EVALUATING THE IMPACT OF OOCEA'S DYNAMIC MESSAGE SIGNS (DMS) ON TRAVELERS' EXPERIENCE USING THE PRE-DEPLOYMENT SURVEY

by

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ABSTRACT

The purpose of this thesis was to evaluate the impact of dynamic message signs (DMS) on the Orlando-Orange County Expressway Authority (OOCEA) toll road network using the Pre-Deployment DMS Survey (henceforth referred to as "pre-deployment survey"). DMS are electronic traffic signs used on roadways to give travelers information about travel times, traffic congestion, accidents, disabled vehicles, AMBER alerts, and special events. The particular DMS referred to in this study are large rectangular signs installed over the travel lanes and these are not the portable trailer mount signs. The OOCEA is currently in the process of adding several fixed DMS on their toll road network. Between January 2007 and February 2008, approximately 30 DMS are planned on their network. It is important to note that there was one DMS sign on the OOCEA network before this study started. Since most of the travelers on OOCEA toll roads are from Orange, Osceola and Seminole counties, this study is limited to these counties.

This thesis documents the results of pre-deployment analysis. The instrument used to analyze the travelers' perception of DMS was a survey that utilized computer aided telephone interviews. The pre-deployment survey was conducted during early November of 2006. Questions pertaining to the acknowledgement of DMS on the OOCEA toll roads, satisfaction with travel information provided on the network, formatting of the messages, satisfaction with different types of messages, diversion questions (Revealed and Stated preferences), and classification/socioeconomic questions (such as age, education, most used toll road, and county of residence) were asked to the respondents.

The results of the pre-deployment analysis showed that 54.4% of the OOCEA travelers recalled seeing DMS on the network. The respondents commonly agreed that the DMS are helpful for providing information about hazardous conditions, and that the DMS are easy to read.

The majority of the travelers preferred DMS formats as a steady message for normal traffic conditions, and use of commonly recognized abbreviations such as I-Drive for International Drive.

The results from the binary logit model for “satisfaction with travel information provided on OOCEA toll road network” display the significant variables that explain the likelihood of the traveler being satisfied. The results from the coefficients show that infrequent travelers are more likely to be satisfied with traveler information on OOCEA toll roads. In addition, the provision of hazard warnings, special event information, and accuracy of information on DMS are associated with higher levels of satisfaction with traveler information.

The binary logit model for “Revealed Preference (RP)” diversion behavior showed that Seminole County travelers were likely to stay on the toll road, and SR 408 travelers were likely to divert off the toll road. The travelers who acknowledged DMS on the OOCEA network were also likely to divert off the toll road, but those who learned of the congestion by DMS were likely to stay on the toll road. Learning of congestion by DMS could encourage travelers to stay, since when they are on the toll roads, diversion at times could be difficult with no access to exits or little knowledge of alternate routes. But it is also possible that travelers stayed because their perception was that the toll roads are faster, especially when messages on DMS show travel times that confirm the travelers’ belief. Travelers who were not satisfied with travel information on the network were more likely to divert off the toll road.

The implications for implementation of these results are discussed in this thesis. DMS should be formatted as a steady message for normal traffic conditions. Commonly recognized abbreviations, such as I-Drive for International Drive, must be used for roadway identification when possible. DMS messages should be pertained to information on roadway hazards when necessary because it was found that travelers find it important to be informed on events that are related to their personal safety. Accuracy of information provided on DMS was important for traveler information satisfaction because if the travelers observe inaccurate travel times on DMS, they may not trust the validity of future messages. DMS information that led to the travelers canceling their intended stops led to a higher likelihood of them being dissatisfied with traveler information. It is important to meet the travelers' preferences and concerns for DMS.

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LIST OF MEDIA/ABBREVIATIONS/NOMENCLATURE/ACRONYMS

1. ATIS — Advance Traveler Information Systems
2. AMBER ALERTS — America’s Missing: Broadcasting Emergency Response
3. CATI — Computer Assisted Telephone Interview
4. DOT — Department of Transportation
5. DMS — Dynamic Message Sign(s)
6. ITS — Intelligent Transportation Systems
7. LIMDEP/NLOGIT — Econometric software for simulation of binomial discrete choice logit models
8. OOCEA — Orlando-Orange County Expressway Authority
9. RP — Revealed Preference
10. SP — Stated Preference
11. SAS — Statistical Analysis System
12. UCF-IRB — University of Central Florida Institutional Review Board

CHAPTER ONE: INTRODUCTION

1.1 Background

Roadway users can face uncertainty of not knowing what their travel time will be from point A to B. Travelers have a good understanding that driving 10 miles on a freeway with no congestion may take them about 10 minutes. The uncertainty comes when there is congestion. Typically, one would expect to experience more congestion during the morning and evening rush hours. The majority of roadway users in urban and suburban areas know that it takes a little more time to get to their destinations during these rush times. The dilemma comes when travelers face unexpected congestion for an unknown period of time due to abnormal conditions such as traffic crashes, disabled vehicles, construction/road work, bad weather, vehicles pulled over by law enforcement, special events, and other causes.

One way to mitigate unexpected delay is to provide accurate and timely traffic information through Dynamic Message Signs (DMS). DMS can display real-time travel information to roadway users.

Figure 1 is an example of the type of DMS studied for this research. These particular DMS are installed over travel lanes, and are not the portable trailer mounted signs that are commonly seen on roadways under construction. These DMS give travelers information about travel times, traffic congestion, crashes, disabled vehicles, AMBER alerts, and special event information.

Figure 1: Dynamic Message Sign

With the knowledge of the current travel time conditions, travelers might be able to make informed decisions that could possibly save them time or save time for other travelers. One could choose to divert from the roadway if he/she is to face a large amount of delay. It is important to note that a traveler can only divert when the capabilities to divert are available. For example, on the freeway, the traveler has access to an exit ramp and has knowledge of alternate routes. When experiencing a large amount of unexpected delay, one could read the travel time from a DMS and tell others who are waiting for him/her that he/she will be delayed by a given amount of time.

DMS is one of the Intelligent Transportation Systems (ITS) technologies whose utilization has increased nationally in recent years. A past report written for the Federal Highway Administration (FHWA) showed that over $330,000,000 was spent by transportation agencies on DMS (1).

The OOCEA is currently in the process of adding several fixed DMS on their toll road network. Between January 2007 and December 2007, approximately 30 DMS will be added on their network. The default message displaying will be travel times. Since most of the travelers on OOCEA toll roads are from Orange, Osceola and Seminole counties, this study is limited to these counties. Together these counties have an estimated combined population of 1,694,420 in 2006 (2).

Figure 2 (3) is a map of the toll road network and other major roadways in the greater Orlando area. It is important to point out that the OOCEA has jurisdiction only under the purple highlighted roads. These roadways are primarily located within Orange County. The state roadways within the OOCEA toll roads network chosen for this study are SR 408, SR 417, SR 429, and SR 528.

Figure 2: Map of OOCEA Toll Road Network

It is important to note that there was one DMS sign on the OOCEA network before this study started. The first DMS on SR 408 was located on westbound (WB) direction, just west of

Interstate 4 (I-4). This single sign was located in a highly developed urbanized area. For this thesis, only the “pre-deployment effects” of the DMS are to be studied. The “post-deployment study” is planned for the spring 2008.

This study sheds insight on how the toll road network users perceived DMS in general. The intention is to know what type of messages toll road users find to be important, and what format and abbreviations toll road users understand. In addition, it is necessary to find out the percentage of commuters that were already aware of DMS on the toll road network is needed. Understanding what encourages travelers to divert off toll roads is also crucial. To answer these needs, a telephone survey was conducted asking questions pertaining to DMS to commuters in the Orlando area who were OOCEA toll road network users.

1.2 Research Objectives and Scope

The primary goal of this thesis is to evaluate the “DMS Pre-Deployment Survey.” In order to satisfy the objectives of this thesis, the tool needed to understand toll road users’ perception of DMS was a survey. It was best to use an over the phone survey instead of other methods in order to ensure complete responses to all the questions in the survey. The following is a breakdown of this thesis’s objectives.

Analyze “DMS Pre-Deployment Survey” results for:

- Knowledge of DMS
- Satisfaction of DMS
- Preferred formatting of DMS
- Statistics of dependency and correlation between different questions and strength of correlation.

Binary Choice Logit Modeling

- User satisfaction of information given on the OOCEA toll road network
- Revealed Preference (RP) diversion behavior.

The survey respondents were only allowed to answer questions in a categorical fashion such as A, B, C, or D. This method was decided upon so there would not be a large variety of responses. Even when describing a respondent's age, the respondents were given ranges to respond categorically. An important aim of this thesis is to describe why certain questions were asked in the "Pre-Deployment Survey," and how this format of survey along with this amount of questions was decided on.

The thesis's preliminary objective is to analyze the "DMS Pre-Deployment Survey" results to the completed 1500 responses. Labeling the mode and the second mode to each question is needed in order to understand the various subjects that these survey questions address.

The most important objective of this thesis is to understand what percentage of those surveyed acknowledge DMS on OOCEA toll roads. The subject of DMS is the foundation of this research. If the respondents had knowledge of the DMS on toll roads, the respondents were asked questions pertaining to their satisfaction on different types of DMS messages and formatting. The responses to these series of questions are important to understand what toll road users desire to see on DMS.

Another objective in this thesis is to evaluate statistically the relationships between multiple question responses to the survey. The tool used for statistics was the Statistical Analysis System (SAS). To achieve this, one question is compared with another in a contingency table. The responses from the two questions A and B are then determined to be either independent or dependent based on the chi-square statistics. Another objective is to use Cramer's V statistics in order to understand how strong the relationship is between two questions A and B. Cramer's V statistic is useful when dealing with categorical data. Using Cramer's V will also help in narrowing down what questions to use for the binary logit modeling.

Another objective in this thesis is to model satisfaction of traveler information given on the OOCEA toll road network, and RP diversion behavior. Binary logit models are constructed using LIMDEP/NLOGIT, an econometrics software for modeling binomial discrete choice model. With binary logit modeling, one can understand what attributes influence an individual traveler's behavior to divert or to stay on the toll road when experiencing congestion. This is also used to profile travelers who are satisfied with travel information on the OOCEA network. For modeling and other relationships to be observed, questions that pertain to classifying a respondent such as age, education, and county of residence are asked.

The final objective is to recommend an implementation plan based on the conclusions from the thesis. These comments reiterate on the strong findings within this research in order to understand the effects DMS has on OOCEA toll road users, and to provide improvements, strategies, and suggestions for the "Post-Deployment Survey" and analysis.

1.3 Organization of Thesis

This thesis is comprised of six chapters in the following organization. Chapter 1 is the introduction to this study and its purpose is to give the reader a background of the study, the objectives, and scope of this thesis. Chapter 2 is a literature review of past studies that focused on DMS surveys as a main subject and other transportation related survey studies that used logit modeling. Chapter 3 is a section describing the methodology of the analysis. Chapter 4 gives the results of the pre-deployment analysis with a report knowledge of DMS, DMS satisfaction; DMS preferred formatting, Revealed and Stated Preference diversion, and SAS statistical values. Chapter 5 presents the LIMDEP/NLOGIT results of the user-choice binary logit modeling for both revealed diversion behavior and information satisfaction. Chapter 6 concludes the overall results of this thesis, provides an implementation plan, and gives recommendations on further research dealing with the subject of DMS.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The intent of the literature review was to understand similar past transportation studies that dealt with the objectives of DMS perception and modeling driver behavior. The literature review is broken into three sections. The first section is the introduction. The second section of the review contains past studies that deal with DMS perception surveys with no modeling. The third section of the review examines studies that deal with a variety of transportation studies that model driver behavior.

The intention of the second section was to investigate the kind of surveys that were conducted when investigating perception of DMS. The types of surveys reviewed ranged from over the phone interviews, web-based questionnaires, mail-in questionnaires, face-to-face interviews, and control group interviews. Other goals of this section were to see what number of completed surveys these studies contained, and what types of questions were in these surveys. This part has a detailed description of the surveys and their results. This research used these surveys to aid in the construction of the pre-deployment survey.

The third section deals with driver behavior modeling. These modeling reports dealt with several subjects such as the perception of cost and benefits of DMS, route choice, trip planning, and other issues. Since diverse and extensive human factors are involved in these issues, several forms of inspection used in this section were surveys and infield data collection. A large amount of the modeling reports used questionnaire surveys as a technique to acquire data. A review similar to the previous section was conducted. Other reports in this section used loop detectors to collect data in the field. There was also a variety of model types used. Most of the studies utilized binary-choice logit models, multinomial-choice logit models, and probit models. An important aspect of this section was to investigate the sample sizes used for the models.

2.2 DMS Perception Surveys

Booz-Allen & Hamilton Inc. (4) used the Computer Assisted Telephone Interview (CATI) to survey 2772 commuters in the Boston area to evaluate the performance of SmarTraveler system that offered real-time traffic information via telephones.

Harris and Konheim (5) used a phone to survey peak-hour travelers in the New York metropolitan area (sample size n= 1002). This study concluded that 88 % of the travelers want Advance Traveler Information Systems (ATIS) and 78% are willing to pay for these systems. Travelers are interested in location and duration of delays and alternative route travel times. Radio and DMS are the most highly preferred options compared to the other technology.

Chun-Ming Yang (6) performed a human factors study to enhance communication with motorists through DMS. Message factors such as display effects, color schemes, wording, and formats were investigated. The study was conducted with the use of two methods involving a questionnaire and lab driving simulation with 36 subjects. The questionnaire had forty-four multiple-choice questions displayed in Microsoft PowerPoint format. Study results suggested that static, one-framed messages with more specific wording and no abbreviation were preferred. Amber, green, or a green-amber combination were the most favored colors. Younger subjects took less response time to DMS stimuli with higher accuracy than older subjects. There were no significant gender differences.

Grit Shonfeld et al. (7) investigated the effective design of graphical traffic information. The objectives were to examine the cognitive and the technological aspects of graphical DMS.

The survey was conducted as an online questionnaire with 820 respondents at Munich University. The questions focused on topics such as drivers' understanding of abbreviations and symbols, interpretation of color-coded networks, and influence of network orientation to identify motorways. The results of the survey showed that drivers mostly used destination names for their orientation, more than road numbers. A network graph, oriented according to the drivers' position, aggravates the orientation of the driver if only motorway numbers are given. It also showed that unspecific time details are understood by the majority of respondents as the travel time. It is interpreted as delay time only by a small minority. More than one time statement along one route is ambiguous to the driver with respect to the reference points.

University of Arizona (8) used a telephone survey to understand the lasting impact of DMS marketing for 511. This particular study had a total of 411 telephone surveys completed. The questions were related to trip purposes, type of transportation used (i.e., private vehicle, commercial vehicle), and satisfaction of information received. Although these studies focused upon 511, their findings suggested that the lasting impact of DMS marketing for 511 was unclear, short-term impacts appeared dramatic and 511 phone calls peaked when driver was en-route and exposed to DMS.

