Chapter 3. Transportation Systems

Except for the basic utilities such as water, electricity, and natural gas, everything you consumed today has been transported to you on a truck.

3.1. Introduction

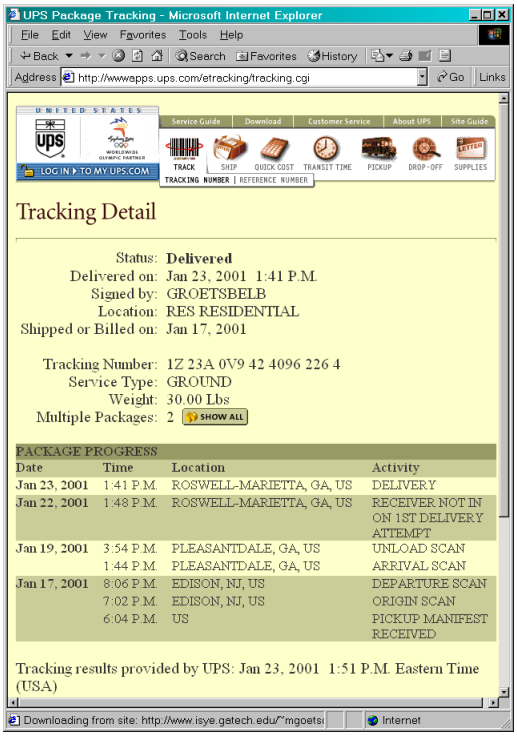

Figure 3.1. Web-Based, Real-Time Tracking of Shipments by UPS

3.2. Transportation Modes and Infrastructure

Introduction

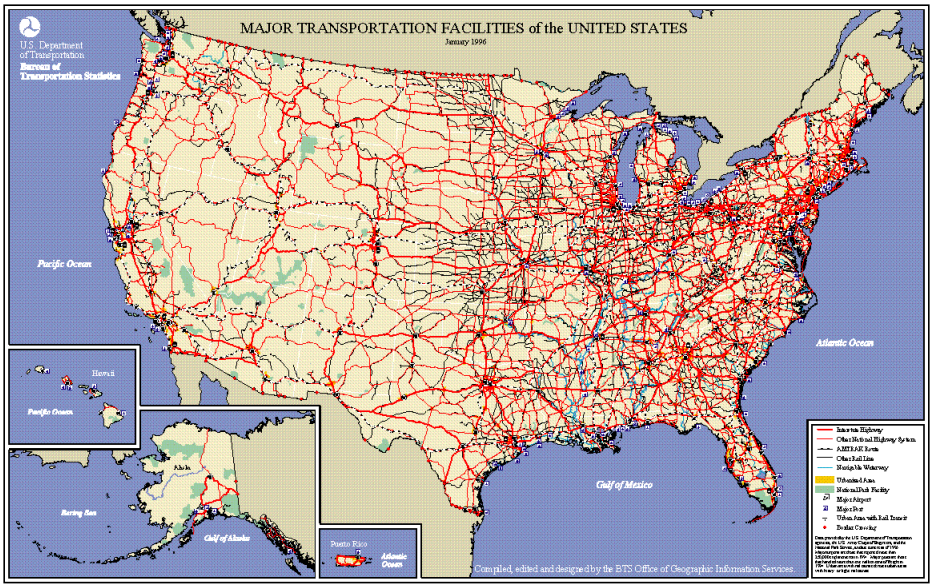

Figure 3.2. Major Transportation Infrastructure in the United States, 1996

Pipeline

A pipeline is a system of connected pipes for the transportation of liquids, gasses, and slurries. Slurries are fine solid particles suspended in a liquid. Pumps, valves, and other control devices control the flow. Products may be stored temporarily in storage tanks. Pipeline diameters can vary from a few inches in chemical refineries and oil gathering lines to more than 30 feet in water and sewage collection systems. Larger diameters are much more efficient. The Trans-Alaskan crude oil pipeline has a diameter of 48 inches. Pipelines inside the facilities are usually suspended from the ceiling and pipelines used for long distance transportation are usually laid underground, although the Trans-Alaskan pipeline is suspended on columns above the ground. Pipelines usually consist of sections of pipe made of metals, such as steel, cast iron or aluminum, concrete, or plastics. Pipelines can be used inside the facilities, on campus environments such as chemical refineries, over for long-distance transportation.

