Logistics for the Public Sector

Introduction

This training course was developed to help members of the public sector understand the motivations and constraints of their private sector counterparts in the movement of freight. Our economy is now more than ever dependent upon the efficient movement of freight. Figure 1 illustrates how Gross domestic Product (GDP) and total employment have historically tracked very closely to changes in measures of freight movement. Truck vehicle miles of travel (VMT) and intercity truck ton miles both parallel the changes in GDP and employment.

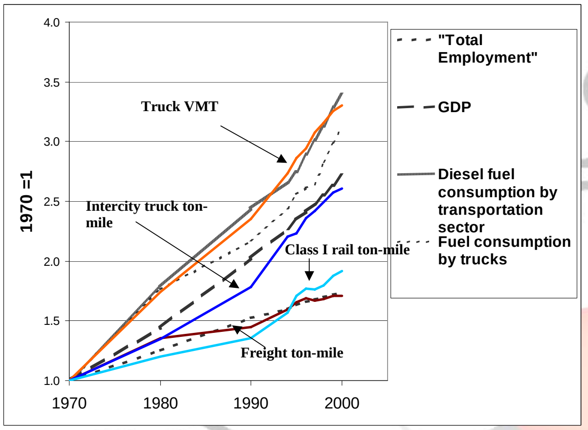

Figure 1. Freight and the Economy
Source: MRUTC

While our economy has always been dependent upon the movement of goods, the 21st Century brings with it new and growing challenges. Figure 2 is a map prepared by the Federal Highway Administration (FHWA) illustrating the routes across the nation that were operating at or near capacity based on 1998 data.

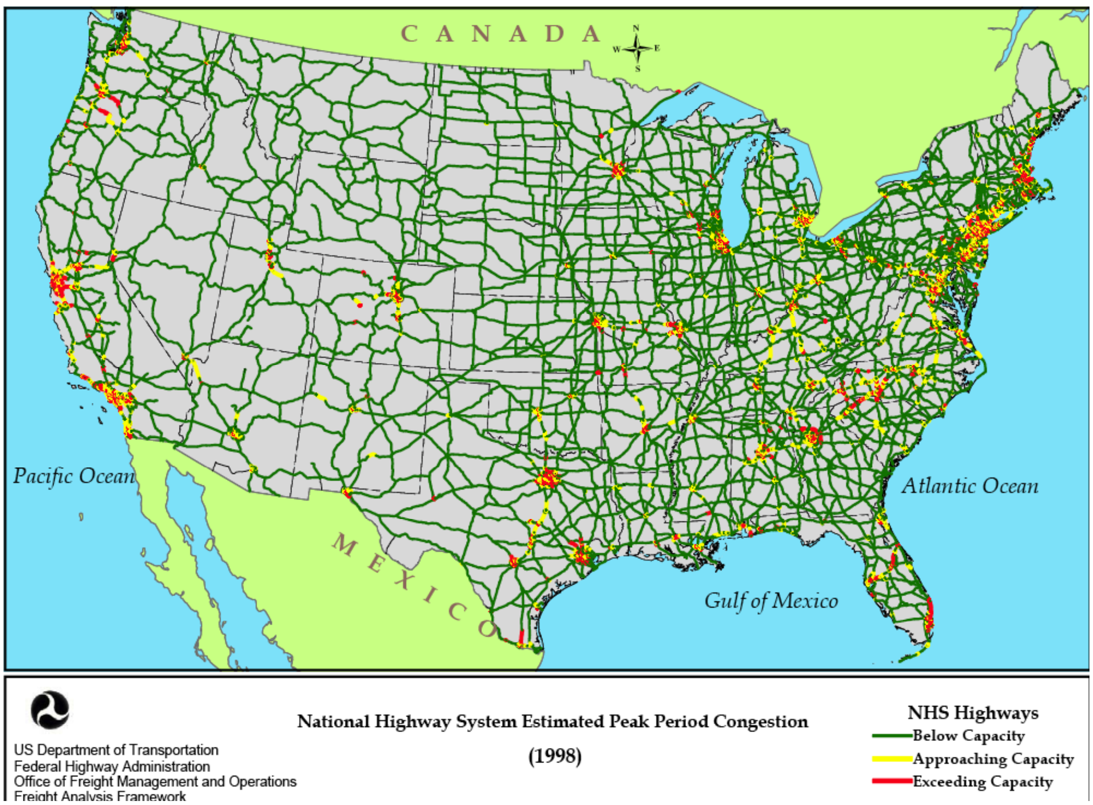

Figure 2. National Highway Congestion--1998

As Figure 2 illustrates, many routes in our major urban centers had exceeded their design capacity in 1998. While congestion is measured based on all vehicles in the traffic stream, trucks are a growing percentage of that stream and they present unique challenges for traffic flow. Growth in freight did not stop in 1998 as is noted in the recently released report by the Bureau of Transportation Statistics (BTS) subtitled: *A Decade of Growth.* In it they outline the change in national ton miles for the decade of 1996 to 2005. The sidebar at left provides a definition of a ton mile. Over those ten years, ton miles grew by more than 20%, with the largest growth in rail and trucking. See Figure 3.

> **What is a ton-mile?**
> A ton-mile is defined as one ton of freight shipped one mile and, therefore, reflects both the volume shipped (tons) and the distance shipped (miles). Ton-miles provide a key measure of the overall demand for freight transportation services, which in turn reflects the overall level of industrial activity in the economy. In addition, ton-miles are used to calculate other measures of transportation system performance, such as energy efficiency and accident, injury, and fatality rates.

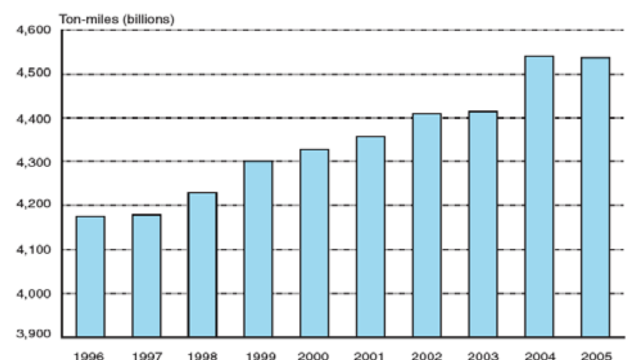

Figure 3. Growth in Ton Miles

Source: BTS Decade of Growth

Rail, truck, and air usage increased over the 1996-2005 period while pipeline and water decreased. Figure 4 illustrates these trends graphically.

Later, we will look at some of the details of the modal share trends to try to understand their significance for the public sector practitioner.

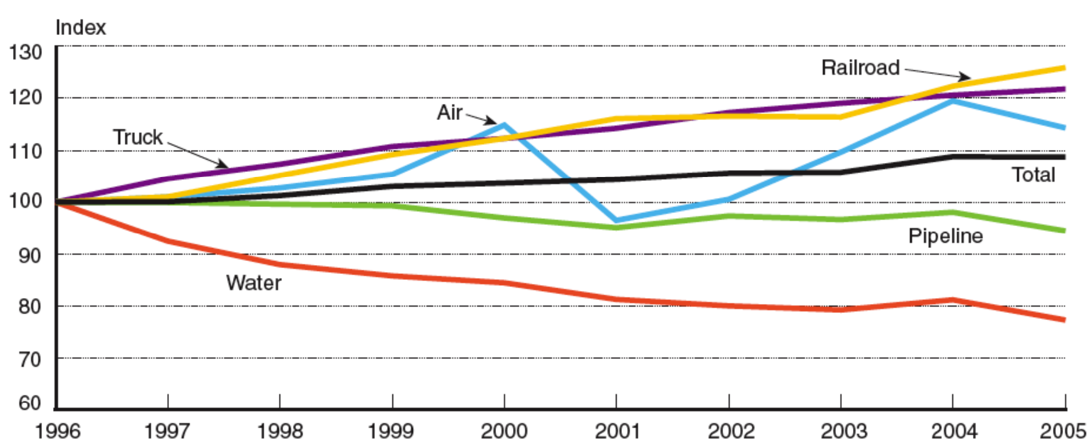

Figure 4. Modal Share Trends

The result of this growth and its expected continuation in the future is illustrated in Figure 5. As projected by the FHWA, many more miles of American highways will be operating near or beyond their design capacity by the year 2020.

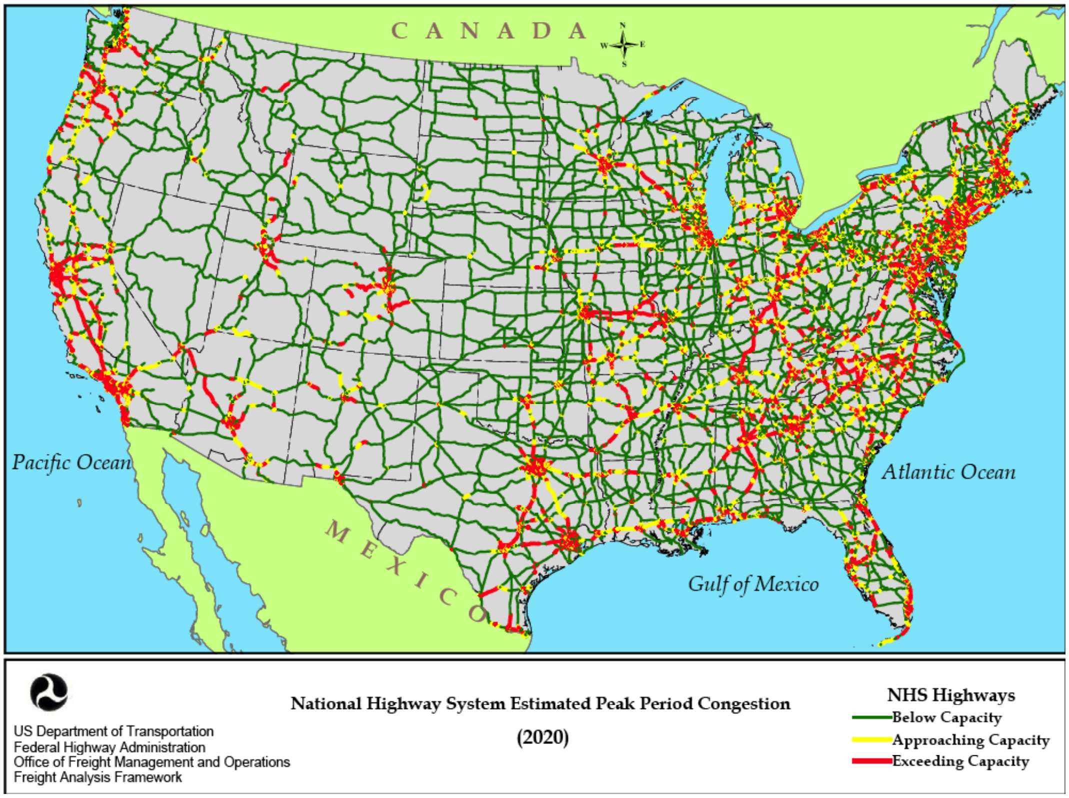

Figure 5. Highway Congestion--2020

Highway congestion is a challenge for public sector agencies, and in the future, historic responses alone will not suffice. The public sector will have to seek new solutions, many in concert with other public agencies and with the private sector. Doing this will require a deep understanding of the objectives and challenges that guide and confront private sector companies, both shippers and carriers, as they pursue their businesses. This course should be a useful first step for many public sector agents in gaining that understanding. For others, it may be a useful fifth or sixth step.

