Mitigating the Social and Environmental Impacts of Multimodal Freight Corridor Operations at Southern California Ports

ABSTRACT

The San Pedro Bay Ports (SPBP) of Los Angeles and Long Beach in Southern California are one of the major container port complexes in the world: in 2004, for example, the SPBP processed over 36% of the U.S. container trade. However, the SPBP complex is also a major source of air pollution caused largely, on the land-side, by diesel locomotives and trucks that transport containers to and from the ports. The resulting annual health costs may exceed $2.5 billion. Low income and minority communities along the major Alameda corridor, a 20-mile railroad line that connects the SPBP to the transcontinental rail network east of downtown Los Angeles, are particular affected. This study will create a tool that will quantify links between SPBP freight traffic, air pollution, and the health of local communities. This tool will help evaluate the effectiveness of various alternatives (such as congestion pricing to decrease peak container traffic flows, biofuels for trucks and locomotives, or intermodal and route shifting of container traffic) in order to mitigate the environmental and health impacts of SPBP activities. Expected results include new insights into the spatial, socioeconomic, public health, and social justice consequences of alternative SPBP multimodal freight operations strategies.

PROBLEM STATEMENT

The importance of the contiguous Port of Los Angeles and Port of Long Beach in Southern California, also known as the San Pedro Bay Ports (SPBP), is difficult to overstate: in 2004, these two Ports processed 27% of all U.S. waterborne trade by value and over 36% of all U.S. container trade (Haveman et al, 2006). The SPBP also play a critical role in California's economy: a February 2007 trade impact study (http://www.portoflosangeles.org/News/news_032207acta2.pdf) released by the Alameda Corridor Transportation Authority (ACTA) found that over 886,000 jobs in California are related to international trade activities conducted through the SPBP, which also generated more than $6.7 billion in state and local tax revenue benefits. Container traffic at the ports has soared in recent years (+32.5% from 2000 to 2004), and it is expected to continue expanding rapidly into the next decade.

However, this growth and its associated economic benefits are threatened by increasing congestion and pollution. Indeed, the SPBP complex is a major source of air pollution, as highlighted by the draft Emission Reduction Plan for Ports and International Goods Movement in California published by the California Air Resources Board (2005). This document estimates that roughly one-third of all goods movement emissions statewide are generated in the Los Angeles region. Moreover, on a typical day, more than 400 tons of NO_x are emitted from port and goods movement activities in California, which represents 10% of the statewide NO_x inventory. Diesel particulate matter emissions are also a problem: according to the South Coast Air Quality Management District's MATES II study, they are responsible for 70% of excess lifetime cancer risk from toxic air pollutants in the region. The resulting health costs are substantial: Jon Haveman, Ph.D., an economist at the Public Policy Institute of California, estimated at a 2005 February conference in Long Beach that these costs exceed $2.5 billion a year.

Air pollution from the SPBP is caused by a number of sources on the ocean-side (ships), within the ports (heavy equipment used for moving containers), and on the land-side (due to heavy reliance on diesel locomotives and large diesel trucks to transport containers to and from the ports). In particular, the major freight corridor that provides access to the port (the Alameda Corridor), comprises a major rail-line (presently about 50 trains per day, with plans to increase to 100 trains per day) flanked by the I-110 and I-

710 freeways, which both carry thousands of trucks per day. These links connect the SPBP complex by rail and road to railyards, intermodal and other freight terminals near downtown Los Angeles some 22 miles away, as shown in Figures 1 & 2 (the average width of the corridor is approximately 9 miles).

Although the economic benefits of the SPBP are enjoyed by the whole country, the burden of the resulting air pollution is carried by the primarily low income communities located around the I-110 and I-710 freeways, and the Alameda corridor. Based on our growing knowledge of the health effects of toxic diesel-fueled vehicle emissions, these communities are at increased risk of respiratory problems, cancer and even death. While previous studies have indicated that these health effects may be relatively localized (within several hundred meters to sources), the width of the Alameda Corridor and the volume of freight movement suggests that the air quality and health impacts of freight operations in the corridor could be quite extensive.

