EXHIBIT L

TRAFFIC FATALITIES AND INJURIES: ARE REDUCTIONS THE RESULT OF 'IMPROVEMENTS' IN HIGHWAY DESIGN STANDARDS?

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Abstract

A cross-sectional time series database of U.S. data on fatalities and injuries is analysed using a fixed effects negative binomial regression. Data from 50 states over 14 years is used to examine the effect of various highway improvements on both fatalities and injuries. These include the total lane miles of capacity, total average number of lanes by functional road category (interstates, arterials, and collectors), lane widths and the relative balance of the various road categories within each state. Results strongly refute the hypothesis that engineering design improvements have been beneficial for reducing total fatalities and injuries. While controlling for other effects it is found that demographic changes in age cohorts, increased seatbelt use, and increases in medical technology have accounted for a large share of overall reductions in fatalities. These results have major implications for the cost benefit analysis of highway projects and for new Federal planning regulations that require safety to be considered as a planning factor.

Introduction

The upgrading of road infrastructure has normally been seen as a technique for reducing fatalities and injuries associated with traffic crashes. Historical trends would tend to support this viewpoint as fatalities per mile travelled have declined substantially over the last 30-40 years in the U.S. This has coincided with the construction of the Interstate highway system and changes in engineering standards that have resulted in roads that generally have fewer curves, fewer roadside hazards, and both wider travel lanes and more travel lanes.

Conventional traffic engineering would not question the assumption that "safer" and newer roads reduce fatalities. However, this type of approach tends to ignore behavioral reactions to safety improvements that may off-set fatality reduction goals. For example, if a two lane road is expanded to four lanes, then many drivers will travel at higher speeds, potentially leading to no gains in safety. Of course, increased speeds allow increased mobility benefits even if the costs associated with crashes are not reduced.

Micro-scale analysis of specific safety improvements may show that various crash types can be reduced by road improvements. This type of analysis will not, however, show what the system-wide effects[1] on total fatalities and injuries may be, nor will it necessarily control for other effects and changes that occur simultaneously, such as demographic changes or increased seatbelt usage. This paper analyzes aggregate state-wide data on fatalities and injuries to determine whether road infrastructure has been beneficial in reducing fatalities and injuries. Several variables are used to define road infrastructure. These are total lane miles, the number of lanes

[1] System-wide effects are defined to include interactions between the road infrastructure, the vehicle, and the behavior of the driver.

for alternative road classes, the lane widths for alternative road classes, and the fractional percent of each road class within a given state. Changes in horizontal curvature, shoulder widths, the separation of lanes with medians, and the presence of roadside hazards, are not examined. However, one would expect new lane miles constructed over time to have fewer of these characteristics than older infrastructure. Thus the lane mile variable serves as a proxy to represent these "improvements" in road design. Cross-sectional time-series data is used in a fixed effects negative binomial regression analysis to analyze the impact of these infrastructure variables. This technique controls for unmeasured variables that may also be affecting the dependent variable.

The underlying engineering hypothesis is that road infrastructure "improvements" will reduce both fatalities and injuries. However, it is not found that this hypothesis can be supported. Results actually tend to suggest the counter-intuitive hypothesis that these type of road "safety improvements" actually lead to statistically significant, though small, increases in total fatalities and injuries, all else equal. This result has also been suggested by other recent research using aggregate safety data, which is reviewed in the next section.

Having found this counter-intuitive result other factors that may have led to the observed decreases in total traffic-related fatalities are analyzed. Changes in demographics, measured by changes in age cohorts are found to have the largest effect, primarily fewer young people and more elderly people. Improvements in medical technology, measured using a proxy of white infant mortality rates is found to also be highly significant. Increased seatbelt usage also has had a major effect on reducing fatalities.

The paper is organized as follows. A brief review of relevant literature on behavioral aspects of safety and some previous empirical analysis that supports the counter-intuitive hypothesis is presented. Trends in the data are then examined. This is followed by the estimation of several models and a discussion of the results. Conclusions and implications for transport and safety policy are then discussed.

Literature Review and Theoretical Background

Much of the research in highway safety and the relationship to infrastructure has focussed on specific design elements and attempts to quantify their accident reduction potential (Transportation Research Board, 1987; McGee et al, 1995). Much of this previous research has focussed on calculating "accident reduction factors" associated with "improvements" in specific design elements. The Transportation Research Board (1987) evaluated much of the existing literature and modelling efforts to develop accident reduction factors. Various gaps in knowledge were identified but the report generally concluded that new and better design standards were leading to safety improvements.

The National Cooperative Highway Research Program (McGee et al., 1995) attempted to fill some of the identified gaps in knowledge and produced a number of new modelling results. All these models, however, do not control for other effects and do not consider system-wide impacts. Many also fail to distinguish between the severity of different crash types which is crucial information needed for cost benefit analysis.

Vogt and Bared (1998) evaluate changes in design parameters for two lane rural roads using data from the Highway Safety Information System. Using a population of highway segments for two states (Washington and Minnesota) they derive detailed statistical models linking design elements to both total crashes and more serious crashes involving a fatality or injury (however, not disaggregating between these two). The results of their modelling support the conventional engineering hypothesis. For example, they find that increasing lane widths and less horizontal curvature reduces total crashes. While using time-series data they do not appear to control for time in their model, nor other factors that may change over time.

They acknowledge the limitations of their model and that various key variables may be omitted. The lack of controlling for time series effects, as well as cross-sectional effects, is likely to bias the results of this study.

In an analysis of system-wide safety effects, Boyle and Wright (1984) hypothesized that safety treatments of accident 'blackspots' may result in increased accidents at other locations. They analyze data for London that suggests some increase in accidents, though a total reduction still appears to occur. They speculate that this effect may be due to drivers encountering fewer 'near miss' situations within the previous blackspot location. This could result in a reduction in cautionary behavior and consequently an increase in accidents in locations near the previous blackspot that would not be measured in a traditional safety study. This type of behavioral reaction implies that drivers now perceive their risk level to be less than it was previously. Most studies of specific behavioral treatments fail to catch the system-wide effects such as those studied by Boyle and Wright (1984).

More recently, aggregate data analysis has allowed other factors in addition to infrastructure related factors to be analysed. Fridstrom & Ingebrigsten (1991) estimate a model using monthly data on traffic accidents for 18 counties in Norway. They find that extensions and improvements to the national road network do not have the expected effect of improving safety. They also find that more congested roads leads to fewer casualties. This study controlled for many different causal factors that also contribute to crashes. Karlaftis & Tarko (1998) analyze county level data from the state of Indiana and find that increased road mileage leads to increased accidents. Both these studies use aggregate cross-sectional time-series data and a negative binomial regression as is done in the analysis presented here.

Milton & Mannering (1998) find similar results using data from the State of Washington. While they find that average annual daily traffic leads to an increase in accidents, they also find that when the percent of this traffic at the peak increases, then accidents decrease (i.e., congestion leads to reduced accidents).

Milton & Mannering (1998) also examine various geometric design elements. They find that increasing the number of lanes on a given road segment, leads to more accidents and that in Eastern Washington, narrower "substandard" lane widths (of less than 3.5 metres or 11.5 ft) reduce accident frequency. They also found that horizontal curvature does not by itself increase accidents but was dependent upon whether large straight sections preceded the curves. While this latter result supports the hypothesis that reducing horizontal curvature reduces accidents, it does suggest that roads with extensive curvature may not necessarily be less safe than straighter roads. Milton & Mannering (1998) do not control for any time series or demographic effects in their study.

Shankar et al. (1995) estimated a series of negative binomial regression models in a study of the Interstate 91 corridor in Washington state. They found that when curves are spaced further apart (i.e., fewer curves per mile) more severe overturn accidents increase. This same study also found that highway segments that have curves with lower design speeds result in fewer accidents relative to those with higher design speeds; though the presence of snowfall tended to increase accidents on those segments with curves of lower design speeds. Shankar et al. (1995) found that those accidents attributable to curves of lower design speeds tended to be less severe than those associated with curves of higher design speeds.

Abdel-Aty & Radwan (2000) found that 'improvements' in geometric design variables reduce accidents. These included the degree of horizontal curvature and shoulder, lane and median widths. They estimated a negative binomial regression model with road segment data from an arterial highway in Florida. One problem with this study (other than the lack of control for time and demographic effects) is that it does not control for repeated observations (that is, multiple sampling of accidents from each segment). Shankar et al. (1995) do control for this by including section-specific constants in their models. This could perhaps account for the very different results shown by these two studies.

Ivan et al. (2000) using data from Connecticut found that link segments with larger shoulder widths have more single-vehicle crashes, but do not explore this result in detail.

Council & Stewart (1999) analysed the safety effects of converting two lane rural roads to either four lane divided roads or four lane undivided roads. They found some significant reduction in accidents for the conversion to divided roads but less significant results for undivided roads. They consider their research preliminary and inconclusive; however, it does suggest that while specific improvements such as separating lanes (or installing medians) may be relatively effective, merely adding more lanes is not. Hadi et al. (1995) analysed specific road improvements such as increasing shoulder and lane widths and found some effectiveness for these treatments. A study by Porter & England (2000) found that red-light running was more likely at intersections with more lanes, this could imply that the likelihood of a crash at these intersections may be greater.

Increased congestion levels have often been assumed to lead to increased risk for drivers. This would imply that infrastructure changes or capacity increases that reduce congestion and increase flow would lead to reductions in risk. For example, wider lanes are acknowledged to lead to increases in vehicle speeds and hence are effectively adding capacity (Transportation Research Board, 1987). Zhou & Sisiopiku (1997) analyze a specific highway link in Michigan and find that the relationship between the volume/capacity ratio and accidents follows a U-shaped curve; initially as the ratio increases, accidents decrease, then turn up again at higher congestion levels. More importantly, fatal accidents were found to decrease consistently with higher congestion levels. This is not a surprising result since speeds will be lower under congested conditions. One would expect more minor vehicle interactions (i.e., fender benders) under congested conditions, but fewer fatalities. Ivan et al. (2000) in a study of link-segments in Connecticut found that single-vehicle crash rates are highest when volume-capacity ratios are low, but found no significance for multi-vehicle crashes.

Shefer & Rietveld (1997) argue that the benefits of congestion reduction must be off-set by higher accident costs. They present some empirical data to support their hypothesis, but do not control for other factors. Currently, most justifications for highway projects assume lower accident costs with decreasing congestion.

Theoretically, the results of these studies are not surprising despite the absence of these type of considerations in risk reduction strategies and cost benefit analysis. To a large extent the idea that both increased capacity and infrastructure improvements may lead to increased risk is not inconsistent with the theory of risk compensation as formulated by Peltzman (1975). This theory states that reductions in the risk of driving will be off-set by changes in driver behavior. Peltzman analysed the impact of automobile safety regulations in the U.S. and concluded that they were virtually ineffective at decreasing fatalities. As postulated by Peltzman, "driving intensity" increases in response to safer vehicles – or alternatively, drivers take additional risks knowing that their vehicles are safer and therefore the severity of a crash, should it occur, is reduced. An alternative formulation would be that "safer" roads result in increased mobility as well as faster speeds and less attentive driving, resulting in less than expected reductions in risk.

Peltzman's hypothesis and methodology has undergone extensive debate in the safety literature. Evans (1986), Graham and Garber (1984), Joksch (1976a, b) and Robertson (1977a, b; 1981) all conducted similar studies that tended to refute the risk compensation hypothesis, generally by specifying different functional forms for the estimated model. Other research, using different data and techniques has tended to support the hypothesis, including Zlatoper (1984), McCarthy (1986), Conybeare (1980), Singh and Thayer (1992) and Traynor (1993). In addition, Wilde (1982) specified a similar theory of risk homeostasis based upon the literature in behavioral psychology.

If one considers risk compensation from an economic perspective one can consider drivers as consumers of a bundle of goods, one of which is safety. Peltzman assumed that increased consumption of safety led to increased risk taking. However, it is more plausible that drivers also consume increased mobility – that is, increased driving and longer distance driving. This increase in exposure results in increased risk taking similar to Peltzman's hypothesis that the "driving intensity" of individuals increases.

Figure 1 illustrates potential behavioral effects graphically. If one assumes that individuals (and society) decide upon explicit trade-offs between risk and mobility then the isoquant shown in the figure illustrates this choice for a given level of technology. The technology represents safety devices in vehicles (e.g. air bags) and the existing road infrastructure. Movement along a given isoquant represents the trade-off that an individual makes in selecting a given bundle of safety and mobility.

The more safety one desires, the less mobility one will have and vice-versa. Point A represents a given consumers choice where the demand curve is tangent to the isoquant of production. If it is now possible to provide more mobility at the same level of safety, for example through some technological improvement such as construction of the interstate highway system or larger lane widths, then the isoquant shifts outward. The new choice along the curve will depend, however, on the shape of the demand curves. As can be seen in the graph, if point B is chosen, then one achieves both safety and mobility improvements. Point C, however, while providing greater mobility improvements actually results in a reduction in safety (the alternative, not shown, is also possible which would be less mobility and more safety). This graph could also be extended into a third dimension which would represent Peltzman's "driving intensity," one component of which might be more aggressive driving, such as increased tail-gating, which would be a complement to increased mobility.

The models estimated in this paper do not analyze the full spectrum of infrastructure "improvements" hypothesized to improve safety. Four explicit variables are analysed, the increase in total lane miles, changes in average number of lanes by functional category, changes in lane widths, and increases in the fraction of total lanes for each functional road type. Capturing the interactions between road categories is important. Chu (1999) shows how shifts to interstates may have resulted in significant reductions in fatalities, though the increase in capacity may have generated significantly more travel (Noland, 2001).

No literature appears to have analysed the impact of medical technology improvements on fatalities and injuries. Lave (1985) used hospitals per square mile to attempt to account for access to medical services (in the event of a crash). This would serve to control for rural areas being less accessible to fast medical care for emergencies. He found this variable to be significant, though his analysis suffers from not controlling for either cross-sectional or time-series effects.

The model developed below uses white infant mortality rates as a proxy for medical technology. This does not appear to have been studied within the safety literature. However, there is a strand of literature that hypothesized that high aggression levels in society lead to increased traffic fatalities. To examine this hypothesis Sivak (1983) correlated homicide rates and fatality rates from other accidents with vehicle fatality rates. This was done using one year of data at the state level, thus it does not control for either cross-sectional or time-series effects. Nevertheless, Sivak (1983) found a correlation between homicide fatality rates and traffic fatality rates. He also found a correlation with fatality rates from other accidents. It is possible that these correlations are merely driven by underlying differences in medical technology between states.

It is clear from a review of the relevant safety literature that most analyses have not controlled for time-series and cross-sectional effects. The two exceptions are Fridstrom & Ingebrigsten (1991) and Karlaftis & Tarko (1998) who found results that question whether new infrastructure (represented by new lane miles) leads to reduced fatalities. Yet many of the other studies, such as Milton & Mannering (1998) have results suggesting that conventional engineering wisdom may be suspect. The large literature on risk compensation also suggests counter-intuitive results but has not focussed on road design variables. In general, none of these studies have highlighted their unexpected results, but taken as a whole, certainly suggest that conventional hypotheses that road "improvements" improve safety should be reevaluated. The analyses presented below evaluates these issues, but first the next section discusses the data used, various trends in the data, and the estimation methodology used.

Data, Trends, and Methodology

To analyze the relationship between road infrastructure and safety a cross-sectional time-series data base was collected for all 50 U.S. states over 14 years (from 1984 to 1997). This data was collected from the Federal Highway Administration (FHWA) Highway Statistics series (see, for example, US DOT, 1998). Total fatalities and total injuries by state was collected. The fatality data was available for every state over the 14 years (for a total of 700 observations). The injury data had some omissions for some states and years giving a total of 657 observations. Figure 2 shows trends in total US traffic fatalities and injuries between 1967 and 1995. Total fatalities have generally been decreasing over this time period while total injuries have shown an upward trend. If measured per vehicle miles of travel (VMT), both fatalities and injuries have decreased significantly over time.

Data on road infrastructure included total lane miles (excluding local roads), average number of lanes by functional road category (interstates, arterials, and collectors), percent of center-line miles with a given lane width by road category, and the fractional percent of each road category in a given state (including local roads within the denominator). Interstates are controlled access highways built to the most rigorous and consistent design standards. Arterials are generally major multi-lane or intercity roads, perhaps with some controlled access, but generally not. These also tend to be major connector roads within cities and suburban areas. Collector roads are smaller scale roads that generally connect local distributor roads with arterials.

Trends in each of these variables, for the entire US, between 1985 and 1996, are described in Table 1. In general, these show that policies aimed at upgrading the design of road infrastructure have been very effective. We see that total lane miles (excluding local roads) have grown marginally over this time period. The average number of lanes on interstates and arterials has grown slightly while there has been a small decrease in the average number of lanes on collectors. In general, there are more lane miles of higher functional classification, with the percent of interstate lane miles growing by 5.75% and the percent of arterial lane miles growing by 8.73%. This has been at the expense of the percent of collector lane miles which have shrunk by 3.26%. The changes in arterial and collector lane widths have been most dramatic. The percent of arterials with lane widths of 9 ft or less has shrunk by 48.59% while arterials with lane widths of 12 ft or greater have increased by 10.33%. Some 67% of arterials already had 12 ft or greater lane widths in 1985 and this fraction increased to 74% by 1995. A similar trend is apparent for collector road lane widths, with a move towards more roads with wider 11 or 12 ft lanes and fewer with 9 ft or 10 ft lanes. Obviously, a casual interpretation of these trends and those for total fatalities would suggest that as we have upgraded highway facilities, we have reduced fatalities.

In addition, estimates of seatbelt usage, by state, were used to control for the effects of increased seatbelt use. This data was only available since 1990. The analyses also attempts to control for seatbelt effects by including dummy variables for those states with either primary or secondary seatbelt laws (described further below).

Data on total population, VMT, per capita income, alcohol consumption and population by age cohorts was also collected. These are used in the models discussed below primarily to control for other factors that are likely to affect fatalities and injuries.

The occurrence of traffic crashes and the resulting injuries and fatalities are poisson distributed. Ordinary least squares regression is inappropriate for count data since it is not normally distributed. In addition, count data is inherently non-negative. The use of a poisson regression will, however, suffer from over-dispersion in the error term due to the inequality of the mean and variance within the data. This is easily corrected by using a negative binomial regression (Karlaftis & Tarko, 1998).

The use of cross-sectional time-series data in this analysis introduces the problem of heterogeneity in the data. These are unobserved factors that might be associated with a given cross-section (or state in the data used here) or time period. Not accounting for heterogeneity can lead to biased coefficient estimates. A technique to account for this was developed by Hausman et al. (1984) and has been described as a negative binomial fixed effects model. The Stata software package (Stata Corp., 1999) provides a procedure for implementing this estimation method which is used in the analysis below.

The model can be written as,

$$\ln \lambda_{it} = k_i + b'x_{it}, \qquad i = 1,\ldots N, \qquad t = 1,\ldots T_i$$

The parameter k_i is a vector representing the effect of excluded variables for each cross-sectional unit; N represents the number of cross-sectional units, and T_i is the time period. The vector of parameters to be estimated is b while x_{it} is the matrix of independent variables. Hausman et al. (1984) provide further details on the model used. The independent variables are further specified logarithmically in the models that follow.

Lave (1989) criticizes the use of aggregate data in accident analysis. He compares results using statewide data for all highway types with data disaggregated by highway type and shows different results on key policy variables. His analysis, however, uses a one-year cross-section of data and hence cannot adequately control for the many other factors that may influence the model. Likewise, Loeb (1987) uses aggregate data with various socio-economic variables to analyze fatality rates. While showing several formulations that suggest robust results, the use of a one-year cross-section cannot control for heterogeneity in the data for the various states.[2] Fridstrom and Ingebrigsten (1991) point out that the key advantage of using aggregate data is that it can capture effects such as blackspot migration which could be potentially lost using disaggregate data (Boyle & Wright, 1984). Despite this, the studies of Loeb (1987) and other work criticized by Lave (1989) are probably not deficient for the use of aggregate data, but rather for the use of indadequate statistical techniques that do not account for heterogeneity and effects unmeasurable to the analyst as causal factors.

Modelling Results

A number of different models were estimated using the data described previously. The key variables of interest are the infrastructure variables. Other variables known to effect crashes are also included, specifically age cohorts, per capita income, state population, and VMT. VMT and population can not be included in the same model due to being highly collinear. Separate models for each are therefore estimated.

Table 2 has results for models estimated controlling for state population while Table 3 has similar models but with vehicle miles of travel (VMT) substituted for population. The results are quite robust across both model specifications. The discussion that follows focuses on Table 2 for brevity, but could equally apply to the results in Table 3. The dependent variables are indicated on the top row of each column; these are the total deaths (DEATHS) and total injuries (INJURED) from traffic-related crashes.

[2] Loeb (1987) identifies three policy variables that may affect fatality rates. These are statewide beer consumption, whether or not the state has a vehicle inspection program, and speed. Interestingly, he finds that highway miles are not significant.

Models A and B contain all the relevant infrastructure variables. In models C and D, the lane width variables are dropped to test the robustness of the model without these variables. Models E and F include ethanol consumption as an independent variable while dropping population due to the high correlation between these two variables (and likewise with VMT). Models G and H, which we discuss further below, contain seatbelt usage as an independent variable and are estimated only for the years 1990-1997.

Total lane miles are found to be highly significant across models A – F for both total fatalities and injuries.[3] The coefficient values are relatively robust, though in models E and F the lane mile coefficient is reduced in value. This is due to a relatively high and coincidental correlation between lane miles and ethanol consumption. Model G, based on a smaller data set, does not give a significant result on the lane mile variable.

No significant effect is found for increases in the average amount of interstate lanes on fatalities. This is an important result that refutes the assumption that more lanes necessarily reduces fatalities. Of more importance, adding interstate lanes is found to increase total injuries. Model G shows this variable to be significant with respect to total fatalities over the shorter time span of 1990-1997. It is unclear why this result occurs.

Increases in the average number of arterial lanes is found to be significant in increasing total fatalities and total injuries while increases in the average number of collector lanes does not affect injuries but results in increased fatalities. It appears that having large arterials and collectors with multiple lanes increases fatalities while this does not happen for interstates. This may be due to cross-traffic, turning movements, and other roadside distractions that would not be present on an interstate. However, multiple lane interstates clearly have safety problems that result in more traffic related injuries.

The percent of lane miles by each road category shows that those states with more lane miles of interstate (relative to other categories) have a statistically significant reduction in injuries. This is consistent with the hypothesis that interstate highways are safer, relative to other road categories (probably due to access controls). However, there is not statistically significant reduction in fatalities when a state has proportionally more interstate lane miles. States with a larger share of arterial lane miles in their networks have more fatalities and injuries, while those with more collectors have more injuries. This result tends to support conventional engineering wisdom that interstate highways are safer but is confounded by the positive coefficient on the average number of interstate lanes increasing total injuries.

Those states with more arterials with lane widths of 9 ft or less have fewer traffic injuries; the coefficient on this variable is not significant for the fatality models, though it is positive. The coefficients for arterials with lane widths of 10 ft are all negative and significant, while those for arterials with lane widths of 11 ft are all insignificant. The coefficient for arterial lane widths of 12 ft or greater is also not significant for either injuries or fatalities.

