



MIT Center for
Transportation
& Logistics



Massachusetts
Institute of
Technology

Innovations in Transportation: Managing Uncertainty in Both Supply and Demand

A Symposium Sponsored by
The MIT Center for Transportation & Logistics (CTL)
Transportation Research Group

Cambridge, MA

April 5-6 2005

This report was prepared by Andrea Meyer and Dana Meyer of Working Knowledge® for CTL and was edited by Chris Caplice of CTL. Please contact Chris Caplice (caplice@mit.edu 617-258-7975) if you have any questions or comments on the report or are interested in participating in CTL's Transportation Research Group.

Table of Contents

I. Introduction to Report	1
II. Symposium Synthesis	2
1. Top Sources of Supply Uncertainty	2
1.1. Infrastructure Capacity: Best of Times, Worst of Times.....	2
1.2. Drivers	3
1.3. Fuel Costs	4
1.4. Regulation.....	5
1.5. Supply and Demand = Accept and Reject Loads	5
2. Short Term Solution Elements.....	5
2.1. Better Utilization	6
2.2. Better Management.....	7
2.3. Adding Capacity	9
2.4. Government	12
2.5. Aligning Incentives	13
2.6. Real Options Have Real Value under Uncertainty	14
2.7 Shifting Demand away from West Coast Ports	15
3. Continuing Challenges to Success	15
3.1. Not in My Backyard (But in My Local Store).....	15
3.2. Correlated Patterns of Demand.....	16
3.3. Multiple Layers of Participants	16
3.4. Natural Cycle of Unintended Consequences	17
3.5. Shift from Price-Sensitivity to Time-Sensitivity	18
3.6. The Gulf of Timescales	19
3.7. Conclusion.....	19

I. Introduction to Report

The MIT Center for Transportation and Logistics (CTL) held the 2nd annual Innovations in Transportation Symposium on 5-6 April 2005. The symposium focused on how shippers, carriers, government agencies, and other players within the transportation industry can better interact. Last year's symposium explored current and pending innovations in the way that transportation is procured, provided, and managed. A key observation made at the 2004 meeting was that uncertainty in transportation demand is the root cause of most of transportation issues raised. The presentations and discussions centered on methods and approaches to identify, mitigate, and manage this uncertainty. Opinions differed and the debate was lively – with all attendees participating in the discussions.

This year's symposium expanded the scope of discussion to include the issue of uncertainty on the supply side. With capacity tight in virtually all regions and across all modes, the increased connectivity that intermodalism has brought the industry has also led to stronger correlation between the modes. The impact of increased international container traffic into the West Coast, for example, now has ramifications on the availability of trucks serving the California agricultural market. Similarly, the linkages between the modes can perversely cause unexpected bottlenecks. For example, the congestion at the Chicago intermodal terminals limits to some degree the dual sourcing of Northwestern ports heading to East Coast markets. In short, congestion and capacity shortages are impacting virtually all shippers across all modes.

A further complication of the supply side uncertainty is that there is not a single owner. At a minimum, a freight transportation move must involve three players: shipper, carrier, and receiver. The rise of intermodalism has increased the number of players by introducing an intermediate mode, usually rail. This adds not only the rail carrier, but an Intermodal Marketing Company (IMC) that coordinates the movement. International shipments pass through an even larger number of players to include the ocean carrier, the terminal operator, longshoreman, yard operators, rail carriers, truck carriers, etc. The government control of the freight shipment network is equally fragmented with policies and responsibilities at the federal, state, and local levels. In essence, because everyone is involved with the US freight transportation network no single entity is responsible for it.

The objective of the symposium, then, was to identify solutions, strategies, and approaches to alleviate or mitigate uncertainties on both the supply and demand sides. Speakers and attendees came from a wide variety of background and represented the shipper, carrier, government, academic, labor, and infrastructure perspectives. A complete list of companies attending is shown in the appendix.

The remainder of this Synthesis Report ties together the major themes of that came out during the day and a half of discussions, presentations, and debate. Members of the CTL Supply Chain Exchange or Transportation Research Group receive the full report with details from each presentation.

II. Symposium Synthesis

The symposium focused on identifying three things: Sources of uncertainty, Potential solutions (both short and long term), and Longer term challenges.

1. Top Sources of Supply Uncertainty

Key uncertainties and risks drive managers' current concerns in the transportation arena. In preparation for the symposium, the speakers and attendees were asked to identify the top sources of uncertainty facing them. During the symposium, presenters and audience members alike shared their lists of the top uncertainties facing their companies and the industry.

1.1. Infrastructure Capacity: Best of Times, Worst of Times

Participants showed great consensus in highlighting the most pressing problem: capacity uncertainties. Carriers are enjoying high growth, but the increasing demand is becoming too much of good thing. A dangerous combination of underinvestment and ongoing growth stretches the limits of transportation capacity in most modes and in many locations. The continuing growth of trade with China and the insatiable appetite for consumer goods in the U.S. is pushing many transportation links to the limit.

A Perfect Storm for Every Port

In the wake of port congestion problems in 2004, the most frightening facts were the growth projections for Chinese ports. The Chinese are investing huge sums on new infrastructure. For example, Shanghai is building a new, massive port facility off the coast that is designed to ultimately handle 25 million TEUs (twenty foot container equivalent units) annually. That one port, when completed in 2010, will have more capacity than all of the existing ports on the US West Coast combined. Moreover, Shanghai is neither an anomaly nor the largest planned Chinese port. Hong Kong intends to grow from 18 million to 31 million TEUs. The development goes beyond the ports as well. The Chinese are spending nearly a quarter of a trillion dollars to create an inland intermodal rail network with 18 mega-terminals and 40 smaller terminals to feed its ports.

The question of the coming decade is where the tsunami of Asian goods will go. Currently, 95% of U.S. trade (by volume) travels by ship. But major U.S. ports, especially those on the West Coast, appear to be reaching their limits -- TranSystems reported that 12 of the top 16 ports in the U.S. will face significant capacity problems by 2010. The current volume of the ports of Los Angeles and Long Beach are only 12 million TEUs and the government of California has declared that no new ports will be built. John Vickerman of TranSystems noted that while the Chinese ports are growing 27% per year, the U.S. ports are only growing 6%-7% per year. Various projections suggest that U.S. ports may need to double, triple, or even quadruple their throughput by 2020 to be able to receive the projected freight flows.