Texas Department of Transportation (DOT) (9) used an online questionnaire to understand how travelers accessed traffic information (i.e., television, radio, TransGuide website, TransGuide Message signs). There were a total of 690 individuals who responded to the survey. One type of questioned asked was "If you encounter significant traffic congestion due to an incident on the freeway, what do you normally do?" 25% of the respondents answered that they would stay on the freeway and wait it out. Another question asked was, "If you find out about a major incident on your normal route before leaving, what do you normally do?" 86% of the respondents answered that they would take an alternate route. Overall, the results of this survey were reported as basic percentages, and other questions focused on satisfaction.

Lai and Yen (10) focused on how DMS affected driver behavior. A questionnaire was completed by 312 respondents. Behavior such as changing lanes, route changing, and decreasing speed was examined. Information such as traffic reports on alternate routes, weather conditions, and trip cautions were expected on DMS from the respondents. Driving experience, driving purpose, level of route familiarity, level of traffic and weather conditions were conditions that were found to affect a driver's attention to DMS. It was also found that gender, age, and education were significant factors to drivers' comprehension and preference for DMS. Another set of questions was posed to the drivers about their preference of color, and display formats. From the survey results, it was found that drivers preferred red and orange colors compared to green. For cautionary messages, drivers preferred flashing formats for the messages.

Martin and Lahon (11) examined ATIS that is used in Utah. Part of the ATIS technology studied in the report was DMS. The DMS is used in order to give en-route information on incidents, alternate routes, and safety precautions. This was a paper questionnaire where 201 surveys were completed. One of the questions pertained to how frequently drivers responded to weather, safety, or traffic alerts as they were posted on DMS. An open ended question was also asked about how to make DMS more effective. From the responses of this study, it was evident that more destinations could be included on travel time messages, maintenance frequency needed to be increased on message boards to minimize non-functioning units, and travel time messages might include high occupancy vehicle (HOV) lane travel time-savings.

The University of Wisconsin's ITS program conducted an evaluation of DMS reported by Bin Ran, et al. (12). This study investigated the extent of drivers' knowledge regarding general freeway issues, and determining awareness and perception of DMS. A mail questionnaire was used for this survey. 500 questionnaires were sent out to licensed drivers and there was a total response rate of 51.6%. The questions addressed issues such as reliability of travel time and traffic information on DMS. Also, a question pertaining to the knowledge of trip length on alternate routes was asked. It was shown in this study that drivers considered prompt emergency response and reduction of traffic congestion as important needs. In addition, users were willing to change time of trips to avoid or minimize congestion.

Al-Deek (13) used CATI as well as web-based survey to investigate the impact of predictive information on traveler behavior. The sample sizes used for these surveys are 400 and 439 respectively. In general, the respondents indicated that the information that they would need the most is the incident location and expected delay.

2.3 Modeling of Survey Responses & Other Transportation Modeling

Abu-Eisheh and Mannering (14) designed a mail-back questionnaire for the morning commuters of the State College, Pennsylvania metropolitan area to estimate a route and departure time model for peak period travel. They sent the mail-back questionnaires to 505 potential respondents, of which they received 151 usable responses (response rate= 30%). One origin destination pair with three different routes (three choices) was used for the modeling. A multi-nomial logit specification was used to model route choice. The logit model assumes that the utility of a route is a function of the route specific characteristics. The utility of a particular route is a function of the expected travel time on the route and other characteristics like number of traffic signals, queue lengths, etc. Expected travel time as predicted by the Bureau of Public

Roads' (BPR) equation was used to avoid problems that would be encountered if actual travel times were used.

Haselkorn et al. (15) conducted a driver survey in Seattle in September 1988. It was analyzed further for information about driver departure time and route choice behavior, particularly about the influence of traffic information (primarily from commercial radio and television traffic announcements and DMS, but also from highway advisory radio and telephone information services) on this behavior. The survey consisted of a 9652 mail-in questionnaire distributed to drivers on I-5 of with 3893 responses. Personal interviews of 96 subjects, selected at random from within the groups identified during the analysis of the first set of results, were performed. Questionnaire topics included among others were:

- Daily commute characteristics
- Network familiarity
- Influence of various factors on route choice
- Use of various sources of pre-trip and en route traffic information
- Response to traffic information
- Socio-economic characteristics.

Data was collected on 62 variables. A principal components factor analysis was performed on this data. The components related generally to route choice issues such as commuting distance and time characteristics, attitudes towards different sources of traffic information (radio – based, television, DMS, etc) and commuter characteristics. From these surveys and clustering, a consistent pattern of commuter behavior and traffic information preference is deduced.

The authors concluded the respondents were likely to correctly understand a message when a reason was given followed by a “specific task” (e.g., “Accident at SR 333 interchange, Use SR 333 to divert”) rather than a “generic task” (e.g., “Accident at SR 333 interchange, Use alternate route”). They further indicated that travelers would be most likely to change route if the message presented a generic reason and with no mention of any task (e.g., “Accident Ahead”).

Uchida and Iida (16) surveyed users of a real-time travel information system in Japan. The system displays the predicted travel times on three routes that connect suburbs of Osaka to the Osaka Downtown using DMS.

The survey was designed to obtain information on two types of driver reaction: short-term tactical choice (the relationship between the displayed message and the drivers’ immediate route choice decision), and long-term strategic choice (the gradual change in route choice behavior that results from use of the displayed messages over time.)

Mail-back questionnaires were handed out to drivers at traffic lights downstream of the DMS; those who responded were later sent out additional questionnaires regarding their longer-term reactions to the DMS system. These questionnaires were therefore sent in 6 waves to capture the long-term (strategic) response of drivers. The numbers of responses were 5817 at the end of the six waves. Survey results showed that drivers thought travel time information was sufficiently accurate for their route choice purposes and thus was useful. Roughly 70% of respondents reported diverting at some time; roughly 15% reported that pre-trip or en route information was the reason for diversion. Over time, roughly 40% of respondents reported that they had changed their habitual route as a result of using the ATIS. Multi-nomial probit models of the short term and long term responses were estimated from the survey data. The long-term model provided evidence of a strong inertia effect in the selection of the "routine" route: drivers had a tendency to continue using the same route that they used on prior days, irrespective of age, income or other socio-economic variable. The tactical model showed that the displayed travel time and the habitual route had a significant effect.

Hato et al. (17) used Stated Preference (SP) investigations of drivers' reactions to DMS messages through mail back questionnaires with a sample size of 6107 and 1907 responses (response rate = 31%). Respondents chose an initial route and were provided with various specific but hypothetical DMS messages. They then responded whether they would switch to the alternative route. The questions investigated the effect of trip purpose, the usual route, traffic conditions on the usual route, expressway tolls, reliability of travel time information provided in DMS messages, the overall trip time, and the length of queues reported in DMS messages with diversion propensity. Ordered probit models were estimated from survey results. The model results showed that route choice was strongly influenced by the information received from the DMS messages. The original route choice had an inertia effect on route choice after information was provided. Drivers on the expressway were reluctant to switch to the parallel route in response to messages although the converse was not true. For daily commute trips where the drivers were under time constraints, the accuracy of the information was proportional to its perceived value.

Emmerink et al. (18) analyzed the joint impact of radio traffic information and DMS on route choice behavior. The empirical analysis was based on a survey held among road users in the Amsterdam corridor in July 1994. 2145 questionnaires were distributed among which 826 were returned (response rate: 38.6%). Several types of discrete choice models (ordered probit, multiple logit and bivariate ordered probit) were estimated to analyze the influence of different factors on route choice. The authors postulated that bivariate models were needed to model the endogeneity of the use of radio traffic information and DMS information. The results find that regular commuters were less likely to be influenced by the information, and the level of satisfaction with alternative routes is strongly related to the type and distance of the alternative road. The analysis also reveals that the impacts of radio traffic information and DMS information on route choice behavior are similar. An important finding in this study was that the results suggested that there was a positive correlation between the use of radio traffic information and DMS information.

Khattak et al. (19) used SP and RP survey (sample size = 586) in the Golden Gate area of California to investigate traveler behavior under ATIS. The study concluded that travelers might change behavior in response to long delays and information.

Yim and Ygnace (20) used loop detector data to estimate the effects of the messages on DMS on the traffic. The objective of this study was to assess the effects of DMS on individual link flow. The French National DOT conducted traveler surveys in Paris to understand the user requirements of DMS. In May 1992, a mail survey was distributed among Paris area motorists with a sample size of 8000. A telephone survey was conducted thereafter with 100 participants. These surveys focused on gathering information about the ability of motorists to correctly interpret roadside messages. Based on the findings of the motorist surveys, DMS were designed and installed at locations that allowed drivers to make diversion decisions before reaching a congested section of a freeway. Based on the traveler survey results, the French DOT estimated that 50 percent of vehicles would divert given the choice between congested and free flowing links. Given the choice between two congested links, 3 to 5 percent of motorists would divert to the less congested link when comparative information was provided on these links. To evaluate these stated preferences, the authors proposed methods to analyze the loop detector data as a means of revealed preference. The study revealed that the RP diversion behavior was more conservative than the SP of those drivers who responded to the 1992 surveys in the Paris region.

Abdel-Aty et al. (21) conducted a CATI survey to obtain information about the usual and alternative commute routes and their attributes, socio-economic characteristics, and conventional traffic information sources and their influence on behavior. A second CATI survey was conducted to identify any changes in commute characteristics, investigated respondents' perceptions of various attributes of the commute trip, and included the effects of uncertainty on commute route choice decision-making. The total number of surveys conducted was 940, while the number of valid responses received was 564 (response rate = 60%). The third wave mail-back survey showed each respondent optimum (minimum path) commute routes generated by a geographic information system (GIS) and asked about the respondent's knowledge of and preference towards these routes. It also asked SP route choice questions involving information availability from a hypothetical ATIS. Binary logit models were estimated to gauge the effect of the travel time information and uncertainty in travel time information on route choice. The results underscored the significance of traffic information and the potential effect of ATIS on route choice.

Khattak and Khattak (22) investigated en-route diversion under ATIS using a mail-back survey of peak commuters in Chicago (sample size n=700) and San Francisco (sample size n=3238). The study concluded that en-route diversions are affected by availability and knowledge of alternative routes and amount of delay.

Wardman et al. (23) used an SP approach to undertake a detailed assessment of the effect on drivers' route choice of information provided by DMS. 900 questionnaires were mailed of which 314 responses were received (response rate: 35%). Although drivers' response to DMS information varied according to the availability of viable alternative routes, it was shown that route choice could be strongly influenced by the provision of information about downstream traffic conditions. The findings were that the impact of DMS information depends on: the content of the message (cause of delay and its extent), local circumstances, drivers' characteristics, and previous network knowledge.

The impact of qualitative indicators, visible queues, and delays were examined. Multi-nomial models and nested logit models were estimated to assess the impact of the aforementioned factors. It was found that delay time is more highly valued than normal travel time and that drivers become more sensitive to delay time as it increased.

Bonsall and Palmer (24) surveyed results from previous studies and presented some new results on factors that influence drivers' compliance with DMS messages related to route choice. For effective dissemination of information on DMS, messages should be visible, legible, and understandable. Prior evidence suggested that messages have the greatest effect if they combine routing advice with descriptive information about an incident. It has also been found that advice that gives clear instructions for an immediate action receives higher compliance than more fuzzy advice. An instruction that specifies a nearby problem location is more likely to be followed than one that does not. The effects of providing qualitative information depend strongly on the specific message wording. Other factors that influence the compliance to DMS advisories include general network traffic conditions, and evidence of congestion visible to the driver. There is a natural inertia for drivers to prefer remaining on their current route. The main driver characteristics, which have been observed to influence DMS compliance, are their familiarity with the network and their previous credibility experience of DMS information. Drivers familiar with the network tend to prefer condition information rather than route recommendations. It has been found that for a given DMS guidance message, compliance by familiar drivers is around 10% lower than that by unfamiliar drivers.

Peeta et al. (25) investigated the effect of different message contents on driver response under DMS. This was carried out through an on-site SP user survey. Binary logit models were developed to model diversion choices of drivers. The authors found that the content and detail of relevant information were significant factors affecting drivers' diversion propensity. Socioeconomic characteristics, network spatial knowledge, and reliability of the traffic information displayed are other important factors. Results also indicated differences in the response attitudes of semi-trailer truck drivers compared to other travelers. They provide substantive insights for the design and operation of DMS-based information systems.

Lai and Wong (26) used responses from 475 respondents on the comprehension of messages and message formats on the DMS in Hong Kong. They used the SP questionnaires using hypothetical driving situations and different DMS message formats. Three kinds of message formats were used and they were numerical (travel times), qualitative (traffic condition in words) and switch on lights (congestion level). Logit models were fit to the utility functions defined as a function of the socio-economic characteristics, traffic characteristics, as well as the formats. It was found that the utility for the numerical format was lesser when compared to the other formats, contrary to the expectations. The authors attributed this to unobserved variables and the reason that the qualitative formats are semantically closer to the messages on the radio, thus increasing their utilities.

Abdel-Aty et al. (27) used a CATI survey for the morning commuters in San Jose and Sacramento to estimate commuters' likelihood of using transit under the provision of different types of information. Respondents were asked to rate the top three most important information items that they may need to consider transit as a viable alternative. In addition, they were also asked to rate their likelihood of using transit. An ordered probit model was used to model the natural ordering of the dependent variable. The results indicated that advanced transit information has potential in encouraging the acceptability of transit as a commute mode. The transit information desired by the commuters included frequency of service, number of transfers, seat availability, walking time to the transit stops, and fare information. Socio-economic characteristics like income, education, and trip characteristics including commute time by transit and carpooling were the factors likely to increase the likelihood of acceptance of transit as a commute mode.

Chatterjee et al. (28) conducted a study on the impact of DMS on driver diversion choices using SP questionnaires. 2000 on site questionnaires were distributed, but only 246 responses were received. The questionnaires included questions on the respondent's driver characteristics such as age, sex, annual mileage; details of the journey being undertaken; attitude to unexpected congestion; and attitude to DMS information. It was found that a significant proportion of respondents knew of the DMS and found the information useful. However, not all the respondents who found that information useful diverted. It was also reported that the significant variable that influenced the diversion probability in case of unexpected congestion (estimated through logistic regression models) was the distance to destination. In the case of DMS, the diversion probability was influenced by variables that represented the distance to destination, non-London origin and "severity of the incident" messages on the DMS. Another questionnaire survey was conducted, but it was a RP questionnaire to obtain what the respondents actually did in response to actual DMS messages in the case of real incidents. It was found, however, that the revealed preference responses indicated a more conservative diversion behavior than the SP models.

