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FINAL REPORT
Transport, Energy and Environmental Benefits of Intermodal Freight Strategies

APEC Transportation Working Group
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Transport, Energy and Environmental Benefits of Intermodal Freight Strategies

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Summary

The present project investigated the benefits of using intermodal approaches to the movement of freight in urban settings as a means of improving energy efficiency and reducing the emission of greenhouse gases (GHG). A number of selected locations throughout the Asia Pacific Economic Cooperation were identified and examined in more detail to understand the benefits for moving freight using intermodal solutions namely rail.

The various metrics that have been used to compare the benefits and efficiencies of different modes and methods of transporting freight were reviewed and discussed. Previously, many comparisons using fuel efficiency such as miles per gallon had been used to compare different vehicles. However, when comparing trucks and trains, the two primary methods for moving freight, such comparisons are not equivalent. Instead, the fuel efficiencies and emissions rates obtained when moving one ton of freight one mile in distance per unit of fuel is seen as a comparison or ratio that is more equivalent across modes.

Thus, using the ton per mile per gallon and the GHG per ton mile different modes of transportation can be evaluated on the same metric and comparisons more readily made. Results of these analyses indicate that on the average the movement of freight by rail enjoys a significant advantage over truck movements ranging from two to one to almost three to one depending upon the distance and amount of freight being moved. Even when additional moves, due to positioning of containers and on-off loading to take advantage of rail, these benefits still accrue.

A number of recommendations that encourage the use of rail for moving freight even over short distances were discussed and reviewed. Policies which encourage the construction of grade separated rail ways, construction intermodal yards outside of congested urban settings, the use of double stack trains, the use of on dock rail, and the discouragement of trucks within urban settings are the main suggestions for reducing GHG and improving fuel efficiencies when moving freight.

1) Intermodal freight movement that utilizes and prioritizes barge, rail and truck modes (in that order) results in a significant saving in GHG emissions, fossil fuel consumption and importation and a concomitant decrease in highway congestion.
2) Intermodal freight movement that creates terminals or yards away from central urban settings likely has the greatest impact on decreasing congestion and GHG.
3) Intermodal freight movement should be guided by dedication to most energy efficient mode given the physical geography.
4) Intermodal freight movement would benefit greatly from dedicated intermodal rail line service.
5) Policies that encourage the development of intermodal yards external to the city or dry docks should also be encouraged.
6) Development of freight corridors for truck traffic over surface streets is also highly recommended.
7) Joint development of transit oriented development and freight handling facilities will result in significant advantages to both passenger and freight mobility.

8) The advantages of moving freight by rail, even if as short as 10 miles is beneficial to the reduction of GHG and may have operational value as well.
9) The findings from these analyses are generalizable to many different APEC cities and regions. The metrics are sound and can easily be converted to different measurement systems and scales.

Project Overview

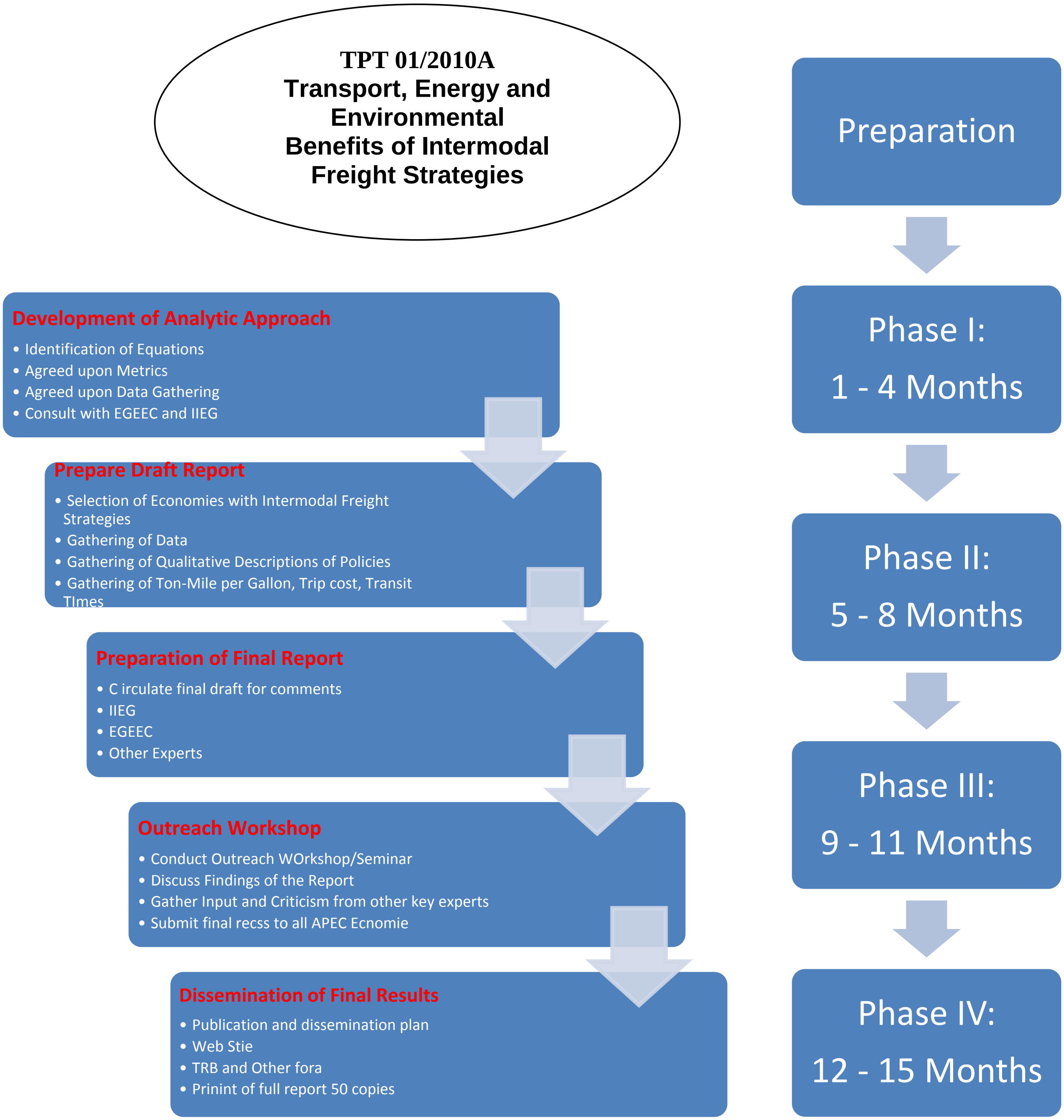


Figure 1. Conceptual Overview of Project

Background

The present report is designed to demonstrate the fuel saving and emission reduction benefits of the increased use of intermodal freight transportation in urban settings and addresses the questions raised by the APEC Working Groups regarding “Transport, Energy and Environmental Benefits of Intermodal Freight Strategies.” These questions address the need to reduce congestion and the use of fossil fuels which contribute to greenhouse gas emissions and the overall consumption of fuels needed to move freight.

The key questions addressed in this report look at the energy, transport and environmental benefits of intermodal freight strategies that can help APEC economies to shift freight transport from energy-intensive transport modes like trucks to energy- economising urban modes like intermodal rail. Using intermodal freight strategies will lead to a reduction in diesel fuel consumption, and indirectly lead to the reduction oil imports. In addition, the report will recommend additional strategies that can lead to the reduced transit times for freight shipments in the APEC economies as well.

The following report will provide recommendation and a rational for increasing the amount of intermodal freight transportation and hopefully provide transport, energy and environment ministers and leaders a clearer understanding of the potential for intermodal freight strategies to reduce reduce energy needs and oil imports, and reduce the overall carbon footprint of transport in APEC economies.

The report consists of the following sections:

a) ***Introduction***
b) ***Background regarding Intermodal Transportation***
c) ***The Development of Analytic Approach.***
d) ***Case studies applicable to intermodal transportation in APEC economies***
e) ***Recommendations***

Introduction

The basis and rationale for the project stem from statements and instructions provided by the APEC Ministers in various communicates over the last several years. APEC Ministers in 2008 encouraged greater cooperation between the Energy Working Group and Transportation Working Group in assessing approaches to fuel-efficient transport. The Draft Declaration for the Sixth APEC Transportation ministerial in 2009 affirms that the Transportation Working Group should collaborate with the Energy Working Group on projects of mutual interest.

As noted in the RFP, the project is intended to address the concerns of the energy ministers who met at the 7th Annual Energy Ministers Meeting in Gyeongju, Korea to discuss the oil import issues. Since transport is highly dependent upon energy efficiency and the use of primarily oil related energy technologies, the transport sector is particularly sensitive to fluctuations in the price of energy. Additionally, the use of oil is dependent upon the technologies selected and most appropriate for the infrastructure configuration of the local economy. In many cases in APEC regions and economies the use of trucks has superseded that of other, more energy efficient modes due to the limitations of the infrastructure, the demands of the geography and the rapid expansion of business demands and commerce which have grown up out of low cost labor intensive industries as opposed to capital intensive heavy industry.

The APEC region has seen dramatic economic success and a significant increase in the use of petroleum based energy supplies to fuel its expansion. Concern over the impact that these developments have had on the environment in addition to the sustainability of such growth has prompted an interest in reducing emissions and oil consumption. It is imperative that the APEC economies address issues related to energy conservation and deployment. In particular, it is the thesis of this project that through the implementation and utilization of various intermodal transportation technologies. It is also important that the identification of effective policies that are designed to promote transportation while at the same time reducing energy usage and increasing energy efficiency are extremely important.

At 7th Annual Energy Ministers Meeting in Gyeongju, Korea also agreed that an effective response to growing oil import dependency for the region as a whole requires a mix of demand- and supply-side measures, including increased energy efficiency in transport. Since transport is highly dependent on oil and by far the greatest user of oil in APEC economies, more fuel-efficient transport is essential to curbing oil dependency. Intermodal freight strategies for shifting freight shipments to less energy-intensive transport modes are effective for boosting transport energy efficiency.

At the 8th Meeting of APEC Energy Ministers in Darwin, Australia in May 2007, APEC Energy Ministers encouraged APEC economies to individually set goals and formulate action plans for improving energy efficiency on an overall and/or sector basis. As a result, in the Sydney Declaration of September 2007, APEC Leaders agreed to work towards achieving an APEC-wide regional aspirational goal of a reduction in energy intensity of at least 25% by 2030 (with 2005 as the base year). To this end, APEC economies were encouraged to set individual goals and action plans for improving energy efficiency, reflecting the individual circumstances of each economy.

APEC Ministers in 2008 again encouraged greater cooperation between the Energy Working Group and Transportation Working Group in assessing approaches to fuel-efficient transport. The Draft Declaration for the Sixth APEC Transportation ministerial in 2009 affirms that the Transportation Working Group should collaborate with the Energy Working Group on projects of mutual interest.

At the 2010 APEC Energy Ministerial Meeting of APEC energy Ministers in Fukui Japan, ministers declared their position on low carbon paths to energy security and identified the need for cooperative energy solutions for a sustainable APEC. The ministers also called for more efficient use of energy and a cleaner energy supply to boost energy security, grow APEC economies and lower emissions. The Ministers committed to further strengthening the Energy Security Initiative (ESI) endorsed by the APEC Leaders in 2001 and to undertaking new measures to build upon it. (#2) In addition, they noted the need for fuel-efficient vehicles using lightweight materials and other advanced technologies can greatly reduce both oil consumption and carbon emissions. Most relevant to the current proposal, the Ministers instructed the EWG to conduct a series of workshops on the potential fuel and carbon savings from: electrification of the transport sector, the use of more energy efficient freight transport, the effects of transit-oriented development and the development of other energy efficient transport strategies, in cooperation with the TWG (#11).

Thus, the present project is an outgrowth of these Ministerial statements in that the objective is to pursue the identification of best practices and policies that will promote the more efficient and effective use of energy in the transport sector.

Background

The objective of the project is to assess the energy, transport and environmental benefits of intermodal freight strategies in APEC economies. One significant improvement in the area of energy efficient transport is certainly the use of more intermodal solutions to the movements of goods and passengers from point to point. The economic, operational and environmental benefits of using more intermodal approaches are thought by numerous experts to warrant considerable investment and investigation.

History of Intermodal

Intermodal transportation refers to the intersection of more than one mode of transportation. The ideal example is an airport that is served by automobiles, trains, and buses, with passengers being able to move seamlessly between the modes.

Figure 2. Intermodal double stack train.

However, in common language, most of the time intermodal refers to freight transportation. Freight Transportation contributes significantly to the economic activity in the USA and the global supply chain. The use of the 20 foot container begun in the late 50's has seen a dramatic expansion of freight traffic and cargo shipments. That coupled with the increasing sophistication of manufacturers in Asia has resulted in a huge explosion in freight traffic from Asia to the US.