Pipelines have a very high initial construction cost, but once installed are highly cost efficient. The cost characteristics are similar to those for rail transportation. The variable cost included the cost for operating the pumping stations and the cost of moving the products. The ratio of fixed cost to total cost is highest among all the transportation modes. Rates for pipeline transportation are competitive with inland waterways and are three to four times smaller than for rail transportation. The average transportation speed of three to four miles per hour is not very large, but this is compensated for by the 24 hours a day, 7 days a week continuous operation. Pipelines form a highly dependable form of transportation since there are few interruptions that may cause transit time variability. Because of the nature of the products and the underground construction, weather does not significantly affect operations. Based on the above characteristics, pipelines are most suited to the transportation of high volume liquids and gasses. The most common examples of pipelines are the transportation of crude oil and refined petroleum products such as gasoline, natural gas, and coal slurries.

The costs of moving a product consist mainly of the power consumed in the pumping stations. The pumps must overcome the frictional resistance in the pipe, which is proportional to the circumference of the pipe. The volume capacity is proportional to the cross section of the pipe. So larger diameter pipes are much more efficient from the marginal cost point of view, provided there is enough product volume to justify the fixed cost of the larger diameter pipe.

Most pipelines are privately owned and are associated or affiliated with major oil companies. The pipeline companies own the pipe, terminals, and pumping stations and either own or lease the right of way for the pipe. The pipeline companies are classified as common carriers since they carry the products of all shippers.

