

Urban Truck Ports

The Long-Haul Trucking Industry

The share of freight handled by trucking has grown steadily in the 35 years since the industry was deregulated. In 2011, trucks carried 63 percent of US domestic cargo by value and 64 percent by weight.¹ The trucking industry is extremely diverse but can be divided along three primary dimensions: the distance the goods are being transported, the ownership of the goods, and the size of the shipment. Truck trips of less than 150 miles are considered local, anything more is considered over-the-road (OTR). Private carriers transport goods they own, while for-hire carriers move goods owned by others for a fee. Finally, trucks either carry full truckloads (TL) from origin to destination or carry less-than-truckload (LTL) shipments of less than 10,000 pounds, which are consolidated and broken down at terminals between their origins and destinations.

This proposal addresses issues that primarily concern private and for-hire OTR TL carriers.

Deregulation and the Modern Trucking Industry

Deregulation of the trucking industry in the late 1970s and early 80s transformed the way trucking services were provided, the work of truckers, and the market structure of the industry. Prior to deregulation the largest carriers transported a limited set of goods, consolidated shipments at terminals and traveled to relatively few locations. After deregulation, the largest carriers began hauling full truckload shipments directly from shippers to consignees (point-to-point) resulting in cheaper, faster, and more fuel efficient freight services. However, point-to-point service has degraded working conditions for drivers and made driver retention a major challenge for carriers.

The most efficient way to schedule drivers in a point-to-point system is to have them haul a load from one location to another and then pick up the nearest available load headed somewhere else, potentially hundreds or thousands of miles away. This system requires drivers to travel in a changing and unpredictable route over very large areas and to be on the road for longer periods of time, typically two to three weeks.

The transition to a point-to-point system has significantly degraded the working conditions for drivers, forcing them to work long, unpredictable hours, live out of their trucks, and absorb much of the cost of downtime and delays in the form of lower wages. These changes, combined with increased competition and de-unionization, have resulted in dramatically longer work hours and an estimated 30 percent decline in trucking wages from the late 1970s until the late 1990s (Belzer 2000).

Deregulation completely transformed the market structure of the trucking industry as well. Most of the largest less-than-truckload (LTL) firms and smaller firms of all types were driven into

¹ US Department of Transportation, Research and Innovative Technology Administration Bureau of Transportation Statistics, *Transportation Statistics Annual Report 2012* (Washington, DC: 2013), Table 3-1.

bankruptcy. What remained was a small handful of growing and profitable LTL firms and tens of thousands of small and under-capitalized truckload (TL) firms. The TL segment today is generally marginally profitable and increasingly employs a low-wage labor force comprised of inexperienced employees and slightly more experienced independent contractors, who own or lease-to-own their trucks.

The development of cheap, fast TL services has been a key building block in the development of today's longer and more fuel dependent supply chains. In particular, the distribution center model, epitomized by Wal-Mart, has allowed companies to leverage inexpensive truck transportation to take advantage of low-cost real estate and labor in rural and exurban areas as distribution points for networks of stores.

The Coming Crises and the Need for Transformation

The current truck freight system is faced with a number of systemic challenges that are set to intensify in the coming years as the US population and economy grow. The Government Accountability Office projects the volume of freight carried by trucks in the US to nearly double by 2035. There are three critical challenges that the industry needs to address in order to maintain the low costs and flexibility that enable complex modern trucking-based supply chains:

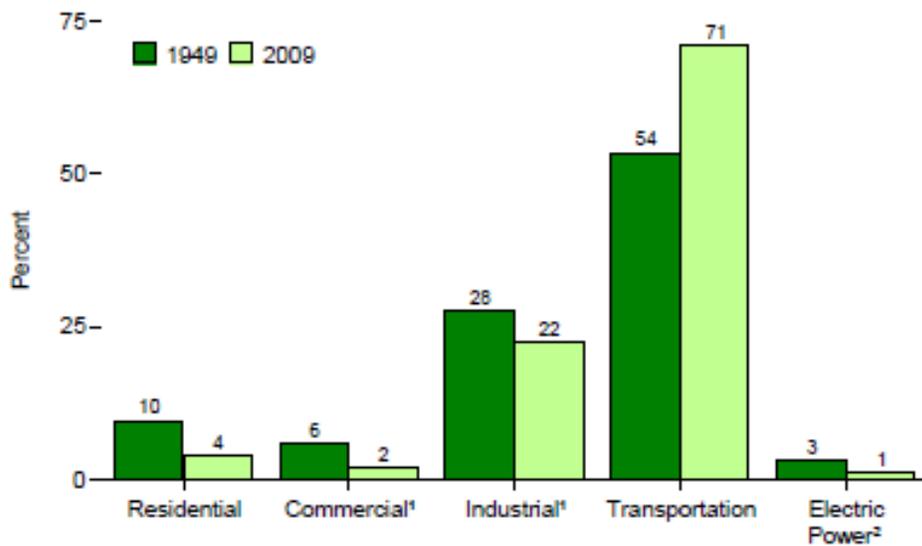
1. Dependence on oil;
2. Increasing traffic congestion and rising infrastructure costs; and
3. High turnover and a shortage of experienced drivers.

Dependence on Oil

The trucking industry's heavy reliance on oil is its most serious challenge. Rising fuel prices and price volatility have the potential to seriously disrupt, not only the trucking industry itself but the entire freight transportation system, which relies on trucks to make the first- and last-mile trips, hauling goods between their origins and destinations and the airports, seaports, and rail yards that may carry them for the bulk of their journey. In addition to price-related issues, dependence on oil makes trucks major emitters of greenhouse gasses (GHG) and toxic air pollutants. Truck emissions generate significant costs to society through their health and environmental impacts and make the industry a target for new regulations designed to decrease its environmental footprint, which could impose substantial new costs on trucking firms.

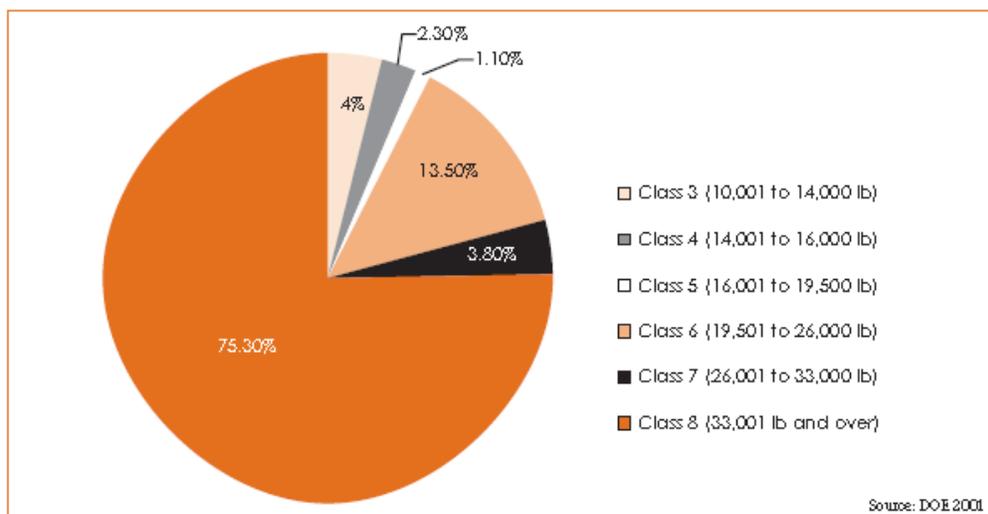
The US consumes nearly a quarter of oil produced globally and now imports more than 60 percent of its supply. Oil use in transportation represents 71 percent of US oil consumption, a share that has grown substantially in recent decades (See Figure 1). As a result of its heavy reliance on oil, transportation accounted for 40 percent of US greenhouse gas (GHG) emissions. Freight trucks represent a large and growing share of transportation fuel consumption and emissions. While medium and heavy duty trucks represented 3.2 percent of all road vehicles and 15 percent of transportation fuel consumption and GHG emissions (FHWA 2003) in 1990, by 2006, they accounted for 3.5 percent of all vehicles and 22 percent of transportation fuel consumption and GHG emissions (NSCCAF 2009).