Many forces have contributed to this dramatic increase. Intermodal largely refers to freight transportation in the USA.

A recent report by the European Union (2010) highlights the issues of sustainability of freight transportation and logistics industry. The report noted that "the use of freight transport has increased over the last decade at a rate faster than GDP and transport as a whole. Hence freight is contributing an increasing proportion of GHG" (ITS, 2010, pg. 13). [1] In addition, the report also notes that while previously in Eastern Europe freight transport was dominated by heavy rail there has been a trend towards road usage as demand shifts to a just in time model (EC, 2009a)[2].

Figure 3. Freight vessel carrying containers.

The AAR reported recently that intermodal rail traffic has increased such that intermodal accounts for almost 21 percent of all us rail revenue just behind coal revenue. Rail intermodal traffic has increased from 1980 from 3 million to 12 million units in 2007. The impact of the recession in 2009 decreased traffic but has since continued to increase to more than 11 million in 2010.

Freight shipment increases and economic growth. SOURCE: RITA. The AAR further noted that that "Trucks are, and will remain, critical to freight transportation and to America's economy. However, railroads are more cost effective, more fuel efficient, and more environmentally desirable than an over-reliance on highways for freight transport." [3]

There is a significant association between the level of freight transport activity and the overall gross domestic product or GDP. This index highlights the importance of freight movement as

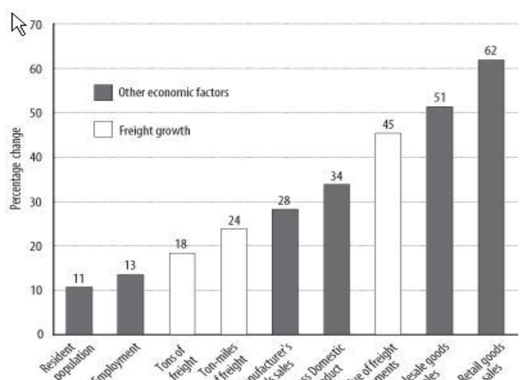


Figure 4. Freight shipment increase and economic growth. *SOURCE*: US DOT RITA.

[1] Institute for Transport Studies, (2010) . "The Future of Sustainable Freight Transport and Logistics," *European Parliament*, IP/B/TRAN/IC/2009_079.
[2] European Commission, Directorate-General for Energy and Transport (2009a), *A Sustainable Future for Transport: Towards an Integrated, Technology-led and User-Friendly System.* Luxembourg, Publications Office of the European Union.
[3] Association of American Railroads (2010, May). "Rail Intermodal Keeps America Moving", AAR, Washington DC.

well the interconnection between economic prosperity and freight Activity. The US Department of Transportation Office of Research Innovation and Technology Administration (RITA) uses the *freight transportation intensity* index to illustrate the relationship (see Figure 4). [4]

Interestingly, the RITA (2002) report concludes that the combination of "intermodal truck and rail moved 173 million tons in 2002, an increase of 47 percent from 118 million tons in 1993. Intermodal truck and rail ton-miles grew 50 percent from 160 billion to 240 billion." [5]

The latest estimate of intermodal traffic reported in the *Journal of Commerce* indicates that US intermodal rail shipments rose 3.8% since October of 2012, while carload traffic fell 6.3% in the same period. This increase reflects a 3.7 percent year to date increase in intermodal while carload traffic is down 2.6 percent for the year. Interestingly, the Canadian intermodal volume is up 7.1 percent for the year and carload traffic is up 2.7% and also Mexican volume increased to 18.1 % year to date with carload volume up only 0.1%.[6] Thus, the amount of intermodal traffic has increased slightly as shippers seek to maximize the efficiencies of intermodal transportation despite the challenging economic conditions worldwide.

Looking at the intermodal industry statistics provided by the Intermodal association of North America (IANA, 2012) presented in Figure 6 we can see that intermodal traffic has increased steadily over the past four years.

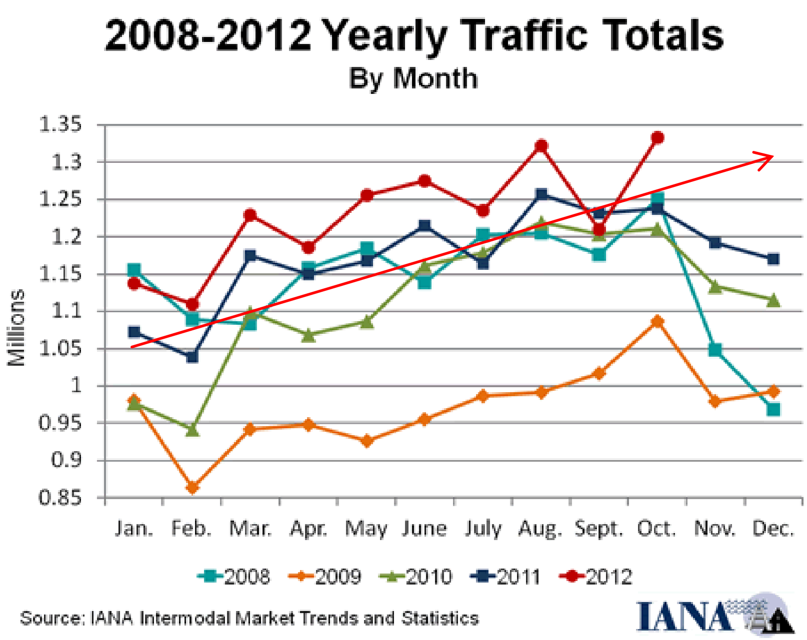


Figure 5. Intermodal traffic 2008-2012.

[4] RITA (2002). Freight Shipments in America: Preliminary Highlights from the 2002 Commodity Flow Survey. United States Department of Transportation Bureau of Transportation Statistics .
[5] Ibid, Page 23.
[6] Journal of Commerce, October 12, 2012. "US Intermodal rail shipments rise 3.8 percent.

Domestic freight traffic has been largely attributable to truck. The American Trucking Association has reported that approximately 40-50% of total transportation revenue is attributable to approximately 5.5 billion tons of freight. The ATA estimates that total truck tonnage increased nearly 40% between 1990 and 2006. Primary shipments of freight within the United States are estimated to increase by 30% in 2018 to almost 14 billion tons, up from 11 billion tons in 2006. (See Figure 7) In addition, the total will be expected to significantly exceed the total volume of rail freight haulage.

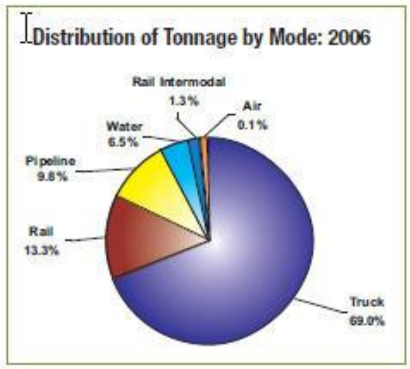


Figure 6. Rail vs. Truck Traffic in 2006.

Increases in Transportation Traffic

According to the AASHTO publication *Commuting in America (TRB, 2006)* since 1980 the percentage of commuters has increased from 64% to 76%. While transit use is higher in densely populated areas there has been an increase in the major population corridors on the east coast. Added to this is of course the projected increase in vehicle miles traveled (VMT) which is projected to more than double by 2055.

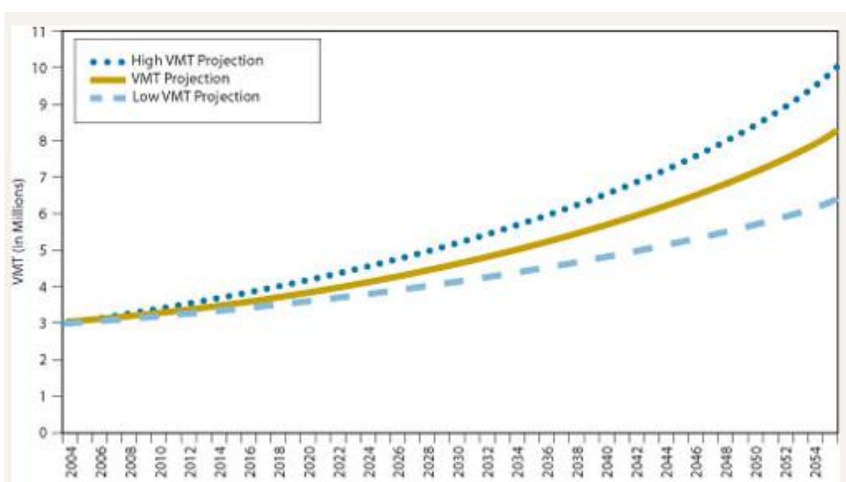


Figure 7. Fifty Year VMT Projections.

Source AASHTO (2007), http://www.transportation1.org/tif1report/demographic_cont.html)

Numerous reports have been published that attempt to demonstrate the economic and environmental benefits of various modes of transport over others. For example, a recent popular news magazine article stated:

> Compared to trucking, rail transit does obtain higher efficiency numbers - today's average train has an efficiency of 400 ton-miles per gallon whereas trucks currently hover around 130 ton-miles per gallon. Still, there are numerous reasons why addressing truck efficiency remains important, if not critical. For example, peer-reviewed research and companies like Wal-Mart have proved that trucks can easily achieve 260 ton-miles per gallon. And reaching 300+ ton-miles per gallon is not much harder, especially when a truck carries two or three trailers.
>
> Maximizing the efficiency of all systems and using each mode for the strengths it possesses is the real key to efficient freight transport. So while we should expand rail infrastructure and increase its utilization, the near-term opportunity to drastically increase truck efficiency cannot be ignored. [7]

Additionally, another report indicated that J.B. Hunt trucking provided a good example of the long-term and economic benefit of intermodal transportation strategies:

> Ultimately, it may prove futile to pit one mode of transport against the other, especially when integrative solutions – like the classic J.B. Hunt case – can reap the benefits from both.
>
> In 1989, J.B. Hunt signed a deal with Burlington Northern Santa Fe Railway Company, whereby a Hunt trailer could be directly loaded onto a railcar. In the beginning, 150 trailers and five railcars moved freight between Chicago and California, in 2008; more than 700,000 shipments were made.
>
> J.B. Hunt's strategic partnership not only decreased emissions, but has provided the company with its largest source of operating revenue since 2003, when it first surpassed the trucking division. In 2007, intermodal transportation represented 47 percent of J.B. Hunt's total revenue and accounted for 65 percent of its net income.
>
> The American Association of Railroads estimates that if an additional 10 percent of truck volume were shifted to intermodal, the annual savings would top 1 billion gallons of fuel.

[7] http://www.treehugger.com/files/2009/05/rail-trucking-greenest.php

> What will contribute to more inter-modal growth? Infrastructure expansions and diesel prices. With rail efficiency, the cost-effectiveness of a transcontinental haul is obvious, but when diesel gets expensive, benefits apply to short hauls as well. (Tree Hugger, 2009).[8]

The benefits of intermodal freight strategies could be evaluated in terms of reduced oil imports, reduced greenhouse gas emissions, and reduced transit times for freight shipments in the APEC economies that have adopted them. Additionally, users' reactions to the systems, reduced congestion times and increased speed of vehicle movement could also be indicators of improvements in these areas.

Through a better understanding of these benefits, the expansion of intermodal freight strategies should be encouraged throughout the APEC region. Since transport is highly dependent on oil and by far the greatest user of oil in APEC economies, this expansion of intermodal freight strategies should ultimately help to curb the region's oil dependency.

Congestion

Moving trucks off the road can have a dramatic effect on traffic congestion. The AAR notes that a train can carry several hundred containers thereby reducing traffic congestion significantly. Even small shifts can significantly reduce congestion. For example, a 5% reduction from 2,000 to 1,900 vehicles per lane-hour typically increases traffic speeds from 40 to 50 mph and eliminates stop-and-go conditions. Congestion does not disappear but is less severe. Several studies indicate that faster transit service increases parallel highway traffic speeds. [9] Modeling by Deakin and Harvey (1998) indicate that a percentage reduction in urban vehicle mileage tends to produce about twice the percentage reduction in traffic congestion delays.[10]

According to a 2006 FHWA report "Trucks contribute significantly to congestion in urban centers….account(ing) for at least one-fifth of the delay for all vehicles in the 50 worst urban bottlenecks in the Nation…. in crowded business districts, pickup and delivery vehicles cause nearly a million hours of vehicle delay each year to other traffic as they stop to serve office buildings and retail establishments.[11] A recent report estimates that the effects of traffic congestion due to trucks will continue to increase over the next few years.