A Quiz

Before we go deeper into the topic, a short quiz may help you to assess your current level of understanding of the freight, logistics and supply chain world.

1. According to FHWA, what portion of the average state truck tonnage simply passes through the state?
2. In 2002 what percent of the 19.3 trillion tons of freight shipped in the US was domestic?

3. Which country is the US's largest trading partner?
4. In 2002 how many people were employed by American railroads?
5. In 2002 what was the total revenues of class I railroads?
6. In 1997 what portion of the US GDP was involved in international trade?
7. What is generally used as the haul length needed to make rail economic?
8. Between 1980 and 2000, which grew fastest: overall VMT, truck VMT, or lane miles of highway?
9. How many trucks would it take to carry the load of one Columbia River barge?
10. What is the value of an average ton of freight moved by air relative to that of truck?

Answers are in appendix A

Logistics and Supply Chains

The title of this course is 'Logistics for the Public Sector'. Understanding two key terms is a way to start. Supply chain management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. Essentially, supply chain management integrates supply and demand management within and across companies. See Figure 6.

Figure 6. Supply Chain Management

Figure 7. Logistics Management

Logistics management is that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements. See Figure 7.

Logistics is considered to be part of the supply chain management that deals with materials movement and storage. Of course, supply chain has other components such as partnership management. In addition, transportation is part of the logistics activities. In this course, we mainly focus on logistics activities. But some supply chain concepts are also introduced as they provide the background of logistics management.

A Supply Chain

A supply chain includes all of the organizations and processes that are involved in storing, moving and recycling from raw materials to final consumption. Figure 8a illustrates a fairly simple supply chain.

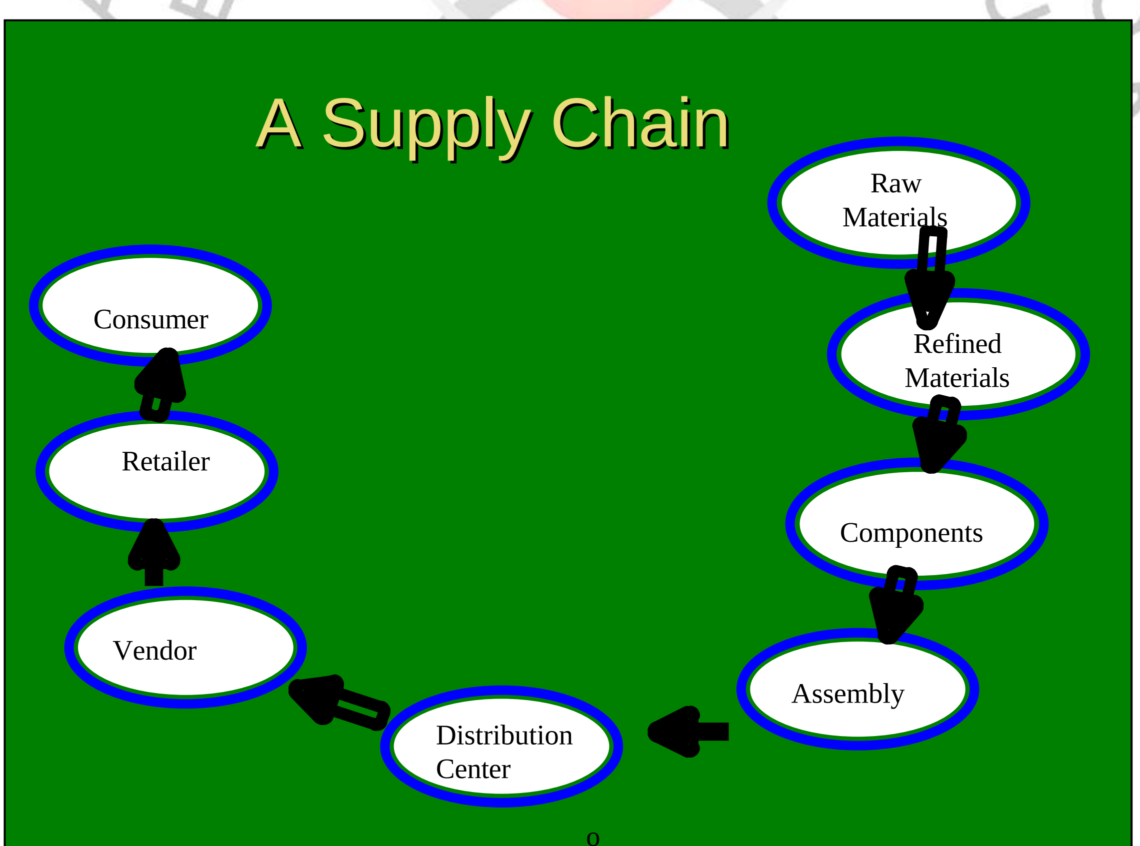

Figure 8a. A Supply Chain

Take automobile industry as an example. Raw materials in the form of iron ore, coal, petroleum and other items are mined. These raw materials ae refined into various types of steel, plastics and rubber. These refined materials are transformed into fenders, frames, engines, dashboard and tires. The components are then assembled into finished automobiles. Some companies, such as Ford, ship finished autos to staging areas, much like distribution centers. From these centers, they are shipped to dealers, who generally function as a retailer and a vendor. The purpose of the retailer is to move the autos to customers.

We could track this further. As autos are scrapped, they become raw materials for other products, and the cycle continues.

The supply chain may be fairly simple and small or it may be very complex, as it the case of the Boeing Dreamliner, which is summarized in the following:

The Boeing Dreamliner

Creation of Boeing's new Dreamliner is an illustration of globalization. It has parts from ten countries and nineteen manufacturers. Figure 8b demonstrates the origin of each of the planes parts.

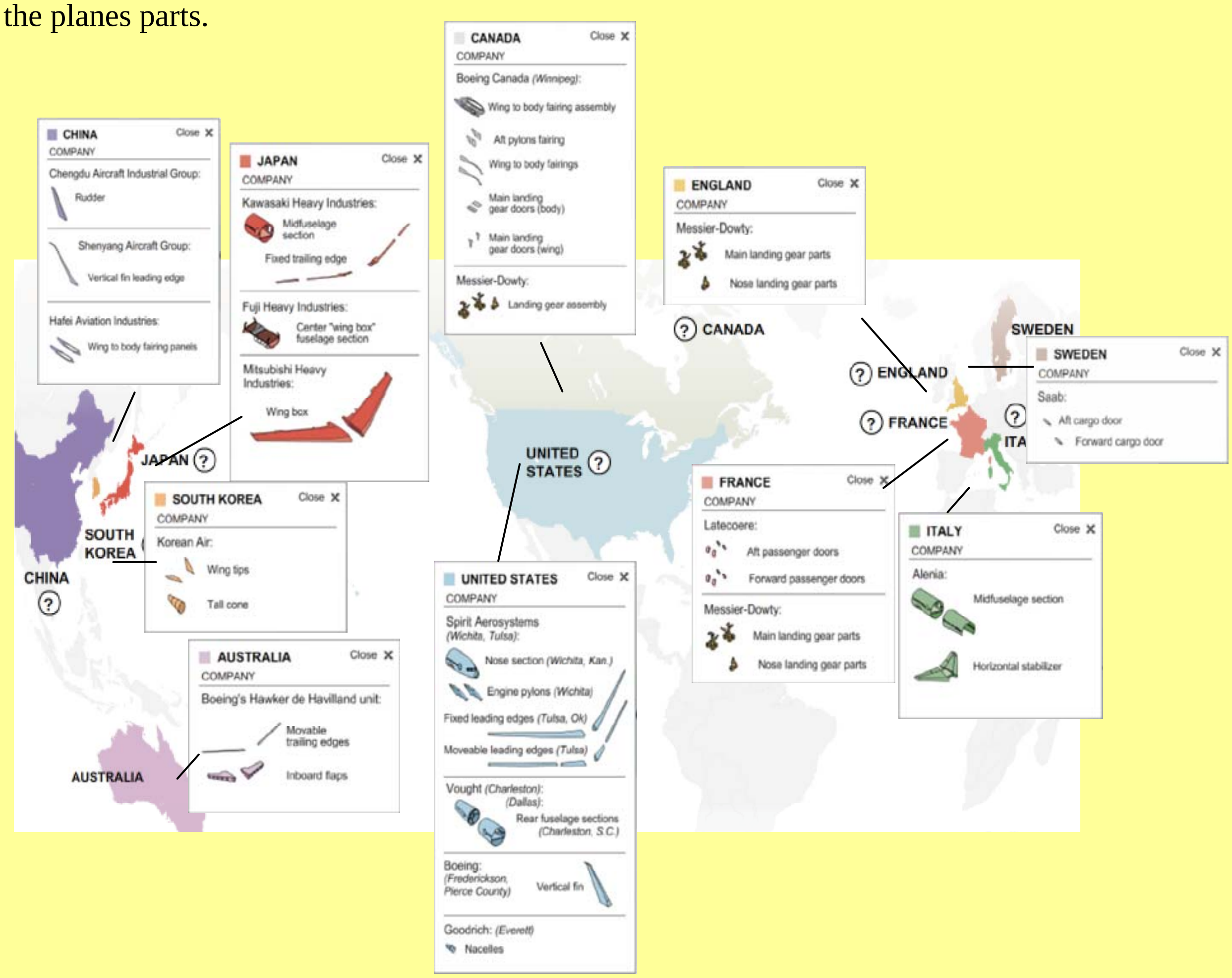

Figure 8b. Dreamliner Countries of Origin

This distributive manufacturing is particularly surprising since historically both companies and nations have held aircraft technology very closely. In fact, this is the first time Boeing has outsourced the production of key parts such as wings. Figure 2 illustrates the assembly of the plane.

