Rural Freeway Level of Service Based Upon Traveler Perception

Scott S. Washburn
swash@ce.ufl.edu

Department of Civil and Coastal Engineering
University of Florida
365 Weil Hall, PO Box 116580
Gainesville, FL 32611-6580
352-392-9537 (phone)
352-392-3394 (fax)

David S. Kirschner
dkirschner@gc-inc.com

Grimail Crawford, Inc.
5444 Bay Center Dr. Suite 204
Tampa, FL 33609
813-387-0084 (phone)
813-387-0085 (fax)

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ABSTRACT

The concept of Level of Service (LOS) is meant to reflect the trip quality a traveler will experience on a roadway or other transportation facility. The objective of this study is to provide insight into how road users perceive trip quality on rural freeways, and to examine how the existing service measure (density) relates to the perceived trip quality.

Study participants were shown a series of video clips of rural freeway travel from a driver's perspective and then filled out survey forms indicating their opinion of the trip quality provided by the conditions in the video clip. The survey participants were also asked to give background information about themselves and their driving habits.

The data from the surveys were analyzed using an ordered probit model. The first model used only density as a predictive factor. The second took into account other roadway and traffic characteristics, and the third examined all the significant factors obtained from the survey. The 'density only' model confirmed that density is a strong indicator of travelers' perceptions of trip quality. The other models showed the significance of other traffic and roadway factors in the perception of trip quality in addition to density, as well as some socio-economic information and personal driving habits. A set of LOS thresholds was also calculated for the 'density only' model using the survey participants' responses. The thresholds estimated from the survey participants' responses were considerably lower than the HCM thresholds for all LOS rankings. This suggests that travelers' tolerance of congestion is lower on rural freeways than the HCM indicates.

INTRODUCTION

Transportation infrastructure investment decisions are often heavily influenced by the results of level of service (LOS) analyses conducted according to the methodologies of the *Highway Capacity Manual* (HCM) [1]. In the HCM facility analysis methodologies, the assignment of a LOS is based on designated performance measures and corresponding threshold values. In the 2000 HCM, LOS is divided into six categories—A through F. LOS A indicates excellent service and LOS F indicates extremely poor service. The currently designated service measure(s) (i.e., the performance measure(s) used to assess LOS) for each facility is (are) based on the collective experience and judgment of the members of the Highway Capacity and Quality of Service (HCQS) committee. The same is true with the selection of the threshold values for the various LOS designations. There is currently no quantitative procedure to define which values are used as LOS thresholds. The LOS determination process, therefore, is based on the perspective of transportation professionals. The selection of service measures by the HCQS committee is, however, guided by two principles: 1) the service measure for each facility should represent speed and travel time, freedom to maneuver, traffic interruptions, and comfort and convenience in a manner most appropriate to characterizing quality of service for the particular facility being analyzed, and 2) the service measure chosen for a facility should be sensitive to traffic flow such that the service measure accurately describes the degree of congestion experienced by users of the facility [2]. It is also the committee's intent that the selected service measures and corresponding thresholds be highly correlated with public perception, but this is not known for sure [3]. Since billions of dollars of transportation investment decisions are made every year based upon the outcome of HCM level of service analyses, it is desirable that the transportation engineers' assessments of the impact of these investments be consistent with traveler perception of the investment impacts.

In this study, the issue of level of service perception for freeways in rural areas was addressed. Rural freeways can differ significantly from urban freeways. For example, rural freeways typically have greater distances between interchanges, higher speed limits, and a higher percentage of social and recreational trips (and lower percentage of work and shopping trips) than urban freeways. Despite these differences, urban and rural freeway segments not only use the same service measure, density, but also the same LOS thresholds. This study was initiated by the Florida Department of Transportation (FDOT) Systems Planning Office due to their belief that this generalized approach to freeway segments was not appropriate. The FDOT believed that traveler expectations and perceptions of quality of service were different for rural and urban freeways. While urban freeways experience the full range of traffic congestion conditions, rural freeways rarely experience enough traffic congestion to cause significant travel speed reductions. Rural freeway travelers likely expect these free-flowing conditions. While urban freeway travelers are concerned with their overall travel time and the reliability of this travel time, rural freeway drivers take travel time for granted. Furthermore, urban freeway drivers expect their

ability to change lanes to be restricted, while a restricted ability to change lanes negatively impacts a rural freeway user's perceived quality of service [4]. The objective of this study was to develop a model, and corresponding thresholds, for assessing level of service on rural freeway segments based upon traveler perceptions.