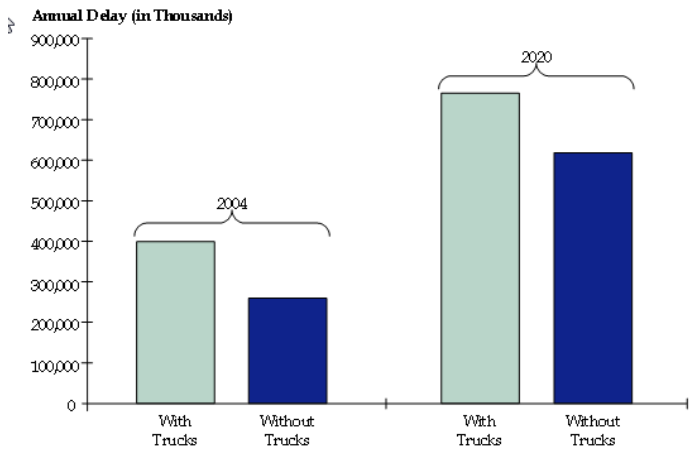
[8] http://www.treehugger.com/files/2009/05/rail-trucking-greenest.php

[9] Litman, T. (2013) Smart Congestion Relief. Paper presented at the Annual meeting of the Transportation Research Board. TRB Paper - P12-5310, Transportation Research Board 2012 Annual Meeting

[10] Deakin, E., Harvey,G., Pozdena, R. & Yarema, G. (1996), *Transportation Pricing Strategies for California: An Assessment of Congestion, Emissions, Energy and Equity Impacts*, California Air Resources Board (www.arb.ca.gov). The same analysis is available in USEPA (1996), *Technical Methods for Analyzing Pricing Measures to Reduce Transportation Emissions*, USEPA Report #231-R-98-006, (www.epa.gov/clariton).

[11] FHWA (2006). FHWA Conditions and Performance Report: Chapter 14 Freight Transportation http://www.fhwa.dot.gov/policy/2006cpr/chap14.htm

Various remedies have been found to reduce congestion. Most notably is the idea that if urban roadway capacity is not expanded traffic volumes reach a point of equilibrium, in which congestion delays discourage further growth in peak-period vehicle trips (Rebound Effects). According to the Victoria Transport Policy Institute [12] adding a general traffic lane significantly reduces short-term congestion, but traffic volumes grow over time so congestion nearly returns to its previous level within a few years (Litman 2011)[13]. A transit improvement, such as grade separated rail, a busway or HOV facility, provides little short-term congestion reduction, but congestion reduction benefits increase over time as delays on parallel highways make alternative modes increasingly attractive (Aftabuzzaman, Currie and Sarvi 2010)[14]. Although roadway congestion continues, it never becomes as bad as would occur without this relief. As a result, shorter-term analysis of congestion reduction benefits tends to favor roadway capacity expansion, while longer-term analysis tends to favor transit and HOV improvements.



Source: FHWA[15]

[12] VTPI (2012). Congestion reduction strategies. http://www.vtpi.org/tdm/tdm96.htm

[13] Litman, T. (2011), *Smart Congestion Relief: Comprehensive Analysis Of Traffic Congestion Costs and Congestion Reduction Benefits*, Victoria Transport Policy Institute twww.vtpi.org/cong_relief.pdf.

[14] Aftabuzzaman, G.C. & Sarvi, M. (2010), "Evaluating the Congestion Relief Impacts of Public Transport in Monetary Terms," *Journal of Public Transportation*, Vol. 13, No. 1, pp. 1-24; atwww.nctr.usf.edu/jpt/pdf/JPT13-1.pdf.

15 FHWA (2004) Traffic Congestion and Reliability: Linking Solutions to Problems. http://www.ops.fhwa.dot.gov/congestion_report_04/chapter3.htm

Rail Fuel Efficiency

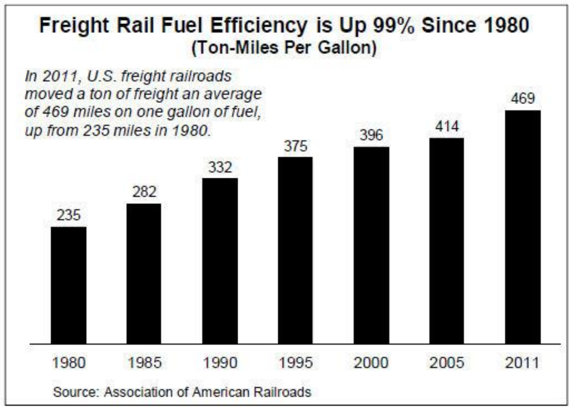


Figure 8. Rail Fuel Efficiency (AAR, 2012)

The Association of American Railroads reported that, based on the results of a study by the Federal Railroad Administration, on average, railroads are four times more fuel efficient than trucks. Thus, since various greenhouse gas emissions (i.e. Co2, SoO2, etc.) are a byproduct of diesel fuel use, moving freight by rail, instead of truck lowers greenhouse gas emissions by 75 percent. The AAR noted that if just 10 percent of the freight that moves by truck could be moved by rail, "fuel savings would be approximately one billion gallons per year and greenhouse gas emissions would fall by approximately 11 million tons — equivalent to taking nearly 2 million cars off the road or planting more than 250 million trees. [16]

In addition to the direct effect on the environment of emitting lower amounts of GHG the AAR also identified the fact that the increasing burden of traffic congestion also contributes significantly to GHG and other inefficiencies. The report notes that "a single freight train can carry the load of several hundred trucks, freeing up the space for other motorists. [17]

Measuring the Impact of Rail Fuel Efficiency and Sustainability

Previous research has also supported the claim that rail operations are more efficient than truck operations. A variety of metrics have been proposed to describe the current state of affairs relative to the efficiency of intermodal transport activities. For example, OECD has published a report entitled "Benchmarking Intermodal Freight Transport" (OECD, 2002)[18]. In this report, benchmarking in the area of intermodal freight movements utilized several key performance indicators (KPIs) including:

[16] AAR, (2012) "Freight Railroads Help Reduce Greenhouse Gas Emissions" June 2012.
[17] Ibid.
[18] OECD, (2002). Benchmarking Intermodal Freight Transport (Complete Edition - ISBN 9264197427). Organization for Economic Co-operation and Development.

Key Performance Indicators (KPIs)

(1) *Vehicle fill:* measured by payload weight, pallet numbers, and average pallet height.
(2) *Empty running:* measured as the number of miles the vehicle travelled empty and the number of miles the vehicle travelled with only returnable items.
(3) *Time utilization:* measured on an hourly basis as one of seven activities (running on the road; rest period; loading or unloading; delayed or otherwise inactive; maintenance and repair; and empty and stationary) over a 48-hour period.
(4) *Deviations from schedule:* measured as problem at collection point, problem at delivery point, traffic congestion, equipment breakdown and lack of driver.
(5) F*uel efficiency of tractor and trailer:* measured as km per liter, ml fuel required to move one standard industry pallet 1 km.

Other measures that have been used to compare different operations have been:

(1) Cost of movement of one ton of freight per mile and similarly
(2) Cost of fuel per ton mile
(3) Motor vehicle miles per vehicle and miles per gallon
(4) Ton miles per gallon
(5) Percent utilization of modes
(6) Fuel consumption by mode and sub mode
(7) Vehicle cargo capacity

After reviewing these metrics it is clear that relative to selecting the most energy efficient and environmentally friendly metric that permits the most efficient comparison is the cost of movement of one ton of freight per mile and similarly the fuel consumed moving one ton of freight per mile – *a ton-mile.* In addition, the GHG emissions when moving one ton of freight one mile is the other unit that is thought to be most useful. These and other metrics will be generated and, in consultation with a representative of the APEC Energy Working group will prepare a final recommended set of statistics.

For example, the Federal Railroad Administration (2009) "Comparison of Rail and Truck Fuel Efficiency on Comparative Corridors[19]" provides a good start for comparing different modes of transport. In the summary of results the authors conclude that "rail is more efficient than truck on all 23 comparative movements" (FRA, 2009, pg. 4) and the graph below shows the relative efficiency of each in comparison.

[19] FRA. (2009) "Comparison of Rail and Truck Fuel Efficiency on Comparative Corridors." USDOT FRA DTFR53-07-Q-00021.

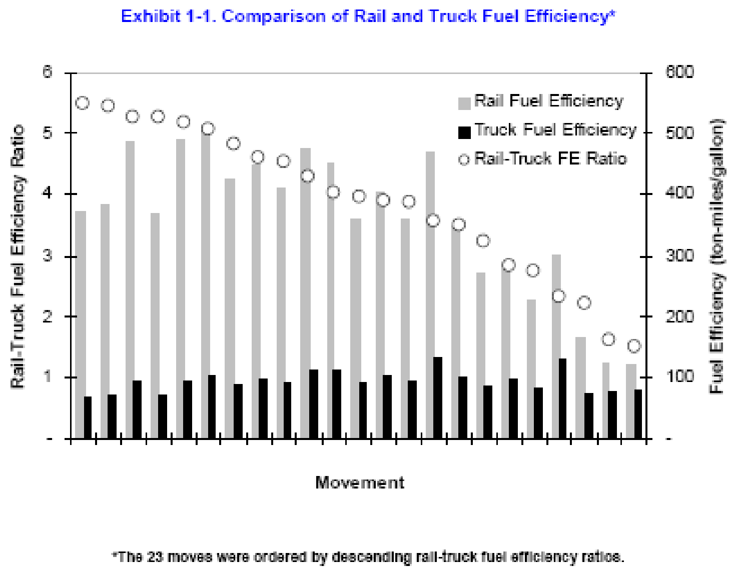


Figure 9. Comparison of Rail vs. Truck Fuel Efficiency. (Permission pending)

The FRA report concluded that rail is more efficient than truck in terms of emissions of *ton-miles per gallon.* The ratio between rail and truck fuel efficiency indicates how much more fuel efficient rail is in comparison to trucks. As illustrated in Figure 9, rail fuel efficiency varies from 156 to 512 ton-miles per gallon, truck fuel efficiency ranges from 68 to 133 ton-miles per gallon, and rail-truck fuel efficiency ratios range from 1.9 to 5.5. Incidentally, a related finding was that the efficiencies were related to the quality and type of vehicle and equipment.

A similar study by the American Association of Railroads (shown in Figure 10) shows that rail freight volume has nearly doubled since 1980, however the actual fuel consumption has not increased significantly.

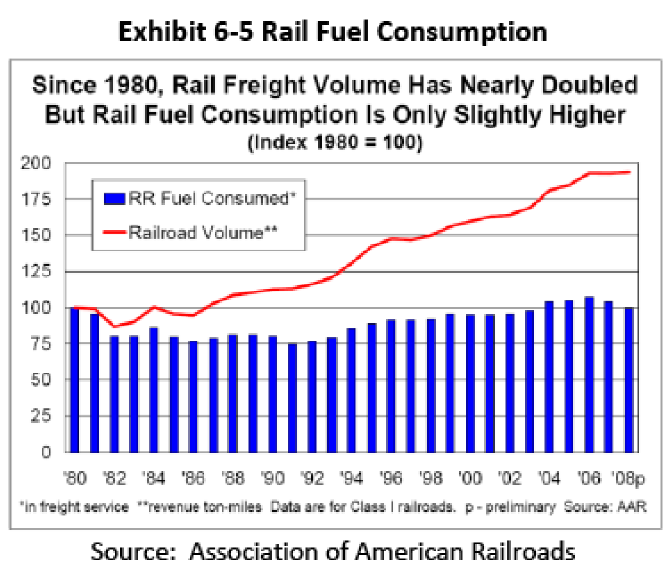


Figure 10. From AAR report "Freight Railroad and Greenhouse Gas Emissions" 2008.

> Freight railroads are the most energy efficient choice for moving goods. Nationally, in 2007 one gallon of fuel moved one ton of freight by rail 436 miles – roughly the round trip distance between Cleveland and Cincinnati. Moving more freight by rail is a straight- forward way to meaningfully reduce both energy use and greenhouse gas emissions without harming the economy. Based on data from the American Association of State Highway and Transportation Officials (AASHTO), if one percent of long-haul freight currently moved by truck were moved by rail instead, fuel savings would be approximately 111 million gallons per year. Moving more freight by rail would also help cut highway congestion by taking trucks off the road, especially along key corridors. A single intermodal train can take up to 280 trucks off the highways. Depending on cargo, other trains can take up to 500 trucks off highways[20].

This relationship is illustrated in Figure 11 adopted from the AAR (2010)[21] report. Consequently, it is widely accepted that rail offers a significant improvement and advantage to shippers seeking to move freight most efficiently with the least amount of impact on the environment.

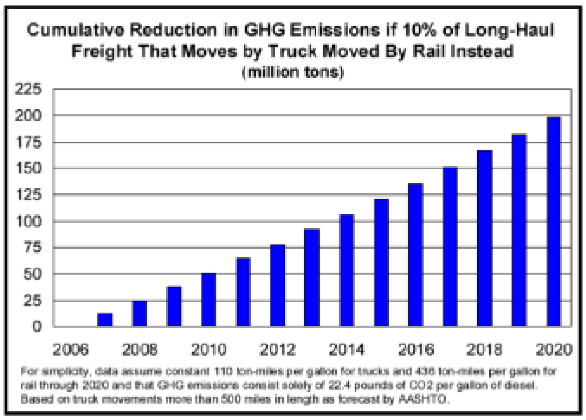


Figure 11. Reduction in Greenhouse Gases from diversion of Track to Rail[22] .