FIGURE 1: US EIA 2009 *Annual Energy Review* Estimate of Petroleum Consumption by Sector



As Figure 2 shows, 75 percent of the fuel consumed by these trucks is used by Class 8 vehicles (those weighing more than 33,000 pounds), nearly all of which are tractor trailers. Fuel consumption by tractor trailers has increased significantly over the last several decades as vehicle miles traveled by them have increased steadily. In 1980 tractor trailers represented less than 1 percent of all vehicles but accounted for 11 percent of all highway fuel consumption. By 2030 these trucks are projected to consume X percent of total highway fuel, representing 12 percent of total US oil consumption, despite a forecasted increase in fuel efficiency from 6 mpg to 6.8 mpg. (Union of Concerned Scientists 2010; DOE 2009; FHWA 2003).

FIGURE 2: Fuel Consumption by Classes of Medium and Heavy Duty Trucks



The fact that so few vehicles represent such a large portion of US oil consumption means the industry is particularly vulnerable to increasing oil prices and oil price shocks. However,

improving the efficiency of tractor trailers is also one of the nation's best opportunities to reduce emissions of GHG as well as the toxic air pollutants pose more immediate threats to human health. Unfortunately, long-haul tractor trailers present a far greater challenge than any other type of vehicle in terms of increasing fuel efficiency. In fact, significant progress has been made in developing and deploying fuel efficient technology for all kinds of trucks except tractor trailers. From 1980 to 2006 the fuel efficiency of single unit trucks increased by more than 40 percent, climbing from 5.8 to 8.2 miles per gallon. The fuel efficiency of tractor trailers, on the other hand, dropped by 4 percent over the same period. Even more dramatic reductions of fuel consumption by smaller, non-Class 8 trucks are on the horizon. However, tractor trailers, particularly those engaged in long distance transport, are unlikely to make significant improvements to their fuel efficiency in the near term due to their size, weight and usage. Even with the new fuel efficiency standards proposed by the EPA heavy truck oil consumption will continue to grow. The proposed maximum 20 percent efficiency gain will not cause the increase in consumption to level off until 2027, at which point the industry will require significantly more liquid fuels than it does today.

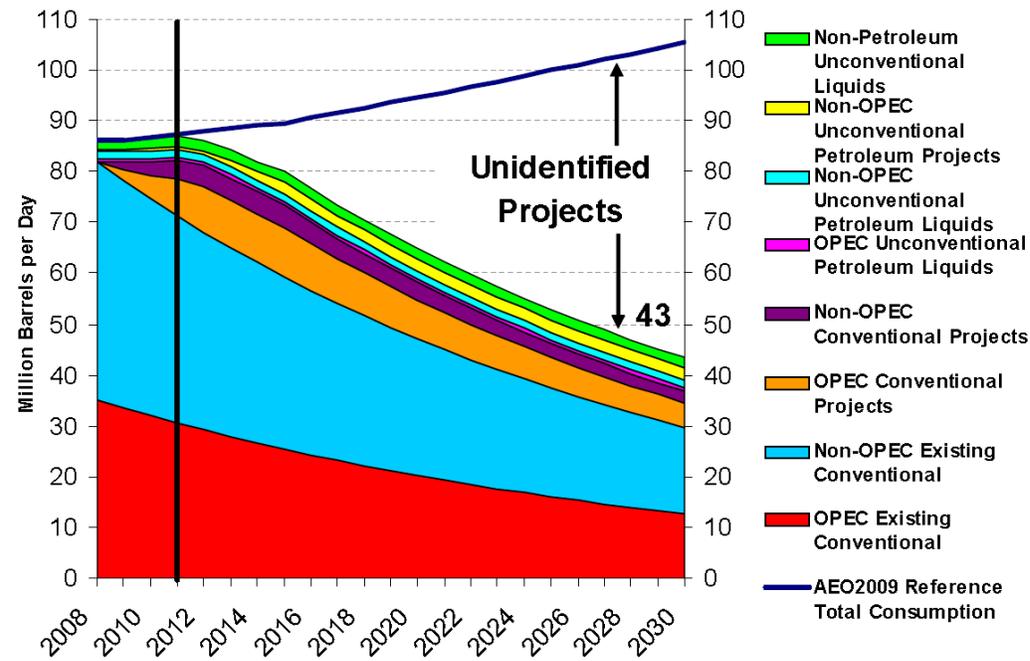
As oil prices climb and grow increasingly volatile, the industry's inability to increase efficiency will create impacts that will ripple through the broader economy. The effect of rapidly increasing fuel prices on the trucking industry were foreshadowed in 2008. From the end of April to the beginning of September 2008, the price of crude oil in the US was over \$100 a barrel, reaching average weekly highs of over \$130 a barrel for several consecutive weeks. The rapid rise in crude prices caused diesel prices to soar. From July 1998 to July 2008 the price of diesel climbed almost 240 percent in inflation-adjusted dollars (See Figure 3). In 2008 diesel prices rose to a record average of \$4.76 a gallon. While large fleets were able to pass along these higher fuel costs to customers and ultimately consumers, many smaller firms were unable to do so. In the first half of 2008, nearly 2000 trucking companies with 5 or more trucks went out of business, removing an estimated 120,000 tractor trailers from service, 6 percent of the industry's total capacity (Christensen).

FIGURE 3: Monthly Diesel Prices, January 1998-July 2008



It is now general consensus that there are few, if any, easily accessible oil reserves remaining. In order to meet future demand, a tremendous amount of new oil will need to be brought online and nearly all of it will be substantially more costly to access than oil from existing sources. The inevitable outcome will be increasing oil prices and price volatility as higher prices will be required to justify the extraction of oil from increasingly inaccessible new sources. Even conservative analysts believe that diesel fuel prices will reach 2008 levels rapidly once economic growth returns to pre-recession levels. The exact price of diesel fuel in the short-to medium term is unclear, but EIA's high price scenario suggests \$4.82 a gallon 2015 and \$7.43 in 2025. Regardless of specific price, the message is clear, as the International Energy Agency concluded in its 2008 *World Energy Outlook*: "current global trends in energy supply and consumption are patently unsustainable...the era of cheap oil is over."

FIGURE 4: Energy Information Agency's Estimate of Future Liquid Fuel Supplies



Source: EIA, AEO2009

The impact of sustained high diesel prices will be severe on trucking companies. Because the industry hauls the vast majority goods produced or consumed in the US economy, its inability to reduce its dependence on diesel fuel represents a serious economic liability in the coming decades. From 1981 to 2002, total logistics costs in the US fell from 16.2 percent of GDP to 8.7 percent of GDP. Much of this decline was due to cheaper, faster trucking services that allowed businesses to reduce their inventory carrying costs. Today trucking makes up about 80 percent of total US business transportation costs, with fuel comprising about a third of this. While the exact trajectory of fuel prices over the coming decades is uncertain, the likelihood of high and

unpredictable prices has the potential to undermine not only the trucking industry, but the entire transportation system and the US economy.

Beyond GHG emissions, diesel engines emit a number of toxic air pollutants including “particulate matter” (PM), which is associated with premature death, increased hospital admissions for heart and lung disease, and breathing problems such as asthma, and nitrogen oxide, which contributes to the formation of ground level ozone, is linked to smog and childhood asthma. According to the American Lung Association, diesel emissions are responsible for 15,000 premature deaths each year. In California, the California Air Resources Board has estimated that the health impacts of diesel emissions are equivalent to that of traffic accidents and second-hand smoke.

The EPA has introduced more stringent emissions standards over the last few years that will significantly reduce the air pollution from new trucks. These have included the use of cleaner burning diesel and new engine technologies. However, by raising the cost of new trucks, these new standards have had, in the short-term, mixed results, leading some truckers to delay replacing older models, thereby reducing fuel efficiency. More significantly, the newest and cleanest burning trucks are used primarily in OTR driving while the older more polluting trucks are sold for local and urban applications. It will take a decade or more for these new trucks to become a majority of the trucks working in congested urban areas.

Congestion and the rising cost of infrastructure investments

Congestion is a growing problem in urban areas throughout the US. In 2007 congestion in urban areas wasted 2.8 billion gallons of fuel and 4.2 billion hours in travel time. The estimated cost of this congestion to travelers was \$87.2 billion. The problem has grown dramatically in recent decades as the US population has grown, metropolitan regions have spread out, and the pace of urban highway expansion has slowed. However, the problem is expected to grow much worse. Over the next four decades, the US DOT estimates that demand for road and rail transport will grow 250 percent, while highway capacity will increase just 10 percent.