LITERATURE REVIEW

While the literature base is not extensive, the number of studies seeking travelers' opinions about what factors and qualities are important to them in assessing the quality of their trip has been increasing in recent years.

A study by Pécheux et al. [5] noted that the HCQS committee recognized a need to improve the HCM methodology of assessing LOS. Specifically, concerns were raised that the LOS of a roadway section did not correspond to road users' perceptions. The authors felt that for LOS to accurately reflect travelers' perception of quality of service they would first have to find out what performance measures were significant to travelers. Participants identified over 40 factors that were important to their perception of trip quality. These included such factors as intersection efficiency—if the intersection was being utilized by opposing traffic while travelers were waiting, and the aesthetic qualities of the intersection.

A study by Hostovsky et al. [4] used focus groups to identify factors important to trip quality on rural freeways and then compared those findings with those from a focus group study using regular urban commuters and commercial truck drivers. The participants in the rural freeway focus group identified three factors that were most important to trip quality—low density, predictable travel time, and maintaining a steady travel speed. Other topics discussed were the safety issues inherent to the isolated locations of rural freeways, aesthetics, speed differential between vehicles, the presence of heavy vehicles, and the need for better traveler information. Urban commuters placed high importance on the overall speed of their trip, where rural freeway travelers felt that the ability to choose their speed was a positive. This reflects the fact that urban drivers rarely have the opportunity to choose their speed in the traffic stream, so a faster speed is usually preferable over a slower one. Urban commuters were also not as concerned with the ability to change lanes and move about the facility at will. Most of the urban drivers were happy if they could stay in one lane and maintain a desired speed for their trip. The rural drivers were pleased if the density of the freeway section was low enough to allow movement between lanes and passing at will.

A study by Nakamura et al. [6] evaluated traffic flow conditions along an expressway in Japan from a driver's viewpoint. The study intended to quantitatively analyze the relationship between traffic flow conditions, drivers' perceptions, and drivers' behaviors. The field data portion of this study collected data on drivers' behavior and perception under various flow conditions. Drivers had a video camera mounted in their own vehicle and were asked to drive a section of expressway. After each trip the subject was asked to complete a survey about the traffic flow conditions. Twenty-two subject vehicles were used and 105 surveys were collected.

The behavioral data collected were number of lane changes, travel time by lane, and percent time spent following. This study found that the most important factor influencing drivers' satisfaction with their trip was the traffic flow rate. Other factors affecting trip quality were found to be number of lane changes, and the percent time spent following.

Several studies have been conducted using road-user surveys and video selections to evaluate LOS methodology. The first study, by Sutaria and Haynes [7], used a road user survey to evaluate the LOS methodology for signalized intersections. Over 300 drivers were shown video clips taken both from a driver's perspective and from an overhead camera at an intersection. The video segments were specifically chosen to represent a specific LOS and were intended to be shown to drivers for one or two signal cycles. The final compilation shown to drivers included both types of view and the clips were put in a random order. The results from the survey showed delay to be the most important factor both before and after the video portion of the survey. This study provided the first results that took into account the perceptions of travelers and changed the performance measure used by the HCM to evaluate LOS in the 1985 edition.

A study conducted by Pécheux et al. [8] addressed the issue of developing a method to assess the perceived LOS at signalized intersections. The first objective was to determine how well the current LOS methodology reflects the opinion of road users. The second objective was to determine the factors affecting users' perceptions at signalized intersections. The study results showed that on average, the participants' delay estimates were fairly accurate, however individual delay perceptions varied significantly. Fifteen factors were identified that contributed significantly to quality of service. Finally, the study found that participants tended to perceive service quality on three or four distinct levels as opposed to the six levels currently defined by the HCM.