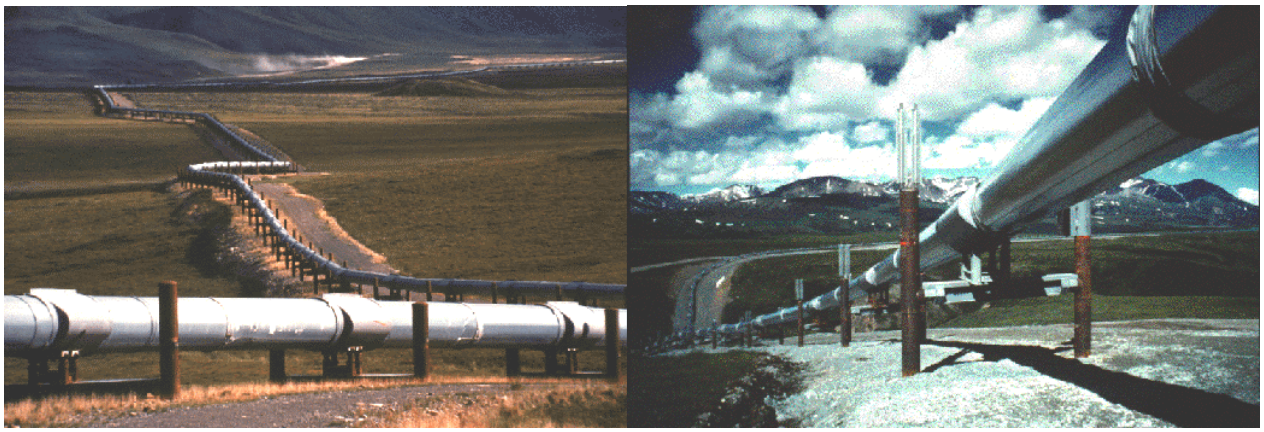

Figure 3.3. Two Views of the Alaskan Crude Oil Pipeline

Rail

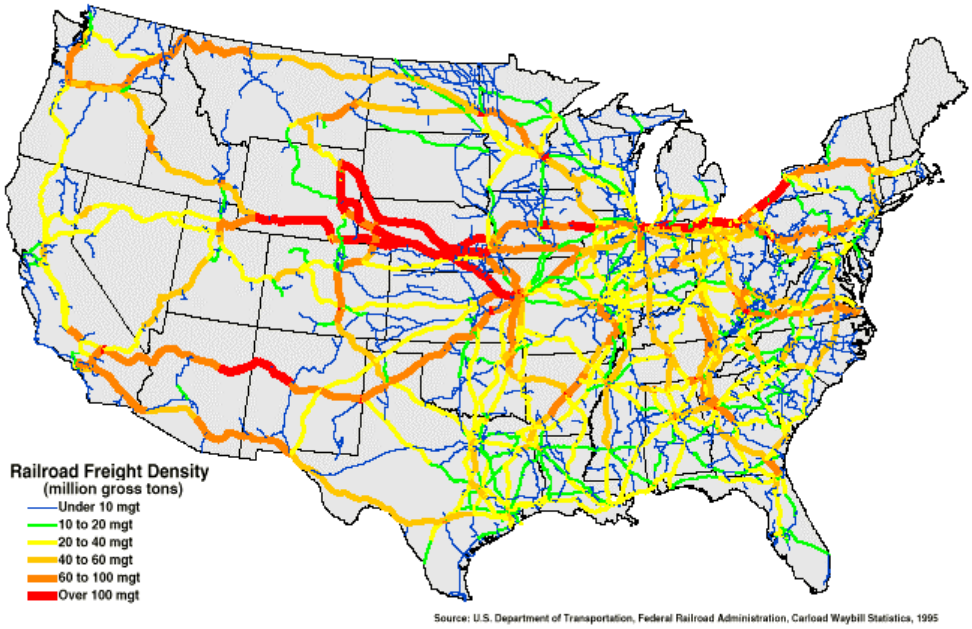

Figure 3.4. Railroad Freight Volumes in the United States, 1995

Figure 3.5. Railroad Switching Yard

Roadway

Examples of a long-haul tractor-trailer truck, used primarily in inter-city transportation, and of a city delivery truck are shown in the next figures.

Figure 3.6. Tractor-Trailer Inter-city Truck Example

Figure 3.7. Local Delivery Truck Example

Figure 3.8. Over-the-Road Trailer Yard

Depending on the type of goods transported, over-the-road vehicles can be capacitated because of their volume, or cubed-out, or capacitated because of their weight-carrying limit, or weighted-out. These two types of capacity constraints are illustrated in the next two figures.

Figure 3.9. Weight-Capacitated and Volume-Capacitated Vehicles

Ocean Going

Figure 3.10. Examples of Ocean-Going Crude Carriers

Figure 3.11. Top View of an Ocean-Going Crude Carrier

Figure 3.12. Specialty Ocean-Going Transportation

The USS Cole is being ferried from Yemen to the United States, October 2000. The carrier had to take the roundabout route around the Cape Point, at the southern tip of Africa, because it would not fit through the Suez Canal. A similar situation exists with respect to the Panama Canal, where some ships are so large that they cannot fit in the various locks when crossing the Panama Canal. Such ships are called "Post Pana-Max" ships since they cannot be used for an "all water" route via the Panama Canal between the Atlantic and Pacific Ocean. Some of the largest containerships when coming in from Europe will discharge first in the Halifax port because of its very deep port. After discharging some of its containers the ship will not lie as deep in the water as when fully loaded and then the ship can continue to more shallow harbors further south along the US East Coast.

Figure 3.13. Containership in a Lock of the Panama Canal

Intermodal Transportation Systems

Figure 3.14. Examples of Ocean-Going Intermodal Container Carriers

Figure 3.15. Material Handling Equipment in an Intermodal Container Port
(Photo of Europe Combined Terminal (ECT), Rotterdam, The Netherlands)

Figure 3.16. Examples of Intermodal Container Carrier Being Unloaded

Figure 3.15 shows an example of the required material handling equipment to unload an ocean-going container ship in a semi-automated manner. The tall cranes on the right are the quay cranes that unload the containers from the ship. The schedule of unloading operations is computer-generated, but the movements are controlled by human operators. The containers are then placed on the orange automated guided vehicles (AGVs), of which one is shown in the foreground. The AGVs are fully computer controlled. The AGVs transports the container to the stacking cranes, shown on the far left. The stacker cranes pick up the containers from the AGVs and put them in stacks of up to three containers for temporary storage. Later the stacker cranes will pick up the containers again and take them to waiting trucks or railroad cars. The stacker cranes are also fully computer controlled. Maximizing the throughput and responsiveness of the combined material handling systems requires extensive computer support for the execution and planning of material handling moves and stores. The feasibility and efficiency of the scheduling rules are tested by a large simulation model of the combined material handling devices. The system shown is installed at the container port of Rotterdam in the Netherlands. Similar automated container unloading operations are also under consideration in the ports of Singapore, Hong Kong, and Inchon, South Korea. Figure 3.17 shows an intermodal container being deposited by crane on yard truck that is driven by human operator.