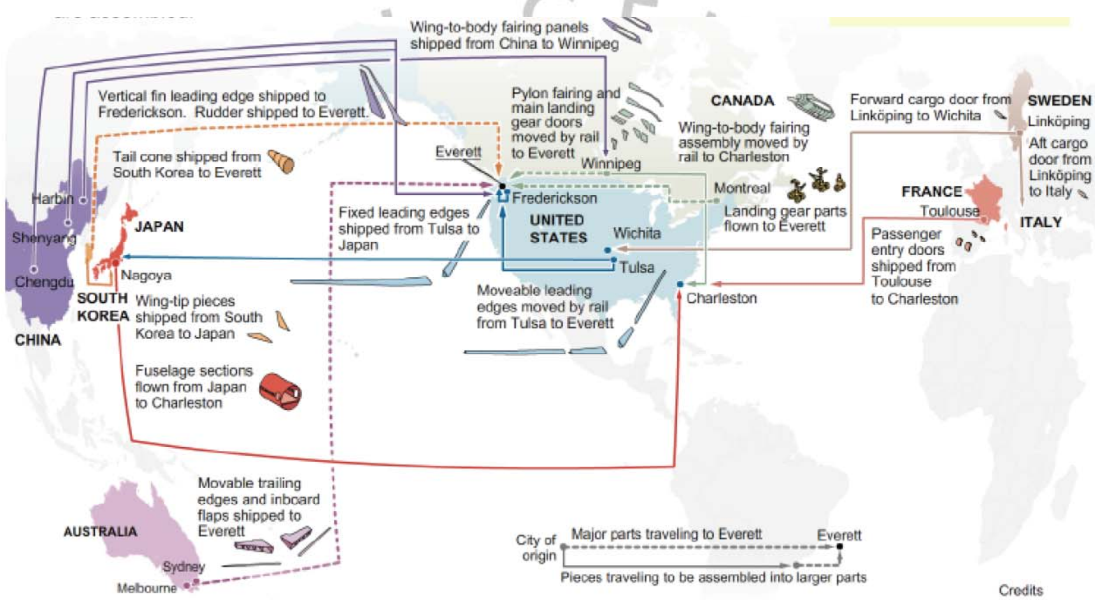

Figure 8c. Dreamliner Assembly

As shown above, many of the parts make stops for subassembly at places across the world before coming to Everett, Washington for final assembly.

Source: The Seattle Times

Total Cost Competition

Businesses exist to serve the needs of their customers. To stay in business, they have to make a profit. To make a profit, they must hold down costs. Costs are incurred in each step of the supply chain in Figure 9.

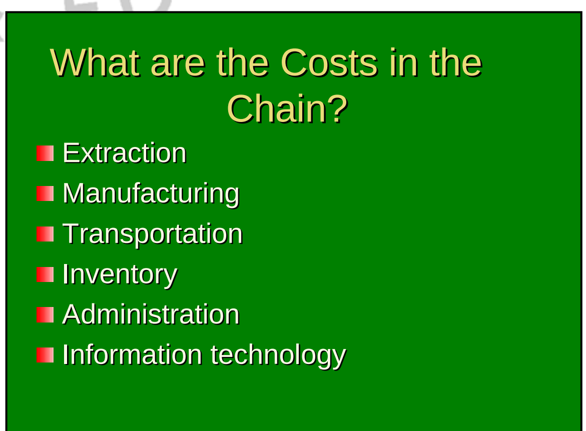

Figure 9. Supply Chain Costs

Obtaining raw materials (extraction) and manufacturing are fairly clear cost issues. The process of mining, drilling, or harvesting involves the use of capital and labor. Transportation is also a fairly clear cost item. To move a product or material from one place to another involves the use of energy, labor, and capital equipment. Inventory, administration, and information technology are more subtle, but they are equally important.

Transportation costs occur throughout the supply chain. If we look at the supply chain again in Figure 10, each of the arrows represents a step in the transportation process. It may be from one building to the next in a manufacturing complex, or it may be across a continent or an ocean, as in the Dreamliner example.

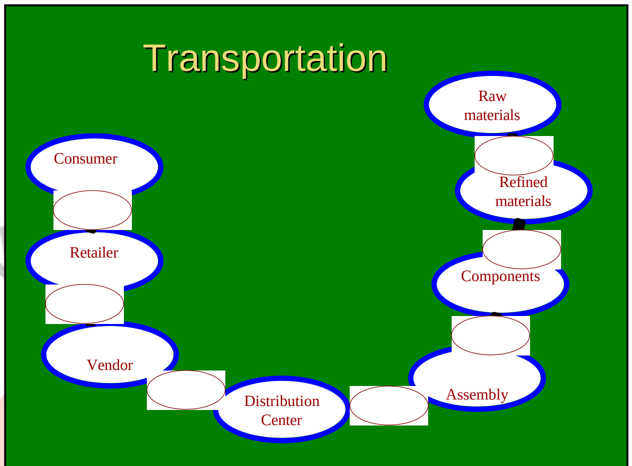

Figure 10. Transportation Costs

Inventory and administration costs exist throughout the supply chain. Capital costs involved in inventory are easy to understand. Every dollar tied up in inventory, either in the inventory itself or the cost of storing the inventory, is not available for other more productive uses. Capital costs are only one of the several costs associated with inventory, as shown in Figure 11. Shrinkage is simply the cost of breakage, theft, and loss throughout the supply chain. Uncertainty is a calculation of risk. For example, buying a large inventory of Christmas stock assumes that the holiday season will be economically robust. Selecting a large supply of a specific toy assumes that the toy will be popular. If either of these assumptions is wrong, the merchandise may go unsold, or sold at a substantial discount. Finally, obsolescence is a cost when a product suddenly becomes less desirable to consumers. If you were a computer wholesaler or retailer, you would not want a large supply of Mac G 3s when the G 4 hits the market. Similarly, if you are in the auto business, you probably do not want a lot full of SUVs when the price of fuel hits $4 per gallon.

- Capital
- Shrinkage
- Uncertainty
- Obsolescence

Figure 11. Inventory Costs

Logistics experts usually estimate the cost of inventory to be between 10% and 25% of purchase price, depending on the product involved.

Administrative costs are also fairly straight forward, but can be high or low based on business practices. For example, the cost of procurement can be very high if a truly competitive process is used for each item. It may be lower if longer-term relationships are built with suppliers.

- Procurement
- Accounting
- Transfer management
- Finance
- Customs clearance
- Personnel
- IT

Figure 12. Administration Costs

All of these costs are significant because companies do not compete only on the cost of production; they compete based on their cost as it reaches the customer. Figure 13 illustrates this with the costs associated with growing and marketing soybeans in the US in South America. The three countries have very different costs of production, but the costs of transportation and marketing are sufficiently different that the costs at market are similar. This table is significant because a decade earlier the same information would have totaled to a significant US advantage in final costs because the South American cost of transportation was much higher. Recent investments in transportation infrastructure by those countries have significantly reduced transportation costs.

	US	***Brazil***	***Argentina***	
Cost Item ($/bu.)	**Hinterland**	**Mato Grasso**	**Parana**	**Santa Fe**
Production cost	5.11	4.16	3.89	3.92
Internal transport & marketing cost	0.43	0.85	1.34	0.81
Cost at border	5.54	5.01	5.23	4.73
Freight to Rotterdam	0.38	0.57	0.57	0.49
Price at Rotterdam	5.92	5.58	5.80	5.22

Figure 13. Cost of Soybeans Delivered To Rotterdam

Source: North Dakota

	Case #1	**Case #2**	**Case #3**
Extraction	$5.00	$5.00	$5.00
Manufacturing	$10.00	$8.00	$12.00
Product cost	$15.00	$13.00	$17.00
Transportation	$5.00	$5.00	$3.00
Inventory	$3.00	$4.00	$1.00
Administration	$3.00	$5.00	$1.00
IT	$2.00	$3.00	$1.00
Total cost	$28.00	$30.00	$23.00

Figure 14. Total Cost Competition

Figure 14 is a hypothetical example of

total cost competition that relates back to the cost items discussed earlier. Figure 14 demonstrates how the initial lowest cost producer can be the total cost loser if other costs are uncontrolled.

Since logistics is primarily concerned with transportation and inventory as items of cost concern, we will focus on those two items.

The following summary of the life of a t-shirt helps to illustrate how total cost competition can move raw materials and finished products over long distances.

The T-Shirt

The simple souvenir t-shirt that many of us buy while on vacation may well have traveled all around the world. Writer Pietra Rivoli traced the history of a t-shirt she bought in Fort Lauderdale, Florida. It was a typical beach scene t-shirt, but she was surprised to find that it was born in Lubbock, Texas, took form in Shanghai, China, and was finished in Miami, Florida. Figure 1 outlines the travels of her vacation t-shirt.

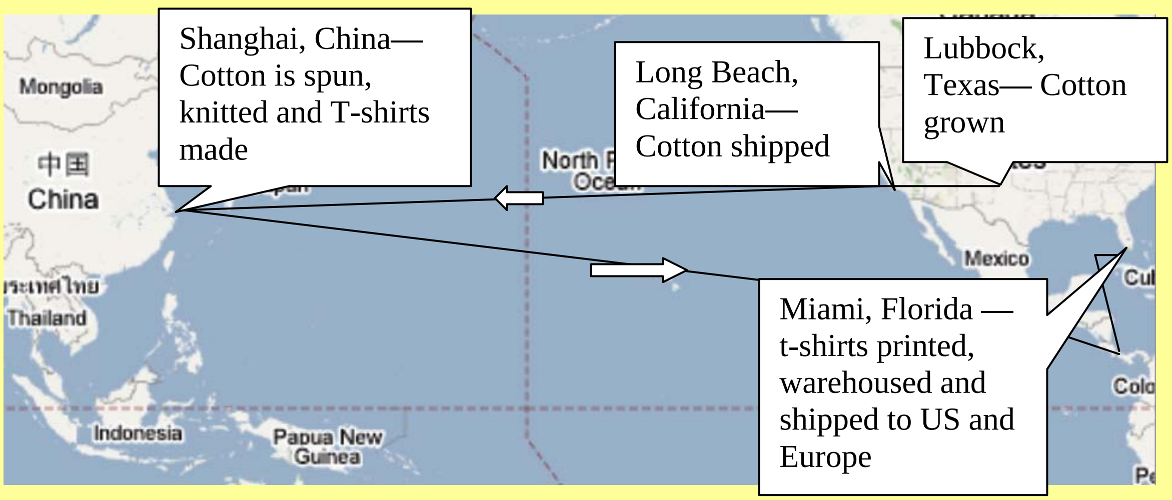

Figure 6. T-shirt Journey

The cotton that will become the t-shirt is grown near Lubbock, Texas. There it is ginned, cleaned and baled. The baled cotton is shipped by truck to Long Beach, Florida. At Long Beach it is put on a ship and shipped to Shanghai, China.