Another study using video clips and traveler surveys was performed by Choocharukul et al. [9] with the intention of evaluating the current HCM methodology of assessing freeway LOS. This study provided a multivariate statistical analysis of the factors that were important to road users' perception of trip quality as well as an assessment of the adequacy of the current service measure, density. The data for this study were collected from several urban freeway segments. Cameras were positioned on overpasses and focused on areas that included inductance loop detectors so density could be calculated from the speed and flow measurements. Thus, the camera position was static and recorded traffic flowing through the field of view. Twelve video clips were prepared, two for each of the six LOS designations (according to the calculated density and HCM thresholds), with one clip at the higher end of the LOS category and one clip at the lower end. The survey participants were provided with the descriptions of the six HCM LOS designations. They then watched the twelve video clips and ranked the LOS they thought best described the conditions. The participants were also surveyed for demographic and driving habit information. This study used an ordered probit statistical model to assess how users perceived the LOS of the freeway operating conditions. The results of the survey and analysis revealed that perceived levels of service do not closely follow the HCM. Almost all the participants in this

study had a lower tolerance for LOS A than the HCM threshold. The HCM threshold for LOS F also does not correspond with the findings of this study, with the participants selecting an average of 82 pc/mi/ln as the upper bound of LOS F as opposed to the HCM threshold of 45 pc/mi/ln. The study also found that factors other than density strongly influence road users' perception of quality of service, such as number of lanes, average speed, speed variance, headway variance, percentage of trucks, and some socio-demographic variables.

A study by Washburn et al. [3] investigated what factors are important to drivers when evaluating the quality of their trip on a rural freeway. A driver intercept survey approach was used. This survey approach was implemented at rest areas and service plazas along rural sections of freeway in Florida. Travelers were asked to rank the factors that contributed to the quality of their trip on a scale from 1 to 7. The most important factor, ranked in the top three 64.3% of the time, was the ability to consistently maintain the desired travel speed. The factor with the next highest ranking was the ability to change lanes freely and pass other vehicles. This was ranked in the top three 33.3% of the time. The third most important factor was the ability to maintain a speed no less than the posted speed limit. This factor was ranked in the top three 33.0% of the time. This preliminary study showed that while density is important to rural freeway travelers, it is not the most important factor in determining trip quality. It also showed that drivers consider many other factors when determining trip quality.

RESEARCH APPROACH

The first issue that needed to be addressed was how traveler perception data would be collected. Common methods of data collection, as found from the literature review, include focus groups, field surveys, in-vehicle surveys, driving simulators, and video surveys.

After considering the various advantages and disadvantages of each method, the approach of using a video survey from the driver's perspective was decided upon. This method would allow larger groups of people to be surveyed simultaneously while providing a reasonably realistic depiction of rural freeway travel. Furthermore, this method allows for complete control and repeatability of the conditions experienced by the participants, ultimately reducing costs, as well as eliminating the liability issues inherent in an in-vehicle survey.

Site Selection

The sites at which the video clips were captured were all within Florida. Reasons for this include the proximity to the University of Florida and the access to the Florida Department of Transportation's (FDOT) network of more than 7,500 traffic monitoring stations.

There were several factors leading to the final site selections, such as presence of a traffic monitoring station (loop detectors), number of lanes, grades, truck percentages, and traffic volume. Traffic information was obtained from archived loop detector data provided by the FDOT [10]. More detail about the chosen data collection sites can be found in the final project report [11].