Benefits of Intermodal Transportation

These results clearly support the importance of promoting the use of rail as a means of reducing emissions and increasing fuel efficiency. The comparative evaluation of rail and truck fuel efficiency on the 23 competitive movements identified by FRA is shown in terms of *ton-miles per gallon* as well as the comparative ratio of train versus truck efficiency. This metric reflects the number of tons of freight (excluding equipment weight) and the distance (in miles) that can be moved with one gallon of fuel. The *rail-truck fuel efficiency ratio*, which is the ratio between

[20] Ohio Statewide Rail plan Report, Chapter 6, May 10, 2010
[21] AAR (2010) “Freight Railroads Help Reduce Greenhouse Gas Emissions” May 2010
[22] Ibid.

rail and truck fuel efficiency (both measured in ton-miles per gallon), is also used by the FRA study. Two additional metrics are considered to analyze modal efficiency individually: (1) *trailing ton-miles per gallon* (rail fuel efficiency at the train level), and (2) *miles per gallon* (truck fuel efficiency). Again, final selection of metrics would be conducted in collaboration with EWG Expert Group on Energy Efficiency (EGEEC) and Conservation and the TPT-WG Intermodal and ITS Experts Group (IIEG).

When electricity-related emissions are distributed to economic end-use sectors, transportation activities accounted for 26 percent of U.S. greenhouse gas emissions in 2011. The largest sources of transportation greenhouse gases in 2011 were passenger cars (40.6 percent), light duty trucks, which include sport utility vehicles, pickup trucks, and minivans (17.8 percent), freight trucks (21.4 percent), rail (6.5 percent), and commercial aircraft (6.3 percent). These figures include direct emissions from fossil fuel combustion, as well as HFC emissions from mobile air conditioners and refrigerated transport allocated to these vehicle types.

Table 1. Greenhouse Gas Emissions Sources.

Sources of GHG: 2011						
Electric		32.8%		Passenger		40.6%
Transportation		27.2%		Light Duty Trucks		17.8%
Industry		19.7%		Freight Trucks		21.4%
Agriculture		8.4%		Rail		6.5%
Commercial		5.6%		Commercial Aircraft		6.3%
Residential		5.3%		Other		7.4%
US Territories		1.0%				100.0%
		100.0%				

SOURCE: (EPA, 2013)[23]

[23] http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2011-Chapter-2-Trends.pdf

Calculations of Metrics

One equation that has been used to generate carbon emissions estimates for vehicles and distance traveled has been printed on the CSX web site[24]. This equation can be used to calculate Rail Freight Greenhouse Gas emissions for various trips[25]. In this tool, CO2 emission estimates are calculated according to the following formula:

Tons of CO2 = {[(Tons of freight) × (Shipping distance)]
× (Mode specific diesel consumption factor)
× (Mode specific emission factor)}

Please note: CO2 emissions related to transloading or transfer operations and those related to the production of diesel fuel are not included. Truck fuel economy is based on an average fuel economy of seven miles per gallon. Rail fuel economy is based on previous year's system average revenue ton-mile per gallon. In addition, in another study by AAR,[26] it has been determined that the relative contribution to emissions produced by railroad in the US is less than 1% (see Figure 6).

In addition to the formula above, the average emissions factors were produced for both freight moved by rail and by truck using data taken from the EPA and the FRA report. Using the EPA's average carbon content value of 22.384 lbs. CO_2 per gallon of diesel and the data provide in the FRA report**,** the following emissions factors were included:

CO_2 Emissions from freight moved by truck: 0.2429 lbs. CO2/ Ton-mile

CO_2 Emissions from freight moved by rail: 0.0593 lbs. $CO_{2/}$/Ton-mile

Note: The average emission factors are very close to the average emission factors used by the EPA for rail and truck.

Adding the average emissions factors to the above formula, we are able to compare CO_2 emissions of freight moved be rail and truck and gives the following two formulas:

Truck CO_2 emissions

Average lbs. CO_2 ={(0.2429 lbs. CO2/ Ton-mile) x (Tons of freight shipped) x (shipping distance in miles)}

Rail CO_2 emissions

Average lbs. CO_2 ={(0.0593 lbs. CO2/ Ton-mile) x (Tons of freight shipped) x (shipping distance in miles)}

[24] www.csx.com
[25] http://www.csx.com/index.cfm/customers/tools/carbon-calculator-v2/
[26] http://www.aar.org/~/media/aar/backgroundpapers/railroadsgreenfromthestart.ashx

Barge CO_2 Emissions

Average lbs. CO_2 ={(0.0385 lbs. CO2/ Ton-mile) x (Tons of freight shipped) x (shipping distance in miles)}

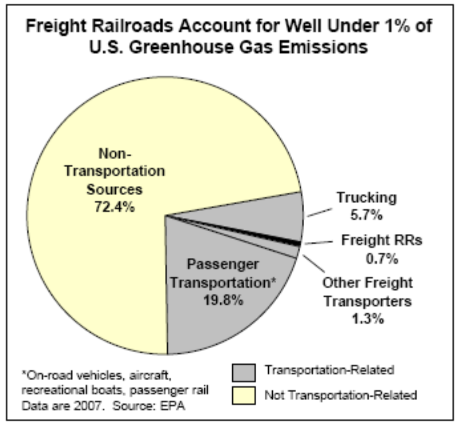


Figure 12. US Freight Railroad Contribution to Greenhouse Gas Emissions.

A recent report published by RITA was based on data provided by the U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics, based on data from various sources. United States—U.S. Department of Commerce, U.S. Census Bureau, Foreign Trade Division, available at www.census.gov/foreign-trade/www as of May 12, 2009. World—International Monetary Fund, Direction of Trade Statistics[27]. These reports have shown that the railroads account for less than 1% of the total greenhouse gas (GHG) emissions.

According to a report by the Texas Transportation Institute[28], to evaluate the differences between the modes in terms of greenhouse gas emissions ir is necessary to consider that the tons of GHG per million ton-miles (10^6) (tons-GHG/106 ton-miles) are determined by the following formulas, for each mode:

10^6 ton-Miles ÷ ton-miles/ton-GHG = ton-GHG/106 ton-Miles

TRUCK 10^6ton-Miles ÷ 13,964.0 ton-miles/ton-GHG = (71.61) ton-GHG/106 ton-Miles

RAILROAD 10^6ton-Miles ÷ 37,207.2 ton-miles/ton-GHG = (26.88) ton-GHG/106 ton-Miles

INLAND TOWING 10^6ton-Miles ÷ 51,891.8 ton-miles/ton-GHG = (19.27) ton-GHG/106 ton-Miles

These results are shown graphically in the following figure (see Figure 13). Clearly, the emissions resulting from truck traffic is significantly greater than that of the other two modes.

[27] available at www.imfstatistics.org/dot/

[28] Kruse, C.J., Protopapas, A., Olson, L., & Bierling, D.H. (2009). "A Modal Comparison of Domestic Freight Transportation Effects on the General Public." Texas Transportation Institute.

Efforts to reduce truck traffic could result in significant overall reductions in emissions. Thus, the thesis of this project, energy usage and intermodal transportation systems is clearly one that warrants further study.

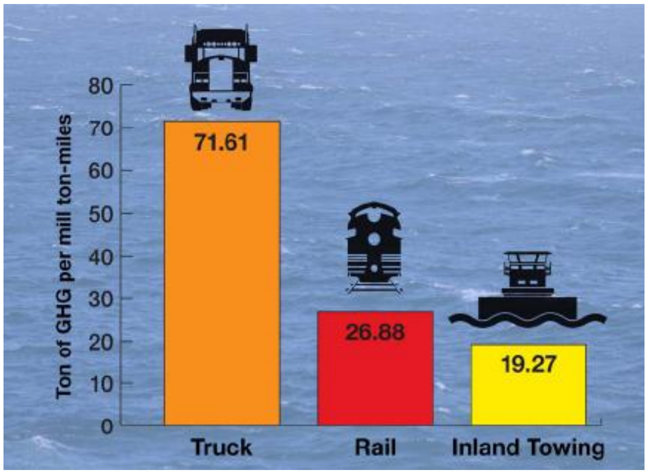


Figure 13. Comparative modal contribution to GHG.
From Texas Transportation Institute report (page 36)[29].

To determine the economies from which to draw upon to build a case study we looked at those economies with the largest gross domestic product. Again, adapting from the USDOT RITA (2010) "Global Highlights Study" we can see that the top economies from APEC are as follows.

Table 2. World's Leading Economies by Gross Domestic Product (Ranked by 2008 GDP)

					Billions of current U.S. $			Share of global GDP (pct.)		
Rank in 1995	**Rank in 2000**	**Rank in 2008**	**Country**		**1995**	**2000**	**2008**	**1995**	**2000**	**2008**
			World		29633	31972	60863	100.0	100.0	100.0
1	1	1	United States		7398	9817	14265	25.0	30.7	23.4
2	2	2	Japan		5278	4669	4924	17.8	14.6	8.1
8	6	3	China		728	1198	4402	2.5	3.7	7.2
17	19	8	Russia		313	260	1677	1.1	0.8	2.8
10	8	11	Canada		591	725	1511	2.0	2.3	2.5
16	10	13	Mexico		314	629	1088	1.1	2.0	1.8
13	14	14	Australia		371	390	1011	1.3	1.2	1.7
11	12	15	Korea		539	534	947	1.8	1.7	1.6
24	28	19	Indonesia		223	166	512	0.8	0.5	0.8

SOURCE: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics data from International Monetary Fund, World Economic Outlook Database, April 2009, available at www.imf.org as of Sept. 14, 2009.

[29] Ibid.

APEC *Survey of Policies Promoting Fuel-Efficient Transport*

Based on these data economies from this list would be primary candidates to participate in the case studies. However, all not all APEC economies have sufficiently unique situations that differ dramatically from various cities. In fact, when looking at the various activities and policies reported on by the Alliance to Save Energy (ASE) APEC *Survey of Policies and Programs that promote Fuel-Efficient transport in APEC economies (2008)* it is apparent that only five main types of freight policy were suggested. These were:

1) Increasing fuel efficiency of new vehicles
2) Purchasing new fuel efficient vehicles
3) Improving the operational efficiency of new vehicles
4) Reducing congestion and
5) More efficient freight movements.

However, these recommendations were not specific to freight alone. The only recommendations that were specific to freight were Japanese Energy Conservation Law, and the United States *Smartway* program which addressed aerodynamics of trucks, efficient routing, driver training and self-inflating tire systems. Consequently, the present report has focused primarily on policies and practices that have resulted in improvements to the freight system alone.

Case Studies

Case Study Overview

The case studies were developed around various situations that have been designed to address the freight traffic of several large urban metropolitan areas in the APEC region. The cases selected were based on those identified in the APEC report and also those for which data was readily available. The cases selected represent various solutions that can be applied in any number of different locations throughout APEC. Lastly, to some extent the selection of cases is affected by the relative availability and accessibility of the data for analysis.

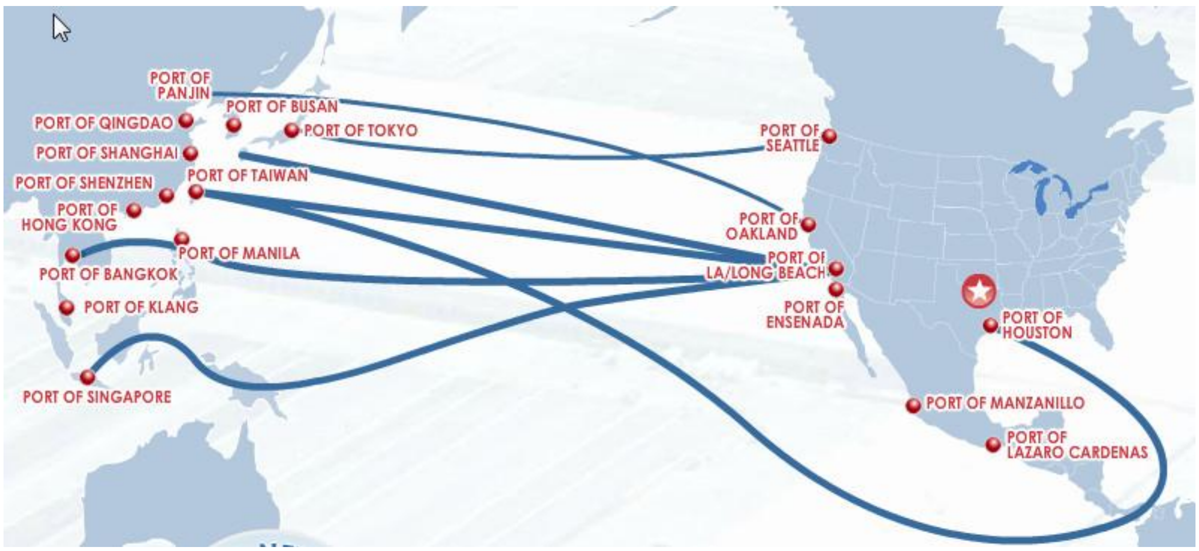


Figure 14. Major Asia North America Shipping Routes.
Source: http://www.dallashub.com/interactive-us-map.aspx

Taking first the West Coast of North America, due to its proximity to Asia and also the ease of accessing the information needed, we were able to look at several different locations and the freight traffic that they deal with.