Representatives from the federal government, IMCs, rail carriers, and port operators seem to agree on a host of factors that seem to be capping U.S. port capacity. First, many ports are now

landlocked. Urban areas have built up around the ports and consumed all available space, leaving them starved for expansion room. Second, local anti-growth constituencies, as well as congestion in the urban transportation networks around the ports, also conspire to limit growth. Third, productivity in U.S. ports is substandard. TranSystems presented figures for port productivity around the world. U.S. ports average only 3,900 TEUs/acre/year. This is less than one quarter the productivity at Asian ports, which average 18,500 TEUs/acre/yr. Even European ports are much more productive than their U.S. counterparts -- European ports handle 6,800 TEUs/acre/year. Antiquated work rules, inadequate adoption of technology, and low labor productivity plague U.S. ports. The net effect is that US ports are capacity constrained today and the situation only appears to get worse in the immediate future.

Highways Become Slow Ways

Port congestion is not the only concern. Presenters also highlighted problems with congestion on public roadways. Whereas rail and maritime infrastructure is often private, truck transportation in the U.S makes use of public roadways. Several speakers commented on the private sector's increasing investments in ships and port facilities but a lack of corresponding public (or private) sector investment in roadways. The interstate highway system was designed in the 1950s and is showing its age. Urban traffic congestion interferes with the movement of goods from logistics terminals to retailers as well as during the last mile of getting goods to consumers. Several companies which either have private delivery fleets or deliver directly to offices or homes noted that they face high last-mile costs due to congestion.

Rail: Live Opportunity on Tracks

During the rise of the trucking industry and the long decline in rail traffic, railroads pulled up or abandoned hundreds of miles of track. As freight has moved back to rail, some companies are beginning to regret these decisions. Rail lines are running into bottlenecks at ports and terminals and on various lines. One shipper noted the railroads' euphemism for poor service with the service code DBOT -- dead body on tracks.

Rail interchanges also create serious delays in places such as Chicago, according to the Hub Group. It can take 24 to 72 hours to ferry goods across the congested Chicago interchanges. This delay is not acceptable for service-sensitive loads.

Unfortunately, rail is extremely capital intensive. BNSF, for example, spends 18 cents of every revenue dollar maintaining and extending its capital assets, including some 33,000 miles of track. Building a single mile of new track costs about \$1.5 million on flat ground; track in rugged terrain can cost \$5 million per mile and track in congested urban areas can be even more expensive (e.g., the Alameda corridor cost on the order of \$34 million per mile of track). Scarred by decades of hard times, railroad executives are wary of making major capital investments.

1.2. Drivers

In the trucking industry, the primary capacity constraint is driver availability. Several of the presenters listed the numerous reasons for the severe and ongoing shortage of drivers. First, and at the core of the problem, is that driving is a hard, dangerous, and demanding job without

enough pay. Drivers spend long hours on the road and away from family. It is often deemed to be a job of last resort behind manufacturing positions.

General consensus at the symposium is that the driver shortage will get worse before it gets better. This is true for several reasons. First, serious legal liabilities come with driving, especially for inexperienced drivers. J.B. Hunt mentioned that the company has a \$2 million deductible on accidents. Carriers are reluctant to let inexperienced drivers behind the wheel and pay very high insurance costs if they do so. As a result, every company has bumper stickers that say "now hiring experienced drivers" -- poaching from each other while doing nothing to expand the pool for drivers. Peter Latta of A. Duie Pyle noted that it costs \$25,000 to train a new driver. With that level of investment and the high incidence of poaching, companies are loathe to invest in an asset that can leave to take a competitor's lucrative signing bonus.

Second, new and forthcoming government regulations, intended to reduce highway fatalities and improve U.S. security, impact the driver shortage in two ways. First, more restrictive hours-of-service rules mean an increasing need for more drivers to haul the current volumes of goods. The less each driver can work, the more drivers that carriers will need. Second, security rules, background checks, fingerprinting, and drug testing mean a shrinking pool of experienced drivers and another serious hurdle to attracting new drivers. Some segments of the driver population will be especially hard-hit. It is estimated, for example, that new regulations will create a 25% reduction in the hazmat-certified driver population.

Third, demographics also contribute to the ongoing shortage of drivers. Driving is less popular among workers who have settled down to raise families. As the U.S. population ages, the pool of potential drivers shrinks. Trucking companies are exploring numerous sources for quality drivers to include Eastern Europe and Mexico.

All of these factors will likely mean a continuation of the current industry practice of cannibalizing drivers from each other. Trucking companies know it is far cheaper to offer a signing bonus to an experienced driver than it is to train a new driver.

1.3. Fuel Costs

The current high price of oil impacts transportation in a very direct way. Different modes have different fuel efficiencies, and thus fuel prices impact the economics of mode choice. Ocean, rail, truck, and air have respectively higher rates of fuel consumption. In that way, the rising cost of fuel becomes a progressive tax on distance, bulk, and speed.

Carriers and some shippers manage their fuel purchases by buying fuel on the global market. Some even go so far as to distribute fuel themselves. Wal-Mart, for example, maintains its own fueling depots at its DCs.

Participants discussed the use of hedging programs -- using the commodities markets to help lock-in a given price of fuel and reduce the risks from potential price increases. Ocean carriers use hedging programs and build the hedged price into their surcharge structures. Although some other carriers are hedging, not all of them do, and they don't necessarily hedge a high percentage of their fuel. The structure of carrier contracts, with built-in fuel surcharges, means that carriers have less incentive to hedge. This use of cost pass-throughs from the carrier to the shipper means that carriers have less incentive to hedge fuel costs.

PepsiCo hedges for their private fleet and watches distillate inventories, and other indices. Other shippers noted that they do not hedge fuel prices and have been discouraged from doing so by the complexity of the process. Complex accounting rules and the chance of locking in a high price for fuel (and seeing prices decline) mean that very few have the expertise to implement a financially sound hedging program. Hedging has limited benefits when fuel prices climb and refuse to drop.