In this context, this study seeks to create a tool that will shed light on the links between SPBP freight traffic, air pollution, and the health of local communities. This tool will help evaluate the effectiveness of various alternatives (such as congestion pricing, biofuels for trucks and locomotives, or intermodal and route shifting of container traffic) in order to mitigate the environmental and health impacts of port activities. Our interdisciplinary team combines expertise in engineering, planning, economics, and public health to inform public policy on a topic of great importance to California and to the country. Although we will be focusing on the SPBP, our methodology will be widely applicable.

RELEVANCE TO UCTC THEME

This research is closely related to the UCTC theme of Transportation Systems Analysis and Policy, and to the US DOT interest area of Congestion Chokepoints: our research addresses congestion mitigation issues with an aim to produce deployable results within one year (although several years may be needed for an in-depth analysis of multiple alternatives of interest) and to identify and ameliorate the factors that contribute to congestion of freight and passenger traffic for one of the largest port complexes and urban areas in the nation.

METHODOLOGY

Microscopic Simulation of the Alameda Corridor Rail and Freeway Network

We will use the PARAMICS microscopic simulation software (Quadstone, 2004) as our traffic modeling tool. A microscopic model is essential to simulate individual vehicle movements over small time periods and properly represent transient traffic characteristics (stop-start movements, lane-changing, accelerations, and weaving/merging behavior) because they very significantly affect emissions. By contrast, regional static planning models are notoriously weak for predicting congestion, because they rely on the fundamental assumption that low travel times occur under low flow levels, even though in reality the worst travel times and emissions occur under low-flow stop-and-go conditions.

PARAMICS is widely considered to be a state-of-the-art microscopic simulation tool; it is utilized by Caltrans, and its underlying models are well-documented and widely accepted. Another asset of PARAMICS is its Application Programming Interface (API), which allows users to easily customize features and to connect PARAMICS to other applications.

Our simulation work will not start from scratch. Professor Regan has already developed a Paramics model of the I-710 freeway for an earlier research project. Traffic demand inputs are based on the larger Southern California network and its corresponding static OD demands, based on periods from the 2000 Southern California Association of Governments (SCAG) traffic study. The methodology to prepare demand inputs is based on TransCAD. Figure 3 illustrates this model and the level of demands and truck counts simulated for the I-710. Calibration of the existing model is based on traffic data obtained from the Caltrans Freeway Performance Measurement System (PeMS). For this study, we will extend our existing PARAMICS model of the I-710 to build a network that will include the I-110 freeway, the I-105, SR-91, and I-405 freeways that cross both the I-110 and the I-710, the connector links near the SPBP, as well as the Alameda corridor and the connectors to the transcontinental rail yards near downtown Los Angeles (see Figure 1). The SR-60 and the I-5 freeways that connect the I-110 and I-710 form the northern edge of the network will also be partly modeled. The calibration of this model will follow guidelines proposed by Caltrans, taking into account that our goals are different from normal traffic operations studies (Chu et al, 2004) and the elaborate calibration tasks otherwise required.

Additionally, although not a primary capability of PARAMICS, rail lines will be modeled with fixed schedules and stops using the tractor and multiple-trailer capabilities of PARAMICS (e.g., see Abdulhai, et al., 2002, Cortes et al., 2005). Our rail simulations will have two purposes: 1) predicting locomotive emissions; and 2) modeling operations at truck-rail intermodal facilities using external APIs.

To generate emissions, we will use the PARAMICS API plug-in that calculates link-by-link traffic emissions using second-by-second speed, acceleration data and emission data for all vehicle types. We will also benefit from recent UCI research that correlates PARAMICS simulation results with link traffic characteristics and EMFAC2007, the California Air Resources Board's motor vehicle emission factor model (Nesamani et al., 2006). These emission predictions form the basis of our area-wide analyses detailed below. We will use APIs to handle train movements, in order to find the emission factors used for the EPA-recommended locomotive emission analysis described below.

Alternative Scenarios and Mitigation Strategies

We have formulated a preliminary list of strategies for corridor operations we wish to simulate, in order to investigate the potential mitigation of air quality impacts associated with landside SPBP operations. These strategies will be finalized during the project in consultation with SPBP authorities, as well as interested local officials and NGOs. After modeling current operations, we will explore how to deal with projected SPBP growth over the next decade (as a starting point). Our scenarios include:

- Congestion pricing and time-of-day shifts in container traffic. We will simulate the impact of further shifts in off-peak container traffic movement into and out of the ports due to changes in the SPBP PierPASS congestion pricing model (http://www.pierpass.org/)
- Intermodal shifts of container traffic, from truck to rail, and rail to truck, in the corridor
- Freeway route shifts of container truck traffic, between I-110 and I-710
- Use of biodiesel for trucks and locomotives, and electrification of the Alameda corridor.