Inductance Loop Detector Data Collection

To investigate the correlation of density with the user perceptions of LOS, it was necessary to collect speed and volume data at each data collection site during the video recording runs. These data were collected from the inductance loop detector (ILD) stations at each test site. FDOT personnel programmed the detectors at the sites selected for the study to record data in five-minute intervals (the hardware minimum interval) rather than the usual one-hour interval. This shorter interval provided traffic data that more accurately reflected the conditions depicted in the video clips. It should be noted that even with a five-minute data collection interval, the conditions shown in the video clips could potentially vary from the average provided by the ILD data. Thus, for the purposes of the statistical analysis, traffic variable values were adjusted as necessary based upon estimations from the conditions observed in the video clips. The ILD data were used to categorize the collected video data and provided a starting point for selecting a range of conditions to be represented in the survey. From the data provided (speed, volume, and vehicle classification by lane) it was possible to calculate descriptive statistics for the traffic flow at each site, such as the percentage of heavy vehicles in the traffic stream, the total 5-minute volume, the average speed, and the density.

Video Clip Production

The production of video clips for this research approach required the undertaking of three specific tasks— equipment and setup, video data collection, and video clip creation.

The objective of the video data collection was to depict travel along a section of rural freeway from a driver's perspective in a reasonably realistic manner. Three in-vehicle video cameras were used to capture three different fields of view: 1) the view through the front windshield, including a view of the interior rear-view mirror, 2) the view of the vehicle's driver-side rear-view mirror, and 3) the view of the speedometer. The video images were recorded by three portable VCRs. A microphone was also connected to one of the VCRs, allowing the researcher to announce when they crossed a loop detector and any other potentially important information. This would allow the researcher to match the captured video clip to the collected loop detector data.

The researcher would simultaneously activate (via remote control) the recording of the three VCRs. The researcher then merged onto the freeway. The cameras captured conditions between the interchange ramps that came before and after the loop detector station. Up to four runs were made at each location, providing a number of options to choose from when creating the clips for the survey. The data collection for this project was performed during November 2003 and March 2004.

The survey participants were shown a single video display that contained the video scenes of the front windshield and interior rear-view mirror, the driver's side rear-view mirror, and the speedometer (composited through video editing software). A screenshot from one of the video clips used in the survey is shown in Figure 1. This display was shown with a video

projector and wall-mounted screen, located between 10 and 20 feet away from the participants depending on the specific survey location.

The clips were between 1.5 and 2.5 minutes in length. The length of an individual clip was chosen based on events in the video that the researchers wanted to include or exclude, as well as with a survey participant's attention span in mind.

Video Clip Selection

There were thirteen video clips chosen for the final survey. The final number of clips chosen was a result of several pilot test sessions, providing a balance between coverage of alternatives and attention span of participants. The pilot tests revealed that many participants lost interest after two minutes and had already started writing their opinions down. The final video clips were chosen to represent a variety of conditions in categories including lane configuration, traffic density, terrain, truck percentage, the presence of a median or guardrail, and shoulder configuration. The relevant data for each video clip included in the final survey is included in Table 1.

Survey Sessions

Survey Form

The first section of the survey form addressed personal information and rural freeway travel habits, such as education level, income, number of years possessing a driver's license, the number of rural freeway trips taken per month, the average length of the rural freeway trips taken, and level of driving aggressiveness.

The second section of the survey was for recording the participants' opinions and rankings of the video clips. It was divided into two parts for each of the thirteen clips. The first part asked the participant to rank the quality of the trip depicted in the video clip with one of the following descriptors: 'Very Poor', 'Poor', 'Fair', 'Good', 'Very Good', or 'Excellent'. For this preliminary study, the number of levels was kept at six for general correspondence with the six levels of the HCM (A-F). Certainly, it has yet to be determined whether travelers actually perceive six different levels of service, but this issue was beyond the scope of this study. The second part asked the participant to record why they ranked the video clip as they did, listing all factors that significantly contributed to their ranking. The participants were to then number these according to their relative significance.

Finally the form included questions about the survey itself. These included the participant's opinion about the video clips as a representation of rural freeway travel and whether the participant would have changed their rankings based on the purpose of the trip (e.g., business, recreational, or social).

Conducting the Survey Sessions

A total of 126 people participated in this study. These participants ranged from randomly selected Alachua county residents to university students to administrative staff to professionals. The locations, dates, and groups of participants taking the survey during each session are given in Table 2.

