maintenance of a canal. This situation endured until the nineteen century when powerful maritime interests saw the need to make a Mediterranean - Red Sea connection again a reality. The Suez Canal was constructed between 1859 and 1869 by French and Egyptians interests, spearheaded by Ferdinand de Lesseps, with a cost of about 100 million dollars. The opening of the Suez Canal in 1869 brought forward a new era of European influence in Pacific Asia. The journey from Asia to Europe was considerably reduced by saving 6,500 km from the circum African route. In 1874, Great Britain bought the shares of the Suez Canal Company and became its sole owner. According to the Convention of Constantinople signed in 1888, the canal was to be open to vessels of all nations in time of peace or in war. However, Great Britain claimed the need to control the area to maintain its maritime power and colonial interests (namely in South Asia). In 1936, it acquired the right to maintain defense forces along the Suez Canal, which turned out to be of strategic importance during World War II to uphold Asia-Europe supply routes for the Allies. The second half of the 20th century saw renewed geopolitical instability in the region with the end of colonialism and the emergence of Middle Eastern nationalisms. In 1954 Egypt and Great Britain signed an agreement that superseded the 1936 treaty and provided for the gradual withdrawal of all British troops from the zone. All the British troops were gone by June 1956 as the canal was nationalized by Egypt. This triggered issues with Israel, as Israeli ships were not permitted to cross the canal. This threat was also extended to France and Britain, the former owners of the canal because they refused to help finance the Aswan High Dam project, as initially promised. Israel, France and Britain thus invaded Egypt in 1956. Egypt responded by sinking ships in the canal effectively closing it between 1956 and 1957. An agreement about the usage of the canal was then reached. However, geopolitical problems persisted as tensions between Israel and neighboring Arab nations increased in the 1960s. The Six Days War between Israel and Egypt and the invasion of the Sinai Peninsula by Israel caused the closure of the Suez Canal between 1967 and 1975. The closure was so sudden and unexpected that several ships were caught stranded in the canal. The canal became the cease fire line and saw again hostilities during the Yom Kippur War of 1973. The closure of the Suez Canal significantly destabilized international transportation and favored the development of ever larger tankers to use the long circum Africa route. The canal was finally re-opened in 1975 as Egypt agreed to let Israel use it. Significant improvements were made between 1976 and 1980, mainly the widening of the canal to accommodate very large crude carriers (VLCC) of about 200,000 tons supporting the oil trade between Europe and the Middle East. The current capacity of the canal at 240,000 tons means that ultra large crude carriers (ULCC; tankers of more than 300,000 tons) cannot pass through the Canal when fully loaded. A common practice is to unload a share of Mediterranean bound ships and use Sumed pipeline.With additional deepening and widening projects, the depth of the canal reached 22.5 meters in 2001 and 23.5 meters in 2008. In 2014, a new expansion project that increased the capacity to about 100 transits per day took place. The 'New Suez Canal' was inaugurated in August 2015 at a cost of over 8 billion dollars. This expansion included a new 35 km section enabling the canal to transit ships in both directions at once. Prior to this expansion, convoys were organized since a section of the canal could only handle ships in one direction. All the existing sections of the canal will also be dredged to 24 meters (78 feet). This expansion substantially improved the operational capabilities of the canal by reducing waiting and transit times in addition to improve capacity. The expanded Suez Canal has draft limitations similar to those of the Strait of Malacca. The canal has the capacity to accommodate up to 25,000 ships per year (about 78 per day), but handled about 16,600 in 2013, on average 55 ships per day, which roughly account for 15% of the global maritime trade. Prior to its expansion in 2015 the canal could only handle unidirectional traffic, with crossings organized into convoys of about 10 to 15 ships. Three convoys per day, two southbound and one northbound, were organized. The transit time were about 17 hours. After the 2015 expansion, two simultaneous convoys per day were organized since a longer section of the canal became bi-directional. Missing a convoy can incur supplementary delays to the point that on occasion maritime shipping companies (particularly for containers) would skip a port call to insure that their ships arrive on time at the Suez Canal to be part of a daily convoy. A rail line also runs parallel to the canal. The transit rates are established by the Suez Canal Authority (SCA). They are computed to keep the canal transit fees attractive to shippers. In fiscal year 2014, Egypt earned USD 5.3 billion in canal fees making it the country's third largest revenue generator after tourism and remittances from expatriate workers. Container ships account for just under half of the

Canal's traffic and a slightly higher percentage of its net tonnage and revenues. The average canal transit fee per TEU (at 90% vessel utilization) amounts to 102 USD for a vessel of 1,000 TEU down to 56 USD for the largest container vessels. The Far East - Europe trade constitutes about 75% of the traffic handled by Suez. In recent years, services to the North American East Coast coming from Asia and transiting through the Suez Canal have increased to account for more than 15% of the traffic it handles.

The Panama Canal The Panama Canal joins the Atlantic and Pacific oceans for 82 kilometers across the Isthmus of Panama, running from Cristobal on Limon Bay, an arm of the Caribbean Sea, to Balboa, on the Gulf of Panama. Since its expansion in 2016, it involves two systems of locks that can both be used at the same time. The old locks, completed in 1914, can handle ships with a draft of 12.2 meters (40 feet), a width of 32 meters (106 feet) and a length of 294 meters (965 feet). The expanded locks, completed in 2016, can handle ships with a draft of 15.2 meters (50 feet), a width of 49 meters (160 feet) and a length of 366 meters (1200 feet). Its initial construction and subsequent expansion rank among the greatest engineering works of all time as the canal prevents a long detour around South America, thus facilitating the maritime flows of world trade. The Panama Canal is of particular strategic importance to the United States as it enables to link the East and the West coast more quickly, saving about 13,000 km (from 21,000 km to 8,000 km) for a maritime journey. It is composed of three main elements, the Gatun Locks (1914) / Agua Clara Locks (2016) giving access to the Atlantic Ocean, the Culebra Cut (Gaillard) crossing the continental divide and the Miraflores and Pedro Miguel Locks (1914) / Cocoli Locks (2016) accessing the Pacific Ocean. The canal handles about 5% of the global seaborne trade and about 12% of the American international seaborne trade. In addition, close to 70% of the traffic handled by the Panama Canal either originates or is bound to the United States. Interest in establishing a short route between the Atlantic and Pacific began with the exploration of Central America in the early 16th century. In 1534, the Spanish surveyed the Panama region in order to construct a canal, but the project never came into existence due to acute technical constraints. Overland portage routes were used instead, initially as paths through the isthmus, but in 1855 the completion of Panama