In Shanghai, it is cleaned again, spun into thread, knitted into fabric, and sewn into t-shirts. The t-shirts are made for a company in Miami, which has contracted for them. Shanghai is only one location from which the company contracts for t-shirts.

The finished t-shirts are loaded onto ships that cross the Pacific, move through the Panama Canal, and then to Miami.

In Miami, the shirts are finished with artwork depicting beach scenes, mountains or rivers, warehoused and shipped to tourist spots across the US and Europe.
Source: Rivoli

Managing Inventory

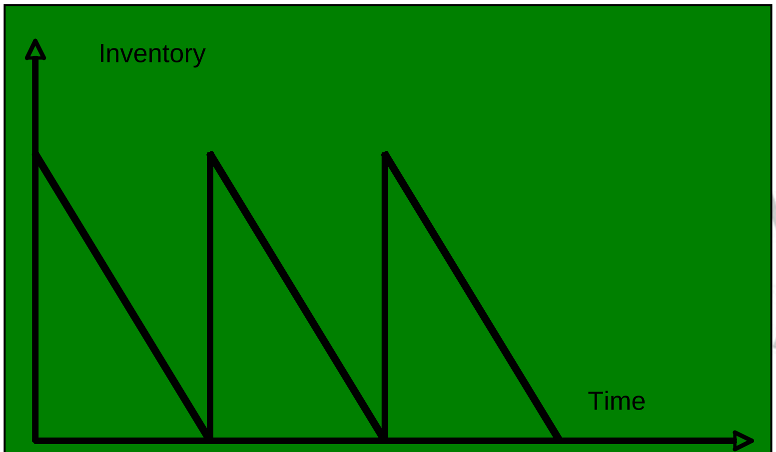

Figure15. A Cyclical Inventory

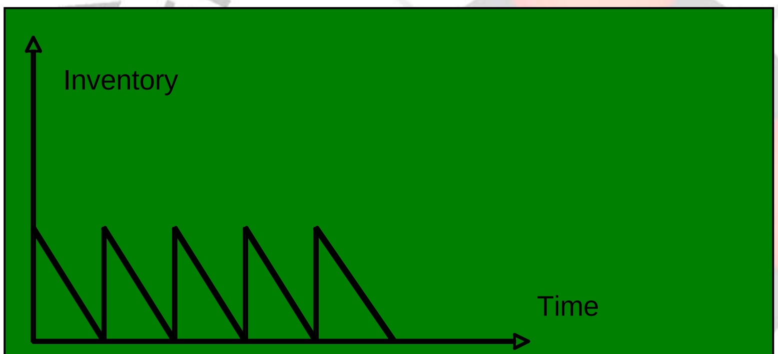

Figure 16. Alternative Cyclical Inventory Pattern

Managing inventory involves two competing objectives: Minimizing the cost of owning and storing inventory and having a sufficient supply available to meet the needs of customers or of production. Figure 15 illustrates a predictable cyclical inventory pattern. In this example, inventory is always used at the same rate and replenished at the same interval to the same level. This would be a fairly easy inventory to manage while meeting both competing objectives.

Figure 16 illustrates another approach to managing the same inventory. Again, the inventory is always consumed at the same rate. It is replenished at regular intervals and always to the same level. The difference is that now the intervals are shorter and the maximum inventory levels are lower. The manager is reducing the cost of holding inventory, but probably increasing costs related to transportation and administration, since deliveries would be more frequent and handling of orders and deliveries would also be more frequent.

More frequent shipping

- Reduces inventory costs
- Increases transportation costs
- Increases service requirements

Larger order quantities

- Reduce transportation costs
- Increase inventory costs
- Reduce service requirements

Figure 17. Inventory Management Trade-offs

Figure 17 summarizes these trade-offs. Keeping a low volume of inventory and utilizing frequent shipping reduces inventory costs but increases the costs associated with managing and transporting a greater number of orders and deliveries. Larger volume inventories have the opposite impact.

Unfortunately, inventory patterns are rarely as uniform as the previous illustrations suggest. Figure 18 outlines a more erratic pattern. Inventories are used over shorter and longer periods of time. This makes management more difficult, because the goal is to always have enough product on hand to meet demands while having as little inventory as possible to hold down the costs.

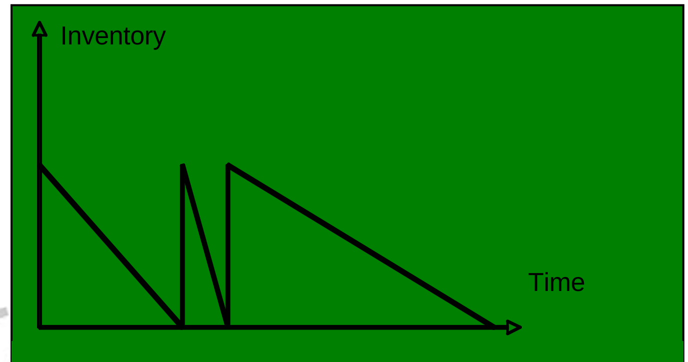

Figure 18. Uneven Inventory Cycle

The manager seeks to avoid the problems suggested by Figure 19 by maintaining a safety stock. This is the minimum stock level that is needed to meet higher than expected demand before a new inventory order can be received: If it takes two days for an order to be received once it is placed and the most that will reasonably be consumed is six units per day, a new order should be placed when the inventory reaches twelve.

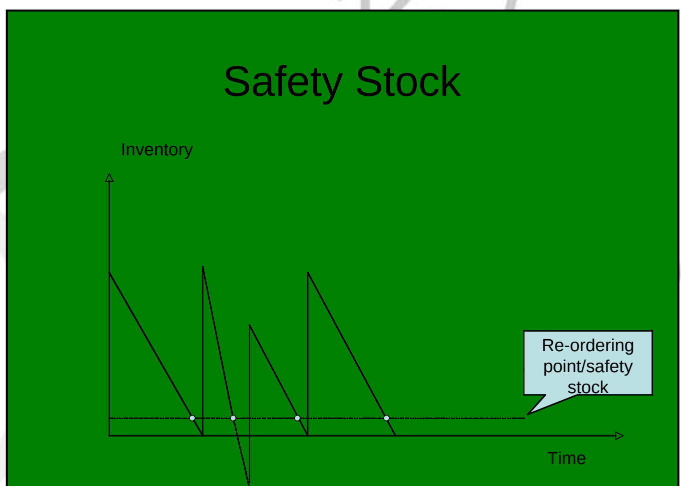

Figure 19. Safety Stock

Figure 20 lists the key issues that must be considered in finding a safety stock level. Uncertainty in demand and time of delivery tend to increase estimated safety stock levels. The cost of holding the inventory lower safety stock levels. Ultimately, the issue comes down to the level of risk the manager is willing to take in not meeting the needs to customers or production, and the costs of failing to meet those needs.

- Uncertainty in demand
- Uncertainty in delivery
- Cost of holding
- Cost of transportation
- Cost of administration

Figure 20. Issues in Safety Stock

Because they compete on a total cost basis, many companies have adopted a Total Cost Inventory Management system. This may be known as Total Cost of Acquisition or Total Cost of Ownership. This is an acquisition and inventory management system that regularly evaluates all of the costs listed in Figure 20 and places orders at times that minimize total cost.

Inventory and production managers have developed a number of strategies for addressing the competing needs of holding down costs while assuring adequate inventory. We will consider briefly three of those strategies: Just-in-time (JIT), Pull logistics, and on-demand manufacturing.

- Targeted delivery window
- Little room for error
- Severe consequence of error

Figure 21. JIT Constraints

JIT is probably the best known strategy. It involves substituting a high level of transportation services for inventory. In an extreme case, an assembly plant might not hold any safety stock. The inventory would be held in trucks until it was needed. Trucks would always be at the unloading docks. Components would move directly from the truck to the assembly line. Trucks become the rolling warehouse for the industry. While this strategy does minimize inventory costs, it does have some shortcomings. Figure 21 lists the three major issues. The window within which delivery can be accepted may be very narrow. If the truck arrives too soon, the dock will not be available and no parking may be available. If it arrives too late, production may have to stop for want of parts. If the production process is at all complex, the delivery windows for dozens of components may have to be coordinated. The consequence of error can be extreme. For example, if deliveries are delayed because of an accident on the freeway, production time may be lost and there could be significant costs in non-productive labor and machine time.

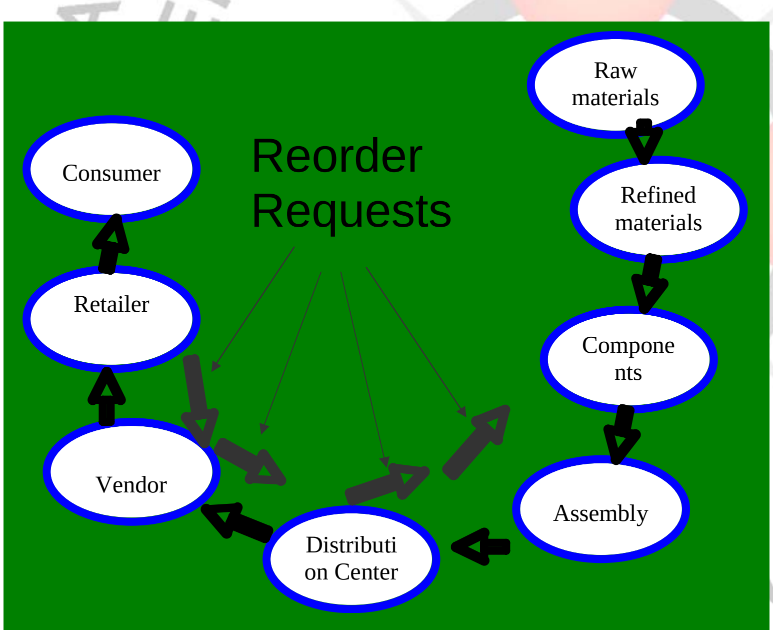

Figure 22. Pull Logistics

Another popular inventory management strategy is pull logistics, illustrated in Figure 22. It uses sophisticated information management systems to trigger reorder requests back through the supply chain to maintain planned inventory levels. In one example, a cash register transaction will update the inventory as you purchase items from a retailer. If the remaining inventory is at or below a set level, a reorder is automatically sent to the supplier. As inventory is removed from the supplier's warehouse, the inventory there is updated. Again, if inventory reaches a trigger point, a reorder will be sent to the next supplier in the chain. Such a system always maintains the desired inventory. It can also be used to communicate changing levels of desired inventory throughout the supply chain, thus minimizing unused or unwanted production.