With the video format of the survey, multiple survey participants could be accommodated during each session. The viewing room was arranged so that each participant had an unobstructed view of the screen, which was placed as close as possible to eye level so it approximated looking through a vehicle's windshield. Two example clips, each 20 seconds long, were shown to the survey participants to demonstrate the upper and lower ends of the range of possible traffic flows. The first was a nearly empty four-lane freeway and the second was stop-and-go traffic along a four-lane freeway. The participants were then shown each of the 13 video clips and instructed to watch each clip entirely before writing their responses. The order of the presented clips was different for each survey session.

ANALYSIS AND RESULTS

Analysis Method

An ordered probit model was chosen for the statistical analysis approach. This model is well suited to the analysis of discrete choice data, particularly data that have an ordinal (or ranking) nature to the response range [12]. The ordered probit model is derived by defining an unobserved variable, z, that is the basis for modeling the ordinal ranking of data (in this case the six clip rankings) [13]. This variable is specified as a linear function for each observation n such that

$$z_n = \boldsymbol{\beta X_n} + \varepsilon_n \tag{1}$$

where $\boldsymbol{X_n}$ is a vector of independent variables (such as traffic conditions) influencing the clip ranking for observation n, $\boldsymbol{\beta}$ is a vector of estimable parameters, and ε_n is a random disturbance. In this analysis, y is defined as each participant's evaluation of each of the 13 video clips. Using this equation, the observed clip ranking (Excellent = 1, …, Very Poor = 6), y_n, for each observation is written as,

$$\begin{aligned} y_n &= 1 \text{ if } z_n \le 0 \\ y_n &= 2 \text{ if } 0 < z_n \le \mu_1 \\ y_n &= 3 \text{ if } \mu_1 < z_n \le \mu_2 \\ y_n &= 4 \text{ if } \mu_2 < z_n \le \mu_3 \\ y_n &= 5 \text{ if } \mu_3 < z_n \le \mu_4 \\ y_n &= 6 \text{ if } z_n \ge \mu_4 \end{aligned} \tag{2}$$

where the μ values are estimable parameters, referred to as thresholds, that are used in the determination of the probability for y_n [13]. The μ values are estimated jointly with the model parameters ($\boldsymbol{\beta}$). The estimation problem then becomes one of determining the probability that a participant will select a particular ranking for each clip. In using the ordered probit model, it is assumed that the error term, ε_n, is normally distributed with a mean of 0 and a variance of 1. A positive increase in the $\boldsymbol{\beta}$ term implies that an increase in x will increase the probability of the highest response category (i.e., $y = 6$). An increase in the $\boldsymbol{\beta}$ term also implies that the probability of the lowest response category ($y = 1$) is decreased. The resulting response category selection probabilities can be calculated as,

$$\begin{aligned}
P(y_n = 1) &= \boldsymbol{\Phi}(-\boldsymbol{\beta X_n}) \\
P(y_n = 2) &= \boldsymbol{\Phi}(\mu_1 - \boldsymbol{\beta X_n}) - \boldsymbol{\Phi}(-\boldsymbol{\beta X_n}) \\
P(y_n = 3) &= \boldsymbol{\Phi}(\mu_2 - \boldsymbol{\beta X_n}) - \boldsymbol{\Phi}(\mu_1 - \boldsymbol{\beta X_n}) \\
P(y_n = 4) &= \boldsymbol{\Phi}(\mu_3 - \boldsymbol{\beta X_n}) - \boldsymbol{\Phi}(\mu_2 - \boldsymbol{\beta X_n}) \\
P(y_n = 5) &= \boldsymbol{\Phi}(\mu_4 - \boldsymbol{\beta X_n}) - \boldsymbol{\Phi}(\mu_3 - \boldsymbol{\beta X_n}) \\
P(y_n = 6) &= 1 - \boldsymbol{\Phi}(\mu_4 - \boldsymbol{\beta X_n})
\end{aligned} \tag{3}$$

In the above equations, $\Phi(\cdot)$ represents the cumulative normal distribution,

$$\Phi(u) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{u} e^{-\frac{1}{2}w^2} \, dw \tag{4}$$

This model can be estimated using maximum likelihood procedures. However, an adjustment must be made to the estimation procedure. Since each of the 126 participants viewed 13 clips and thus generated 13 observations (for a total of 1638 observations), there are unobserved characteristics that are unique to each participant that will be reflected in all 13 of their rankings. If this is not accounted for in the model, the model will be estimated as though each of the 1638 observations came from a unique participant. This approach would result in lower standard errors in the model's estimated parameters, leading to inflated t-statistics and potential biases in parameter estimates.