Railway provided a faster and higher capacity link. The United States became interested in building a canal when gold was discovered in California in 1848. A possible path through Nicaragua was also surveyed. However, in 1878 the French Geographical Society of Paris signed a treaty with Columbia (then the owner of the Province of Panama) for the construction of a canal. From 1879 to 1899, the French Canal Company (Compagnie Universelle du Canal Interoceanique) under the initiative of Ferdinand de Lesseps (who was the key driver behind the construction of the Suez Canal in 1869) undertook construction after capitalizing 1 billion francs from 800,000 private investors. However, the ambitious project failed due mainly to financial problems, tropical diseases (an estimate of 25,000 workers died) and the technical difficulties of trying to build a sea level canal where it could not be realistically done. The resulting crash of the company was estimated to be the largest of the 19th century. The Spanish-American war of 1898 gave an incentive to build a canal due to the long repositioning of American ships between the Atlantic and Pacific oceans. It is only in the twentieth century that the project would become a reality. Under the rule of Colombia the United States was unsuccessful in attempts to plan a canal. However, in 1903 the Panamanian revolution, supported by the United States, resulted in the independence of Panama. In that same year, the United States and the new state of Panama signed the Hay-Bunau-Varilla Treaty by which the United States guaranteed the independence of Panama and secured a perpetual lease on a 16-km (10 miles) strip for the canal, over which the United States had complete sovereignty. Panama in return got a monetary compensation of $10 million and an inflation-indexed annual compensation. The Panama Canal was constructed between 1904 and 1914 by American engineers and has a total length of 82 km at a cost of $387 million (including the $10 million compensation to Panama and $40 million to purchase the previous project from the French Canal Company). In 1906, President Theodore Roosevelt, mainly credited for the achievement, put the construction of the canal under the authority of the U.S. Army Corps of Engineers. The Soo Locks linking Lake Huron to Lake Superior, which at the time were the most heavily used in the world, became the engineering template for Panama's locks. The construction of Gatun Dam enabled the creation of an artificial lake (Lake Gatun), which reduced the need for excavation as well a providing a large reservoir of water to supply the locks. A total of 70,000 people worked on the project and about 5,600 died in the process, mainly because of tropical diseases. The work was completed in 1914 and involved excavating 143 million cubic meters of earth and sanitizing the entire canal area, which was infested with mosquitoes that spread yellow fever and malaria. Since its completion in 1914, more than 1.04 million vessels transited the canal, carrying 11.17 billion tons of cargo (as of 2013). About 13,000 ships transit the canal every year, with an average of 35 ships per day. However, the canal has the optimal capacity to handle 50 ships per day. Using the canal requires in average transit time of about 16.5 hours if the passage has been reserved in advance. With no reservations, the transit takes an average of 35 hours due to the additional time spent waiting for a transit slot. Containers, grains and petroleum account for the dominant share of the cargo transited. The introduction of super-tankers at the beginning of the 1950s forced the reconsideration of its strategic importance as economies of scale in petroleum shipping are limited by the size of the canal. It is synonymous of a standard in maritime transport related to capacity, the Panamax standard, which equals to 65,000 deadweight tons, a draft of 12 meters and a capacity of about 4,500 TEUs depending on the load configuration (about 5,200 TEU if most of the containers are empty). Under the control of the United States until 1979, its administration was entrusted to the State of Panama by the Panama Canal Treaty of 1977 (also called the Carter-Torrijos Treaty). In December 1999, the canal was reverted to Panama under the jurisdiction of the Panama Canal Authority. The authority generates revenue by collecting tolls on all ships crossing the canal and is responsible for the operation and maintenance of the facility. A loaded ship pays about $2.57 per net ton and the average toll is about $45,000. For container ships the toll (as of 2011) was $74 per TEU of capacity on laden containers and $65.60 per TEU of capacity on ships with empty containers. In 2008, $1.32 billion in tolls were collected, of which 54% were generated by container shipping. In 1999, the Hong Kong terminal operator, Hutchison Port Holdings (HPH), was granted a 25 years concession for the operation of port terminals on both the Atlantic (Port of Cristobal) and Pacific (Port of

Balboa) sides of the Canal. This raised concerns within the American government as it was perceived that the control of the canal was falling into foreign interests shortly after it was handed back to Panama. The rail line between the Atlantic and Pacific sides was reopened in 2002 to handle the growing containerized traffic. The Panama Canal Railway Company (concession to KCS and Mi-Jack Products), offers an alternative to the size limitations of the canal and supports transshipment activities between the Atlantic and the Pacific sides through doublestack services. The same rationale applies to oil circulation with the trans-panama pipeline that resumed its operations in 2003, but the additional capacity this pipeline conveys is only about 1 Mb/d. In spite of being a century old, the Panama Canal remains a critical bottleneck in global trade. The continuous growth of global trade since the 1990s has placed additional pressures on the Panama Canal to handle a growing number of ships in a timely and predictable manner. This raised concerns that the existing canal would reach capacity by the second decade of the 21st century. Because of these capacity limits, many shipping companies have changed the configuration of their routes. This became increasingly apparent as a growing share of the global containership fleet reached a size beyond the capacity of the Panama Canal, which came to be known as "post-panamax" containerships. Through economies of scale, they offer significant operational costs advantages that cannot be exploited by the existing canal. The increasing usage of those ships along the Pacific Asia / Suez Canal / Mediterranean routes as well as the development of the North American rail landbrige have created a substantial competition to the canal as an intermediate location in global maritime shipping. There are thus a range of alternatives to the Panama Canal trade routes, with the North American landbridges being the most salient. Yet, concerns about the reliability of the landbridge connection incited the setting of "all-water routes" linking directly Pacific Asia and the American East Coast, particularly in light of the booming China-United States trade relation. A decision to expand the Panama Canal was reached in 2006 by the Panamanian government. The expansion was a 5.4 billion US dollars project that involved building a new set of locks on both the Atlantic and Pacific sides of the canal, which would accommodate ships up to 12,500 TEU depending on their load configuration. The dredging of access channels as well as the widening of several sections of the existing canal was also required. This allows Aframax and Suezmax vessels to pass through the canal, thus permitting new opportunities for container shipping services such as the re-emergence of round-the-world services. Essentially, a new containership class will be created to add to the existing Panamax ship class. It will be dubbed New-Panamax (or Neo Panamax; NPX). The new locks complement the existing lock systems, creating a two tier service; one for the very large ships and the other for Panamax, or smaller, ships. The outcome allows about 12 ships per day in the new lock system to be added to the existing capacity of about 45 ships per day in the existing locks. The additional capacity is however constrained by the fact that the new locks are unidirectional compared with the existing double locks. The new infrastructures came online in July 2016, after some delays since initially the expansion was expected to be completed for 2014. However, this expansion is taking place in an environment of notable commercial changes such a revision of sourcing strategies and the possibility of building a competing canal in Nicaragua. Further, the latest generation of containerships (such as the Triple E class) has reached sizes that are beyond the expanded locks. Within the foreseeable future the expanded Panama Canal will still be able to handle 95% of the global containership capacity. As a global intermediary location, Panama is shifting from being a point of transit towards being a logistics cluster and a trade platform for the Americas.

The Strait of Malacca The Strait of Malacca is one of the most important strategic passages of the World because it supports the bulk of the maritime trade between Europe and Pacific Asia, which accounts for 50,000 ships per year. About 30% of the world’s trade and 80% of Japan’s, South Korea’s and Taiwan’s imports of petroleum transits through the strait, which involved approximately 15.2 Mbd in 2013. It is the main passage between the Pacific and the Indian oceans with the strait of Sunda (Indonesia) being the closest existing alternative. It measures about 800 km in length, has a width between 50 and 320 km (2.5 km at its narrowest point) and a minimal channel depth of 23 meters (about 70 feet). It represents the longest strait in the world used for international navigation and can be transited in about 20 hours. Traditionally, the Strait was an important passage point between the Chinese and the Indian worlds and was controlled at different points in time by Javanese and Malaysian kingdoms. From the 14th century, the region came under the control of Arab merchants who established several fortified trading towns, Malacca being the most important commercial center in Southeast Asia. Again, the control of the trade route shifted as the era of European expansion began in the 16th century. In 1511, Malacca fell to the Portuguese and this event marked the beginning of European control over the Strait. In 1867, England took control of the passage with Singapore as a main harbor and other important centers such as Malacca and Penang, forming the Strait Settlements. This control lasted until the Second World War and the independence of Malaysia in 1957. As Pacific trade increased considerably after the Second World War, so did the importance of the passage. Singapore, located at the southern end of the Strait of Malacca is one of the most important ports in the world and a major oil refining center. One of the main challenges facing the Strait of Malacca is that it requires some dredging, since it is barely deep enough to accommodate ships above 300,000 deadweight tons. The Strait being between Malaysia, Indonesia and Singapore, an agreement is difficult to reach about how the dredging costs should be shared and how fees for its usage should be levied. Political stability and piracy along are also major issues for the safety of maritime circulation, especially on the Indonesian side with the province of Aceh, which has experienced political instability. The Strait of Malacca ends up in the **South China Sea**, another extremely important shipping lane and a region subject to contention since oil and natural gas resources are present. The Spartly and Paracel groups of islands are claimed in whole or in part by China, Vietnam, Malaysia, Indonesia, Brunei and the Philippines. The region has proven oil reserves estimated at about 7.0 Bb with oil production accounting for 2.5 Mb/d. With the substantial economic growth taking place in the region large flows of oil, liquefied natural gas and other raw materials (iron ore, coal) are transiting towards East Asia. About 25% of the global shipping fleet transits through the region each year, underlining the importance of the South China Sea as an extension of the

Malacca chokepoint. Still, the potential for disruptions of trade routes in the South China Sea must take account of the high level of reliance China has on such routes and thus has limited interest in seeing them compromised.Using the Kra Isthmus in Thailand as a shortcut between the Gulf of Thailand (Pacific Ocean) and the Andaman Sea (Indian Ocean) has been considered as early as in the 17th century. The **Kra Canal** project aims at building a 102 km long canal along the narrowest segment of the Kra Isthmus. By avoiding a detour through the Strait of Malacca, the potential canal could reduce shipping distance by 1,200 km, which corresponds to about 5 shipping days (such figures do not take account of canal transit times). Although the project represents a shortcut, this benefit is rather marginal, particularly for long distance shipping routes and due to the importance of Singapore and Tanjung Pelepas as major transshipment hubs linking Asia / Oceania / Europe trade routes. The canal would mainly benefit Thailand, Burma, Cambodia and Vietnam as they would see more significant shipping time and cost reductions for their maritime trade. China is pursuing this project for both commercial and strategic reasons, since it will give it an additional option to the usage of the Strait of Malacca.