Pull logistics is often contrasted with push logistics. In the latter case, the manufacturer has sent, or pushed, product to distribution centers, vendors and retailers in the hope that it would be sold. To some degree, we can still see this used in the auto industry. Autos are produced and shipped, to some degree without regard for immediate demand. If the demand does not materialize, the inventory must be reduced through discounts and other incentives to purchasers.

Successful pull systems are very dependent on sophisticated information management systems. They usually require long-term, more managed, relationships between the members of the supply chain. They also require higher transportation service levels, since shipment quantities will tend to be smaller and at less predictable intervals.

On-demand manufacturing can be seen as an extreme version of pull logistics. Figure 23 outlines the way that Dell Computer company uses on-demand manufacturing. Suppliers move components to Dell, who assembles them based on orders directly from customers. The finished product can then be shipped directly to the customer, removing several layers from the supply chain.

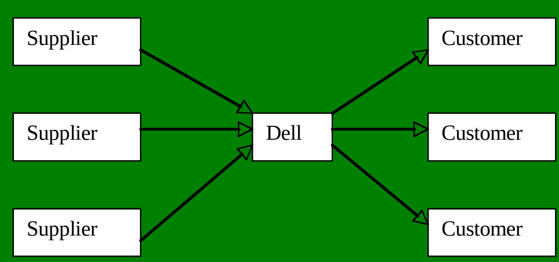

Figure 27. Dell Computer's On-demand Manufacturing

The advantages of this arrangement are obvious. Several layers of administration and profit are removed from the system (see Figure 24), giving more profit to the manufacturer and lower prices to the consumer. Inventory costs are kept down because final product is shipped when manufactured and manufactured when ordered. A potential downside of the approach is that the product is shipped to the customer, which means more local freight pick-up and delivery trips. Another potential downside is the dependence on quality transportation services from the suppliers.

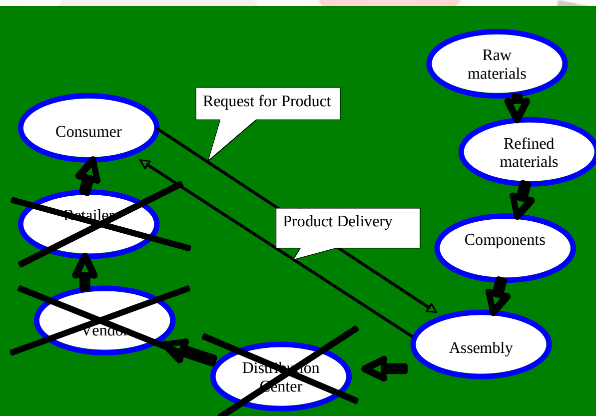

Figure 24. Manufacturing on Demand

With recent advances in information and manufacturing technology, manufacturing on demand has become more common. For example, if you have a size 14 neck and a size 44 waist, you can now get shirts made to order to fit your figure. On demand publishing is also a form on manufacturing on demand. Unusual or low-demand books can be printed when they are ordered and shipped directly to the customer. Another application can be found at John Deere, the largest agricultural implement maker in the world. Nearly all of its US-made large tractors are made based on orders from dealers. Those orders usually are committed to a specific customer.

Figure 25. Inventory Management Implications for the Public Sector

All of these strategies have impacts on the transportation system, particularly on the highway system, and thus have implications for how the public sector operates (See Figure 25). If these techniques are to work, the transportation system must be extremely reliable, facilitating closely timed deliveries. It also tends to move more freight to truck and require more truck movements.

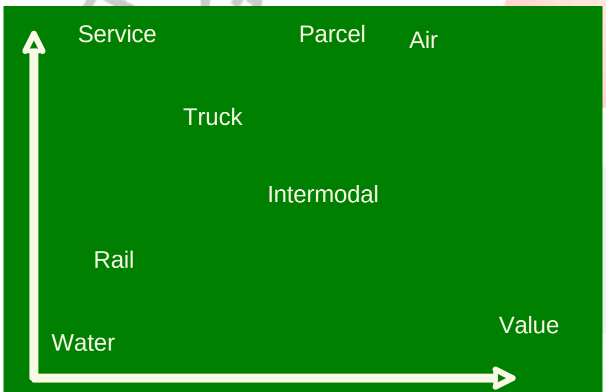

Figure 26. Service/Value Characteristics by Mode

Managing Transportation

Inventory strategies have a great impact on how transportation is managed. Service requirements tend to lead to mode choices. The operating characteristics and objectives of each of the modes tend to influence the service that can be provided.

Figure 26 provides a simple view of freight service and typical cargo value by mode. Water tends to move low value products with low service requirements. Rail provides a higher level of service and tends to move higher value products. At the other extreme air provides the highest level of service and attracts the highest value products.

Mode	Average value per Ton
Truck	793
Rail	166
Water	131
Air (includes truck and air)	70,468
Parcel, U.S.P.S. or courier	38,715
Intermodal (truck and rail)	1,627
Truck and water	616
Rail and water	32

Figure 27. Average Value of Cargo per Ton

Source: NCHRP 08-40

Figure 27 shows the average value per ton of freight moved by each of the modes, based on the 2002 Commodity flow Survey.

The value/service/mode relationship is borne-out when we look at the type of products typically moved by each mode. Figure 28 shows the 2006 tonnage and commodity originated on rail. Coal is more than 40% of the total. Farm products, chemicals, metallic and non-metallic ores, and other low value products with low service requirements account for another 30%.

A similar picture can be seen in the maritime mode. Low value products with low service requirements account for much of the freight moved along our coasts, across the great Lakes, and on our rivers (See figure 29). Moreover, as shown in Figure 29, the volume of many of the commodity items decreased between 2004 and 2005, which supports the generally downward trend in water's modal share shown earlier in Figure 4.

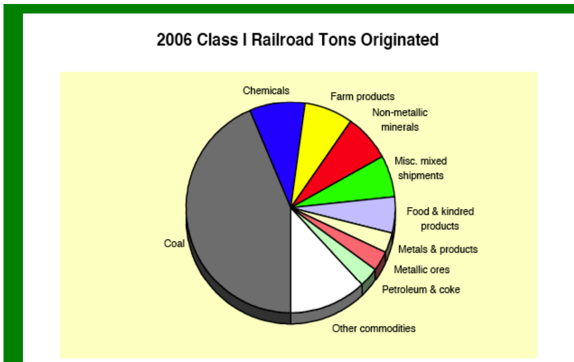

Figure 28. Class I Railroad Tons Originated

Source: AAR

U.S. Waterborne Traffic by Major Commodities in 2005
(Millions of Short Tons[1] and Change from 2004)

	Domestic							
	Coastwise		Lakewise		Internal		Total	
Commodities[2]	Tons	%	Tons	%	Tons	%	Tons	%
Total[3]	**213.7**	**-3.1**	**96.2**	**-7.1**	**624.0**	**-0.4**	**1,028.9**	**-1.7**
Coal	9.8	0.0	21.2	5.9	181.9	6.2	228.9	6.1
Coal Coke	**	0.0	0.7	-5.0	5.1	-11.5	6.3	-10.3
Crude Petroleum	44.9	-6.5	**	0.0	33.0	-4.8	79.4	-5.9
Petroleum Products	112.0	-1.4	1.4	-18.0	120.6	3.8	283.3	0.8
Chemical and Related Prod.	10.3	-9.8	0.2	-12.1	50.3	-4.2	72.7	-4.1
Forest Prod., Wood & Chips	2.3	6.9	**	1429.3	6.3	-3.6	9.3	-4.0
Pulp and Waste Paper	**	-64.8	**	0.0	**	-80.2	**	-32.9
Sand, Gravel and Stone	8.4	-14.4	26.6	-11.4	85.3	-0.2	128.8	-4.1
Iron Ore and Scrap	0.7	4.1	40.3	-11.4	10.8	-18.5	55.0	-12.9
Non-Ferrous Ores & Scrap	**	-99.9	**	-100.0	6.2	-10.2	6.2	-12.1
Sulphur, Clay and Salt	0.3	79.8	1.1	40.8	7.6	-9.2	9.2	-4.0
Primary Manuf. Goods	9.1	-0.1	3.9	-0.2	30.7	6.0	44.9	4.5
Food and Farm Products	6.1	8.7	0.3	206.6	70.9	-12.1	77.7	-10.6
All Manuf. Equipment	9.6	-0.7	**	40.1	9.9	-1.6	20.2	-2.1
Waste and Scrap, NEC	**	-80.6	**	-100.0	1.5	14.3	2.0	-34.5

Figure 29. Waterborne Commodities (for missing values)**

Source: Navigation Data Center

Obviously, the cost of shipping by air or parcel service is high, so only high value products move by those modes, but the service typically required for high value product is also high. Part of the service characteristic that is important to shippers is the presence, or perception of the existence, of a custodian of the cargo. A truck driver is the typical custodian, but air carriers and parcel carriers are also seen as having high security, which is desired for high value product.

The following summary of the Kansas meat packing industry illustrates the importance of the custodial issues in mode choice. Fresh meats move by truck in part because of the custodial issue, in part because of service issues and in part because of the specialized equipment that is required.

Meat Processing in Southwest Kansas

Kansas is the third largest meat producing state in the country, with about 17% of the nation's output. The meatpacking industry in Kansas is centered on Southwestern Kansas. Each year about 3.7 million cattle are slaughtered in 369 feedlots in that part of the state. Many more are shipped from nearby states to processing plants in Kansas. Figure 1 illustrates the growth in meatpacking in Kansas in recent years.