The situation can be handled with a standard random effects approach, by rewriting Eq. (1) as,

$$z_{ic} = \boldsymbol{\beta X_{ic}} + \varepsilon_{ic} + \varphi_i \tag{5}$$

where i denotes each participant ($i = 1,\ldots,126$), the c denotes each video clip ($c = 1,\ldots,13$), φ_i is the individual random effect term and all other terms are as previously defined. The random effect term φ_i is assumed to be normally distributed with mean 0 and variance σ^2. An output from this random effects model estimation is an estimate of σ, the significance of which determines the significance of the random effects model relative to the standard ordered probit model [12].

Statistical Analysis

Three models were estimated in this study, and the results for all three are shown in Table 3. The first analysis explored how the quality of service perceptions of the survey participants correlated with just the measure of density and the HCM LOS thresholds. The positive coefficient calculated for density indicates that, as density increases, the likelihood of a traveler perceiving a worse LOS increases. The very high *t*-statistic (coefficient divided by its standard error) for density indicates that it is certainly significant in the model. The standard deviation of the random effects term, σ, is also highly significant, meaning that the choice of a random effects model for this data set was justified. The overall model fit, indicated by the goodness-of-fit measure, adjusted ρ^2, was 0.355. The ρ^2 value can range between 0 and 1. A ρ^2 value of 1.0 indicates a perfect model fit.

Using the calculated values in Table 3, the threshold values for density can be calculated as $(\mu_k - \beta_0)/\beta_1$, where k designates the four threshold values for this model in Table 3 (assuming the lowest threshold is 0, i.e., $\mu_0 = 0$). A comparison between the calculated threshold values from this survey and the HCM LOS thresholds is given in Table 4. These thresholds are lower than the HCM thresholds across all LOS rankings, indicating the participants in this study had a lower tolerance for traffic congestion than is generally indicated by the HCM LOS thresholds.

The second analysis incorporated additional traffic and roadway characteristics into the random effects model to predict perceived LOS. The additional traffic variables found to be significant have intuitive coefficient signs. As expected, a higher average speed resulted in a more favorable LOS ranking. Speed differential (calculated as the difference in average speeds between the inner lane and the outer lane) as weighted by traffic volume, has a positive coefficient sign, indicating that as the average speed difference between lanes increases, participants were more likely to assign a worse LOS. Likewise, an increase in the truck percentage, as weighted by traffic volume, resulted in a higher probability of a worse LOS ranking. The speed differential and truck percentage variables were weighted by traffic volume since these variables were more significant than their non-weighted versions. This makes some intuitive sense as lane speed differentials and higher percentages of trucks probably only begin to affect motorists' perceptions of trip quality under higher volume conditions. Survey participants were also more likely to give a better LOS ranking to three-lane (in one direction) roadway cross sections than two lanes. The rationale given by the vast majority of the participants for this was because they felt they had more movement opportunities for any given traffic conditions and more "outs" in case something went wrong. While density was still a significant variable, its *t*-statistic was considerably lower in this model. Furthermore, the adjusted ρ^2 value improved, although not by a large amount, to 0.361. The standard deviation of the random effects term was again significant in this analysis, justifying the use of a random effects model.