BNSF noted that it is changing its fuel surcharge program. The old program levied a simple additional percentage of the tariff or contract price regardless of the distance. If the railroad changed the tariffs, the fuel surcharge changed, too, even though the fuel consumption for the move may be independent of the negotiated or listed price of the service. BNSF's new system is per mile and better reflects a fairer pass-through of the distance-sensitive nature of fuel costs. This is more in line with existing fuel surcharge contracts in the trucking market.

1.4. Regulation

Several participants highlighted uncertainties created by regulation and government action. The ongoing evolution of the hours-of-service rules present potential future risks to transportation capacity. Both the DOT and Maersk highlighted the potential uncertainties with freight security regulations, which could add new costs, bureaucratic procedures, and delays in global supply chains. Convolutional local project approvals processes can also delay or derail critical infrastructure development efforts. Much-needed legislation, such as SAFETEA, can get delayed for years or suffer from amendments and compromises that damage the original intentions of the bill.

1.5. Supply and Demand = Accept and Reject Loads

As carriers hit capacity limits, they stop accepting loads. Shippers, such as PepsiCo, worry about the carrier over-commitments that result in the promised capacity not being available when it is needed. Research by Matt Harding of MIT is looking at making better use of Accept/Reject data in robust transportation planning.

Companies in the bulk material business complained about the increasing reluctance of railroads to take their loads. Some railroads are spurning the heavy, bulk commodity loads that once were their bread and butter. The shippers wondered about this seeming reversal of the trend to move freight from truck to rail. But it was clear that the phenomenon is one of supply and demand. As shippers with high-value cargos move to rail, those with lower-value cargo are likely to see either higher prices or less availability.

2. Short Term Solution Elements

The attendees proposed and debated a number of potential solutions to the major uncertainties facing transportation. Many of these suggestions focused on capacity issues -- improving utilization, for example, to raise the productivity of transportation assets. Other suggestions

focused on the need for new investment, or simply for better coordination of investment, by government, carriers, terminal operators, and shippers.

2.1. Better Utilization

Despite the universal claims of limited capacity, there are many parts of the transportation chain that are not at 100% utilization. Off-hours, non-peak seasons, and empty miles all attest to how underutilized the network is. Ineffective or sporadic use of assets means congestion is not perpetual. Better utilization would see the demand for transportation more evenly spread across the supply and thus make more effective use of existing assets. More effective utilization can be a quick win, because it often requires only a slight change in business practices or a modest investment in infrastructure.

Demand Smoothing

Carriers complained about the weekly "hockey stick" in shipments. Many shippers have severely imbalanced patterns of shipping during the week. For example, one shipper admitted that they ship 74% of their goods on Thursdays and Fridays. If more shippers (and the customers that demand inbound arrivals on particular days) would smooth the load across days of the week, then carriers could better utilize slack capacity on the slow days.

APL noted that the weekly cycle of spiky demand propagates all the way back to China. Ships leave China on particular days of the week in order to get to port in time to ensure that goods reach stores by the weekend. The weekly pulse in activity forces transportation networks to size for high peak demand and suffer low utilization at other times.

Going beyond more uniform 5-day-a-week shipping would include full 24x7 operations. Both J.B. Hunt and Wal-Mart recommended that more shipping and receiving activities on the weekend, in particular, would be especially beneficial. One carrier suggested that the driver shortage could be alleviated by using less experienced drivers on the weekend. The lighter traffic levels on the weekend mean lower risks of accidents and thus less liability exposure from employing new drivers.

A move toward smooth 24x7 shipping, movement, and receiving operations would let carriers more fully utilize their capacity and accelerate the flow of goods. Maersk noted that expanded hours of operation for ports would provide much needed added capacity for dock-side operations. This shift implies operational changes at the shipping and receiving end, as well as at all points along the route. Some of these changes may be impractical, given that retailers organize receiving schedules around patterns of demand and the weekly cycle of promotions and shopping habits.

Virtual Private Fleets

Empty miles represent both a sign of underutilized assets and imbalance in the flow of goods. For trucks, the solution to the empty mile problem is in finding a backhaul. Shippers' migration to dedicated or private fleets, (spawned by the need to ensure access to capacity), has exacerbated the empty mile problem. This practice had the unintended effect of pulling capacity from the shared common carrier fleet. Unless the shipper has substantial reverse logistics needs,

they seldom have a backhaul. As a result, the total number of empty miles in the trucking industry is increased with the use of dedicated and private fleets.

PepsiCo recommended the creation of industry-wide virtual private fleets. The idea is that multiple shippers and carriers could collaborate to both ensure needed capacity for each shipper and allow the use of virtual private assets for more efficient back-haul freight from other shippers. Virtual private fleets would represent a move toward more globally-optimized transportation. Rather than having each shipper or carrier try to optimize their own internal operations, virtual private fleets would lead to more coordinated solutions.

Rail Car Rationalization

Empty miles plague not only the trucking industry but the rail industry as well. BNSF noted that it runs 50% empty miles. For the railroad, one reason for excessive empty miles is the excessive differentiation of car types. BNSF has 220 different types of railcars. Too many industries -- or even individual companies -- want specialized cars or containers for their loads. The diversity of railcar types creates a management nightmare because the carrier needs to reposition the right type of asset for each type of load. Thus, for example, BNSF hauls full grain hopper cars and empty freight cars to the West Coast and then hauls empty grain cars and full freight cars east.

To mitigate this problem, the railroad is in the process of rationalizing by standardizing its cars. For example, BNSF is experimenting with hauling grain in containers. Moreover, the specialized rail cars have a very low return on investment; specialized cars cost more and are used less than standard cars. BNSF, for its part, is divesting itself of these multitudinous varieties of rail cars, insisting that customers take ownership of them if they require using non-standard cars. The problem with overly-diverse assets occurs throughout the transportation industry. In ports, for example, having too many container chassis types reduce overall productivity. Having a large number of container, van, pallet, tote, or other conveyance types always limits the use of risk pooling in asset management and always leads to increased asset inventory levels.