For collector lane widths we see a similar, but slightly different pattern. The coefficient for collectors with lane widths of 9 ft or less are negative and significant indicating that smaller lane widths reduce both fatalities and injuries. For 10 ft lane widths there is no statistical significance and for 11 ft lane widths there is a negative

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[3] Given that the conventional engineering hypothesis assumes that added (or new) lane miles should reduce fatalities and injuries we can use a one-tailed test to reject this hypothesis. Therefore our 95% confidence interval is equivalent to a test statistic of 1.65.

and significant effect. The coefficient for lane widths of 12 ft or greater on collectors is significant and positive for fatalities but insignificant for injuries.

The data on the lane width variables was also analysed by including only one of the corresponding variables in each model. This was done due to moderate (but not large) correlation between some of the lane width variables. Generally, the correlations between these variables were about 0.50 with only 3 of the 28 correlations exceeding 0.70. In Table 4 these coefficient values and their test statistic are shown (other coefficients had similar values to those in Tables 2 and 3 and are omitted for brevity). The pattern in the coefficients for both the fatality and injury models is quite clear. As more arterial and collector lane widths are increased up to 12 ft or more, traffic fatalities and injuries increase. The coefficients for 12 foot or greater lane widths are the only estimates that are positive and significant. Estimates for coefficients of smaller lane widths are either significantly negative or insignificant.

These results are quite stunning as it is general practice to improve the safety of roads by increasing lane widths. Clearly these results suggest that drivers must react to increased lane widths, which can increase driver comfort, by reducing their caution, increasing their speeds and therefore off-setting expected safety benefits.

Table 5 summarizes the conventional engineering wisdom on how highway engineering "improvements" affect safety and are compared with the results derived here. As can be seen, it is in general, not possible to support the engineering hypotheses. The one result consistent with engineering hypotheses is that arterial roads are generally less safe than controlled access facilities (interstates). This analysis found significant injury reduction benefits from controlled access facilities compared to more fatalities and injuries due to arterial roads.

Other variables are included in the regressions primarily to control for other effects. However, these variables also show some interesting results and help explain the observed trends in total traffic related fatalities and injureis. States with higher per capita income tend to have higher fatalities and injuries. Larger population does not seem to conclusively lead to more fatalities (model C shows a significant effect, while A does not), but does lead to fewer injuries. Increased VMT (Table 3) is significant in increasing fatalities and in decreasing injuries. Most importantly it was found that changes in age cohorts has a large significant effect on both fatalities and injuries. The percent of the population between 15 and 24 years of age increases both fatalities and injuries as one would expect, since drivers in this age group are well known for being involved in more crashes. However, increases in the percent of the population over age 75 leads to fewer fatalities and injuries, which is a surprising result.[4]

Models E and F in Table 1 replace the population variable with a variable for total ethanol consumption. These variables are highly correlated with each other and thus cannot be included in the same model. Other variables, with some minor exceptions are quite robust. Lane miles is also relatively correlated with ethanol consumption and shows a reduced value in both the fatality and injury model. Ethanol consumption is, not surprisingly, highly significant in the fatality model, but not in the injury model.

Two different sets of variables are included to capture effects from seatbelt use. The first is the inclusion of a dummy variable representing whether a state has either a primary seatbelt law, a secondary seatbelt law, or none at all. Primary laws allow police officers to ticket those they see who are not wearing seatbelts.

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[4] Interestingly, some preliminary analysis of impacts on pedestrian fatalities shows that states with a

Secondary laws only allow tickets to be given if drivers have committed some other moving violation. Most states have secondary laws while a few have recently enacted primary laws. These variables are included in Models A – F. Primary laws seem to reduce fatalities and injuries, while secondary laws result in an increase in fatalities. McCarthy (1999), using California data, found that enactment of a seatbelt law had no significant effect on fatalities. Both laws are found to increase seat belt usage, as shown in Table 6. Models G and H include seatbelt usage and this is found to be highly significant at decreasing fatalities, but not significant for decreasing injuries. These results are quite interesting and deserve more exploration, but are not examined further in this paper. These variables are included only to control for these effects to verify the robustness of our key variables of interest which are the infrastructure variables.

The year variable, which represents a time trend, is negative and significant for deaths. This means that over time the overall number of deaths is decreasing due to unmeasured factors not included in the regression. Injuries show an increase over time in the models controlled for VMT (Table 3). In the fatality model with seatbelt use data (Model G), however, the year variable becomes insignificant, suggesting that much of the unmeasured downward trend is picked up by increased seatbelt use. Model G, however, uses only 8 years of data and therefore it is difficult to know whether the lack of significance may also be due to a shorter time trend. The year trend is insignificant for injuries but shows a significant positive effect in the seatbelt model (Model H). The fixed effects methodology used accounts for state-specific effects that are missing in the model, such as seatbelt usage in Models A – D.

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higher fraction of elderly people have more pedestrian fatalities.

Therefore, it is likely that the change in significance levels in Models G and H are at least partly due to the shorter time trend.

This was tested by running Models A-D with data for the shorter time trend (1990-1997). Results (not shown here for brevity) indicate that the year variable is barely significant at the 90% level. The coefficient level is about –0.008, which is about midway between the values estimated with the full time trend and the seatbelt usage model. This suggests that some of the time trend is probably captured by the seatbelt coefficient, but not necessarily all of it.

Another factor that could be missing from the model are various improvements in vehicle safety over this time frame. The largest innovation that occurs within the time frame of the data is the introduction of air bags, starting about 1993. Given that airbag penetration rates within the total vehicle fleet were not yet substantial within the data set, this is unlikely to be a major influence. It may be having more of an effect within the seatbelt model with a shorter time series and airbag use could perhaps also make seatbelts more effective.

Another possibility is that improvements in medical technology may also be playing a significant role in reducing overall traffic-related fatalities. To examine this effect, two variables are tested. The first, is the density of hospitals within a state which may serve as a proxy for emergency response times and for the relative amount of rural areas within a state. One would expect a higher density of hospitals to result in fewer fatalities. Lave (1985) showed that this was a significant variable, with those states having a higher density of hospitals per square mile having fewer fatalities, however, he did not use time series data in his analysis. This variable was not significant in the models estimated.

A better reflection of changes in medical technology is to find a good proxy for life saving capabilities. Many of these are often correlated with per capita income. For this reason, white infant mortality levels is tested, to avoid the stronger correlations that total infant mortality or expected life expectancy per state would have. This variable shows a large variation both across time and across states. Nationwide white infant mortality rates have decreased by 34%, from 9.43 to 6.18 deaths per 1000 births between 1985 and 1996. For a given year, there is a large variability between states, ranging from a minimum of 7.5 deaths per 1000 births in 1985 for the states of Hawaii and Massachusetts to a high of 12.2 deaths per 1000 births for the states of Wyoming and Delaware. In 1996 the range was 4.4 to 8.4 with Hawaii and Maine having the lowest rate and Nebraska and Arkansas having the highest rates. Overall correlation with per capita income is only 0.48.

This variable is used in the models presented in Tables 7 and 8 (for population and VMT models, respectively). The logarithm of the inverse of the white infant mortality rate is used so that increasing values represent an increase in the level of medical technology. Data was available only for 1985 – 1986, 1988, 1990, and 1992-1996. Missing years were filled in with averaged values from bordering years. Tests of the model with missing years produced essentially the same results.

As can be seen, this variable is negative and highly significant in the fatality models, implying that increases in medical technology reduce total traffic-related fatalities. The coefficient is also significant in Model G which explicitly controls for seatbelt usage. Equally important, the variable is not at all significant in the injury models. Therefore, it appears to be picking up the ability of medical technology to reduce the incidence of fatalities in the most severe crashes; though, as one would expect, injuries would not be affected by medical technology improvements.

The year trend variable is reduced in magnitude when the medical technology proxy is included in the model. While the time trend is generally still significant, in some of the estimates it is no longer significant at the 95% level. There is less difference in the time trend for the injury models. While this indicates that there are still some other unmeasured factors that are reducing fatalities over time, accounting for medical technology effects picks up some of this effect. It is probable that the remaining unmeasured effects are due to various improvements in vehicle technology over time.

As mentioned previously, the seatbelt models (Model G) also capture much of the time trend effect. When Models A-D are estimated with the shorter time trend data and with the medical technology proxy, it is still significant. The time trend variable, however, has about the same magnitude, though it is not significant at the 95% level. This tends to suggest that medical technology improvements are picking up some of the residual time trend effect in the data, at least between 1985-1996, and most likely in the shorter time trend from 1990-1996.

These results show that in general, infrastructure "improvements" have led to an increase in total traffic-related fatalities, while demographic changes and medical technology improvements have decreased fatalities. Increased seatbelt usage also appears to have decreased fatalities though the impact of seatbelt legislation is less clear. A relevant question is what the relative impact of changes over time have been.

Table 9 and Table 10 show for the population and VMT models (A and B) how 1985 fatalities and injuries would have changed with the infrastructure, demographics and medical technology levels for 1996. Medical technology improvements (as measured by the proxy) indicate that between 3767 – 4158 fewer fatalities would have occurred in 1985 if 1996 medical technology were available.

This is almost 10% of all traffic-related fatalities. If 1996 infrastructure were available in 1985, this would have resulted in between about 1995-2249 additional fatalities and 302,000 to 489,000 more injuries. Amongst the infrastructure variables, increases in lane widths to 12 foot widths seems to account for over half of the total increase in fatalities and about one-quarter of the increase in injuries. Increases in the arterial network also account for a large share of the increase in fatalities due to infrastructure "improvements."

Increases in per capita income account for the greatest estimated increase in fatalities and injuries. Increased seatbelt usage appears to have the greatest impact on fatality reduction based upon estimated nationwide usage of only 21% in 1985 increasing to 68% nationwide in 1996 (US DOT, 1998). Applying the estimate from Model G, using just 8 years of data to 1985 – 1996, some 15574 fatalities could have been avoided if 1996 seatbelt usage rates were occurring in 1985. The other largest influence on reducing fatalities is the reduction in the percent of people aged between 15-24 and the increase in those aged over 75. If 1996 population cohorts are applied to 1985, then in total, over 10,000 fatalities and nearly 1,000,000 injuries would have been avoided.

Conclusions

The results of this analysis suggest that changes in highway infrastructure that have occurred between 1984 and 1997 have not reduced traffic fatalities and injuries and have even had the effect of increasing total fatalities and injuries. This conclusion conflicts with conventional engineering wisdom on the benefits of "improving" highway facilities and achieving higher standards of design (Transportation Research Board, 1987). While not all explicit highway design improvements were analysed, the fact that adding new and higher design standard lane miles leads to increased fatalities and injuries suggests that new "improved" design standards are not achieving safety benefits. The review of the literature identified other studies that have found this effect, though these studies have not clearly interpreted the implications for transport and safety policy.

Other factors, primarily changes in the demographic age mix of the population, increased seatbelt usage, and improvements in medical technology are responsible for the downward trend in total fatal accidents. To date, these changes have been more than sufficient to off-set the effect of increasing per capita income and the effects of various infrastructure improvements.

The results tend to support the theory of risk compensation, in that driver behavioral changes will off-set various factors aimed at improving safety. In the results of our models, much of this may result from higher design standards allowing drivers to increase their speeds on roads and reduce their levels of caution. This allows the driver to make a trade-off between mobility and safety. It also implies that to reduce fatalities it is necessary to change driver behavior, as demonstrated by the effectiveness of increased seatbelt usage.

Traffic calming initiatives were not analysed in this study. Traffic calming safety enhancements, however, tend to lower driving speeds and require the driver to increase their attentiveness. To some extent, this could result in a behavioural effect opposite of that resulting from higher design standards. This would suggest that traffic calming, while not explicitly studied here, may be an effective infrastructure change for improving safety.

Currently the US Department of Transportation uses the Highway Economics Requirements System (HERS) to forecast future financial requirements for nationwide highway needs. This modelling system includes explicit consideration of various engineering design criteria, such as lane widths, shoulder widths, and horizontal curvature and calculates crash reduction rates based upon various engineering studies (Cambridge Systematics, 1998; US DOT, 1999). These studies provide explicit coefficient linking infrastructure improvements to crash reduction. However, they do not control for other effects as the analysis here does. It is not known how the contribution of estimated safety benefits in the current HERS model affects total forecast needs, but presumably if the current safety relationships were removed the financial need for more highway spending would be reduced.

Highway project decision making is critically linked to current assumptions about the beneficial aspects of "improved" design standards. Many projects are justified based upon their crash reduction benefits, for example, as stated in environmental impact statements. Implied in this is the decision that allowing some level of environmental damage is acceptable when safety benefits can be achieved. The Clean Air Act explicitly exempts safety related projects from the need to conform with air quality requirements as stated in state implementation plans. Obviously, if safety benefits cannot be achieved while allowing environmental degradation, this challenges a critical justification for many projects.

This is not to say that all highway projects that may decrease safety are necessarily not beneficial. Mobility improvements may still be achievable, though explicitly recognizing any safety costs would improve decision making.

While it is difficult to forecast what future trends in fatalities will occur, current demographic trends with an increase in the elderly population and fewer younger people suggest that downward trends will continue. It is even more difficult to know how much more medical technology will improve over time, but it is certainly possible that the pace of improvement may be less rapid than in the past (or alternatively it may accelerate). Increased seatbelt usage is still feasible and can still be effective at reducing future fatalities. It is likely that downward trends may continue despite increased design upgrading of highway and road infrastructure.

The modelling framework used in this paper can be expanded in several ways. First, it should be feasible to analyze various sub-categories of crash types, such as pedestrian fatalities and injuries or those involving children. In addition, it would be desirable to include data on other infrastructure elements, such as horizontal curvature and shoulder widths. This data may be available in the Highway Performance Monitoring System database. It is hoped that further analysis of these relationships will help to clarify the effects found here.

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References

Abdel-Aty, Mohamed A. and A. Essam Radwan, 2000, Modeling Traffic Accident Occurrence and Involvement, *Accident Analysis and Prevention*, 32: 633-642.

Boyle, A.J., and C.C. Wright, 1984, Accident 'Migration' After Remedial Treatment at Accident Blackspots", *Traffic Engineering and Control*, 25: 260-267.

Cambridge Systematics, 1998, *New Safety Analysis Procedures for HERS*, final report prepared for the Federal Highway Administration

Chu, Xuehao, 1999, Effects of Changes in Travel Patterns on Highway Fatalities, *Accident Analysis and Prevention*, 31: 221-27.

Conybeare, J. A. C., 1980, Evaluation of Automobile Safety Regulations: The Case of Compulsory Seat Belt Legislation in Australia, *Policy Sciences*, 12: 27-39.

Council, Forrest M., and J. Richard Stewart, 1999, Safety Effects of the Conversion of Rural Two-Lane to Four-Lane Roadways Based on Cross-Sectional Models, Paper presented at the 78th Annual Meeting of the Transportation Research Board, Washington, DC.

Evans, L., 1986, Risk Homeostasis Theory and Traffic Accident Data, *Risk Analysis*, 6: 81-94.

Fridstrom, Lasse and Siv Ingebrigsten, 1991, An Aggregate Accident Model Based on Pooled, Regional Time-Series Data, *Accident Analysis and Prevention*, 23: 363-378.

Graham, J. D. and S. Garber, 1984, Evaluating the Effects of Automobile Safety Regulation, *Journal of Policy Analysis and Management*, 3: 206-224.

Hadi, Mohammed A., Jacob Aruldhas, Lee-Fang Chow, and Joseph A. Wattleworth, 1995, Estimating Safety Effects of Cross-Section Design for Various Highway Types Using Negative Binomial Regression, *Transportation Research Record*, 1500: 169-177.

Hausman, Jerry, Bronwyn H. Hall & Zvi Griliches, 1984, Econometric Models for Count Data with an Application to the Patents-R & D Relationship, *Econometrica*, 52: 909-938.

Ivan, John N., Chunyan Wang & Nelson R. Bernardo, 2000, Explaining Two-lane Highway Crash Rates Using Land Use and Hourly Exposure, *Accident Analysis and Prevention*, 32: 787-795.

Joksch, H. C., 1976a, Critique of Sam Peltzman's Study: The Effects of Automobile Safety Regulation, *Accident Analysis and Prevention*, 8: 129-137.

Joksch, H. C., 1976b, The Effects of Automobile Safety Regulation: Comments on Peltzman's Reply, *Accident Analysis and Prevention*, 8: 213-214.

Karlaftis, Matthew G. & Andrzej P. Tarko, 1998, Heterogeneity Considerations in Accident Modeling, *Accident Analysis and Prevention*, 30: 425-433.

Lave, Charles A., 1985, Speeding, Coordination, and the 55-MPH Limit, *American Economic Review*, 75: 1159-1164.

Lave, Charles A., 1989, Speeding, Coordination, and the 55-MPH Limit: Reply, *American Economic Review*, 79: 926-931.

Loeb, Peter D., 1987, The Determinants of Automobile Fatalities: with Special Consideration to Policy Variables, *Journal of Transport Economics and Policy*, 21: 279-287.

McCarthy, P. S., 1986, Seat Belt Usage Rates: A Test of Peltzman's Hypothesis, *Accident Analysis and Prevention*, 18: 425-438.

McCarthy, P. S., 1999, Public Policy and Highway Safety: A City-wide Perspective, *Regional Science and Urban Economics*, 29: 231-244.

McGee, H.W., W.E. Hughes, and K. Daily, 1995, *Effect of Highway Standards on Safety*, National Cooperative Highway Research Program, Report 374, Transportation Research Board, National Research Council, National Academy Press: Washington, DC.

Milton, John and Fred Mannering, 1998, The Relationship Among Highway Geometries, Traffic-related Elements and Motor-vehicle Accident Frequencies, *Transportation*, 25: 395-413.

Noland, Robert B., 2001 "Relationships Between Highway Capacity and Induced Vehicle Travel", *Transportation Research A*, 35(1): 47-72.

Peltzman, S., 1975, The Effects of Automobile Safety Regulation, *Journal of Political Economy*, 83: 677-725.

Porter, Bryan E. and Kelli J. England, 2000, Predicting Red-Light Running Behavior: A Traffic Study in Three Urban Settings, *Journal of Safety Research*, 31(1): 1-8.

Robertson, L. S., 1977a, State and Federal New Car Safety Regulations: Effects on Fatality Rates, *Accident Analysis and Prevention*, 9: 151-156.

Robertson, L. S., 1977b, A Critical Analysis of Peltzman's "The Effects of Automobile Safety Regulation", *Journal of Economic Issues*, 11: 587-600.

Robertson, L. S., 1981, Automobile Safety Regulations and Death Reductions in the United States, *American Journal of Public Health*, 71: 818-822.

Shankar, Venkataraman, Fred Mannering, and Woodrow Barfield, 1995, Effect of Roadway Geometrics and Environmental Factors on Rural Freeway Accident Frequencies, *Accident Analysis and Prevention*, 27(3): 371-389.

Shefer, Daniel and Piet Rietveld, 1997, Congestion and Safety on Highways: Towards an Analytical Model, *Urban Studies*, 34: 679-692.

Singh, H. and M. Thayer, 1992, Impact of Seat Belt Use on Driving Behavior, *Economic Inquiry*, 30: 649-658.

Sivak, Michael, 1983, Society's Aggression Levl as a Predictor of Traffic Fatality Rate, *Journal of Safety Research*, 14: 93-99.

StataCorp, 1999, *Stata Statistical Software: Release 6.0*, College Station, TX: Stata Corporation.

Transportation Research Board, 1987, *Designing Safer Roads: Practices for Resurfacing, Restoration, and Rehabilitation*, Special Report 214, National Research Council, Washington, DC.

Traynor, T. L., 1993, The Peltzman Hypothesis Revisited: An Isolated Evaluation of Off-setting Driver Behavior, *Journal of Risk and Uncertainty*, 7: 237-247.

US DOT, 1998, *Highway Statistics 1997*, Federal Highway Administration, Office of Highway Information Management, FHWA-PL-98-020.

US DOT, 1998, *Buckle Up America – The Presidential Initiative for Increasing Seatbelt Use Nationwide*, First Report to Congress. http://www.nhtsa.dot.gov/people/injury/airbags/buckleplan/presbelt2/

US DOT, 1999, *1999 Status of the Nation's Highways, Bridges and Transit: Conditions and Performance*, Report to Congress, Federal Highway Administration, Federal Transit Administration.

Vogt, Andrew and Joe Bared, 1998, Accident Models for Two-Lane Rural Segments and Intersections, paper presented at the 77th Annual Meeting of the Transportation Research Board.

Wilde, G. J. S., 1982, The Theory of Risk Homeostasis: Implications for Safety and Health, *Risk Analysis*, 2: 209-225.

Zhou, Min and Virginia P. Sisiopiku, 1997, On the Relationship Between Volume to Capacity Ratios and Accident Rates, Paper presented at the 76th Annual Meeting of the Transportation Research Board, Washington, DC.

Zlatoper, T. J., 1984, Regression Analysis of Time Series Data on Motor Vehicle Deaths in the United States, *Journal of Transport Economics and Policy*, 18: 263-274.