The third analysis incorporated all of the variables of the second analysis, as well as personal and rural freeway travel characteristics. The indicator variable, 'Age > 25' indicates that participants over 25 years of age are more likely to assign a given set of conditions a better LOS, and likewise for those with higher household incomes (this variable was coded as a continuous

variable, using the midpoints of the presented ranges). Travelers who drive on rural freeways more frequently are more likely to perceive a worse LOS, as are those whose average rural freeway trip is over 100 miles in one-way length. This would imply that those individuals who spend more time traveling on rural freeways are probably more critical of any given set of conditions on those roadways. The same traffic characteristic variables included in this model as in the second model maintained very similar coefficient and *t*-statistic values. While the personal and travel characteristics variables added in the third model were statistically significant by virtue of their respective *t*-statistics, overall they added very little additional predictive power of LOS perceptions as indicated by a very small improvement in the adjusted ρ^2 value. From a practical standpoint, this result is encouraging as it does not make a case for the collection of data other than roadway and traffic characteristics. The standard deviation of the random effects term was once again significant.

CONCLUSIONS AND RECOMMENDATIONS

Three model formulations were explored in this study. The first model demonstrated two important points. First, density is definitely highly correlated with traveler perceptions of trip quality on rural freeways. Second, travelers are less tolerant of traffic congestion on rural freeways than is currently suggested by the HCM. If the single service measure of density is to be retained in the HCM for freeways, the concept of having different sets of thresholds for rural and urban freeways should be considered. This would be consistent with the treatment of arterials in the urban streets chapter of the HCM, where there are currently four different sets of average speed thresholds for four different arterial classifications.

The second model, with the inclusion of additional traffic and roadway variables showed some improvement in the replication of LOS perceptions. Density was still very significant, but this model indicates that the incorporation of additional traffic and roadway variables into the level of service methodology should be considered, especially since these variables are easily collected with the traffic monitoring infrastructure and roadway inventories available to almost all transportation agencies.

The third model identified some significant personal and travel factors, as well as the roadway and traffic characteristics from the previous model. The results of this model indicated that the personal and travel characteristics of the individual road user can influence their perception of LOS. However, from a practical standpoint, the implementation of this model versus the second model is hardly warranted due to the negligible gain in model fit and the complexity of trying to measure these variables.

This study provided some preliminary insight into travelers' perception of trip quality on rural freeways. However, additional research is certainly needed to further define the complex relationship between traveler perceptions of LOS and the interrelated factors of traffic, roadway, and personal characteristics corresponding to those perceptions. For example, a more regionally diverse population might be surveyed. Additionally, an expanded sample, both geographically

and in roadway conditions, could provide more comprehensive coverage of the roadway and traffic condition combinations. Eventually, the results from this type of video-based study should also be compared to results obtained from a comparable in-field driving experiment. If the video survey is shown to be an accurate method of simulating traffic conditions, it can be used in future studies and will be more effective than in-field surveys. Ultimately, a better understanding of travelers' perceptions of quality of service will lead to better decisions about infrastructure investments.

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Figure 1. Sample Video Screenshot

Table 1. Traffic Data for 13 Video Clips

					Observed or Estimated from Video Clip[1]							
Clip #	**Road**	**Dir.**	**Lanes**	**Clip Length**	**Terrain**	**Volume (veh/h/ln)**	**Avg. Speed (mi/h)**	**Density (veh/mi/ln)**	**Speed Diff. (mi/h)**	**Wtd. Speed Diff.**	**Truck %**	**Wtd. Truck %**
1	I-75	S	2	2:10	flat	550	75	7.3	4	2.2	0	0.0
2	I-75	S	3	1:52	flat	1200	70	17.1	9	10.8	30	36.0
3	I-75	N	2	2:00	flat	1300	65	20.0	12	15.6	0	0.0
4	I-95	N	2	1:35	flat	1400	54	25.9	8	11.2	10	14.0
5	I-75	S	3	1:40	rolling	600	72	8.3	10	6.0	10	6.0
6	I-95	S	2	1:59	flat	1100	72	15.3	7	7.7	0	0.0
7	I-75	S	2	2:00	flat	1550	70	22.1	6	9.3	30	46.5
8	I-75	N	3	2:01	flat	1350	70	19.3	15	20.3	20	27.0
9	I-75	S	2	2:00	flat	1900	63	30.2	7	13.3	0	0.0
10	I-95	N	2	1:43	flat	1150	73	15.8	6	6.9	30	34.5
11	I-75	S	3	1:26	flat	1000	75	13.3	6	6.0	10	10.0
12	I-75	S	2	1:27	flat	1800	65	27.7	8	14.4	15	27.0
13	Turnpike	S	2	2:03	rolling	700	75	9.3	12	8.4	40	28.0

[1] Density was calculated from volume and speed; speed differential is the difference in average speed between the inside lane and outside lane; truck percentage was rounded to nearest 5 percent; the weighted speed differential and truck percentage values are derived by multiplying the respective value by the volume and then dividing by 1000.

