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Driver Population Factor in Highway Capacity: Interim Tech Report (Phase 1: Experimental Design for Data Collection and Analysis)

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DRIVER POPULATION FACTORS IN HIGHWAY CAPACITY:

INTERIM TECHNICAL REPORT (PHASE I: EXPERIMENTAL DESIGN FOR DATA COLLECTION AND ANALYSIS)

SUBMITTED TO:
FLORIDA DEPARTMENT OF TRANSPORTATION

SUBMITTED BY:
CENTER FOR URBAN TRANSPORTATION RESEARCH

APRIL 1996
DISCLAIMER

The opinions, findings and conclusions expressed in this interim technical report are those of the authors and not necessarily those of the State of Florida Department of Transportation.
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I. INTRODUCTION

BACKGROUND

An important factor in the calculation of highway capacity is the driver population factor. This factor is designed to reflect the presence in the traffic stream of non-commuters, non-local drivers, or those otherwise unfamiliar with the local traffic system. As noted in the 1994 Highway Capacity Manual (HCM), the factor is said to range from 0.75 to 0.99 and is to be applied when there are significant percentages of non-commuters in the traffic stream. Unfortunately, the HCM offers little guidance on how to select appropriate values for this factor. The new modifications to HCM include this factor for freeway calculations, but not for other facilities. One might expect such a factor to be equally important for uninterrupted flow on arterials, as well as for capacity computations at signalized intersections.

The purposes of this research project are: (1) to develop potential experimental procedures to relate observed saturation flow rates or peak flow rates to the magnitude of non-local or non-commuter drivers in the traffic stream, and (2) to test one of the experiments to estimate the driver population factor for a particular category of roadway.

APPROACH

Since it is impractical to finalize an experimental design prior to an examination of the availability of various data resources, the project is comprised of two distinct phases. The first phase, which is the subject of this report, focuses on designing feasible experiments to relate traffic flow characteristics to the unfamiliar drivers in the traffic stream. The second phase will consist of the execution of one of the selected experimental designs to generate data to estimate the driver population factor for one roadway type. More specifically, Phase I consists of the following tasks:

1. Literature Review and Survey - A review of available technical
literature on the topic of driver population factor has been performed. In addition, telephone interviews have been performed with selected national experts, and an annotated bibliography has been prepared.

2. Review Available Data Sources - A review of available traffic data sources has been performed. This has included both historical data sources, and also the feasibility of gathering new data.

3. Estimation of Non-Commuter Traffic - Sources and methods for estimating non-commuters in the traffic stream have been examined. These have included both historical data and potential sources of new data.

4. Prepare Experimental Designs - Based on the preceding tasks, experimental designs were prepared with which data collection and analysis could be performed.

5. Interim Technical Report - This report summarized the findings of Tasks 1 through 4.

Phase II will build on Tasks 1 through 5, with the following:

6. Determination of Research Priorities - CUTR and FDOT will jointly review the resources required to carry out the research protocols for the different roadway types and will determine the best application of remaining project resources. It is likely that it will be determined to focus on one specific roadway type and to undertake a data collection effort to estimate the effect of the driver population factor for that single roadway type.

7. Implementation of Research Design - Based on the determination made in Task 6, data collection and analysis will be performed within the constraints of the remaining project resources. It is anticipated sufficient experimentation will be completed for one particular roadway type to produce meaningful results. The research will be translated into a table of factor values, which could be readily usable by the practitioner.

8. Project Final Report - A final report will be prepared which
fully documents the project activities, including Tasks 1 through 7. It is anticipated that the final report will be targeted to an audience of technical practitioners familiar with the methods of the Highway Capacity Manual.

9. Technology Transfer - The project findings will be distilled into one or more technical articles, suitable for publication by a forum such as the Institute of Transportation Engineers or the Transportation Research Board. It is anticipated that the articles will be prepared principally by CUTR staff, but a representative of Florida DOT will be given the opportunity to co-author. Presentations will be made to the Florida Section of the Institute of Transportation Engineers. Copies of technical articles will be distributed to the MPO Advisory Council, to the Florida Section of ITE, and to the Florida Association of Counties and the Florida League of Cities.

RELATED RESEARCH

A comprehensive literature search was performed, to identify previous research which might be of relevance to this project. A primary source was the Transportation Research Board's Transportation Research Information Service. In addition, numerous personal telephone conversations were conducted with nationally recognized experts in the field of highway capacity analysis. This review was detailed in a separate annotated bibliography. In general, it was found that there has been very little in the way of previous research to specifically quantify the magnitude of the driver population factor. It appears that some of the early interest in the driver population factor can be traced to a number of individuals working in the Office of Traffic Operations at the California Department of Transportation. Rooney, in particular, could recall a number of studies performed in the early 1970s on California freeways, that indicated substantially lower highway capacity levels involving high levels of recreational traffic.\textsuperscript{1}

He observed a number of locations in California at which normal

\textsuperscript{1}Rooney, Frederick, Caltrans Office of Traffic Operations, Sacramento, California. Personal Telephone Conversation, October 4th, 1995.
peak traffic flow rates in the range of 2,000 vehicles per hour per lane would be expected. Instead, during certain weekend periods characterized by large numbers of recreational travelers returning from their recreational destinations, capacity levels on the order of 1,500 vehicles per hour per lane were observed. Rooney's recollections were independently confirmed by Blackburn, and Harvey, who had similar recollections of various traffic studies performed in the early 1970s. Unfortunately, the traffic studies to which these sources referred took the form of internal Caltrans working memos. Due to the fact that the studies were done over twenty years ago, it was impossible to locate them. It was interesting however, that in recollecting these studies there were repeated references to the presence of campers, mobile homes, and autos with boats on trailers, being part of the traffic stream. These early studies were highly perceptive in terms of identifying the reduction in freeway capacity based on recreational traffic, but it appears that some portion of the explanation may lie in the mix of vehicles, which would generally be highly confounded with the driver population factor. Nonetheless, in discussions with several members of the TRB Highway Capacity Committee, it appears that the range of values suggested in the Highway Capacity Manual for the driver population factor (0.75 to 0.99) was largely based on these anecdotal recollections.

More recently, Sharma has taken considerable interest in the

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³ Harvey, Stuart, Deputy District Director, Caltrans, San Diego. Personal Telephone Conversation, October 4th, 1995.

driver population factor. His primary contribution is in the area of classifying roadways in terms of their traffic composition. He developed a classification system that characterized roads as ranging between the two extremes of urban commuter and highly recreational. The driver population factor for urban commuter traffic would be 1.0 and for highly recreational would be 0.75. He identified five additional categories between those two extremes, and has associated a different driver population factor with each. In his TRB article, he goes through a fairly involved process of characterizing roadways based on the variations in traffic flow that occur. He accounts for both seasonal variation and daily variation and, based strictly on those characteristics, he classifies the roads. In spite of the interesting treatment to roadway classification based on the traffic variation characteristics, the assignment of values to the driver population factor appears to be purely judgmental; certainly rational and logical, but purely judgmental.

Reilly⁵ and Schoen⁶ are currently completing a TRB project, NCHRP 3-45, Speed Flow Relationships on Basic Freeway Segments. Although they were unable to address the factor of commuter vs. non-commuter traffic, they were able to provide some interesting comparative data on the relationships between flow rates and average vehicle speed in four different cities: San Diego, Sacramento, Seattle, and Des Moines. These relationships are shown in Figure 1. Although this is unrelated to the driver population factor, it was interesting to note significantly different speed flow relationships among these four cities. It is believed that comparisons of commuter facilities and recreational facilities would show similar shifts in the speed-flow curves.