Although trucks are a small fraction of the vehicles on the road, they make a disproportionately large contribution to traffic congestion and pay a disproportionate share of the costs. According to Federal Highway Administration (FHWA) estimates, a single truck can have an effect on traffic congestion of more than 10 cars during congested periods due to their size, slow acceleration, and greater following distances (FHWA 2000). But trucks also pay a much greater price for congestion than most other road users. Though trucks represent only 5 percent of all vehicle traffic, they experience an estimated 27 percent of all congestion costs (GAO). According to the American Trucking Associations (ATA), congestion was a critical factor driving the 15 percent decline in per-truck productivity between 2002 and 2007 (Costello 2008).

The cost of congestion to trucks comes in the form of wages, wasted fuel, and poor service quality due to missed appointments (FHWA 2005). The American Trucking Associations estimates that the trucking industry loses about \$19 billion a year to congestion related costs. Congestion causes driver stress and fatigue and can dramatically lower per-hour pay for drivers, who are often paid by the mile. In addition, it increases the likelihood of collisions, leading to

higher insurance costs (Heavy Duty Trucking 2010). With truck freight forecasts indicating continued growth in the coming decades, the costs of congestion to the industry will grow.

In coming years, the trucking industry's most critical routes, those urban freeways that carry over 10,000 trucks each day, are expected to shoulder a disproportionate share of increasing highway congestion. While these routes currently include 3,300 miles with slowed traffic and 3,000 with stop-and-go conditions, by 2035, without expansion or significant operational changes, 10,000 miles of these critical roads will have slow traffic and 23,000 miles will have stop-and-go conditions (Freight Story 2008). This congestion will pose a serious challenge to improving freight system efficiency by increasing trucks' fuel consumption and emissions and increasing crash risk.

The solution to the problem of congestion normally favored by the industry and many policy makers involves expanding roadway infrastructure. However, this approach is becoming increasingly untenable due to insufficient funding and growing highway maintenance backlogs. Today, the US is not spending enough to even maintain its estimated \$2.8 trillion worth of public roads. Estimates indicate that one third of the nation's major roads are in poor or mediocre condition and at current spending levels the nation's highways and bridges will continue to deteriorate. While a 2006 US DOT report to congress suggested that \$120 billion should be spent by all levels of government each year just to maintain current performance of this infrastructure, this figure is growing rapidly, as prices for materials and services for highway and bridge construction have risen 74 percent since 1993 (USDOT 2006, Builders Association).

Despite our inability to maintain our ailing infrastructure, proposals to solve the looming freight capacity crisis center on adding new roadway capacity. For instance, in 2007, the FHWA developed a proposal called "Corridors of the Future" which identified six key freight corridors for which tens of millions of dollars in planning money has been given. One such corridor is I-70 from Kansas City, MO to Columbus, Ohio. Four states have developed a plan to add 2 dedicated truck lanes in each direction over more than 700 miles. While estimates for the urban sections are ill-defined the project is already estimated at a build cost of more than \$35 billion dollars. Despite their high price tags, proposals such as these still fail to address the urban bottlenecks that host the most severe congestion and where expansion projects are far more costly and contentious.

Aside from the huge costs of highway expansion, spending funds on expansion while neglecting maintenance needs simply exacerbates the problem. Expanded roadways, particularly in urban areas, rapidly return to their pre-expansion congestion levels and deferring maintenance generally means more costly fixes in the future.

Labor Shortage

For the last several decades the OTR segment of the US trucking industry, which transports the bulk of freight hauled by trucks, has suffered a severe labor crisis. The development of point-to-point shipping has degraded the working conditions of truck drivers while extreme competition and low-profits have caused trucking firms to steadily push down wages. The average long-haul driver now works 70 hours a week and many work up to 100 hours a week. Most of this time is

spent either unpaid or working for less than minimum wage. Increased congestion, restrictive changes to hours-of-service rules, and delays at customer locations have all contributed significantly to the demands on truckers. All of this is compounded by the fact that the typical OTR driver must be away from his or her family for one to two weeks at a time. Not surprisingly, the rate of turnover for OTR truckers is extremely high. Except for recessionary periods, annual turnover at large OTR TL firms exceeds 100 percent. Estimates suggest that as many as 200,000 workers are trained each year just to maintain the nation's 600,000 truck-for-hire OTR TL fleet. Nearly all of these drivers will pay thousands of dollars to be trained. In addition training costs firms billions of dollars a year. The largest fleets rely on workers new to truck driving altogether, which has serious consequences for fuel efficiency. Studies and industry reports suggest that skilled drivers can operate a truck 30 percent more efficiently than newly trained workers. OTR TL fleets also rely heavily on owner-operators working under long-term leases who make significantly less than company drivers and often self-sweat in order to survive. Like the other problems facing the industry, the labor crisis is likely to continue getting worse. The industry is currently dependent on a core of very experienced older drivers who will soon begin retiring at high rates.

Why an Urban Truck Port Network Is Needed

The threats to the trucking industry's current paradigm make transforming the industry a goal of critical national importance. The potential benefits to the public are tremendous as are the potential economic returns to a wide range of stakeholders—all levels of government, businesses, consumers, and trucking companies themselves. Stakeholders will view and prioritize each of the critical problems outlined above somewhat differently. However, each of these challenges can be addressed immediately through the development of a national Urban Truck Port Network (UTPN).

The trucking industry cannot transform itself for two reasons:

1. The industry is extremely conservative about new technologies;
2. Developing critical infrastructure to maximize the effectiveness of new technologies and freight hauling strategies is beyond the ability of even the largest truckload carriers.

Trucking's Conservative Approach to New Technology

The basic technologies to dramatically reduce OTR fuel consumption have been around since the early 1980s but market failures inherent in the current structure of the long haul trucking industry have prevented their introduction. The OTR TL trucking industry is extremely competitive and returns marginal profits, leaving companies with little capital to invest and difficulty borrowing. Trucking is also subject to boom and bust cycles that regularly shakeout highly leveraged firms. OTR companies typically only hold their trucks for 3 to 5 years, making it necessary for new technologies to pay for themselves in no more than 3 years. Finally, reliability is of the utmost importance to OTR companies because OTR trucks are driven over wide geographical areas and mechanical failures far from company facilities can be extremely costly. This is a critical problem for adoption of many promising new technologies. For instance, all major US truck manufacturers are developing hybrid models of Class 8 trucks. But these trucks will be very expensive and require different maintenance than traditional diesel trucks. Given these obstacles,

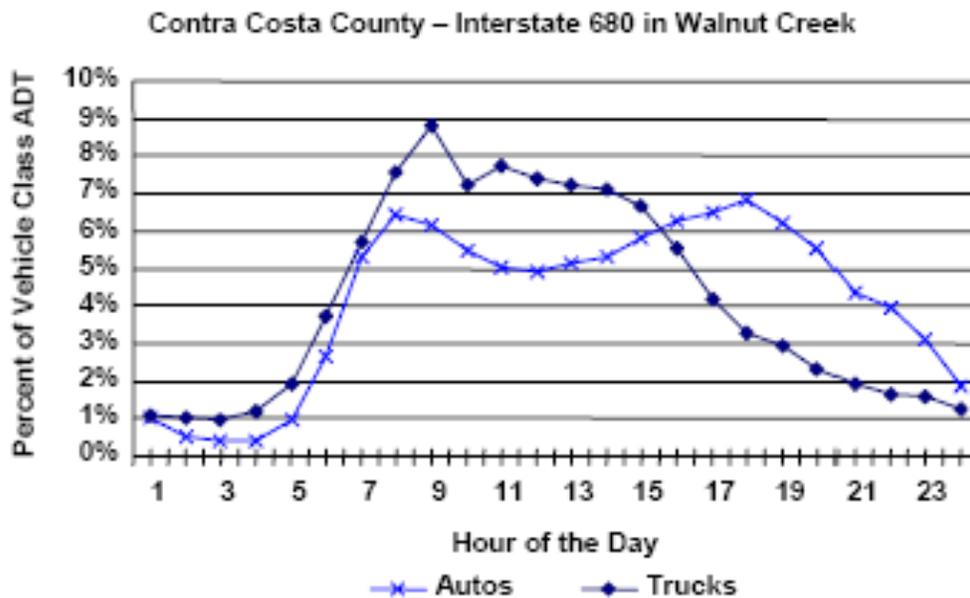
it is hard for carriers to justify investing in trucks that could be 50 percent more expensive for an expected 5 percent boost in fuel economy for long-haul applications.