The Strait of Hormuz The Strait of Hormuz forms a strategic link between the oil fields of the Persian Gulf, which is a maritime dead-end, the Gulf of Oman and the Indian Ocean. It has a width between 48 and 80 km, but navigation is limited to two 3 km wide channels, each exclusively used for inbound or outbound traffic. Circulation in and out of the Persian Gulf is thus highly constrained, namely because the sizable amount of tanker and containership traffic makes navigation difficult along the narrow channels. In addition, islands that insure the control of the strait are contested by Iran and the United Arab Emirates. The strait is deep enough to accommodate all the existing tanker classes. The security of the strait has been often compromised and its commercial usage has been the object of contentions. Between 1984 and 1987 a “Tanker War” took place between Iran and Iraq, where each belligerent (Iran-Iraq War of 1980-1988) began firing on tankers, even neutrals, bound for their respective ports. Shipping in the Persian Gulf dropped by 25%, forcing the intervention of the United States to secure the oil shipping lanes. About 85% of all the petroleum exported from the Persian Gulf transits through the Strait of Hormuz and bound to Asian markets. Its importance for global oil circulation cannot be overstated. For instance, 75% of all Japanese oil imports transit through the strait. There are thus very few alternatives to oil exports if the traffic of about 17 million barrels per day going through Hormuz was compromised. While the Persian Gulf has conventionally been centered on the production and distribution of oil, the growth of container shipping has also expanded its commercial importance. For instance, Dubai ranked in 2014 as the world's 9th largest container port with a traffic of 15.2 million TEU and can only be accessed through the Strait of Hormuz. It has become a major transshipment hub linking major Asian, Middle Eastern and East African trade routes. Consequently, compromising circulation through the Strait of Hormuz would impair global oil trade as well as commercial trade along Europe / Asia routes.

Other Important Passages

- **The Strait of Bab el-Mandab** is controlling access to the Suez Canal, a strategic link between the Indian Ocean and the Red Sea. It has between 48 and 80 km of width, but navigation is limited to two 3 km wide channels for inbound and outbound traffic. The sizable amount of tanker traffic makes navigation difficult along the narrow channels. A closing of this strait would have serious consequences, forcing a detour around the Cape of Good Hope and in the process demanding additional tanker space. Like the Strait of Malacca, Bal el-Mandab is a crucial link in the Europe - Asia trade route.
- The Strait of **Gibraltar**. As a peninsula between the Atlantic and the Mediterranean oceans, Gibraltar represents an obligatory passage point between these two oceans. The strait is about 64 km long and varies in width from 13 to 39 km. Under British control since its conquest from Spain in 1704 and its formal cession by the treaty of Utrecht (1713). During the Second World War, Gibraltar blocked the access to the Atlantic to the Italian and German fleets of the Mediterranean, which represented a major strategic stronghold.
- The Strait of **Bosporus**. The Passage of Bosporus has a length of 30 km by of width of only 1 km at its narrowest point linking the Black Sea to the Mediterranean

Ocean. Its access was the object of two conflicts, the War of Crimea (1854) and the battle of the Dardanelles (Gallipoli, 1915). The passage was fortified by Turkey after the Convention of Montreux in 1936 which recognized its control of Bosporus but granted free passage in peace time to any commercial vessel without inspection. With the passage of the Dardanelles, Bosporus forms the only link between the Black Sea and the Mediterranean Ocean. In the current context, Bosporus represents a passage of growing strategic importance, notably after the fall of the Soviet Union. The Caspian Sea has vast oil reserves and a large amount of it must transit trough the Black Sea and Bosporus to reach external markets, namely around the Mediterranean Ocean. Although pipelines offer an alternative, the cost differentials are clearly advantaging the use of maritime transportation. For instance, the cost of moving oil along the Baku – Ceyhan pipeline ranges between $1 and $2 per barrel while shipping oil by tankers through the Black Sea costs 20 cents per barrel. About 50,000 ships, including 5,500 tankers, are transiting through the passage each year, which is getting close to capacity. Further, due to its sinuosity, Bosporus is one of the most difficult passage to navigate, particularly for larger ships. Oil transiting through the Bosporus has growth substantially in recent years with the exploitation of oil fields around the Caspian Sea and about 2.9 Mb/d were transiting through the passage in 2013. The future growth of petroleum circulation through Bosporus is thus highly problematic, notably the risk of collisions and oil spills in the midst of Istanbul. In 2002, the Turkish government forbade the use of the passage during the night by large tankers.

- **The Strait of Magellan**. Discovered in 1520 by the Portuguese explorer Ferdinand Magellan. Separates South America to Tierra del Fuego. It is 530 km long and 4 to 24 km of width. Held secret during more than one century to assure the supremacy of Portugal and Spain for the Asian trade of spices and silk. With the construction of the Panama Canal in 1916 and later on the setting up of the North American transcontinental bridge in the 1980s, this passage has lost most of its strategic importance.

- **The Cape Good Hope**. Extreme tip of Africa discovered by the Portuguese at the end of the fifteenth century. It separates the Atlantic and Indian oceans. It took its name because of the fact that it offered a maritime passage towards India and Asia, thus the hope of a fortune for the one who passed it. Vasco de Gamma got around it in 1497 and was the first European to reach India by sea. Since the widening of the Suez Canal in the 1970s, the Cape of Good Hope has lost some of its strategic importance but still remain an important passage. Still, the growth of trade relations between Latin America and East, South and Southeast Asia has incited the growing use the Cape route and of South Africa as a transshipment hub.

4. Port Terminals

Ports and Port Sites

Ports are points of convergence between two geographical domains of freight circulation (sometimes passengers); the **land** and **maritime** domains. While the maritime domain can involve substantial geographical coverage related to global trade, the land domain in related to the port's region and locality. The term port comes from the Latin *portus*, which means gate or gateway. Historically, many ports emerged as safe harbors for fishing and those with convenient locations became trade hubs, many of which of free access and designed to protect trade. As such, they became nexus of urbanization with many becoming the first port cities playing an important role in the economic welfare of their regions. Today, many of the most important cities in the world owe their origin to their port location. The port is a multidimensional entity at start anchored within geography, but also dependent on its operations, governance structure and embedded within supply chains. Ports are bound by the need to serve ships, and so access to navigable water has been historically the most important site consideration. Before the industrial revolution, ships were the most efficient means of transporting goods, and thus port sites were frequently chosen at the head of water navigation, the most upstream site. Many major cities owed their early pre-eminence to this fact, such as London on the Thames, Montreal on the St. Lawrence River or Guangzhou on the Pearl River. Ship draft was small, so many sites were suitable. Sites on tidal waterways created a particular problem for shipping because of the twice-daily rise and fall of water levels at the berths, and by the 18th the technology of enclosed docks, with lock gates was developed to mitigate this problem. Because ship transfers were slow, and vessels typically spent weeks in ports, a large number of berths were required. This frequently gave rise to the construction of piers and jetties, often called finger piers, to increase the number of berths per given length of shoreline.

The gradual shift from conventional break-bulk terminals to container terminals since the early 1960s brought about a fundamental change in layout of terminals as well as site selection. Ports increasingly became impacted by global processes. Containerized transportation has substantially changed port dynamics to favor the emergence of specialized container ports. As compared to conventional break-bulk cargo ships containerships did not have onboard cranes, container terminal facilities had to provide capital intensive cranes and well as ample storage space to stack containers dockside. Finger piers were no longer adequate and berths were redesigned to accommodate for quick ship turnaround and more effective dockside operations between the crane and the container storage areas.