Zwahlen et al. (29) used mail surveys to evaluate the performance of DMS deployed in Dayton, Ohio in a construction work zone on I-75. The surveys were mailed to around 3177 drivers of which 809 responses were returned. Of these, 660 were analyzed. Survey responses indicated that the motoring public does perceive a certain inaccuracy in the travel times. Almost 97% of surveyed motorists felt that a system providing real-time travel time information, in advance of work zones and in advance of open exit ramps, is either outright helpful or maybe helpful.

Wang et al. (30) studied effect of variable formatting of DMS on the response of car drivers in Taiwan. Driving experience, route familiarity, and traffic crowd also affected drivers' attention to DMS. Age, gender, and education were also significant factors for drivers' preference and response to DMS.

Ulfarsson et al. (31) measured the effect of DMS on mean speeds and speed deviations section on I-90 near Snoqualmie Pass, Washington. The results show that the DMS do significantly reduce mean speed and significantly increase speed deviation. The results also indicate that DMS effectiveness in reducing vehicle speeds may last only in the DMS zone and drivers may engage in compensatory behavior outside the zone.

Levinson (32) studied the effectiveness of DMS using loop detector data with incident data to conduct a before-and-after study which attempts to quantify the network-wide travel time benefit of DMS systems. The effectiveness is measured using a discrete choice model to estimate the response of drivers to messages provided by DMS, and a statistical analysis on the variation of diversion rate with and without DMS. A weighted probit model is used to estimate the drivers' diversion behavior given the characteristics of messages and the nature and location of the incident. Factors considered in this study were: availability of an alternate route, nature of the incident (i.e., congestion, crash, stalled vehicles, or roadwork), peak period or non-peak period, whether the message attracts vehicle to exit ramp, discourage vehicles from diverting, or has no influence on the route. The model showed that the probability of diversion increased in response to the message of the incident and congestion. With the statistical analysis, DMS was shown as an effective tool in route guidance that could increase drivers' diversion rate significantly. The study also concluded that DMS was more effective in light traffic than in heavy traffic. This may have been due to the fact that it is difficult to change lanes, merge or divert in heavy traffic. Also stated, drivers prefer to start to divert at several exits prior to an incident. The before-after part of the study results showed that DMS has no obvious effects on the reduction of travel time. However, DMS along with ramp meters was shown to reduce travel times.

Henderson (33) investigated the effectiveness of DMS in managing freeway traffic. Factors such as number of DMS installations, location, messages displayed, varied traffic network characteristics, and drivers' response to incident conditions played a function in effective the freeway network. A logit model was used to understand driver diversion and the benefits of DMS. Questions that were asked to a respondent included sex, age, education, regular driver in region, and the trust of the information. These were broken down into binary levels. Questions on diversion behavior were also asked. It was stated in this report that the decision to divert is related to various factors such as severity of the incident, current extent of queue caused by the incident, the driver's experience and familiarity of the network, and incident characteristics delivered via the DMS. The findings in this study showed that female and older drivers are, on average, less willing to divert than males and younger drivers. Also, well-educated individuals are more likely to comply with the DMS messages than their lesser educated counterparts under similar conditions. Incident location is significant in the diversion decision. Truck drivers are more resistant to divert than other drivers. Delay attributed to accidents had the biggest impact on route choice. Visible queues were found to have a significant effect on driver route choice. Those who had never used alternate routes were less likely to be persuaded by the DMS panel advice.

Anirban (34) produced a binary logit model from the responses of 787 persons responding to an online questionnaire. Findings in the literature review of this paper were that historically there is a decreasing tendency for commuters to drive through commercial or industrial area during peak hours. Also, in the literature review of this paper, it was stated that past studies showed that commuters set a threshold of delay and compare this with their perceived travel time and congestion expectation. When frustration or this threshold limit is exceeded, commuters might be inclined to make a route diversion. With the logit model it was found that the significant variables for route choice were gender, age of commuter, home to school average commute time, and the difference between the shortest and longest commute time.

Kim and Chon (35) modeled the en-route diversion behavior with traffic information provided on-site. The factors influencing drivers' route diversion were driver's characteristics, trip characteristics, route attributes, traffic information, and prior experience. The literature review of traffic information summarized that route diversion depends on the reliability of information source, the way information is presented, and the contents of the information. It was also reported that information about accidents, delays and congestion when displayed on DMS, can have a great influence on route choice behavior. The effects of DMS are very dependent upon the phrasing of the message. Another interesting note in this review of literature was that the descriptive information (i.e., information without advice) was likely to have more impact on route choice than prescriptive information, but drivers were more willing to divert in response to a combination of prescriptive and descriptive traffic information than either of the two separately. In this study, 340 questionnaires out of 400 were completed. A logit model was created for this study and found drivers prefer routes with shorter travel times. Though with diversion in mind, as the uncertainty in predicted travel time of a route becomes smaller, the reliability of the information (i.e., DMS) becomes higher, and the propensity for the driver to divert routes gets stronger. Also, found in this study is the conclusion that with DMS, accident information is the most effective in encouraging drivers to divert. The results of this study show that on-site information has significant influence on drivers' decision to divert to alternative routes.

Peeta and Yu (36) modeled the utility functions for diversion under provision of information as variables with fuzzy components. They coded some of the variables associated with the traffic and network characteristics and the perceptions of these by drivers as fuzzy variables and then proceeded to fit logit models on the utility functions derived from this coding. The performance of the hybrid model was compared with that of a pure multi-nomial logit model. The authors concluded that the hybrid model had better prediction capability, more robustly captured qualitative phenomena, and better explanatory power for qualitative attributes.

Chiu et al. (37) applied a systematic and rigorous statistical approach to investigate relations between DMS message presence and traffic redistribution, and found that DMS signs do cause higher or equal average diversion rates with speed and DMS related to diversion rates.

Peeta and Ramos (38) investigated driver response attitudes to traffic information provided through DMS. They developed DMS driver response models using SP data collected through three different survey administration methods: an on-site survey, a mail-back survey, and an Internet-based survey. In process, they highlighted the strengths and limitations of each method in eliciting driver response attitudes to information provision. The use of different media for the survey administration provided insights for the design of travel surveys. The results illustrated that a combination of survey administration methods may generate more representative data. They also indicate a high correlation between DMS message type and driver response. This suggests message content as a control variable for traffic system operators to trigger optimal routing policies under congested conditions to improve network performance.

Lim and Taylor (39) studied the route diversion under DMS signs in the San Antonio area. They measured the percentage of traffic that diverted to an alternate route when a DMS message was displayed. The sensitivity of the diversion to different factors like familiarity and time constraints, historical or existing traffic conditions, and geographic location were also tested. This study determined that DMS effectiveness is influenced by familiarity and time constraints of the drivers, visibility of the congestion while the DMS message is displayed, an accident with recurring congestion, and a location with a freeway alternate route, which has higher diversion than a site with no alternate freeway route.

Foo (40) evaluated the impact of DMS messages on traffic flow using loop detector data by measuring the flow at the transfer locations before and after the message was changed and found that on average a DMS message change can alter the diversion rate by up to 5%, and can shift up to 278 vehicles per hour.

2.4 Conclusions from Literature Survey

From the literature review, it is evident that the acceptance of DMS is associated with the travelers' perception and their subjective attitudes towards information and its presentation. Most of the studies have found that demographic and socio-economic characteristics are important factors in assessing the satisfaction of the travelers towards a novel traveler information technology like the DMS. However, travelers also have specific preferences about the formats and contents of messages and information posted on the DMS. While most of the studies show that the travelers adopt DMS for their traveler information needs, DMS do not necessarily change their travel behavior. Network familiarity, proactive information, and advisory information have been found to have different effects at different locations of the study. Also, it was concluded from the literature review that responses to SP and RP are not in agreement all the time. Generally, RP diversion rates were more conservative than SP. They are highly correlated. Also, multinomial and binomial logit models have been predominantly used to model the diversion behavior under traveler information scenarios with DMS. The effect of DMS has been found to vary in different study sites.

The previous studies that were examined in the literature review generally covered the topics of transportation surveys, DMS, and modeling diversion behavior. Where this current research differs from the others is that this thesis investigates these subjects while targeting toll road users. It is important to note that toll road users are a different subgroup of roadway users from the general population. Unlike public roads that generally get their funding through taxes, toll road authorities charge their users while traveling on the roads. Thus, toll road users have to budget money in order to travel on the toll roads, either by using a toll road pass or keeping adequate change in their vehicle. Toll road users could display different behavior from travelers in general.

CHAPTER THREE: METHODOLOGY

3.1 Design and Implementation of the Survey Instrument

The methodology was to conduct a survey to gather the opinions of the toll road travelers on the DMS and analyze the responses from the survey. It was decided that the survey would be conducted in two stages scheduled according to the deployment plan of the DMS by OOCEA.

The developed methodology consisted of the following steps:

3.1.1 Identify the OOCEA Network and the Implementation Plan of the DMS

In the Fall of 2006, there was one DMS sign installed on SR 408 (WB) between I-4 and Orange Blossom Trail. Additional DMS were added throughout the Spring of 2007, and will be installed through Spring 2008 on SR 408, SR 417, SR 429, and SR 528. On the following page, **Error! Reference source not found.** shows the map of the OOCEA network with the implementation plan of the DMS (41) on various toll roads in the network. Of particular emphasis were the traveler expectations of traffic information from DMS, and the attitude of travelers towards the single DMS already installed on SR 408. The responses from the pre-deployment survey will serve as the basis to be compared with a post DMS deployment traveler survey (henceforth referred to as "post-deployment survey"), where the utility of the DMS messages in enhancing the driver experience will be assessed. A sufficiently large sample size was deemed necessary for the before and after studies to obtain statistically significant results, that can capture the representative sample of travelers commuting on the OOCEA toll facilities.

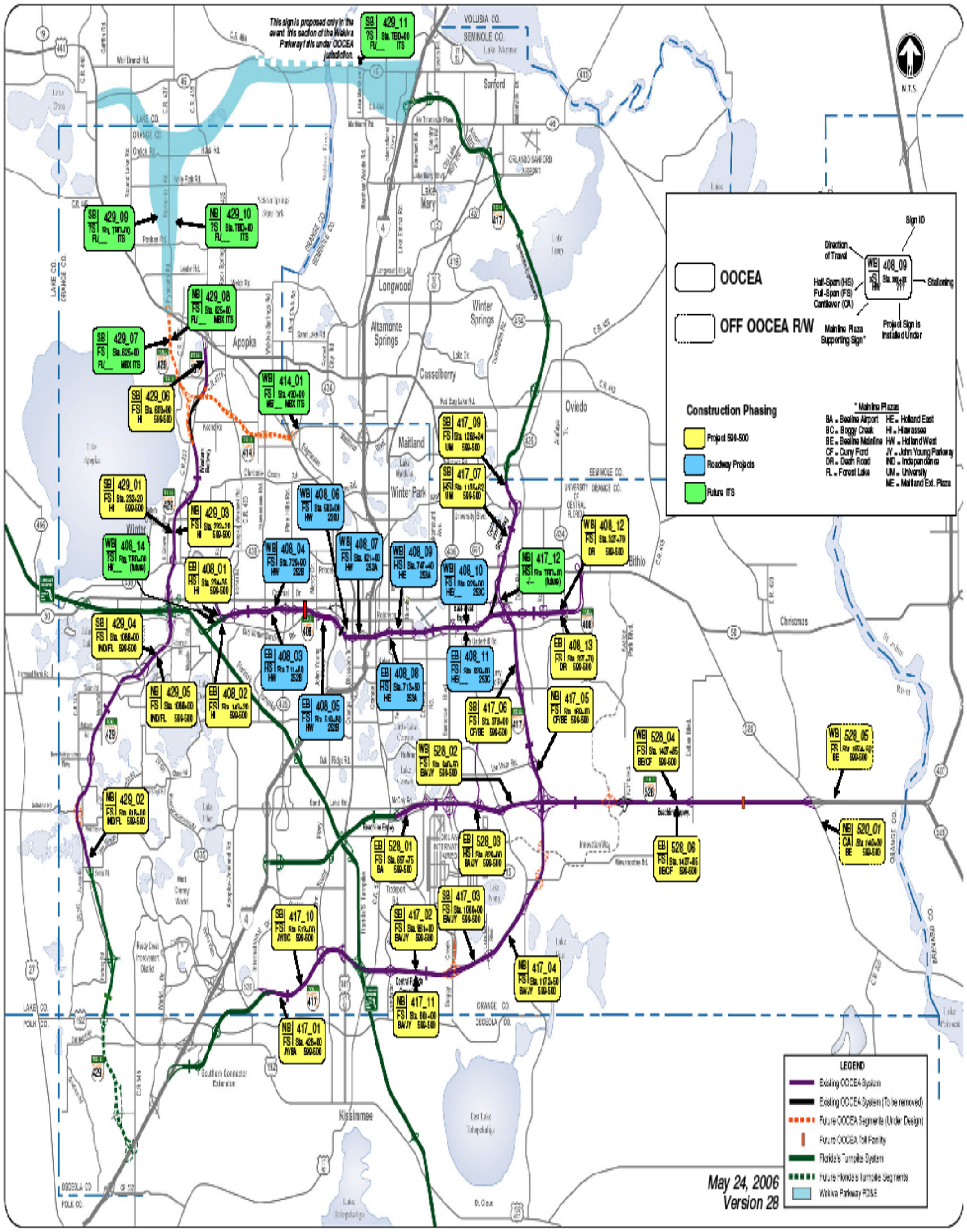

Figure 3: Implementation Plan for DMS Installation on the OOCEA Network (source: OOCEA (41))

3.1.2 Survey Instrument Design

The pre-deployment and post-deployment surveys were aimed at travelers in the Central Florida region who use the OOCEA toll system. Since OOCEA operates toll roads in Orange County, most of the travelers on the toll roads have their origins and destinations in and around Orange County. It was decided that the survey instrument would be directed towards toll road users from Orange, Seminole, and Osceola Counties due to the majority of OOCEA toll road users reside and work in these counties.

A telephone survey was considered appropriate based on the scope and time constraints of the research. The other alternatives were mail questionnaires or internet surveys, which were shown to have a very low response rate from literature surveyed. The Computer Assisted Telephone Interview (CATI) has been known for its success and effectiveness. The survey had to be conducted before the Thanksgiving holiday in November 2006 after which a significant number of travelers were likely to be on vacation.