⁶Schoen, Jim, Catalina Engineering, Inc., Fax Correspondence, October 9, 1995.
The challenge of this research project is to link traffic flow characteristics specifically speed/volume relationships and peak flow rates with the relative proportions of non-local or non-commuters in the traffic stream. As will be described in subsequent sections of this interim technical report, there are a number of specific issues that need to be addressed. Among these are the use of historical data vs. new data. Another issue will deal with defining the time period of analysis in terms of traffic variations (5-minute vs. 15-minute vs. hourly). Finally the third major issue involves the difficulty in defining what is meant by the driver population factor (i.e. non-commuter, non-local,
unfamiliar) and then estimating its relative magnitude. Each of these issues will be dealt with in the sections that follow.

**BASIC PRINCIPLE OF DEVELOPING DRIVER POPULATION FACTORS**

Non-local drivers may have a number of impacts on roadway facility capacity. The main characteristics reflecting non-local driver behavior could be car-following behavior (headway), gap acceptance behavior (lane change), traffic sign recognition behavior (total reaction time), and vehicle speed. With these combined impacts included in capacity analysis, a certain amount of capacity reduction is expected. This concept is shown in Figure 2. The value $\Delta C$ shown in Figure 2 is the capacity reduction due to non-local driver population. Mathematically, the non-local driver population adjustment factor can be used to adjust capacity estimation by the following equation.

$$C = f_p \cdot C^*$$

where

- $C$ - capacity under prevailing conditions including non-local driver population
- $C^*$ - capacity under prevailing conditions not including non-local driver population
- $f_p$ - non-local driver population adjustment factor

![Figure 2. Impact of Non-local Driver population.](image-url)
There are two basic issues that must be addressed in this study. First, from existing or new traffic data (including traffic flow rate, speed, and vehicle classification), capacity reduction due to non-local driver population should be identified using statistical methods. Consequently, the adjustment factor \( f_p \) can be estimated under different conditions. Second, methods should be developed to estimate non-local driver population levels. A statistical analysis should be conducted to relate the adjustment factor \( f_p \) with the estimation of non-local driver population levels. A wide range of non-local driver population levels should be covered so that a reasonable calibration of \( f_p \) can be reached.

Two types of data should be collected in this study. First, the reduction in capacity due to non-local driver population should be analyzed. This reduction can be represented by an adjustment factor \( f_p \). Secondly, information on the non-local driver population level at the corresponding roadway facility should be collected. By combining the driver population factor \( f_p \) with the corresponding non-local driver population level, a table could be developed to present driver population factors at different non-local driver population levels. Conceptually, Figure 3 can be used to illustrate the principle involved in developing a driver population adjustment factor table.

**Figure 3. Basic Principle of Developing Driver Population Adjustment Factor Tables.**
Capacity data at different test sites and test times are needed to estimate the driver population adjustment factors at these sites and times. Alternatively, capacity data can be observed longitudinally at a particular site, over an extended time period, e.g. one year. Meanwhile, the proportion of non-local drivers needs to be estimated at these sites. The necessary data to be used to estimate capacity reduction include short time interval (e.g. 5-minute or 15-minute) traffic data, including traffic flow rate, speed, and vehicle classification. Without speed and vehicle classification we cannot evaluate capacity reductions, without making bold assumptions about the characteristics of observed peak flow rates.
II. TRAFFIC DATA SOURCES

This discussion of traffic data sources is divided into two major sections: freeways/uninterrupted flow arterials, on the one hand, and signalized intersections on the other. In the case of freeways and uninterrupted flow arterials, traffic operating conditions are primarily a function of interactions between vehicles and the physical characteristics of the roadway facilities. Peak flow rates are governed by the vehicle headway and operating speeds. Under idealized conditions, peak flow rates as high as 2,200-2,300 passenger cars per hour per lane (pcphpl) have been observed. Beyond these volumes forced flow conditions occur, with flow rates dropping dramatically. For non-idealized conditions, including conditions with high numbers of non-commuters or non-local drivers, one might expect these peak flow rates to be substantially lower. It is hypothesized that unfamiliar drivers will generally drive more cautiously, allow greater distances between vehicles, and otherwise reach peak flow rate conditions substantially lower than the idealized 2,200-2,300 pcphpl.

At intersections, a significant component of capacity is comprised of the start-up lost time, which occurs each time the traffic signal turns green, and by the saturation flow rates that occur once the traffic stream entering the intersection reaches an equilibrium situation. Therefore, for intersections, the primary variables of interest will be start-up lost time and saturation flow rate, and any experiments would attempt to relate these parameters to the extent of non-familiar drivers in the traffic stream.

FREEWAYS AND UNINTERRUPTED FLOW ARTERIALS

FDOT Permanent Count Traffic Data

The Florida DOT permanent count traffic stations can be a very valuable source of traffic data for freeways and uninterrupted flow arterials. The permanent count traffic monitoring sites make use of inductive loop vehicle detectors placed in the pavement and sealed with an appropriate adhesive sealant. Data are stored in roadside computers, and transmitted to the FDOT central computer using a telemetry system, with the data summarized in one hour time intervals.
In calendar year 1994 there were 103 monitoring sites at which data were reported. The sites are located throughout Florida, primarily along the State Highway System, and include freeway sections and other principle arterial highways. A significant number of the monitoring sights include data regarding average vehicle speeds, vehicle classification, and at selected weigh-in-motion sites, information about vehicle weights. While the historical traffic count data are reported on a directional basis summarized in hourly intervals, the classification data are reported as a 24 hour average, and the speed data are reported as a distribution, on a 24 hour summary basis.

These data are potentially very valuable. However, their utility is limited by the fact that, while the volume data are summarized on an hourly basis, the speed and classification data are 24 hour summaries. The hourly flow rates may not allow for precise calculation of peak flow rates, which may sometimes occur only for a short 5-15 minute duration. The fact that classification and speed distribution data are summarized on a 24 hour basis, makes it impossible to relate these characteristics to peak flow rates. Apparently it is feasible, although difficult, to go back into historical data files to relate vehicle classification and average speed on an actual hourly basis, coincident with the hourly traffic volumes.

Another limitation on the use of historical data gathered at the permanent count stations is the need to account for special events. These might include accidents, unusual weather conditions, construction activity, holidays, school vacation days, and other events. Fortunately, FDOT records make note of apparent unusual conditions that may influence the data. Further, a number of these special events (e.g. holidays, school vacation days, weather conditions) can be identified quite precisely.

The permanent and continuous traffic monitoring data of these locations also could potentially make them a useful source for the collection of future data. There may be substantial value to the project of reprogramming a small sample of sites to report data on a more refined basis (e.g. 5 minute intervals or 15 minute intervals).
Pneumatic Tube Counts or Solid State Roadway Traffic Counters

Pneumatic tube roadway traffic counters are widely used to collect sample traffic count data on roadways throughout the state. These types of traffic counters are still commonly used for short duration (several day) traffic counts by DOT districts and local governments throughout Florida. However, they are extremely labor intensive, expensive, and expose the technician to the hazards of high speed traffic. Moreover, ensuring the reliable placement and maintenance of the pneumatic tubes requires frequent monitoring and repair, as repeated vehicle loading and roadway conditions often result in the tube loosening or in some cases breaking off. There is new technology which allows small solid state devices to be mounted in the center of a lane where they can store information about traffic volumes and classification of vehicles passing over them. They are not as troublesome as pneumatic tube counters to maintain, but reportedly there have been significant problems on the part of those using these new devices.