Looking at Figure 14 we can see that there are a number of interesting problems that each of these locations addresses. In addition we can also see that Vancouver BC and both Manzillo and Lazaro Cardenas Mexican ports are a part of this system as well and provide intermodal freight capability for Canada imports throughout the system. The West coast system absorbs the majority of freight that flows into the US and North America through Vancouver, Prince Rupert, Seattle-Tacoma, Portland, Oakland, and the Port of Long Beach and Los Angeles.

The Asian ports that contribute significantly to the export of containers to the North American economies are Shanghai, Singapore, Hong Kong, Shenzhen, Bussan, Ningbo, Guangzhou, Qingdao, Tianjin, and Kaohsiung.

Top Ranked US and Asian Ports
Source: JOC, August 20, 2012[30]

Port	Rank	2011 Volume	Port	2011 Volume
LA	1	7,940,511	Shanghai	31,740,000
Long Beach	2	6,061,091	Singapore	29,940,000
New Jersey	3	5,503,485	Hong Kong	24,380,000
Savannah	4	2,944,678	Shenzhen	22,570,000
Vancouver	5	2,507,032	Busan	16,170,000
Oakland	6	2,343,504	Ninbo-Zhoushan	14,720,000
Seattle	7	2,033,535	Guangzhou Harbor	14,260,000
Hampton Roads	8	1,918,029	Qingdao	13,020,000
Houston	9	1,866,450	Tianjin	11,590,000
Manzanillo, MX	10	1,762,508	Kaoshiung	9,640,000
Tacoma	11	1,485,617	Port Klang	9,600,000
San Juan	12	1,484,595	Keihin (JP)	7,640,000
Charleston	13	1,381,353	Tanjung Pelapas	7,500,000
Montreal	14	1,362,975	Xiamen	6,470,000
Lazaro Cardenas	15	953,497	Dalian	6,400,000

Figure 15. Major Asia and North American Container Ports.
Source: http://www.dallashub.com/interactive-us-map.aspx

Case Study # 1 – Seattle – Puget Sound

Seattle is a large urban setting with a seaside port located in the heart of the central city. The city ranks in the top in terms of its scenic and tourist value, it is also the home of several high tech software firms. Lastly, it was the 7th busiest seaport in 2011 serving 22 international steamship lines moving more than 2.03 million TEUs.

Table 3. Port of Seattle Container Volume 2002-2011.

Containerized Cargo in TEUs										
(TEU's)	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Int'l Import	537,503	542,863	704,664	846,311	799,138	810,453	664,472	612,236	897,224	768,964
Int'l Export	358,524	348,773	387,503	484,997	438,806	503,690	434,546	459,557	558,237	612,450
Int'l empty	277,224	293,062	374,084	414,490	398,317	314,351	277,478	212,748	380,114	331,259
Total International	1,173,251	1,184,698	1,466,251	1,745,798	1,636,261	1,628,494	1,376,496	1,284,541	1,835,575	1,712,673
Total Domestic	265,625	301,684	309,607	342,131	351,099	345,010	327,996	300,055	304,002	320,862

30 Journal of Commerce, (2012). "The JOC Top 50 Container Ports," August 20-27, 2012. www.joc.com

Combined Total	1,438,872	1,486,382	1,775,858	2,087,929	1,987,360	1,973,504	1,704,492	1,584,596	2,139,577	2,033,535

The Port of Seattle has a yearly combined flow of containers of 2.03 million TEUs. While not all of these containers are placed on rail there is a significant portion of these containers that are handled locally and moved throughout the city using trucks.

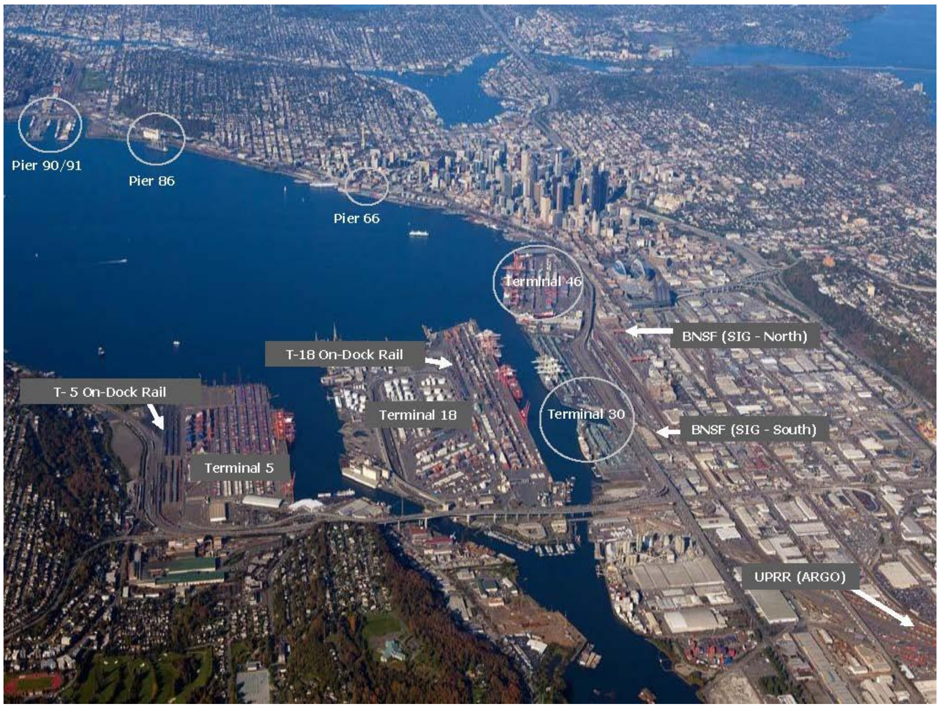


Figure 16. Port of Seattle in Puget Sound.

The Port of Seattle is set in a very large metropolitan urban setting with multiple modes of freight converging into small urban seafront. The city and the metropolitan area have received considerable national attention due to the fact that they have a very active and collaborative planning organization between the various state and local government municipalities. Very active MPO and citizen group involved in planning freight and passenger movements. Active NGOs that are trying to improve the freight situation.

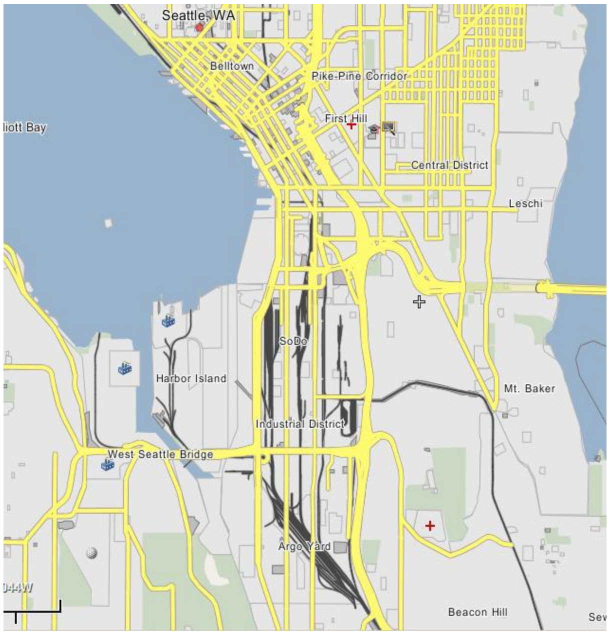


Figure 17. Port of Seattle.

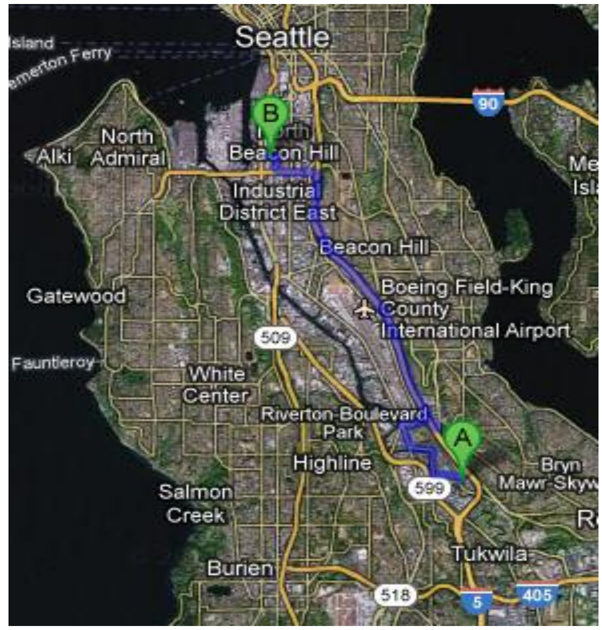


Figure 18. Port of Seattle and South Seattle Intermodal Rail Yard.

The present case study examined the possibility of developing a daily train that would move a number of containers from the port proper to a holding yard approximately 8 miles south of the city. The purpose of this movement would be to eliminate the number of trucks coming in to the city to pick up containers. Thereby reducing traffic congestion on the I-4 and decreasing fuel consumption, greenhouse gas emissions and the like.

The South Seattle Yard is approximately 8 miles south of the city of Seattle when traveling over city streets to drive from Stacey Yard to the South Seattle location. A small intermodal train could easily be constructed that would transfer the containers to the holding yard at South Seattle. It should be noted that the Stacey yard is for all practical purposes “on dock” and also adjacent to the large sports complex that serves as the venue for weekly sporting events such as football and baseball games that draw on the average over 45000 attendees. However, the rail roads and port facilities are BNSF and the South Seattle Yard are private facilities. Additional work from a public private partnership would need to take place to make it likely that this would occur.

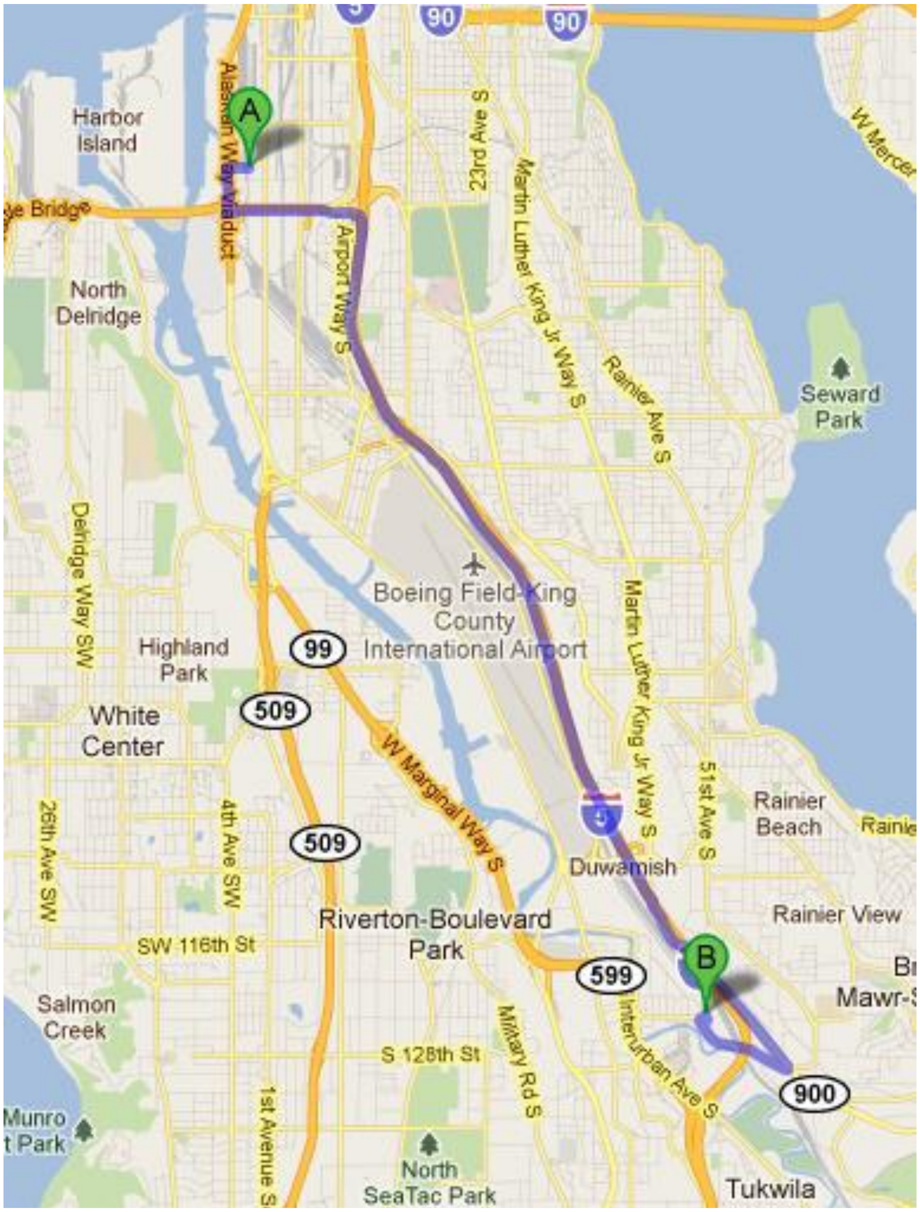


Figure 19. Enlargement of South Seattle Yard Location relative to Stacey Yard.