The survey needed to incorporate questions pertaining to:

a. Demographic characteristics of the respondents: These characteristics which included age, education and location characteristics enable analysis of the different perceptions of the commuters belonging to different demographic and socio-economic groups.
b. Trip characteristics of the respondents: These characteristics included the toll road used, the trip purpose, the number of weekly trips, familiarity of the traveler with the network and other characteristics for their most frequent trips undertaken on the toll road network.

c. Source for acquiring traffic information on toll roads: The questions were needed to know whether the travelers were aware of DMS on the toll roads and if they used them to actively acquire real-time traffic information.
d. Perception of benefits and satisfaction from the information on DMS: These set of questions were needed to assess the perception of the travelers towards the information presented on the DMS and if they appreciate the same.
e. Formats and interpretation of information presented on the DMS: These set of questions were needed to know the preferences of the travelers with respect to the formats of the contents presented on the DMS.
f. RP and SP towards diversion: These set of questions were needed to analyze the behavior of the commuters under unexpected congestion scenarios in the presence of information. The aim of these questions was to know if the DMS made it easier for the commuters to either continue on, or divert from, the toll roads.

The draft questionnaire was tailored to the objectives of this study. However, it was also essential to make sure that the questions would not be deemed invasive by the respondents. The number of questions asked to the respondents needed to be kept under a reasonable limit, so as to not have the respondent abort the questionnaire and to solicit honest responses. Also, depending on the characteristics and responses from the respondent, multiple branches of questions emerged in the preliminary survey draft. The draft was revised multiple times. Furthermore, the researchers secured approval from the UCF Institutional Review Board (IRB). Appendix A contains the IRB approval pages for both survey versions 14 and 14A. The final survey included questions pertaining to the characteristics described above. Table 1 shows a concise description of the questions asked in the survey. The Appendix A includes the complete survey. It contained a total of 32 questions on the whole. However, depending on the branches in the survey, the respondent would have to answer a lesser number of questions. The survey included two filtering questions that excluded any respondents below 18 years and those who had not used OOCEA toll roads in their recent past. It was decided to collect 1000 completed responses. An additional 500 responses were collected (albeit using a slightly different version of the survey) increasing the total number of completed responses to 1500.

Table 1: Description of Questions Asked as the Part of Final Survey Design

Question Number	Question	# of choices	Category
-	Are you above 18 years	2	Filtering
Q1	Have you traveled on OOCEA toll roads in the past 6 months	2	Filtering
Q2	Frequently traveled toll road	4	Trip
Q3	Number of one-way trips per week	4	Trip
Q4	Trip purpose	5	Trip
Q5	Alternate routes known	5	Trip / familiarity
Q6	Pay tolls	2	Trip
Q7	Type of vehicle used for trips	4	Trip
Q8	Acquisition of traffic information while on toll road	5	Source for acquisition
Q9	Satisfied with traveler information on toll roads	4	Satisfaction
Q10	Recall seeing DMS on toll roads	2	Source for acquisition
Q11	Are DMS helpful in improving traveling experience	4	Satisfaction
Q12	Are DMS helpful in providing hazard warnings	4	Satisfaction
Q13	Are DMS helpful in giving special event information	4	Satisfaction
Q14	Are DMS easy to read while driving	4	Satisfaction
Q15	Do DMS display accurate travel time information	4	Satisfaction
Q16	Steady / Alternating messages on DMS	2	Format
Q17	Flashing / All Flashing / Non Flashing messages on DMS	3	Format
Q18	Encounter congestion in the past 6 months	2	Diversion behavior
Q19	Cause of unexpected congestion	6	Diversion behavior
Q20	First source of unexpected congestion	5	Diversion behavior
Q21	Response to unexpected congestion	4	Diversion behavior
Q22	SP to diversion	4	Diversion behavior
Q23	Additional travel added to the congestion	4	Diversion behavior
Q24	Reason to continue on the toll road	5	Diversion behavior
Q25	How did DMS help reschedule travel	5	Satisfaction
Q26	Do DMS help save time	4	Satisfaction
Q27	Is I-Drive a good abbreviation for International Drive	4	Format
Q28	Preference to identifying a roadway	2	Format
Q29	Interpretation of travel time to airport	2	Format
Q30	Age	5	Demographic
Q31	Education	5	Demographic
Q32	Zip code	Input	Demographic

3.1.3 Survey Instrument Implementation

The pre-deployment survey was conducted from 1st November, 2006 to 10th November, 2006 to gather 1000 completed responses from the Central Florida Orange, Seminole, and Osceola counties by adopting CATI. The survey selection was totally random. Thousands of travelers residing in these three Central Florida counties were interviewed on the telephone. This technique was proven efficient through national studies. In about two weeks, the desired sample size of 1000 responses was reached.

For this first 1000 completed survey version, Q18 was asked to all the respondents to see if they had experienced any unexpected congestion within the last six months on the toll roads. If the travelers responded that they had, these respondents were asked the RP diversion Q21. If the travelers responded that they had not experienced any congestion, these respondents were asked SP diversion Q22. The respondents that were asked Q21 were not asked Q22. If the respondents in the RP diversion Q21, and SP diversion Q22 answered "A-Stay on the toll road and wait it out," they were then filtered to Q23 (What amount of unexpected congestion would cause you to divert off your route?).

The issue with the first version (14) of the survey was the travelers who were asked the RP diversion Q21 and were not asked the SP diversion Q22. It was thought that it was important to have both questions answered to aid in the RP diversion modeling. In addition, Q23 was changed so that it can be used in the RP diversion model.

The second survey version (14A) varies by the following: Those who answered RP diversion Q21 were also asked SP diversion Q22, and Q23 was changed to new Q23A in order to ask Q21 respondents about the unexpected congestion, how much time did you expect it to add to your trip?

These changes prompted the collection of 500 additional responses, albeit using version 14A. This additional sample was collected in another week. The two surveys of combined 1500 sample were completed as scheduled before the 2006 Thanksgiving holiday.

The two surveys were conducted on both weekdays and weekends to complete study as soon as possible and also to capture customers who like to respond during certain periods of the week as their preferences were different.

Both versions of the pre-deployment survey, 14 and 14A, are located in Appendix B. The results of the 1500 completed responses to the pre-deployment surveys are located in Appendix C.

3.2 Descriptive Analysis and Modeling

3.2.1 Descriptive Analysis of Response from the Survey

The responses from the survey were then analyzed and certain relevant descriptive statistics were reported. These statistics included the distribution of responses for the demographic and trip characteristics, the DMS formatting questions, the satisfaction with DMS questions and the RP and SP response to diversion questions. The mode (most frequent response) was reported question by question, and certain responses were analyzed for different groups (for example, response to formatting questions with Age groups, etc). Cross tabulations were performed and chi-square tests were conducted to check for the dependence between characteristics of the respondents and their preferences towards various aspects of traffic information.

3.2.2 Modeling Satisfaction and Diversion

The responses from the survey were used to set up binary logit models that estimate the satisfaction of the toll road users with the traffic information available on toll roads, and their revealed diversion preferences. The predictor variables used in these models are predominantly categorical. They capture the demographic, trip characteristics of the travelers. In addition, the model for satisfaction captures the different aspects of information presented on DMS and the satisfaction of the travelers with the same attributes. The RP diversion model captures the exposure of the commuters to DMS, and their actions to real-world congestion and delays.

An example of how the data was set up for modeling is located in Appendix D, and samples of the LIMDEP/NLOGIT model outputs are located in Appendix E.

3.2.3 Conclusions

The results of the descriptive analysis and the modeling of satisfaction and diversion are interpreted to provide an insight into the behavior and attitude of the travelers towards DMS. These results serve as basis for an implementation plan for OOCEA that can be utilized in improving the DMS. These conclusions will also serve as a launch pad for the post-deployment survey.

CHAPTER FOUR: RESULTS OF THE PRE-DEPLOYMENT ANALYSIS

4.1 Descriptive Statistics

Most of variables collected as part of this survey are predominantly qualitative and categorical. Hence, for most of these variables, there is no inherent order, except for variables like age group, education level, and additional travel time. In some circumstances, it is useful to view different levels of satisfaction on an ordinal scale. For example, "most frequently used toll road" has four categories / levels: SR 408, SR 417, SR 429, and SR 528. These categories do not have an increasing or decreasing order. On the other hand, age has categories; 18-25, 26-35, 36-50, 51-65, 65 and above. These categories can be represented in an increasing / decreasing order depending on the context. With different levels of satisfaction or agreement, "Strongly Agree", "Agree", "Disagree", and "Strongly Disagree", it is sometimes beneficial to look at them as just different labels for agreement or to assign them an increasing order of agreement or disagreement. It is essential to know the distinction between ordinal and categorical variables as descriptive statistics should have different meanings depending on whether a variable is interpreted as categorical or ordinal.

For categorical variables with no inherent order (also referred to as nominal variables), the mode is an important measure of central tendency. The mode refers to the observation or value that repeats most frequently in a sample. In the case of continuous numerical variables, a mode is of limited importance when compared to mean and median. Therefore, the mode will be reported for the qualitative variables collected from the responses in the survey, while the mean (average) will be reported for the ordinal variables in the survey. The mode is an important statistic as it describes the most frequent response from the respondents of the survey. It can indicate an overwhelming preference of the commuters with respect to the relevant questions. Further discussion of the mode for various questions from the survey is provided in the results section.

The combined 1500 responses, from the two surveys 14 and 14A, are the focus of these following results unless noted otherwise.

4.2 Awareness of DMS on OOCEA Toll Roads

One of the objectives of the survey is to know the percentage of travelers that have knowledge of the presence of DMS. Survey Question 10 was used to measure what percentage of travelers had knowledge. In the survey, before Question 10 was asked to the respondent, it was clearly defined what the DMS were, and for the purpose of the questionnaire the DMS referred to were specified as being the ones used only on OOCEA toll road network. Question 10 is shown in Figure 4.

10) A Dynamic Message Sign is an electronic traffic sign used on roadways to give travelers information about travel times, traffic congestion, accidents, disabled vehicles, AMBER ALERTS, or special events. The particular dynamic message signs referred to in this survey are large rectangular signs installed over the travel lanes. These are not the orange, portable trailer mounted signs you see on the side of the road during construction. For the purpose of this survey, please limit your comments to dynamic message signs on Central Florida toll roads only, not those found on local roads or interstate highways.

Do you recall seeing a Dynamic Message Sign during your travel on State Road 408 (East-West Expressway), State Road 417 (GreeneWay), State Road 429 (Western Expressway), State Road 528 (Beach Line)?

a) Yes
b) No

Figure 4: Question 10

From the results of Question 10, 54.4% (816/1500) of the people surveyed recalled seeing DMS on the OOCEA toll roads. Hence, 45.6% (684/1500) of the people surveyed did not recall seeing DMS on the OOCEA toll roads. The percent knowledge of DMS was also explored by grouping the responses by the following demographic variables:

- Age group
- Education level
- Most traveled OOCEA toll road
- County

Age group was investigated to see if it plays a role in the percent knowledge of DMS. Figure 5 displays the frequency values for the age groups. It can be observed that the age groups are somewhat evenly distributed along the pattern of a bell shaped curve.

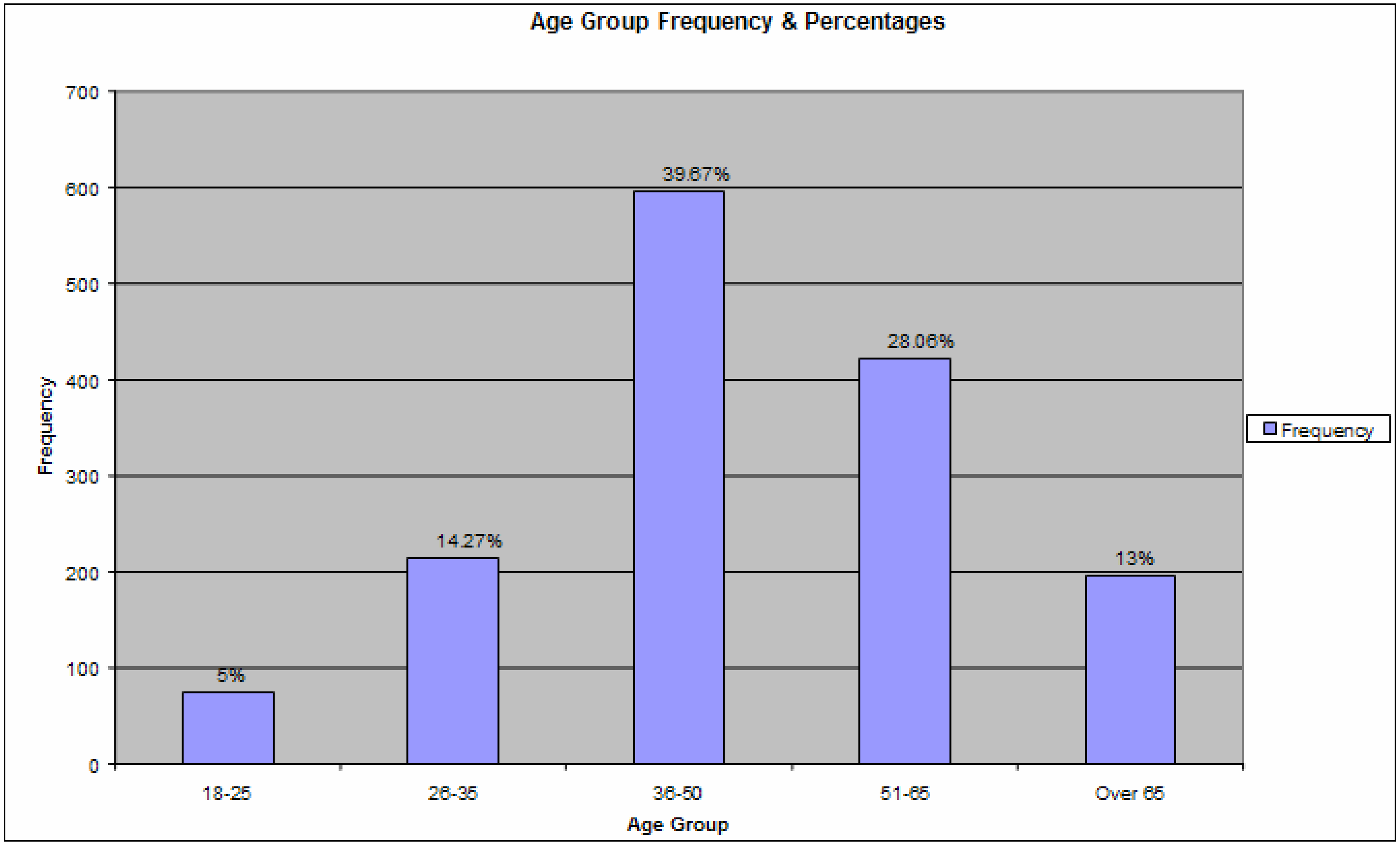

Figure 5: Age Group Frequencies and Percentages

On the following pages, Figure 6 through Figure 9 show the format of the graphs that will be presented for the remainder of this section. These graphs show the distribution of percent knowledge of DMS by different classifications like Age Group, Education Level, Most Used OOCEA Toll Road, and County.