Compared to the FDOT permanent traffic count locations, the use of these methods seems to be a much less practical alternative for this project. Their usefulness from a practical point of view is still limited by the small time samples (e.g. a few days ago) that might conceivably be obtained, when compared to FDOT per unit car data, but they may be acceptable for short-duration efforts. The cost of contracting for these types of counts can vary over a wide range, but is under typical conditions is reported to be on the order of several hundred dollars per day per location.

Manual Data Collection

It is certainly possible to place manual observers in the field with conventional traffic counting devices, to observe vehicle volumes and classifications. In addition, vehicle speeds could be monitored at least on a sample basis. It may even be possible for trained observers to record level of service conditions based on physical observations. While this is a feasible method, compared to the FDOT permanent count data, it is extremely labor intensive. It might have applicability for short-duration data collection efforts.
**Video Data Collection**

Video technology can be used in lieu of manual field data collection. Video has the advantage that it is a permanent record, which can be analyzed in a controlled office environment. In addition, through the use of video, it is possible to obtain volume counts, vehicle classification, and even vehicle speeds during the same time period.

Many of the shortcomings associated with the manual collection and processing of data can be overcome through the use of video camcorders and machine vision license plate readers. Modern video camcorders are capable of capturing very clear images on license plates on vehicles operating in high-speed, high-volume traffic. These images can be converted to computer files by automatic license plate readers with high levels of speed and accuracy. By matching license plates at two different locations, it is possible to compute vehicle speeds over the defined section of roadway.

Processing the camcorder tapes involves transferring the license plate images recorded on videotape at each camera station into a computer file along with the precise time at which each license plate image was recorded. Each separate station file is then matched against a logically related file to obtain the number of vehicles traveling from one station to another and the interval of time required by each vehicle to accomplish this movement. Thus, for example, if the license plates observed at Station 1 were matched against the plates observed at Station 2, the difference between the time stamp of a given license was observed at the upstream station and the time stamp at which that same plate was observed at the downstream station can be used to compute the travel time.

Using video technology to simultaneously obtain vehicle speeds, volume, and classification, requires two cameras for each lane of traffic. At one location, cameras would monitor volume, classification, and license plates. At the second location only license plates would be observed, for the purpose of computing speed. This set up would provide speed over a measured distance. The cost would be $1550 per hour for a two-lane directional roadway, and would include data collection and reduction. Based on license plate characteristics, or other features, it may be
possible to estimate non-local drivers from the same video source, at an increased cost.

Although there are some real benefits of video data collection, the costs are very high, particularly when compared to using FDOT's permanent count locations.

Summary

The preferred method of traffic data collection for freeways and uninterrupted flow arterials appears to be the FDOT permanent count traffic stations. Retrieving historical permanent count data to create hourly summaries of vehicle classification and speed to correspond to hourly volume summaries could be accomplished. This would allow the creation of speed-flow relationships to correspond with seasonal adjustment factors, weather conditions, presence of school traffic, etc.

Reprogramming a selected sample of about 6-8 locations for which continuous traffic data could be downloaded on a short term interval basis also may be desirable. If reprogramming can be accomplished, it would be possible to investigate the short-duration relationship between speed, flow, seasonal traffic factor, and other adjustments identified above.
INTERSECTIONS

As noted previously, the primary variables of concern with respect to intersections are start up lost time and saturation flow rates. There are well defined methods for observing start up lost time and saturation flow rates. One such procedure is summarized by Murthy and Mohle7. A similar method is specified in the current edition of the Highway Capacity Manual. In any case the method involves the observation of a stream of vehicles stopped at an intersection for a red traffic light. When the light turns green, field observers can monitor the length of time it takes the first few vehicles to clear the intersection, and the length of time it takes all the vehicles in the queue to clear the intersection and thereby compute the start up time and the saturation flow rate. These field experiments can be performed at intersections with similar field geometry but with known differences in the make-up of driver characteristics. For example, saturation flow rate studies done on International Drive in Orlando, at Lake Buena Vista, or in St. Augustine (all of which clearly are reflective of high percentage tourist environments) could be compared to conditions observed in a clearly business oriented environment such as the West Shore area of Tampa, or other high density business and commerce centers. While the data collection methods for these studies are labor intensive, it is believed that a small number of field data collection teams could collect sufficient data within a several month period to ascertain differences between intersections located in different characteristic areas.

III. ESTIMATION OF NON-COMMUTER OR NON-LOCAL DRIVERS

DEFINITIONS OF NON-COMMUTER OR NON-LOCAL DRIVERS

As noted at the outset, the driver population factor is designed to reflect the presence of non-commuters and/or others unfamiliar with the roadway. In fact there are a number of driver factors that might effect roadway capacity, including trip purpose, driver age, duration of trip, and others.

This study attempts to focus on the effect of traffic of the driver's familiarity with the road. The "driver's familiarity with the road" indicates the level of knowledge that the driver has with the road in question, including location of signs and exit, characteristics of the road (what's on the other side of the next overpass and which is the best lane to be in to avoid bottlenecks, for example). This variable would be measured on a continuous scale, and would ideally be based on objective measures rather than subjective opinions. Clearly, "familiarity" with the road is an imprecise term. How to measure it is equally imprecise and subject to interpretation. It might, for example, be defined: as "out-of-state" drivers, out-of-county drivers, non-commuters, and other variants. Several specific methods have been examined to measure or approximate the driver population's aggregate familiarity with the road.

ROADSIDE INTERVIEWS

One source available for historical analysis of the percentage of unfamiliar drivers is the Florida Department of Transportation's Roadside External Origin and Destination Survey and Data Collection Project (State Job # 99990-1606), conducted by the Transportation Consulting Group. A sample of drivers passing certain roadside interview sites were surveyed. Respondents were asked their origins and destinations and to define the purpose of their trip (coded as home-based work, home-based shopping, etc). License plate data and vehicle occupancy also were recorded. The survey does provide estimates of O/D patterns, which might be used to define non-local, which could be used as a surrogate for degree of familiarity.
A serious limitation of these historical surveys is that they could only provide estimates of unfamiliar drivers in the time periods during which the surveys were conducted. The only way that this information could be used is if traffic data from the same time period were collected and analyzed to estimate the impact of those drivers on the traffic flow conditions at that time.

Alternatively, it is possible to perform new roadside interview surveys. The procedure would be to conduct roadside interviews in a manner similar to TCG's methodology, but the survey instrument would be designed to get personal information about the driver and to determine the familiarity of the driver with the particular road in question.

**Advantages**

- Data Quality. The major advantage to this method is that the data collected will reflect precisely upon the definition of unfamiliar drivers.

**Disadvantages**

Major disadvantages of this method include:

- Cost. This is an extremely expensive option to pursue, due to the number of interviewers that will need to be employed. TCG estimates costs in the range of $2,000-4,000 per day per location, for 4-hour surveys. Another consulting firm reports costs of approximately $5,500 per day per location, for an 11-hour day.

- Inconvenience to the public. The public will have to be greatly inconvenienced, since a certain percentage of the traffic is stopped.