Lack of Critical Infrastructure

While new roads and upgrades to existing roads may be appropriate in places, it is not possible to pave our way out of the problems of congestion. Aside from the political, social and environmental constraints that preclude this path, it is simply unaffordable. Fortunately, we already have excess road capacity, we just need to utilize it.

Most solutions proposed for our freight capacity crisis focus on expanding roadway capacity to accommodate more traffic during peak periods rather than shifting a portion traffic on the road from peak periods to less congested times. Figure 5 illustrates how little sense this makes. It depicts the percent of average daily trips occurring each hour on I-680 East of Oakland, CA and displays the same basic pattern as nearly every other congested freeway in the country. Each of these roads has a roughly bell-curve shaped distribution with one or two peaks. Notice how the truck trips peak slightly earlier than autos and have a second peak later in the day (when the heaviest car traffic is headed in the opposite direction), but how the bulk of their distribution overlaps with the bulk of auto trips. Many “congested” urban freeways are only heavily congested between 8:00 and 9:30 am. An urban truck port network could create tremendous value by facilitating more efficient use of existing urban roads.

FIGURE 5. A Typical Distribution of Auto and Truck Trips on an Urban Freeway



Source: Caltrans 2001-02 Weigh-In-Motion Data.

How a UTPN Would Speed the Transformation of Trucking

A network of urban truck ports could address the root of many of the OTR trucking industry's most serious challenges—the conflicting demands of goods movement in urban and rural areas. By separating the urban and rural duty cycles and providing a system of hubs for cargo pickup, drop off, and short-term storage as well as operations and maintenance activities, an urban truck port network could:

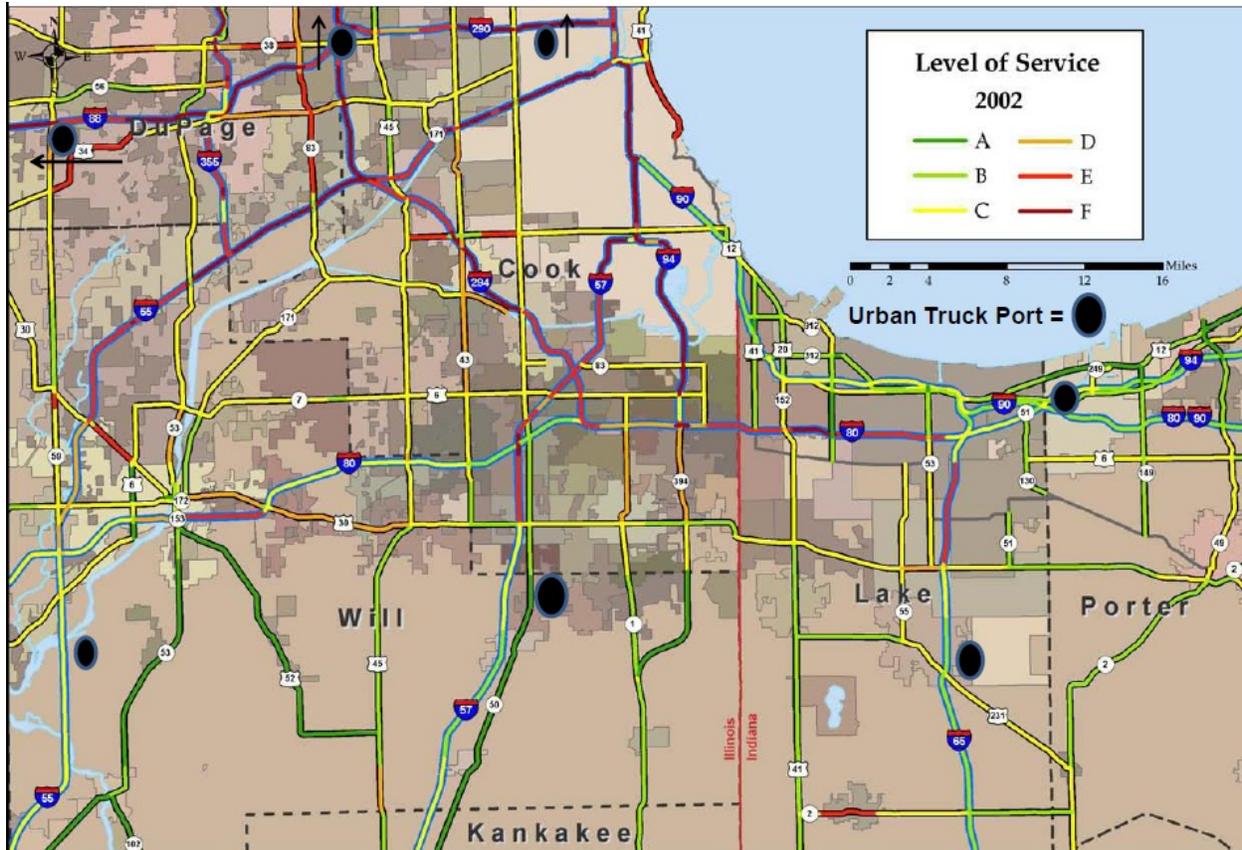
1. Foster the development and adoption of fuel saving technologies;
2. Reduce fuel consumption and resultant emissions by allowing for the use of specialized vehicles for urban and rural trips;
3. Reduce congestion experienced by trucks and other highway users by facilitating off-peak delivery; and
4. Reduce driver turnover by improving the quality of trucking jobs providing cost and fuel efficiency benefits to the industry and improving truck safety.

What is an Urban Truck Port Network?

An urban truck port network would consist of a set of large lots strategically located on major interstate truck routes outside of congested urban areas to facilitate short-term storage and transshipment between long haul and locally based truckers. Facilities would include basic driver services along with truck, trailer, and personal vehicle parking. Depending on freight volumes, ports should handle 1,000 to 4,000 tractor trailers per day. The largest of these ports could be several hundred acres in size, made up of a series of interconnected lots. Alternatively, in some locations, truck ports could be established by developing partnerships with existing truckstops or other truck-related businesses with excess lot space. Facilities could be located on one or both sides of the interstate depending on available space and could use existing exit and entrance ramps if they provide adequate road geometry for maneuvering and acceleration by OTR trucks, including those with multiple trailers. In the absence of suitable ramps, dedicated exits and entrances could be constructed directly from interstate lanes. Truck port networks could be developed regionally or in individual metropolitan areas. A national network of urban truck ports could eventually consist of 300 or more facilities outside of the largest 60 or so largest metropolitan freight markets.

Figure 6 illustrates how a network of truck ports could be arranged to serve the City of Chicago. The color of each road represents the level of peak period congestion. Green indicates no problems with congestion; red indicates that the road is above capacity for some parts of the day. Given the incredible forecast growth of Chicago area truck traffic, a network of seven ports with parking for 20,000 to 30,000 tractor trailers may be appropriate.