Observing Figure 6 on the following page, the age group 18-25 has 62.33% knowledge of DMS. The fraction to the right of the percentage displays that this 62.33% is from 46 respondents out of the total 75 respondents from this category. The percent knowledge results from this table show that the age group 26-35 as 53.27%, group 36-50 as 52.61%, group 51-65 as 55.11%, and the group Over 65 as 56.92%. No clear trend can be taken away from observing this Figure 6 because the group with the highest percent knowledge is the youngest group, and this group had the smallest number of respondents to the survey. Second in percent knowledge of DMS are the elderly. The lowest percent knowledge of DMS was within the age group of (36-50), and this group had the largest number of respondents to the survey.

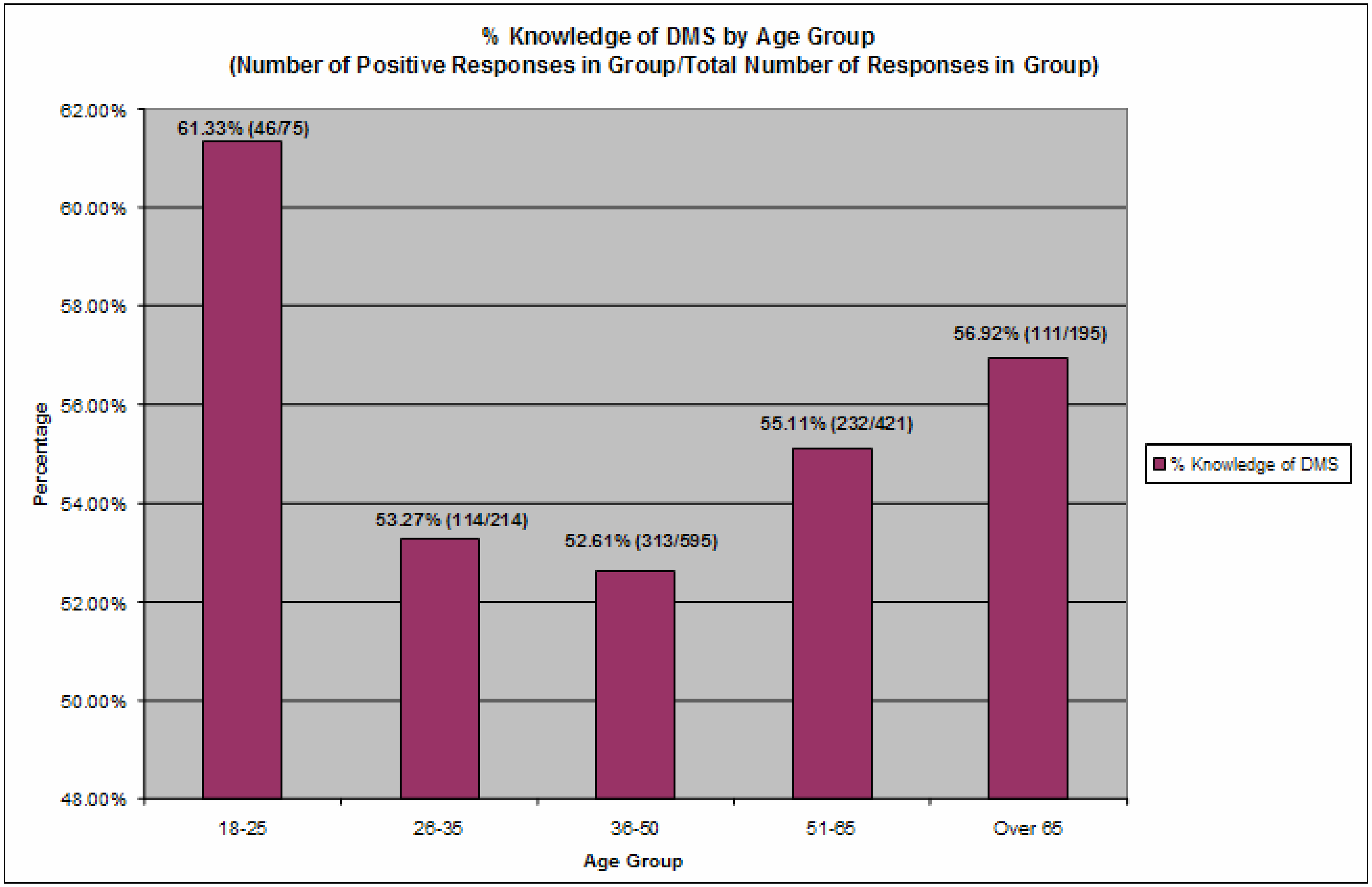

Figure 6: Percent Knowledge of DMS by Age Group

Observing Figure 7 on the following page, the results show knowledge of DMS by education level. The results from the education level are somewhat random. The "Some College" respondents had the highest knowledge of DMS with 56.63%, and the "Post Graduate Degree" respondents had the lowest knowledge of DMS with 50%. The "Bachelor Degree" respondents had the highest number of respondents with 471, and the "Associate Degree" respondents had the least number of respondents with 148.

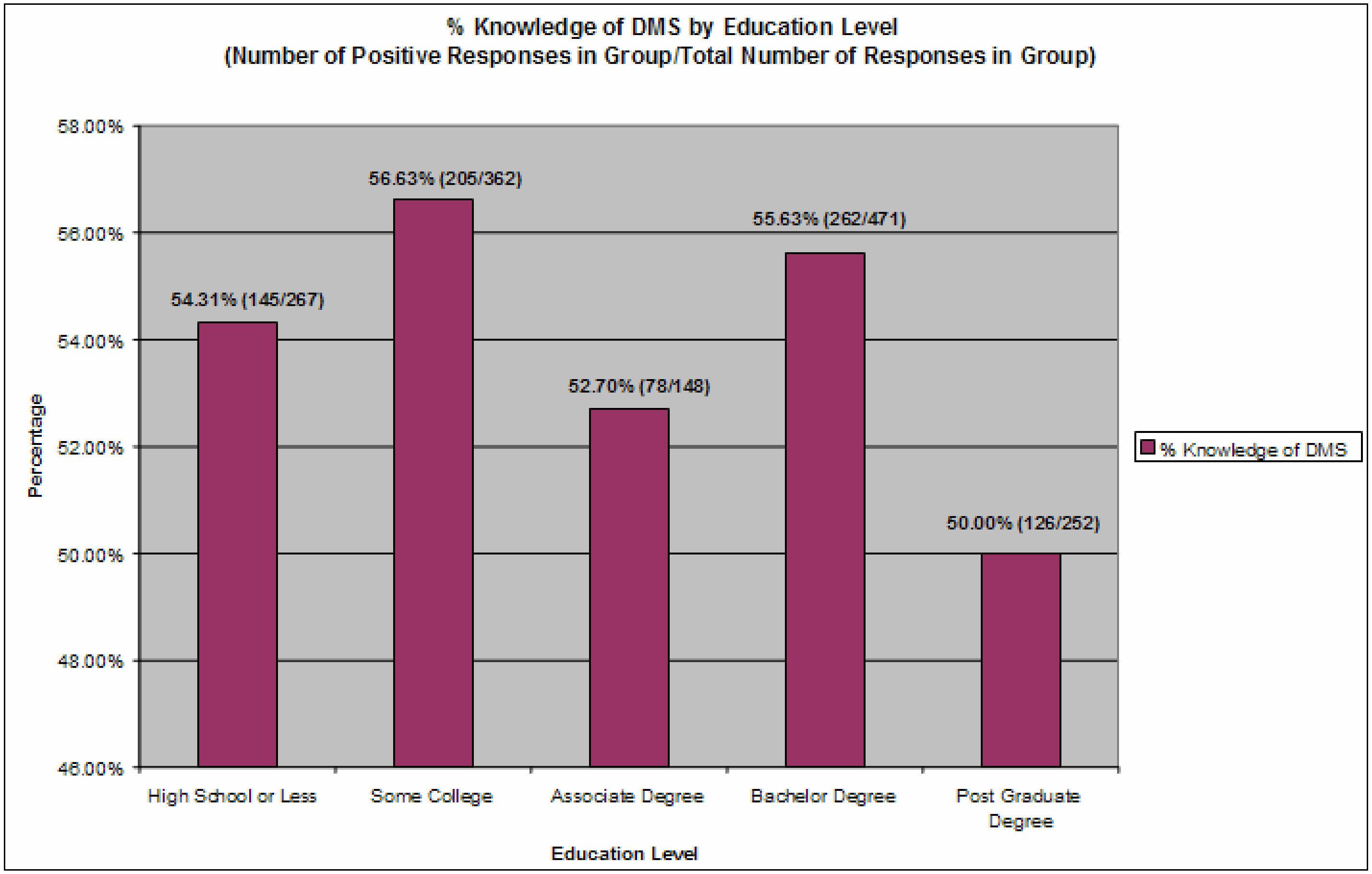

Figure 7: Percent Knowledge of DMS by Education Level

Observing Figure 8 on the following page, “SR 408” travelers have the highest knowledge of DMS with 57.25%. This result was somewhat expected, since the only DMS so far in the OOCEA toll road system is located on this route. “SR 528” users have the lowest knowledge of DMS with 51.85%. “SR 417” has the highest frequency of respondents with 723. “SR 429” has the lowest frequency of respondents with 91.

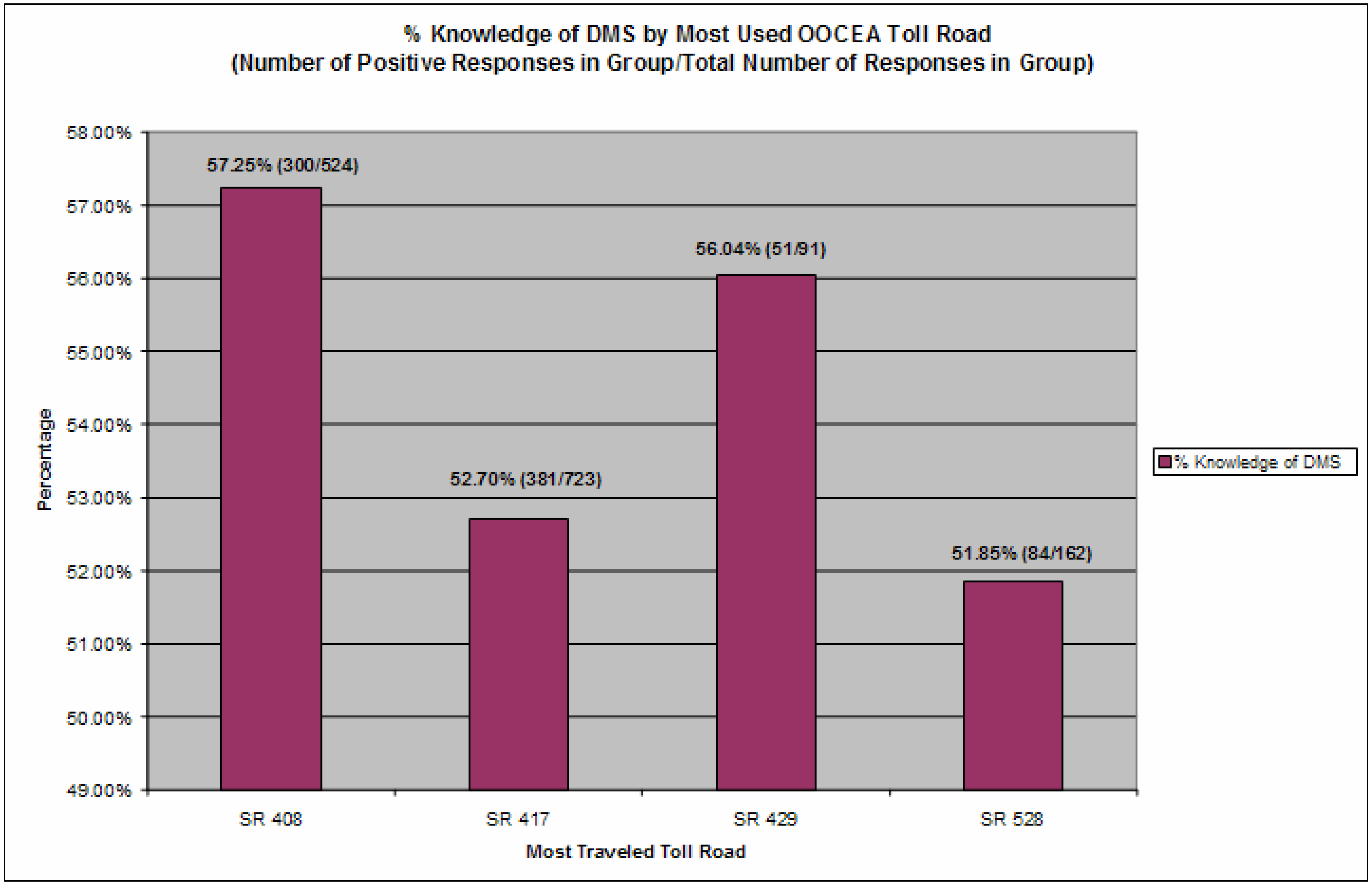

Figure 8: Percent Knowledge of DMS by Most Used OOCEA Toll Road

Observing Figure 9 on the following page, “Orange County” residents have the highest knowledge of DMS with 58%, while “Seminole County” residents have the least knowledge of DMS with 51.5%. This was expected since the only DMS sign during the pre-deployment survey was located in Orange County. Frequencies of the county response are not exactly the same values but somewhat close.