The figure demonstrates the route that trucks use to transport the containers from the near dock yard to the South Seattle Yard. As can be seen the truck traffic traverses the center of the city and bypasses the nearby sports venues. The relocation of the major intermodal facility would clear out a major contribution to the traffic congestion in downtown Seattle.

Various calculations were performed that enabled a comparison of the emissions that would be created by using trucks versus trains. By using this analysis we can estimate the fuel and emissions reductions from this type of proposed operation. As can be seen from this table the end results of putting 100 containers from 100 trucks on a train results in significant fuel savings and cost savings depending on the distance traveled. However, unlike the previous example, the distance covered by this scenario is only a little over 8 miles to the nearest intermodal yard.

While the savings are still impressive, the average fuel cost savings is not that much on an annual basis. The percent reduction in CO2 emissions is 44% or a little less than half the emissions due to truck. Again, there is the substantial intangible of taking 100 trucks off the road.

Table 4. CO2 Reductions and Fuel Savings for Seattle (distance 8 miles).

Containers	Trucks	Trains		CO2 Reductions		Fuel Savings	
number of containers per day	lb. CO2 generated single truck trip	lb. CO2 from single train trip	Annual CO2 reductions moving X containers on trains (lbs.)	Annual reduction in CO2 - corrected for on dock movements (lbs.)	Percent CO2 reduction Train vs. Truck	Annual Diesel Fuel savings from using rail (gals)	Annual Fuel Cost Savings (@ $3.84/gal)
50	1457	356	396576	233117	44%	10414	$ 2,712
100	2915	712	793152	466235	44%	20829	$ 5,424
150	4372	1067	1189728	699352	44%	31243	$ 8,136
200	5830	1423	1586304	932469	44%	41658	$ 10,848
250	7287	1779	1982880	1165587	44%	52072	$ 13,560

*(Emissions due to additional on/off movements added.)

Case Study # 2 – Florida East Coast Railway

In order to investigate various cases that will show the value of the use of intermodal means of transporting freight in urban settings there were several situations identified that could benefit from the addition or inclusion of additional intermodal means of transport. For the most part these solutions involved the use of rail and container modes.

The first setting selected is that of the Port of Miami Florida. The Port of Miami has been called the "Cruise Capital of the World" and "Cargo Gateway of the Americas", according to Wikipedia. It has retained its status as the number one cruise/passenger port in the world for well over two decades . The port primarily handles containerized cargo with small amounts of break-bulk, vehicles and industrial equipment. It is the 17th largest container port in the United States. The Port of Miami is an important contributor to the local south Florida and state economies. Over four million cruise passengers pass through the Port, 7.4 million tons of cargo and just under 1 million at 906,607 TEUs (FY 2011) of intermodal container traffic move through the seaport per year.31 This combination of cruise and cargo activities supports approximately 176,000 jobs, and has an economic impact in Miami-Dade County of over $17 billion, $14 billion of which is generated by its cargo operations.

[31] JOC. (2012).

Historical Snapshot

Cargo Volumes				
Item	2008	2009	2010	2011
TEUs	828,349	807,069	847,249	906,607
Cargo Ships Docked	1,624	1,706	1,663	1,936
Inbound Tonnage	3,774,504	3,330,948	3,524,262	3,845,666
Outbound Tonnage	3,655,459	3,500,547	3,864,903	4,376,090
Total Tonnage	7,429,963	6,831,495	7,389,165	8,282,374

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Figure 20. Container Volumes Port of Miami (Source: Miami/Dade Govt. web site).

The port currently operates eight passenger terminals, six gantry crane wharves, seven Ro-Ro (Roll-on-Roll-off) docks, four refrigerated yards for containers, break bulk cargo warehouses and nine gantry container handling cranes. In addition, the port tenants operate the cruise and cargo terminals which includes their cargo handling and support equipment.

With the coming re-opening of the Panama Canal it is believed that that there may be an influx of container traffic to the east coast, by-passing the Port of LA/Long Beach for shorter routes direct to the eastern seaboard. With additional container traffic there could also be an increase in truck traffic as some shippers and freight forwarders choose a highway method of delivery. At the very least there will be increased truck traffic due to local destinations. To address this potential surge in the need to transport freight through the Miami-Dade Metropolitan area the Florida East Coast Railroad in conjunction with the City and Port of Miami has formed a partnership to expand intermodal rail transportation to a location outside of the congested central city.

Miami Rail Line Upgrades

The Florida East Coast Railroad (FEC) received a $49 million grant ($22 million in 2010 from the United States Department of Transportation (USDOT) TIGER (Transportation Investment Generating Economic Recovery) grant program. The grant is designed to assist in the restoration of rail service between the port and the Florida East Coast Rail Yard in Hialeah, Florida. The line and a bridge that previously linked the Port and the FEC Yard was damaged in Hurricane Wilma. The new rail service will connect the port with the FEC Hialeah Intermodal Rail yard, and from there will provide direct cargo access to the national rail system. The project also includes a $72.8 million plan to build an intermodal transfer facility (ITCF) at Port Everglades in Fort Lauderdale.32 The ICTF will be used to transfer international containers between ships and rail within the port instead of relying on trucks to haul containers to and from nearby off-port rail terminals in Fort Lauderdale and central Miami-Dade County.[33] FEC plans to relocate its

[32] Sneider, J. (October, 2011) "FEC Partners with two south Florida ports to tap more import container traffic. Progressive Railroading, http://www.progressiverailroading.com/intermodal/article/.
[33] Progressive Railroading, February, 2012). "South Florida Port to develop container transfer facility with FEC." http://www.progressiverailroading.com/intermodal/news/South-Florida-port-to-develop-container-transfer-facility-with-FEC-install-new-leader--29773.

existing domestic intermodal operations from a nearby yard to the ICTF, which is expected to divert about 180,000 trucks from local highways by 2027. Currently, the ports of Miami and Ft. Lauderdale are completely dependent on trucks to transport containers to three primary distribution centers. “This project is a win for everyone,” said U.S. Maritime Administrator David Matsuda, “Businesses will get the goods much faster and fewer trucks on the already congested roads will mean drivers in Miami will spend less time stuck in traffic.” The project will also help reduce greenhouse emissions by eliminating approximately 60,000 fewer truck trips every year between the port and the Florida East Coast Railway’s (FEC) Hialeah intermodal rail yard. A total of 400,000 truck trips are expected to be eliminated annually from the road within eight years of completing the project. [34]

Table 5. CO2 Reductions and Fuel Savings for FEC Intermodal Line (distance 18.9 miles).

Containers	Trucks	Trains		CO2 Reductions truck-train		Fuel Savings	
number of containers per day	lb. CO2 generated single truck trip	lb. CO2 from single train trip	Annual CO2 reductions moving X containers on trains (lbs.)	Annual reduction in CO2 - corrected for on dock movements (lbs.)	Percent CO2 reduction Train vs. Truck	Annual Diesel Fuel savings from using RAIL vs. truck (gals)	Annual Fuel Cost Savings (TRAIN vs. TRUCK)(@ $3.84/gal)
50	3,902	953	1,061,832	898,374	63.95%	40135	$ 10,452
100	7,804	1,905	2,123,664	1,796,747	63.95%	80269	$ 20,903
150	11,707	2,858	3,185,497	2,695,121	63.95%	120404	$ 31,355
200	15,609	3,811	4,247,329	3,593,494	63.95%	160539	$ 41,807
250	19,511	4,763	5,309,161	4,491,868	63.95%	200673	$ 52,259

As can be seen from the analyses provided in Table 5 there is a 63.95% reduction in carbon emissions and at least a $20,903 dollar fuel savings if 100 cars are moved from the port by train to an intermodal yard 18.9 miles away. It is difficult to quantify the impact on congestion other than to state that this would reduce the number of trucks on the road by 100 thereby reducing congestion, wear and tear on the road and noise etc. The savings in fuel costs increase and the actual volume of lbs. of CO2 emitted decreases the more containers are moved. However, the relative savings in CO2 emissions remains a constant 63.95%

The CO2 savings remains even if we factor in the fact that an additional movement of the container on and off the train would have to be made. Additional CO2 and fuel usage due to idling and miscellaneous movements of trucks was assumed to be constant and not necessarily reduced due to the fact that the waiting and positioning would still have to take place albeit in

[34] Railco (July, 18, 2011). “Port of Miami intermodal and rail reconnection project receives TIGER grant.” Rail.co Magazine, www.rail.co/2011/07/18/port-of-miami-intermodal-and-rail-reconnection-project-receives-grant/

another location. However, the less urban the setting the greater the likelihood of freedom of movement.

Case Study #3 – Alameda Corridor

The next case that was examined was that of the Alameda Corridor. This is a unique attempt to address the role of intermodal freight movements in an urban setting that has been highly regarded in many different locations.

Figure 21. Alameda Corridor

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The Alameda Corridor was originated as an attempt to combine four different freight rail lines that were operated through the city of Los Angeles from the Port of Long Beach and the Port of Los Angeles. The current situation is that the corridor handles upwards of 40 trains a day with an average load of 250 containers. Thus, 40 trains x 250 containers is equal to almost 10,000 trucks per day. By reducing the number of trucks that enter the highway system and city street both a reduction in GHG emissions, **as well as congestion, noise and safety concerns have been alleviated.**

From a quantitative standpoint the amount of GHG that has been reduced simply by consolidating the rail lines and increasing the speed and throughput of the containers has been substantial. A recent report, commissioned by the Alameda Corridor Transportation Authority, investigated the emissions savings attributable to the successful completion and operation of the corridor. The ACTA reported on the total number of trains operated and the total number of TEUs moved during July 2009 to September of 2012. During the year 2009 4.34 million TEUs were moved during 2010, 5.024 during 2011, and 4.95 million TEUs thus far in 2012. Taken together these movements would have resulted in over 7 million truck movements. Additionally, taking into account the fact that the minimum movement or trip distance was approximately 16 miles we can estimate that comparatively the Alameda Corridor resulted in approximately a 61% reduction in emissions over what would have been emitted by trucks in that same period. Put another way, the resulting savings in diesel fuel would have amounted to over 4.5 billion gallons of diesel fuel and a corresponding reduction in the actual amount of carbon emissions. A report published by the ACTA stated that:

> The increased efficiency of running locomotives through a consolidated Corridor versus a variety of pre-existing rail line routes resulted in a NOx

emission reduction of 201 tons in the year 2002 and 317 tons in 2004. Correspondingly, PM emissions were reduced by 8 tons in the year 2002 and 12 tons in 2004. Cumulative NOx and PM10 emission reductions from the implementation of the Alameda Corridor project were 807 and 31 tons, respectively. Emissions of all other criteria pollutants (ROG, CO, SOx) show corresponding reductions from 2002 to 2004 (Table 4, pg. 11, ACTA, 2005).[35]

The bottom line is that the ACTA has had a substantial impact on the reduction of GHG emissions, fuel savings, and reduced congestion over the past eight years. These benefits have also included additional safety, quality of life, and economic impacts as well. The Alameda Corridor is considered by many to represent a significant milestone in the identification of best practices for dealing with urban freight movement and environmental impact.

Table 6. GHG Reductions and Fuel Savings from Alameda Corridor (distance 16 miles)..