FIGURE 6: Urban Truck Port Facilities for Chicago

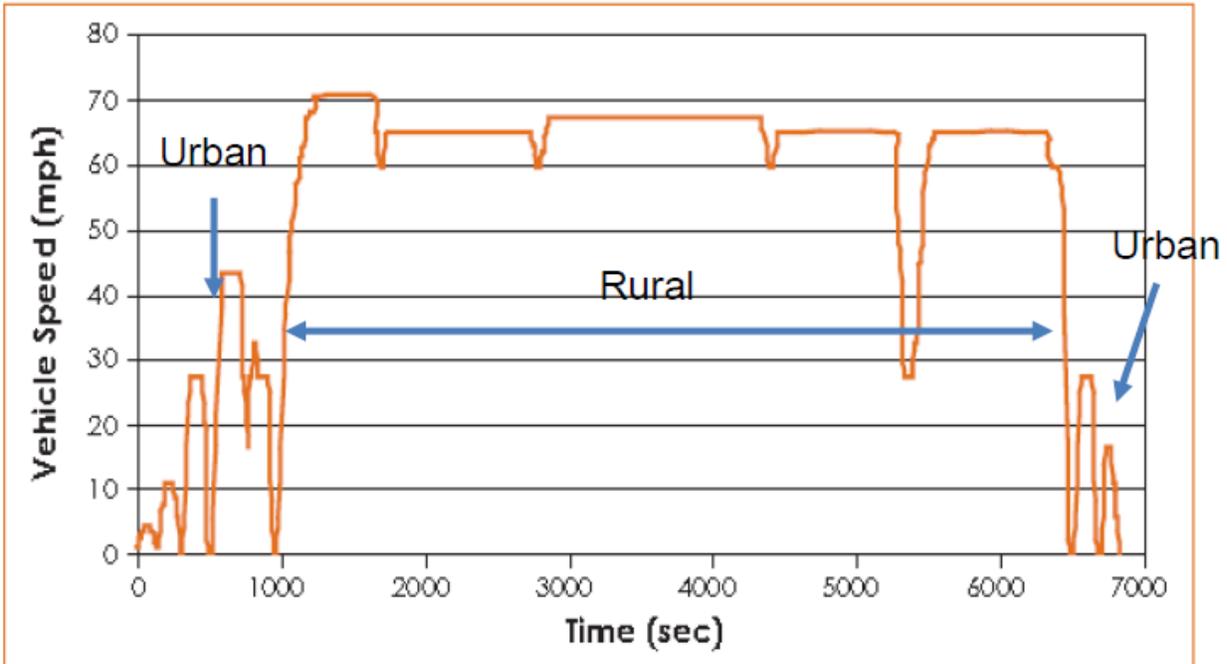


Separating the Rural and Urban Duty Cycles

The biggest problem with developing fuel saving technologies and getting the industry to adopt them is the usage pattern, or duty cycle, of OTR trucks. The average distance OTR trucks travel to haul each load has been steadily decreasing as shipment of intermodal containers by rail has captured an increasing share of long-distance freight transport. The average trip for OTR truckload freight is now less than 500 miles and this trip increasingly includes travel through congested urban and suburban areas. As a result, a typical OTR truck trip might consist of 400 miles of travel on uncongested rural highways and 100 miles of travel through congested urban areas. During the 400 mile segment on uncongested rural highways a truck might average 60 mph and make just one stop for fuel or driver needs. However, during the final 100 miles, a truck might average 20 mph or less due to congestion, speed limits, and traffic signals as well as the backing and idling required to pick up and drop off freight. In other words, a typical OTR truck driver might spend about 6 ½ hours operating in a rural environment and 5 hours in an urban one during his or her shift. These different modes of operation, known as duty cycles, entail different vehicle speeds, rates of acceleration and deceleration, intensity and frequency of braking, grade conditions, traffic conditions, road geometries, etc. Duty cycles determine the best technologies for reducing fuel consumption.

Figure 7 shows a model of such a mixed duty cycle used to determine the benefit of fuel saving technologies for OTR trucks. It estimates about 75 percent of time spend at high speeds.

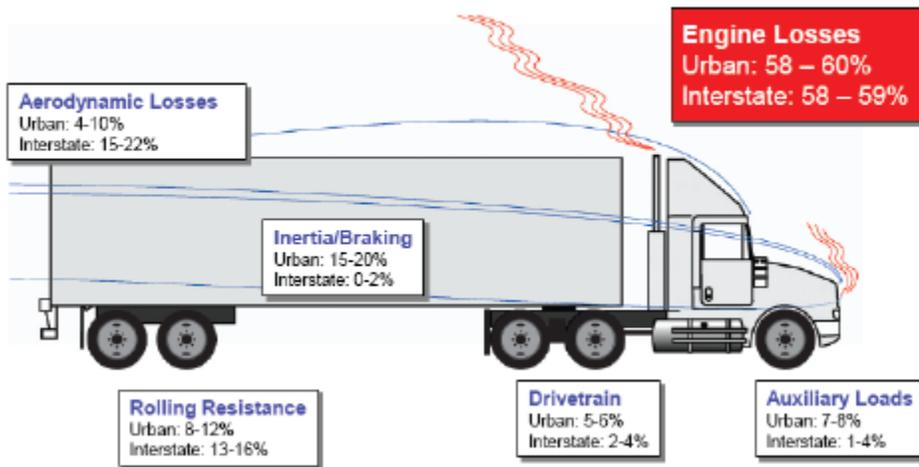
FIGURE 7: Tractor trailer Line-Haul Duty Cycle Model



As shown in Figure 7, an OTR tractor trailer is essentially a jack-of-all-trades. Unfortunately, it is a master of none. OTR tractor trailers are designed for maximum reliability in high-speed travel on interstates and must accommodate the needs of drivers who live and work in them 24 hours a day, with sleeper cabs and other amenities. As a result they are longer, heavier and geared differently than the trucks used for local hauling. But as average length of haul continues to decline, intermodal rail takes a larger share of long distance freight, and congestion levels increase, these trucks are increasingly operating in conditions for which they are ill-suited. At the same time they cannot maximize their efficiency for long-distance travel because of the conditions they must negotiate in urban areas—tight turns, frequent stops and starts, and interaction with a variety of other road users, which make the use of longer vehicles, aerodynamic designs, and other potential efficiency upgrades illegal, infeasible, or unsafe.

The simple breakdown of energy losses in Figure 8 (published in TRB 2010 p. 29), illustrates the critical relationship between duty cycle and fuel consumption for these trucks. For example, there are two key areas where fuel consumption can be quickly and cheaply reduced for trucks making long highway trips: aerodynamics and rolling resistance. For interstate operations, where trucks are traveling long distances on the open road, these represent 28 to 38 percent of all energy losses but for urban operations they represent only 12 to 22 percent of losses. While an investment of less than \$6000 in easily available aerodynamics and low-rolling resistance tires can reduce fuel consumption by more than 10 percent during interstate driving, the value of this reduction and the return on investment for these technologies is determined by the mix of interstate versus urban driving in a truck's duty cycle (TIAX 2008). Further, the best technologies for one environment may pose problems in the other. Fairings, for example, which close the gap between truck and trailer completely, may be damaged during tight turns required in urban areas or backing into docks (see figure 10).

FIGURE 8: Energy Losses from a Tractor trailer During Interstate and Urban Driving



On the other hand, in urban areas 15-20 percent of energy losses result from braking, while braking represents just 0-2 percent of losses in interstate operation. Braking represents not just an energy loss but also an opportunity to recapture energy through the use of electric or hydraulic hybrid systems that use braking force to charge batteries or high pressure tanks, which then propel the truck or power accessories. Hybrid systems for tractor trailers are expensive and return very little benefit during interstate driving. But in urban areas a hybrid system could yield significant fuel savings. A fully electric hybrid is estimated to result in 5.6 percent fuel savings for a typical OTR duty cycle, but a fuel savings of 41 percent in urban conditions with many stops.

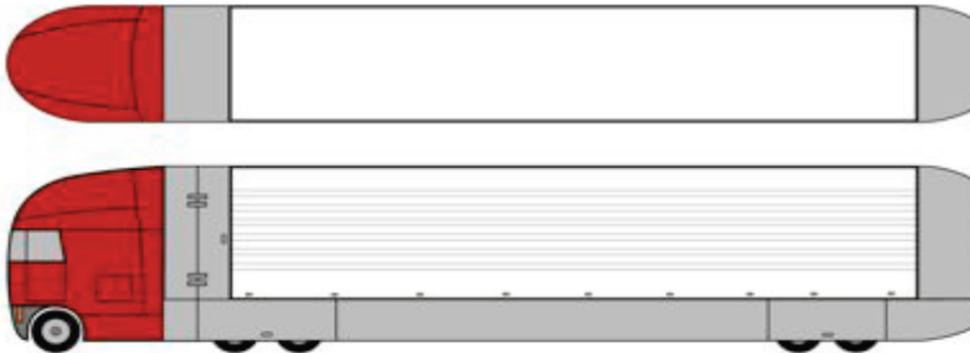
Currently, manufacturers and their customers must balance the needs of long stretches of rural highway driving with extended periods of urban driving. The result is that OTR trucks incorporate few of the technological solutions that would make them particularly well-suited to either duty cycle.