Design-for-Transportation

PepsiCo suggested that many shippers have put the package before the cart; that is, they design products and packaging without regard to the transportation systems that will carry the product. Better packaging and carton design would lead to more effective cubing of containers. Considering the transportation costs for different configurations of WIP can also lead to more efficient supply chain design. Packaging for shipment is becoming even more important with the use of RFID tags. The placement of tags is now impacted by the contents of the box in order to improve read rates.

2.2. Better Management

Related to improved utilization are better freight and asset management practices that reduce delays, costs, or inefficiencies. Tight capacity is forcing companies and carriers to measure and manage their transportation better. For example, Wal-Mart started examining driver productivity issues when the Hours-Of-Service regulations arose.

Carrier Portfolios: More or Less?

As shippers hit the capacity limits of carriers, they are displaying polar opposite strategies for coping. On the one hand, some shippers are expanding their base of carriers. This reverses the ten year trend of carrier rationalization, in which shippers winnowed the supply base to a few core providers in order to reduce the costs and complexities of the system. As transportation capacity becomes scarce, these shippers are looking for alternate carriers to add to their portfolios.

On the other hand, other shippers such as Linens-n-Things and Wal-Mart, are taking the opposite approach. These shippers are further reducing the number of carriers and sharing long-term plans with those carriers. The rationale is that developing a deeper relationship with a smaller number of carriers helps both parties understand each other. This includes better coordination of future business plans, shipping volumes, and capacity development efforts. Whereas an expanded portfolio of carriers provides more opportunity for capacity, a consolidated portfolio of carriers provides a greater likelihood of accepted loads.

Matt Harding of MIT is studying how companies should select carriers in order to maximize the robustness of the assignment. That is, to minimize the need for using more expensive back up carriers

Carrier Portfolios: Expand to Dedicated Fleet

Related to the concept of expanding the portfolio of transportation options that a shipper manages is the use of dedicated fleets. With a dedicated fleet, PepsiCo gains a fixed cost structure that avoids paying high prices on the spot market. For PepsiCo, a dedicated fleet can operate more like the private fleet which the company has for its Frito-Lay division. Dedicated fleets can mean happier drivers, too, because dedicated arrangements often come with fixed lane assignments or routes that ensure the driver gets home. There is added complexity, however, with the use of a mix of for-hire and dedicated fleets. This topic is being addressed in on-going research at MIT as part of the Transportation Research Group.

Visibility

"Information is the raw material for creativity," said Keith Thurgood of PepsiCo. The more that shippers and carriers know about the shipments, future demand, and about each other, the better they can mutually improve their service, freight velocity, and their transportation networks. More accurate forecasts would enable carriers to optimize transportation and provide carriers with greater visibility onto future shipments.

Visibility means more than just tracking the status of pending shipments or forecasting demand. Some of the proposed transportation innovations involve better awareness of the destination of goods. Rather than pile containers on ships or trains, companies can improve performance by blocking freight -- that is, by arranging it so that freight intended for the same destination is located together on the train or ship. For example, Wal-Mart is working with steamship lines to sort freight so that goods destined for the northern U.S. arrive in Seattle and goods destined for southern states arrive in California.

Visibility extends to pricing, too. In a dynamic capacity-constrained environment, pricing becomes more volatile. With intermodal freight, the presence of multiple carriers for each

shipment makes for a complex cost structure. Hub Group, for example, noted that it had 97 rate actions last year and that that makes it hard to provide visibility into costs for its customers. Creating a mechanism for sharing pricing data would enable shippers to forecast costs and optimize modes.

The government can also benefit from better visibility for purposes of security, economic/trade policy, regulation, and infrastructure investments. Mr. Biter, DOT, noted that the government is working to better understand the pattern of freight movements in the U.S. The old survey process means the government is using data that is between two and seven years out of date.

2.3. Adding Capacity

Solutions to the Driver Shortage

As much as the trucking industry complains about the problem, the driver shortage is confined to the only some segments of the industry. Non-fixed long-haul routes pose the greatest problems. In contrast, companies such UPS have no problems hiring and retaining drivers, despite a preponderance of stressful urban driving conditions, because the drivers are paid well and they get to go home in the evening. Similarly, dedicated and private fleets - with fixed route schedules that give the driver a predictable return home - can also attract drivers.

Wal-Mart noted that its driver turnover is only 5%. Wal-Mart also shared the results of a recent driver survey. Surprisingly, pay was down at #6 on the list of most important issues for drivers. Other quality-of-life issues ranked much higher than pay. For example, beyond the predictable issue of homelife, Wal-Mart drivers also cited respect and self-image as very important issues. Wal-Mart endeavors to hold its drivers in high esteem, and the drivers return the compliment with their on-the-job loyalty.

A. Duie Pyle is doing something about the driver shortage. Whereas many carriers at the conference sheepishly admitted to hiring away drivers from other carriers, A. Duie Pyle has an extensive training program to create new ones. The training isn't cheap. The company spends \$25,000 per driver and then uses a good retention strategy to hold on to 98% of its newly trained drivers. One carrier wondered if the government should do more to either create or more uniformly screen and vet drivers so that individual carriers wouldn't incur the risks of training and then losing good drivers.

BNSF noted that rail is a solution to the driver shortage. A train crew of two can haul 250 trailers. Moreover, BNSF organizes its crew into regions only a few hundred miles across. When a crew reaches the boundary of their zone, they hop off the train and get on a train returning home. This ensures that employees make it home on a regular basis, and that many senior crews are home every night.

Increasing Vehicle Size and Weight

Some participants argued for increases in vehicle size and weight. If each truck carried more, the industry would need fewer drivers. For example, adding axles would allow for heavier trailers, and triples would be an automatic boost in capacity per driver. In some areas, such as around terminals and intermodal interchanges, special roads and rules could permit extra wide, tall, or heavy loads on designated sections of public roads.

One major barrier to any changes is the roadway. Bigger, longer trailers or trailer trains would not be practical in many areas. Chokepoints in major East-Coast routes, such as the George Washington Bridge, imply fundamental upper limits on vehicle size and length. Public perceptions about the wear and tear caused by trucks mean that relaxed regulation is unlikely.