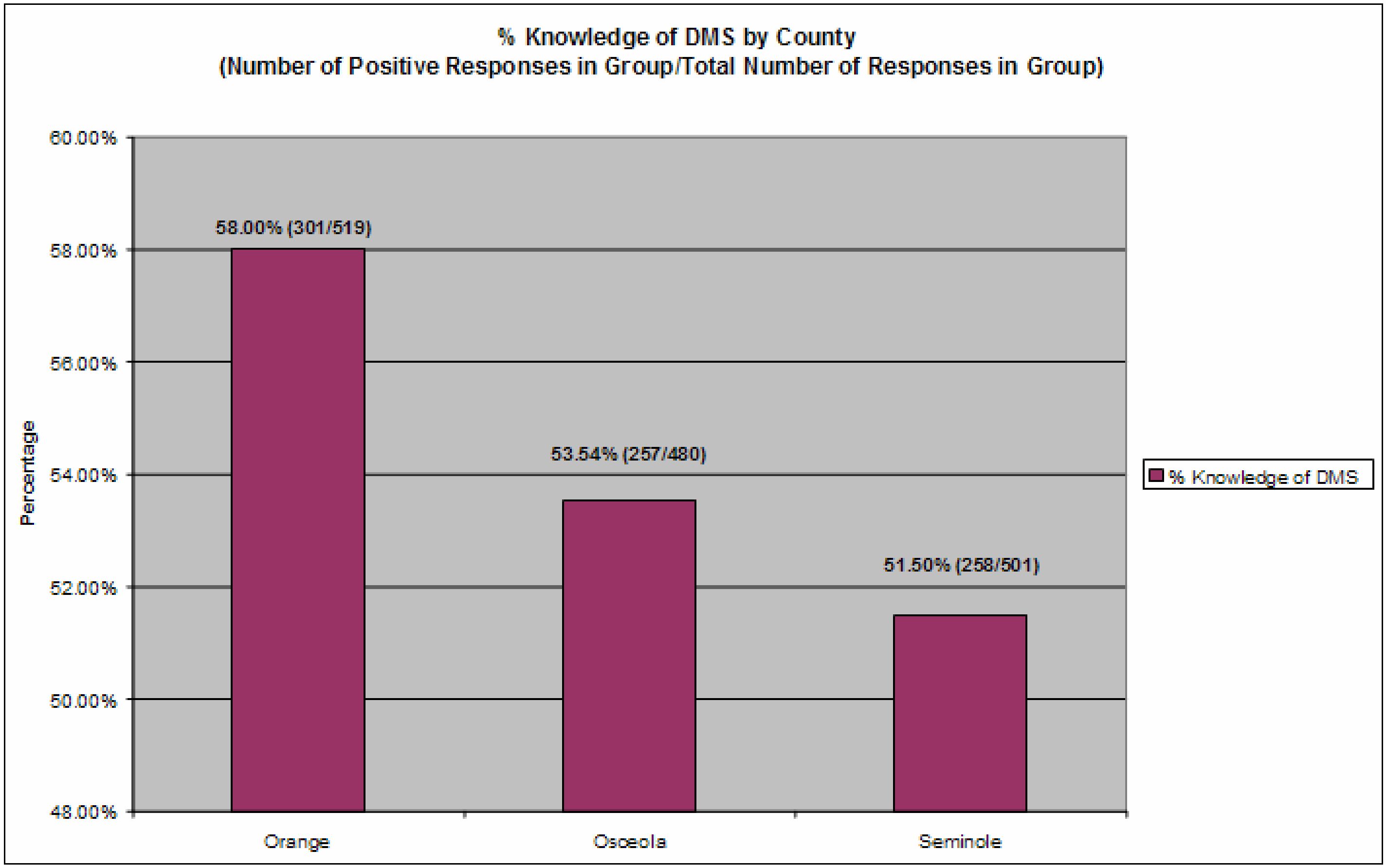

Figure 9: Percent Knowledge of DMS by County

4.3 DMS Satisfaction Results

The following DMS questions covered were only asked to the 816 people who recalled seeing DMS.

The questions covered in this section consist of how the respondent agrees or disagrees with issues that concentrate on the satisfaction of a DMS subject. The questions consist of the following subjects:

- Helpful about hazards
- Easy to read while driving
- Improves travel experience
- Travel time accuracy
- Helped save time
- Helpful with special event information
- Satisfaction of traveler information on OOCEA toll roads.

The DMS questions are covered in a descending order of highest satisfaction grade to the lowest satisfaction grade. The grading system is broken down in the following Table 2. The satisfaction with different subjects with the DMS was measured by assigning a numeric value to each of the responses. This method was used to evaluate the satisfaction of subject like the grade point average of a class of students.

Table 2: Grading System Breakdown

Response	Numeric Value Assigned
Strongly Agree	4
Agree	3
Disagree	2
Strongly Disagree	1

The grade averages were used to rank each question against other questions, and to rank different variables. The variables included in the following tables are:

- Age group
- Education level
- Most used OOCEA toll road
- County

Observing Table 3 below, the respondents most strongly agreed that "DMS Have Been Helpful for Giving Warnings on Roadway Hazards" (Question 12). This is evident from the high "Average Grade" measure, which is 3.34 out of a maximum value of 4. The question also ranks first out of the six questions related to satisfaction (highest average grade value among the six). The subject of this question is closely related to the travelers' personal safety, and this topic maybe of a high concern. Observing the categories, the age group with the highest grade was 18-25, and the lowest is 26-35. It is important to note that even though there is a difference in the categories' score, it is quite small. The associate degree has the highest grade and post graduates the lowest. SR 429 ranks first in grading, and SR 408 ranks last. Osceola County ranks first in grading, and Orange County ranks last.

Table 3: DMS Grade Results for Question 12

DMS Subject	Mode 1	Mode 2	Average Grade	Standard Deviation
Helpful About Hazards (Q12)	Strongly Agree (374)	Agree (364)	3.34 (816)	0.72

Category-wise Grades for Question 12

AGE	Grade	Education	Grade	OOCEA Toll Road	Grade	County	Grade
(1) 18-25	3.43	(1) Associate Degree	3.47	(1) SR 429	3.43	(1) OSCEOLA	3.40
(2) 51-65	3.36	(2) Some College	3.41	(2) SR 528	3.36	(2) SEMINOLE	3.37
(3) Over 65	3.34	(3) High School or Less	3.40	(3) SR 417	3.35	(3) ORANGE	3.26
(4) 36-50	3.32	(4) Bachelor Degree	3.27	(4) SR 408	3.30		
(5) 26-35	3.31	(5) Post Graduate Degree	3.18				

Observing Table 4 below, the subject "Easy to Read DMS While Driving" (Question 14) scored second highest overall when compared with the other six satisfaction questions (3.31 / 4). Observing the categories, the age group with the highest grade was 18-25, and the lowest is Over 65. The difference of grade in age level is the biggest compared with all categories. It is most likely that a good amount of respondents 18-25 do not have problems with vision, and the older a person gets, the more their vision is likely to deteriorate. The associate degree has the highest grade and post graduates the lowest. SR 429 ranks first in grading, and SR 528 ranks last. Seminole County ranks first in grading, and Orange County ranks last.

Table 4: DMS Grade Results for Question 14

DMS Subject	Mode 1	Mode 2	Average Grade	Standard Deviation
Easy to Read While Driving (Q14)	Agree (391)	Strongly Agree (352)	3.31 (816)	0.71

Category-wise Grades for Question 14							
AGE	**Grade**	**Education**	**Grade**	**OOCEA Toll Road**	**Grade**	**County**	**Grade**
(1) 18-25	3.48	(1) Associate Degree	3.37	(1) SR 429	3.41	(1) SEMINOLE	3.36
(2) 36-50	3.39	(2) High School or Less	3.34	(2) SR 417	3.33	(2) OSCEOLA	3.32
(3) 26-35	3.31	(3) Some College	3.32	(3) SR 408	3.31	(3) ORANGE	3.28
(4) 51-65	3.26	(4) Bachelor Degree	3.30	(4) SR 528	3.20		
(5) Over 65	3.14	(5) Post Graduate Degree	3.26				

Observing Table 5 below, the subject “DMS Improves Travel Experience” (Question 11) ranked third highest overall when compared with the other six satisfaction questions (3.23 / 4). Observing the categories, the age group with the highest grade was 18-25, and the lowest was 36-50. The associate degree has the highest grade and post graduates the lowest. The difference of grade in both education levels was the biggest of the categories. SR 429 ranks first in grading, and SR 528 ranks last. Seminole County ranks first in grading, and Orange County ranks last.

Table 5: DMS Grade Results for Question 11

DMS Subject	Mode 1	Mode 2	Average Grade	Standard Deviation
Improves Travel Experience (Q11)	Agree (353)	Strongly Agree (341)	3.23 (816)	0.80

Category-wise Grades for Question 11

AGE	Grade	Education	Grade	OOCEA Toll Road	Grade	County	Grade
(1) 18-25	3.41	(1) Associate Degree	3.42	(1) SR 429	3.33	(1) SEMINOLE	3.27
(2) Over 65	3.28	(2) High School or Less	3.30	(2) SR 417	3.24	(2) OSCEOLA	3.25
(3) 51-65	3.24	(3) Some College	3.28	(3) SR 408	3.23	(3) ORANGE	3.17
(4) 26-35	3.19	(4) Bachelor Degree	3.15	(4) SR 528	3.12		
(5) 36-50	3.19	(5) Post Graduate Degree	3.11				

Observing Table 6 below, the subject "DMS Travel Time Accuracy" (Question 15) ranked fourth highest overall when compared with the other six satisfaction questions (3.08 / 4). Observing the categories, the age group with the highest grade was 18-25, and the lowest was 51-65. The difference of grade in age level was the biggest amongst the categories. The "Some College" category under education level has the highest grade and bachelor degree the lowest. SR 429 ranks first in grading, and SR 408 ranks last. Osceola County ranks first in grading, and Seminole County ranks last.

Table 6: DMS Grade Results for Question 15

DMS Subject	Mode 1	Mode 2	Average Grade	Standard Deviation
Travel Time Accuracy (Q15)	Agree (459)	Strongly Agree (226)	3.08 (816)	0.73

Category-wise Grades for Question 15

AGE	Grade	Education	Grade	OOCEA Toll Road	Grade	County	Grade
(1) 18-25	3.24	(1) Some College	3.18	(1) SR 429	3.25	(1) OSCEOLA	3.12
(2) 36-50	3.12	(2) High School or Less	3.16	(2) SR 528	3.11	(2) ORANGE	3.07
(3) 26-35	3.06	(3) Associate Degree	3.15	(3) SR 417	3.09	(3) SEMINOLE	3.06
(4) Over 65	3.05	(4) Post Graduate Degree	3.01	(4) SR 408	3.04		
(5) 51-65	3.03	(5) Bachelor Degree	2.98				

Observing Table 7 below, the subject "DMS Helps Save Time" (Question 26) ranked fifth highest overall when compared with the other six satisfaction questions (3.00 / 4). Observing the categories, the age group with the highest grade was over 65, and the lowest was 26-35. The associate degree has the highest grade and bachelor degree the lowest. The difference of educational level was the biggest amongst the categories. SR 429 ranks first in grading, and SR 528 ranks last. Osceola County ranks first in grading, and Orange County ranks last.

Table 7: DMS Grade Results for Question 26

DMS Subject	Mode 1	Mode 2	Average Grade	Standard Deviation
Helped Save Time (Q26)	Agree (415)	Strongly Agree (224)	3.00 (816)	0.80

Category-wise Grades for Question 26							
AGE	**Grade**	**Education**	**Grade**	**OOCEA Toll Road**	**Grade**	**County**	**Grade**
(1) Over 65	3.10	(1) Associate Degree	3.17	(1) SR 429	3.10	(1) OSCEOLA	3.04
(2) 18-25	3.04	(2) High School or Less	3.12	(2) SR 417	3.02	(2) SEMINOLE	3.01
(3) 51-65	3.02	(3) Some College	3.07	(3) SR 408	2.99	(3) ORANGE	2.96
(4) 36-50	2.97	(4) Post Graduate Degree	2.92	(4) SR 528	2.86		
(5) 26-35	2.91	(5) Bachelor Degree	2.86				

Observing Table 8 below, the subject "DMS Helpful for Special Event Information" (Question 13) ranked last overall when compared with the other six satisfaction questions (2.9 / 4). Travelers may have not been exposed as much to these types of messages as compared to other types. Therefore, they would not have strong satisfaction score with this type of information. In addition, travelers may not find special event information to be as important as messages that pertain to personal safety. Observing the categories, the age group with the highest grade was 18-25, and the lowest was 26-35. The associate degree has the highest grade and post-graduate degree the lowest. The difference of educational level was the biggest amongst the categories. SR 429 ranks first in grading, and SR 528 ranks last. Osceola County ranks first in grading, and Orange County ranks last.

Table 8: DMS Grade Results for Question 13

DMS Subject	Mode 1	Mode 2	Average Grade	Standard Deviation
Helpful Special Event Information (Q13)	Agree (333)	Strongly Agree (229)	2.90 (816)	0.88

Category-wise Grades for Question 13

AGE	Grade	Education	Grade	OOCEA Toll Road	Grade	County	Grade
(1) 18-25	3.07	(1) Associate Degree	3.09	(1) SR 429	2.94	(1) OSCEOLA	3.02
(2) Over 65	3.00	(2) High School or Less	3.08	(2) SR 417	2.93	(2) SEMINOLE	2.87
(3) 51-65	2.91	(3) Some College	3.03	(3) SR 408	2.87	(3) ORANGE	2.83
(4) 36-50	2.88	(4) Bachelor Degree	2.76	(4) SR 528	2.87		
(5) 26-35	2.79	(5) Post Graduate Degree	2.67				

The six DMS questions related to travelers' satisfaction were averaged out, and the value was 3.14 / 4. The results are presented in Table 9. Observing the categories, the age group with the highest grade was 18-25, and the lowest was 26-35. The associate degree has the highest grade and post-graduate degree the lowest. The difference of educational level was the biggest amongst the categories. SR 429 ranks first in grading, and SR 528 ranks last. Osceola County ranks first in grading, and Orange County ranks last. This

Table 9: DMS Grade Results for Overall Satisfaction Questions

DMS Subject	Mode 1	Mode 2	Average Grade	Standard Deviation
Overall	Agree (386)	Strongly Agree (291)	3.14 (816)	0.80

Category-wise Grades for Overall Satisfaction with DMS

AGE	Grade	Education	Grade	OOCEA Toll Road	Grade	County	Grade
(1) 18-25	3.28	(1) Associate Degree	3.28	(1) SR 429	3.24	(1) OSCEOLA	3.19
(2) Over 65	3.15	(2) High School or Less	3.23	(2) SR 417	3.16	(2) SEMINOLE	3.16
(3) 36-50	3.15	(3) Some College	3.22	(3) SR 408	3.12	(3) ORANGE	3.09
(4) 51-65	3.14	(4) Bachelor Degree	3.05	(4) SR 528	3.09		
(5) 26-35	3.10	(5) Post Graduate Degree	3.03				

Below, Table 10 shows the results of average grade for Question 9 (satisfaction with traveler information available on toll roads) which was asked to everyone (1500 respondents) and should not be compared or ranked with DMS satisfaction questions. Observing the categories, the age group with the highest grade was 18-25, and the lowest was 26-35. The associate degree has the highest grade and post-graduate degree the lowest. The difference of educational level was the biggest amongst the categories. SR 429 ranks first in grading, and SR 528 ranks last. Osceola County ranks first in grading, and Orange County ranks last. The categorical results are not any different from the other previous satisfaction questions.