Generating Emission Factors

To calculate emission factors from traffic on the I-110 and I-710 freeways, we will rely on EMFAC2007. This software calculates air pollution emission factors for many classes of vehicles (including passenger cars, trucks and buses) manufactured up to 40 years ago. It is based on improved data and it is more user-friendly than previous versions of EMFAC. EMFAC calculates the emission rates of HC, CO, NOx, PM, lead, SO2 and CO2 for each vehicle class within each calendar year, for twenty four hourly periods, for each month of the year, and for a variety of geographical areas. Its use is required in all new transportation conformity analyses in California.

For locomotives, we will rely on estimated average emission rates developed by the EPA (1997). Because of significant variability in in-use emission rates, we will develop scenarios for diesel locomotives based on low, medium, and high emission rates for NOx and PM.

In our scenarios, we will also take into account EPA's proposed three part program, which was made public in March 2007. Its goal is to cut PM emissions from locomotives by 90% and NOx emissions by 80% (http://www.epa.gov/OMSWWW/locomotv.htm). It will set new, Tier 3 exhaust emissions standards and idle reduction requirements for locomotives. If approved, it will start in 2009. Data about the characteristics of locomotives circulating in the Alameda corridor will be collected from the railroads and the Alameda Corridor Transportation Authority.

Modeling the Dispersion of Criteria Pollutants

To model the dispersion of pollutants, we will rely on CALRoads View from the Scientific Software Group (http://www.scientificsoftwaregroup.com/pages/software.php). CALRoads View is an integrated air dispersion modeling software package for predicting air quality impacts of pollutants near roadways. CALRoads View features three well-known mobile source dispersion models: CALINE4, CAL3QHC, and CAL3QHCR. CALINE4 predicts air concentrations of carbon monoxide (CO), Nitrogen Dioxide (NO_2), and suspended particles (PM) near roadways (UC Davis Air Quality Project, 1998). It is capable of handling intersections, parking lots, elevated or depressed freeways and canyons. These features will come in handy for modeling the dispersion of pollutants from diesel locomotives circulating along the Alameda corridor. CAL3QHC estimates total air pollutant concentrations (CO or PM) near highways from both moving and idling vehicles. CAL3QHCR is an enhanced version of CAL3QHCR. It can process up to a year of hourly meteorological data and vehicular emissions, traffic volume, and signalization (ETS) data for each hour of a week.

Assessing Health Impacts From Air Quality Data

We will use EPA's "Benefits Mapping and Analysis" software (BenMAP 2.3; Abt Associates, 2005) for estimating the health impacts of air quality and improvement attributable to various freight operations strategies in the corridor, including alternative fuels. BenMAP is a GIS-based program that uses a damage-function approach to estimate the health benefits of changes in air quality. It relies on local concentrations of air pollutants, population distribution, and well established health-response relationships (attributable-risk levels) to generate incidence estimates for health impacts such as mortality, heart attacks, and respiratory distress (asthma) (Davidson et al, 2007). BenMAP is the gold standard for these levels of assessment. Although a newer version of BenMAP was recently released (BenMAP 2.4.8, May, 2007), it covers national scale assessments. It is also not as easily customizable as BenMAP 2.3, which was developed for specialized applications including high resolution analyses at the urban- or metropolitan-level. BenMAP 2.3 will allow us to import our own spatial data (air quality, population, and baseline health) and specify many of the input parameters to match the types of demographic and health surveillance data collected in the study area.

Social Justice Issues

A key feature of this project is to understand who bears the costs of freight transport to and from the SPBP. The reasons for environmental inequality are complex and long-standing. For generations Los Angeles has been known as a place where one could go to achieve the American Dream. A major problem is, of course, historical legacy. The cities along the Alameda Corridor took the brunt of the restructuring of the 1970's and 80's, characterized by heavy losses of manufacturing jobs (between 1978 through 1982, more than 75,000 well-paying jobs were lost). Today, low–wage jobs have replaced many of the jobs that once provided a gateway to a middle-class life (Valle and Torres, 2000). Not surprisingly, the restructuring corresponded to a full-scale metamorphosis in this region, where the once white working class suburbs were transformed into majority Latino working class cities. In cities such as South Gate the Latino population leaped from 4 % of the population in 1969 to 46 % by 1980, and 83 % in 1990. Similar population changes occurred in Maywood, Lakewood Bellflower, and Bell.