Freight Sequencing for Higher Productivity

More intelligent arrangement of freight in one part of the transportation network can improve efficiencies in other parts of the network. The Port of Tacoma has completed successful proof-of-concept tests for better transfer for goods between ocean and rail. The port can double its productivity through smarter organization of goods on the ship and on the train. By looking ahead to the destination of the goods, they can better organize the container of the ship for faster loading onto trains and can better organize containers on trains for loading onto ships. Smarter organizing of containers on one mode of conveyance accelerates the transfer and handling of the containers on the next mode of conveyance.

Blocking of containers on rail cars can reduce delays in rail transport. Ensuring that all containers on a car are bound for same destination reduces off-loading and handling of the containers. Ensuring that adjacent cars are bound for the same destination reduces the amount of switchyard delays in reworking the train. The practice of blocking requires both transparency and forethought during loading.

Freight arrangement requires changes in the source port of the cargo. The source port must load the containers on the ship such that they can be conveniently off-loaded in a blocked configuration at the destination port. Proper stacking and layering of the containers on the ship ensures that they can be efficiently unloaded in a blocked pattern for the train. This practice may be hard to achieve in some Asian ports, such as Hong Kong, where limited space forces the port to quickly load incoming containers with little regard for destination.

Robust Planning

Matthew Harding, MIT, presented research on better, robust approaches to planning. In attempting to optimize transportation, companies should seek a solution that minimizes the sum of planned and unplanned costs as a function of service level. The planned costs include the costs of primary carriers, contracted capacity, and the routing guide design. The unplanned costs include the costs of backup carriers and the costs to the organization of failing to meet service requirements some fraction of the time. If a company chooses too low a service level, it may enjoy low planned costs but suffer from high unplanned costs from later, failed, or expedited deliveries.

Traditional transportation optimization software uses data on average volumes to optimize a static model. A robust version would consider the variability in shipping volumes and costs of coping with unplanned events. Robust planning considers various randomly-simulated scenarios of planned and unplanned volume to estimate the costs of stochastic events and to help optimize the plan to minimize total cost across these uncertainties. Mr. Harding presented a graph illustrating the value of robust planning as a function of acceptance ratios and unplanned costs: as acceptance ratios declined or unplanned costs increased, the value of robust planning increased.

Double tracking of rail lines provides a major boost in rail capacity, according to BNSF. The company is completing a double tracking project on its California-to-Chicago line. Because double tracking reduces the need to sideline trains to permit passing or overtaking by other trains, it creates an eight-fold boost to capacity. BNSF is starting to triple-track in some areas, because that will allow fast trains to overtake slower trains without delays for either train.

Investment in Infrastructure

Dr. Caplice asked participants what investments need to be made in infrastructure. The discussion spanned public and private investments and highlighted the need for collaboration and coordination among diverse parties.

Gene Pentimonti of Maersk argued for greater government funding of critical road and rail infrastructure. He noted that Maersk's Sealand unit received dozens of letters complaining of poor service during 2004 peak season. Yet the problems were due to port congestion and reflected ongoing under-investment in on-land infrastructure. Sadly, both Maersk and the DOT acknowledge that the proposed SAFETEA bill, currently in Congress, includes little money for the kind of new infrastructure needed to prevent a repeat of the 2004 congestion delays.

Although SAFETEA may not provide much money, it does have several provisions that will enhance infrastructure investment for freight transportation. First, SAFETEA includes a mechanism for increased use of public, tax-exempt bond funding of new privately-managed infrastructure. Second, the bill mandates a 2% set-aside that forces states to spend money on intermodal connectors. It also requires states to create a transportation coordinator position, which should raise the profile of freight.

Maersk is building a brand new deep draft port in Virginia. They plan to create the largest single terminal on the East Coast. Although California may be off limits for large-scale new developments, other areas on the East, West, or Gulf coast could provide new ports of entry for volumes of goods.

Perhaps the greatest and most mandatory investments are the coordinated intermodal investments that are needed to make the entire system work. For example, the Port of Tacoma could double its volume with recently proven methods of organizing containers. But that improvement means nothing if the rail lines in Washington can't handle the added traffic. Washington's main link eastward currently sees 18 trains per day, but it cannot handle double the traffic because a critical tunnel only permits 24 trains per day. This highlights the critical issue of interdependence with freight transportation networks.

A promising alternative route could help the Port double its capacity, but the route requires \$40 million in upgrades to handle double-wide cars. Yet the port authority does not feel that they are in a position to make these investments. For its part, the railroad is reluctant to invest because it has no control over the freight volumes coming to the port that would help justify the upgrade to the rail line. Without coordinated commitments by both port and rail, the proposed capacity enhancement cannot happen.

2.4. Government

Bush's goal of free and open trade depends on transportation. Efficient world trade depends on the efficient movement of goods. Port congestion, delays, and high transportation prices are just as effective as import duties at forestalling global commerce.

The Need for National Infrastructure Plan

The U.S. is a rarity amongst major developed countries in that the central government does not play an active role in managing the country's infrastructure. In fact, Richard Biter described the ongoing shift in power and spending away from the federal level and toward local levels. Although the federal government provides the money for many infrastructure projects, the projects are developed and implemented at the local level.

In many ways, the DOT has very little say in how the money is spent. Legislative mandates and congressional earmarks consume the majority of the budget. Mr. Biter noted that this trend toward local government power runs counter to the business trends of globalization. Whereas business is moving toward greater levels of global collaboration in logistics, the U.S. government is moving toward more independent, local decision-making. Another speaker joked that he wanted 10% communism - just enough central control to create a sound transportation infrastructure in the U.S.

SAFETEA

The SAFETEA (Safe, Accountable, Flexible and Efficient Transportation Equity Act) legislation will help freight transportation in numerous ways. Various programs in the bill would bolster the government's awareness of freight transportation issues on all timescales. This includes real-time awareness, planning processes, and long-term research. Other portions of the bill should boost investment in transportation infrastructure. For example, one provision of the bill mandates that a certain fraction of federally-provided dollars go to intermodal infrastructure. Other parts of the bill increase the availability and lower the threshold project size for public-private partnerships such as tax-exempt private activity bonds and TIFIA (Transportation Infrastructure Finance and Innovation Act) credit assistance. Passage of SAFETEA, however, is not assured. The legislation was originally drafted in 2003 and is currently stuck in the U.S. Senate.