Containerization has consequently become a fundamental function of global port operations and has changed the structure and configuration of port terminals that tend to occupy more space. While inland port sites (such as at the end of a bay or along a river) generally have the advantage of being closer to the final market they imply longer deviations from maritime shipping routes. Therefore, the most successful inland ports sites are those that act as gateways (e.g. Antwerp, Montreal, Constanza).As terminals, ports handle the largest amounts of freight, more than any other types of terminals combined. To handle this freight, port infrastructures jointly have to accommodate transshipment activities both on ships and inland and thus facilitate convergence between land transport and maritime systems. In many parts of the world, ports are the points of convergence from which inland transport systems, particularly rail, were laid. Considering the operational characteristics of maritime transportation, the location of ports is constrained to a limited array of sites, mostly defined by geography. Most ports, especially those that are ancient, owe their initial emergence to their site as the great majority of harbors are taking advantage of a natural coastline or a natural site along a river.

Many port sites are constrained by:

- **Maritime access**, which refers to the physical capacity of the site to accommodate ship operations. It includes the tidal range, which is the difference between the high and low tide, as normal ship operations cannot handle variations of more than 3 meters. Channel and berth depths are also very important to accommodate modern cargo ships. A standard Panamax ship of 65,000 deadweight tons requires more than 12 meters (40 feet) of depth. However, about 70% of world ports have depths of less than 10 meters and are unable to accommodate ships of more than 200 meters in length. In view of the construction of larger ships, namely tankers and containerships, many port sites found themselves unable to provide maritime access to modern cargo operations. Since container terminals were constructed much more recently, they have a better nautical profile as depth and available space were fundamental factors in site selection. There is thus a pressure in increase channel depth where possible, but this is a costly and environmentally controversial endeavor. Berths and channel depth have become important constraints for maritime operations in light of growing ship size. Many ports are also impacted by sedimentation, particularly ports in river deltas. This requires continuous dredging, which adds to the costs of port operations. Some river ports may be impacted by periods of flooding and drought while other ports may be impeded or closed during winter because of ice conditions.
- **Maritime interface**. Indicates the amount of space that is available to support maritime access, namely the amount of shoreline that has good maritime access. This attribute is very important since ports are linear entities. Even if a port site has an excellent maritime access, namely deep water waterways, there may not be enough land available to guarantee its future development and expansion. Containerization has expanded the land consumption requirements of many ports. It is therefore not surprising to see that modern port expansion projects involve significant capital investments to create artificial port facilities.
- **Infrastructures and equipment**. The site, to be efficiently used, must have infrastructures such as piers, basins, stacking or storage areas, warehouses, and equipment such as cranes, all of which involving high levels of capital investment. In turn, these infrastructures consume land which must be available to insure port

expansion. Keeping up with the investment requirements of modern port operations has become a challenge for many ports, particularly in light of containerization which requires substantial amounts of terminal space to operate. Many terminals are also becoming increasingly automated, particularly for stacking areas that can be serviced by automated cranes and vehicles.

- **Land access.** Access from the port to industrial complexes and markets insure its growth and importance. This requires efficient inland distribution systems, such as fluvial, rail (mainly for containers) and road transportation. The land access to ports located in densely populated areas is facing increasing congestion. For instance, the ports of Los Angeles and Long Beach have invested massively to develop the Alameda rail corridor in an attempt to promote inland access and reduce truck congestion. A similar trend has taken place in Europe where ports such as Rotterdam and Antwerp have been involved in the setting on inland barge and rail shuttle services.

All these constraints have a significant impacts on port operations and which can be called the port performance continuum. There is also an array of problems related to port infrastructures. Ports along rivers are continuously facing dredging problems and the width of rivers is strongly limiting their capacity since it provides constraints to navigation. Rarely a port along a river has the capacity to handle to new generation of giant ships, namely Post Panamax containerships, which have put additional pressures on port infrastructures to accommodate the transshipment generated by these ships. Ports next to the sea are commonly facing a lateral spread of their infrastructures. Several ports have growth problems that force them to spread their infrastructures far from the original port sites. Since ports are generally old, and in several cases were responsible for urban growth, they are located nearby central areas. This is creating congestion problems where the transport network has the least capacity to be improved.

The city and the port are often competing for the same land, which can create prioritization problems. Ports thus have a complex set of relationships, sometimes conflicting, with the cities they service, often a function of the port and city size.

While ports are sources of employment of commercial interactions, they also generate externalities such as noise and congestion near their access points. The pressure of many ports on their sites is even more demanding than those of airports because they have to be adjacent to deep water. Such sites are very limited, and may give rise to conflicts with the city that sees waterfront land as potential high value residential and commercial areas, park space, or as environmentally sensitive. Many ports are now constrained by urban and environmental pressures, which did not exist when the initial facilities were developed.

Port Functions and Traffic

The main function of a port is to supply services to freight (warehousing, transshipment, etc.) and ships (piers, refueling, repairs, etc.). Consequently, it is misleading to consider a port strictly as a maritime terminal since it acts concomitantly as a land terminal where inland traffic originates or ends. Ports are at start cargo-oriented facilities. To this significant cargo related function, many ports are also involved in other activities such as fishing, ferries, cruises (a growing activity) and recreational (e.g. marinas).Ports are becoming increasingly regional in their dynamics, which represents a new development from their traditional local function, namely as industrial complexes. For instance, the port of Hong Kong owes its wealth to its natural site and its geographical position of a transit harbor for southern China. A similar function is assumed by Shanghai for central China with the Yangtze river system. Singapore, for its part, has been favored by its location at the outlet of the strategic Strait of Malacca and is therefore a point of convergence of Southeast Asian transportation. More than 90% if the traffic it handles is strictly transshipments. New York has traditionally acted as the gateway of the North American Midwest through the Hudson / Erie Canal system, a function which Western European ports such as Rotterdam or Antwerp perform with their access to the Rhine system.

A port throughput is linked to a variety of local and regional industrial activities as the largest ports in the world are all gateways to massive industrial regions. However, comparing ports on a tonnage basis requires caution as it does not indicate the nature and the value of the cargo. For instance, a mineral port (e.g. iron ore), an energy port (e.g. coal or oil) and a commercial port (containers) could handle a similar tonnage but significantly different value levels. They will also be related to different commodity chains. In terms of the freight they handle, ports can be classified in two categories; monofunctionnal ports and polyfunctionnal ports.

Monofunctionnal ports transit a limited array of commodities, most often dry or liquid bulks (raw materials). The oil ports of the Persian Gulf or the mineral ports of Australia, Africa and in some measure of Canada are monofunctional ports. They have specialized piers designed to handle specific commodities and where the flows a commonly outbound, implying that they are usually load centers.

Polyfunctionnal ports are vast harbors where several transshipment and industrial activities are present. They have a variety of specialized and general cargo piers linked to a wide variety of modes that can include containers, bulk cargo or raw materials.

About commercial 4,600 ports are in operation worldwide, but only less than one hundred ports have a global importance. There are about 500 container ports with 110 handling a traffic above half a million TEU. Maritime traffic thus has a high level of concentration in a limited number of large ports, a process mainly attributed constraints related to maritime access and infrastructure development. Major ports have established themselves as gateways of continental distribution systems and have access to high capacity inland freight distribution corridors, notably rail. Such a position is very difficult to challenge unless a port is facing acute congestion forcing maritime shipping companies to seek alternatives. Gateways have seen the development of port-centric logistics activities that support export and import-based activities.

The world container throughput is the summation of all containers handled by ports, either as imports, exports or transshipment. In 2014, about 677 million TEU were handled by container ports, with a notable growth in containers transshipped at intermediate locations as well as the repositioning of empty containers. This means that a container is at least counted twice; as an import and as an export, but also each time it is handled at the ship-to-shore interface, such as at a transshipment hub where it will be counted when unloaded and reloaded. Empty containers, most of them being repositioned, account for about 20% of the world's throughput. Thus, throughput should ideally be counted in container moves, but for basic commercial and strategic reasons, both port authorities and terminal operators prefer to communicate throughput figures in TEU. The world container traffic is the absolute number of containers being carried by sea, excluding the double counts of imports and exports as well as the number of involved transshipments. The throughput reflects the level of transport activity while the traffic reflects the level of trade activity.

Port Authorities and Port Holdings

Due to the growing level of complexity of port operations, public port authorities were created at the beginning of the 20th century. For instance, the London Port Authority, the world's first, was established in 1908 by consolidating all the existing harbor facilities. Such a management structure became a standard that was adapted to many other ports. For North America, in 1921, the States of New York and New Jersey created the Port Authority of New York and New Jersey, which has become one of the world's most diversified port authority with a portfolio including port facilities, bridges, airports and public transit systems. Administratively, port authorities are regulating infrastructure investments, its organization and development and its relationships with customers using its services.