Splitting the duty cycle and utilizing trucks designed specifically for each segment could generate much greater efficiency than relying on one design to satisfy the demands of driving in both urban and rural areas. This is the same principle that makes intermodal transport, where containers travel the majority of their trip distance by rail before being transferred to truck for the last leg, so cost effective and fuel efficient. An urban truck port network would achieve efficiency gains in the same way, by facilitating the transfer of goods from trucks designed for rural transport to trucks designed for urban driving at the urban-rural fringe. Using different trucks and drivers for the urban delivery portion of the trip would also free drivers to travel into the city during less congested off-peak hours, by eliminating the need for drivers, who may already have driven most of their shift, to continue driving into urban areas during peak hours in order to complete their delivery before exceeding their hours-of-service (HOS) limit.

In addition to the changes mentioned above, the modern OTR tractor trailer could be further reconfigured to include: additional aerodynamic upgrades; more duty-appropriate engine size,

gearing, and axle ratios; different driver accommodations; and new fuel types. A truck designed for interstate travel might look like the one shown in Figure 8, a concept developed by the Rocky Mountain Institute (RMI). This design employs currently available or feasible technologies that minimize aerodynamic drag and rolling resistance. Because of its lower energy losses in these areas, it would require less horsepower and allow for the use of a lighter and more fuel efficient engine that would enable it to achieve a highway fuel economy of nearly 12 mpg compared to 6.5 mpg for a conventional tractor trailer. This fuel efficiency boost would save its owner \$30,000 per year, several times the likely cost of these upgrades.² Replacing 500,000 conventional OTR trucks with these more efficient models could reduce overall US diesel consumption by 10 percent. This tractor might also be configured with an auxiliary power unit to provide electrical power for driver needs, such as climate control, radio, and lights, eliminating the need to idle when the truck is not driving, and saving up to one gallon per hour of time spent stopped. The aerodynamic panels used to seal the gaps between the truck cab and trailer and between trailer wheels would significantly reduce drag but might present serious problems in an urban environments due to tight turns and backing requirements.

FIGURE 8: RMI's "Transformational Truck" Designed for Optimal Aerodynamic Drag Reduction



At an urban truck port, long haul drivers could swap their inbound trailers with local truck drivers' outbound loads. The design of local trucks could focus less on aerodynamic improvements and more on weight reduction, to reduce pavement damage and boost fuel economy; enhanced turning and visibility, for safety and maneuverability; and the reduction of harmful air emissions and noise. One way short haul trucks could dramatically reduce their emissions and noise would be to use non-conventional engines such as hybrid or fully alternative fuel engines, such as electric, hydrogen or natural gas, all of which are currently in use as prototypes for short-haul Class 8 tractors, but incapable of long-haul service. Short haul tractors might look something like those pictured in Figure 9. These prototypes, designed to reduce the

² This analysis also assume a slight increase in freight capacity that would be difficult to integrate into existing infrastructure. However, it does not include a number of modifications such as specialized gearing, etc.

emissions impacts of intermodal truck traffic on air quality, are currently working as drayage trucks at US ports. The truck on the left is fully electric and produces zero emissions. It can pull a 60,000-pound load 30 to 60 miles per charge. The truck on the right is a Class 8 zero-emission hydrogen fuel cell hybrid electric truck that can haul a similar load up to 400 miles.

FIGURE 9: Zero-Emissions Fully Electric and Hydrogen Fuel Cell Drayage Trucks



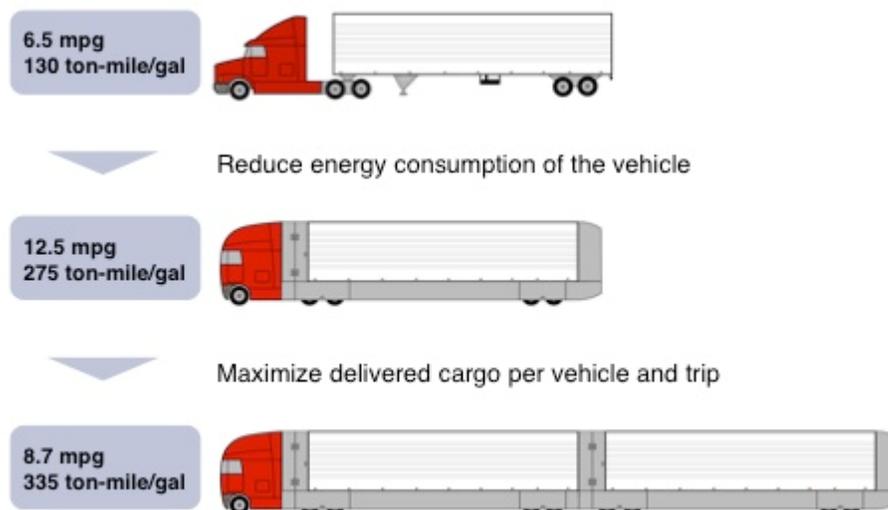
The Use of Long-Combination Vehicles

One of the greatest opportunities for gains in truck efficiency in interstate driving comes at the lowest cost. By combining tractors with more than one trailer to create long-combination vehicles (LCVs), carriers can use their hauling capacity much more efficiently. This is because the amount of cargo carried on roughly 80 percent of all OTR trips is limited by trailer volume of the trailer, which is known as “cubing out.” The remaining 20 percent of trips are limited by the total weight of the truck as regulated by state and federal law. Increasing the weight of trucks can be problematic because weight per axle is the key factor in how much damage a truck will do to roadways. Currently regulations limit the size and weight of trucks in most states to less than 80,000 pounds and no more than a 53 foot trailer without a special permit. Though local surface streets and bridges are most vulnerable to damage from heavier trucks, highway pavement also suffers from increased weight. Length, on the other hand, is primarily limited by road geometry. Rural interstate highways can be safely used by vehicles of much greater length than is currently allowed by regulations in most areas. In particular, the use of two 48- or 53-foot trailers or three trailers of shorter length would greatly reduce the fuel consumption of trucks for each unit of freight hauled per mile (or ton-mile). While a typical tractor hauling a 53-foot trailer has a fuel consumption rate of approximately 130 ton-miles per gallon, an aerodynamic turnpike double (tractor trailer hauling two 48’ trailers) has a fuel consumption rate of approximately 335 ton-miles per gallon. In other words, the aerodynamic turnpike double can perform 2.5 times as much work per gallon as a conventional truck. Because the weight on each axle is generally lower, these configurations often do less damage to roadways than conventional trucks. LCVs also have significantly better highway safety records than standard tractor trailers.

This configuration also eliminates the need for a second tractor and increases revenue per tractor substantially, providing much stronger justification for additional investments in fuel saving

technologies. In addition, in a UTPN system load patterns could become more regularized for carriers because LCVs would allow them to reduce the costs of working in areas with freight imbalances. For example, some metropolitan areas, like Chicago, are net load senders – far more shipments go out by truck than come in, while other cities, like Miami or New York are net load receivers. In both cases the imbalance of freight means that a number of trucks must regularly drive empty on their way into or out of these areas, sometimes for significant distances. LCVs could eliminate this wasteful practice by allowing carriers to haul doubles in one direction and singles in the other.