Researchers predict that the trend line will remain fairly flat in the foreseeable future.

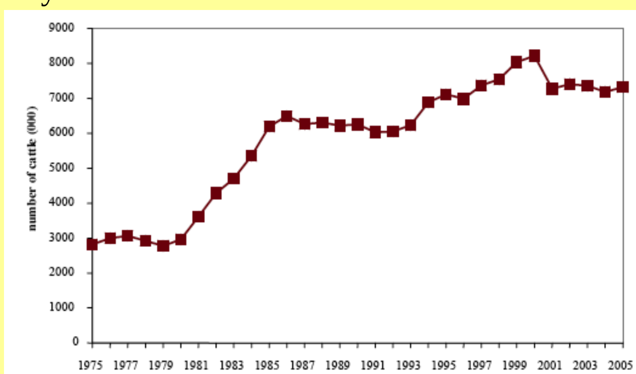

Figure 1. Cattle Slaughtered in Kansas

The supply chain for cattle feeding is shown in Figure 2.

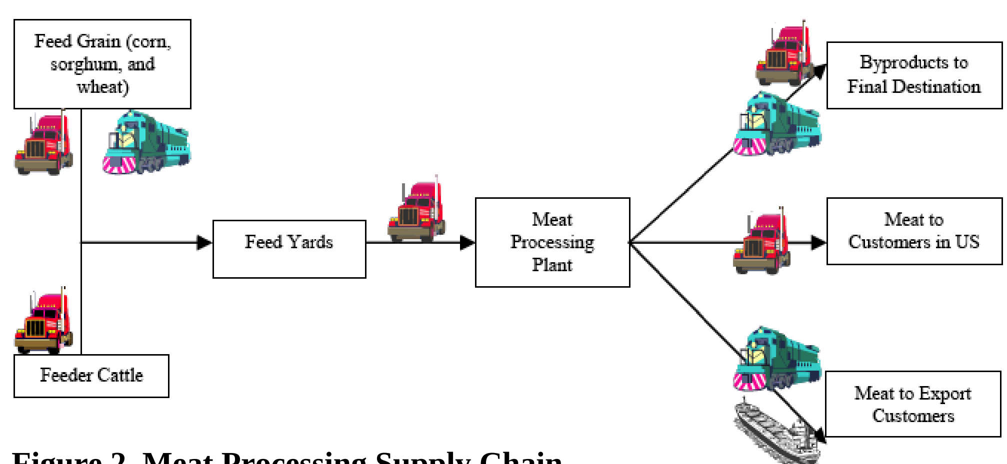

Figure 2. Meat Processing Supply Chain

Cattle from Texas, Missouri, Oklahoma, Kentucky, Tennessee, New Mexico, California and Oregon are trucked to Kansas for slaughtering. Kansas is a desirable location for feeding because it is close to the source of feed grains and has a climate that allows cattle to prosper. Four of the nation's major meat packers are located in the region.

In addition to cattle, the major input in the feeding operation is feed. As shown in Figure 3, each animal consumes about 28 pounds of feed per day.

Alfalfa Hay (Lbs./day)	Corn (Lbs./day)	Grain Sorghum (Lbs./day)	[a]Supplements (Lbs./day)	Total (Lbs./day)
3.4	14.4	9.6	0.8	28.2

Figure 3. Daily Feed Consumption per Animal

A typical animal spends 150 days in the feedlot so many pounds of feed are consumed:

3,700,000*150*28.2=15,651,000,000 pounds.

While some grain is moved into the state by train, most moves are entirely by truck. And all moves ultimately depend on truck.

Once the cattle are at market weight they are shipped by truck to the processing plants. The output of the plants are boxed beef for the domestic market, which moves entirely by truck; boxed beef for the export market (about 10% of the total), which moves by rail and ship to its final market; and byproducts, which move about 50% by truck and 50% by rail. The final destinations for domestic meat include all major US population centers. Byproducts are sent throughout the US and to Mexico.

Adding all of the inputs and outputs together yields nearly 700,000 annual truckloads moving to and from feedlots and processing plants in Southwest Kansas.

	Annual Truck Loads
Feeder Cattle	49,614
Feed	365,392
Finished Cattle KS	82,392
Finished Cattle Out state	56,416
Processed Meat	107,308
Byproducts	35,760
Total	**696,882**

Figure 4 Annual Truck Loads in the SW Kansas Meat Industry

Trucking is the preferred mode of transporting live cattle and processed meat because the higher service characteristics of the mode, the specialized equipment needed and the perception of greater security-- a truck is attended by a driver, while train cars generally do not have individual oversight. Good service is also a reason for choice of trucking for the movement of grains.

In the movement of byproducts, which are less time sensitive, price tends to be the determining factor in the choice of modes.

Source: Bai

The relative importance of the several factors that influence mode choice has been debated on many occasions. Figure 30 presents the Maslow-like hierarchy used in NCHRP 8-42.

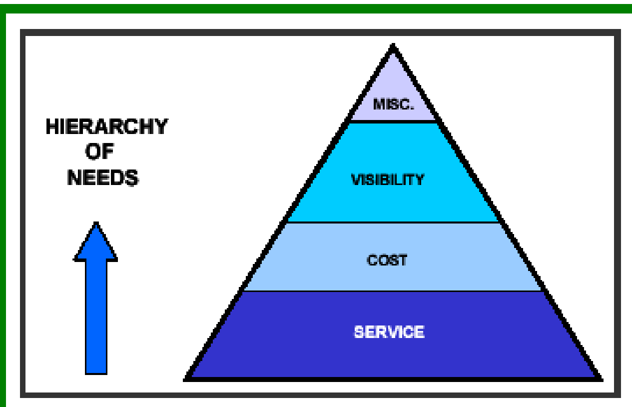

Figure 30. A Shipper's Hierarchy of Needs

Source: NCHRP 80-42

In this model, service is the basic requirement. Once service requirements are met, cost becomes a consideration. At first glance, this may seem counter-intuitive. Earlier, we discussed total cost competition, in which transportation figures as a cost item. The reality is that transportation is a smaller cost item than inventory in most situations. If more expensive transportation is required to make an inventory management strategy work, the trade-off will usually fall in the favor of the inventory strategy. If service requirements are low or if the service provided is similar, cost becomes a deciding factor, as in the case of meat by-products in the above example.

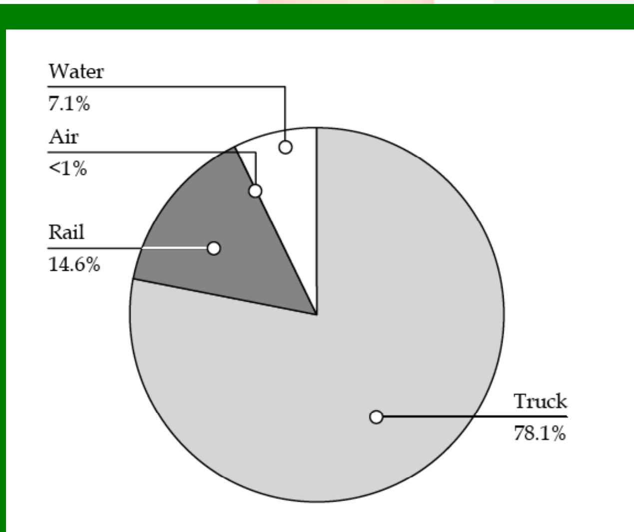

Figure 31. Freight Trips Generated.

Source: FHWA, Financing Freight

Trucking is by far the most used freight mode in terms of trips generated (see Figure 31) in part because of service issues. This may seem confusing, but freight can be measured in terms of ton miles, by this measure rail leads. It can also be measured in tonnage, value and trips. By these last three criteria, trucking leads.

Service can be a somewhat subjective concept. Good service may depend upon the circumstances and upon the desires of the customer. As used here, it simply describes the ability of a mode or carrier to meet the reliability and frequency of delivery criteria that is usually associated with the inventory management strategies outlined earlier. Based on these criteria, truck, air and parcel usually have a distinct advantage over water and rail.

The following example illustrates how service can literally create a market. Californians use air cargo to move agricultural products to distance markets, making fresh produce and similar products available in markets they might not otherwise reach.

Air Cargo and California's Agricultural Exports

Air Cargo is usually associated with very high value commodities, or with emergency delivery of products when the surface modes break down. California's agricultural export business demonstrates a field in which the availability of airfreight significantly enhances the value of a product. It allows fresh produce to be delivered to distant markets while it is still at its peak of value.

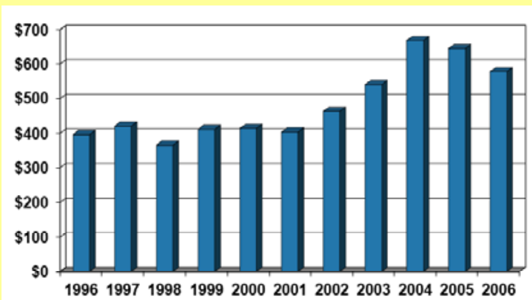

Figure 1. California's Air Borne Agricultural Exports in Millions of Dollars

Figure 1 shows the growth in air borne agricultural exports from California over the past eleven years. In inflation adjusted terms the value of this trade grew by nearly 25% over those years.

Much of the market for air borne agricultural products is in Japan, but the UK, Australia and Italy also figure strongly into the mix, see Figure 2.

The products moved in this way range from live horses, to fresh produce and seeds, see Figure 3.

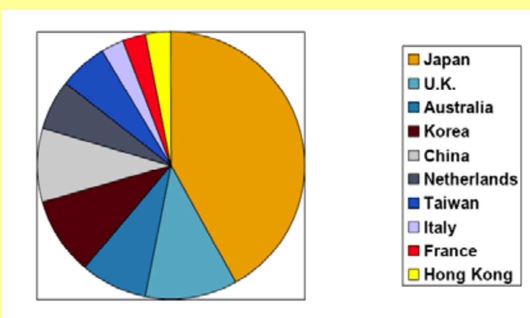

Figure 2. Top Destinations for Air Freighted Agricultural Products from California

- Food Preparations NESOI ($105.3 million)
- Seeds for Sowing Vegetables ($82.2 million)
- Fresh Cherries ($73.1 million)
- Fresh Strawberries ($35.8 million)
- Purebred Breeding Animals ($26.4 million)
- Fresh Grapes ($22.1 million)
- Asparagus ($19.0 million)
- Seeds for Sowing Flowers ($17.7 million)
- Bovine Semen ($15.9 million)
- Wine (14.8 million)
- Fruit Seeds for Sowing ($12.4 million)
- Lettuce ($9.5 million)
- Onions and Shallots ($8.8 million)
- Live Horses ($8.6 million)
- Fresh Miscellaneous Berries (7.9 million)
- Fresh Fruit NESOI ($7.6 million)
- Peaches and Nectarines ($6.9 million)
- Fresh Tomatoes ($4.7 million)
- Chicory ($3.8 million)
- Guavas and Mangoes ($1.9 million

Figure 3. Top Air Borne Agricultural Exports over a Three-Year-Average Period

While air moves only a small part of the total California agricultural exports (between five and seven percent), without air, this portion of the market would likely not exist.