Port Authority. An entity of state or local government that owns, operates, or otherwise provides wharf, dock and other marine terminal investments and services at ports.

The main rationale behind the setting of many port authorities was their ability to manage more efficiently port facilities as a whole rather than privately owned and operated terminals. Since port facilities were becoming more complex and more capital intensive, it was perceived that public agencies would be better placed to raise investment capital and mitigate the risk of such investments. Port authorities tend to be vertically integrated entities as they are involved in most of the activities related to port operations, from the construction and maintenance of infrastructure to the marketing and management of port services. Yet, their activities were limited within their jurisdictions, an attribute that became increasingly at odds with the transformations of the maritime shipping industry through globalization.Occasionally, terminals were leased to private companies but throughout the greater part of the 20th century, public ownership and operation of ports was dominant. Most port authorities are owned by federal, state or municipal agencies. Privatization marks a reversal in this trend since many became inefficient, unable to cope with market expectations (performance, reliability and quality of service) and provide adequate financing for infrastructure and equipment becoming increasingly capital intensive. As public agencies, many port authorities were seen by governments as a source of revenue and were mandated to perform various non-revenue generating community projects, or at least provide employment.

The emergence of specialized and capital intensive container terminals servicing global trade has created a new environment for the management of port terminals, both for the port authorities and the terminal operators. Port authorities are gradually incited to look at a new array of issues related to the governance of their area and are increasingly acting as cluster managers. For port operations that have conventionally be assumed by port authorities, a significant trend has been an increase in the role of private operators where major port holdings have emerged with the purpose to manage a wide array of terminals, the great majority of which are containerized.

Port holding. An entity, commonly private, that owns or lease port terminals in a variety of locations. It is also known as a port terminal operator.

In an era characterized by lower levels of direct public involvement in the management of transport terminals and port privatization, specialized companies involved in the management of port terminals are finding opportunities. They thus tend to be horizontally integrated entities focusing on terminal operations in a variety of locations. As of 2013, port holdings accounted for over 58% of the world's container port capacity.The main tool for global port operators to achieve control of port terminals has been through concession agreements.

A concession agreement is a long-term lease of port facilities involving the requirement that the concessionaire undertakes capital investments to build, expand, or maintain the cargo-handling facilities, equipment, and infrastructure to satisfy a minimum level.

A number of issues are involved in the decision of a terminal operator to invest in a particularly port, namely the transparency of the bidding process and the quality of infrastructures (port and inland). The market potential however remains one of the determining criteria. The range of port terminals controlled by port holdings covers several of the largest freight markets. As globalization permitted the emergence of large multinational corporations managing assets in a variety of locations, global port holdings are a similar trend concerning the management of port terminal assets. Yet, regional orientation remains a strong characteristic of container terminal operators. The emergence of global terminal operators have changed the parameters of port competition. While ports have always to some extent been competing to service their hinterland, which is known as inter-port competition. Concessions agreements in larger port have permitted the setting of more than one terminal operator who are now competing over the port foreland and addition to the hinterland. This is known as intra-port competition.

Port Evolution and Development

The evolution of transport terminal development has been examined most extensively in port site studies. Port terminals and activities, as documented by Bird's Anyport, tend to expand away from their original sites towards locations offering better maritime and land access. The site of the port is thus the object of a process of valorization through capital investments in infrastructures, the convergence of inland and maritime transport networks with their flows as well as the complex management of the concerned supply chains. Port development can be perceived within a sequential perspective, where each phase builds upon the previous, from port cities of the 19th century to the emerging port logistics network of the 21st century. Conventionally, port terminals where located close to city cores as many where the initial rationale for the existence of the city. The proximity to downtown areas also insured the availability of large pools of workers to perform the labor intensive transshipment activities that used to characterize port operations. But these activities tended to have low productivity levels as a stevedoring team could handle 10 to 15 tons per day and a berth could handle 150,000 tons per year. At their peak in the early 1950s ports such as London and New York each employed more than 50,000 longshoremen. Containerization had the dramatic impact of lowering the need for labor for port operations. For instance, the number of longshoremen jobs in the Port of New York and New Jersey declined from 35,000 in the 1960s to about 3,500 in the 1990s.Over time, changes in ships and handling equipment gave rise to new site requirements. By the post World War II period a growing specialization of vessels emerged, especially the development of bulk carriers. These ships were the first to achieve significant economies of scale, and their size grew very quickly. For example, the world's largest oil tanker in 1947 was only 27,000 dwt, by the mid 1970's it was in excess of 500,000 dwt. There was thus a growing vessel specialization using semi-automated transshipment equipment and increase in size which resulted in new site requirements, especially the need for dock space and greater water depths. The mechanization of cargo handling and the storage requirements because of greater vessel capacities have greatly extended the space demands for port activities. Many ports, such as Rotterdam and Antwerp are larger in area than the cities they serve. The expansion of Chinese ports, such as Shanghai, has required altogether the use of entirely new sites outside central areas. Further, growing ship sizes have implied several new constraints for port sites such as deeper waterways, larger terminal space, both for ship handling and warehousing, and more efficient inland road and rail access. Modern port infrastructures are often intensive in capital and several port authorities are struggling to keep up with large infrastructure investment requirements. However, the presence of infrastructures does not necessarily guarantee traffic as maritime companies can select the ports they service as business opportunities changes. Over this, three recent mega projects are particularly revealing:

- **Maasvlatke II (Rotterdam)**. For decades, the port of Rotterdam, Europe's largest port, has expanded downstream. The growth of container traffic along with continued expansion of bulk traffic caused the port to consider expansion out in the North Sea. This led to the construction of an entirely new facility on reclaimed land at

Maasvlatke in the 1980s. However, subsequent traffic growth in the 1990s resulted in the port authority proposing a new facility further out in the North Sea: Maasvlatke II. The project began construction in 2008 and operations began in 2013, with full completion expected by 2030. Once completed, this terminal facility would likely mark the end of the geographical expansion for Rotterdam, outside the reconversion of existing terminal sites into more productive uses.

- **Deurganck dock (Antwerp)**. Like Rotterdam, the expansion options of the port of Antwerp are limited. With the right bank of the River Scheldt, where the bulk of the port's facilities are located, reaching capacity a new dock complex was built on the left bank. The Deurganck dock opened in 2005 and can add about 9 million TEUs to the existing capacity of about 10 million TEUs.
- **Yangshan container port (Shanghai)**. A rare case where a completely new facility has been built from scratch, and this well outside the existing port facilities in the Changjiang delta to a facility located in Hangzhou Bay, 35 km offshore. It opened in 2005 and was built for two purposes. The first was to overcome the physical limitations of the existing port facilities, too shallow to accommodate the latest generation of containerships. The second was to provide additional capacity to meet traffic growth expectations as well as room for new terminal facilities if container growth endures. The fully completed port would have an expected capacity of 15 million TEUs. To link the port to the mainland, the world's third longest bridge with a length of 32.5 km was built.

The success of major container ports is jointly the outcome of a shift to containerized shipping in new industrializing regions (containerized commodity chains), the quality of their infrastructure and services and an efficient interface with inland transport systems. Still, container traffic is subject to fluctuations mainly related to seasonal variations in the demand. Another aspect concerns the automation of port terminal operations. Although container ports are highly mechanized entities, the equipment is operated by workers. It is therefore possible to automate one or all three of the main stages of port operations; the portainer, the dock to stacking yard movements and the stacking yard gantry cranes. Another notable impact of automation is the ability to operate on several work shifts per day. Although a conventional container port can add additional work shifts if required, this is easier to implement in automated terminals since less workers are involved. As a result, automated terminals are usually twice as productive as standard mechanized terminals.