Containers	Trucks	Trains		CO2 Reductions truck-train		Fuel Savings	
number of containers per day	lb. CO2 generated single truck trip	lb. CO2 from single train trip	Annual CO2 reductions moving X containers on trains (lbs.)	Annual reduction in CO2 - corrected for on dock movements (lbs.)	Percent CO2 reduction Train vs. Truck	Annual Diesel Fuel savings from using RAIL vs. truck (gals)	Annual Fuel Cost Savings (TRAIN vs. TRUCK)(@ $3.84/gal)
200	13,214	3,226	3,595,622	2,941,788	61.84%	131424	$ 34,225
250	16,517	4,032	4,494,528	3,677,235	61.84%	164280	$ 42,781

Case Study #4 – Port of Tianjin

The Port of Tianjin, formerly known as the Port of Tanggu, is the largest port in Northern China and the main maritime gateway to Beijing. It is located on the western shore of the Bohai Bay, centered on the estuary of the Haihe River, 170 km south east of Beijing and 60 km east of Tianjin city. It is the largest man-made port in mainland China and one of the largest in the world. It covers 107 square kilometers of land surface, with over 31.9 km of quay shoreline and 140 production berths at the end of 2010.[36]

[35] Weston, S. (2005). Alameda County Transportation Authority Air Quality Report., 2005.
[36] http://www.portoftacoma.com/page.aspx?cid=529

According to published statistics on the web, Tianjin Port handled 453 million tons of cargo and 11.5 million TEUs in 2011, making it the world's fourth largest port by throughput tonnage, and the eleventh in container throughput. The port trades with more than 600 ports in 180 countries and territories around the world. It is served by over 115 regular container lines run by 60 liner companies, including all the top 20 liners. Capacity is increasing at a high rate, with 550–600 Mt of throughput capacity expected by 2015.

Among the imports and exports going through Tianjin, 50 percent are from Tianjin, 20 percent are from Beijing, 12 percent are from Hebei Province and 18 percent are from other areas. Seventy percent of the total cargo volume and 50 percent of the total cargo value come from provinces and regions outside Tianjin.[37]

Correspondence from APL executives, personal inspections and site visits by the authors, indicate that the port prepares two trains per day to send to various locations external to the port.[38] It should be noted that there was considerable disagreement among shippers and that the main authority in charge of these trains is controlled by the Ministry of Railways. An onsite inspection of the operations conducted by the first author revealed that while there is a rail line present it is almost completely underutilized. The rail line was originally constructed to assist with the import and export of coal. However, this has become a secondary and even tertiary activity due to the huge increase in the export of automobiles.

Presently, the port is in the process of developing the Tianjin Xingang North Rail Container Central Station. Located between No.8 road, East of Free Trade Port, Tianjin Port Area and Sea Rail Road, Tianjin Port Area. The rail line will directly connected to this central station, from the Port Authority. This project is currently planned and will probably be completed by the end of 2013.

Examining the map shown in Figure xx it can be seen that the rail line does indeed connect with

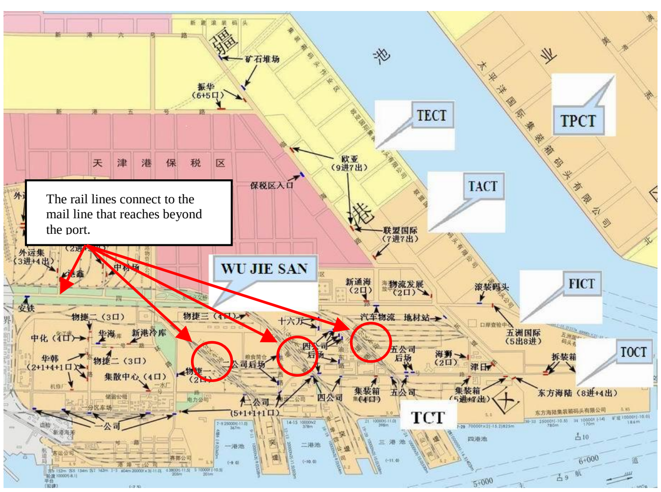

Figure 22. Port of Tianjin layout.

The Port of Tianjin is quite large and covers nearly 62 square kilometers. Existing rail spurs currently provide access to the berths in the port. However, full utilization of these lines is not fully achieved.

[37] http://www.portoftacoma.com/page.aspx?cid=529
[38] Lee, J. (2012) Personal communication. October 16, 22012.

Intermodal Transportation and Dry Ports

Tianjin Port serves a vast economic region including the municipalities of Beijing and Tianjin, and the provinces of Hebei, Henan, Shanxi, Shaanxi, Ningxia, Gansu, Qinghai, Tibet and Xinjiang, amounting to over 5 million km^2, or 52% of China's area, and covering 17% of the country's population. Tianjin is also one of the railheads of the Eurasian Land Bridge

In keeping with the goal of becoming North China's Trade and Logistic Center, the Port has been expanding its intermodal transport capacity, and deepening its presence in inland regions through dedicated container train lines, dry ports and direct partnerships.[39] Tianjin port has built 17 dry ports so far along the Yellow River basin to serve the exporters in hinterland, marking the Harbour-Yellow River shipping co-operation a highlight of the country's regional economic co-operation, reports Xinhua.[40]

Tianjin Port owns and operates 15 different scheduled railway routes and has the capacity for dispatching 50-car (100 TEU) trains to 15 different cities in China, including Xi'an, Chengdu, Taiyuan, Ürümqi, Baotou, Shizuishan, Erenhot, Alashankou, and Manzhouli, the last three being border crossings. In the first half of 2011, these dedicated train lines carried 129,000 TEU, including cargoes for Eurasian destinations.

The Port of recently initiated container sea-rail intermodal service to the northwestern city of Xian with the launch of new box train service, reports Xinhua. According to an unidentified staff member at the port, each train will have 50 cars able to carry 100 TEU. Each train covers 1,200 kilometres and takes three days to make the trip. Containers will be provided to the shippers by the port, so that they do not have to worry about finding boxes for their cargo. Including Xian, the Port of Tianjin has launched container sea-rail intermodal services to more than 10 cities, including Chengdu, Taiyuan, Urumqi, Baotou, Shizuishan, Erenhot, Alashankou and Manzhouli. Port of Tianjin moved 143,000 TEU of containers via sea-rail intermodal during the first three quarters of this year. 46,000 TEU were carried on the service to Alashankou and Manzhouli then transited to Europe destinations, 43 per cent more than the volume recorded in the same period a year ago.[41]

As of October 2011, Tianjin Port had established 21 dry ports,[] of which 8 were fully operational. According to the United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP) a dry port "provides services for the handling and temporary storage of containers, general and/or bulk cargoes that enters or leaves the dry port by any mode of transport such as road, railways, inland waterways or airports. Full customs-related services and other related services such as essential inspections for cargo export and import, whenever possible, should be put in place in a dry port." [42]

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[39] http://en.wikipedia.org/wiki/Port_of_Tianjin#Intermodal_Transportation_and_Dry_Ports

[40] http://www.seanews.com.tr/article/TURSHIP/PORTS/79417/Tianjin-port-Shipping/

[41] http://www.shippingonline.cn/news/newsContent.asp?id=17727

[42] UN ESCAP (2010). "Regional Expert Group Meeting on the Development of Dry Ports along the Asian Highway and Trans-Asian Railway Networks" Bangkok, Thailand. November 1-3, 2010.

The ports include Chaoyang (Beijing), Pinggu (Beijing), Baoding (Hebei), Shijiazhuang (Hebei), Zhangjiakou (Hebei), Handan (Hebei), Zibo (Shandong), Dezhou (Shandong), Zhengzhou (Henan), Hebi (Henan), Daqing(Heilongjiang), Baotou (Inner Mongolia), Bayannur (Inner Mongolia), Erenhot (Inner Mongolia), Houma (Shanxi), Xi'an (Shaanxi), Datong (Shaanxi), Jiayuguan (Gansu), Yinchuan (Ningxia), Huinong (Ningxia), Dulat (Xinjiang).

Erenhot and Dulat are border crossings. In 2010, the Tianjin dry ports processed 150,000 TEU worth of containers. The 12th five year plan envisages increasing throughput by Tianjin's dry ports to up to 1 million TEU by 2015.

Figure 23. Tianjin's Network of Dry Ports and Intermodal Trains.

According to news reports during the Chinese New Year holiday from February 22 to 28, 2012 the Port of Tianjin recorded a throughput of 150,000 TEU, or 5.47 million tons. It was noted that during the seven day period a total of 241 vessels called at the port, including the 13,000-TEU mega ship Maersk Evora. The port also handled 281,000 tons of coal and 10,500 automobiles by ro/ro.[43] The majority of these containers are for export primarily to other locales.

Although no official data are available, port personnel report that the majority of these containers reach the port by transport via truck. A small portion of the total annual cargo that reaches the port is deliverd by barge and is estimated to be about 300,000 TEU per year. Considerable roadway congestion occurs in the roadways leading into the port of Tianjin. Since much of this container traffic is generated from the manufacturing facilities in the hinterland, where many of the dry ports have been located, the need for more aggressive intermodal rail service connecting the hinterlands and the port would seem to be in order. If a substantial portion of the container throughput could be put on rail the amount of congestion and pollution could be greatly reduced.

[43] http://www1.chinaccm.com/k1/k117/k11701/news/20120207/102748.asp

However, one concern with moving containers to rail would definitely be the displaced truck drivers currently engaged in moving the containers manually with their rigs.

Lee (2012) indicates that only 2 to 4 trains per day with approximately 100 TEUs are received at the port. Taking the 11 million TEUs for the annual activity of the port at face value, and assuming that they could be converted to 40 foot containers, leaves about 5.5 million containers to be moved. Assuming further that trains carrying these containers were constructed at the remote in-land dry ports and placed on trains we would still expect to see about 60 trains per day to reach the reported numbers. Again, port personnel indicate that only one or two trains per day are received. Thus, a dramatic increase in the number of trains per day would greatly reduce truck traffic, decrease diesel fuel use and ultimately reduce GHG emissions.

Table 7. CO_2 Reductions and Fuel Savings for Tianjin, Truck vs. Train (50 Containers).

	Trucks	Trains		CO2 Reductions truck-train		Fuel Savings	
travel distance (miles)	lb. CO2 generated single truck trip	lb. CO2 from single train trip	Annual CO2 reductions moving X containers on trains (lbs.)	Annual reduction in CO2 - corrected for on dock movements (lbs.)	Percent CO2 reduction Train vs. Truck	Annual Diesel Fuel savings from using RAIL vs. truck (gals)	Annual Fuel Cost Savings (TRAIN vs. TRUCK)(@ $3.84/gal)
10	2064	504	561816	398357	53%	17796	$4,634.51
25	5161	1260	1404540	1241081	66%	55445	$14,438.81
50	10323	2520	2809080	2645621	71%	118192	$30,779.30
100	20646	5040	5618160	5454701	73%	243687	$63,460.29

Table 8. CO_2 Reductions and Fuel Savings for Tianjin, Barge vs. Train (50 Containers).

	Trucks	Barge	CO2 Reductions Barge - Truck		Fuel Savings	
travel distance (miles)	lb. CO2 generated single truck trip	lb. CO2 from single barge trip	Annual CO2 reductions moving 50 containers on barge (lbs.)	Percent CO2 reduction Barge vs. Truck	Annual Diesel Fuel savings from using Barge vs. truck (gals)	Annual Fuel Cost Savings (Barge vs. TRUCK) (@ $3.84/gal)
10	2064	327	625464	84%	27987	$7,288.40
25	5161	818	1563660	84%	69968	$18,221.01
50	10323	1636	3127320	84%	139937	$36,442.02
100	20646	3272	6254640	84%	279874	$72,884.04

Table 9. CO2 Reductions and Fuel Savings for Tianjin, Train-Barge (50 Containers).

	Barge	Trains	CO2 Reductions	Fuel Savings		
travel distance (miles)	lb. CO2 generated single barge trip	lb. CO2 from single train trip	Annual CO2 reductions moving X containers on barge (lbs.)	Percent CO2 reduction Barge vs. Train	Annual Diesel Fuel savings from using Barge vs. train (gals)	Annual Fuel Cost Savings (Barge vs. train)(@ $3.84/gal)
10	327	504	63648	35%	2848	$741
25	818	1260	159120	35%	7120	$1,854
50	1636	2520	318240	35%	14240	$3,708
100	3272	5040	636480	35%	28480	$7,416

Analysis of Tianjin Port data comparing the use of trucks versus trains shows that there would be a considerable improvement in reduction of CO2 if a substantial number of trucks were moved off road and onto either trains or barges. The data in the table above indicate that reductions as high as 84% could be achieved if containers were moved from trucks to barges. Savings as high as 73% could be achieved if containers were moved from trucks to trains. Comparatively, the savings of moving containers from trains to barges is about 35%. Thus, the GHG savings appears to be greatest with utilization of barge movements.

These same tables also show that less fuel is consumed by the different modes as well. The relationships remain approximately the same with the relative comparison of train versus truck, and barge versus train or truck having the advantage. Thus, there would be an overall reduction of oil imports if the containers could be moved on barge or train over truck.