FIGURE 10: RMI Analysis of Efficiency Gains from Aerodynamic and LCV Trucks



Source: RMI Analysis, NPTC, 2008 Benchmarking Survey

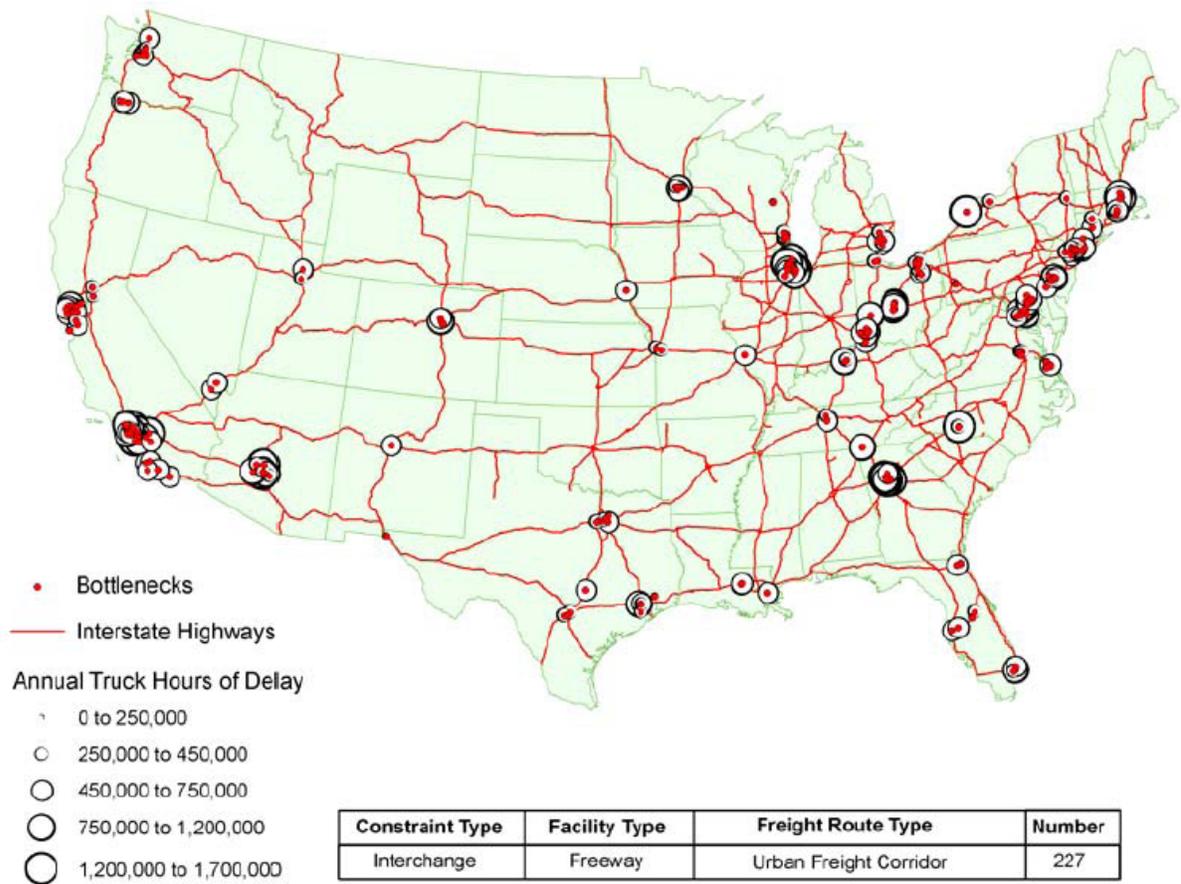
The problem is that roadway geometry limitations, such as tight corners, in urban areas make LCVs difficult or impossible to maneuver safely. Because longer vehicles require wider roadways to make turns these trucks simply could not exit interstates in many urban areas or use local roads to travel to final destinations. The UTPN would solve these problems by providing a network of strategically located spaces for LCVs to be assembled and disassembled. This sort of activity is strongly desired by trucking companies, who have long advocated for regulations to be changed to allow LCVs. The problem for these companies is that spaces to combine and breakdown these vehicles are scarce. OTR TL companies could not afford to build a sizable network of their own terminals that allow for such activities.

By providing space for firms to transition from one type of truck to another, the UTPN would allow for highly specialized vehicles best suited to the carriers' goals in each driving environment.

Congestion and Off-Peak Delivery: Creating a 24-hour Highway Freight System

Not only does the alternative of expanding highway and road capacity to solve congestion problems overlook the limited time-sensitive nature of congestion, it greatly exaggerates the need for rural highway lane-miles for trucks. Virtually every mile of rural highway, with the exception of steep grades, is free of any regularly recurring congestion. Widespread use of LCVs could substantially mitigate the effects of growing freight volumes in rural areas. FHWA analysis of freight traffic and bottleneck locations clearly demonstrates that congestion is a highly localized urban phenomenon. Increasing the capacity of rural corridors simply brings more trucks into the problem areas. Figure 11 illustrates the major freight bottlenecks in the US. Truck ports located outside of these bottlenecks would reduce traffic congestion by facilitating off-peak delivery and removing long-haul trucks from the traffic stream before they reach problem areas. In addition, truck ports could improve the functioning of bottlenecks throughout urban areas. Most large cities have numerous bottlenecks located on the same or connecting freeways. As a result, expansion projects focused on a single bottleneck may provide localized relief, but shifting truck travel to less congested hours across the network can improve bottlenecks throughout the area.

FIGURE 11: Locations of the Worst US Freight Bottlenecks



The concept of managing traffic flows by encouraging off-peak truck travel through incentives or discouraging peak-time travel through bans or tolling has been around for decades and has been used successfully in cities around the world. In Europe the concept is used in several cities and it has been successfully employed in at least two cases in the US. In 2010, New York City ran a pilot program promoting off-peak delivery in Manhattan that returned promising results. The program yielded significant economic savings for truckers and increased delivery speeds, receiving high marks from customers, trucking companies and drivers. The most successful US off-peak program has been the PierPass program at the Ports of LA and Long Beach, which encourages off-peak drayage movements of containers to reduce congestion and air pollution near the ports. This program provides discounted port fees to carriers making off-peak pick-ups and is used extensively by Walmart, Home Depot, Target, Mattel, Mitsubishi Corp, and others. Shippers cite increased productivity and faster deliveries as the main attractions. While the program initially aimed to divert 15 to 20 percent of trips from the port to off-peak shifts, by the end of its first year, it was diverting 30 to 35 percent of trips to off-peak periods, amounting to a total of 2.5 million truck trips diverted from peak period congestion in its first year (FHWA 2009).

Both of the US off-peak programs have demonstrated the desire and ability of trucking companies and their customers to alter driving schedules to accommodate off-peak delivery. Of course, these programs have been aimed at local trucks, which simply needed to shift their work schedule from day to night, and required little additional infrastructure. Off-peak pickup and delivery of OTR loads would be somewhat more complicated, but because the UTPN would alleviate the structural and regulatory issues that force truckers to operate in cities during the most congested times of day, it may prove to be even more popular and beneficial. Ensuring that staff is available to receive loads at delivery locations during off-peak hours can sometimes be challenging. However, greater reliability or lower freight costs would persuade many receivers to extend nighttime hours for receiving staff.

OTR drivers plan extensively to avoid congestion. However, they are constrained in their ability to schedule work around congestion by pick-up and delivery appointments and hours of service (HOS) regulations that govern how much and when they can work. For example, a driver hauling a load from Nashville to Chicago that has a pickup appointment in Nashville at 9:30 am may park outside the city at a truckstop close to the customer's location the previous night. He then begins work at 8:00 am, driving through Nashville's inbound rush hour spending an hour driving to and inside the shipper's facility. If loading and paperwork go smoothly, he may leave Nashville around noon. With 475 miles to cover between Nashville and Chicago, it will take him about 9 hours driving under optimal conditions. If he takes one break to stretch his legs and eat and one to fuel, for a total of one hour, he will reach the edge of Chicago around 10:00 pm after working for 14 hours, and is required by law stop driving. Mandated to take a 10 hour break before resuming driving, he cannot start driving again until 8:00 am the next morning. The driver, not wanting to waste time that could be spent driving, drives into Chicago with rush hour traffic. If his destination is in Chicago itself he will need to pass through 3 of the country's 25 worst bottlenecks, if it is on the City's west or north sides, he may pass through several more.

Another driver, departing at noon from the Louisville area might arrive in Chicago at 5:00 pm and face the choice of either forgoing several hours of work time and sitting in her truck or

driving through peak traffic and delivering her load. If she opts for the latter, her hourly wage will be poor but the next morning she will be able to pick up a new load and begin driving highway miles again, where she makes most of her money. Virtually every OTR driver would choose to drive through Chicago traffic rather than reduce her overall pay by spending much of the next day performing the largely unpaid work of delivering her load. Although the afternoon delivery will require a longer workday and will count against her hours-of-service limit, she will not record hours working in excess of the limit. But if the same driver had the option of pulling into a truck port, dropping her trailer, picking up a pre-loaded one, and getting back on the highway, she would avoid the unpaid work and could start her mandatory 10-hour break at 5:00 pm and be ready to drive again by 3:00 am.

By allowing long-haul drivers to transfer their loads to local drivers and pick up new ones without entering congested urban areas, truck ports would enable many loads to reach their destinations faster than they currently do while reducing the economic pressure that pushes drivers to exceed HOS limits. For example, a driver coming from Knoxville to Chicago could drop his trailer at a truck port, pick up a new load and quickly get back on the highway, wringing substantial earnings from his last remaining hours of legal service and making progress towards his next destination. The load he dropped off could be shuttled to its final destination by local drivers in the evening, after congestion has subsided.