To study these environmental justice issues, we will model the study area using GIS. We will combine socio-economic data from the 2000 census with results from our dispersion models and from our health impact assessment to quantitatively assess the characteristics of the populations bearing the brunt of air pollution from the freight activities related to the SPBP. This will also allow us to estimate the potential improvements that can be obtained under the different scenarios we will consider.

TASK DESCRIPTIONS

List of Tasks	Start Date	End Date
1. Assemble relevant data and code PARAMICS network	9/01/07	1/31/08
2. Select corridor strategies to be simulated	9/01/07	12/31/07
3. Run PARAMICS simulations	1/01/08	3/31/08
4. Assemble emission factors for road and rail traffic	9/01/07	11/30/08
5. Model the dispersion of criteria pollutants in the corridor	12/01/07	4/30/08
6. Assemble demographic data and public health impacts	9/01/07	7/31/08
7. Assess environmental justice implications for corridor population	3/01/08	8/31/08
8. Write final Summary report and academic papers	8/01/08	8/31/08

EXPECTED RESULTS AND PRODUCTS

The expected results include new insights into the spatial, socioeconomic and public health air quality impacts, and thus social justice consequences, of alternative SPBP freight operations strategies in the Alameda corridor. This will allow us to rank such strategies in terms of these criteria for use in decision-making and selecting the best option(s), or combinations thereof. The resulting tool and insights we develop will be useful for ongoing policy analyses pertaining to this corridor, and could be adapted and/or expanded for analysis of other corridors and strategies. The deliverables for the project also include Progress Reports and a Final Summary Report that will present the overall findings of the research, as well as algorithms and software developed with project funding.

KEY REFERENCES

Abdulhai, B., Shalaby, A.S. and Georgi, A. (2002) "Microsimulation Modelling and Impact Assessment of Streetcar Transit Priority Options: The Toronto Experience". Proc. 81st TRB Annual Meeting. *Transportation Research Board*. Washington D. C.

Abt Associates, Inc. (2005) "BenMAP Environmental Benefits Mapping and Analysis Program." Prepared for Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC (see also http://www.epa.gov/ttn/ecas/benmodels.html)

California Air Resources Board (2005). State Goods Movement Action Plan, Phase I, California Emission Inventory Development and Reporting System (CEIDARS) September.

Chu, L., Lu, H. L., OH, J.S., and Recker, W. W. (2004) "A Calibration Procedure for Micoprscopic Traffic Simulation". Paper 04-4165, Proc. 83rd TRB Annual Meeting. Washington D. C.

Cortes.C., Pages, L., and Jayakrishnan, R. (2005) "Microsimulation of Flexible Transit Systems in Realistic Urban Networks". *Transportation Research Record*, Vol. 1923, pp. 153-163.

Davidson, K., A. Hallberg, D. McCubbin, and B. Hubbell (2007) "Analysis of $PM_{2.5}$ using the environmental benefits mapping and analysis program (BenMAP)." Journal of Toxicology and Environmental Health, Part A. **70**:332-346.

Desert Research Institute (2005) Environmental Justice Saturation Monitoring of Selected Pollutants in Wilmington. Report prepared Prepared for: State of California Air Resources Board.

Haveman, J. D., Jennings, E.M., and Shatz, H.J. (2006) California and the Global Economy: Recent Facts and Figures, 2006 Edition, PPIC Occasional papers, Prepared for the California Trade Education Center for Presentation at the California Council for International Trade's 8th Annual California Trade Policy Forum, San Diego, California.

Houston, D., Krudysz, Margaret, and Winer, Arthur (2006) "Direct Measurements of Diesel Truck Traffic Associated with Goods Movement at Southern California Ports." Presented at the 11th World Conference on Transportation Research (WCTRS 2007).

Nesamani, K.S., Chu, L., McNally, M. G., Jayakrishnan, R (2007) "Estimation of vehicular emissions by capturing traffic variations" Atmospheric Environment, Vol. 41, #13, pp. 2996-3008.

