Container Ship Routing: Panama Canal vs. U.S. Land Bridge

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In our work, we investigate choices for container ship transportation from the eastern Pacific to the western Atlantic based solely on time. Choices include traveling through the Panama Canal or using the U.S. as a land bridge (via truck and rail car). A breakeven methodology, given vessel size, is employed to discriminate between paths. Interested parties of our work might include those investigating multi-modal integration opportunities, those seeking transportation efficiencies in water, truck and rail, and students as a case assignment in Transportation and Logistics courses.

INTRODUCTION

A new era in container shipping is coming. The Panama Canal Authority will soon complete a third lane to the water-way that will double its capacity and allow access to the largest cargo-carrying vessels. However, the impact that the canal will have on global trade patterns remains to be seen. Roughly 65% of the goods sailing through the canal go to or from U.S. ports, and those ports and American rail-yards that compete with the canal will fight to retain as much business as possible (Lynch, 2009). Cargo from Asia, for example, can reach U.S. markets either through the canal or by docking at a west coast port and riding rail lines to inland or east coast destinations.

The issues of container transportation traffic and timely route choice are ones that increase in complexity, as opportunities for trade expand and supply chain activities evolve internationally. Today's container traffic moves mostly from the Far East to the U.S., Europe and other western ports. Two routes of choice have evolved over time. One is through the Panama Canal, and the other uses the United States as a land bridge where container ships dock on the west coast, unload, then travel by truck and/or rail car to the east coast and are loaded onto other container ships headed across the Atlantic.

Time is the variable of most importance in our work, as time is the common denominator to both distance and cost in this industry. "Estimated Time of Arrival (ETA)" is the cry of many ship captains and others in the industry, making time of arrival, dock time, and time of departure very important parameters in the shipping industry.

Our work begins with an explanation of how the U.S. is used as a land bridge. We then discuss how poor port productivity and congestion create dead time for vessels that end up waiting in a queue for service. We then give careful consideration to the impact of the Jones Act in restricting U.S. maritime commerce. Next, we discuss how canal expansion in Panama stands ready to alleviate port productivity and congestion problems by moving cargo to other areas for dispersion. Finally, we move to the development of our modeling methodology for determining best choice routing – through the Panama Canal or the U.S. land bridge.

THE U.S. LAND BRIDGE AND WEST COAST PORT TRAFFIC

European bound cargo from Asia has several options for reaching its destination. One would be to go west over many treacherous mountain ranges and several seas. Customs stops are required by many countries along the route, making the trip quite long and segmented. Another route would be to go east across the Pacific Ocean, cross the U.S. by rail or highway, then cross the Atlantic Ocean to reach Europe. This path takes the freight through only one country, requiring only one customs checkpoint. It is obvious that the second option may be longer in miles, but stands to be shorter in time, prompting those in the global transportation industry to refer to it as a "land bridge" across the U.S. When time is the important factor, the U.S. "land bridge" is the option many use. However, there is one bottleneck along the way – the U.S.'s west coast ports.

The Ports of Los Angeles and Long Beach are the first and second busiest container ports in the U.S, respectively. The Port of Los Angeles is located just north of the Port of Long Beach on the California coastline. Together, the two ports are known as the San Pedro Bay Ports. These two ports handle more than 40% of the nation's total containerized cargo import traffic and 24% of the nation's total exports (Port of Long Beach, 2007). Combined, the San Pedro ports moved 1.16 million containers in January 2012, up from 1.14 million a year earlier (White, 2012).

In turn, the large amount of cargo traffic has led to a rise in congestion at the two bustling ports. Such deep draft ports experience delays as space for increasing volumes of import and export cargo is limited by environmental and community concern factors. Congestion also occurs when vessels arrive at the same time rather than dispersed throughout the week (U.S. Department of Transportation, 2009). The time lost as a result of this bottleneck can be 3 to 6 days depending on the season (Conway Consulting, 2008). Even when ports can berth and unload ships quickly, the increasing size of container ships is moving congestion from ports to access roads, rail and highways (U.S. Department of Transportation, 2009). Such delays and congestion at the Long Beach and Los Angeles ports have shippers and receivers looking for more reliable, efficient options for transportation.

THE JONES ACT

The Merchant Marine Act of 1920, commonly referred to as the Jones Act, is a U.S Federal statute that regulates maritime commerce in U.S. waters and between U.S. ports (Brackins, 2009). Two parts of the Jones Act are of specific importance. The first part heavily supports American built, owned, and staffed ships. This was accomplished by restricting shipping and passenger trade within the U.S. to American-owned or American-flagged ships, and specifying that at least 75% of a ship's crew must comprise American citizens. In the second part of the Jones Act, the use of foreign parts and labor in ship construction and repair was also greatly restricted. This section of the Jones Act was created to produce a strong, well staffed merchant marine that could be responsible for efficiently serving the U.S. (Smith, 2010).