- Use of other resources. Law enforcement officers will need to be used to assist in this project, as they were in the TCG projects mentioned above.

- Coverage of roadway types. This method is not feasible for main-line freeway studies, only for arterials and intersections.
Non-replicability. This method does not use data readily available to traffic engineers and planners, and is thus not directly transferrable to them for planning purposes. Some type of approximation or a series of assumptions would have to be made to create data that could be used for planning purposes.
FLORIDA OFFICE OF TOURISM RESEARCH DATA

The Office of Tourism Research, of the Bureau of Economic Analysis of the Florida Department of Commerce creates an estimate of the total number of out of state visitors arriving in Florida each month by air and by auto. They also conduct a fairly extensive survey of visitors to determine where they came from, where they have visited in Florida, and how long they stayed.

The estimate of out-of-state drivers by area by month developed from the tourist surveys could be used as a proxy for direct observations of vehicles to estimate percent of unfamiliar drivers in the traffic stream.

Estimate of Out of State Air Visitors

The monthly report of the Office of Tourism Research contains the following definition:

"A visitor is defined as someone who has spent at least one night in Florida and has traveled at least 200 miles round-trip from home....Sample surveys are conducted in thirteen Florida airports twice each month. Flights surveyed are randomly selected from all departing regularly scheduled passenger flights on a randomly selected day. The surveyors are trained to adhere to a passenger selection process which ensures randomness and sampling proportionate to flight size. Each month, between 3,500 and 4,000 surveys are conducted throughout the state. The proportion of visitors in the sample is calculated, then applied to enplanement data received from the respective airports. The resulting figure is the number of estimated visitors to each airport, which are then summed to produce the state total."

On any given sampling day in any given airport, about 125 - 150 interviews will be conducted. From these data, visitor profiles are developed. A separate data collection effort is conducted to determine the proportion of passengers that are from out of state,

"Florida Visitors - Monthly Estimates - December 1994", Office of Tourism Research, Bureau of Economic Analysis, Florida Department of Commerce
and this information is combined with airline enplanement data to estimate the total number of out-of-state air visitors. Assuming the two days selected each month for sampling each airport are representative, the methodology is reasonably sound.

**Estimate of Out of State Auto Visitors**

The Office of Tourism Research’s monthly report contains the following definition:

"A visitor is defined as someone who has spent at least one night in Florida and has traveled at least 200 miles round-trip from home…. The auto visitor estimate results from 120 separate 30 minute observation periods each month on 27 roads entering Florida at randomly selected locations and times. The observation coverage is stratified by weekday/weekend and day/night periods. Each of the four major incoming highways is sampled 18 times per month. Visitor characteristics such as number of passengers per vehicle and state of origin are recorded and tallied and the resultant proportion is multiplied by the Florida Department of Transportation (DOT) telemetry count for that road. Twenty-three other incoming roads are further stratified by traffic flow into busy, moderate and idle categories. Forty-eight observations are taken on these smaller roads and calculations are performed which result in an ‘other road’ estimate.”

The observations are made by manual recognition of out-of-state license plates and head counts, and combined with the telemetry data collected to produce the total estimate. Night observations are made only on the four major highways at well-lit locations. This may introduce minor biases in the estimate of out-of-state visitors, since data is not (and realistically cannot) be collected on the minor roads.

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"Florida Visitors - Monthly Estimates - December 1994", Office of Tourism Research, Bureau of Economic Analysis, Florida Department of Commerce
Estimate of Total Tourists and Tourists by Geographic Area in Florida

The Office of Tourism Research’s monthly report contains the following definition:

"The survey data collected is combined with data from administrative sources to produce the visitor estimate, which becomes the visitor data series in the state’s econometric model....The purpose of the program is to produce monthly estimates of visitors to Florida at the 95% confidence level within +/- 10% of the true value."\(^1\)

A random sample of the out-of-state visitors departing Florida by air and by car are surveyed and asked a number of questions relating to their stay in Florida. The interviews are conducted in airports and on roadways near the state lines. The questionnaire includes questions about what cities and attractions the respondent visited, and how long they spent in each destination.

The data from the above surveys, combined with the estimates of the total number of air and auto visitors by month, can also be used to create an estimate of how many out-of-state visitors were in any given place in Florida during a given month.

Since the data includes the number of nights spent in each place, we can actually estimate the number of tourist-days in any place for any given month, divide that number by 30 (or 31), divide again by the resident population, and obtain a weighted estimate of the percentage of the total driver population that was from out of state in any given month. Following is an estimate, based on the Office of Tourism data sets, for the Orlando region.

\(^{10}\)Florida Visitors - Monthly Estimates - December 1994", Office of Tourism Research, Bureau of Economic Analysis, Florida Department of Commerce
## COMPARISON OF VISITOR ESTIMATES AND SEASONAL TRAFFIC FACTORS

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>1,435,507</td>
<td>1.18</td>
<td>1.00</td>
<td>0.96</td>
</tr>
<tr>
<td>February</td>
<td>1,324,956</td>
<td>1.09</td>
<td>1.04</td>
<td>1.06</td>
</tr>
<tr>
<td>March</td>
<td>1,567,544</td>
<td>1.29</td>
<td>1.05</td>
<td>1.07</td>
</tr>
<tr>
<td>April</td>
<td>1,246,064</td>
<td>1.03</td>
<td>1.04</td>
<td>1.07</td>
</tr>
<tr>
<td>May</td>
<td>946,329</td>
<td>0.78</td>
<td>1.01</td>
<td>1.04</td>
</tr>
<tr>
<td>June</td>
<td>1,230,819</td>
<td>1.02</td>
<td>1.02</td>
<td>1.04</td>
</tr>
<tr>
<td>July</td>
<td>1,374,456</td>
<td>1.13</td>
<td>1.00</td>
<td>1.09</td>
</tr>
<tr>
<td>August</td>
<td>1,090,822</td>
<td>0.90</td>
<td>0.99</td>
<td>1.04</td>
</tr>
<tr>
<td>September</td>
<td>1,037,866</td>
<td>0.86</td>
<td>0.96</td>
<td>0.95</td>
</tr>
<tr>
<td>October</td>
<td>1,014,357</td>
<td>0.84</td>
<td>0.97</td>
<td>0.89</td>
</tr>
<tr>
<td>November</td>
<td>1,127,427</td>
<td>0.93</td>
<td>0.96</td>
<td>0.89</td>
</tr>
<tr>
<td>December</td>
<td>1,154,634</td>
<td>0.95</td>
<td>0.97</td>
<td>0.95</td>
</tr>
<tr>
<td>TOTAL</td>
<td>14,550,781</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sources:** Estimates derived from Tourism Bureau Surveys Florida DOT District V Traffic Data
Comparisons with Other Sources of Estimates

Many local governments obtain estimates of visitors from independent sources, usually from research/consulting companies. CUTR has obtained estimates from the Miami Visitor/Convention Bureau (prepared by Strategy Research Corp.), Orlando (prepared by DKS & Affiliates), and Lee County (Prepared by Research Data Services). Compared to these sources, the model created above consistently estimates the total number of visitors to any of these areas at a lower level than the locally generated estimates.