Table 1
Trends in Highway Infrastructure Variables

	1985 value	1996 value	Percent change
Total Lane Miles (excludes local roads)	8,015,290	8,174,379	1.98%
Average Number of Interstate Lanes	4.39	4.52	2.78%
Average Number of Arterial Lanes	2.38	2.44	2.40%
Average Number of Collector Lanes	2.02	2.02	-0.04%
Percent of Lane Miles that are Interstates	2.37%	2.50%	5.75%
Percent of Lane Miles that are Arterials	10.58%	11.50%	8.73%
Percent of Lane Miles that are Collectors	20.27%	19.61%	-3.26%
Percent Arterials with 9 ft or less Lane Widths	3.06%	1.57%	-48.59%
Percent Arterials with 10 ft Lane Widths	12.87%	9.50%	-26.12%
Percent Arterials with 11 ft Lane Widths	17.01%	14.93%	-12.24%
Percent Arterials with 12 ft or greater Lane Widths	67.07%	74.00%	10.33%
Percent Collectors with 9 ft or less Lane Widths	16.21%	11.03%	-31.95%
Percent Collectors with 10 ft Lane Widths	31.60%	27.54%	-12.83%
Percent Collectors with 11 ft Lane Widths	20.25%	22.73%	12.26%
Percent Collectors with 12 ft or greater Lane Widths	31.95%	38.70%	21.13%

Table 2
Fixed Effect Negative Binomial Regressions with State Data (controlled for population)

Aggregate State Data	Dependent Variable			
	DEATHS	INJURED	DEATHS	INJURED
	(A)	(B)	(C)	(D)
Years of data	1984-1997	1984-1997	1984-1997	1984-1997
Log(total lane miles)	0.403 (3.632)	0.661 (4.914)	0.378 (3.585)	0.675 (4.833)
Log(average number of interstate lanes)	-0.030 (-0.116)	2.486 (6.186)	-0.172 (-0.673)	2.203 (5.252)
Log(average number of arterial lanes)	0.208 (1.829)	0.531 (2.215)	0.309 (2.836)	0.808 (3.125)
Log(average number of collector lanes)	1.281 (3.226)	-0.751 (-0.775)	1.339 (3.249)	-0.028 (-0.025)
Log(percent interstate lane miles)	0.099 (1.112)	**-0.224** **(-1.781)**	0.045 (0.511)	**-0.386** **(-2.945)**
Log(percent arterial lane miles)	0.181 (2.301)	**0.277** **(2.066)**	0.208 (2.715)	0.474 (3.368)
Log(percent collector lane miles)	0.088 (1.207)	0.332 (3.603)	0.072 (0.981)	**0.326** **(3.459)**
Log(per capita income)	1.267 (11.536)	1.053 (5.398)	1.270 (11.615)	1.097 (5.301)
Log(population)	0.029 (0.314)	-0.503 (-4.760)	0.151 (1.825)	-0.586 (-5.552)
Log(percent population aged 15-24)	0.680 (9.609)	0.639 (5.649)	0.682 (9.992)	0.626 (5.196)
Log(percent population over age 75)	-0.651 (-7.517)	-0.732 (-5.847)	-0.604 (-7.287)	-0.621 (-4.543)
Year	-0.012 (-4.312)	**0.008** **(1.829)**	-0.013 (-4.860)	**0.013** **(2.761)**
Log(percent arterials with lane widths of 9 ft. or less)	0.007 (1.461)	-0.022 (-2.819)	-	-
Log(percent arterials with lane widths of 10 ft.)	-0.020 (-2.066)	-0.031 (-2.362)	-	-
Log(percent arterials with lane widths of 11 ft.)	0.001 (0.100)	-0.017 (-1.067)	-	-
Log(percent arterials with lane widths of 12 ft. or greater)	-0.013 (-0.233)	**0.096** **(0.896)**	-	-
Log(percent collectors with lane widths of 9 ft. or less)	-0.021 (-2.806)	-0.031 (-2.805)	-	-
Log(percent collectors with lane widths of 10 ft.)	0.029 (1.603)	-0.013 (-0.432)	-	-
Log(percent collectors with lane widths of 11 ft.)	-0.028 (-2.971)	-0.048 (-3.804)	-	-
Log(percent collectors with lane widths of 12 ft. or greater)	0.064 (2.367)	0.015 (0.263)	-	-
Primary Seatbelt Law	-0.060 (-3.966)	**-0.050** **(-1.618)**	-0.054 (-3.627)	-0.051 (-1.568)
Secondary Seatbelt Law	0.022 (2.181)	0.015 (0.777)	0.028 (2.750)	0.012 (0.580)
Constant	11.501 (2.339)	-27.952 (-3.406)	11.569 (2.490)	-36.307 (-4.409)
N	700	657	700	657
Log likelihood	-3307.06	-6026.78	-3321.85	-6060.95

Test statistic is in parentheses

Table 2 (continued)
Fixed Effect Negative Binomial Regressions with State Data (controlled for population)

Aggregate State Data	Dependent Variable			
	DEATHS	INJURED	DEATHS	INJURED
	(E)	(F)	(G)	(H)
Years of data	1984-1997	1984-1997	1990-1997	1990-1997
Log(total lane miles)	0.190 (1.933)	0.441 (3.679)	-0.228 (-0.995)	0.895 (3.284)
Log(average number of interstate lanes)	-0.192 (-0.791)	2.129 (5.424)	1.334 (3.259)	2.308 (3.143)
Log(average number of arterial lanes)	0.146 (1.332)	0.505 (2.090)	0.389 (2.193)	0.702 (1.350)
Log(average number of collector lanes)	1.157 (2.961)	-0.512 (-0.522)	0.033 (0.060)	0.511 (0.353)
Log(percent interstate lane miles)	0.069 (0.800)	-0.321 (-2.652)	-0.008 (-0.049)	-0.104 (-0.356)
Log(percent arterial lane miles)	0.076 (1.072)	0.122 (0.960)	-0.075 (-0.676)	0.307 (1.403)
Log(percent collector lane miles)	0.047 (0.711)	0.287 (3.048)	-0.047 (-0.509)	0.159 (1.638)
Log(total ethanol consumed)	0.326 (5.236)	-0.319 (-3.165)	-	-
Log(per capita income)	1.094 (9.870)	1.160 (5.441)	1.130 (6.037)	-0.684 (1.814)
Log(population)	-	-	0.167 (1.008)	-0.949 (-4.315)
Log(percent population aged 15-24)	0.546 (7.282)	0.720 (5.941)	0.885 (5.920)	0.963 (3.607)
Log(percent population over age 75)	-0.566 (-6.476)	-0.732 (-5.643)	-0.494 (-2.393)	-0.797 (-2.549)
Year	-0.009 (-3.328)	0.005 (0.708)	-0.004 (-0.803)	0.024 (2.727)
Log(percent arterials with lane widths of 9 ft. or less)	0.007 (1.530)	-0.019 (-2.468)	0.008 (1.317)	-0.022 (-2.499)
Log(percent arterials with lane widths of 10 ft.)	-0.018 (-1.789)	-0.037 (-2.762)	-0.009 (-0.635)	0.012 (0.614)
Log(percent arterials with lane widths of 11 ft.)	-0.005 (-0.393)	-0.0012 (-0.736)	-0.010 (-0.620)	0.003 (0.144)
Log(percent arterials with lane widths of 12 ft. or greater)	-0.029 (-0.518)	0.095 (0.867)	-0.152 (-1.219)	0.081 (0.277)
Log(percent collectors with lane widths of 9 ft. or less)	-0.016 (-2.190)	-0.030 (-2.538)	-0.016 (-1.438)	-0.004 (-0.237)
Log(percent collectors with lane widths of 10 ft.)	0.025 (1.400)	-0.026 (-0.852)	0.009 (0.314)	-0.112 (-2.229)
Log(percent collectors with lane widths of 11 ft.)	-0.020 (-2.166)	-0.046 (-3.498)	-0.008 (-0.704)	-0.048 (-3.117)
Log(percent collectors with lane widths of 12 ft. or greater)	0.055 (2.141)	0.061 (1.084)	0.129 (2.853)	0.161 (1.377)
Primary Seatbelt Law	-0.046 (-3.208)	-0.059 (-1.880)	-	-
Secondary Seatbelt Law	0.020 (2.001)	0.016 (0.802)	-	-
Log(percent seatbelt usage)	-	-	-0.134 (-4.627)	-0.036 (-0.701)
Constant	7.528 (1.535)	-21.481 (-2.549)	1.283 (0.152)	-51.475 (-3.147)
N	700	657	400	378
Log likelihood	-3294.40	-6033.08	-1678.00	-3245.00

Table 3
Fixed Effect Negative Binomial Regressions with State Data (controlled for VMT)

Aggregate State Data	Dependent Variable					
	DEATHS	INJURED	DEATHS	INJURED	DEATHS	INJURED
	(A)	(B)	(C)	(D)	(G)	(H)
Years of data	1984-1997	1984-1997	1984-1997	1984-1997	1990-1997	1990-1997
Log(total lane miles)	0.340 (3.526)	0.461 (3.546)	0.354 (3.678)	0.477 (3.412)	-0.175 (-0.817)	0.313 (1.419)
Log(average number of interstate lanes)	-0.078 (-0.311)	2.188 (5.544)	-0.147 (-0.594)	1.879 (4.540)	1.397 (3.498)	1.693 (2.523)
Log(average number of arterial lanes)	0.145 (1.228)	0.575 (2.360)	0.227 (2.005)	0.872 (3.338)	0.388 (2.172)	0.585 (1.167)
Log(average number of collector lanes)	1.303 (3.274)	-1.188 (-1.231)	1.373 (3.326)	-0.616 (-0.553)	0.049 (0.088)	0.156 (0.112)
Log(percent interstate lane miles)	0.081 (0.901)	-0.294 (-2.385)	0.014 (0.161)	-0.429 (-3.266)	0.004 (0.022)	-0.606 (-2.431)
Log(percent arterial lane miles)	0.151 (2.101)	0.122 (0.960)	0.205 (2.942)	0.299 (2.218)	-0.050 (-0.474)	-0.023 (-0.116)
Log(percent collector lane miles)	0.063 (0.927)	0.342 (3.533)	0.076 (1.114)	0.335 (3.321)	-0.027 (-0.306)	0.158 (1.389)
Log(per capita income)	1.186 (10.113)	1.117 (5.344)	1.148 (9.769)	1.209 (5.473)	1.104 (5.672)	0.388 (0.980)
Log(VMT)	0.132 (1.925)	-0.307 (-3.039)	0.199 (2.969)	-0.396 (-3.719)	0.097 (0.757)	-0.407 (-2.244)
Log(percent population aged 15-24)	0.667 (9.391)	0.652 (5.650)	0.650 (9.572)	0.672 (5.437)	0.891 (5.937)	0.751 (2.696)
Log(percent population over age 75)	-0.633 (-7.186)	-0.708 (-5.659)	-0.578 (-6.833)	-0.649 (-4.823)	-0.457 (-2.054)	-0.922 (-3.214)
Year	-0.014 (-4.728)	0.012 (2.520)	-0.016 (-5.512)	0.020 (4.061)	-0.005 (-0.909)	0.034 (3.640)
Log(percent arterials with lane widths of 9 ft. or less)	0.007 (1.522)	-0.021 (-2.712)	-	-	0.007 (1.238)	-0.021 (-2.222)
Log(percent arterials with lane widths of 10 ft.)	-0.020 (-2.083)	-0.033 (-2.401)	-	-	-0.009 (-0.640)	-0.000 (-0.009)
Log(percent arterials with lane widths of 11 ft.)	0.003 (0.281)	-0.021 (-1.316)	-	-	-0.009 (-0.555)	-0.011 (-0.498)
Log(percent arterials with lane widths of 12 ft. or greater)	-0.012 (-0.202)	0.084 (0.765)	-	-	-0.151 (-1.204)	0.137 (0.455)
Log(percent collectors with lane widths of 9 ft. or less)	-0.021 (-2.872)	-0.026 (-2.287)	-	-	-0.017 (-1.574)	0.003 (0.165)
Log(percent collectors with lane widths of 10 ft.)	0.028 (1.514)	-0.024 (-0.792)	-	-	0.005 (0.172)	-0.117 (-2.280)
Log(percent collectors with lane widths of 11 ft.)	-0.027 (-2.906)	-0.042 (-3.383)	-	-	-0.008 (-0.745)	-0.046 (-3.063)
Log(percent collectors with lane widths of 12 ft. or greater)	0.059 (2.219)	0.066 (1.184)	-	-	0.117 (2.576)	0.232 (1.951)
Primary Seatbelt Law	-0.055 (-3.677)	-0.064 (-2.084)	-0.049 (-3.344)	-0.064 (-1.951)	-	-
Secondary Seatbelt Law	0.020 (1.949)	0.022 (1.101)	0.023 (2.252)	0.022 (1.047)	-	-
Log(percent seatbelt usage)	-	-	-	-	-0.133 (-4.607)	-0.045 (-0.768)
Constant	16.548 (2.959)	-38.157 (-4.173)	19.098 (3.609)	-53.205 (-6.012)	5.135 (0.461)	-73.854 (-4.246)
N	700	657	700	657	400	378
Log likelihood	-3305.28	-6033.55	-3319.18	-6069.13	-1678.20	-3252.31

Test statistic is in parentheses

Table 4
Coefficients on Lane Width Variables when Modelled Individually in Population Model

	Fatality Models	Injury Models
Percent Arterials with 9 ft or less Lane Widths	0.001 (0.103)	-0.035 (-4.130)
Percent Arterials with 10 ft Lane Widths	-0.029 (-2.758)	-0.063 (-3.988)
Percent Arterials with 11 ft Lane Widths	-0.025 (-2.252)	-0.064 (-4.026)
Percent Arterials with 12 ft or greater Lane Widths	0.091 (1.647)	0.310 (2.769)
Percent Collectors with 9 ft or less Lane Widths	-0.018 (-2.524)	-0.039 (-3.255)
Percent Collectors with 10 ft Lane Widths	0.007 (0.426)	-0.031 (-1.021)
Percent Collectors with 11 ft Lane Widths	-0.027 (-3.255)	-0.073 (-6.392)
Percent Collectors with 12 ft or greater Lane Widths	0.060 (2.606)	0.110 (2.232)

Test statistic is in parentheses

Table 5
Hypothesized and Modelled Effect of Infrastructure Variables

	Fatalities		Injuries	
	Engineering Hypothesis	Results of Analysis	Engineering Hypothesis	Results of Analysis
Total Lane Miles	-	+	-	+
Average Interstate Lanes	-	*	-	+
Average Arterial Lanes	-	*	-	+
Average Collector Lanes	-	+	-	*
Percent Interstate Lane Miles	-	*	-	-
Percent Arterial Lane Miles	+	+	+	+
Percent Collector Lane Miles	*	*	*	+
Percent Arterials with 9 ft or less Lane Widths	+	*	+	-
Percent Arterials with 10 ft Lane Widths	+	-	+	-
Percent Arterials with 11 ft Lane Widths	*	*	*	*
Percent Arterials with 12 ft or greater Lane Widths	-	*	-	*
Percent Collectors with 9 ft or less Lane Widths	+	-	+	-
Percent Collectors with 10 ft Lane Widths	+	*	+	weak -
Percent Collectors with 11 ft Lane Widths	*	-	*	-
Percent Collectors with 12 ft or greater Lane Widths	-	+	-	*

+ = positive and significant effect
- = negative and significant effect
*** = insignificant effect**

Table 6
Seatbelt Usage, fixed effects regression

	Percent seatbelt usage
Years of data	1990-1997
Primary Seatbelt Law	0.072 (2.855)
Secondary Seatbelt Law	0.112 (8.127)
Year	0.017 (11.540)
Constant	-32.974 (-11.396)
N	400
R-Sq	0.517

Test statistic is in parentheses

Table 7
Fixed Effect Negative Binomial Regressions with State Data (controlled for population), with Medical Technology variables

Aggregate State Data	Dependent Variable			
	DEATHS	INJURED	DEATHS	INJURED
	(A)	(B)	(C)	(D)
Years of data	1985-1996	1985-1996	1985-1996	1985-1996
Log(total lane miles)	0.435 (3.517)	0.743 (4.764)	0.411 (3.430)	0.826 (5.348)
Log(average number of interstate lanes)	-0.077 (-0.268)	2.681 (5.961)	-0.128 (-0.450)	2.543 (5.400)
Log(average number of arterial lanes)	0.119 (0.974)	0.335 (1.297)	0.230 (1.987)	0.565 (2.021)
Log(average number of collector lanes)	1.813 (3.278)	0.174 (0.152)	1.569 (2.817)	0.196 (0.147)
Log(percent interstate lane miles)	0.095 (0.957)	*-0.155* *(-1.068)*	0.067 (0.683)	-0.302 (-2.042)
Log(percent arterial lane miles)	0.196 (2.220)	0.360 (2.382)	0.219 (2.549)	0.582 (3.781)
Log(percent collector lane miles)	0.128 (1.581)	0.360 (3.464)	0.105 (1.285)	0.403 (3.777)
Log(per capita income)	1.222 (9.775)	0.785 (3.409)	1.228 (9.827)	0.844 (3.463)
Log(population)	0.129 (1.209)	-0.575 (-4.670)	0.227 (2.350)	-0.724 (-6.298)
Log(percent population aged 15-24)	0.638 (7.692)	0.786 (5.976)	0.649 (8.104)	0.762 (5.538)
Log(percent population over age 75)	-0.689 (-6.959)	-0.797 (-5.637)	-0.679 (-7.287)	-0.773 (-5.140)
Year	-0.007 (-1.852)	0.015 (2.540)	-0.006 (-1.746)	0.019 (3.266)
Log(percent arterials with lane widths of 9 ft. or less)	0.009 (1.618)	-0.023 (-2.731)	-	-
Log(percent arterials with lane widths of 10 ft.)	-0.026 (-2.335)	-0.040 (-2.486)	-	-
Log(percent arterials with lane widths of 11 ft.)	-0.002 (-0.133)	0.005 (0.277)	-	-
Log(percent arterials with lane widths of 12 ft. or greater)	0.008 (0.125)	0.147 (1.143)	-	-
Log(percent collectors with lane widths of 9 ft. or less)	-0.018 (-2.193)	-0.033 (-2.743)	-	-
Log(percent collectors with lane widths of 10 ft.)	0.002 (0.11)	-0.059 (-1.696)	-	-
Log(percent collectors with lane widths of 11 ft.)	-0.025 (-2.511)	-0.054 (-4.138)	-	-
Log(percent collectors with lane widths of 12 ft. or greater)	0.066 (2.108)	-0.035 (-0.514)	-	-
Primary Seatbelt Law	-0.043 (-2.471)	-0.059 (-1.581)	-0.035 (-2.017)	-0.064 (-1.643)
Secondary Seatbelt Law	0.004 (0.368)	0.009 (0.451)	0.010 (0.954)	0.005 (0.211)
Log(inverse of white infant mortality rate)	-0.181 (-3.431)	0.007 (0.994)	-0.192 (-3.603)	0.058 (0.751)
Log(hospitals per square mile)	0.002 (0.769)	*0.008* *(1.350)*	0.002 (0.649)	0.006 (0.985)
Constant	-1.712 (-0.259)	-38.073 (-3.530)	-3.919 (-0.599)	-45.440 (-4.222)
N	597	558	597	558
Log likelihood	-2757.64	-5024.79	-2771.57	-5053.70

Test statistic is in parentheses

Table 7 (continued)
Fixed Effect Negative Binomial Regressions with State Data (controlled for population), with Medical Technology variables

Aggregate State Data	Dependent Variable			
	DEATHS	INJURED	DEATHS	INJURED
	(E)	(F)	(G)	(H)
Years of data	1985-1996	1985-1996	1990-1996	1990-1996
Log(total lane miles)	0.300 (2.675)	0.528 (3.984)	-0.049 (-0.194)	1.185 (3.984)
Log(average number of interstate lanes)	-0.104 (-0.378)	2.337 (5.358)	1.381 (3.100)	2.940 (3.262)
Log(average number of arterial lanes)	0.091 (0.767)	0.347 (1.323)	0.402 (2.316)	0.570 (0.968)
Log(average number of collector lanes)	1.669 (3.103)	0.612 (0.525)	0.183 (0.323)	1.127 (0.657)
Log(percent interstate lane miles)	0.062 (0.643)	-0.277 (-2.009)	0.072 (0.394)	0.142 (0.458)
Log(percent arterial lane miles)	0.135 (1.664)	0.235 (1.617)	0.005 (0.047)	0.382 (1.662)
Log(percent collector lane miles)	0.126 (1.676)	0.298 (2.835)	0.070 (0.713)	0.197 (1.784)
Log(total ethanol consumed)	0.308 (4.353)	-0.425 (-3.806)	-	-
Log(per capita income)	1.057 (8.298)	0.994 (3.984)	1.283 (6.598)	0.988 (2.430)
Log(population)	-	-	0.293 (1.533)	-1.155 (-4.764)
Log(percent population aged 15-24)	0.501 (5.628)	0.895 (6.399)	0.947 (5.518)	1.310 (4.380)
Log(percent population over age 75)	-0.605 (-5.998)	-0.809 (-5.589)	-0.274 (-1.148)	-0.765 (-1.812)
Year	-0.003 (-0.888)	0.009 (1.556)	-0.003 (-0.636)	0.021 (2.233)
Log(percent arterials with lane widths of 9 ft. or less)	0.008 (1.562)	-0.019 (-2.264)	0.010 (1.553)	-0.026 (-2.813)
Log(percent arterials with lane widths of 10 ft.)	-0.025 (-2.188)	-0.050 (-3.209)	-0.009 (-0.521)	0.016 (0.711)
Log(percent arterials with lane widths of 11 ft.)	-0.009 (-0.660)	0.011 (0.614)	-0.009 (-0.515)	0.033 (1.257)
Log(percent arterials with lane widths of 12 ft. or greater)	-0.007 (-0.109)	0.158 (1.198)	-0.068 (-0.528)	0.108 (0.334)
Log(percent collectors with lane widths of 9 ft. or less)	-0.015 (-1.807)	-0.031 (-2.443)	-0.009 (-0.734)	-0.013 (-0.782)
Log(percent collectors with lane widths of 10 ft.)	0.001 (0.030)	-0.067 (-1.921)	-0.012 (-0.393)	-0.168 (-3.166)
Log(percent collectors with lane widths of 11 ft.)	-0.020 (-2.102)	-0.054 (-3.919)	-0.002 (-0.128)	-0.054 (-3.305)
Log(percent collectors with lane widths of 12 ft. or greater)	0.058 (1.924)	0.018 (0.264)	0.144 (3.011)	0.159 (1.204)
Primary Seatbelt Law	-0.032 (-1.898)	-0.069 (-1.837)	-	-
Secondary Seatbelt Law	-0.001 (-0.124)	0.009 (0.431)	-	-
Log(percent seatbelt usage)	-	-	-0.159 (-5.206)	-0.037 (-0.675)
Log(inverse of white infant mortality rate)	-0.184 (-3.627)	-0.055 (-0.699)	-0.147 (-2.526)	0.043 (0.446)
Log(hospitals per square mile)	0.001 (0.464)	0.009 (1.551)	-0.001 (-0.181)	-0.000 (-0.010)
Constant	-6.142 (-0.923)	-32.405 (-2.937)	-4.509 (-0.460)	-48.095 (-2.643)
N	597	558	347	325
Log likelihood	-2749.48	-5028.50	-1405.50	-2714.21

Test statistic is in parentheses

Table 8
Fixed Effect Negative Binomial Regressions with State Data (controlled for VMT), with Medical Technology variables