Regulation: The Great Balancing Act

Perhaps the greatest challenge which the government faces is the balancing act of regulation. The need for economic development and open trade must be balanced against a host of safety, security, and environmental concerns. Shared public infrastructure, such as roadways, raises tough issues concerning who uses the infrastructure versus who pays for it.

Carriers were particularly concerned about regulations that further restrict the productivity or availability of drivers. The regulations for hours-of-service, driver background checks, and driver drug tests pose a challenge to carriers and illustrate the challenge of the government. The DOT argues that these regulations are necessary for the safety and security of everyone. One carrier admitted that reduced hours-of-service have led to fewer accidents, suggesting that the regulations weren't unwarranted.

One audience member suggested deregulation of the trucking industry went too far -- forcing trucking companies to compete on short-term price cuts that sub-optimized long-term performance. In this view, deregulation gave too much power to the shippers and led to under-investment in drivers, equipment, and infrastructure. Others debated this effect, suggesting the before deregulation, trucking had excess capacity and severe inefficiencies. Overall, logistics costs have dropped from 16.1 % of GDP to about 10%. Now that the trucking industry has consolidated, supply is matching demand and truckers can command a more reasonable price for their services.

Political Power

Carriers noted that they feel they have too little political power in Washington. Steamship carriers, who are largely foreign-owned, have even less say in Washington. Because foreign-owned companies cannot contribute to political campaigns, Congress does not listen to them. At the same time, shippers refuse to use their limited political leverage to defend carriers' interests, because freight is only 4% of a shipper's costs. Finally, consumers want cheap imported goods in local stores, but they don't want to share the road with the trucks that deliver those goods.

Part of the problem may be a lack of involvement by companies with the government. When Mr. Biter asked how many of the audience members had met with their local state Department of Transportation, very few people raised their hands. Yet these local officials have a tremendous influence on spending on infrastructure. Mr. Biter cautioned that companies that do not interact with the government may well discover that the government is making rules and spending decisions that don't align well with the company's interests.

2.5. Aligning Incentives

Pay for Performance

Keith Thurgood of PepsiCo, PPG, and Tyco brought up the potential for pay-for-performance to motivate carriers toward better service. For many shippers, service factors are as, or more, important than cost factors. Thus, shippers would like to use some combination of bonuses or penalties to ensure high service levels. The group, both shippers and carriers, discussed the pros and cons of pay-for-performance.

When the audience was polled, several shippers cited use of pay-for-performance arrangements. For example, Tyco Healthcare uses an aggregate service level metric to adjust air freight rates. If the carrier is on-time less than 90% of the shipments, Tyco gets a 15 cent rebate on shipping. If the carrier is on-time more than 95% of the time, Tyco pays a 15 cent bonus. Tyco noted that, so far, the carrier has not met the target. Although Tyco has enjoyed the lower air freight rates, they would much prefer on-time deliveries to lower costs.

Despite interest in pay-for-performance programs, several participants noted that carriers seem reluctant to accept such contracts. The only somewhat facetious reason for this is that the carriers know they will lose because they are unlikely to meet the performance targets. Some of this under-performance is due to capacity constraints, over-commitment of capacity by the sales force, and the vagaries of transportation. But carriers also cited service problems that are caused by shippers and recipients. Erroneous routing guides, forecast errors, driver waiting times, and asset detention all detract from carriers' service levels and make carriers reluctant to promise

what they know they can't deliver. Pay-for-performance reduces shipper and customer incentives to help service levels, and that fact contributes to carriers' reluctance to accept such contracts.

Some companies, such as Mohawk Industries, use freight audit firms to cross-check carrier performance. Late or misrouted deliveries are subject to fines. International Paper would like to use pay-for-performance but wonders who will measure the performance, how they will measure the performance and whether it can trust the data.

Another potential concern of pay-for-performance is that it increases the spread or financial uncertainty for both sides -- shipper costs and carrier revenues become more variable. Pay-for-performance means that costs (for the shipper) and revenues (for the carrier) can vary. Bad weather or an unexpected surge in demand that congests shared infrastructure can, unexpectedly, affect performance and change shippers' costs and carriers' revenues. If companies want to reduce uncertainties, they will seek more simplistic cost and revenue structures that are risk free. This issue is less of a concern for shippers because higher payments to carriers, due to exemplary performance, may be offset by reductions to unplanned costs associated with lower service levels.

Accessorial Charges: Creating an Incentive System

Accessorial charges could be considered the flip-side of pay-for-performance -- carriers charge for cost-increasing behaviors such as wait time, live loading/unloading, and asset detention. PepsiCo's Keith Thurgood suggested levying a \$200/hour waiting charge when a shipper makes a driver wait. Although one could view these charges as outrageously punitive, they actually reflect the high costs and consequences of non-ideal behavior by shippers and their customers. If a shipper keeps drivers waiting for a load, that driver will be unhappy, may quit the carrier, and force the carrier to pay thousands of dollars as a signing bonus for a replacement. Similarly, Hub Group noted that railroads are levying high storage charges to reduce congestion in railyards and improve asset utilization.

Paradoxically, some shippers welcomed these charges because they help motivate improvements in transportation management, yard management, and logistics operations. Without specific accessorial charges, the costs of suboptimal behavior and business practices become hidden. Accessorial charges provide a business case for much-needed changes such as implementing yard management systems.

As with pay-for-performance, accessorial charges add some level of complexity and uncertainty to transportation. Contentious issues of how the charges are defined and who measures them can complicate the relationship.

2.6. Real Options Have Real Value under Uncertainty

Real options provide a means of quantifying the costs of uncertainty and assessing the value of mechanisms that reduce uncertainty. Sigurjon Palsson, MIT, described ongoing research on the use of real options in transportation. A real option provides the right, without obligation, to perform some action. Examples of real options in transportation include having a dedicated fleet (giving the shipper the right to capacity) or over-engineering the structure of railroad bridge (giving the right to add additional tracks later).