Figure 3.17. Intermodal Container on Yard Truck and Road Trailer

In 1998 the Sovereign Maersk is launched and becomes the world's largest container vessel, able to carry over 6,500 20 ft-long containers (TEUs or Twenty-foot Equivalent Unit). The Europort of Rotterdam, the Netherlands, has become the largest container terminal in the Europe, with Europe with over 6 million containers shipped in 1998.

Air

Figure 3.18. Wide-Body Commerical Cargo Aircraft

Figure 3.19. Lockheed C5 Galaxy Wide-Body Military Cargo Aircraft

Figure 3.20. Lockheed C5 Galaxy Cargo Aircraft Loading a Tank

Figure 3.21. Russion Cargo Aircraft Loading a Lockheed EP3 Plane

Space

Increasingly the transportation operations into space and in particular into low orbital space are evaluated by the same criteria of performance and price as the more traditional transportation operations. Building the international space station, that will circle the earth in the 21st century, will require numerous space carrier trips from earth to a low orbit. According to the Atlanta Journal and Constitution the average cost of launching one pound into earth orbit at the end of 1999 was about $5000 (AJC, 19 September, 1999, pp. G4).

Figure 3.22. Landing of an Orbital Space Carrier

3.3. Exercises

True-False Questions

A first order approximation of the weight capacity of an over-the-road trailer is 20 metric tons, (TF) _____(1).

A freight bill for a shipment does not include prices and rate information for that shipment, (TF) _____(2).

A freight bill is a legal contract between the shipper and the carrier for the movement of the designated freight between the indicated sites, with reasonable dispatch, and without damage, (TF) _____(3).

A slurry is transportation technology where solid products are suspended in liquid and then pumped through a pipeline between different locations, (TF) _____(4).

A transport broker functions as the middleman between the carrier and the shipper and assumes liability for the timely transportation of the goods, (T/F)_____(5).

Consolidation will yield relative greater benefits if the original shipment size is larger, (TF) _____(6).

Contract carriers hire themselves out to service all shippers that want to use their services, (TF) _____(7).

Demurrage refers to the penalty charges imposed on a shipper if it retains a transportation carrier beyond an allowed free time period, (TF) _____(8).

Empty container management, movement, and storage are significant costs for the logistics systems using intermodal containers, (T/F)_____(9).

F.O.B. pricing means that the sales price includes the transportation costs to the final customer, (TF) _____(10).

Low variable costs and high fixed costs create significant economies of scale in railroad transportation costs, (TF) _____(11).

Piggyback refers to the shipment of over the road containers in a convoy of trucks, (T/F)_____(12).

Railroad corporations have a higher fixed cost but lower operating cost than a highway transportation corporations that can handle equivalent transportation requests, (TF) _____(13).

The average amount of goods in a LTL shipment is larger than in a CL shipment, (T/F)_____(14).

The average delivery time is inversely related to the cost per flow unit per mile in the major transportation modes, (TF) _____(15).

The fundamental principle of freight consolidation is to reduce costs by achieving economies of scale on the transportation moves, (T/F)_____(16),

The rates for first class mail in the United States are an example of uniform or distance-invariant rates, (TF) _____(17).

The relatively low fixed costs of highway motor carriers tend to create a larger turnover of carrier corporations than for other transportation modes, (TF) _____(18).

The standard size for a full size intermodal container is 8 by 8 by 40 feet, (TF) _____(19).

3.4. References

1. Ballou, R. H., (1999). **Business Logistics Management**, 4th Edition, Prentice Hall, Englewood Cliffs, New Jersey.