Aggregate State Data	Dependent Variable					
	DEATHS	INJURED	DEATHS	INJURED	DEATHS	INJURED
	(A)	(B)	(C)	(D)	(G)	(H)
Years of data	1985-1996	1985-1996	1985-1996	1985-1996	1990-1996	1990-1996
Log(total lane miles)	0.471 (4.255)	0.529 (3.400)	0.472 (4.240)	0.644 (3.944)	0.079 (0.323)	0.584 (2.156)
Log(average number of interstate lanes)	-0.031 (-0.110)	2.410 (5.382)	-0.051 (-0.180)	2.233 (4.714)	1.520 (3.440)	2.530 (2.909)
Log(average number of arterial lanes)	0.080 (0.626)	0.428 (1.623)	0.176 (1.442)	0.683 (2.404)	0.396 (2.226)	0.480 (0.855)
Log(average number of collector lanes)	1.875 (3.362)	-0.365 (-0.332)	1.646 (2.897)	-0.501 (-0.379)	0.276 (0.479)	0.143 (0.088)
Log(percent interstate lane miles)	0.090 (0.888)	**-0.232** **(-1.623)**	0.037 (0.368)	-0.338 (-2.247)	0.121 (0.657)	-0.395 (-1.391)
Log(percent arterial lane miles)	0.223 (2.738)	0.189 (1.303)	0.274 (3.471)	0.399 (2.645)	0.053 (0.489)	0.055 (0.248)
Log(percent collector lane miles)	0.147 (1.904)	0.371 (3.401)	0.153 (1.991)	0.437 (3.804)	0.105 (1.101)	0.207 (1.598)
Log(per capita income)	1.175 (8.824)	0.867 (3.541)	1.140 (8.439)	1.005 (3.860)	1.274 (6.127)	0.752 (1.728)
Log(VMT)	0.08 (1.055)	-0.349 (-2.986)	0.143 (1.927)	-0.535 (-4.389)	0.078 (0.559)	-0.577 (-2.621)
Log(percent population aged 15-24)	0.628 (7.516)	0.799 (5.855)	0.614 (7.653)	0.822 (5.666)	0.967 (5.600)	1.141 (3.462)
Log(percent population over age 75)	-0.689 (-6.927)	-0.780 (-5.500)	-0.657 (-6.971)	-0.801 (-5.348)	-0.273 (-1.065)	-1.049 (-2.747)
Year	-0.008 (-2.069)	**0.021** **(3.374)**	-0.009 (-2.392)	0.031 (4.957)	-0.004 (-0.640)	0.035 (3.361)
Log(percent arterials with lane widths of 9 ft. or less)	0.008 (1.580)	-0.022 (-2.610)	-	-	0.009 (1.328)	-0.027 (-2.456)
Log(percent arterials with lane widths of 10 ft.)	-0.026 (-2.327)	-0.047 (-2.810)	-	-	-0.009 (-0.589)	-0.007 (-0.242)
Log(percent arterials with lane widths of 11 ft.)	-0.001 (-0.090)	0.000 (0.006)	-	-	-0.007 (-0.427)	0.012 (0.492)
Log(percent arterials with lane widths of 12 ft. or greater)	0.010 (0.154)	0.151 (1.136)	-	-	-0.081 (-0.626)	0.80 (0.242)
Log(percent collectors with lane widths of 9 ft. or less)	-0.021 (-2.640)	-0.026 (-2.041)	-	-	-0.012 (-0.987)	0.002 (0.106)
Log(percent collectors with lane widths of 10 ft.)	0.002 (0.096)	-0.067 (-1.895)	-	-	-0.019 (-0.612)	-0.171 (-3.139)
Log(percent collectors with lane widths of 11 ft.)	-0.027 (-2.798)	-0.048 (-3.711)	-	-	-0.005 (-0.426)	-0.051 (-3.281)
Log(percent collectors with lane widths of 12 ft. or greater)	0.057 (1.840)	0.038 (0.563)	-	-	0.134 (2.712)	0.264 (1.958)
Primary Seatbelt Law	-0.043 (-2.400)	-0.075 (-2.065)	-0.036 (-2.012)	**-0.083** **(-2.106)**	-	-
Secondary Seatbelt Law	0.003 (0.299)	0.012 (0.566)	0.008 (0.693)	0.014 (0.631)	-	-
Log(percent seatbelt usage)	-	-	-	-	-0.159 (-5.189)	-0.038 (-0.582)
Log(inverse of white infant mortality rate)	-0.164 (-3.220)	-0.056 (-0.693)	-0.160 (-3.122)	-0.005 (-0.057)	-0.127 (-2.269)	-0.023 (-0.215)
Log(hospitals per square mile)	0.002 (0.759)	0.009 (1.503)	0.002 (0.671)	0.007 (1.169)	-0.001 (-0.310)	0.002 (0.214)
Constant	2.176 (0.298)	-53.878 (-4.471)	3.940 (0.552)	-73.046 (-6.214)	-1.231 (-0.105)	-79.603 (-3.997)
N	597	558	597	558	347	325
Log likelihood	-2757.81	-5031.30	-2772.44	-5063.20	-1406.49	-2721.56

Test statistic is in parentheses

Table 9

Estimated Changes in Fatalities and Injuries using Elasticity Values from Population-based Models

Results from Models 7-A and 7-B	Fatality Elasticity	Injury Elasticity	Change in 1985 fatalities with 1996 values of each variable	Change in 1985 injuries with 1996 values of each variable
Total Lane Miles	0.435	0.743	378	50867
Average Interstate Lanes	*	2.681	*	256943
Average Arterial Lanes	0.119	*	125	*
Average Collector Lanes	1.813	*	-28	*
Percent Interstate Lane Miles	*	*	*	*
Percent Arterial Lane Miles	0.196	0.360	749	108394
Percent Collector Lane Miles	*	0.360	*	-40940
Percent Arterials with 9 ft or less Lane Widths	*	-0.023	*	38551
Percent Arterials with 10 ft Lane Widths	-0.026	-0.040	297	36041
Percent Arterials with 11 ft Lane Widths	*	*	*	*
Percent Arterials with 12 ft or greater Lane Widths	*	*	*	*
Percent Collectors with 9 ft or less Lane Widths	-0.018	-0.033	252	36372
Percent Collectors with 10 ft Lane Widths	*	-0.059	*	26118
Percent Collectors with 11 ft Lane Widths	-0.025	-0.054	-134	-22837
Percent Collectors with 12 ft or greater Lane Widths	0.066	*	610	*
Total for Lane Width Variables			**1025**	**114245**
Total for Infrastructure Variables			**2249**	**489509**
Average Inverse White Infant Mortality	-0.181	*	-4158	*
Average Per Capita Income	1.222	0.785	10707	542071
Total Population	*	-0.575	*	*
Total Percent aged 15-24	0.638	0.786	-5258	-510561
Total Percent aged over 75	-0.689	-0.797	-4948	-451122
Seatbelt Use (model 7-G, 7-H)	-0.159	-0.037	-15574	-285634

* Not significant at 90% level

Table 10

Estimated Changes in Fatalities and Injuries using Elasticity Values from VMT-based Models

Results from Models 8-A and 8-B	Fatality Elasticity	Injury Elasticity	Change in 1985 fatalities with 1996 values of each variable	Change in 1985 injuries with 1996 values of each variable
Total Lane Miles	0.471	0.529	409	36216
Average Interstate Lanes	*	2.410	*	230970
Average Arterial Lanes	*	0.428	*	35437
Average Collector Lanes	1.875	*	-29	*
Percent Interstate Lane Miles	*	-0.232	*	-45984
Percent Arterial Lane Miles	0.223	*	852	*
Percent Collector Lane Miles	0.147	0.371	-210	-41727
Percent Arterials with 9 ft or less Lane Widths	*	-0.022	*	36874
Percent Arterials with 10 ft Lane Widths	-0.026	-0.047	297	42348
Percent Arterials with 11 ft Lane Widths	*	*	*	*
Percent Arterials with 12 ft or greater Lane Widths	*	*	*	*
Percent Collectors with 9 ft or less Lane Widths	-0.021	-0.026	294	28657
Percent Collectors with 10 ft Lane Widths	*	-0.067	*	*
Percent Collectors with 11 ft Lane Widths	-0.027	-0.048	-145	-20299
Percent Collectors with 12 ft or greater Lane Widths	0.057	*	527	*
Total for Lane Width Variables			**973**	**87580**
Total for Infrastructure Variables			**1995**	**302492**
Average Inverse White Infant Mortality	-0.164	*	-3767	*
Average Per Capita Income	1.175	0.867	10295	598695
Total VMT	0.08	-0.349	1398	-480597
Total Percent aged 15-24	0.628	0.799	-5176	-519006
Total Percent aged over 75	-0.689	-0.780	-4948	-441499
Seatbelt Use (model 8-G, 8-H)	-0.159	-0.038	-15574	-293354

* Not significant at 90% level

e 1
:-offs Between Safety and Mobility

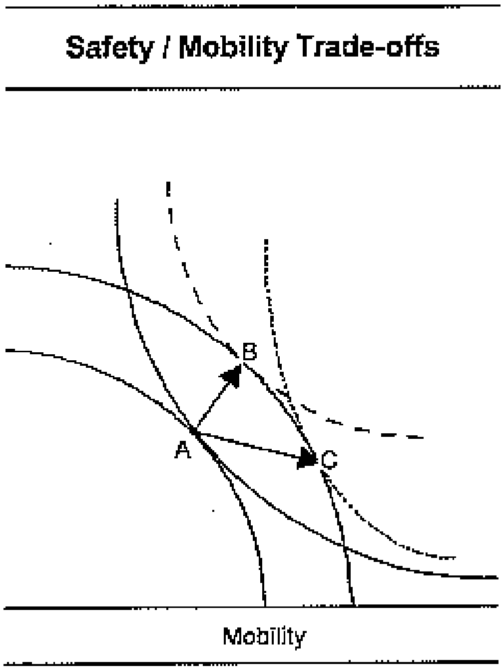


Figure 2
Trends in US Traffic Fatalities and Injuries (index = 100 in 1967)

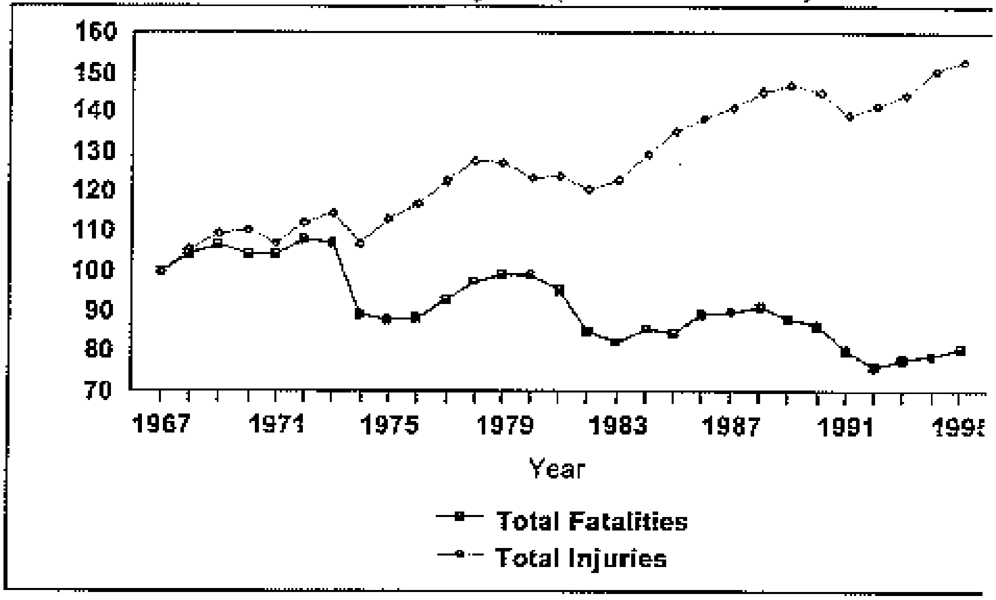


EXHIBIT M

TOTAL TRUCK MOVEMENTS ON HIGHWAY CROSSINGS BETWEEN SOUTHEAST MICHIGAN AND ONTARIO

prepared on 11 May 2001 by D. R. Bergmann

Calendar	Ambassador Bridge		Detroit-Windsor Tunnel		Both Detroit Crossings		Blue Water Bridge		All Three Crossings	
Year	Trucks	% Change*	Trucks	% Change*	Trucks	% Change*	Trucks	% Change*	Trucks	% Change*
1995	2,218,596		267,187		2,485,783		1,178,730		3,664,513	
1996	2,476,360	11.62%	269,388	0.82%	2,745,748	10.46%	1,184,862	0.52%	3,930,610	7.26%
1997	2,697,176	8.92%	257,557	-4.39%	2,954,733	7.61%	1,269,697	7.16%	4,224,430	7.48%
1998	2,993,292	10.98%	241,271	-6.32%	3,234,583	9.47%	1,350,860	6.39%	4,585,423	8.55%
1999	3,428,151	14.53%	205,015	-15.03%	3,633,166	12.32%	1,495,325	10.69%	5,128,491	11.84%
2000	3,486,110	1.69%	182,392	-11.03%	3,668,502	0.97%	1,576,839	5.45%	5,245,341	2.28%

SOURCE: Year-end "Traffic Reports" prepared by the United States-Canada Bridge and Tunnel Operators Association

NOTES:

(1) Data in "% Change*" columns are the percentages by which the number of truck movements in the given year increased (or decreased) from the number of truck movements in the immediately preceding year.

(2) The tabulations shown above do not account for the highway trailer movements accomodated by railroads through the railroad tunnel between Detroit and Windsor and through the railroad tunnel between Port Huron and Sarnia. Railroads providing intermodal freight services through one or both of the two railroad tunnels include the following: CN Rail; CP Rail; Norfolk Southern; and possibly others

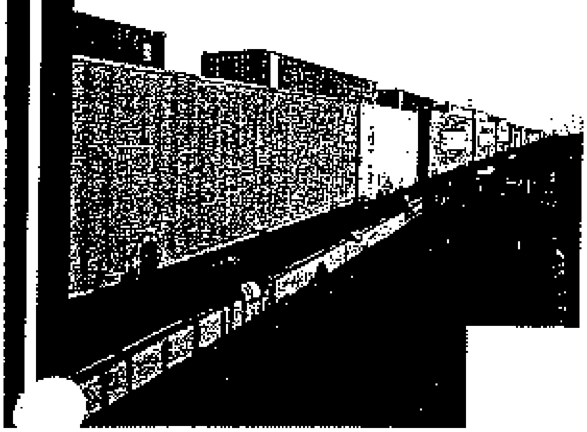
(3) The tabulations shown above also do not account for US-Canada border crossings by trucks using St. Clair River ferry services.

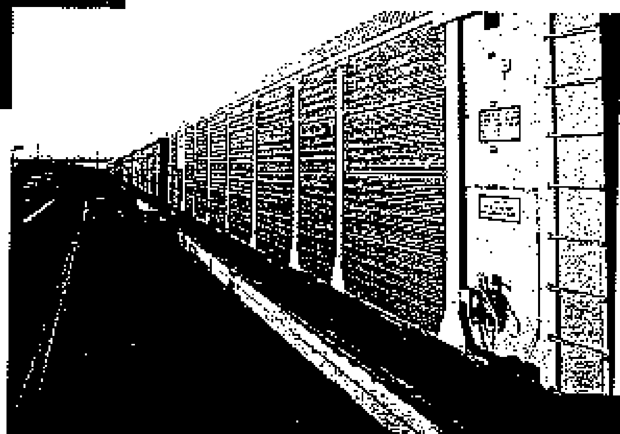
EXHIBIT N

Detroit Intermodal Freight Terminal Study

Undertaken by the

MDOT
Michigan Department of Transportation





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March 2001

DIFT STUDY PURPOSE & GOALS

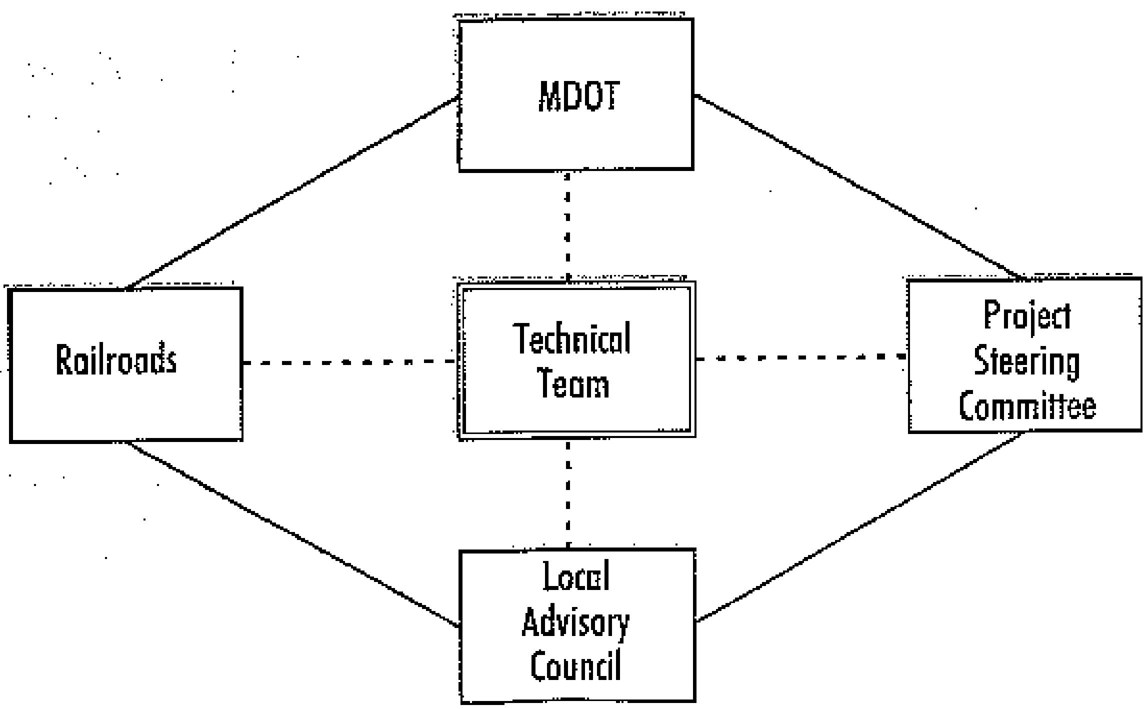
The ***purpose*** of the Detroit Intermodal Freight Terminal project is to support the economic competitiveness of southeastern Michigan, by improving freight transportation opportunities and efficiencies for business and industry. The ***goal*** is to develop a regional intermodal facility with sufficient capacity to provide for existing and future intermodal demand. The ***goal of this Feasibility Study*** is to facilitate the project goal by:

- Identifying the footprint, and requirements for right-of-way, and/or ancillary railway facilities, for the Intermodal Freight Terminal;
- Identifying practical alternatives for highway access to the Intermodal Freight Terminal; and,
- Identifying potential environmental impacts of the project, and where possible, avoiding and/or minimizing these impacts.

DEFINITION OF INTERMODAL TRANSPORTATION

Intermodal transportation involves movement of people or goods by two or more modes. In the freight context, it frequently involves transportation of a container by ship, rail, and truck. A key component of the intermodal transportation system involves a terminal where transfer between modes occurs. For purposes of this study, intermodal transportation means the movement of truck trailers or shipping containers to/from rail. An intermodal terminal is the location where the trailers or containers are loaded onto, or unloaded from, railcars.

ORGANIZATION



DIFT ROLES

MICHIGAN DEPARTMENT OF TRANSPORTATION Contracting agency for the study. Has ultimate responsibility for making study recommendations to Governor Engler. Has responsibility for implementing study results.

Project Steering Committee Comprised of MDOT, City of Detroit, Wayne County, City of Dearborn, SEMCOG, Federal Highway Administration, Detroit Economic Growth Corporation, Daimler Chrysler Corporation, Ford Motor Company, General Motors Corporation, Arbor Vista Transportation Consultants. Provides monthly guidance of project. Meetings are open to the public.

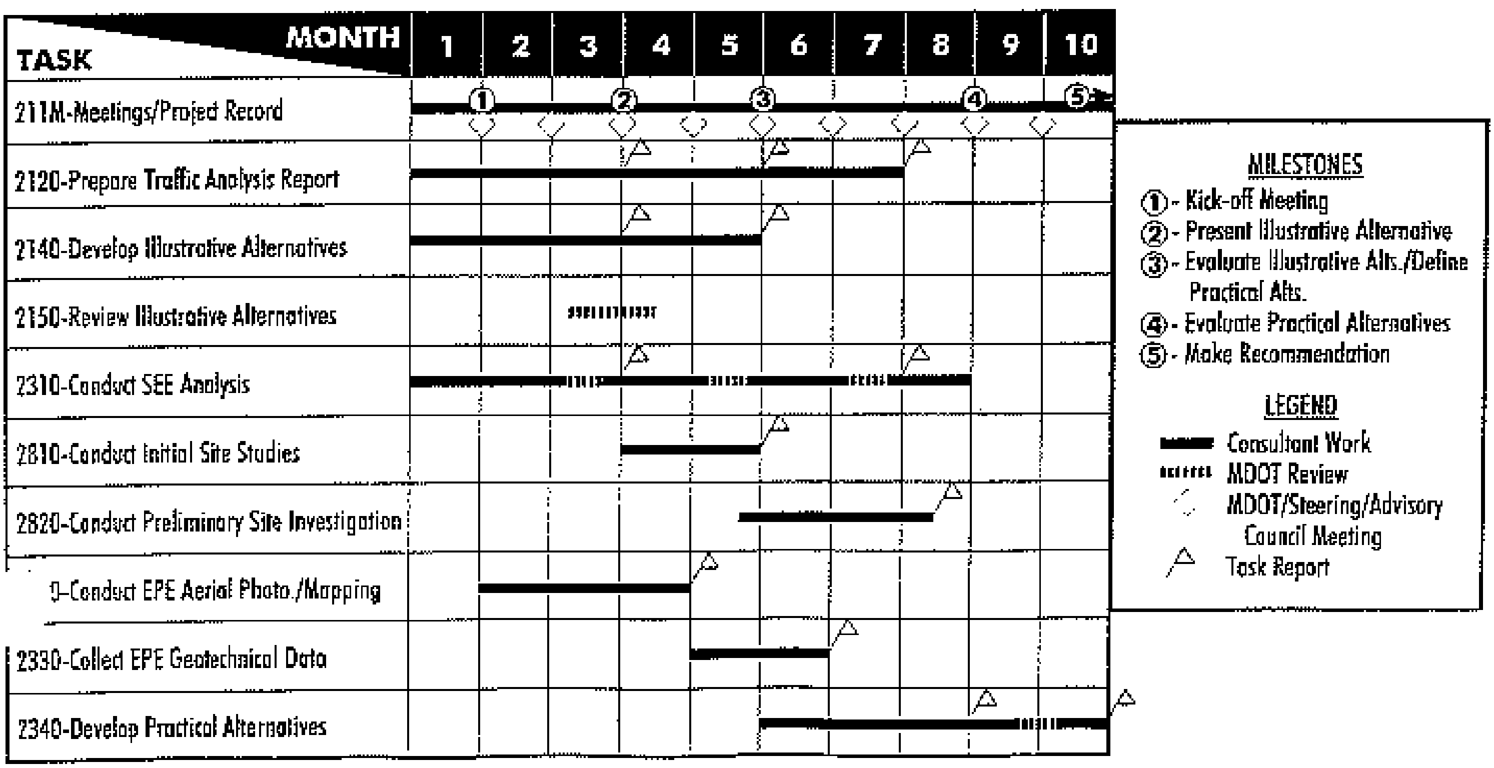
Local Advisory Council Comprised of Alliance Shippers, Inc., Barge Transit, Boniface Community Center, The Canadian Transit Company, Centra Inc., City of Windsor, Corktown Citizens District Council, Detroit Chamber of Commerce, Detroit International Bridge Company, Detroit Police Department, Hispanic Business Alliance, Hubbard-Richard Citizens District Council, Latino Family Services, Michigan Environmental Council, Mt. Zion MBC, The O-J Group, Southwest Detroit Business Association, Southwest Detroit Coalition, U.S. Customs Ambassador Bridge Station, and others to be added.

Receives project reports prior to discussions at public meetings. Provides regular input to course of project including evaluation of highway access alternatives. Meetings are open to the public.

Railroads Comprised of Burlington Northern Santa Fe, Canadian National Railway, Canadian Pacific Railway, CSX Transportation, Norfolk Southern Corp., and Union Pacific Railroad. Review, as appropriate, products of project. Develop intermodal terminals, construct appropriate rail connections and provide intermodal transportation service.

Technical Team Comprised of a technical representative of each government agency represented on Project Steering Committee. Meets monthly to review/direct work of consulting team, The Corradino Group, et al.