The math underpinning options may be complex -- the Black-Scholes formulas are not for the faint of heart. Yet the key implications of options math is simple -- the value of the option grows as uncertainty grows. Given all of the serious sources of uncertainty identified at this conference, the value of real options is quite high. Palsson reviewed the use of flexibility in contracts and noted that there are opportunities in ocean contracting for these types of contracts.

2.7 Shifting Demand away from West Coast Ports

One set of, potentially long-term, solutions is to bring more Asian cargo through ports in locations other than the West Coast. This includes trans-Siberian routes, Suez Canal routes, and ports in Canada and Mexico.

The New Trans-Siberian Supply Chain

One long-term solution to West-Coast port congestion is to change the direction of the flows -- to bring goods from China west across Russia to warm-water ports in Norway and then across to US East Coast ports and demand centers on that side of the U.S. The proposed "N.E.W." corridor would include routes through northern China and a southern route through Kazakhstan. Such a route might be cost competitive and even time-competitive in the event of severe West Coast congestion. Interestingly, as the manufacturing base in China moves further inland as part of their Go West policy, the likelihood of shipping via the N.E.W. corridor increases as the transit time approaches that of the Pacific to West Coast routes.

Suez-Max Shipping

A similar, west-from-China proposal would see the use of very large ships sailing west from Asia, through the Indian Ocean, Suez Canal, Mediterranean, and to European ports or across the Atlantic to U.S. ports. Whereas the Panama Canal limits so-called Panamax ships to a 13 m beam, the Suez Canal could accept 28 m beam behemoths carrying 15,000 to 18,000 TEUs. Several of the meeting participants acknowledged that such ships are feasible, but the practicalities of loading and unloading them remain to be solved.

Non-U.S. North American Ports

Other ports in the Americas could alleviate congestion on West Coast ports. For example, a Canadian group is looking at the building a port in Prince Rupert in British Columbia. The port could be as large as the Los Angeles/Long Beach complex and link to Canadian railroads that could move goods to the northwest coast, Chicago or the East Coast. Similarly, the port of Ensenada, Mexico could host a sizable port and is only 70 miles from the Southern California border.

3. Continuing Challenges to Success

3.1. Not in My Backyard (But in My Local Store)

Both the DOT and BNSF noted the outsized impact of NIMBYs -- the "Not In My Back Yard" protesters who object to infrastructure development projects. For example, BNSF received 1000 protest letters the day after they were selected for a port development project. The letters

protested the potential for smoke-belching locomotives despite the reality that rail is far more environmentally-friendly than trucks. The NIMBYs don't realize that trucks consume 2.5 times more fuel for the same load while congesting local highways. Moreover, protesters of California projects don't realize that 30-40% of the goods coming into the port stay in California because the state has such a massive economy.

As much as carriers would like to avoid urban areas, they cannot. Major logistics hubs of the past, ports, industrial centers, and rail interchanges have grown to become congested cities. Moreover, the point of demand -- the destination of most of the goods -- is inevitably urban. Demand is where the people are and thus goods must come into congested areas.

3.2. Correlated Patterns of Demand

One core challenge is that, to a great extent, everyone needs to use the same transportation capacity to move from the same sources to the same destinations at the same time.

It's Christmas Time Around the World

Because Christmas falls on the same day all across the country, every retailer experiences the holiday surge at the same time of year. Similarly, the weekly cycle is driven, in part, by the retail demand cycle and retailers' promotional surges: weekend sales drive weekday transportation surges.

Trade Imbalances = Freight Imbalances

The problem also occurs on a geographic level. Heavy manufacturing and export-oriented regions will always have a preponderance of loads for tender. Consumer-dense affluent urban areas will always have a preponderance of destinations and a scarcity of loads. This makes of the empty mile problem not completely solvable.

This fact is even more important on a global level. Unless the U.S. discovers something bulky that Chinese consumers need (e.g., grain? coal?), the country and its transportation systems will continue to experience imbalanced East-West flows.

3.3. Multiple Layers of Participants

Discussions at the conference revealed the deep complexity of relationships in the transportation industry. For transpacific shipments, every shipment is intermodal, getting to the Asian port, across the ocean, onto rail or truck, and onward to its destination. A given load passes through multiple hands as it goes through terminals, ports, rail and truck yards, and on various conveyances. No single party has control. Libby Ogard noted that the Port of Tacoma is in the middle of the supply chain. The port does not control what comes to it or when it leaves. Yet it is a gateway to the national network and must work collaborative to move freight in a timely way.

Hidden Intermediaries Mean Low Mutual Visibility

In offering intermodal service, a railroad such as BNSF is a hidden intermediary. In some 40% of its business, BNSF is a subcontractor with little contact with the customer. This means that BNSF lacks visibility onto the needs of shippers, upstream carriers, downstream carriers and the

recipient of the freight. To improve performance and long-term decision-making, BNSF is now talking to shippers and customers. Although BNSF and all carriers are bound to adhere to the interests of their paying customers, they also need to understand other parts of the transportation chain in order to plan effectively and make the best infrastructure investments for the future.

Assets: Hot Potatoes

Asset ownership is no bed of roses. Assets consume capital, are a management nightmare, and cost money to maintain. The problem, for many transportation asset owners, is that the asset owner seldom has full control of what they own. First, the shipper defines demand and thus defines the utilization of the asset -- without demand, the asset goes unutilized and provides poor return on investment. Second, the practices of the shipper, the recipient, and other subcontracted carriers in the move can affect utilization of the asset by detaining the asset or leaving the asset at an unfavorable destination. For these reasons, some carriers are trying to divest themselves of troublesome assets. For example, BNSF is selling off specialized rail cars to customers, selling short side-branch lines to local shortline railroads, and exiting the North American Container System (NACS) system of shared containers. With NACS, for instance, BNSF noted that the assets were only in use 60% of the year. The assets created service problems when everyone wanted them during peak times, and they did not provide an acceptable return on capital. BNSF's divestiture is forcing some assetless IMCs to bite the bullet and become asset owners themselves. The Hub Group is buying more trailers and said that they get 50% better turns than NACS by managing their private fleet. Other carriers are devising complex accessorial charge systems to motivate other participants in the transportation system to better manage their use of carriers' assets such as containers and trailers.