Regionalization and Transshipment Hubs

The current port development phase underlines that ports are going beyond their own facilities to help accommodate additional traffic and the complexity of freight distribution, namely by improving hinterland transportation. Port regionalization is such an outcome and indicates a higher level of integration between maritime and inland transport systems, particularly by using rail and barge transportation, which are less prone to congestion than road transportation. The development of global supply chains increased the pressure on maritime transport, port operations, and on inland freight distribution, which in turn has incited active container transloading activities in the vicinity of port terminals. Inland accessibility has become a cornerstone in port competitiveness since it can be serviced by several road, rail and barge transportation. Those three options a particularly present in Europe. Port regionalization is characterized by strong functional interdependency and even joint development of a specific load center and logistics platforms in the hinterland. This leads ultimately to the formation of a regional load center network, strengthening the position of the port as a gateway. Many factors favor the emergence of this phase, namely:

- **Local constraints**. Ports, especially large gateways, are facing a wide array of local constraints that impair their growth and efficiency. The lack of available land for expansion is among one of the most acute problem. This issue is exacerbated by the deep water requirements for handling larger ships. Increased port traffic may also lead to diseconomies as local road and rail systems are heavily burdened. Environmental constraints and local opposition to port development are also of significance. Port regionalization thus enables to partially circumscribe local constraints by externalizing them.

- **Supply chain management**. Global production and consumption have substantially changed distribution with the emergence of regional production systems as well as large consumption markets. No single locality can service efficiently the distribution requirements of such a complex web of activities. For instance, globally integrated logistics zones, including Free Trade Zones (FTZ) have emerged near many load centers, but seeing logistics zones as a functionally integrated entity may be misleading as each activity is part of a specific supply chain. Port regionalization thus permits the development of a distribution network that corresponds more closely to fragmented production and consumption systems.

Cargo at ports always required some transshipment to smaller ships used a feeders to smaller ports. For obvious reasons, it is impossible to connect directly all possible port pairs, so transshipment is required to insure connectivity within the global trading system. Transshipment was initially developed to service smaller ports unable to accommodate larger containerships, which is commonly because of limited draft and port infrastructure. However, as maritime networks became increasingly complex, specialized transshipment hubs emerged. Transshipment requires significant yard space as containers are stored up for a few days while waiting for the connecting ship(s) to be serviced.The growth in global trade has involved greater quantities of containers in circulation, which has incited maritime shipping companies to rely more on transshipment hubs to connect different regions of the world. In such a context, many gateway ports were facing the challenge of handling export, import and transshipment containers. This went on par with the growing share of transshipments in regard to the totality of maritime containerized traffic, from around 11% in 1980, 19% in 1990, 26% in 2000 to about 29% in 2010 and 28% in 2012. The number of times a container is handled at a port is also increasing, underlining the setting of complex containerized transport chains as well as the growing difficulties of transferring cargo into large containerships. Maritime shipping companies also elect for transshipment as a way to use more rationally their networks; more ports are serviced without increasing ship assets. In a conventional deep sea container service, a maritime range such as the American East Coast or Northern Europe involve several port calls. If the volume is not sufficient, this may impose additional costs for maritime companies that are facing the dilemma between market coverage and operational efficiency. This is particularly the case with the growing size of containerships that forces a lower number of port calls. By using an intermediate hub terminal in conjunction with feeder shipping services, it is possible to reduce the number of port calls and increase the throughput of the port calls left.

An intermediate hub (or transshipment hub) is a port terminal used for ship-to-ship operations within a maritime transport system. These operations do not take place directly, which requires the temporary storage of containers in the port's yard, usually for one to three days. The term offshore hub has often been used to characterize such locations because the cargo handled at the port of destination is transshipped at a location commonly in a country different than the country of origin.

There are several patterns in which intermediate hubs can be inserted by connecting long distance and short distance (feeder) maritime services, by connecting different long distance services and by connecting services calling different ports along a similar maritime range. The most common pattern is hubbing where an intermediate hub links regional port calls to mainline long distance services. Intermediate hub terminals can thus become effective competitive tools since the frequency and possibly the timeliness of services can be improved. By using an intermediate hub terminal in conjunction with short sea shipping services, often organized along a sequence, it is possible to reduce the number of port calls and increase the throughput of the port calls left. Transshipment also comes with a level of risk for the cargo since containers are handled more times than for direct services. This is notably the case for the chemical industry.While in theory intermediate hubs do not have an hinterland, but a significant foreland, the impact of feedering (mainly by short sea shipping) confers them a significant indirect hinterland. Feedering combines short sea and deep sea containerized shipping at a hub where traffic is redistributed. The usage of larger containerships has lead to the concentration of traffic at terminals able to accommodate them in terms of draft and transshipment capacity. Smaller ports, particularly those well connected to inland transport systems, become feeders through the use of short sea shipping. As the transshipment business remains a highly volatile business, offshore hubs might sooner or later show ambition to develop services that add value to the cargo instead of simply moving boxes between vessels.The intermediate hub enables a level of accessibility that incites them to look beyond their conventional transshipment role. This includes actions to extract more values of cargo passing through and, as such, get more economic rent out of transshipment facilities. Such strategies have led to some transshipment hubs, such as Gioia Tauro and Algeciras, to develop inland rail services to capture and serve the economic centers in the distant hinterlands directly. A more common strategy is the development of port-centric logistics zones. The multiplying effects of being an intermediate hub in terms of frequency of port calls and connectivity to the global economy can thus be leveraged for developing hinterland activities.

5. Inland Ports / Dry Ports

A New Role for Inland TerminalsIn many places around the world bimodal and trimodal inland terminals have become an intrinsic part of the transport system, particularly in gateway regions having a high reliance on trade. Transport development is gradually shifting inland after a phase that focused on the development of port terminals and maritime shipping networks. The complexity of modern freight distribution, the increased focus on intermodal and co-modal transport solutions and capacity issues appear to be the main drivers behind a renewed focus on hinterland logistics. While trucking tends to be sufficient in the initial phase of the development of inland freight distribution systems, at some level of activity, diminishing returns such as congestion, energy consumption and empty movements become strong incentives to consider the setting of inland terminals as the next step in regional freight planning. Also the massification of flows in networks, through a concentration of cargo on a limited set of ports of call and associated trunk lines to the hinterland, have created the right conditions for nodes to appear along and at the end of these trunk lines.

The evolution of inland freight distribution can be seen as a cycle in the ongoing developments of containerization and intermodal transportation. The geographical characteristics linked with modal availability, capacity and reliability of regional inland access have an important role to play in shaping this development. As maritime shipping networks and port terminals become better integrated the focus shifted on inland transportation and the inland terminal as a fundamental component of this strategy. Thus, after a phase that relied on the development of port terminals and maritime shipping networks, the integration of maritime and inland freight distribution systems has favored the setting of inland ports.

Inland port. A rail or a barge terminal that is linked to a maritime terminal with regular inland transport services. An inland port has a level of integration with the maritime terminal and supports a more efficient access to the inland market both for inbound and outbound traffic. This implies an array of related logistical activities linked with the terminal, such as distribution centers, depots for containers and chassis, warehouses and logistical service providers.

Since the inland terminal is essentially an extension of some port activities inland, the term "dry port" has gained acceptance. However, using this term to define an inland terminal is subject to debate since many inland terminals are in fact ‘wet’ given their direct access to inland waterway systems. Moreover, the inland location can effectively be a port if a barge service is concerned, but fundamentally cannot be considered a port if it involves a rail terminal or more simply truck depots. Thus, there seems to be no consensus on the terminology resulting in a wide range of terms including dry ports, inland terminals, inland ports, inland hubs, inland logistics centers, inland freight villages, etc. The reason for this lies in the multiple shapes, functions and network positions these nodes can have. A similar issue applies with the inclusion of airport terminals, mainly the freight component, as an element of an inland port. A whole array of transport terminal infrastructures is therefore often presented as a dry port. Therefore, the concept of inland port is polymorphic, implying that it can have different meaning depending on its location, connectivity, role and function. Regardless of the terminology used, three fundamental characteristics are related to an inland node:

- An intermodal terminal, either rail or barge that has been built or expanded.
- A connection with a port terminal through rail, barge or truck services, often through a high capacity corridor.

- An array of logistical activities that support and organize the freight transited, often co-located with the intermodal terminal.

The functional specialization of inland terminals has been linked with cluster formation of logistical activities. Inland terminals in many cases have witnessed a clustering of logistics sites in the vicinity, leading to a process of logistics polarization and the creation of logistic zones. They have become excellent locations for consolidating a range of ancillary activities and logistics companies. In recent years, the dynamics in logistics networks have created the right conditions for a large-scale development of such logistics zones.