SCHEDULE



Detroit Intermodal Freight Terminal Study

STUDY AREA

Internal Circuit — Road →
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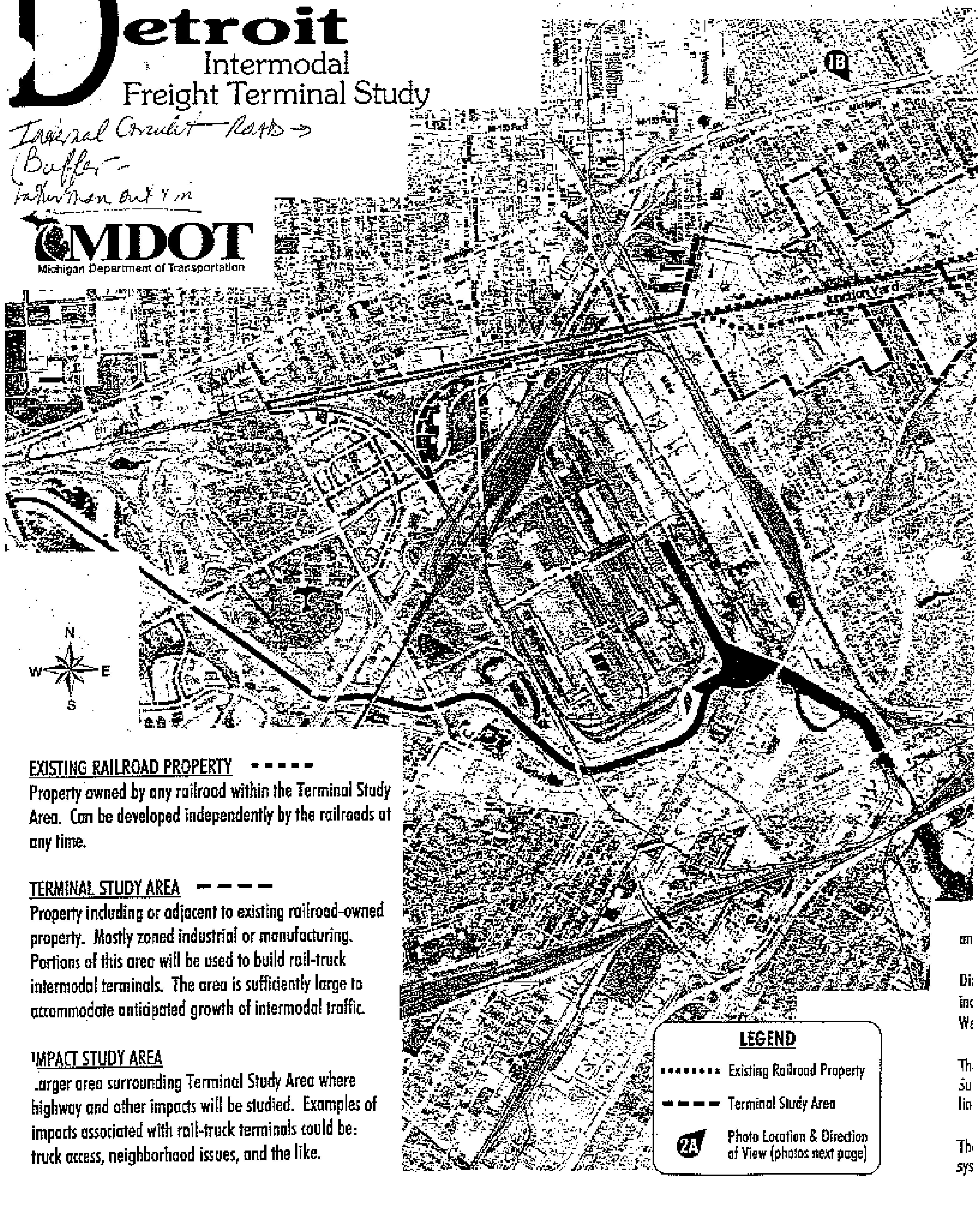
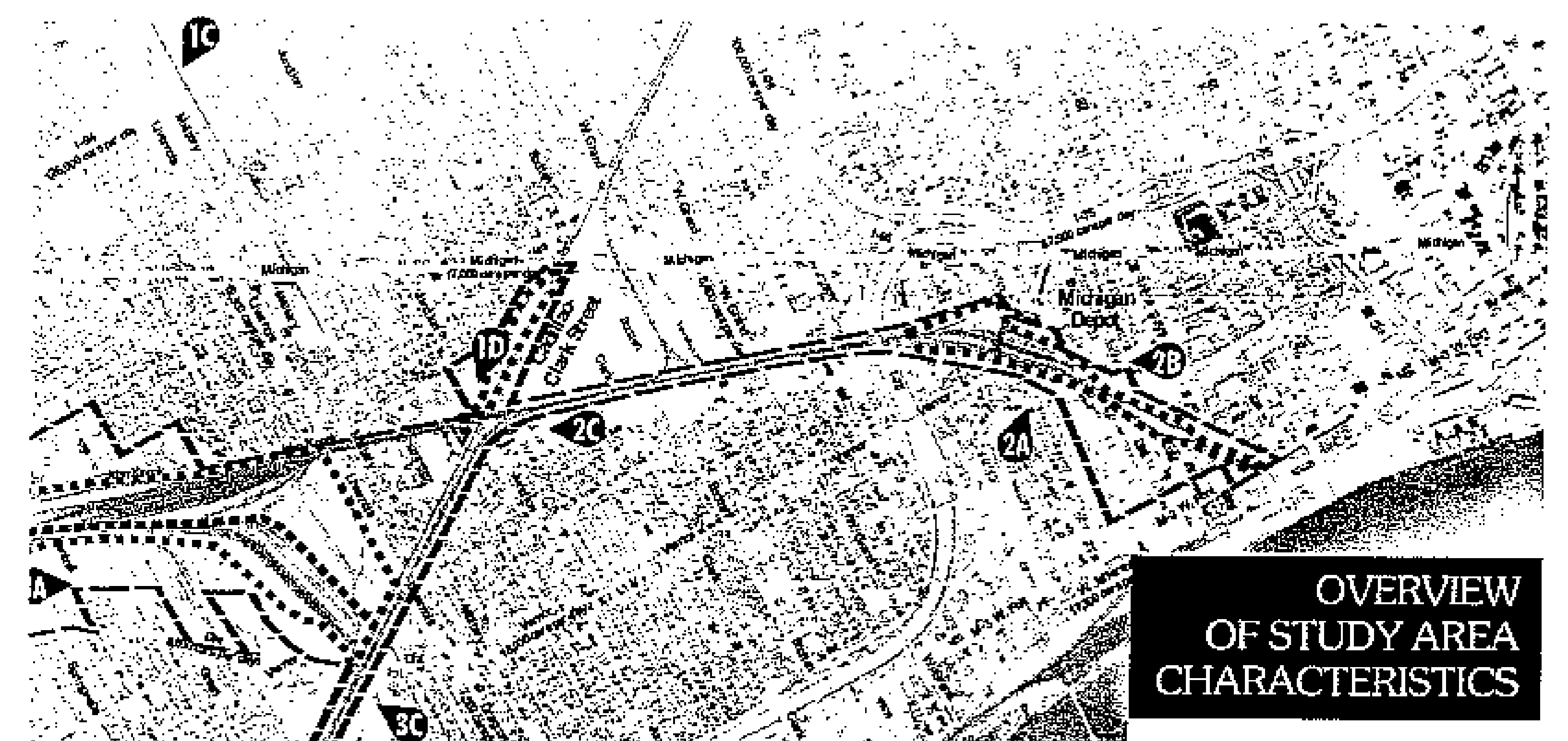
MDOT
Michigan Department of Transportation



EXISTING RAILROAD PROPERTY - - - - -
Property owned by any railroad within the Terminal Study Area. Can be developed independently by the railroads at any time.

TERMINAL STUDY AREA — — — —
Property including or adjacent to existing railroad-owned property. Mostly zoned industrial or manufacturing. Portions of this area will be used to build rail-truck intermodal terminals. The area is sufficiently large to accommodate anticipated growth of intermodal traffic.

IMPACT STUDY AREA
Larger area surrounding Terminal Study Area where highway and other impacts will be studied. Examples of impacts associated with rail-truck terminals could be: truck access, neighborhood issues, and the like.



OVERVIEW OF STUDY AREA CHARACTERISTICS

The Detroit Intermodal Freight Terminal Project study area is shown here. The study area is bounded roughly by I-94 and US-12 to the north, M-39 to the west, I-75 to the south, and M-10 to the east. Land uses in the study area are a blend of industrial, commercial, recreational, and residential functions.

The neighborhoods in the project area and some of the organizations that serve them include Mexicantown, Briggs Community Council, Bagley Housing Association, Corktown CDC, Hubbard-Richard CDC, LaSED, Southwest Business Owners Association, Southwest Detoit Improvement Association, DelRay Community District Council and Southwest Detroit Business Association.

Four railroad companies in Michigan have intermodal activity in this area because of its convenient access to the major metropolitan freeways and trade routes. International border crossings at the Ambassador Bridge, the Detroit-Windsor Tunnel, and the Detroit-Canada Rail Tunnel are nearby. The Wayne County waterport is in the study area's "backyard". And, the region's airports are directly connected to the DIFT study area by the freeway system.

The Fisher Freeway (I-75) is a major north-south interstate that connects Miami, Florida, to the south and Sault Ste. Marie to the north in Michigan's Upper Peninsula. I-75 is a major economic corridor that is critical to Michigan's and the nation's economy.

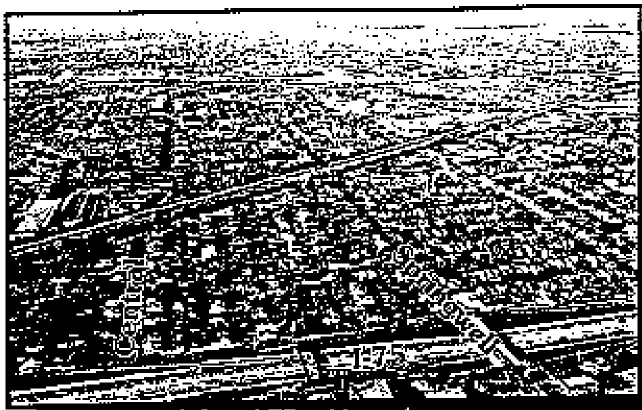
The Edsel Ford Freeway (I-94) is a primary east-west connector linking Canada through Port Huron, Michigan, to Chicago and points west. I-94 also links four regional airports in southeast Michigan. I-96 (Jeffries Freeway) originates at the Ambassador Bridge where it intersects with I-75 and I-94. It runs west through Lansing, Michigan, and Grand Rapids before terminating near Grand Haven.

Michigan Avenue (US-12) connects Downtown Detroit to Dearborn and to several suburbs to the west. Michigan Avenue is important to this area's neighborhoods esses for efficient movement of people and goods.

ay and Fort Street (M-85) are important arterials that connect downriver communities to the area. Other streets which are critical to this area's transportation network efferson, Vernor, Toledo, John Kronk, Schaeffer, Wyoming, Miller, Springwells, Lonyo, Central, West End, Green, Waterman, Livernois, Dragoon, Junction, Clark, Scotten, d Blvd., 14th Street, and others.

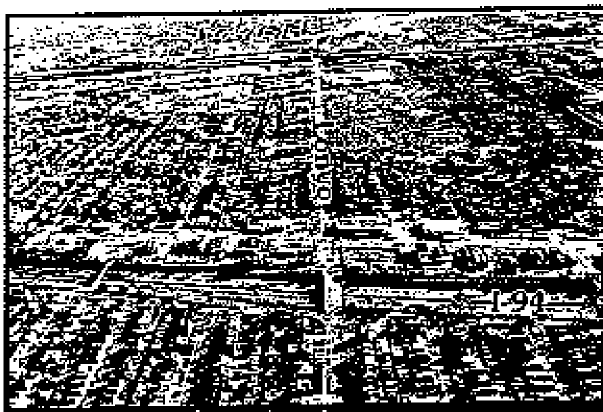
tw c transit systems presently serving this area of Detroit. The Detroit Department of Transportation (DDOT) has more than a half dozen routes that serve this area. M Authority for Regional Transportation (SMART) offers service in and out of Detroit and the suburbs. It offers two lines that serve the study area including the Fort Street he Michigan Avenue line.

portation infrastructure is showing its age, due to its heavy use. Street pavement, railroad grade separations, and traffic control devices are part of the entire transportation be addressed for operations as well as safety considerations in the DIFT Study.

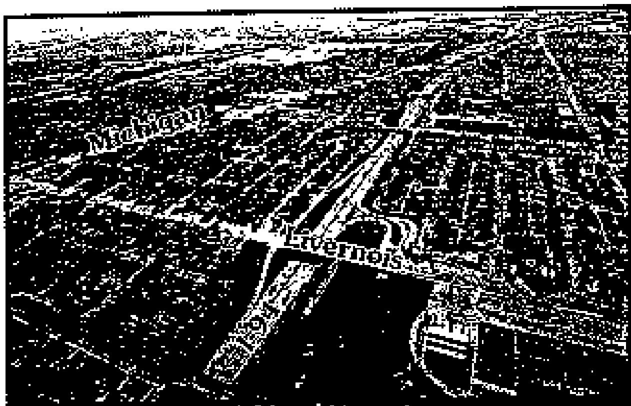


1A View north from I-75 at Livernois

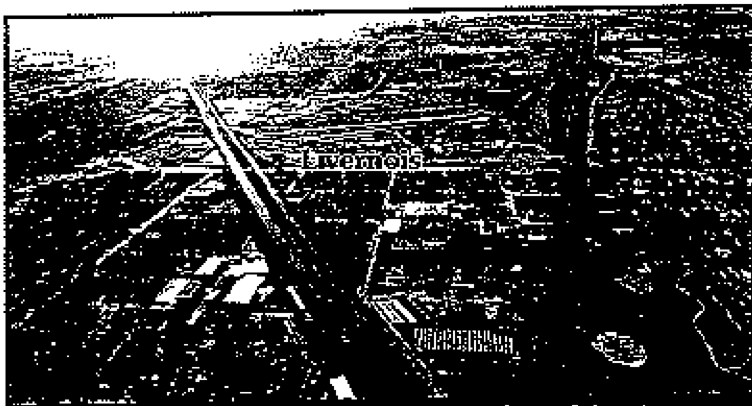
See map on previous page for photo location and direction of view



1B View south from I-94 at Lonyo

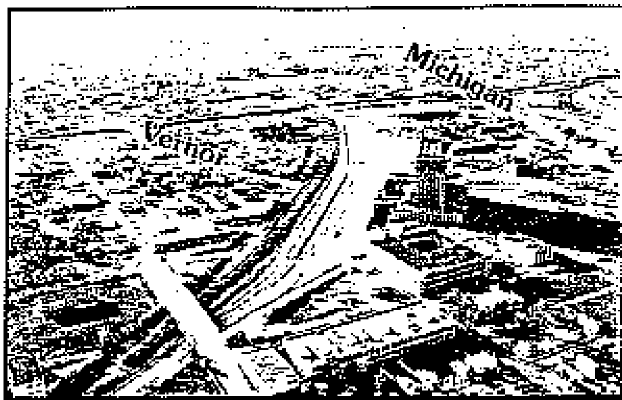


1C View to west at I-94 and Livernois

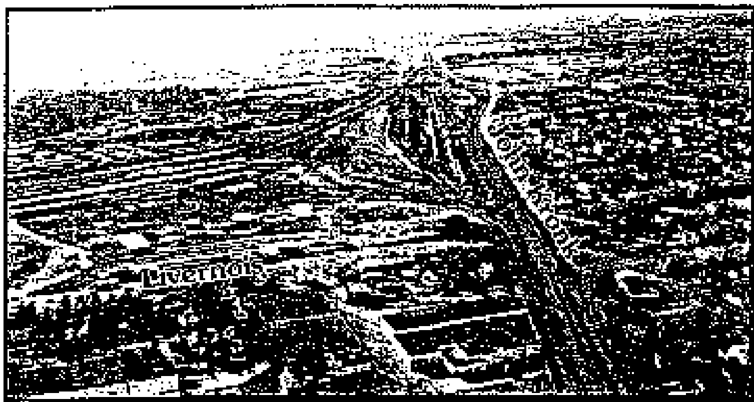


1D View southwest from rail junction near Michigan & Junction

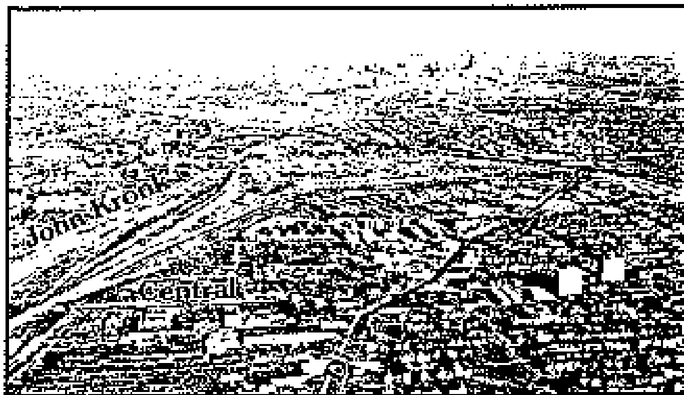
2A View north at Michigan Central Depot



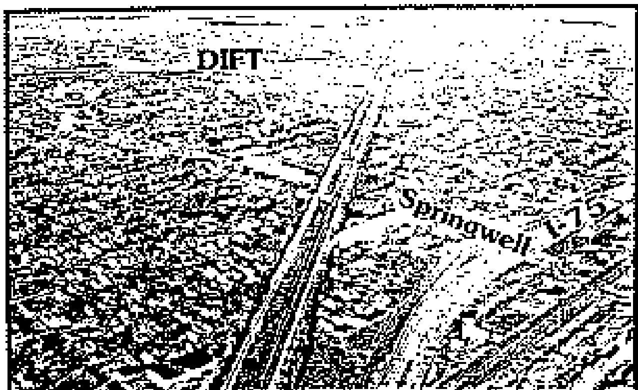
2B View west of Michigan Central Depot



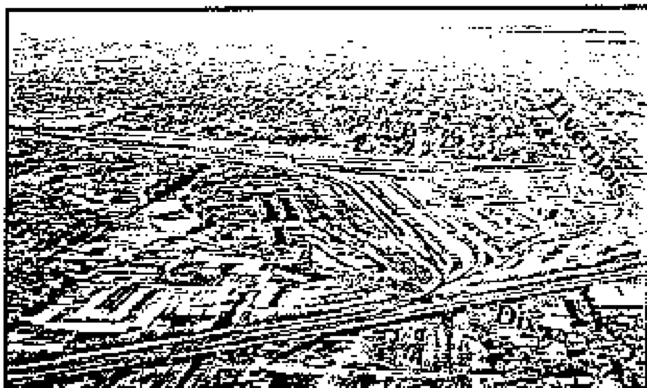
2C View west along Conrail lines



3A View east toward downtown from DIFT



3B View northeast from I-75 toward DIFT



3C The Detroit Intermodal Freight Terminal looking north from Dix

KEY FACTS

- There are nine existing intermodal freight terminals in the Greater Detroit Area and many are operating at or close to capacity.

- Existing traffic of 400,000 trailers or containers per year could increase to one million by 2015 or before.

- A complex of intermodal terminals centered on the Junction Yard will be a more attractive location for investment which will have regional benefits.

  - ✔ The public will benefit from opportunities for economic development and from reduced highway congestion and pollution, and

  - ✔ Shippers will benefit from increased competition and improved transportation service.

Notes

For more information visit our Web site:

http://www.mdot.state.mi.us/projects/dift/

or call

313-964-4543

EXHIBIT O

Detroit Intermodal Freight Terminal

Background

Intermodal transportation, the fastest growing segment of the freight industry, is an essential element in the growth and success of industries and businesses in southeast Michigan. Detroit is already one of the top ten intermodal markets in North America. Its key location as the gateway to Canada, its long history as the home of the automotive industry, its role as a major manufacturing center, and its population of five million consumers make the Greater Detroit Area a major intermodal transportation market.

The Michigan Department of Transportation (MDOT) sponsored studies to look at intermodal growth issues and terminal needs in the Greater Detroit Area. The studies determined that approximately 400,000 trailers or containers per year are handled at the existing terminals in the Detroit area and an additional 180,000 are trucked to other intermodal terminals located in Chicago, Toledo, Cincinnati, and Toronto. The traffic that is trucked to other rail gateways adds further congestion to the major international corridors across Michigan, including I-94 and I-75.

The studies also found that the area was served by a dispersed set of relatively small intermodal terminals which were mostly operating at or above their design capacity. Estimates of growth of intermodal traffic for the region were generated (which have been shown to be conservative) and compared with the terminal capacity. The total number of trailers or containers that will be handled in Detroit, including those currently trucked to other gateways, could increase to one million by 2015 or sooner. It was evident that the existing terminals were insufficient to accommodate the expected growth of traffic and that the "do nothing" approach would result in each railroad adding additional terminal capacity, and perhaps additional terminals, when needed and without any coordination with other carriers or shippers. The result would be an even more inefficient, widely dispersed set of terminals--each of which would place demands on the highway system for access. Since the planning efforts began, two railroads have constructed additional terminals to accommodate intermodal traffic growth.

MDOT's consultants then proposed the development of a large intermodal terminal which would be served by all Class I railroads and provide the economies of scale which would allow lower operating costs and increased capacity. Additionally, the Michigan Department of Transportation and local road agencies could focus their resources on providing a high-level access to a single intermodal terminal site. An extensive site selection process was undertaken for a possible location. The area including and surrounding the existing Junction/Livernois Yard was determined to be the best location for the intermodal terminal complex. The area has the following attributes:

- The rail yard has been in existence for over a century and is underutilized
- The area is accessible to all Class I railroads (Canadian National, Canadian Pacific, CSX Transportation, Norfolk Southern) and is centrally located between I-75 and I-94, Michigan's principal commercial highways and international corridors
- The area is centrally located with respect to shippers in southeast Michigan

- The area is predominantly zoned for industrial or manufacturing purposes

Project Benefits

Development of the Detroit Intermodal Freight Terminal complex will provide significant benefits to both the public and private sectors.

For the State of Michigan and the Greater Detroit Area, the project will provide:
- Reduced truck traffic, particularly on the major border access corridors of I-94 and I-75 and international border crossings, resulting in less congestion and lower maintenance costs
- An opportunity to focus development of intermodal connectors
- Increased competitiveness for goods produced
- A world-class transportation hub around which further industrial redevelopment can occur
- Improved long-term viability of the automotive industry
- Job growth and an improved tax base

For the railroads, the project will provide:
- Opportunities to gain additional intermodal traffic from the automotive industry, their suppliers, and other major shippers
- Additional low-cost, efficient, local rail infrastructure and terminal capacity

For the automotive industry and other major shippers, the project will provide:
- Enhanced access to both international and domestic intermodal freight transportation systems
- Efficient service based on equal access for all Class I railroads in southeast Michigan
- Improved intermodal access to the 8th largest metropolitan area in the United States
- A greater range of freight transportation service options

Development Plan

The consulting team's original concept proposal called for the development of a single, large intermodal terminal which would be utilized by all the Class I railroads serving the Greater Detroit market. The terminal would possibly be publicly-owned and developed cooperatively by the public and private sectors. The concept was discussed extensively with the railroads, which had concerns about ownership issues and operations into an intermodal terminal that they did not control. As a result of these very useful discussions with the railroads, the concept was modified slightly to include a complex of intermodal terminals, each owned or operated by individual railroads. This allows each railroad to control its own service, operations, and reliability, while preserving the benefits of consolidating intermodal services into a single area.