Table 10: Grade Result for Question 9

Subject	Mode 1	Mode 2	Average Grade	Standard Deviation
Satisfaction Information All Surveyed	Agree (873)	Strongly Agree (324)	2.95 (1500)	0.78

Category-wise Grades for Question 9

AGE	Grade	Education	Grade	OOCEA Toll Road	Grade	County	Grade
(1) 18-25	3.09	(1) High School or Less	3.14	(1) SR 528	3.01	(1) OSCEOLA	3.00
(2) Over 65	3.07	(2) Some College	3.01	(2) SR 429	2.99	(2) SEMINOLE	2.94
(3) 26-35	2.94	(3) Associate Degree	2.95	(3) SR 417	2.96	(3) ORANGE	2.91
(4) 51-65	2.92	(4) Bachelor Degree	2.87	(4) SR 408	2.91		
(5) 36-50	2.91	(5) Post Graduate Degree	2.81				

4.4 DMS Preferred Formats and Abbreviations, and Benefits

The following tables display the mode of each question in bold. These results are summarized below.

The following Table 11 through Table 13 have the results only of the 816 respondents who were aware of DMS from Question 10. Table 11 shows the results for Q16 (the preferred format of message on DMS), Table 12 shows the results for Q17 (preference for flashing / non-flashing messages on DMS), and Table 13 shows the results for Q25 (if and how DMS have helped to reschedule travel plans).

From Table 11 below, the results show that with 63.5%, the majority of toll road users preferred DMS with steady message, and not alternating. An alternating message, for example, would be a two-page message, and a steady message would be one page.

Table 11: What is Preferred on DMS (Q16)

Variable	Frequency	Percent (%)
A) Steady Message	**518**	**63.5%**
B) Alternating Message	298	36.5%
# of Respondents Who Answered Q16	816	100.0%

From Table 12 below the results show that when a message on DMS displays abnormal traffic conditions, the mode of the travelers (42.6%) responded that they preferred a non-flashing message to either of the flashing type messages.

Table 12: What is Preferred for Abnormal Traffic Conditions (Q17)

Variable	Frequency	Percent (%)
A) All Flashing Message	256	31.4%
B) One Line Flashing Message	212	26.0%
C) Non-Flashing Message	**348**	**42.6%**
# of Respondents Who Answered Q17	816	100.0%

From Table 13 below, the majority of toll road users (57.5%) responded that DMS helped them reschedule travel by "Informing someone that you are running late." 22.7% of the users responded, "It did not help with rescheduling." Therefore, 77.3% of the respondents responded that DMS helped them reschedule travel plans.

Table 13: DMS Helped Reschedule Travel Plans (Q25)

Variable	Frequency	Percent (%)
A) Adding unintended intermediate stops	57	7.0%
B) Canceling intended intermediate stops	25	3.1%
C) Informing someone that you are running late	**469**	**57.5%**
D) Other	80	9.8%
E) It did not help with rescheduling	185	22.7%
# of Respondents Who Answered Q25	816	100.0%

Table 14 through Table 16 have the results of all 1500 respondents. Table 14 shows the results for Q27 (preference towards using abbreviations for street names), Table 15 shows results for Q28 (preference towards street numbers to street names) and Table 16 shows the results for Q29 (interpretation of travel time message to the Airport exit).

From Table 14 below, the mode for Question 27 (satisfaction of I-Drive Abbreviation) was "agree." The second mode to this question was "strongly agree." Totally, 16.1% of the respondents "disagree" or "strongly disagree," hence, 83.9% of the respondents find the abbreviation acceptable.

Table 14: I-Drive as Abbreviation of International Drive (Q27)

Variable	Frequency	Percent (%)
A) Strongly Agree	586	39.1%
B) Agree	**673**	**44.9%**
C) Disagree	153	10.2%
D) Strongly Disagree	88	5.9%
# of Respondents Who Answered Q27	1500	100.0%

From Table 15 below, it can be seen that when identifying a roadway, 54.7% of the respondents preferred using the state road number. For example, SR 50 would be preferred over Colonial Blvd.

Table 15: What is Preferred for Identifying Roadway (SR # vs. Name) (Q28)

Variable	Frequency	Percent (%)
A) State Road Number	**821**	**54.7%**
B) Street Name	679	45.3%
# of Respondents Who Answered Q28	1500	100.0%

Below, Table 16 shows the responses when the respondents were asked if they saw DMS displaying information that describes travel time about "Orlando International Airport," how they would interpret it as. The answers were "The travel time is the amount of time it takes to get to the airport exit," or "The travel time is the amount of time it takes to get to the airport terminal." 54.2% of the travelers responded that it is the time to the airport exit. This would actually be the correct interpretation if the OOCEA were to display travel time to this airport. Therefore, 45.8% of the respondents would not have correctly interpreted the information given to them.

Table 16: Perception of Travel Time to "Orlando International Airport" (Q29)

Variable	Frequency	Percent (%)
A) Airport Exit	**813**	**54.2%**
B) Airport Terminal	687	45.8%
# of Respondents Who Answered Q29	1500	100.0%

4.5 Revealed Diversion (Q21) & Stated Diversion (Q22)

For the following section of results on RP to diversion from Question 21, only people who responded to Question 23A "How much time did you expect it to add to your trip?" as "20-30 minutes" and "Over 30 minutes" (in the sample size *n*=500 survey) were compared to the results of Question 22. This was because the SP from Question 22 asked "Suppose that you encounter 30-minutes of unexpected congestion due to an accident or disabled vehicle on a toll road, what would you do?" While this is not as comparing apples to apples, it is somewhat close. If a person responded to Question 21 or Question 22 with "a) Stayed on the toll road and waited it out" then this was classified as "Stayed" on the route, while other responses including "b), c), or d)" were classified as "Diverted" from the route. Table 17 shows the number of respondents who answered either "Stayed" or "Diverted" to each of these questions.

Table 17: Comparison of Q21 (RP) and Q22 (SP)

	Stayed	Diverted	Total
Q21 (RP)	56	39	95
	58.95%	41.05%	100.00%
Q22 (SP)	34	61	95
	35.79%	64.21%	100.00%

Even though there were a total of 255 respondents who were asked Question 21, and 500 respondents who were asked Question 22, for this comparison, 95 responses could be compared. The responses, for Question 21, are of those respondents who expected the delay that they actually experienced to be 30 minutes or more. So, Question 22 asks what they would do if facing 30 minutes of delay. The results from Question 21 (RP) showed that 41.05% of the respondents diverted off the toll road. The results from Question 22 (SP) showed that 64.21% of the same respondents said that they would divert.

Below, Table 18 shows the number of respondents who agreed or disagreed in their responses towards the SP and RP to diversion. From observing Table 18 below, 44.21% of the respondents showed conflicting statements when comparing RP and SP, while 55.79% of the respondents showed agreement. The difference between RP (Q21) and SP (Q22) is that RP (Q21) is the actual past diversion. This is the respondents' commented past behavior to divert. SP is more like the respondent's motivation because in real situations as in RP (Q21) respondents may be stuck between exits where they have no choice but to stay. Even though SP (Q22) is a fictitious situation, examining the responses is beneficial because it shows overall drivers' propensity to divert.

Table 18: RP & SP Response Agreement and Contradictions

	Stayed & Stayed	Stayed & Diverted	Diverted & Stayed	Diverted & Diverted	Total
Q21 (RP) & Q22 (SP)	24	32	10	29	95
	25.26%	33.68%	10.53%	30.53%	100.00%
Negative					44.21%
Positive					55.79%

The following tables are from the combined 1500 results excluding those not qualified.

From Table 19 below, the response "Accident" had the highest frequency of the cause of congestion with 64.7%. This cause was apparently the most frequent of the causes, with "Construction/road work" falling far behind in second.

Table 19: Cause of Unexpected Congestion from RP (Q20)

Variable	Frequency	Percent (%)
A) Accident	**476**	**64.7%**
B) Disabled vehicle	22	3.0%
C) Construction/road work	142	19.3%
D) Weather Related	11	1.5%
E) Other	51	6.9%
F) Don't know	34	4.6%
# of Respondents Who Answered Q20	736	100.0%

Observing Table 20 below, Question 24 was asked to everyone who in both/either Question(s) 21 and 22 responded that they "Stayed." The answer "It would be faster to stay on the toll road" had the highest frequency with 35.4%. It is probably understood by these travelers that the toll roads are generally a more efficient means of travel even under unfriendly circumstances. The next highest frequency of an answer is the combination. However, it is important to point out that 21.4% of the users are unfamiliar with alternate routes in comparison with the OOCEA toll roads. Without knowing alternate routes, it can be concluded that most travelers would not be likely to divert.

Table 20: Main Reason to Stay on the Toll Road and Wait it Out (Q24)

Variable	Frequency	Percent (%)
A) Unfamiliar with alternate routes	139	21.4%
B) Do not trust travel time information	8	1.2%
C) It would be faster to stay on the toll road	**230**	**35.4%**
D) Combination of any of the above	162	24.9%
E) None of the above	111	17.1%
# of Respondents Who Answered Q24	650	100.0%

4.6 Pre-Modeling Correlations of Pre-Deployment Survey Questions

In the analysis of surveys, the emphasis is on the characteristics and preferences of the OOCEA travelers that are measured by qualitative variables. In these cases, the frequency counts of the variables provide important information about the distribution of the characteristics and / or preferences of the commuters. As was explained in the previous section, the mode is an important univariate measure of central tendency for qualitative variables. However, in addition to univariate analysis, bi-variate analyses need to be performed to gauge the relationships between sets of variables. Contingency tables are used to compare two variables with one another. On the following page, the Table 21 shown is an example of a contingency table comparing the County, and (Q2) "Most used toll road".

Table 21: Contingency Table of SR and County

Table of (Q2 "SR") by County				
(Q2 "SR") (Respondents)	County (Respondents)			
Frequency Percent Row Pct Col Pct	ORANGE	OSCEOLA	SEMINOLE	Total
SR 408	321 21.40 % 61.26 % 61.85 %	75 5.00 % 14.31 % 15.63 %	128 8.53 % 24.43 % 25.55 %	524 34.93 %
SR 417	83 5.53 % 11.48 % 15.99 %	311 20.73 % 43.02 % 64.79 %	329 21.93 % 45.50 % 65.67 %	723 48.20 %
SR 429	48 3.20 % 52.75 % 9.25 %	17 1.13 % 18.68 % 3.54 %	6 1.73 % 28.57 % 5.19 %	91 6.07 %
SR 528	67 4.47 % 41.36 % 12.91 %	77 5.13 % 47.53 % 16.04 %	18 1.20 % 11.11 % 3.59 %	162 10.80 %
Total	519 34.60 %	480 32.00 %	501 33.40 %	1500 100.00 %

To model the relationships between two variables, it is needed to check for dependency or association between them. In the case of qualitative variables, the measures of association are calculated using the number of occurrences (counts) for a combination of levels of different variables. Observing Table 22, the counts for each combination of levels form the contingency table, with *r* rows corresponding to *r* levels of variable (or *r* possible responses to a specific question in the survey) and *c* columns corresponding to *c* levels of another variable (responses to a different question). This is referred to as an *r* X *c* contingency table. For two variables with *r* and *c* levels respectively, the contingency table is referred to as a two-way *r* X *c* contingency table. For three variables with *r*, *c,* and *p* levels respectively, the contingency table is referred to as three-way *r* X *c* X *p* table, and so forth. i = level of variable 1 = 1, 2,…,r

j = level of variable 2 = 1, 2,…,c

xij = number of occurrences (observed frequency) of variable 1 at level *i* and variable 2 at level *j*

cell (i,j) = cell in the contingency table corresponding to level shows a simple two-way contingency table.

Table 22: A Representation of a Simple Two-Way Contingency Table

		Variable 2 (m levels)					
		1	2	…	J	…	C
Variable 1 (n levels)	1	x_{11}	x_{12}				ΣX_{1c}
	2	x_{21}	x_{22}				ΣX_{2c}
	…						
	I	x_{i1}	x_{i2}	…	x_{ij}	…	ΣX_{ic}
	…						
	R	ΣX_{r1}	ΣX_{r2}				ΣX_{rc}

i = level of variable 1 = 1, 2,…,r

j = level of variable 2 = 1, 2,…,c

xij = number of occurrences (observed frequency) of variable 1 at level *i* and variable 2 at level *j*

cell (i,j) = cell in the contingency table corresponding to level

Contingency tables can be used to check the assumption of whether two qualitative variables are associated with each other or not. If two variables are independent, then the expected frequencies in each cell of the table (corresponding to each level of the variables 1 and 2) should be the same as the observed frequencies. The expected frequencies of each cell (i,j) are calculated as below in Equation 1:

$$(\text{column total of column j/grand total}) \times \text{ row total of row i}$$

$$\bar{E}_{ij} = \left(\frac{\left(\sum_{i=1}^{r} x_{ij}\right)\left(\sum_{j=1}^{r} x_{ij}\right)}{\sum_{i=1}^{r}\sum_{j=1}^{c} x_{ij}} \right)$$

where $\bar{E}_{ij}$ is the expected count for cell (i,j) in the contingency table.

Equation 1: Expected Frequency Count for Cell

By examining the difference between $\bar{E}_{ij}$ and x_{ij} for all cells, it is possible to hypothesize if the difference is purely due to chance or if it is due to an underlying relationship between variable 1 and variable 2. This is achieved by the Chi-square test for independence.

Chi-square test for independence is used to assess the probability that a relationship between two variables is due to chance. This is done by measuring the squares of deviations between the observed frequencies in each cell of a table and the expected frequencies normalized by the expected frequencies. The larger these differences are, the less likely it is that they occurred by chance. A statistic is derived from this, known as the chi-square statistic, which can be compared to a theoretical chi-square distribution identified by the degrees of freedom (*df*). For a two-way contingency table with r rows and c columns, the *df* for comparison with the theoretical chi-square is (r-1) (c-1). The whole description can be formulated as below in Equation 2:

$$\text{test statistic } \chi^2 = \sum_{i,j} \frac{(\bar{E}_{ij} - x_{ij})^2}{\bar{E}_{ij}}$$

(Null hypothesis) H_0: The variables are independent

(Alternate hypothesis) H_a: The variables are not independent

Equation 2: Chi-squared Test Statistic

If χ^2 is large enough (corresponding to a very low significance level or p-value), when compared to a standard chi-square χ^2 distribution with (degrees of freedom) *df*= (r-1) (c-1), then the null hypothesis can be rejected. This shows that there is not sufficient evidence to show that the variables are independent. This implies that the variables could be associated.

The chi-squares test for independence is a standard test for detecting the presence of association among qualitative variables. However, the test by itself cannot indicate the strength of relationship between variables. It does indicate pointers to the researchers and practitioners with enough domain knowledge to identify related variables and draw useful conclusions regarding the relationship and causality between variables. It must be noted that chi-square test by itself does not indicate causality.

The chi-squares test is also an important pre-modeling technique in identifying related factors / variables that could cause multi-collinearity in various regression models. Multi-collinearity is a problem in statistical regression modeling due to redundancy caused by correlated variables. This leads to the estimates of the parameters having high standard errors with a dubious strength in the model. Such a model will not be useful as the conclusions are misleading. Since objectives of this thesis include modeling the satisfaction of the commuters with traffic information on toll roads as well as their diversion behavior, the chi-squares test is an important precursor in identifying redundant variables in modeling. However, stronger measures of association are required to identify potentially correlated variables.