There are already fleets of local drayage trucks in most cities that handle intermodal loads that could be enlisted to make these local deliveries during a second shift. These local deliveries would initially need to be subsidized, since OTR companies pay drivers by the mile, essentially getting their labor during pick-up and delivery for free. As congestion costs grow, however, the difference between driving through congestion and paying local drayage drivers will diminish.

Urban truck ports vs. urban highway capacity expansion – a real world comparison

The Dan Ryan Expressway on Chicago's South Side, which is just over 11 miles long, with 7 lanes each direction, carries an average of about 157,000 inbound trips every day. 31,350 of which are made by trucks. During the daily peak hour, between 8:00 am to 9:00 am, the highway carries 9 percent of all daily car traffic (11,300) and 6 percent of all daily truck traffic (1880). FHWA estimates that during periods of congestion each truck is equivalent to between 7 and 10 cars. Assuming each truck is equivalent to 7 cars, removing just over 700 trucks from the traffic mix during the peak hour—less than 40 percent of the trucks on the road—would free up space for 5,000 more cars, a 24-percent increase in capacity. That additional 24-percent of capacity is roughly equivalent to adding 1.75 lanes to the road. Based on a 2007 expansion project, which added a single lane in each direction at a cost of \$975 million, the cost of adding that capacity by expanding the roadway would approach \$2 billion. A network of truck ports that reduced peak period truck traffic on every major freight route entering the Chicago area during peak hours could add more highway capacity than even the most ambitious highway expansion program.

Driver Retention and Trucking's Labor Crisis

Drivers are forced to drive through congestion in order to make a living. Recent changes in HOS rules have increased the need to do so by instituting the requirement that drivers must not drive

after they have been on duty for 14 hours. This rule forces drivers to drive through congestion, bad weather, and times when they would prefer to rest. Drivers are limited to 11 hours of actual driving over those 14 hours and most don't exceed this regularly due to the tremendous time they spend waiting. A 1999 survey of truckers hauling dry vans found that the average wait time at each stop for a driver was 3 hours. Most drivers make one to two stops a day. On average a trucker hauling a dry van spends 35-40 on duty simply waiting to get his trailer loaded or unloaded. In order to make a salary of around \$35,000 a new driver will put in between 80 and 100 hours of work per week. Most drivers are content as long as they are able to drive 500-600 miles per day, but congestion and excessive load times mean that drivers are lucky to average 400 miles a day and drivers quickly become frustrated. If a driver makes several stops and experiences longer than average wait times, he may work 16 hours in a day, earning just \$3 or \$4 per hour. A UTPN could free drivers from much of this unpaid work.

A UPTN would also have several other benefits for drivers. First, it would give them the ability to upgrade their skills and be rewarded for safe and efficient driving by transitioning to drive LCVs at a higher pay rate. Retaining skilled drivers significantly increases fuel efficiency and improves safety. It could also improve driver satisfaction because, by reducing freight imbalances and reducing the time drivers spend performing non-driving tasks, companies could regularize drivers' routes, allowing them more time at home. In fact, a UPTN system could function similarly to the terminal systems of the 1970s, prior to deregulation, where drivers were home every night or every other night. Being out on the road for shorter periods might also facilitate the use of team drivers who can drive almost continuously, thus improving truck productivity.

A number of studies have suggested that the current system of unpredictable point-to-point dispatching that causes such problems for drivers is actually no more efficient or profitable than alternatives. Several studies conducted using historical freight tracking data from JB Hunt, one of the larger truckload carriers, suggest that modes of dispatching that kept drivers on regular routes were at least as good as point-to-point dispatching on key measures of efficiency while allowing drivers more time at home.

Additional Uses

Urban truck ports could accommodate a range of uses tailored to the specific needs of carriers or to foster new technologies. For instance, companies might use them to facilitate multiple drivers using the same truck, to increase per truck productivity and get drivers home more regularly.

Truck ports could also serve as hubs for the introduction of new technologies, such as alternative fuels. Currently, the industry is exploring the use of liquid natural gas (LNG) trucks. These trucks are relatively clean burning, get better fuel economy than conventional trucks, and could help to reduce GHG emissions. Their use in trucking has been jump-started, like that of a number of other technologies, by the Ports of Los Angeles and Long Beach. California is developing a fuel network to allow these trucks to travel several hundred miles. Using LNG as fuel for OTR trucks, however, presents an intractable chicken-and-egg problem. Fleets will not buy LNG trucks until they can fuel them everywhere they are likely to drive but LNG fueling stations are very expensive and no one will build them until there is sufficient demand. Truck ports could

serve as a distribution centers for these and other energy sources like hydrogen, compressed natural gas (CNG) or electricity. These alternative fuel distribution points could start by serving local trucks but would begin to establish the widespread fueling networks required by OTR trucks.

Finally, truck ports could be used to integrate other forms of traffic management. They might be used to weigh and inspect trucks, or for a variety of intelligent transportation systems. They could, for example, coordinate with traffic management centers to divert trucks off roads during traffic incidents and emergencies and provide them with a place to park.

How Much Would It Cost and Who would Pay for It?

Costs for building these ports will vary significantly, but pale in comparison to most congestion-related infrastructure projects. Assuming adequate exits and entrances all that might be needed would be a dirt lot with adequate storm water management and restrooms for drivers. Other driver services, including food and fuel, could be leased out to private companies. Since ports could be a significant distance from bottlenecks, even 10 miles or so, the siting could be quite flexible. Brownfields and under-utilized government or private lots might be appropriate sites. Such sites might be developed for just a few million dollars.

A subsidy for local hauling fleets would likely be needed to encourage use by private and for-hire OTR fleets because they typically pay drivers by the mile and do not pay for time spent loading and unloading. Local drivers would need to be paid by the hour or the number of trips they make during their shift.

Infrastructure and operating costs at truck ports could be paid for with revenues generated through tolling or an increase in state or federal fuel taxes.

Building the UTPN coalition

In general, the ideas of off-peak delivery, congestion relief, and fuel efficiency discussed here have all been proposed by existing stakeholders. This proposal's primary innovation is the focus on using the urban-rural transition to integrate these solutions. The stakeholders likely to favor the creation of a UTPN include:

1. Legislatures for required funding and regulatory changes (LCVs)
2. State and Federal agencies: DOT, DOE, EPA, etc.
3. Metropolitan planning boards
4. Large shippers and shipper associations;
5. Large carriers and carrier associations;
6. Third-party logistics providers;
7. Environmental, highway safety and health

Conclusion

It is increasingly clear that the trucking industry is no longer sustainable, economically or environmentally, in its current form. In the absence of more thoughtful measures, rising fuel

prices, crushing congestion, environmental impacts, poor employee satisfaction, and piecemeal government regulations aimed at solving these issues will render the industry increasingly unpredictable and reduce profits for both carriers and the shippers they serve. While government, think tanks, and the industry itself are developing solutions to some of these problems, fundamental issues, such as how to best organize the actual work of providing freight services remain largely unaddressed. Thus far public policy solutions have focused exclusively on the role of public investment in roads, regulating truck safety, and, more recently, fostering the development of new technologies to reduce fuel consumption and mitigate environmental impacts. The issue of how transportation services are organized is often cited as critical but has been viewed as the organic outcome of market forces, outside the purview of public sector involvement.

Prior to industry deregulation, government involvement was seen as fundamental to ensuring the health of the industry by regulating prices and market entrance. However, although regulation produced excellent results for regulated carriers and labor, it resulted in inefficient trucking services. There is a critical need for public sector involvement in shaping the way trucking services are provided. Not through direct regulation of freight markets as in the past, but through targeted infrastructure investment to develop a more sustainable, efficient, and cost effective trucking industry.

Creating a truly 21st century freight transportation system requires innovations in vehicle technology, infrastructure, and, most importantly, logistics. The urban truck port solution is one way to reorganize the truck freight system to meet the often competing goals of industry stakeholders and could provide an immediate and dramatic reduction in the industry's negative economic, environmental, and social impacts while serving as the foundation of a more fundamental transformation of the industry.