Some examples of the estimates:

<table>
<thead>
<tr>
<th>Location</th>
<th>Time Period</th>
<th>Estimate based on Tourism data</th>
<th>Local estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orlando</td>
<td>1994</td>
<td>9.4 MM</td>
<td>12.1 MM</td>
</tr>
<tr>
<td>Miami</td>
<td>1994</td>
<td>7.2 MM</td>
<td>8.2 MM</td>
</tr>
<tr>
<td>Lee County</td>
<td>1994</td>
<td>1.4 MM</td>
<td>1.6 MM</td>
</tr>
</tbody>
</table>

There are a number of possible explanations for these differences, including:

- Definition of market area. The local sources refer to "Greater Miami and beaches", "Orlando area," etc.
- Definition of "visitor." The Office of Tourism estimate requires at least one night in Florida.
- Out-of-state versus in-state visitors. This distinction is not always clear in the local estimates.

Estimates of In-state Visitors to Other Parts of Florida

The Florida Department of Commerce also supports a section of the Consumer Confidence Survey which attempts to determine the number of Florida residents who visit other parts of the state for recreational/tourist purposes. The survey is conducted with approximately 1,000 Florida residents each month. Of these, frequently less than 10% take a trip anywhere in Florida. This sample size does not support drawing conclusions about the number
of Florida residents who visit a particular geographic location in Florida during a particular month.

Advantages

• Cost. This method uses data that is already being collected, and no additional cost burden is created to estimate non-familiar drivers in the traffic stream.

• Replicability. This data is collected on an on-going basis, and it would be relatively simple to provide updates and estimates to planners.

Disadvantages

• Data Quality. This data will provide only an approximation of non-local drivers in the traffic stream. It provides an estimate of the number of out-of-state drivers in the area for a given month, rather than an estimate of the number of drivers in the traffic stream that is being observed.
LIGHTS-ON TYPE SURVEYS

One possible experiment would be to inform drivers through roadside signs to indicate if they are "familiar" with the roadway. A simple, objective definition of "familiarity" (for example, "Have you driven on this roadway at least twice in the past month?") would have to be developed. Drivers would indicate that they are unfamiliar with the roadway by, for example, turning on their hazard lights (or some similar action). It would probably also be necessary to develop some way of having drivers who are familiar with the roadway have some different method of indicating that fact (for example, by flashing their headlights), so that the level of familiar drivers, non-familiar drivers, and non-respondents to the experiment could be determined. Data collection methodology (video recording, in-person observation, etc.) could also impact costs. This method is illustrated conceptually in Figure 4.

Advantages

• Data Quality. This method still allows for collection of data on the level of driver familiarity with the roads, rather than assuming that certain types of license plates indicate unfamiliarity.

• Control of non-response. Properly designed, this method would also allow for estimations of co-operation rates as well as percentage of drivers familiar and unfamiliar with the road.

• Inconvenience to the public would be minimized.

Disadvantages

• Measurement Error. This method could be prone to recording error. Personal observations could easily miss some response, particularly if traffic is moving at high speeds. Also, weather conditions could affect visibility.

• Potential co-operation rates are unknown but might be very low. Signs might be ignored or not understood.

• Question wording. The options for how to word the question are limited by the time frame the respondent will have to read the question, and response is limited to two categories
• Non-replicability. This method does not use data readily available to traffic engineers and planners, and is thus not directly transferable to them for planning purposes. Some type of approximation or a series of assumptions would have to be made to create data that could be used for planning purposes.
Figure 4. Conceptual Design of Field Experiments for Estimation of Percentage Levels of Non-Local Driver Population.
LICENSE PLATE RECOGNITION

Another possibility is to read license plates, either manually or through video technology, to determine state (and county, where possible) of origin of the vehicle, and make assumptions as to familiarity with the roadways in question. It would be conceivable to run a list of Florida license plate numbers through the Department of Motor Vehicles database, but previous experiences would suggest many anomalies such as local vehicles and business vehicles which are often not registered at the residence of the driver.

Advantages

• Potential multiple applications. Video could be used both to estimate non-familiar drivers and to record speed, traffic volume and to pinpoint saturation-flow events.

• Permanent data record. Unlike personal observations of traffic, if video data collection is used, the data can be reviewed multiple times, and may be a potential source for different types of traffic studies.

Disadvantages

• Inability to identify county of residence. Perhaps the greatest disadvantage is that it is impossible to assign many Florida license plates to a county. In a small experiment performed at a regional shopping center in Tampa, it was found that of a sample of 206, approximately ten percent of the plates were of the specialty variety (e.g. Florida Manatee, Challenger, Super Bowl, USF, FSU, etc.) that did not include a county designation. A more complete accounting from the Florida Department of Highway Safety and Motor Vehicles indicated 562,470 passenger cars and pickup trucks registered in Hillsborough County. Of these, 96,750 (17 percent) were specialty plates of one kind or another (e.g. Challenger, Florida Panther, etc.), for which there is not county designation.

Even more significant, for twenty percent of the shopping center sample, it was impossible to identify the county, as it was covered by a license plate frame. Thus, we might conclude
that thirty to forty percent of the Florida plates can not be
categorized by county.

In addition, past experience with DMV data indicated that many
cars are registered to companies in far-off cities, even
though they are operated by local residents. Local drivers
are thus incorrectly classified as unfamiliar. In our Tampa
shopping center sample of 206 license plates, it was possible
to identify 77 from Hillsborough, 10 from Pinellas, 10 from
Pasco, 4 from Polk, 2 from Hernando, and 2 from Manatee, for
a total of 105 that one might assign as "local". What of the
5 with Dade, the 2 with Duval, the 2 from Okaloosa, 2 from
Orange, and the 16 that represented individual counties,
ranging from Escambia to Putnam to Broward? Even the 15 from
states other than Florida may or not may be local drivers.

Many non-local drivers use rental cars in Florida. These
rental cars cannot be readily identified based on license
plates.

Finally, recent discussions with the DMV indicate that county
designations are being deleted from new vehicle registrations,
as the county designation has apparently been used to target
vehicles for theft and carjacking.

• Cost. This is a very high cost method.

• Potential visibility problems. Fog, rain, etc. could hamper
recognition efforts.

• Sample Quality. The definition of unfamiliar drivers is
compromised. This method requires a number of assumptions
about what an unfamiliar driver is from their place of
residence.
UTILIZATION OF TOLL PLAZA SURVEYS

It may be possible to ascertain driver characteristics at toll plazas, which might then be linked to traffic flow characteristics sufficiently upstream or downstream from the toll plaza so that uninterrupted flow conditions can be observed. This might be accomplished by placing observers at a toll plaza and either observing license plate characteristics or directly asking a brief question (e.g. county of residence) of motorists.

Potential sites might include the East-West Expressway in Orlando, the Tampa Crosstown Expressway, the Homestead Extension of Florida's Turnpike, the Palmetto Expressway, the Sawgrass Expressway or sections of the Florida Turnpike in South Florida. Ideally, it would be preferable to identify toll plazas in relative proximity to permanent count stations capable of monitoring volume, speed and vehicle classification.

Advantages

- Might allow the direct correlation of traffic flow characteristics with actual driver characteristics in the traffic stream. Particularly if a direct question could be asked of the motorist, use of assumptions would be minimized.

Disadvantages

- For reasons noted in previous section, observation of license plates has serious limitations in terms of translating into degree of local familiarity.

- Asking a question of motorists at a toll plaza has the distinct potential to cause additional toll plaza delays. Even a simple one-question verbal survey may cause delays. If verbal surveys are done at toll plazas, they would probably need to be accomplished by surveying motorists in standing queues, so as not to be responsible for any additional delay.