Quadstone Limited (2004) *Quadstone Paramics V5.1 Monitor User Guide*.

U.C. Davis Air Quality Project (1998) "USER'S GUIDE FOR CL4: A USER-FRIENDLY INTERFACE FOR THE CALINE 4 MODEL FOR TRANSPORTATION PROJECT IMPACT ASSESSMENTS." Prepared for Caltrans, Sacramento, CA.

USEPA (1997) Emission Factors for Locomotives – Technical Highlights. Available at: http://www.epa.gov/otaq/regs/nonroad/locomotv/frm/42097051.pdf.

Valle, V. M., and R. D. Torres (2000) Latino Metropolis, the University of Minnesota Press.

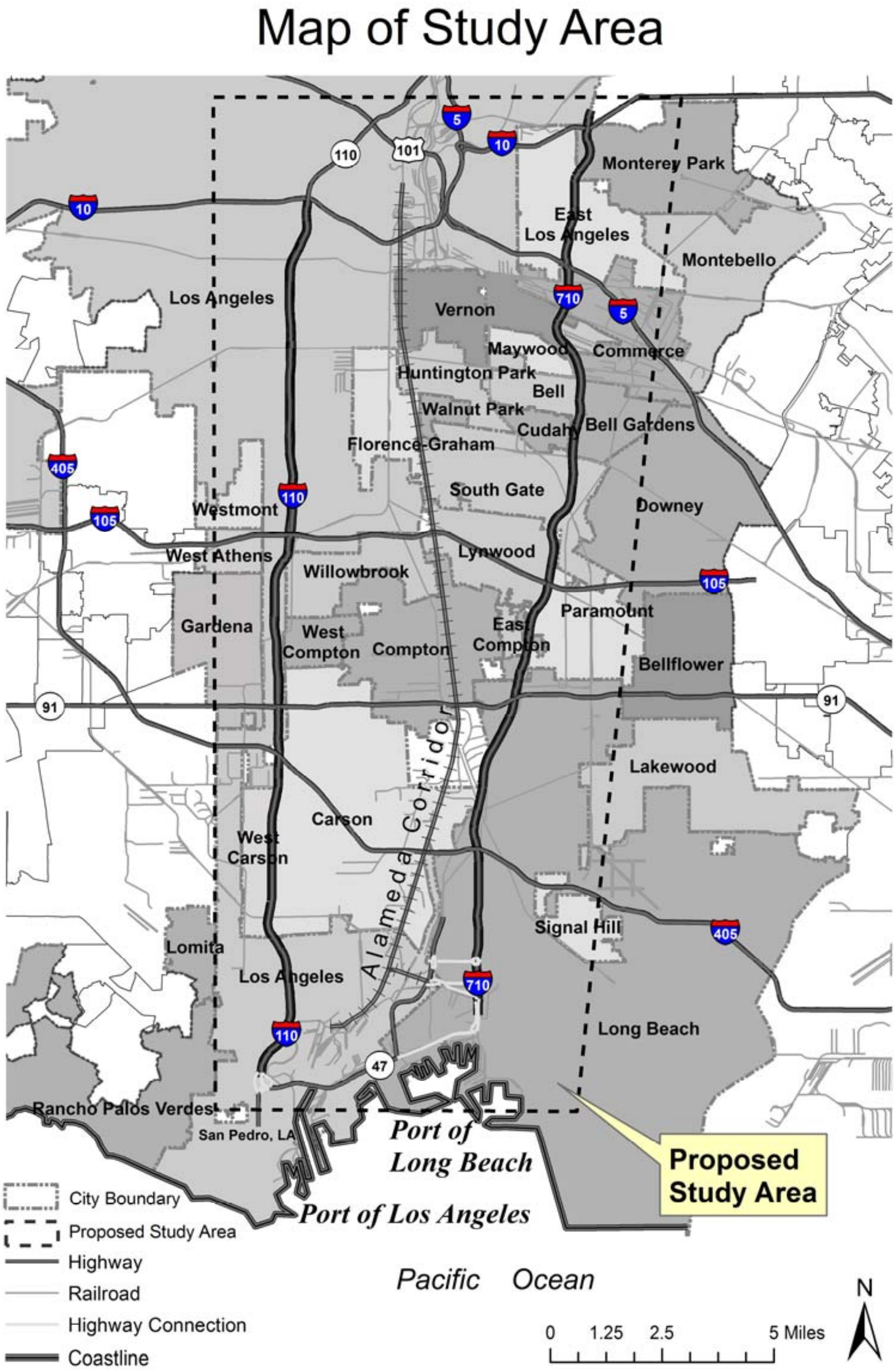
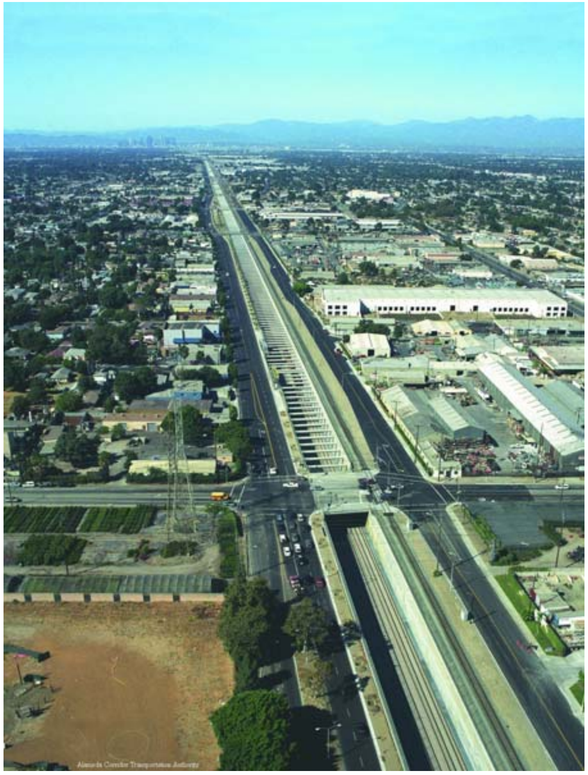