Actual development of the terminal complex will be a partnership between the public sector and the private railroads which provide intermodal freight services. Public monies will be made available on a matching basis, either through loans or grants, to individual railroads for the construction of or improvements to intermodal terminals within the complex, or for improvements to the rail infrastructure which provides access to the complex. The automotive industry and other major shippers will participate in the form of agreements with the railroads to offer intermodal cargo to be carried by the railroads. Provision of adequate highway access to the terminal complex will be the responsibility of the appropriate state, county, or city road authority.

Current Status

Planning and coordination have continued to refine the concept and address issues including property requirements, funding mechanisms, governance, terminal operations, trackage rights, highway improvements, and environmental impacts. Negotiations with each of the railroads, the automotive industry, and other major shippers continue.

A project Steering Committee meets monthly to monitor the progress and guide the project. It includes representatives from the Michigan Department of Transportation, Detroit Department of Transportation, Detroit Economic Growth Corporation, City of Dearborn, Wayne County, Southeast Michigan Council of Governments, Federal Highway Administration, DaimlerChrysler Corporation, Ford Motor Company, General Motors Corporation, and the consulting firms under contract to MDOT.

A Local Advisory Council has been established and is comprised of a variety of organizations and agencies. It receives project reports prior to discussions at public meetings and provides regular input to the project, including the evaluation of highway access alternatives.

A series of meetings for the general public are scheduled to be held within the local community. The purpose is to provide information concerning the project to the local residents and other interested parties, as well as receiving comments from them.

The project is included in the Southeast Michigan Council of Government's Regional Transportation Plan and Transportation Improvement Program, and in the Michigan Department of Transportation's State Transportation Improvement Program.

Public Endorsements

The project has received strong support from Governor John Engler, Mayor Dennis Archer, Congresswoman Kilpatrick, Congressman Dingell, and others. Governor Engler's support has included personal conversations with the CEO's of the Class I railroads and automotive industry executives, as well as approval for continued state planning activities for the project. Mayor Archer has stated his support through numerous meetings and conversations with automotive industry executives and direction to city agencies to participate in the project. As a state legislator, Ms. Kilpatrick sponsored legislation leading to the initial consultant study of the project. As a Congresswoman, she and Congressman Dingell have expressed their support for the project by including it as a high priority project within TEA-21 and providing $18 million in federal funding. Support from private parties includes the automotive manufacturers, other shippers, and railroads. Negotiations and discussions with these parties continue and they are directly participating in the planning process for the project.

Detroit Intermodal Freight Terminal Study

Possible Questions/Responses

Q. What is the purpose of this study?

R. The ***purpose*** of the Detroit Intermodal Freight Terminal project is to support the economic competitiveness of southeastern Michigan, by improving freight transportation opportunities and efficiencies for business and industry. The ***goal*** is to develop a regional intermodal facility with sufficient capacity to provide for existing and future intermodal demand.

Q. How long will this study take?

R. This phase will be completed in early December 2001. If the project is deemed feasible, additional work will be undertaken in 2002.

Q. Is there any money to make improvements?

R. Yes. First, the state, the city of Detroit, and the railroads have and will continue to invest in the existing rail facilities. Additionally, the federal government, thanks to Congresswoman Kilpatrick and Congressman Dingell and other Michigan legislators, has made almost $20 million available to invest in freight terminal development following receipt of environmental clearances. Federal money, along with additional state funds would be used to finance terminal development or expansion, railroad track improvement, and upgrades to roads and streets connecting the terminal area to nearby major highways.

Q. Are you going to expand the freight terminal beyond the Junction Yard?

R. A plan has been developed by MDOT that calls for establishing at least four separately-operated, intermodal terminals. Property including or adjacent to existing railroad-owned property, that is mostly zoned industrial or manufacturing, will be used to build rail-truck intermodal terminals

Q. What do you mean by "intermodal"

R. For purposes of this study, intermodal transportation means the movement of truck trailers or shipping containers to/from rail. An intermodal terminal is the place where the trailers/containers are loaded into, or unloaded from railcars.

Q. What is the situation today?

R. There are nine existing intermodal freight terminals in the Greater Detroit area and many are operating at or close to capacity. Detroit is already one of the top ten intermodal markets in North America. And, intermodal transportation is the fastest growing segment of the freight industry.

Q. What's in this for me, the average taxpayer?

R. A complex of intermodal terminals centered on the Junction Yard in southwest Detroit will be a more attractive location for investment, which will have regional benefits. The public will benefit from opportunities for economic development and from reduced highway congestion and pollution.

Q. What's the benefit for me, a shipper?

R. Shippers will benefit from increased competition and improved transportation service

Q. Who's involved in this project?

R. Five groups: 1) MDOT; 2) a Project Steering Committee including Daimler-Chrysler, Ford and GM plus representatives of Detroit, Dearborn, Wayne County and SEMCOG and the federal government; 3) a local Advisory Council, which any citizen or group is welcome to join; 4) the railroads; and, 5) the consultant team, lead by The Corradino Group.

Q. Will the public be involved?

R. Yes. Five rounds of public meetings will be held from mid-March to mid-December 2001. Additionally, the Advisory Council is opened to the public. Its members will receive reports prior to the public at-large to provide input.

Q. Where can I get more information?

R. If you want any information at any time visit the Web site at www.mdot.state.mi.us/projects/dift/, or call 313-964-4543. Let us know if you or your group would like a special meeting and it will be arranged.

Detroit Intermodal Freight Terminal

Background

Junction Yard
For more than a century, a large railroad yard has existed between John Kronk, Livernois, and Dix extending west to about Miller Street. This yard is just a short distance west of the junction of the intersection of mainline railroad tracks running east-west and another line running roughly north-south.

The Truck/Train Partnership
A significant volume of freight being moved by railroads today is being delivered to the rail line on a truck. Following the train trip, it is again moved by truck to its final destination.

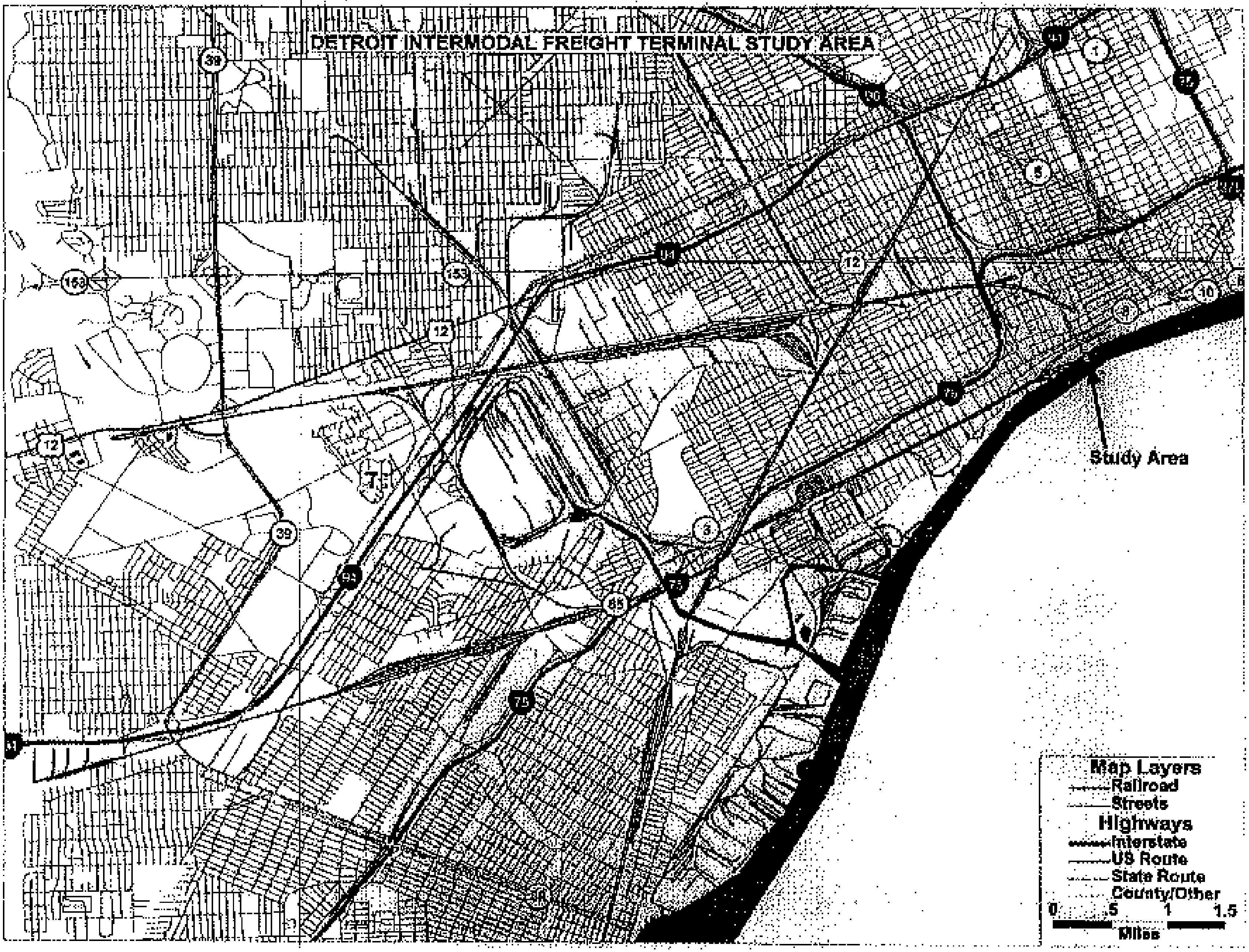
Intermodal Freight
These movements between rail and truck are termed intermodal freight transportation. The most common movements involve transferring containers or trailers between railroad flatcars and trucks. This activity usually takes place at a location called a terminal.

The Detroit Intermodal Freight Terminal (DIFT)
The Detroit Intermodal Freight Terminal project consists of the development of a complex of terminals operated by several railroads, which will provide efficient intermodal service to business and industry. Presently, there are two intermodal terminals in close proximity in Southwest Detroit. These are: Junction/Livernois Yard (operated by CSX and Norfolk Southern) and the newly-created yard behind the Michigan Central Depot just north of Bagley (operated by Canadian Pacific Railway). There is another smaller area that may be used for intermodal freight just south of Clark Street adjacent to the old Cadillac plant. These three form the nucleus of what is referred to as the Detroit Intermodal Freight Terminal, the DIFT. There are six other intermodal freight terminals in the Detroit and Southeast Michigan area.

The Inevitability of Growth
Because of the growth of intermodal rail freight, the amount of freight moving through the DIFT yards is certain to grow over the foreseeable future. Whether or not this will require more land for the railyards themselves is the subject of another study. Intermodal traffic using terminals in Southwest Detroit will grow significantly, whether developed independently by the railroads or in cooperation with MDOT.

Involving the Nearby Community
It is the charge of this study to evaluate the impacts of this movement of trucks into and out of the intermodal freight terminal(s). It is important that the movement of the freight that drives jobs and economic growth be facilitated. It is also important that the movement of these trucks to and from the interstates and other local points respect the quality of life of the residents of Southwest Detroit. The current DIFT Study is designed to address this issue.

For the remainder of the year, MDOT and its consultants will be estimating these truck movements, evaluating their impacts, and making recommendations to protect the neighborhoods as much as possible. This can only be done well if the neighbors are involved.



DETROIT INTERMODAL FREIGHT TERMINAL STUDY AREA
Study Area
Map Layers
Railroad
Streets
Highways
Interstate
US Route
State Route
County/Other
0 .5 1 1.5
Miles

EXHIBIT P

REGIONAL PASSENGER RAIL - a Concept for Southeastern Michigan

SUMMARY REPORT

Southeastern Michigan Regional Rail Study

Regional Passenger Rail - A Concept for Southeastern Michigan

This report represents the findings and/or professional opinions of De Leuw, Cather & Company of Michigan, under contract to the Michigan Department of Transportation. This publication does not represent an official opinion of the Michigan Department of Transportation or State Transportation Commission.

Photos courtesy of De Leuw, Cather & Company of Michigan; except page 2, center, courtesy of Amtrak and page 6, bottom, courtesy of Conrail.

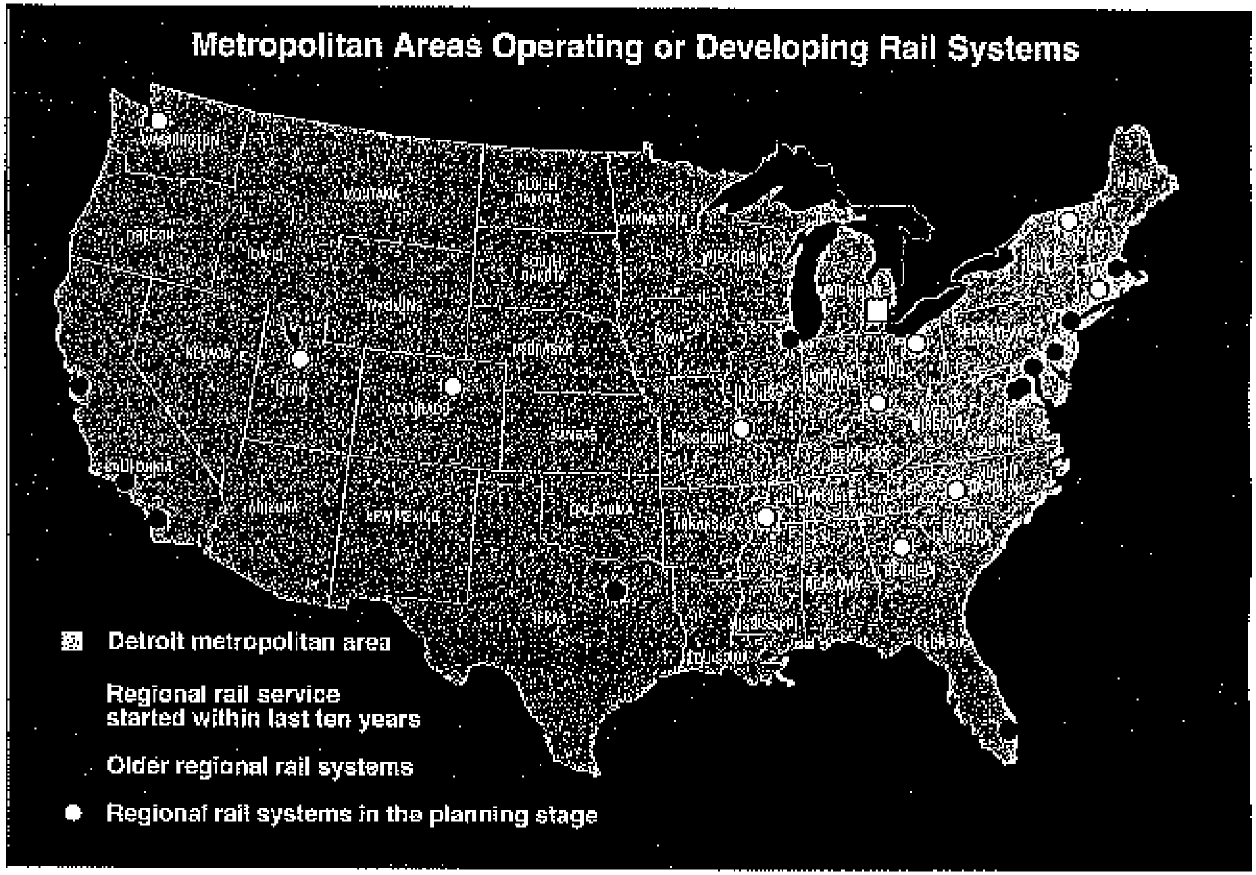
OVERVIEW: Regional Rail Systems in North America

Regional rail is the fastest growing segment of the public transportation industry. It is helping meet the increasing demand for transportation in the nation's larger metropolitan areas between population and employment concentrations within a region.

Several North American urban areas have implemented regional passenger rail service over the past decade, including Miami, San Diego, Los Angeles, Vancouver, Northern Virginia and Dallas. Rail services in these areas, as well as existing systems in Chicago, New York, Philadelphia, Boston, San Francisco, Washington, D.C., Baltimore, Montreal and Toronto, are thriving. In these cities, rail transportation has proven to be an environmentally and economically superior form of transportation, providing safe, fast, reliable, and relaxed travel.

Regional rail offers services beyond commuter rail, including: off-peak and weekend travel; peak-hour service to outlying areas for "reverse" commuters; and service to areas not located along historical central city-suburban corridors (suburb-to-suburb travel). These rail systems frequently connect to intermodal system centers, interfacing with other rail and bus services to provide a truly regional transportation network.

Rail technology is also advancing at a rapid pace. It is important that regional and state agencies continue to invest in their existing rail systems in preparation for future rail advancements, including high speed rail service between major regional centers.



REGIONAL RAIL: An Investment for Southeastern Michigan

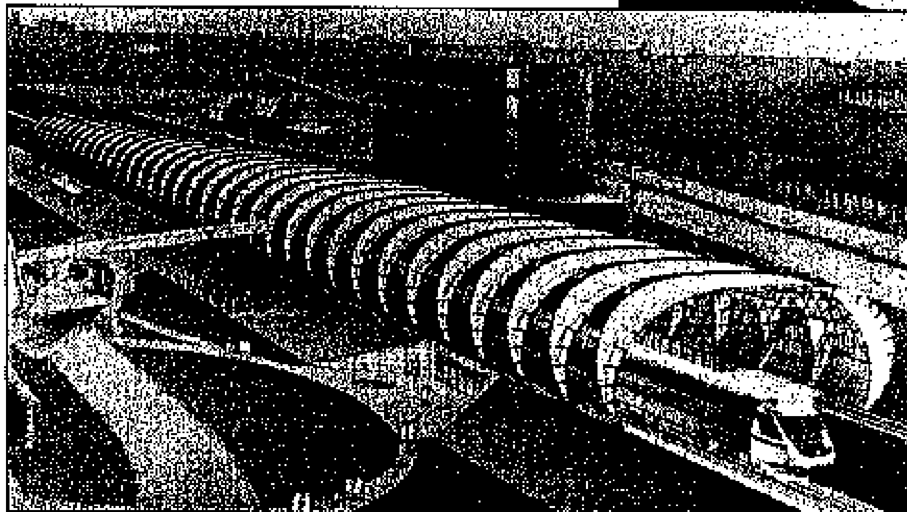
The Detroit metropolitan area is the largest in the country without regional rail service. With the anticipated resurgence of commerce in the downtown Detroit area, local and state officials face new challenges in managing increased traffic congestion. It is now recognized that there may be sufficient demand to warrant regional rail service in southeastern Michigan.

Regional rail service within southeastern Michigan could achieve the following:

- Provide cost-effective, reliable and attractive rail service for residents and visitors;
- Optimize transportation and socioeconomic benefits for the region;
- Serve recently proposed land developments, and encourage future transit-oriented developments;
- Coordinate with Amtrak's intercity rail passenger service, proposed high speed rail passenger operations and local transit services.

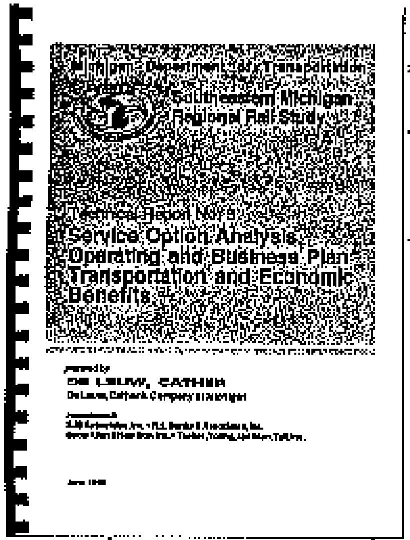
By improving regional mobility and accessibility, regional passenger rail services can make a significant contribution to uniting people; provide recreational, educational and social opportunities; and create an environment favorable for new economic activity and investment. A regional rail system serving southeastern Michigan offers significant transportation benefits, ensuring continued improvement in the quality of life.

Present Amtrak station in Detroit

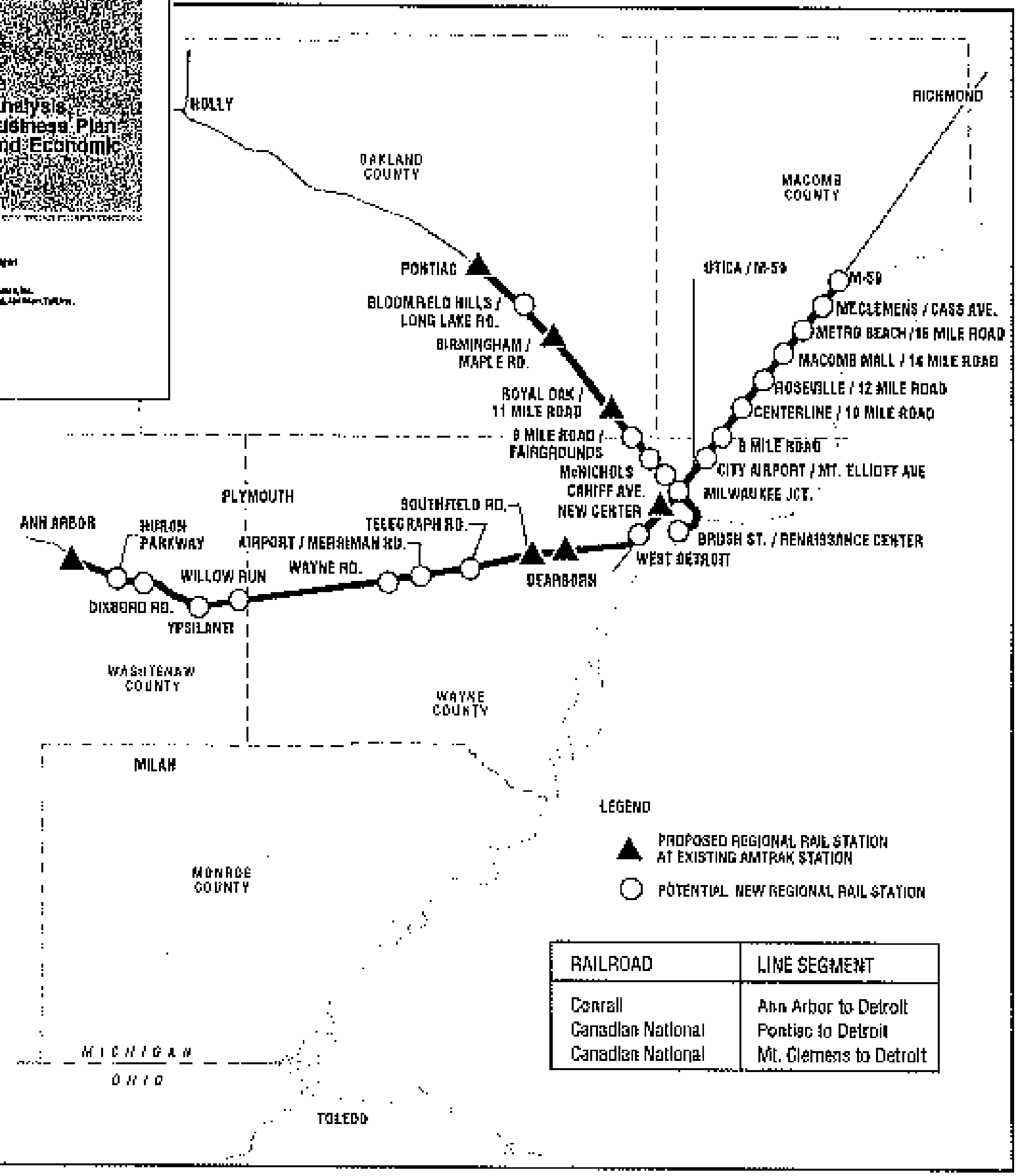


Conceptual rendering for an ultra-modern high-speed rail station

Regional rail startups elsewhere have been welcomed by local communities.