Source: O'Connell and Mason

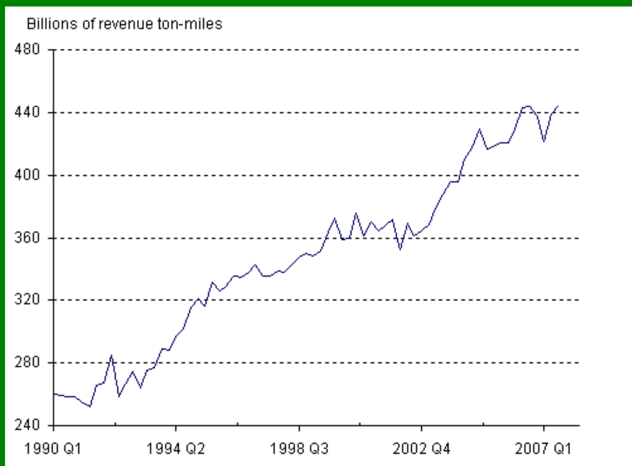

Figure 32. Rail Revenue Ton Miles

Source: BTS Rail Revenue Ton Miles

Item	2004	2006
Freight Revenue per Mile	2.354c	2.840c
Freight Revenue	$39 B	$50 B
Return on Equity	6.16%	11.3%

Figure 33. Freight Rail Economics
Source: AAR

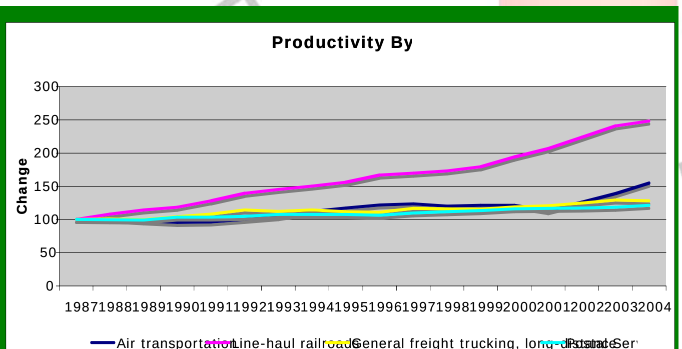

Figure 34. Productivity per Employee

Source BTS

To understand the reasons for this advantage, we need to look at the nature of the modes and the companies involved. Rail companies are private businesses. They must replenish and maintain their capital stock while making a profit. By most measures, class I rail companies are more profitable now than they have been in decades. Figure 32 shows revenue producing ton-miles for class I rail companies over a 17-year period. The trends are sharply up. Moreover, freight revenue per ton-mile has increased by 21% between 2004 and 2006. Overall freight revenues for the class I rail companies increased by 28% over the same period; and return on equity nearly doubles over those years (See Figure 33). Rail companies are healthier financially than they have been since the heyday of rail.

In large part they have attained this health by becoming more efficient. Figure 34 shows the trends in productivity for each mode. By the measures of production per employee**,** rail companies have steadily increased their output, while other modes have remained constant or made more modest gains. They have done this by focusing more traffic into fewer corridors and using longer trains.

Figure 35 illustrates the average length of haul by mode using 2002 date. The average length of a haul by rail is more than double that of truck.

Rail companies have become economically successful by focusing on what they do best: Moving product over long distances in dense corridors, LA/Long Beach to Chicago or NY/NJ to Chicago or the coal fields of Wyoming to the Midwest or the East.

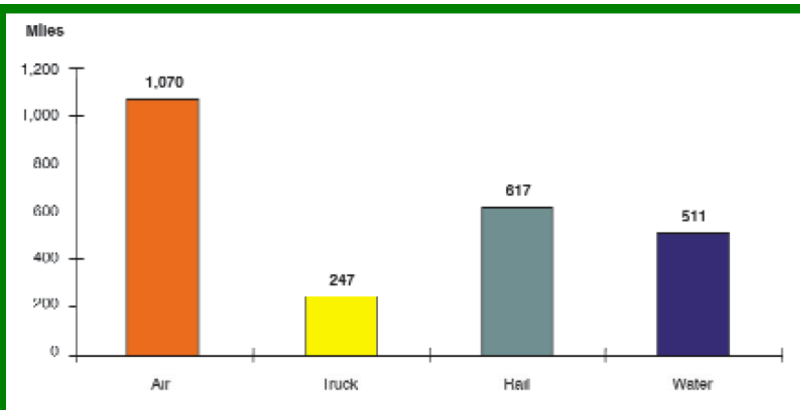

Figure 35. 2002 Average Length of Haul

Source: AASHTO Freight Rail Bottom Line Report

Corridor density is another issue that must be understood. It is simply an expression of the amount of freight that moves in a given corridor between two points. Figure 36 is an illustration of the importance of density.

One river tow is equal to 2.25 unit trains or 870 trucks. One unit train is thus equal to 386 trucks. Consider the amount of product that would be required to fill 386 trucks. Consider the delay as a shipper waited to fill the last truck before any could move. This is essentially what happens with a rail shipment. The first car cannot move until the last is filled, or the first truck cannot move until the 386th is filled. The amount of freight moving in a corridor must be enormous for rail to provide frequent departures and thus, based on the criteria of the inventory management strategies outlined earlier, good service.

Figure 36. Modal Capacity Equivalents

Very few corridors in the US have the density that is required for frequent rail service which makes best use of rail's inherent advantages in moving large amounts of cargo long distances and at low cost. But the tonnage in those corridors is large enough to keep rail's share of total cargo high and to make rail companies profitable.

Truck and rail intermodal service is a fast-growing mode of transporting freight that is often seen as a way to get the benefits of both rail and truck. Figure 37 illustrates a truck rail intermodal approach.

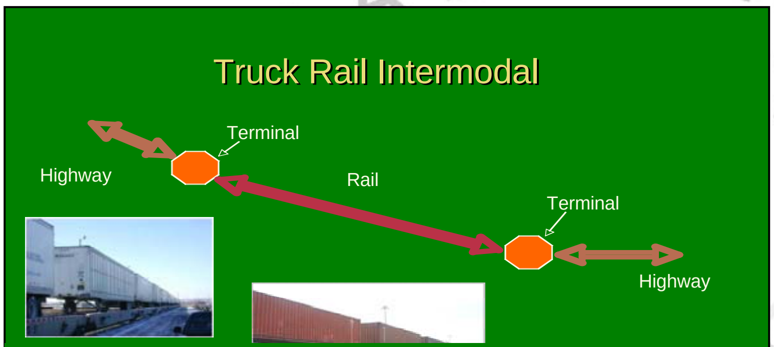

Figure 37. Basic Truck to Rail Intermodal

A cargo is drayed to a terminal by truck, transferred to a train and moved over a long haul to another terminal where it is transferred to truck for final delivery. This can be accomplished by putting a truck trailer on a flatcar, see Figure 38, or by using containers, see figure 39.

Figure 38. Trailer on Flatcar Intermodal

Figure 39. Container-based Truck Rail Intermodal

Containerized intermodal has a major advantage over putting trailers on a flatcar because it can take advantage of double stacking, which essentially doubles the capacity of a train. Because of the advantage that containerization has, many of the larger trucking companies involved in intermodal transportation have moved to containers.

While truck rail intermodal is growing and it does hold promise for the future, it does have some drawbacks. First of all, the cost savings associated with the use of rail over the long haul has to offset the cost of handling the cargo from truck to train and back to truck. As shown in Figure 40, NCHRP 8-42 found that nearly 75% of the total cost of an intermodal trip was consumed by drayage and lift costs in short distance moves. Short distance in this case is up to 699 miles.

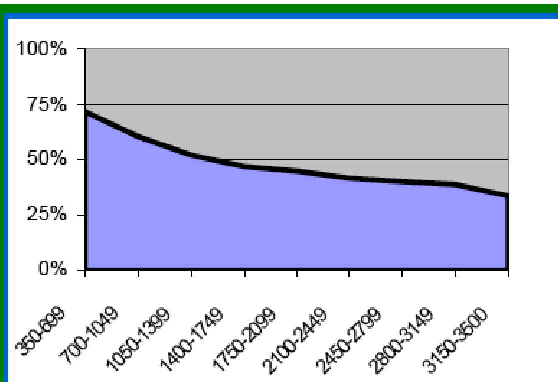

Figure 40. Drayage and Lift Cost and Trip Distance

Source: NCHRP 8-42

This cost equation makes truck-only very competitive compared to truck-rail intermodal in those shorter hauls. The literature normally uses 600 miles as the minimum distance in which rail could be considered. For the Western railroads, that serve long distances, the number is probably closer to 1,000 miles.

Cost is not the only issue to consider in evaluating truck rail intermodal. Figure 41 lists several other important issues. Will intermodal provide an equivalent service to truck? As we noted earlier, service is the basic issue in modal choice. Next, does the shipper have access to an intermodal terminal? If a 300 mile trip by truck is necessary for a 700 mile total trip, the choice may well be to truck the entire distance.

Market Viability	Institutional Readiness	Public Barriers
1. Equivalent Service	1. Capacity	1. Public Acceptance
2. Access Limitation	2. Capital	2. Competitive Reckoning
3. Interoperability	3. Institutional Commitment	
4. Density	4. Institutional Structure	
	5. Sustained Performance	

Figure 41 Obstacles to Diversion to Rail

Source: NCHRP 8-42 Guidebook

Interoperability simply refers to the ability of the rail carrier to interact with the trucking system. Are equipment and operating issues compatible? Can the two interact smoothly and efficiently?

Density is the issue discussed previously. Does a corridor have sufficient freight traffic to support good rail service, even in an intermodal form?