Overall, Tianjin has a truly intermodal approach to the movement of freight and other goods. It is a well-designed modern port that has taken advantage of its geographic location and the natural harbor it is blessed with. The GHG, congestion and fuel savings that the port could obtain, if it invested more heavily in rail would be substantial. The port could beenft from the natural waterway that empties into the sea. Ina ddtioin, there is a basic infrastructure that could also be taken advantage of as well.

Case Study #5 - Shanghai

The Shanghai International Port (Group) Company, Limited (SIPG) is responsible for operating the terminals in Shangai. The company was incorporated in 2003 and in 2006 became the single largest operating entity. 44 SIPG operates 125 berths in the Port of Shanghai with a total quay length of about 20 kilometers. Of the total, 82 Port of Shanghai berths can accommodate vessels of 10 thousand DWT and above. SIPG owns public bulk, break-bulk, specialized roll-on/roll-off, and cruise terminals within the Port of Shanghai. It operates a total of 293 thousand square meters of warehouses and over 4.7 million square meters of storage yards. It also owns 5143 units of cargo-handling equipment. One of the key reasons for Shanghai's success comes from the fact that it occupies an ideal geographic and nautical location. In addition, it is adjacent to and interconnected with the well-developed manufacturing economy of the central China

[44] http://www.worldportsource.com/ports/commerce/CHN_Port_of_Shanghai_411.php

mainland. Moreover, the Yangtze River Delta is home to some of China's most economically active cities.

With just little over one percent of China's population, the city of Shanghai accounts for some five percent of China's gross domestic product. Adding the surrounding provinces of Jiangsu, Anhui and Zhejiang – the region that might be called Shanghai's manufacturing heartland – raises this share to nearly 25 percent. Shanghai's ships handle more than a quarter of China's total exports. Port expansion projects will nearly triple this capacity.[45]

Just about all of the major manufacturing industries in China are located near Shanghai. As a result, the average per capita income in 2004 for Shanghai was US $2,950 while the average for all of China was about US $1,690, according the China Daily, April 20, 2005. What isn't given in the statistics is an adjustment for the cost of living.

Figure 24. Yangshan Bridge to Shanghai and mainland.

Any discussion of Shanghai would be incomplete without mention of the development of the new Shanghai Port of Yangshan. This new port just 20 miles from Shanghai is a result of the investment the Chinese are making in port infrastructure (see figures 12 and 13). The first two phases of the US$14.5 billion Yangshan deep-sea port are now open, with a 2020 target year for achieving the full capacity of the port (33 to 50 deep-sea berths) at 25 million TEUs per year. The port is connected to the mainland by a highway bridge (there is no direct rail connection to the port, although there is a new intermodal rail yard on the mainland near the bridge gateway).[46] Unfortunately, the port is limited in its overall infrastructure with relatively little barge traffic and only a small amount of rail capacity. Barge traffic is being phased out, and the upriver container terminals are being converted to more expensive housing and office space property.

[45] http://www.containership-info.com/misc_publ_shanghai.pdf
[46] http://international.fhwa.dot.gov/pubs/pl08020/fmic_08_03.cfm

According to a report by the FHWA, rail use in mainland China's hinterland still remains the key bottleneck for the future. Rail rates over long distances are still challenged by truck, which enjoys fuel price protection on diesel. There is little enforcement of over-the-road weight limit, allowing one truck to carry what would normally require two to three. This makes some long-haul truck routes competitive with rail, especially because of speed.[47]

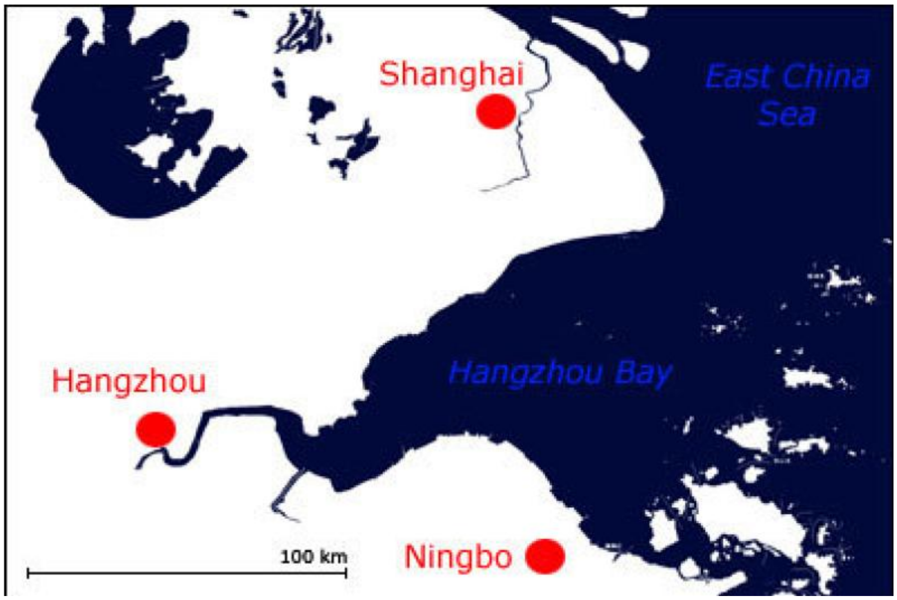

Figure 25. Shanghai Freight Port Triangle.

Together, the ports of Shanghai and Ningbo, and to some extent Hangzhou, have developed into China's most important international trade hub. Their success is backed by a rapid terminal development, as well as he tremendously fast growth of the Yangtze River regions's economy. Both ports enjoyed double digit growth rates over the last couple of years. Shanghai now exceeds overtook Rotterdam and Singapore in terms of cargo volume. Surpassing Singapore and Hong Kong, Shanghai now ranks first among the world container ports with over 31 million TEU loaded and unloaded last year.

The GHG emissions, congestion and fuel consumption analyses for Shanghai are nearly identical to those of Tianjin reported earlier. Those completed for Tianjin are equally applicable to Shanghai as to Hong Kong. The lack of a definitive rail line (i.e. Yangshan) and the phasing out of barge traffic suggest that the conclusion from the previous set of analyses still applies. Namely, that the utilization of truck on trail would result in savings of anywhere from 50% to nearly 73% in reduction of greenhouse gases if trucks were moved to rail. Similarly, nearly 84% savings would result from transferring truck freight to barge. Finally, we could also expect to see reductions in traffic congestion of a similar magnitude. And, we could also expect to see reductions in the importing of oil and consumption of fossil fuels.

[47] http://international.fhwa.dot.gov/pubs/pl08020/fmic_08_03.cfm

Recommendations

Based on the review and analysis of the data and case materials presented the following recommendations appear to be in order for increasing the intermodal movement of freight.

1) **Intermodal freight movement that utilizes and prioritizes barge, rail and truck modes (in that order) results in a significant saving in GHG emissions**, fossil fuel consumption and importation and a concomitant decrease in highway congestion. Results of these analyses consistently show that barge and rail are superior to truck in the reduction of GHG, and the efficient movement of freight with a concomitant reduction in congestion. This appears to be a universal phenomenon related to the efficiency of moving large quantities of goods over a specified distance. All things being equal the findings are relatively consistent.
2) **Intermodal freight movement that creates terminals or yards away from central urban settings likely has the greatest impact on decreasing congestion and GHG**. Setting up facilities away from central urban areas so as not to compete with passenger travel appears to make the most sense. As is being done in Shanghai, moving container terminals out of urban areas to be within close proximity to ocean going vessels and decreasing the interaction with smaller single occupancy vehicles is most likely to lead to decreased congestion.
3) **Dedication to Most Energy Efficient Mode Given the physical Geography.** The findings reported in Figure 13 hold true across the various sites studied. Barge is the most energy efficient followed brain and then truck. Policy efforts to promote the most energy efficient mode of transport will be able to decrease the GHG emitted, reduce oil consumption and also decrease congestion accordingly.

4) **Dedicated Intermodal Rail Line Service.** In most of the locations studied, there appears to be a need for dedicated intermodal freight rail lines or service to and from ports specifically designed to keep trucks from entering urban areas or competing with autos for roadway space. These lines could be developed and maintained to form staging yards outside the city limits and yet in sufficient proximity to provide access to warehouses and trans-loading facilities needed to process and manage some of the goods. More sophisticated, grade separated infrastructure, such as the Alameda Corridor, may be needed in more densely populated urban areas where strains might drastically interfere with the mobility of the local citizenry. However, these types of infrastructures are extremely costly to build. Construction of more useful railways in younger cities that are less developed, without the so-call retrofitting costs, would appear to be well worth the long term investment.

5) **Policies that encourage the development of intermodal yards external to the city or dry docks should also be encouraged.** In addition to the development of rail lines that serve to move freight from congested urban areas to less densely populated and less traffic congested areas need to be encourage through policy and other investment incentives wherever possible. Different groups of investors may seek to band together to identify industrial development zones, in close proximity to existing rail lines appears to be well worth the investment. However, it should be noted that not all of these structures and constructions will end up with equivalent financial benefits and that careful planning and consultations

with rail lines will be needed to determine where the proper placement of these and facilities should be established.

6) **Development of freight corridors for truck traffic over surface streets is also highly recommended.** Given the logic and benefits of having dedicated rail freight intermodal service it also seems imperative to develop similarly restrictive but also useful dedicated infrastructure to facilitating intermodal truck and trailer traffic. Many of these passage ways have been termed "intermodal connectors" and there appears to be a continued need for developing these types of connectors.

7) **Joint planning of transit and freight oriented urban development.** While seemingly contradictory, transit oriented development appears to hinge on the development of a certain density of population within an area. Similarly, designing freight with a certain degree of proximity to other modes also seems to hold promise. Ensuring that freight and passenger area able to co-exist is an important consideration rather than simply going for the most cost efficient alternative.

8) **The advantages of moving freight by rail, even if as short as 10 miles is beneficial to the reduction of GHG and may have operational value as well.** The results of our calculations indicate that there is a savings of 45% to 64% for short hauls of 1 to 20 miles of less. The greater the distance, the flatter the terrain, and the more reliable the equipment the greater the benefits. Contrary to popular belief, that argued that only runs or trips of 400+ miles were cost effective for the railroads, there may be other benefits to short hauls. However, there do appear to be cost benefits for the shorter runs as well.

9) **These findings are generalizable.** The findings from these analyses are generalizable to many different APEC cities and regions. The metrics are sound and can easily be converted to different measurement systems and scales.
10) **Need for additional databases and case studies with common metrics.** The difficulty in pulling together data from various economies is significant. Lack of reliable statistics, lack of access to statistics, and lack of common measurement terms presented large difficulties in making comparisons. APEC should be encouraged to obtain uniformity in measuring and reporting tis freight oriented intermodal activities across various economies.

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Appendix

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Dr. Patrick Sherry is a professor with a specialization in human factors, safety, intermodal transportation and occupational psychology at the University of Denver. Since 2002 he has served as the Director of the National Center for Intermodal Transportation and as a member of the Board of Directors of the Intermodal Transportation Institute at the University of Denver. In addition to scientific research he has consulted extensively with Fortune 500 transportation companies throughout the US and Canada in the areas of safety, intermodal workforce development in transportation, and leadership training. He has conducted research in the area of human factors related to the hours of service for the transportation industry. He developed and validated an assessment battery for selecting and hiring managers in a large rail transportation company. Dir. Sherry led several pioneering efforts with US railroads designed to implement behaviorally based safety and peer feedback programs that resulted in significant reductions in reported injuries. He has conducted numerous surveys and focus groups regarding perceptions of transportation services and systems.

Dr. Sherry addressed the US House of Representatives' Committee on Transportation & Infrastructure and identified five major challenges facing the US transportation system in 2006 and in 2007, he addressed this same committee on the proposed revision of the railroad Hours of Service laws.

Dr. Sherry has been extremely active in the identification and development of leaders in business and industry. His book on training and development needs of leaders in the transportation industry and 150+ articles and scientific papers have influenced thousands of professionals and students. Applying cutting edge behavioral science to training and education he was a co-founder of the Pioneer Leadership Program – an on-campus training program that had the highest enrollment of students on campus. In addition, he directs and evaluates potential participants for the Founding Fathers Project, an in-depth study of 40 CEOs and leaders of transportation companies. Most recently Dr. Sherry co-authored a study on the workforce development needs of professional in the transportation industry.

Dr. Sherry is a regular advisor to the Transportation Working Group of the Asia Pacific Economic Cooperation (APEC) and recently addressed the Transportation Ministers 6th Bi-annual meeting in Manila Philippines on the topic of Human Capital Infrastructure Development in Times of Economic Crisis. He has conducted highly successful training workshops for the APEC focusing on the development of capacities needed to function effectively in the intermodal transportation industry. These workshops are designed to introduce participants to current developments in intermodal transportation in the APEC region, in the areas of best practices, infrastructure, and technology. Sherry and his team have conducted these workshops in Manila, Philippines; Beijing, China; and Jakarta, Indonesia. Several more are planned for Hong Kong and Vietnam.

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