FEASIBILI'ı ı STUDY: Three-Line Regional Rail System ıdentified



RAILROAD	LINE SEGMENT
Conrail	Ann Arbor to Detroit
Canadian National	Pontiac to Detroit
Canadian National	Mt. Clemens to Detroit

To address pressing transportation needs within the Detroit metropolitan area, the Michigan Department of Transportation (MDOT), in coordination with the Southeast Michigan Council of Governments (SEMCOG), launched a study to determine the feasibility of regional rail service within southeastern Michigan. A consultant team, led by De Leuw, Cather & Company of Michigan, was assembled to conduct the Southeastern Michigan Regional Rail Study.

The study encompassed a 13-county area, portions of two additional counties, and Toledo, Ohio. Twelve existing railroad lines were initially identified as potential regional railroad corridors. Each alternative was ranked according to a set of nine criteria, which included factors such as population densities in proximity to proposed station areas, ridership projections, operating expenses, types and sources of system equipment, and operational capacity of the route.

From this evaluation, the 12 railroad lines were reduced to seven lines, and further refined to three lines that exhibit the best combination of characteristics required for the successful implementation of a regional rail system. They consist of:

- Ann Arbor-to-Detroit line;
- Pontiac-to-Detroit (Brush St.) line; and
- Mt. Clemens-to-Detroit line.

Existing railroad infrastructure on each line is in good physical condition and potentially useable for regional rail service. Passenger service could be operated on these lines with track and signal improvements.

SERVICE CHARACTERISTICS

This three-route operating system catering to the greater Detroit metropolitan area would consist of 100 miles of track, 30 rail stations and 14 daily trains on each line. In addition, the system would serve reverse commuting, provide interregional trips and connect with the New Center Intermodal Terminal offering a variety of local transit services.

The proposed system would complement, rather than compete with existing Amtrak service. Initially, operations on each route would consist of weekday-only service, with four peak period/peak-direction trains, two reverse peak trains, and a single midday round trip. Through service would be operated between Ann Arbor and Mt. Clemens, and between Pontiac and Brush Street. This basic weekday service would be expanded as demand increases.

Improved access to educational and business centers, recreational areas and cultural facilities and events could significantly enhance the way people work, shop, attend school, and participate in cultural and recreational activities. Regional rail would provide convenient and frequent service to medical centers that offer specialized services not available in outlying areas. Regional rail service also caters to the elderly and handicapped.

Projected ridership for the regional rail system is 19,000 passengers daily for the year 2015. The table above shows proposed single-ride fares. As with regional rail systems elsewhere, the majority of rail users would be commuters traveling to and from work. Tickets for daily commuters would be discounted; a typical train ride would cost $1.80 in current-year dollars. Reliable, comfortable and cost-effective trains are critical to maintaining high ridership levels.

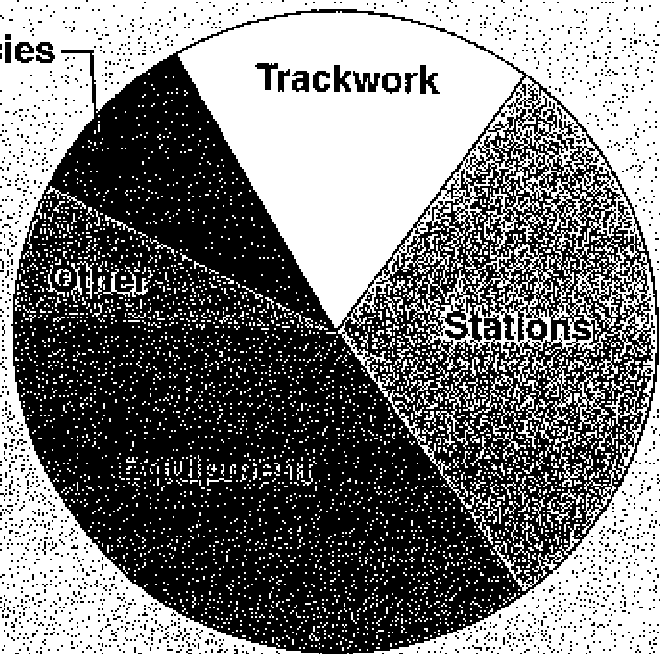
Sample Distance-Based Fare Structure for Single Trips									
Distance (miles)	0-10	15	20	25	30	40	50	60	70
Fare* (1997 dollars)	1.75	2.15	2.55	2.95	3.35	4.15	4.95	5.75	6.55

*Base single-ride fare for a 10-mile zone is $1.75 plus $0.08 per mile for each additional mile.

Train service and new developments would be a good fit. The following developments and activities would have a positive effect on the generation and maintenance of high ridership demand for regional rail service:

- General Motors is relocating its Flint, Lansing, Pontiac and World Headquarters offices to the new GM headquarters in the Renaissance Center or to their Technical Center in Warren, resulting in large-scale employee transfers.
- The development process for a governmental office/service complex in the New Center Area is underway.
- New federally-sponsored employer incentives are being offered by companies to encourage employee use of regional rail service.
- A new entertainment complex, featuring both the new Tigers and Lions stadiums, is proposed for construction in the downtown Detroit area.
- The construction of three new casinos is proposed for the downtown Detroit area.

CAPITAL COST ELEMENTS



Trackwork	18.4%	$23.8 million
Stations	30.1%	$39.0 million
Equipment	35.9%	$46.5 million
Other	6.5%	$8.5 million
Contingencies	9.1%	$11.8 million
TOTAL	100.0%	$129.6 million

	Daily Riders	Farebox Recovery
Ann Arbor	6,700	28%
Pontiac	5,500	36%
Mt. Clemens	7,200	59%
	19,400	38%

SYSTEM FUNDING

The proposed three-line regional rail system maximizes use of the existing railroad infrastructure, which helps to reduce implementation costs and improve the benefit-cost ratio. However, estimated capital costs for implementation of a regional rail system are $130 million. Capital costs include track improvements, train stations, refurbished locomotives and passenger coaches. A key concern is how the regional rail system would be funded, as there currently is no regional funding source in southeastern Michigan for regional rail.

Unfortunately, not all of the financing required for regional rail service can be generated through farebox revenues. External funding from state and local governments, federal agencies, and the private sector would be necessary to finance the initial start-up costs and operational subsidies of regional rail service. Annual operating costs are expected to reach $23.4 million. Of this total, it is estimated that $8.8 million would be covered by annual farebox revenue; the remaining $14.6 million would need to be funded from other sources. Private sector participation could include commuter rail investments in lieu of parking ramps and tax deductible contributions ($65 per month) to an employee's transit fare.

Although regional rail is a major investment, the costs are far below those for highway expansions. By comparison, improvements to I-94 may cost up to $170 million per mile, which exceeds the capital cost of the entire regional rail system.

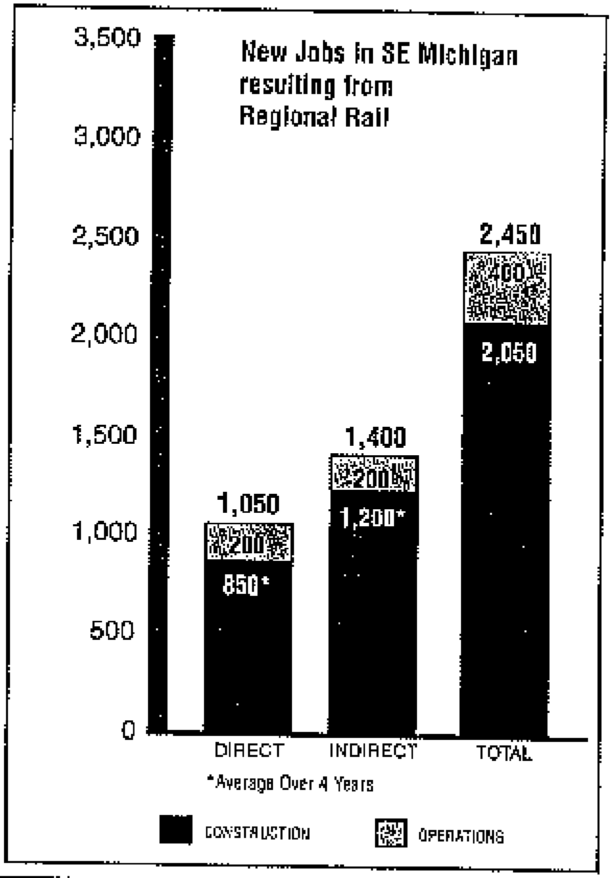
BENEFITS AND OPPORTUNITIES

The feasibility study identified several economic, environmental and transportation-related benefits that would result from the implementation of regional passenger rail service in southeastern Michigan. Many of these benefits are already being enjoyed by residents and businesses within areas currently served by regional rail.

Economic Benefits

Regional rail follows and promotes economic growth. In fact, the capital and operating expenditures associated with regional rail would directly impact the economy of southeastern Michigan. Following are some of the economic benefits that may occur within the southeastern Michigan area:

- Regional rail would directly generate 800 to 900 construction jobs
- Regional rail would directly create 200 operations jobs in the first year of service
- Regional rail would enhance business activity and property values throughout the region, especially in the vicinity of passenger rail stations.
- A regional rail system would allow land to remain on tax rolls, compared to the widening of highways.
- Regional rail would improve opportunities for access to jobs. It would increase the size of the workforce available within an hour's travel to major manufacturing hubs and professional centers.
- Expanded regional transportation options and improved access to nearby cities would encourage and foster new business development and relocation to southeastern Michigan.
- The total economic benefits from regional rail would equal $1.1 billion, yielding a benefit-cost ratio of 4 to 1.



BENEFITS AND OPPORTUNITIES (continued)

Environmental Benefits

Regional rail is an environmentally-sensitive transportation alternative. This is especially important, as part of the Detroit metropolitan area is classified as a non-attainment area for carbon monoxide. Environmental benefits of regional rail include the following:

- Regional rail helps to reduce auto pollutant emissions due to the diversion of highway traffic to rail, improving the region's overall air quality.
- Regional rail helps conserve energy (about 500,000 gallons of fuel per year).
- The three-line operating system would be on existing railroad right-of-way and would not require the acquisition of additional right-of-way such as open space or farmland.

Transportation Benefits

Regional rail is one of the safest transportation modes available and provides several transportation-related benefits for users. These include:

- Regional rail contributes to the reduction of highway traffic congestion. This also improves driving time and lowers fuel consumption.
- Regional rail substantially reduces travel costs to the user in comparison with automobile operation.
- Regional rail is aided by the existence of coordinated bus services. In some instances, the ridership on local transit services has increased due to the existence of regional rail service.
- Regional rail may defer the need to provide additional highway capacity.
- Regional rail provides an alternative mode of transportation during reconstruction projects such as I-94.

Offsetting impacts of regional rail implementation include a reduction in fuel tax receipts as highway travelers switch to the rail mode.

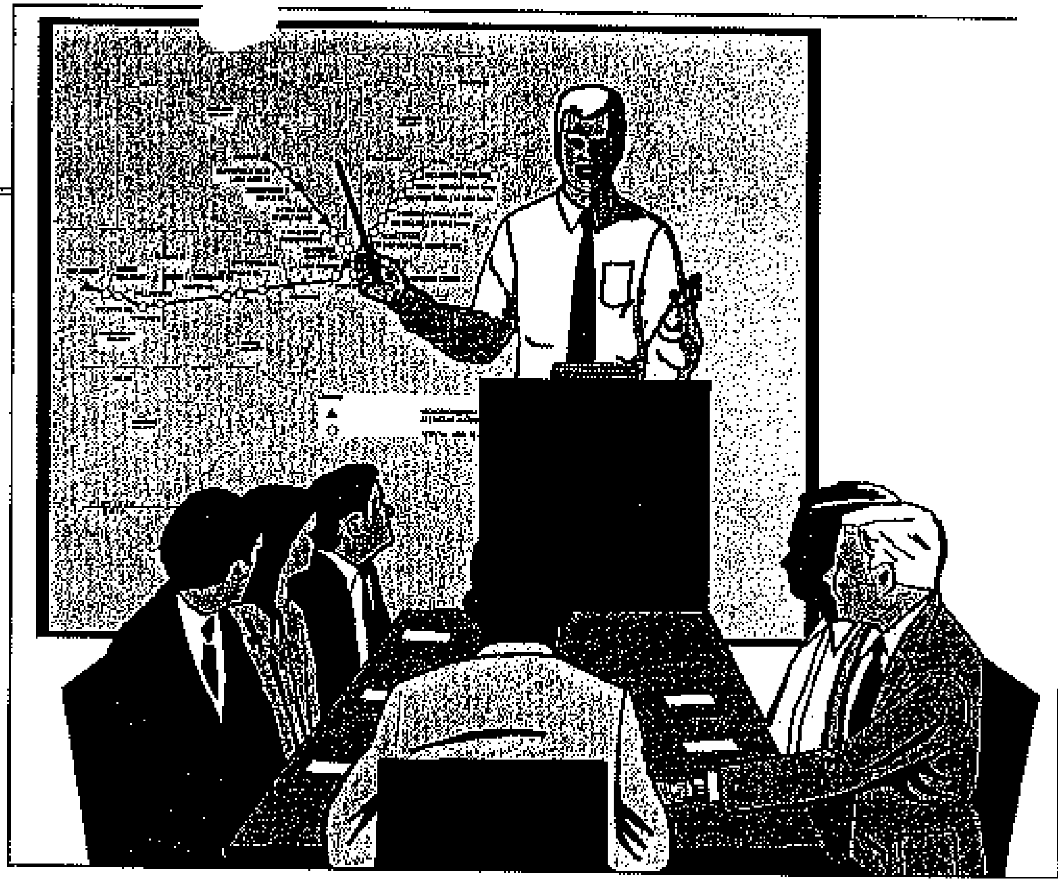
NEXT STEPS: Working Toward System Development

A review of regional rail in southeastern Michigan is part of the transportation planning process. The Southeastern Michigan Regional Rail Study took a first step in developing a conceptual passenger rail system for the greater Detroit area.

However, prior to the initial start-up of regional passenger rail service, there are a number of required key steps, including:

- development of a community consensus,
- local, regional and state approval,
- identification of funding sources,
- identification of a sponsoring agency,
- legislative relief for freight railroad liability concerns
- successful negotiation with the host railroads,
- railroad infrastructure physical plant improvements,
- procurement of locomotives and coaches,
- establishment of operating and business agreements with a sponsoring agency, and
- marketing of the service to heighten public awareness.

To achieve consensus regarding a regional rail system in southeastern Michigan, many people, groups, interests and points of view will have to be considered. For example, assigning ownership of the regional rail system is a major decision that will guide project development and system operation. However, some steps have been taken as the railroads have identified the critical issues they face and measures that could resolve them.



Key elements for successful project development include community consensus-building, constructive negotiation with potential host railroads, and marketing of existing and proposed public transportation systems to increase the public's awareness of regional rail opportunities. Regional rail requires interagency coordination to champion its development and strong grass-roots support for long-term success.

Finally, a demonstration project should be considered as part of this development process. This would provide an opportunity for government agencies and the public to experience a sophisticated passenger rail service that is part of a balanced transportation network.

Regional rail and the development of an enhanced multi-modal transportation network will continue to be important considerations as redevelopment and reinvestment occur within the city of Detroit. It is recognized that regional rail is a viable transportation alternative that would furnish service to thousands of residents of southeastern Michigan, help alleviate traffic congestion and help foster regional redevelopment and reinvestment.

Documents:

Technical Report No. 1:
  Infrastructure, Equipment and Generators
Technical Report No. 2:
  Service Options and Demand Estimates
Technical Report No. 3:
  Service Options Analysis, Operating and Business Plan, Transportation and Economic Benefits
Technical Report No. 4:
  Development Plan
Summary Technical Report
Summary Report

STUDY TEAM

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Bureau of Transportation Planning
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In association with:
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R.L. Banks & Associates, Inc.
Booz•Allen•Hamilton, Inc.
Tucker, Young, Jackson, Tull, Inc.

Steering Committee:

Michigan Railroads Association
Macomb County
Oakland County
Washtenaw County
Wayne County
City of Detroit
DDOT
SMART
Greater Detroit Chamber of Commerce
New Center Area Development Council
Amtrak
SEMCOG
Michigan Department of Transportation

EXHIBIT Q

MODERN DETROIT RENAISSANCE CENTER - OAKLAND COUNTY COMMUTER RAIL SERVICE

Presenter: Dietrich R. Bergmann, PhD, PE
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St. Clair Shores, MI 48080-0351
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e-mail: BergmannDR@cs.com

Forum: SEMCOG Transportation Advisory Council

Topics at 25 April 2001 meeting:

- Service features
- Infrastructure costs
- Infrastructure costs of the highway-only solution for Chrysler Freeway capacity expansion
- Municipal and Legislative Support for evaluation and/or implementation of commuter railroad service
- Impact of failure to regain access to former RenCen terminal site
- Limited discussion

Proposed Topics at May 2001 meeting:

- Additional differences between proposed service and the service that was dropped in 1983
- Characteristics of GO Transit service in metro Toronto
- Recent commuter rail service development in other North American metro areas
- Funding options
- Implementation timetable
- Additional discussion

STATIOI ;TOPS FOR DETROIT-OAKLAND COU Y COMMUTER RAIL SERVICE (PREL):

Station Name	Nearby Major Cross Street(s)	*Miles from RenCen*	Service Dropped in 1983	MDOT 1997 Proposal	Possible at this Time*
Detroit Renaissance Center		*0.0*	X	X	X
Detroit Riverfront Casinos	Jefferson				X
Detroit Eastern Market	Gratiot				X
Detroit Med/Univ/Cultural Ctrs	Forest/Warren				X
Detroit (Milwaukee Jct)	E Grand Blvd	*3.1*	X	X	X
Detroit/Hamtramack	Caniff	*4.6*		X	X
Highland Park (Chrysler Corp)	Davison		X		
Detroit/Highland Park	McNichols/6 Mile Rd	*6.4*		X	X
Detroit - State Fair Grnds/Ferndale	8 Mile Rd	*8.7*		X	X
Ferndale	9 Mile Rd		X		X
Royal Oak	11 Mile Rd	*12.2*	X	X	X
Royal Oak	12 Mile Rd		X		X
Birmingham/Troy	Maple/15 Mile Rd	*16.8*	X	X	X
Bloomfield Township (South side)	Charing Cross		X		X
Bloomfield Hills	Long Lake Rd	*20.2*	X	X	X
Bloomfield Township (North side)	Square Lake Rd				X
Pontiac CBD (Transportation Ctr)	Orchard Lake Rd	*24.7*	X	X	X
Pontiac (Oakland County Govt Ctr)	Telegraph Rd. (0.5 mi N)				X
Waterford and/or Clarkston	to be determined				X
Station dwell time at each stop:			???	3 min	1 min
RenCen to Pontiac run times:	*southbound*		60 min	52 min	38 min**
	northbound		65 min	52 min	38 min**

* Not all of the station stops listed in the column entitled "Possible at this time" would be served by all trains. The decision regarding the frequency of train stops at a particular station depends on the availability of parking at the station in the case of stations in residential areas, the bus service connections, the scheduling of special events at locations such as Eastern Market, the State Fair Grounds, etc.) and in the case of the casino stop, casino center shift schedules and patronage patterns.

** Estimate is based on MDOT's 1997 proposal for a train run involving seven intermediate stations, changed by substituting new low-floor passenger coaches for used high-floor passenger railcars id ified in MDOT's 1997 proposal. Trip time will incre if stops are made at all stations listed.

SELECTED RECENT AND PROPOSED DETROIT CBD PARKING STRUCTURE INVESTMENTS

Owner and Location	Parking Spaces	Cost of Construction	Construc. Cost per Space	Is Parking Structure Designed to Support Development Above It?
Detroit Parking Auth. First & Congress	610	$9,000,000	$14,750	No
City of Detroit Hudson's block	1,100	$28,000,000	$25,500	Yes
Wayne County adj to Old Cnty Bldg	550	$15,000,000	$27,270	???
GM ERFA Parcel F	2,100	$17,400,000	$8,290	No

SOURCES:

First two structures:	Crain's Detroit Business "Turning the Corner" issue dated "Spring 2000"
Wayne County structure:	Detroit News for 21 March 2001
GM structure on ERFA Parcel F:	Building permit application filed 27 Jan 2000 at Detroit Building and Safety Engineering Dept.

CAPITAL INVESTMENT FOR DETROIT-OAKLAND COUNTY COMMUTER RAIL SERVICE

Estimates included in 1997 MDOT's "Southeastern "Michigan Regional Rail Study" Proposal for...		
Facilities (7 station plan)		
Central Shop (for this service + AA-Det-MC service)	$6,681,000	
Station facilities, trackwork, grade crossing improvements, etc.	$20,846,000	
Contingencies (10%)	$2,084,600	
Facilities Subtotal:		$29,611,600
Rolling stock (all used)		
5 locomotives @ $750,000	$3,750,000	
24 coaches @ $450,000 (seats/coach unspecified; estimated to be 80)	$10,800,000	
Contingencies (10%)	$1,455,000	
Rolling Stock Subtotal:		$16,005,000
TOTAL:		$45,616,600
Reduction due to elimination of used rolling stock		($16,005,000)
Increase in facilities costs of 3% per annum due to inflation		$2,745,795
Cost of new locomotives and new low-floor rolling stock		
5 GM EMD locomotives (combination electric/ diesel-electric @ $3,750,000)	$18,750,000	
16 coaches @ $2,000,000 (lower fleet size stems from faster trip time and seating capacity of about 135/car)	$32,000,000	
Subtotal:		$50,750,000
REVISED TOTAL:		$83,107,395

"Revised Total" does not account for following: cost of replacing trackage removed since 1997; costs of building stations in addition to those identified in MDOT 1997 proposal; investment required to extend service north of Pontiac CBD; costs of electrifying last mile of route in Detroit CBD to avoid diesel exhaust emissions in Casino and RenCen stations; reduction in central shop cost in event its size can be reduced due to non-implementation of Ann Arbor-Detroit-Mount Clemens rail service.