- The cooperation of the FDOT Bureau of Toll Operations will be necessary.
USE OF SEASONAL TRAFFIC VARIATIONS AS A SURROGATE FOR NON-COMMUTERS

It might be hypothesized that the seasonal peaking characteristics on roadways can be used as a surrogate for non-local or non-commuter traffic. This methodology would assert that a major portion of the additional traffic observed at peak seasons, as contrasted to non-peak seasons, is made up of non-local drivers. We might expect that during seasons where the average daily traffic (ADT) is low, this is an indication of relatively few non-local drivers in the traffic stream. Conversely, we might assert that when average daily traffic is at its seasonal highs, the increment contributing to that high traffic is largely made up of non-local or non-commuter traffic.

If this hypothesis is true, we might expect an inverse relationship between average daily traffic and peak period flow rates, at a given level of service. In other words, we might expect that on low ADT traffic days the peak period flow rates, for a given level of service, would be higher than on days where the ADT is higher, indicative of more non-local drivers in the traffic stream. This relationship, if it exists, may be more discernable for either morning or evening peak periods.

The hypothesized relationships might be illustrated as the following two figures (Figures 5 and 6). Very preliminary studies have been unable to confirm this relationship based on only volume data without considering speed; however, the use of only volume data makes it impossible to evaluate the level of service associated with various volume levels. It is believed that with volume, speed, and classification data it may be possible to relate seasonal traffic factors to peak period level of service.

This proposal calls for a scientific time-series analysis of traffic variations that accounts for at least the following factors:

- 24-hour ADT - representative of the extent of non-locals in the traffic stream
- Peak period directional flow rate, speed, and classification - to determine the peak period level of service associated with the various conditions
• Other possible explanatory variables -
  Local schools in session or not
  Degree of daylight during peak period
  Weather conditions
Advantages

- Can make use of historical data at numerous permanent count sites at which it is possible to obtain volume, speed and classification data.

- Can make use of new real time data, including the possibility of shorter duration (e.g. 15-minute interval) data.

- Can apply statistical time series analysis methods to evaluate significance of various factors.

Disadvantages

- Requires considerable cooperation from FDOT Office of Transportation Statistics.

- Presence of non-local drivers is inferred from variations in seasonal traffic.
Figure 5. Monthly Variation in Peak Flow Rate and ADT

Figure 6. Peak Flow Rate and ADT Factor
IV. RESEARCH PRODUCT FORMATS AND EXPERIMENTAL DESIGN

PRODUCT FORMAT

One of the main objectives in this study is to develop non-local driver population adjustment factor tables which can be used to calculate roadway facility capacity with the consideration of non-local driver population in the traffic stream. The procedure of using non-local driver population adjustment factor $f_p$ is:

Given Conditions → Check Corresponding $f_p$ → Adjust Capacity

A question is: what type of explanatory variables could be used to develop $f_p$? Three types of given conditions may be considered: (1) percentage level of non-local driver population in the traffic stream (intersections and freeways), (2) land use near the intersections (intersections only), and (3) tourist level near freeway facility (freeway only). Product formats generated from this study may be based on these three types of given conditions. Based on Percentage Level of Non-Local Driver Population

Figure 7 shows a possible product format which is based on percentage level of non-local driver population. If the information on percentage level of non-local driver population is given, a population adjustment factor $f_p$ during certain time periods can be found from this table shown in Figure 7. However, practically, users may not be able to precisely know the percentage level of non-local driver population. In this case, the users would have to use their experience to estimate the percentage level of non-local driver population.

<table>
<thead>
<tr>
<th>Percentage Levels of Non-Local Driver Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Level ($&gt;20%$)</td>
</tr>
<tr>
<td>Weekday Peak Hour</td>
</tr>
<tr>
<td>Weekday Non-Peak Hour</td>
</tr>
<tr>
<td>Weekend</td>
</tr>
</tbody>
</table>

Figure 7. Product Format of Driver Population Adjustment Factors, Based on Percentage Level of Non-Local Driver Population.
Based on Land Use Near Intersections

This is a very different approach, in that it would be based on adjacent land uses, rather than an explicit identification of non-commuters or non-local drivers. This format can be considered for signalized intersections only. The possible product format for signalized intersections is shown in Figure 8. To adjust the intersection capacity calculation using \( f_p \), it would be unnecessary to know the percentage level of non-local driver population at the intersection. Instead, the users should be able to determine the main land use around the facility. For example, if the intersection was located at an area with heavy tourism, at a business area, at a residential area, or at a shopping area. Based on this information, users may be able to select a driver population adjustment factor \( f_p \). This formula could be used in practical situations. However, this format may not reach the accuracy that the first format (based on percentage level of non-local driver population) could reach.

<table>
<thead>
<tr>
<th>Land Use Near the Roadway Facility</th>
<th>Tourist Area</th>
<th>Office</th>
<th>Residential Area</th>
<th>Shopping Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekday</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak Hour</td>
<td>( f_p )</td>
<td>( f_p )</td>
<td>( f_p )</td>
<td>( f_p )</td>
</tr>
<tr>
<td>Non-Peak Hour</td>
<td>( f_p )</td>
<td>( f_p )</td>
<td>( f_p )</td>
<td>( f_p )</td>
</tr>
<tr>
<td>Weekend</td>
<td>( f_p )</td>
<td>( f_p )</td>
<td>( f_p )</td>
<td>( f_p )</td>
</tr>
</tbody>
</table>

Figure 8. Format of Driver Population Adjustment Factors for Signalized Intersections, Based on Land Use Near the Roadway Facility.

Based on Tourist Level Near Freeway Facility

For freeway facilities, it may be more difficult to estimate non-local driver population levels, as compared to intersections. The possible explanatory variables to be used for adjusting non-local driver population include tourist level near freeway facility, type of city, urban/suburban or rural area, and so on. Figure 9 shows a format based on tourist level near a freeway facility. This format only considers the attraction of an area or a city to tourists from other areas and has the similar advantage and disadvantage associated with the format shown in Figure 8. For
example, the City of Orlando could be considered a heavy tourist area. There may be two different non-local driver population adjustment factors for high tourist season and low tourist season, respectively.

<table>
<thead>
<tr>
<th>Tourist Levels Near Roadway Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy Tourism Areas</td>
</tr>
<tr>
<td>High Season</td>
</tr>
<tr>
<td>Low Season</td>
</tr>
</tbody>
</table>

Figure 9. Format of Driver Population Adjustment Factors for Freeways, Based on Tourism Levels Near Roadway Facility.
DESIGN FOR DEVELOPMENT OF \( f_p \) TABLES FOR FREEWAY SECTIONS AND UNINTERRUPTED FLOW ARTERIALS

Methods for Estimation of Driver Population Adjustment Factors (\( f_p \))

The basic principle to estimate \( f_p \) will be based on the 1994 Highway Capacity Manual (HCM) for the definition of \( f_p \) and equation for calculation of service flow rate at level of service \( i \) (LOS\( i \)) under prevailing conditions, including pavement lane width and lateral clearance adjustment factor \( f_w \), heavy vehicle adjustment factor \( f_{hv} \), and non-local driver population adjustment factor \( f_p \). Figure 10 presents the procedure for estimation of \( f_p \). Traffic data (flow rate and speed) will be needed from test sites at different times. If flow rate and speed are known, traffic density can be estimated. Thus, based on HCM, the maximum service flow rate at LOS\( i \) under ideal conditions (MSF\( i \)) can be estimated by using the level-of-service criteria table in HCM. With considerations of prevailing conditions, service flow rate \( S_F i \) at LOS\( i \) can be calculated by using HCM procedures. On the other hand, \( S_F i \) can be estimated from field traffic counts. The service flow rate data obtained from traffic counts can be used to calibrate non-local driver population factors with the assumption that other adjustment factors are available.