Longshoreman Unions Aren't Going Away

Ole Sweedlund of the United States Maritime Alliance noted the ongoing role of unions at U.S. ports. In doing their best for their membership, the unions representing the port workers have crafted very nice salary packages. The average salary is over \$100,000 per year and some make as much as \$400,000. Contracts aren't set to expire until 2008 and 2010 for West and East coast ports, respectively, so the likelihood of a repeat of the West Coast port lockout is not likely for a few years.

Although the unions do have a lock on the ports, Mr. Sweedlund was optimistic about ongoing improvements in productivity and the use of technology. For example, Mr. Vickerman and Ms. Ogard described a productivity-doubling proof of concept at the port of Tacoma that was accepted by the union.

3.4. Natural Cycle of Unintended Consequences

The Alameda corridor was intended to solve congestion around the port of Long Beach. This model of public-private partnership saw the use of public bonds to create a shared rail line between the port and the inland empire. The bonds paid for a 10-year project to bury the rail lines -- reducing congestion at 200 railway crossings and allowing trains to go from 5 mph before the project to 45 mph. A modest fee on containers shipped on the buried rail lines would pay back the public bonds.

Initial revenues on the corridor were good, but then they flattened. Logistics managers decided it was cheaper to move containers by truck and reload them into 53-foot domestic trucking containers. The result is that only 25% of shipments travel on the corridor. The other 75% of shipments travel by truck, creating serious congestion on I-710. Part of the DOT's efforts will be to look for and avert these types of unintended consequences.

3.5. Shift from Price-Sensitivity to Time-Sensitivity

Part of the rising concern with congestion is due to a shift in transportation management imperatives from price-sensitivity to time-sensitivity. As companies rely on lean manufacturing and produce fashion-oriented consumer goods, they come to depend on reliable high-velocity logistics. Shipper still want low costs but are becoming much less tolerant of late loads.

More Shipments In the Air

Time-sensitivity is forcing some companies away from low-cost modes. Although no one was surprised to hear that Texas Instruments uses air freight for 99.5% of its chips, they were surprised that Limited Brands uses air freight on 40% of its fashion apparel. Similarly, UPS is moving away from intermodal rail for its ground service because rail is not achieving UPS' strict delivery time targets.

Supply Chains: 13,000 Miles and Growing

The shift to time-sensitivity is especially difficult as the centroid of manufacturing shifts further into Asia. Operating a 13,000-mile long supply chain on schedule is not easy. Moreover, the challenge will only increase as more manufacturing moves to China and as rising wages on China's coasts force manufacturing to move inland and further away from Chinese ports. One can only hope that China's massive investments in intermodal infrastructure will ensure high velocity operations on its side of the Pacific.

But Bigger Ships Mean More Delays

The shift to time-conscious transportation means less tolerance of delays. Yet both Ole Sweedlund and John Vickerman noted the ever-increasing size of vessels. Recent-generation ships are 1000-foot long giants carrying 6,000 TEUs. Yet ship size continues to increase, with 8,000 TEU ships recently coming into service and ships as large as 18,000 TEU looming on the drawing board. Although such ships may be more cost-efficient for the steamship line, they will also mean longer delays in loading and unloading times and greater intermodal congestion around ports, thus adding to potential headaches for time-conscious shippers.

The Danger of Congestion

Mr. Biter, DOT, described the insidious effect of congestion on the U.S. economy. Modern logistics practices have converted companies from holding fat stocks of "static" inventory to one of maintaining a lean "rolling" inventory. This practice makes American businesses more agile and robust, but it also makes them reliant on predictable velocity. Congestion breeds a vicious cycle for lean supply chains. The more congested the transportation network, the more goods that companies will have stuck in the logistics cycle. With delivery times prone to delays, companies will put more goods into the system as a buffer, thus creating even more congestion.

3.6. The Gulf of Timescales

A number of the comments and discussions highlighted the vast gulf in timescales between different participants in the transportation arena. Shippers and their customers operate on much shorter timescales of demand than do carriers' investments in supply.

Same-Day Demand = The Impossibility of Forecasting

On the one hand, some shippers have no idea of tomorrow's demand. Customers can call at any time and demand same-day or next-day shipment. Routing guides go of date the day they are published. Shifting patterns of demand, competitive dynamics, fashion-oriented trends in consumer behavior, and economic cycles mean that many companies have little visibility onto demand in the coming days, weeks, or months. Matthew Harding, MIT, noted the role of unplanned demand in crafting robust transportation planning software.

Ownership is For Life

On the other hand, carriers, terminal operators, and port operators face an entirely different timescale reality. BNSF, for example, delineated the long timeline for even a simple port-rail project, requiring two years for environmental approvals alone. Major projects can take 10 or 15 years to progress from inception through to studies, public hearings, approvals, design, construction, and commissioning. Moreover, these decisions have long-lived impacts because they represent long-lived assets. Buying a \$1.5 million locomotive has very long-term implications -- the equipment will sit on the railroad's books for 40 years. Physical plants can last even longer. BNSF noted that one of its terminal buildings date from the '60s -- the 1860s.

Creating Investment = Creating Commitment

The point is that infrastructure providers often need years of lead-time and won't commit resources without some assurance of decades of future demand. Asset-intensive companies such as railroads do not want to invest money unless they are assured of the long-term revenues and profits needed to create an acceptable return on investment. Long-lived assets such as locomotives, steamships, tracks, and concrete make infrastructure providers and operators very cautious about investments.

3.7. Conclusion

Visibility and collaboration are probably the most important innovations in transportation. Given both the data and the will to jointly solve pressing problem, shippers, carriers, and the government can cope with the utilization, service performance and asset capacity issues facing transportation. With greater visibility and greater collaboration, participants can reduce the gulf of timescales and create mutual understanding of expected and necessary balancing of future supply and demand. Techniques such as robust planning and real options can help companies, especially those that make significant capital investments, to deal with high uncertainties. Better visibility and coordination across modes and between companies can improve utilization of existing assets, boost the return on those assets, and thus encourage further investments in much-needed infrastructure. Better connections between the participants will mean better movement of goods.