				CONSTRUCTION COSTS	
I-375 & Related Infrastructure					
I-375 expansion (ref: EA p. 37)				$72,000,000	
Nearby street improvements					
Funded by Build Michigan 3				$25,000,000	
To be funded by City of Detroit (per Build Mich 3)				$15,000,000	
Parking structure investments not yet committed					
Construction cost estimates:					
Development above parking structure?					
No	*$10,000/space*				
Yes	*$20,000/space*				
		Floor Area (gsf)	Parking spaces		
per Hines' 09 Sep 1999 River East Master Plan					
Parcel B		not stated	950	$19,000,000	
Parcel D1 (Compuware??)		790000	2500	$50,000,000	
Parcel D2		634000	???	???	
Parcel E1		161000	???	???	
Parcel E2		176000	???	???	
Parcel F (2100 space parking structure built in 2000)		0	n/a	???	
Parcel G		308000	???	???	
MGM Riverfront casino – 3,000 spaces (est.)				$30,000,000	
SUBTOTAL FOR I-375 AND RELATED INFRASTRUCTURE:					$211,000,000 + ???
MDOT-proposed Oakland County I-75 Investment					
8 Mile Road to 12 Mile Road (including interchanges)				$109,000,000	
12 Mile Road to north Oakland County line				$328,000,000	
Noise walls				$10,000,000	
SUBTOTAL:					$447,000,000
TOTAL:					$658,000,000 + ??

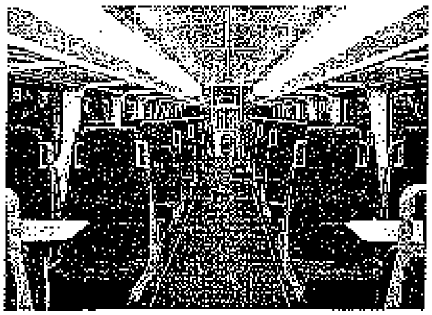
GOVERNMENT ACTIONS SUPPORTING EVALUATION AND/OR IMPLEMENTATION OF MODERN COMMUTER RAIL SERVICE BETWEEN DETROIT'S RENAISSANCE CENTER AND OAKLAND COUNTY

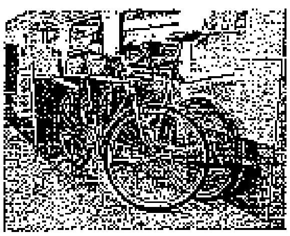
	Date	Description of Action
Municipalities		
City of Troy	02 June 2000	Acquired 2.71 acre parcel adjacent to railroad right-of-way for a "Transportation Center" to include 24,000 square foot building + 120 surface parking spaces [S of Maple; W of Coolidge]
Ferndale City Council	Dec 2000	Resolution requesting EIS for I-375 and Oakland County I-75 Expansion Proposals
Detroit City Planning Commission	18 Jan 2001	Resolution requesting EIS for I-375 and Oakland County I-75 Expansion Proposals
Birmingham City Commission	22 Jan 2001	Resolution requesting EIS for I-375 and Oakland County I-75 Expansion Proposals
Detroit City Planning Commission	March 2001	Resolution requesting modificaton of MDOT's I-375 EA in various ways, including incorporation of public transportation (supersedes 18 Jan 2001 resolution)
US Senator, Congressional Representatives, and State Legislators		
US Senator Levin	31 Jan 2001	Request for EIS re proposed I-375 expansion proposal, including requests for co-operative review of I-375 and Oakland County I-75 expansion proposals and for review of public transportation option
US Representative Conyers	01 Feb 2001	Request for EIS re proposed I-375 expansion project
US Representative Kilpatrick	01 Feb 2001	Request for EIS re proposed I-375 expansion project
State Representative Clarke	01 Feb 2001	Request for EIS re proposed I-375 expansion project
State Representative Kilpatrick	Jan 2001 (est.)	Request for EIS, et al?

Suburban & Regional Transport

Bi-Level Vehicle

Greater Seattle / Tacoma, USA





Fifty-eight bi-level commuter cars have been ordered from Bombardier Transportation since 1998 for the greater Seattle / Tacoma area.

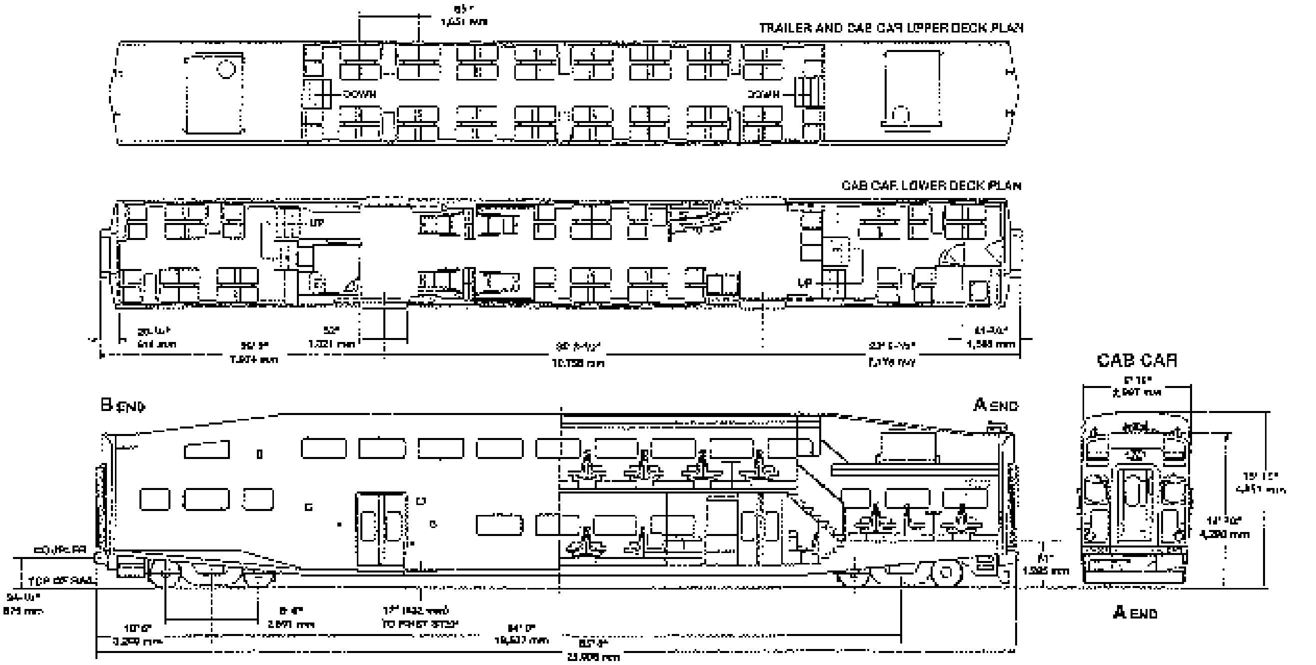
The vehicles are similar to those already delivered by Bombardier for the Southern California "Metrolink" system, the North San Diego County "Coaster" service, Florida "Tri-Rail", Toronto "GO Transit", Vancouver "West Coast Express" and Northern California "ACE".

The bi-level Sounder cars feature two full decks with intermediate end decks over the trucks, which optimize the use of the existing space and allow for higher ceilings and better seat, stairway and door positioning. The low-level platform doors permit a full carload of passengers on or off the coaches within 90 seconds, minimizing platform congestion.

An attractive interior with tinted windows, toilet facilities, wheelchair accessibility, bicycle racks and an electronic public address system guarantees a comfortable ride for all Sound Transit passengers.

BOMBARDIER
TRANSPORTATION

NONSTOP



GENERAL DATA	
type of vehicle	bi-level commuter car
operator	Sound Transit Central Puget Sound Regional Transit Authority
order dates	1998, 1999, 2000
ality	58 cars
consist	up to 10 vehicles

DIMENSIONS AND WEIGHT	Metric	Imperial
length over couplers	25,908 mm	85' 0"
width over side sheets	2,997 mm	9' 10"
rail to roof height	4,851 mm	15' 11"
rail to lower floor height	635 mm	25"
headroom centre aisle	2,007 mm	6' 7"
side doorway width	1,321 mm	52"
side doorway height	1,981 mm	6' 6"
aisle width (upper deck)	711 mm	28"
aisle width (lower deck)	711 mm	28"
wheel diameter	838 mm	33"
truck wheelbase	2,591 mm	8' 6"
truck centre distance	19,507 mm	64' 0"
track gauge	1,435 mm	4' 8 ½"
car weight (empty)		
- cab car	53,750 kg	118,500 lb
- trailer car	53,200 kg	117,300 lb

TECHNICAL CHARACTERISTICS

- 480 V, 3 ph, 60 Hz head end power supply
- 72 Vdc low-voltage power supply complete with nickel-cadmium emergency battery
- welded aluminum carbody
- 2 cast steel trucks per car, with inboard bearings
- pneumatic tread brakes and disk brakes with wheel-slide protection
- rubber chevron primary suspension
- pneumatic secondary suspension
- electric convection floor heaters, overhead forced-air heaters
- 2 air-conditioning units
- fixed, tinted, double glazed side windows
- 4 bi-parting side doors
- one washroom per car, fully accessible

PERFORMANCE AND CAPACITY	Metric	Imperial
maximum design speed	160 km/h	100 mph
maximum operating speed	150 km/h	95 mph
service braking	0.90 m/s²	2.0 mphps
emergency braking	1.08 m/s²	2.4 mphps
buff load	3,600 kN	800,000 lb

	cab car	trailer car
wheelchair locations	4	2
double bicycle racks	1	1
seated passengers per car (with wheelchairs and bicycles)	130	142
seated passengers per car (without wheelchairs or bicycles)	139	148
crush load		365 passengers

BOMBARDIER
TRANSPORTATION

Parent Street, St. Bruno, Québec, Canada J3V 6E6 • Telephone 1 (450) 441-2020

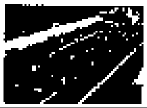
• Austria - Tel.: (43-1) 25 110 • Belgium - Tel.: (32-50) 40 13 11 • Canada - Tel.: 1 (613) 384-3100 • Czech Republic - Tel.: (42-0425) 802 111
• France - Tel.: (33-3) 27 23 53 00 • Germany - Tel.: (49 30) 6793-0 • Mexico - Tel.: 52 (5) 209-67-00 • People's Republic of China - Tel.: 8610-8529-9100
• Switzerland - Tel.: (41 21) 967 0505 • United Kingdom - Tel.: (44-1-924) 271 881 • United States - Tel.: 1 (212) 682-5860

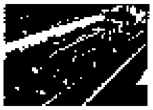
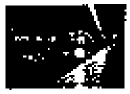
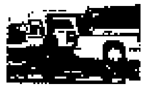
www.transportation.bombardier.com

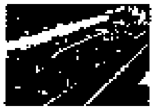
EXHIBIT R

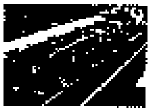
Levels of Service and Their Characteristics

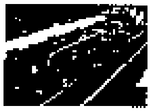
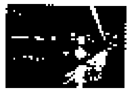
Southeast Michigan Council of Governments Transit Vision Forum May 2001

Levels of Service	High Level of Service					Medium Level of Service		Flexible Level of Service	
des of vice	Bus Rapid Transit (BRT) *Think trains, use buses*	Light Rail Transit (LRT)	Automated Guideway Transit (AGT)	Commuter Rail (CR)	Heavy Rail (HR)	Conventional Bus Service (CBS)	Water Taxi (WT)	ParaTransit (PT)	Taxi/Jitney
									
Vehicle Descriptions	- State-of-the-art buses -Low floor, clean fuel, can be articulated	- Light-rail trains, can be articulated - Low floor - Overhead power lines	- Driver-less elevated or subterranean light-rail trains - Same as Detroit People Mover	-Passenger cars pulled by locomotives -Self-propelled Diesel Multiple Units[1]	-Elevated trains -Subways -Trains powered by electrified third rail	-Standard diesel bus -Can be articulated or clean fuel	-Small boats, hovercraft	-Vans, small buses, cabs	-Cabs, vans, small buses, private cars
Average Speed	15-30 mph	15-30 mph	18-30 mph	18-40 mph	18-36 mph	15-25 mph	Unknown	Unknown	Unknown
Type of Services	Rapid mass transit	Rapid mass transit	Rapid mass transit	- Long-distance mass transit	Rapid mass transit	- Varies, regular and express services	-Transportation along water front	-Community trip services, feeder services	-Personal trip transportation
General Description of Services	-Fixed Routes - 5-10 min between buses in rush hour possible	-5-10 min between trains in rush hour possible	-5-10 min between trains in rush hour possible	- 4-6 trains daily -Similar to Amtrak - Can reach high speeds over long distances	- 5-10 min between trains in rush hour possible	-Fixed routes and fixed schedules -Varying time between buses	- Water borne passenger services along waterways	- Public and private on-demand, door-to-door short-range transit services for special groups	-Private, driven vehicles for hire -Demand responsive door-to-door service

	BRT	LRT	AGT	CR	HR	CBS	WT	PT	Taxi/Jitney
									
How many riders can be served?	Up to 3,000 people per hour each direction	Up to 4,800 people per hour each direction	Up to 3,000 people per hour each direction	Up to 18,000 people a day with commuter schedule	Up to 20,000 people per hour each direction	About 700 people per hour each direction	-Unknown	-Unknown	-Unknown
Right-of-Way (ROW) Options	-Mixed traffic lanes in streets -Dedicated lanes in existing streets -Exclusive ROW	-Mixed traffic lanes in streets -Dedicated lanes in existing streets -Exclusive ROW	-Requires exclusive ROW, usually elevated or subterranean tracks and stations	-Requires exclusive ROW -Uses existing tracks -Mixed rail traffic	-Requires exclusive ROW, either elevated or underground	-Currently uses existing road network	-Unknown	-Uses existing road network	-Uses existing road network
Station Spacing	1/4 mile to 1 mile	1/4 mile to 1 mile	½ mile to 1 mile	2 to 10 miles	¼ mile to 1 mile	-Varies	-Unknown	No stations	No stations
Additional Infrastructure Requirements	-Requires more maintenance/ storage facilities	-New rail tracks required -Overhead power lines required -Requires new maintenance/ storage facilities	-Requires more maintenance/ storage facilities	-Park and ride lots -Requires new maintenance/ storage facilities	-Requires new maintenance/ storage facilities	-Maintenance facilities already exist in Southeast Michigan -Requires more maintenance/ storage facilities	-Stations/Docks -Requires new maintenance/ storage facilities	-No construction required -Requires maintenance/ storage facilities	-No construction required -Maintenance/ storage facilities
Additional Technology	-Automatic Vehicle Location (AVL)[2] - 2 way radio	-AVL - 2 way radio	-AVL -Computer controlled vehicles	- 2 way radio	-Automatic Vehicle Location - 2 way radio	-Can use dispatching -Can use AVL - 2 way radio	-Dispatching -AVL - 2 way radio	-Dispatching -AVL - 2 way radio	-Dispatching -AVL - 2 way radio

	BRT 	LRT 	AGT 	CR 	HR 	CBS 	WT 	PT 	Taxi/Jitney 
Capital Costs (including Right-of-Way, construction, and vehicles)	About $11-$13 million per mile	About $25-$56 million per mile	About $93-$128 million per mile	About $2-$10 million per mile	$100-$300 million per mile -Wide range due to various construction factors	(with no construction) $13.5 million annually DDOT/SMART (1998)	-Unknown	-Varies	-Varies
Operating Costs	$4 per vehicle mile	$9 per vehicle mile	$4 per vehicle mile	$13 per vehicle mile	-Unknown, near $11 pvm	$6 per vehicle mile	-Unknown	-Varies	-Varies
Positive Benefits/ Strengths	-Predictable time between buses -More flexible than rail -Potential for economic/ social/ environmental benefits -Complements CR, CBS, WT, PT	-Predictable time between trains -High capacity -Good potential for economic/ social benefits -Complements CR, CBS, WT, PT	-Predictable time between trains -Automation reduces costs -No traffic conflicts -Compatible with Detroit People Mover -High potential for economic/ social benefits -Complements CR, CBS, WT, PT	-Relatively inexpensive and quick to implement -Few conflicts w/ automobile traffic -Uses existing tracks -Commuter services complement BRT, LRT, AGT, HR, CBS, WT, PT	-Highest capacity -Predictable time between trains -High potential for economic/ social benefits -No traffic conflicts -Complements CR, CBS, WT, PT	-Least expensive -More flexible than BRT, LRT, AGT, CR, or HR -Technology and expertise already exist in Southeast Michigan	-Suitable for river accessible sights -Could connect riders to transit in Windsor -Can provide low cost, temporary connections	-Very important for people unable to use the regular transit system (e.g. disabled, elderly) -Supplements existing services	-Supplements existing transit services and private cars -Customized transportation -Provides connections to and from airports, train and bus stations -On call any time

	BRT	LRT	AGT	CR	HR	CBS	WT	PT	Taxi/Jitney
									
Negative Impacts/ Limitations	-Some traffic disruption -*Must* be distinguished from conventional bus service	-Some traffic disruption -Overhead power lines are unsightly -No existing facilities or expertise in Southeast Michigan -Potential engineering problems (e.g. Woodward/8 Mile Rd.) -New maintenance/ storage facilities needed	-Very expensive to build -Extremely visually intrusive -Disruptive to construct -May require expensive land acquisition -New maintenance/ storage facilities needed	-Must use freight rail corridor -Little chance for economic development -May only serve commuter market -No cross town routes -Schedule subject to track owners discretion (can conflict with the movement of freight trains)	-Extremely expensive to build -Very disruptive to construct -May require expensive land acquisition -New to Southeast Michigan, no facilities or expertise -New maintenance/ storage facilities needed	-Serious image problem; commonly perceived as unreliable, unsafe, dirty, loud, slow, polluting and used only by those who have no other option -Causes traffic conflicts -Does not have the speed, capacity and image benefits of "rapid transit"	-Can only serve water-front areas -Service dependant on weather conditions -May be problematic during winter	-Is not suitable for mass transit -Many small, private unregistered providers (churches, etc.) make coordination difficult -Usually not cost effective	-Expensive -Inconvenient for long trips -Difficult to coordinate -Not necessarily cost effective

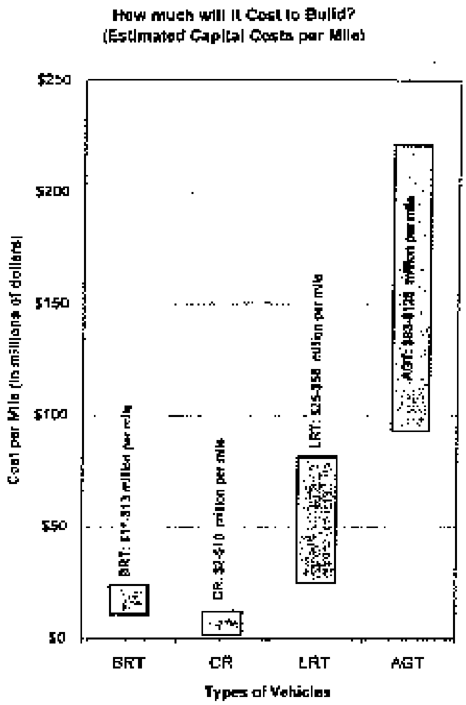
	BRT	LRT	AGT	CR	HR	CBS	WT	PT	Taxi/Jitney
									
…atured Amenities	-Covered stations -Operates all day and night w/ driver -Automatic or personal fare collection -Can be upgraded to LRT -Automatic green lights -Various security options	-Covered stations -Operates all day and night w/ driver -Automatic or personal fare collection -Automatic green lights -Various security options	-Covered stations - Turn-style fare collection -Operates all day and night with out driver -Various security options	-Covered stations -Most efficient for longer distances -Most appropriate for commuter use -Various security options	-Operates all day and night w/ driver - Turn-style fare collection -Various security options	-Will stop frequently to pick up and drop off passengers -Set schedule -Printed schedules available in various locations -Personal fare collection -Various security options	-Most appropriate for special events -Various security options	-Can be equipped to help people with special needs (e.g. disabled, elderly) -Various security options	-Personalized service -Operates all day and night w/ driver -Personal fare collection -Will stop frequently to pick up and drop off passengers
Related Amenities	-Wide variety of information options -ADA[3] accessible -Can be clean fuel vehicles	-Wide variety of information options -ADA accessible -Can be clean fuel vehicles	-Wide variety of information options -ADA accessible -Can be clean fuel vehicles	-Wide variety of information options -Can be very comfortable -ADA accessible	-Wide variety of information options -ADA accessible -Can be clean fuel vehicles	-Wide variety of information options -Sometimes ADA accessible -Can be clean fuel vehicles	-Wide variety of information options	-Wide variety of information options -ADA accessible -Can be clean fuel vehicles	-Personal seating

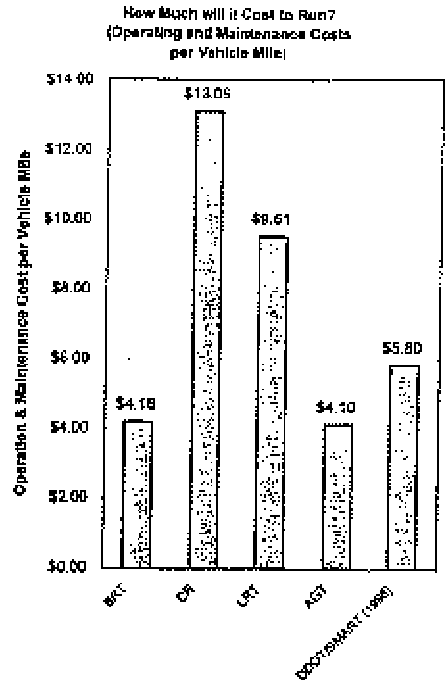
Source: Woodward Corridor Transit Alternatives Study, May 2000. Transportation Management and Design, 2001. SEMCOG

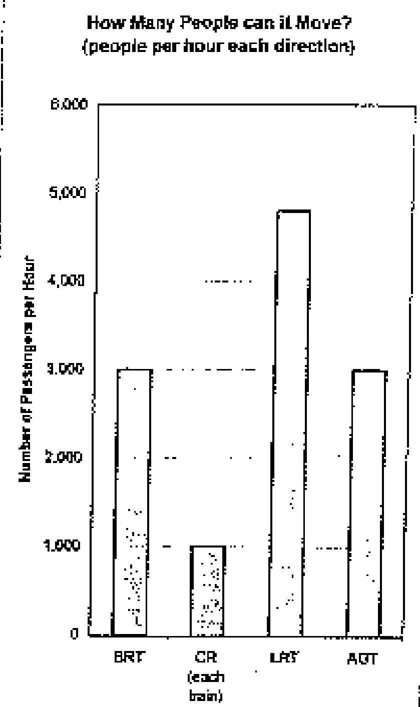
1.Diesel Multiple Units - Self propelled rail cars

2.Automatic Vehicle Location - Technology that enables automatic green lights, proper vehicle spacing, and reliable "Next Bus in . . ." signs.

3. ADA - The Americans with Disabilities Act calls for transit to be accessible to people with disabilities such as wheelchairs.







A "Vehicle Mile" is every mile a vehicle travels while in service