![Diagram](image)

Figure 10. Procedure to Estimate Driver Population Adjustment Factors.

In practical situation, if the data source is sufficient, a flow-speed curve could be obtained for given conditions. In this
case, flow-speed curves under different non-local driver population levels may be obtained from existing data source or from future field observations. Figure 11 presents the curves with different non-local driver population levels. Conceptually, if the difference between the curve without non-local driver population impact and the curve with a certain level of non-local driver population impact is $\Delta V$, or

$$V^* = V + \Delta V$$

where

$V =$ traffic volume under prevailing conditions including non-local driver population

$V^* =$ traffic volume under prevailing conditions not including non-local driver population

Then, the non-local driver population adjustment factor $f_p$ could be roughly estimated by

$$f_p = \frac{V}{(V + \Delta V)}$$

The above equation is based on the assumption that $f_p$ is constant under different speed. Practically, $f_p$ may changes as speed changes. However, statistical methods could be used to obtain optimal $f_p$ values.

![figure 11](image_url)

Figure 11. Impact of Non-local Driver population.
Data Required for Estimation of \( (f_p) \)

Generally, 15-minute data intervals are preferable to estimate service flow rates. The Florida DOT has many permanent traffic count stations along interstates and other primary highways. Most stations have the capability to count traffic flow rate and determine vehicle classifications. Information on vehicle classifications will be needed to determine heavy vehicle adjustment factors \((fhv)\). Lane width and lateral clearance adjustment factors \((fw)\) can be determined from field test site measurements which include lane width and lateral clearance, or from FDOT's roadway characteristics inventory. The following are the considerations regarding count site location and number of count stations, data observation duration and number of observation days during which traffic counts are needed, and other factors.

Location and number of count stations

The count stations selected for estimation of non-local driver population factors should cover the areas ranging from the areas with many non-local drivers to the areas with very few non-local drivers. It is preferred that the freeway sections near the test count stations have similar geometric and/or traffic composition characteristics to minimize the impacts of other factors on the estimation of non-local driver population adjustment factors. Practically, a minimum of six or more count stations are suggested with two stations located at the areas with many non-local drivers, two stations with relatively moderate number of non-local drivers, and two stations with very few non-local drivers.

Other factors

To minimize the impacts of other roadway factors, it would be desirable to select locations that meet standardized design characteristics, such as minimal grade, minimal curvature, standard twelve foot lanes, etc.
DESIGN FOR DRIVER POPULATION FACTORS AT SIGNALIZED INTERSECTIONS

Capacity analysis at signalized intersections is based on saturation flow rates and effective green ratios of designated lane groups as described in the 1994 HCM. The saturation flow rate is computed from the ideal saturation flow rate, usually 1900 pcphgpl, with the adjustments for a variety of prevailing conditions that are not ideal, such as heavy vehicles, approach grade, parking lane, right/left turns, area type, and bus activity. The effective green ratio is calculated from the lost time, (usually 3 seconds/phase,) which is the summation of the total start-up lost time $t_1$ and clearance lost time $t_2$.

According to the HCM, the capacity of a lane group is calculated from the following equations:

$$
c = s \cdot \frac{g}{C},
$$

$$
s = s_0 \cdot N \cdot f_w \cdot f_w \cdot f_g \cdot f_{pk} \cdot f_{bb} \cdot f_{RT} \cdot f_{LT},
$$

$$
g = C - L
$$

where:

- $c =$ capacity, vph;
- $s =$ saturation flow rate, vphg;
- $s_0 =$ ideal saturation flow rate, pcphgpl;
- $N =$ number of lanes;
- $f_i =$ adjustment factors for lane width, heavy vehicles, parking lane, bus blocking, area type, right turn, and left turns respectively;
- $g/C =$ effective green ratio;
- $C =$ cycle length, seconds;
- $L =$ lost time per cycles, seconds.

The impact of the population factor, if there is any, would be shown on the lost time and the saturation flow rate. Non-local
drivers may drive more cautiously. As a result, the saturation flow formed by them would be lower than the normal saturation flow rate, and their lost times would be greater than normal drivers. Mathematically, if the driver population factor needs to be considered, the equations for capacity analysis should be revised. The recommended new equations are:

\[ c = s \left( \frac{g}{C} \right), \]

\[ s = s_c N f_u f_{k_f} f_{g} f_{p_k} f_{b_d} f_s f_{k_f} f_{l_f} f_{p_1}, \]

\[ g = C - L_k f_{p_2} \]

where:

- \( f_{p_1} \) = non-local driver population adjustment factor for the saturation flow;
- \( f_{p_2} \) = non-local driver population adjustment factor for the lost time.

To produce two adjustment factors, \( f_{p_1} \) and \( f_{p_2} \) for the ideal saturation flow rate and the start-up lost time, field experiments would be necessary.
Experimental Considerations

Type of Data Needed

By definition, the saturation flow rate of a traffic lane is best expressed as a saturation headway, which is more easily understandable and measurable. The headway saturation is the time difference between two successive vehicles in a traffic lane as they pass a point on the roadway, measured from rear axle to rear axle. The relationship between the saturation flow rate and the saturation headway is shown as follows:

\[ h = \frac{3600}{s} \]

where:
- \( h \) = saturation headway, seconds;
- \( s \) = saturation flow rate, vphg.

The lost times are directly measured from headway studies. When a traffic flow starts as the traffic signal turns green, the first several vehicles will have longer headways than the saturation headways \( h \). The increments between these headway and \( h \) are called start-up lost times. The summation of these start-up lost times is \( l_1 \). When the traffic light turns amber some vehicles will still enter the intersection if the traffic flow is not completely discharged. The clearance lost time \( l_2 \) is the unused portion of the change interval which consists of the yellow phase plus the all-red phase.

For this research project, headway data collections should be applied to traffic flows with different driver population levels so that different saturation rates and lost times could be measured. At the same time, the driver population levels of these traffic flows should be determined so that it is possible to perform a mathematical analysis of the relationship between driver population and roadway capacity.

Type of intersections to be measured

For the selection of intersection types, the first consideration is the non-local driver population level. Intersections near central business district areas might have less non-local drivers. On the
other hand, non-local drivers could be more easily found in intersections near tourist attractions. Traffic and geometric conditions should be considered as well. Intersections with ideal or near ideal conditions are preferable. Intersection lanes to be surveyed should meet condition requirements such as through traffic only, no or few heavy vehicles, no bus activity, no parking lane, and zero approach grade, etc.
Traffic Data Collection

The general task of the traffic data survey is to determine the saturation headway and the lost time. In this survey, the time is recorded when the rear axle of a vehicle passes the stop line in each cycle. Data processing could generate headway distribution curves which include the information on lost time and saturation headway. The difference between these curves might show some impacts of different non-local driver levels. Left- or right-turning vehicles are not recorded until they proceed through the opposing traffic. Other traffic information is also recorded, such as intersection geometric conditions, the beginning of green, yellow, and red light, and vehicle type, etc.