Driving Forces

Each inland port remains the outcome of the considerations of a transport geography pertaining to modal availability and efficiency, market function and intensity as well as the regulatory framework and governance. Their emergence underlines some deficiency in conventional inland freight distribution that needed to be mitigated. This mitigation includes:

- **Input costs**. Land and labor costs are among the most significant logistics costs. Many deep sea terminal facilities have limited land available for expansion, implying higher land costs, while inland locations tend to have land available. Many port areas are also facing higher labor costs since they are located within large metropolitan areas. High input costs favor the intensification of activities at the main terminal and the search of lower value locations supporting less intensive freight activities.
- **Capacity and congestion**. Capacity issues appear to be the main driver of inland port development since a system of inland terminals increases the intermodal capacity of inland freight distribution. While trucking tends to be sufficient in the initial phase of the development of inland freight distribution systems, at some level of activity, diminishing returns such as congestion, energy and empty movements become strong incentives to consider the setting of inland terminals as the next step in regional freight planning.

- **Hinterland market**. Through long distance transport corridors, inland ports confer a higher level of accessibility because of lower distribution costs and improved capacity. These high-capacity inland transport corridors allow ports to penetrate the local hinterland of competing ports and thus to extend their cargo base. In such a setting, the inland port becomes a commercial and trade development tools that jointly increase imports, exports and intermodal terminal use. It is thus better placed to support regional and international trade patterns.
- **Supply chain management**. An inland port is a location actively integrated within supply chain management practices, particularly in view of containerization. It is reflective of the level of vertical integration between the port and hinterland actors such as transport companies and supply chain managers. This takes many forms such as the agglomeration of freight distribution centers, custom clearance, container depots and logistical capabilities. The inland terminal can also become a buffer in supply chains, acting as a temporary warehousing facility.
- **Policy and regulations**. Economic development strategies, land use policy, and financial incentives by port authorities and economic development agencies can lead to the development of inland ports. This can be supported by policies related to foreign trade zones and customs procedures, enabling a transfer of functions that were previously taking place at the port to an inland location. This is commonly as significant hurdle since many national trade regulations only enables containers to be cleared for imports or exports at a port. A similar trend applies to cargo safety and security procedures where the inland port becomes a component of a chain of cargo integrity.

The geographical characteristics linked with modal availability and the capacity of regional inland access have an important role to play in shaping the emergence and development of inland ports. Each inland market has its own potential requiring different transport services. Thus, there is no single strategy for an inland port in terms of modal preferences as the regional effect remains fundamental. In developed countries, namely North America and Europe, which tended to be at the receiving end of many containerized supply chains, a number of inland ports have been developed with a focus on inbound logistics.

The setting of global supply chains and the strategy of Pacific Asian countries around the export-oriented paradigm have been powerful forces shaping contemporary freight distribution. Indirectly, this has forced players in the freight transport industry to examine supply chains as a whole and to identify legs where capacity and reliability were an issue. Once maritime shipping networks and port terminal activities have been better integrated, particularly through the symbiotic relationship between maritime shipping and port operations, inland transportation became the obvious focus and the inland terminal a fundamental component of this strategy. This initially took place in developed countries, namely North America and Europe, which tended to be at the receiving end of many containerized supply chains. The focus has also shifted to considering inland terminals for the early stages of global supply chains (outbound logistics), namely in countries having a marked export-oriented function.

Inland terminals have evolved from simple intermodal locations to their incorporation within logistic zones. Rail terminals in particular have historically been locations from which specific market coverage was achieved. Containerization has impacted this coverage through the selection of terminals that were servicing a wider market area. This spatial change also came with a functional change as intermodal terminals began to experience a specialization of roles based on their geographical location but also based on their function within supply chains.

Functions within Transport Chains

A functional and added value hierarchy has emerged for inland terminals as they try to replicate inland several services performed at a port terminal, namely customs clearance, container storage, cargo consolidation and deconsolidation. In many instances, freight transport terminals fit within a hierarchy with a functionally integrated inland transport system of gateways and their corridors, where they service three major functions:

- **Satellite terminals**. They tend to be close to a port facility, but mainly at the periphery of its metropolitan area (often less than 100 km), since they mainly assume a service function to the seaport facilities. They accommodate additional traffic and serves functions that either have become too expensive at the port such as warehousing and empty container depots or are less bound to a location near a deep sea quay. A number of satellite terminals only have a transport function transshipping cargo from rail/barge to trucks and vice versa, as is the case for the 'container transferium' concept of the port of Rotterdam or the Gateway Access Point (GAP) concept in Belgium. Satellite terminals can also serve as load centers for local or regional markets, particularly if economic density is high, in which case they form a multi-terminal cluster with the main port they are connected to through regular rail or barge shuttle services. For gateways having a strong import component, a satellite terminal can also serve a significant transloading function where the contents of maritime containers are transloaded into domestic containers or truckloads.

- **Freight distribution clusters (load centers)**. A major intermodal facility - load center - granting access to well defined regional markets that include production and consumption functions. It commonly corresponds to a metropolitan area where a variety of terminals serve concomitantly intermodal, warehousing, distribution and logistics functions. These tend to take place in logistics parks and free trade zones (or foreign trade zones). The inland terminal is thus the point of collection or distribution of a regional market. The more extensive and diversified the market, the more important is the load center. If the load center has a good intermediary location, such as being along a major rail corridor, then freight distribution activities servicing an extended market will be present.

- **Transshipment facilities**. Link large systems of freight circulation either through the same mode (e.g. rail-to-rail) or through intermodalism (rail-to-truck, or even rail-to-barge). In the later case, the inland terminal assumes the role of a load center. The origin or the destination of the freight handled is outside the terminal's market area, a function similar to that of transshipment hubs in maritime shipping networks. Such transshipment terminals are often found near country borders in view of combining administrative processes linked to cross border traffic to value-added logistics activities. Although this function remains marginal in most parts of the world, ongoing developments in inland freight distribution, where the scale and scope of intermodal services are increasing, are indicative that transshipment services are bound to become more prominent.

These functions are not exclusive, implying that inland terminals can service several functions at once. Therefore, there is no single model for an inland port. For inbound or outbound freight flows, the inland terminal is the first tier of a functional hierarchy that defines its fundamental (activities it directly services) and extended (activities it indirectly services) hinterlands. Considering the potential mix of the functions of inland ports, five major criteria insure that they fulfill efficiently their role as an interface between global and regional freight distribution systems:

- **Site and situation**. Like any transport facility of significance, an inland port requires an appropriate site with good access to the rail or the barge terminal as well as available land for development. Access to an area of significant economic density, such as large population base, is of importance since it will be linked to the level of import and export activities handled by the inland port. Transportation remains the most significant logistics cost, underlining the importance of an accessible location. Several inland ports also have an airport in proximity which can help support a variety of freight activities.
- **Massification**. The hinterland massification opportunities offered by inland ports are associated with lower transport costs and a better accessibility. It takes place over two interdependent dimensions. The first concern the massification of flows between the port terminal and the inland port through a high capacity corridor. Intermodal rail and barge services represent the dominant means over which this process is achieved. The second relates to the consolidation and deconsolidation of cargo flows depending if it concerns inbound or outbound logistics.
- **Reconciling cargo flows**. Since most long distance trade (and some domestic) is supported by containerization, there are numerous instances where a regional market imports more than it exports (or vice-versa). Under such circumstances, an inland port must provide the physical and logistical capabilities to insure that empty containers are repositioned efficiently to other markets if local cargo

cannot be found. This can take the form of empty container depots and arrangements with freight forwarders to have slots available for repositioning. Whether there are imbalances in container flows or not, an inland port must insure that the inbound and outbound flows are reconciled as quickly as possible. A common way involves a cargo rotation from imports activities where containers are emptied to exports activities where containers are filled with goods. For container owners, let them be maritime shipping or leasing companies, a rapid turnover of their assets is fundamental and will secure a continuous usage of the inland port. Effective repositioning and cargo rotations strategies insure higher revenue for both the container owners and the inland port operators.

- **Trade and transactional facilitation**. An inland port can also be a fundamental structure promoting both the import and export sectors of a region, particularly for smaller businesses unable to achieve economies of scale on their own. Through these, new market opportunities become possible as both imports and exports are cheaper. The setting of a Foreign Trade Zone (FTZ) is also an option to be considered as a trade facilitation strategy. The functional pairing of inland ports is a transactional strategy where an inland port is activity seeking agreements with other inland ports so that reciprocal supply chains are established or reinforced.
- **Governance**. The way an inland port is owned and operated is indicative of its potential to identify new market opportunities and invest accordingly. In many cases, the commitment of a large private investor such as a terminal operator or a real estate developer can be perceived as a risk mitigation strategy in addition to provide expertise in the development of facilities and related activities. Sections of an inland port can be shared facilities (e.g. distribution centers) so that smaller players can get involved by renting space and equipment. This also applies to the appropriate strategies related to each stage in the life cycle of an inland terminal from its construction to its maturity where its potential has essentially been taped off.