Figure 1. Map of Alameda Corridor Study Area



(a) Alameda Corridor Rail-line (source: ASCE)

(b) I-710 Freeway approaching the ports

Figure 2. Overviews of Study Area Sections

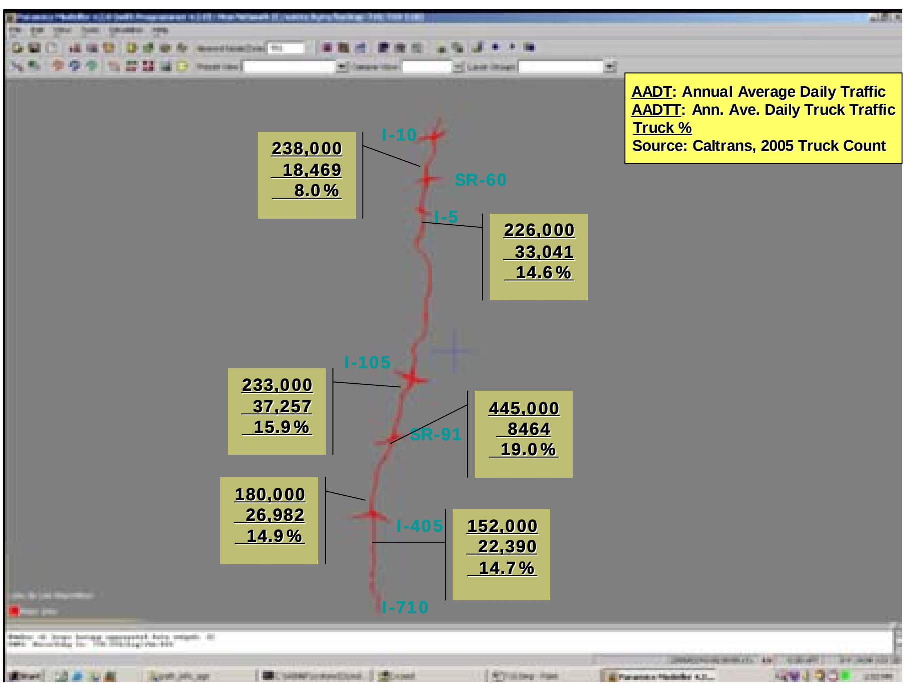


Figure 3. PARAMICS I-710 network and truck counts based on 2005 data.