A video method could be used in this survey. The video camera would be set up alongside the observed traffic lane to record traffic passing the stop line. Two people would be needed to set up video recording equipment and record traffic flows. Other traffic information, such as the beginning of green, could be recorded on tapes too. Vehicle headway could be measured by reviewing the video tapes.

A manual method could be used where it is difficult to find a satisfactory camera position. Two people are needed to record accurate traffic headway data; one is the recorder, the other is the timer. The timer would count aloud each time the rear axle of a vehicle passes the stop line, and the recorder would record it in a survey sheet. All the other information would be recorded in the survey sheet as well.

The advantage of the video method is that it has less labor cost and higher data accuracy than the manual method, but the manual method would be required where it is difficult to set up the video equipment.

If intersection studies are performed it is suggested that study sites be selected based on known characteristics of the driving population. For example, saturation flow rate studies could be conducted in International Drive in Orlando during periods of known high levels of tourism. Similarly, studies of commuters could be performed at intersections at which it is known that virtually all entering vehicles are commuters going to work or returning. Locations might include Cypress Street in Tampa,
which is characterized almost exclusively by office complexes. Similarly, studies could be performed at regional shopping centers, securing sites at which virtually all the traffic is either entering or leaving the shopping center.
V. RECOMMENDATIONS FOR PHASE II RESEARCH

Based on the preceding, it is recommended that Phase II move forward with the following experiments:

• **Correlation of historical permanent count traffic data on freeways with seasonal traffic factors and with Bureau of Tourism data.**

This would require that volume, speed and classification data be retrieved from a sample of six to eight permanent count stations. The assistance of the FDOT Office of Transportation Statistics would be sought, to identify permanent count stations at which reliable speed, volume, and classification data can be obtained. A minimum of one year's continuous data (24 hours per day) would be desired at each location. CUTR is prepared to assign a highly skilled and computer-literate graduate student to the Office of Transportation Statistics to facilitate processing of FDOT's data files.

With a comprehensive set of volume, speed and classification data summarized on an hourly basis, a statistical time series model would be created to relate the fundamental traffic flow parameters of speed, volume and density to possible explanatory variables such as seasonality (indicative of non-local drivers), local school schedules, relationship between sunrise/sunset and peak traffic period, and weather conditions, and Bureau of Tourism data. For each of the sites, it would be necessary to obtain historical local school schedules, sunrise/sunset times, and weather conditions.

Initially an analysis of variance could be performed to identify factors that have statistical significance. After these are identified, models can be constructed to estimate their effect.

• **Use of real time permanent count traffic data on freeways.**

The basic procedures and experiment would be similar to the preceding, with the exception that traffic flow
characteristics would be evaluated on the basis of shorter duration time intervals (e.g. 15 minutes). This would require that a sample of FDOT permanent count traffic stations be reprogrammed to report volume, speed, and classification data in 15-minute intervals.

To obtain as wide a range as possible of traffic variations, it would be desirable to compare locations with similar geometric conditions but different levels of tourism, or alternatively, to collect data for a continuous that spans the high season and the low season of the year at each location, to cover a range of seasonal traffic conditions.

At this point it is very difficult to estimate the resources that might be required to perform these tasks, as it is anticipated that CUTR staff would need to work with FDOT Transportation Statistics Office staff to process various data files. However, our preliminary estimate is that to accomplish the preceding tasks will consume approximately $28,000 of project resources -- $5,000 more than allocated for research implementation. However, with other available project resources, it is anticipated that the project could accommodate this amount. It is recommended that CUTR be authorized to move forward with these two activities. Depending on the resources needed to obtain and analyze permanent count data, a later assessment can be made of the necessary resources, and the possibility of performing intersection saturation flow rate studies, within the resources available for the current contract.

I resources permit, the following additional experiment might be undertaken.

- **Intersection saturation flow rate studies.**

Saturation flow rate studies could be performed at intersection locations for which the driver makeup can be reasonably asserted. It is suggested that a total of six intersections be studied, with several hours of data collection at each. While this would not constitute a definitive study, it would provide some preliminary results. The six locations might consist of two each at locations reflective of heavy commercial (office) uses, retail uses, and tourism uses. For these surveys, it is anticipated that
field data collection would be accomplished using a video camcorder mounted on a stationary tripod, that would permit precise data reduction in the office.

APPENDIX

The following pages include a number of preliminary analyses performed on the FDOT permanent count traffic data at two sample locations.
### Weekday Daily Volume, am PH Volume, pm PH Volume

**County Orange**  **Site I-4, Orlando**  **Direction East**

<table>
<thead>
<tr>
<th>Date</th>
<th>Daily Volume</th>
<th>am PH Volume</th>
<th>pm PH Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/1/95</td>
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<td>70000</td>
<td>60000</td>
</tr>
<tr>
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<td>40000</td>
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<tr>
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<td>0</td>
<td>2000</td>
<td>1/1/95</td>
</tr>
</tbody>
</table>

**Notes:**
- 15 per. Mov. Avg. (am PH Volume)
- 15 per. Mov. Avg. (pm PH Volume)
- 15 per. Mov. Avg. (Daily Volume)
Weekday Daily Volume, am PH Volume, pm PH Volume
County Hillsborough  Site I-275, Tampa  Direction North

Date

Daily Volume

am PH Volume

pm PH Volume

15 per. Mov. Avg. (am PH Volume)

15 per. Mov. Avg. (pm PH Volume)

15 per. Mov. Avg. (Daily Volume)
Weekday Daily Volume, am PH Volume, pm PH Volume
County Hillsborough Site I-275, Tampa Direction South

Date
1/1/95 2/15/95 4/1/95 5/16/95 6/30/95 8/14/95 9/28/95 11/12/95 12/27/95

Daily Volume
- Daily Volume
- am PH Volume
- pm PH Volume
- 15 per. Mov. Avg. (am PH Volume)
- 15 per. Mov. Avg. (pm PH Volume)
- 15 per. Mov. Avg. (Daily Volume)
Daily Volume vs. am & pm PH Volume
County Hillsborough  Site I-275, Tampa  Direction North
Daily Volume vs. PH Volume
County Hillsborough  Site I-275, Tampa  Direction North

- Weekday
- Weekend

Linear (Weekday)
Linear (Weekend)
Daily Volume vs. PH Volume
County Hillsborough  Site I-275, Tampa  Direction North

Daily Volume

PH Volume
Daily Volume vs. am & pm PH Volume

County Hillsborough  Site I-275, Tampa  Direction South
Daily Volume vs. PH Volume
County Hillsborough Site I-275, Tampa Direction South

- Weekday
- Weekend
- Linear (Weekday)
- Linear (Weekend)
Daily Volume vs. PH Volume
County Hillsborough  Site I-275, Tampa  Direction South
Daily Volume vs. am & pm Volume
County Orange Site I-4, Orlando Direction East
Daily Volume vs. PH Volume

County Orange  Site I-4, Orlando  Direction East
Daily Volume vs. PH Volume
County Orange Site I-4, Orlando Direction East

[Graph showing daily volume vs. PH volume with data points for different quarters.]
Daily Volume vs. PH Volume
County Orange  Site I-4, Orlando  Direction East

High Tourist Level: Mar, Jan
Low Tourist Level: May, Oct