The Regional Impacts of Inland Ports

Regional issues, namely how inland ports interact with their regional markets, remain fundamental as it defines their modal characteristics, their regulatory framework and their commercial opportunities. Depending on the geographical setting and the structure, governance and ownership of inland transport systems, inland terminals have different levels of development and integration with port terminals. They are part of a port regionalization strategy supporting a more extensive hinterland. It is in Western Europe that the setting of inland terminals is the most advanced with a close integration of port terminals with rail shuttles and barge services. Rail-based dry ports are found throughout Europe, often linked to the development of logistics zones. Depending on the European country considered, these logistics zones are known under different names: ‘platformes logistiques’ in France, the Güterverkehrszentren (GVZ) in Germany, Interporti in Italy, Freight Villages in the UK, Transport Centres in Denmark, and Zonas de Actividades Logisticas (ZAL) in Spain. The rail liberalization process in Europe is supporting the development of real pan-European rail services on a one-stop shop basis. All over Europe, new entrants are emerging while some large former national railway companies have joined forces. Rail terminals in Europe are mostly built and operated by large railway ventures. The largest rail facilities have bundles of up to 10 rail tracks with lengths of maximum 800m per track. Rail hubs are typically equipped to allow simultaneous batch exchanges (direct transshipment) through the use of rail-mounted gantry cranes that stretch over the rail bundles.

In northwest Europe, barge transport is taking up a more prominent role in dealing with gateway traffic. Barge container transport has its origins in transport between Antwerp, Rotterdam and the Rhine basin, and in the last decade it has also developed greatly along the north-south axis between the Benelux and northern France. Antwerp and Rotterdam together handled nearly 5 million TEU of inland barge traffic in 2010 or about 95% of total European container transport by barge. Promising barging developments are also found on the Seine between Le Havre and the Paris region, in the Rhône/Seine basin between Marseille, Lyon and Dijon, on the Elbe and the Weser in Northern Germany and on the Danube River out of the port of Constantza. Barge services have also been initiated on the Po River connecting the Port of Venice with Mantua and Cremona near Milan.

European integration processes have permitted the setting of more natural (commercially based) hinterlands that did not exist before. Since a good share of the European market is inland, a growth in international trade required the setting of intermediary locations inland to help accommodate larger flows between ports and their hinterland. A large concentration of inland terminals can be found around the Rhine/Scheldt delta, which is Europe's most important gateway region with a total container throughput of 22.2 million TEU in 2010, and where the function of satellite terminals is prominent. Almost every European port has an inland terminal strategy as a way to secure hinterland traffic.

There have been large inland terminals in **North America** since the development of the continental railway system in the late 19th century. Their setting was a natural process where inland terminals corresponded to large inland market areas, commonly around metropolitan areas commanding a regional manufacturing base and distribution system. Although exports were significant, particularly for agricultural goods, this system of inland terminals was mostly for domestic freight distribution. With globalization and intermodalism two main categories of inland terminals have emerged in North America.

The first is related to ocean trade where inland terminals are an extension of a maritime terminal located in one of the three major ranges (Atlantic, Gulf and Pacific) either as satellite terminals and more commonly as inland load centers (e.g. Chicago or Mexico). The second category concerns inland terminals mainly connected to NAFTA trade that can act as custom pre-clearance centers. Kansas City can be considered the most advanced inland port initiative in North America as it combines intermodal rail facilities from four different rail operators, foreign trade zones and logistics parks at various locations through the metropolitan area. There is even the world’s largest underground warehousing facility, Subtropolis, where temperature stable space can be leased. Like Chicago, the city can essentially be perceived as a terminal.

Several recent logistic zones projects in North America are capitalizing on the planning and setting of a new intermodal rail terminal done concomitantly with a logistics zone project. This co-location partnership fundamentally acts as a filter for the commercial potential of the project as both actors must make the decision to go ahead with their respective capital investment in terminal facilities and commercial real estate. Compared to Europe, North American dry ports tend to be larger, but covering a much more substantial market area.

For **Asia**, inland terminals are almost unknown, so they can be considered to be in their infancy. Geographical characteristics, namely coastal population concentrations, and export oriented development strategies have not been prone to the setting of inland terminals. Several container depots have appeared inland as a way to improve the availability of export containers within manufacturing clusters (e.g. South Korea, Thailand, India), but containers are mainly carried by truck. It is in the case of China that resides the largest potential for the emergence of a network of inland terminals, with three main types emerging:

- The first are satellite facilities in the vicinity of port terminals. They assume the conventional role of accommodating activities decongesting port operations, such as container deports, as well as performing customs clearance.
- The second type concerns inland facilities located at major metropolitan areas to provide better connectivity to port terminals along the coast as well as to support the logistics of a growing internal consumption market. Significant dry port development is taking place on the Yangtze river all the way up to the upper stretches near Chongqing, some 2,400 km upstream from Shanghai. Intermodal rail development faces the challenge of the strong focus of the existing rail network on passengers and dry bulk commodities. As the Chinese economy moves towards a more extensive internal market intermodal rail and barge traffic will increase, and so the usage of inland ports.
- The third type are border facilities that play the function of custom clearance, consolidation and deconsolidation of cargo as well as emerging trans-modal functions of linking different systems or circulation. The setting of Asia-Europe rail connections may promote this function.

Another system of inland terminals is likely to emerge in Southeast Asia, particularly along the Mekong. In light of the North American and European experiences, the question remains about how Pacific Asia can develop its own inland port strategy and regionalism. The unique geographical characteristics of the region are likely to rely much on the satellite terminal concept and inland load centers in relative proximity. For this context, the European example is more suitable. However, the setting of long distance intermodal rail corridors within China and through Central Asia is prone to the development of the inland load center system common in North America.

Future Prospects

The setting of dry ports (inland ports) have been a dominant paradigm in the development of hinterland transportation as the growth of maritime transportation and its economies of scale have placed pressures on the inland segment of freight distribution. The prospects for inland ports remain positive with large continental markets like North America and Europe relying on a network of satellite terminals and load centers as a fundamental structure to support hinterland freight movements, particularly their massification. This entailed the emergence of extended gates and with them extended forms of supply chain management in which inland terminals play an active role. As congestion increases, inland terminals will be even more important in maintaining efficient commodity chains. It can also be expected that resources will play a greater role within containerized trade with inland terminals, again underlining unique regional characteristics. This implies a set of repositioning strategies where inland terminals play a fundamental role either to improve the efficiency of this repositioning, by providing better cargo rotation opportunities, or by acting as an agent that can help promote containerized exports. Inland ports will take part of the ongoing intermodal integration between ports and their hinterland through long distance rail and barge corridors. They are likely to be more important elements within supply chains, particularly through their role of buffer where containerized consignments can be cheaply stored, waiting to be forwarded to their final destinations.

Like several stages in intermodal transport development, such as in port infrastructure, there is a potential of overinvestment, duplication and redundancy as many inland locations would like to claim a stake in global value chains. This appears to be the case in Western Europe where an abundance of inland terminals, particularly within the Rhine / Scheldt delta, is indicative of an over competitive environment and the waste of resources it implies. In North America, because of a different ownership and governance structure, the setting of an inland port, at least the intermodal terminal component, is mostly in the hands of rail operators. Each decision thus takes place with much more consideration being placed on market potential as well as the overall impact on their network structure. The decision of a rail company to build a new terminal or to expand existing facilities commonly marks the moment where regional stakeholders, from real estate developers to logistics service providers, readjust their strategies. In some instances, local governments will come with inland port strategies adjusting to existing commercial decisions in the hope to create multiplying effects.

The development of dry ports around the world has clearly underlined an emerging functional relation of port terminals and their hinterland. Based upon their regional setting, dry ports assume a variety of functions with co-location with logistical zones a dominant development paradigm. While the interest in dry ports has increased we have to be aware that no two dry ports are the same. Each dry port is confronted with a local/regional economic, geographical and regulatory setting which not only define the functions taken up by the dry port, but its relations vis-à-vis seaports. Best practices can only be applied successfully if one takes into account the relative uniqueness of each dry port setting.