It is important to realize that at the time the Jones Act was enacted, a strong, resilient merchant fleet was crucial for a country's success and commerce. Today, the effects of the Jones Act have been felt widely in the shipping industry as foreign cargo vessels are not allowed to travel port-to-port in the U.S. – they must drop off and pick up only. In comparison to other nations that lack such cabotage restrictions, there has been a noticeable decline in the U.S. shipping fleet, losing out to the competition of other nations using alternate routes (Brackins, 2009).

THE PANAMA CANAL

The Panama Canal opened in 1914 and instantly revolutionized water transportation. For ships steaming between California and the east coast of the U.S., the canal turned a 15,000 mile journey around Cape Horn into a relatively swift 6,000 mile jaunt (Lynch, 2009). The current expansion includes dredging the existing channel to the depths needed for the largest cargo vessels. Table 1 contrasts the lock dimensions of the original canal lanes and the new lane.

TABLE 1
PANAMA CANAL LOCK COMPARISONS
(Panama Canal Authority, 2006)

Dimensions	Current Locks	Panamax	New Locks	New Panamax
Length	320.04 m (1,050 ft)	294.13 m (965 ft)	427 m (1,400 ft)	366 m (1,200 ft)
Width	33.53 m (110 ft)	32.31 m (106 ft)	55 m (180.5 ft)	49 m (160.7 ft)
Draft	12.56 m (41.2 ft)	12.04 m (39.5 ft)	18.3 m (60 ft)	15.2 m (49.9 ft)
TEUs		5,000		12,000

The centerpiece of the expansion is the pair of massive new locks at the Pacific and Atlantic canal entrances. Today, the largest ships that can use the canal are the *Panamax* class, capable of carrying about 5,000 standard shipping containers. They squeeze through the waterway's 110-foot-wode locks with just 2 feet to spare on either side (Lynch, 2009). Wider, deeper and longer than the existing portals, the new locks will handle a class of bigger ships known as *New Panamax* vessels, the world's largest cargo carriers, which can haul more than twice as many containers.

METHODOLOGY FOR ROUTE CHOICE

The methodology for route choice compares the sum of expected times and deviations from an import point to an export point on each side of the U.S. land bridge against the sum of expected times and variances using the Panama Canal. It is straightforward, but based on several assumptions:

1. Cost is not an issue. Any costs that arise will be passed on to the customer.
2. Import and export container ports work around the clock for loading, unloading, sorting, and preparing for additional container transportation.
3. There is adequate rail and highway infrastructure support, and an ample supply of trucks and rail cars to ferry containers across the U.S.
4. Container vessels of similar size are waiting at east coast ports to complete the journey.

Our expected time functions and three step methodology follows.

Calculation of Expected Travel Time across U.S. Land Bridge (μ_{lb})

$$\mu_{lb} = (t_i + t_r + t_t + t_e) + \sigma_{lb} \quad (1)$$

Where t_i = time at an importing port; t_r = time on a rail car; t_t = time on a truck, and t_e = time at an exporting port. A similar structure is used to determine the variance for the land bridge.

$$\sigma_{lb}^2 = (\sigma_i^2 + \sigma_r^2 + \sigma_t^2 + \sigma_e^2) \quad (2)$$

Calculation of Expected Sailing Time via the Panama Canal (μ_s)

$$\mu_s = (t_{ie} + t_{pc}) + \sigma_s \tag{3}$$

Where t_{ie} = sailing time from an import point to an export point, and t_{pc} = time through the Panama Canal. A similar structure is also used to determine the sailing variance.

$$\sigma_s^2 = (\sigma_{ie}^2 + \sigma_{pc}^2) \tag{4}$$

Step 1: Evaluation of Time based on Container Ship Size

Using equations 1 & 2, determine the expected total travel time across the U.S. land bridge from import point to export point for each container ship size of interest. Placing this data in a table may help during analysis.

Step 2: Evaluate Sailing Time using Panama Canal

Using equations 3 & 4, determine the necessary sailing time through the Panama Canal traveling from the same import and export points selected earlier. This value should be valid for any size vessel.

Step 3: Analysis

Inspect the container ship-land bridge travel times for a "breakeven" point created by the travel time through the Panama Canal. Linearly interpret the "breakeven" vessel size. Assign smaller ships to the U.S. land bridge and larger ships to the Panama Canal route. Total travel time should be minimized for a given size vessel.

CONCLUSIONS AND FURTHER STUDY

After reviewing the Panama Canal's exciting expansion news, we find that the U.S. transportation industry is poised for a revolution in container cargo movement in the near future. We studied the choice between traveling the U.S. land bridge or the Panama Canal using only one west coast and one east coast port – abiding by Jones Act restrictions. However, other maritime and Canadian opportunities may exist in the future creating a network of routes from which to choose.

Through the methodology presented here, we have been able to discriminate between route choices for container vessels based solely on ship size and time. In future research, we plan to explore more of the economic effects on commerce associated with shifts to and from the land bridge and the canal. The objective is to transfer a "perfect" shipment from point A to point B as cheaply, quickly and consistently as possible (Bowersox, et al., 2010). However, in the long run we expect that delivery speed (time) will still be the variable of interest in the shipping industry.

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