Table 2. Dates and Locations of Survey Sessions

Survey Session	Date	City	Location	Participants	# of Surveys
1	8/4/04	Gainesville	UF Technology Transfer Center	T[2] employees	16
2	11/16/04	Tallahassee	Florida DOT Central Office	DOT employees	11
3	12/2/04	Gainesville	University of Florida	undergraduate students	14
4	12/2/04	Gainesville	University of Florida	undergraduate students	9
5	12/4/04	Gainesville	UF Hilton Conference Center	public[1]	13
6	12/4/04	Gainesville	UF Hilton Conference Center	public[1]	15
7	12/4/04	Gainesville	UF Hilton Conference Center	public[1]	11
8	12/9/04	Gainesville	University of Florida	undergraduate students	20
9	1/22/05	Gainesville	University of Florida	public[1]	9
10	1/27/05	Gainesville	University of Florida	graduate students	8
			Total Number of Surveys		**126**

[1]Participants were recruited through the University of Florida Survey Research Center

Table 3. Model Estimation Results

	Model 1		Model 2		Model 3	
Independent Variable	**Parameter**	***t*-statistic**	**Parameter**	***t*-statistic**	**Parameter**	***t*-statistic**
Constant	-0.730	-9.34	1.750	2.28	1.702	2.16
Traffic Characteristics						
Density (pc/mi/ln)	0.127	44.41	0.097	11.48	0.097	11.14
Average Speed (mi/h)			-0.032	-3.30	-0.032	-3.18
Volume Weighted Speed Differential			0.014	1.47	0.014	1.38
Volume Weighted Truck %			0.012	5.36	0.012	5.29
3 Lanes (1 - Yes, 0 - No)			-0.107	-1.67	-0.105	-1.57
Personal and Travel Characteristics						
Age > 25 (1 - Yes, 0 - No)					-0.251	-2.26
Income (thousands of $)					-0.004	-2.78
Avg. # of Rural Freeway Trips per Month					0.029	1.68
Average One-Way Trip Distance > 100 miles? (1 - Yes, 0 - No)					0.294	2.35
Threshold Values						
μ_1	1.004	24.62	1.024	24.20	1.017	23.94
μ_2	2.060	43.60	2.102	42.65	2.094	41.81
μ_3	3.005	58.61	3.062	59.03	3.050	58.20
μ_4	4.221	68.41	4.294	65.31	4.278	63.63
Standard Deviation of Random Effects						
σ	0.481	9.40	0.492	9.422	0.435	8.99
Number of Observations		1638		1638		1625
Log Likelihood at Zero		-3500.30		-3500.30		-3465.70
Log Likelihood at Convergence		-2257.68		-2233.07		-2207.58
$\bar{\rho}^2$		0.3547		0.3612		0.3616

Note: A *t*-statistic of 1.282 corresponds to a 90% confidence level for a one-tailed *t*-test.

$\bar{\rho}^2 = 1 - \frac{LL(\beta) - K}{LL(0)}$, where K represents the number of variables in the model, $LL(\beta)$ represents the log likelihood at convergence, and $LL(0)$ represents the log likelihood at zero [13].

Table 4. Comparison of Estimated and HCM LOS Thresholds from Model 1

LOS	Estimated Thresholds (pc/mi/ln)	HCM thresholds (pc/mi/ln)
A	0-6	0-11
B	>6-14	>11-18
C	>14-22	>18-26
D	>22-29	>26-35
E	>29-39	>35-45
F	>39	>45