Capacity should be an obvious issue. Class I rail lines are operating many corridors at or near track and terminal capacity. Is there sufficient space in the system to support an intermodal service? What will be the impact

An instructive example of the intricate nature of capacity and its interference with diversion comes from a Class I railroad in 2004. A premium intermodal train for a major motor carrier, designed to produce highly competitive three-to-four-day transcontinental service, created system congestion and delays for other trains. Limitations of track, siding, signaling and labor capacity, coupled with the need to create headroom (a clear lane) for the much faster intermodal train, created cascading disruption for other operations, which lasted up to a week.

Source: NCHRP 8-42 Guidebook

on other services, if intermodal is introduced? The sidebar above to the right points out some secondary impacts that have occurred.

Other institutional issues such as capital and commitment are clearly needed. If the companies do not have the capital to add cars, locomotives, and other capital needed for the service, it cannot happen.

Public acceptance is an issue that too often is not considered with rail service, but if the number or length of trains in a given corridor increases significantly, it will likely create a public response. Homeowners and business people do not want the noise, vibration and inconvenience of many long trains.

The bottom line is that putting more reliance on rail freight, even in the form of intermodal, may not be as easy as it might seem at first blush. The service has to be good. The economics have to work. And the public has to accept a change in train movements.

Another transportation management approach that is being used by some trucking companies is the use of transfer or staging points, as illustrated in Figure 42.

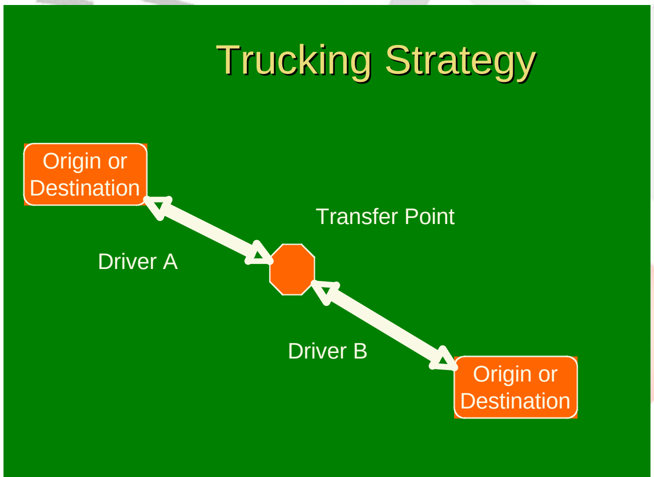

Figure 42. Using Transfer Points

Trucking companies who are attempting to address driver shortages by creating conditions in which drivers can be home every night, or at least more often have often used this strategy. Under this approach two or more drivers begin from opposite directions. They meet at a transfer point in the middle and exchange loads and head back in the direction they started from. The result is less time away from home and, it is hoped, a more attractive working experience.

The obvious challenge in this strategy is the need for close coordination between drivers and loads. They must arrive at the transfer point on a planned schedule, or downtime will be the result.

International Experience
We tend to see the experience of the US as a model of what can be done, but other countries have taken steps to change their historic transportation network. The European Union (EU) is a prime example. It has articulated its approach in a policy statement dealing with its proposed, and partially implemented transportation system:

> Modern economies cannot generate wealth and employment without highly efficient transport networks. This is particularly true in Europe where, for goods and people to circulate quickly and easily between Member States, we must build the missing links and remove the

> bottlenecks in our transport infrastructure. The trans-European transport network is a key element in the re-launched Lisbon strategy for competitiveness and employment in Europe for that reason alone: to unblock major transport routes and ensure sustainable transport, including through major technological projects. (Trans-European Transport Network: TEN-T Priority Axes and Projects, 2005)

The EU is dealing with increased demand for transportation, in keeping with the above vision, in several ways. The first is an effort to diversify its system to move more goods from highways to rail and water. As Figure 43 indicates, it has been partially successful in that effort. While road (red line) remains near the top in terms of growth, short-sea-shipping (dark blue line) has responded to the effort the EU has placed on the promotion of this mode. Inland waterways and rail also seem to be responding in the later years.

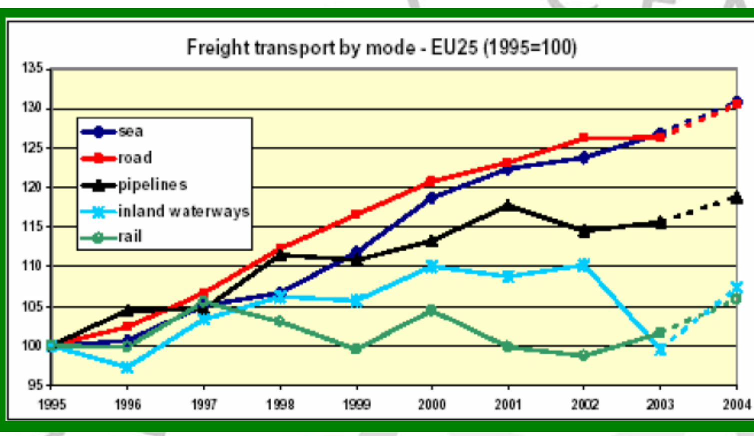

Figure 43.. Freight transport modal split in the EU25
Source: Consultation document on logistics for promoting freight

The EU has also devoted much energy to promoting intermodal freight (short-sea, rail, inland waterway and truck) through a program called Marco Polo. Through this program the EU is funding projects that will better connect the modes.

Closely tied to the Marco Polo program is Galileo, the EU's version of the Global Positioning System (GPS). Unlike America's GPS, Galileo was designed primarily with transport in mind. When completed, it will allow transit times to be monitored, allowing advanced warning of road system breakdowns. It will also assist in tracking goods, making intermodal more attractive.

It also has ambitious plans for improved roadway, rail, inland waterway and short sea shipping connections between its member countries. This has become a higher priority with the recent and continued expansion of the EU. Efficient transport is needed to bring the benefits of membership to all parts of the continent. Budget constraints have slowed the implementation of these plans, but progress is being made. For example, the map of Ireland in Figure 44 shows sections of railways that are either completed or under construction.

Figure 44. Priority projects in Ireland
Source: Trans-European Transport Network: TEN-T Priority Axes and Projects, 2005

Similar efforts are underway throughout the EU. Roads, waterways and railways are being improved to bring the continent closer together and to improve its productivity and competitive position.

The EU is not alone. Japan, Korea, China, India and Brazil are all countries that have made a commitment to improving and changing their transportation systems. They are taking actions through public investment and public policy to encourage the building of the kind of system they see as most beneficial. Each is proceeding within its historic structure and societal constraints, but they are taking steps to shape their future.

Summary
The US is currently facing a major challenge in the movement of freight. With a little hyperbole, AASHTO has referred to it as the coming tsunami of freight. Since our economic well- being depends on the movement of freight, we must find ways of meeting

this coming challenge. A first step is for the public sector to gain a better understanding of the needs, motivations and constraints of their private sector counterparts as they attempt to do their jobs.

- Cost reduction is the major objective of private firms that drives much of what happens in the movement of freight. Total cost competition forces companies to hold down all costs. Just-in-time, pull logistics and manufacturing on demand are all inventory management structures that relate to this basic need.

- All of the inventory management systems now in use tend to require dependable, more frequent and timed deliveries. They also tend to put more freight on trucks.

- Mode choice is driven by many factors. Most observers find service to be the highest consideration in reaching a mode decision. In this context, service is simply the ability of a mode to make the timely, planned deliveries needed to allow modern inventory management systems to operate.

- Rail companies are private businesses that have to make a profit while renewing their physical assets. They are very profitable now relative to the recent past. In large part they have gotten that way by focusing on what they do best—moving freight over long distances in long trains.

- Doing what they do best has limited their ability to provide the types of services needed to make modern inventory practices work. They must operate in high-density corridors.

- Trains and water tend also to move lower value products, coal, grains, non-metallic ores, etc., with relatively low service demands. Truck, air and parcel services tend to move products with higher values and higher service demands.

- Truck-rail intermodal is often seen as a way of gaining the benefits of both truck and rail, but the cost of drayage and transfer, as well as the service challenges of rail, have limited its effective operation to only long-haul situations, typically 600 miles or more.

All of these factors and others point to new challenges and roles for the public sector:

- First of all, the historic response to congestion, building more roads, will still be needed, but it will have to be used in concert with other efforts as well.

- Among those efforts will be better system management and operations to ensure that the movement of trucks and other vehicles is reliable and able to meet the needs of industry.

- It will also be necessary to build better working relationships with the private sector. In many cases, being reactive will not suffice. Some states have reported that they are now making an effort to become involved as businesses are making site decisions, so that they can find he best transportation solutions.

- It will also be necessary to think about transportation from a more holistic perspective. Efforts will have to be made to better connect the modes and to use the best feature of each mode.

- This holistic view must not be a field of dreams view. It must be taken with a realistic understanding of the strengths of each mode and the constraints under which they operate.

- This leads to another role that will be new to many public sector transportation professionals in the world of freight. Increasingly, the role will be that of facilitator. Bringing people together to solve problems will be a major challenge.

- The solutions found may also be quite different from what we have used in the past. Innovative institutions between public agencies will be required, as they will between public and private agencies.

- Financial arrangements will also probably be more intricate than they have been in the past, as private and public agencies are forced to recognize that they share an interest and a responsibility for solving transportation problems.

The above are but some of the reasons for public transportation officials and professionals to better understand private sector issues in logistics management.

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Appendix 1
Quiz Answers

1. According to FHWA, what portion of the average state truck tonnage simply passes through the state?
   A. 43%

2. In 2002 what percent of the 19.3 trillion tons of freight shipped in the US was domestic?
   A. 91%

3. Which country is the US's largest trading partner?
   A. Canada

4. In 2002 how many people were employed by American railroads?
   A. 177,000

5. In 2002 what was the total revenues of class I railroads?
   A. $35.3 billion

6. In 1997 what portion of the US GDP was involved in international trade?
   A. 25%

7. What is generally used as the haul length needed to make rail economic?
   A. 600 miles

8. Between 1980 and 2000, which grew fastest: overall VMT, truck VMT, lane miles of highway?
   A. Truck VMT (89%); overall VMT (80%); lane miles (3.8%)

9. How many trucks would it take to carry the load of one Columbia River barge?
   A. 134, or 35 rail cars

10. What is the value of an average ton of freight moved by air relative to that of truck?
    A. About 90 to one