Cramer's V is a measure that is derived from the chi-square test statistic that is analogous to correlation coefficient in the case of continuous variables. It varies between 0 and 1, and higher values indicate a stronger relationship between the levels of the variable. Cramer's V is formulated as below in Equation 3:

$$V = \sqrt{\frac{\chi^2}{nm}}$$

where n = sample size,

m= smaller of (r-1, c-1)

where r = number of rows, c = number of columns

Equation 3: Cramer's V Statistic

Table 23 (42) shows the strength of the association between two variables on the basis of the different possible Cramer's V values.

Table 23: Strength of Association as Given by a Range of Cramer's V Values

Correlation value	Verbal designation of the strength of relationship
0	No relationship
0.01 - 0.1	Very weak
0.11-0.25	Weak
0.26-0.50	Moderate
0.51-0.75	Strong
0.76-0.99	Very Strong
1	Perfect association

Therefore, if two variables show a relationship that is at least as strong as "Moderate" or stronger, then the variables are deemed to be correlated. These variables should not enter a regression model together as they will induce redundancy and multi-collinearity that would render the model misleading and un-interpretable.

The following Table 24 summarizes the number of correlations each question has with another. Question 11 had the most number of correlations, and this subject is "DMS improve travel experience." The satisfaction questions all in general Q9, Q11-15, and Q26 have more than one correlation.

Table 24: Summary of the Number of Correlations

Question	# of Correlation(s)
Q2 Most used OOCEA toll road	1
Q3 Number of trips a week	1
Q4 Trip purpose	1
Q9 Satisfaction about traveler information	4
Q10 Recall seeing DMS on toll road	1
Q11 DMS improve travel experience	6
Q12 DMS helpful in informing about hazards	4
Q13 DMS helpful in giving special event information	3
Q14 Easy to read DMS while driving	3
Q15 Travel time on DMS is accurate	4
Q20 How first learned of unexpected congestion	1
Q21 Response to unexpected congestion	1
Q22 Suppose 30 minutes of unexpected congestion	1
Q26 DMS have helped you save time	4

In the following page, from Table 25, which shows the strength of association between two variables, the strongest correlation found was between Q11 “DMS improve travel experience” and Q12 “DMS was helpful in informing travelers about hazards.” This means a significant amount of responses from Q11 are associated with Q12. The other correlations listed are only the moderate ones. Most of the satisfaction questions Q9, Q11, Q12, Q13, Q14, Q15, and Q26 are moderately correlated. Q2 “Most Used Toll Road” and “County” are moderately correlated. Q21 “RP Diversion Behavior” and Q22 “SP Diversion Behavior” are also moderately correlated. The correlation between variables is a starting point in modeling.

Table 25: Cramer's V and Chi-Square P-values

Correlation	Cramer's V	Chi-Sq P-value	Question by	Question
Moderate	0.362909	0.0001	Q2 Most used toll road	County
Moderate	0.292322	7.09778E-75	Q3 Number trip a week	Q4 Trip purpose
Moderate	0.301479	6.24229E-43	Q9 Satisfaction about traveler information	Q11 DMS improve travel experience
Moderate	0.3053	3.98843E-44	Q9 Satisfaction about traveler information	Q12 DMS helpful in informing about hazards
Moderate	0.306342	1.87253E-44	Q9 Satisfaction about traveler information	Q15 Travel time on DMS accurate
Moderate	0.27739	9.06031E-36	Q9 Satisfaction about traveler information	Q26 DMS have helped you save time
Moderate	0.31872	2.23463E-15	Q10 Recall seeing DMS on toll road	Q20 How first learned of unexpected congestion
Strong	**0.543798**	**4.9907E-150**	**Q11 DMS improve travel experience**	**Q12 DMS helpful in informing about hazards**
Moderate	0.350988	1.20958E-59	Q11 DMS improve travel experience	Q13 DMS helpful in giving special event information
Moderate	0.287032	1.46932E-38	Q11 DMS improve travel experience	Q14 Easy to read DMS while driving
Moderate	0.359911	6.11532E-63	Q11 DMS improve travel experience	Q15 Travel time on DMS accurate
Moderate	0.39132	3.13795E-75	Q11 DMS improve travel experience	Q26 DMS have helped you save time
Moderate	0.416298	9.12698E-86	Q12 DMS helpful in informing about hazards	Q13 DMS helpful in giving special event information
Moderate	0.329322	5.31412E-52	Q12 DMS helpful in informing about hazards	Q14 Easy to read DMS while driving
Moderate	0.319084	1.44174E-48	Q13 DMS helpful in giving special event information	Q26 DMS have helped you save time
Moderate	0.314408	4.88911E-47	Q14 Easy to read DMS while driving	Q15 Travel time on DMS accurate
Moderate	0.326997	3.27524E-51	Q15 Travel time on DMS accurate	Q26 DMS have helped you save time
Moderate	0.280785	1.1669E-09	Q21 RP Diversion	Q22 SP Diversion

4.7 Summary of Pre-Deployment Analysis

Most travelers surveyed who are aware of DMS signs are of the age range between "26-65." "26-65" age range is an important target group because most of these travelers are of the working age. The respondents who live in (Orange County) and the respondents who travel on SR 408 should be focused on for possible improvement in the post-deployment survey because the only DMS sign in the pre-deployment survey was located on SR 408. Some of the categories that have the highest measure of satisfaction contain a low number of respondents. For example, (SR 429) has the highest overall satisfaction of the most used OOCEA toll roads, but the lowest number of respondents. Hazard warning was deemed to be the most important aspect of traveler information on DMS as it is concerned with personal safety of travelers using toll roads. It was also found to be strongly correlated to the improvement of traveling experience on toll roads by DMS. Commuters did not seem to be very satisfied with special event information on the toll roads. However, this could be due to limited special events and comparatively lesser exposure of the commuters towards such messages. A majority of the commuters also reported rescheduling travel plans based on DMS messages. The deployment of more DMS should be beneficial to OOCEA travelers.

CHAPTER FIVE: MODELING RESULTS

5.1 Choice Modeling

5.1.1 Theoretical Background

The next objective of this research is two fold:

1. To model the overall satisfaction of the OOCEA commuters with the traffic information on toll roads with emphasis on the source of traffic information, specifically on the DMS.
2. To model the diversion behavior of the OOCEA commuters when faced with real-life, unexpected delays and congestion, and the role of DMS in this behavior.

The goal of the first objective of modeling is to predict the likelihood of satisfaction of OOCEA commuters with the traffic information on the toll roads with respect to their demographic and trip characteristics, and importantly, the perceptions of the travelers with respect to different aspects of the DMS. Such a model formulation would show the significant demographic and trip characteristics of the individuals that are likely to influence their satisfaction level towards traffic information and their expectations for an effective traveler information system. As a result, it will be easy to see if the DMS meet their expectations as an effective traveler information system. Such a model can be fit to both pre- and post-deployment surveys so that we can compare how the public perceives the benefits from the DMS over a period of increasing exposure to DMS.

The goal of the second objective of modeling is to know how DMS are utilized in real-time situations. When faced with unexpected delays with insufficient or uncertain information, the travelers are likely to be confused about the "right" decision to be taken. More often, the right decision is circumstantial and the travelers make subjective decisions. While the DMS on OOCEA toll road network do not usually provide messages that direct the actions of the travelers (except in special circumstances), it is required to know whether (or not) the DMS ease the decision making process for the travelers by providing reliable information. Modeling RP to diversion (what the travelers actually did in the field in response to unexpected delays) helps to analyze the effect the DMS have had in easing the decision process for the individual travelers in the face of unexpected delays.

The basis of the choice modeling is the logit model. Ordinary regression is used to model the relationship between a continuous dependent variable *y* and continuous / qualitative predictor variables $x_1, x_2, \ldots, x_n$. When *y* is a qualitative variable, ordinary least squares regression violates certain assumptions and becomes difficult to interpret. In such situations, binary logit or probit models are appropriate. The binary logit model is represented as the following in Equation 4:

$$Logit(p(y=1)) = \ln\left(\frac{p_{(y=1)}}{1-p_{(y=1)}}\right) = \beta_0 + \beta_1 x_1 + \cdots + \beta_n x_n$$

Where $y=1$: the targeted dependent is a success (binary $y=0,1$).

$p(y=1)$ is the probability of occurrence / $1-p(y=1)$ is the probability of non-occurrence.

$\ln p(y=1)/(1-p(y=1))$ is the natural logarithm of the odds of target for variable *y*.

β_0 is the estimated constant, $\beta_{1 \ldots}\ \beta_n$ are the coefficients for each independent variable *x* (*n*=total number of independent variables)

Logit($p(y=1)$) is the probability of the targeted event occurring

Equation 4: Binary Logit Model

Therefore, in the data that is to be used in modeling, if the dependent variable is binary with two categories, the outcome can be coded as 1 and the other outcome as 0. The predictor variables can be the characteristics of the individuals and / or the characteristics of the alternatives. This is known as the binary logit model.

5.1.2 Interpretation of Coefficients

The coefficients for the predictor variables in the binary logit model are the increase (or decrease) in the log odds for the outcome y=1 with respect to y=0. For continuous or ordinal predictor variables, a positive value corresponds to the increase in log odds for one unit increase in the predictor variable, when all the other predictors are held constant. In simple terms, a significant positive coefficient implies that the outcome that is being modeled increases the likelihood of occurrence than the base case for that particular predictor. A negative coefficient implies that the modeled outcome is decreases the likelihood of occurrence than the base case for the particular predictor.

5.2 Logit Model for Satisfaction

5.2.1 Variable Selection and Justification for Satisfaction Model

To begin the modeling of satisfaction with traffic information acquired from DMS, question (Q9) is targeted along with 15 independent variables thought to be theoretically significant. Only the survey responses indicating knowledge of DMS (yes to Q10) were used in this satisfaction analysis (816 responses).

Using the results of the DMS pre-deployment survey, the results of Question 9 (Satisfaction with traveler information provided on the toll roads) are modeled as a binary variable as shown below for Question 9 (satisfaction with traveler information provided on the toll roads):

1 = Success (Strongly Agree or Agree),

0 = Failure (Disagree or Strongly Disagree)

The important explanatory variables that seem theoretically relevant for explaining the propensity of the commuters to be satisfied with the information available on toll roads are listed in Table 26:

Table 26: Important Explanatory Variables for Modeling Satisfaction from Q9

Variables	# of levels	Levels of explanatory Variables
County	3	Orange, Seminole, Osceola
Q2-Most traveled toll road	4	SR 408, SR 417, SR 429, SR 528
Q3-Number of trips on the most traveled toll road	4	<1, 1-5, 6-10, >10
Q4-Main purpose of most frequent trips	5	Work, Shopping, School, Recreational, Other
Q5-Number of alternate routes known	5	None, 1, 2, 3, 4 or more
Q8-Acquisition of traffic Information	5	DMS, Radio, 511, Other, None
Q11-Do DMS improve traveling experience on toll roads	4	Strongly Agree , Agree, Disagree, Strongly Disagree
Q12-Are DMS helpful for giving warnings about hazards on toll roads	4	Strongly Agree , Agree, Disagree, Strongly Disagree
Q13-Are DMS helpful for giving special event information	4	Strongly Agree , Agree, Disagree, Strongly Disagree
Q14-Are DMS easy to read while driving?	4	Strongly Agree , Agree, Disagree, Strongly Disagree
Q15 – Are DMS accurate with travel time	4	Strongly Agree , Agree, Disagree, Strongly Disagree
Q25-How did DMS help you reschedule your travel	5	Informing someone you are late, Canceling intended stops, Adding unintended stops, Other, It did not help
Q26-Did DMS save you time	4	Strongly Agree , Agree, Disagree, Strongly Disagree
Q30-Age	5	18-25, 26-35, 36-50, 51-65, 65+
Q31-Education Level	5	High School, Some College, Associate Degree, Bachelors Degree, Post Graduate Degree

5.2.2 A Priori Expectations for the Explanatory Variables for Overall Satisfaction

The following Table 27 summarizes the a priori expectations for the explanatory variables for the overall satisfaction model.

Table 27: A Priori Expectations for the Effect of Explanatory Variables for Satisfaction

Variables	A Priori Expectations for the Explanatory Variables
County	OOCEA toll roads are in Orange County. *Orange County residents might have a different attitude towards DMS than residents of Seminole or Osceola Counties.*
Q2 – Most traveled toll road	SR 408 is the most congested, and had the only DMS located on it in the pre-deployment period. *SR 408 travelers might have different attitude towards DMS than SR 417, SR 429 or SR 528*.
Q3 – Number of trips on the most traveled toll road	*Frequency of travel* might influence travelers' familiarity with the toll road, and therefore, influence them differently towards DMS.
Q4 – Main purpose of the most frequent trips	Work and School trips are bound by tighter time constraints than Shopping and Recreational trips. Travelers with *Work and School purposes might have different attitudes towards DMS.*
Q5 – Number of alternate routes known	As number of alternate routes known increases, familiarity of the traveler with the network increases. *Higher familiarity could be associated with the travelers' expectations for more information*.
Q8 – Acquisition of traffic Information	The source of traveler information could influence the travelers' satisfaction with information. *The OOCEA is optimistic that DMS would be associated with higher traveler satisfaction.*
Q11 – Do DMS improve traveling experience on toll roads?	If travelers are *satisfied with their travel experience with DMS* on toll roads, it is likely that their overall satisfaction improves
Q12 – Are DMS helpful for giving warnings about hazards on toll roads?	If travelers are *satisfied with hazard warning messages on DMS* on toll roads, it is likely that their overall satisfaction improves.
Q13 – Are DMS helpful for giving special event information?	If travelers are *satisfied with special event information on DMS* on toll roads, it is likely that their overall satisfaction improves.
Q14 – Are DMS easy to read while driving?	If travelers are *satisfied with readability of messages on DMS* on toll roads, it is likely that their overall satisfaction improves.
Q15 – Are DMS accurate with travel time?	If travelers are *satisfied with accuracy of information on DMS* on toll roads, it is likely that their overall satisfaction improves.
Q25 – How did DMS help you reschedule your travel?	If travelers feel that *DMS helped them to reschedule their trips* due to DMS on toll roads, it is likely that their overall satisfaction improves.
Q26 – Did DMS save you time?	If travelers feel that *DMS on toll roads helped them save time*, it is likely that their overall satisfaction improves.
Q30 – Age	The *age of the travelers* might influence their attitude towards DMS on toll roads.
Q31 – Education Level	The *education level of the travelers* might influence their attitude towards DMS on toll roads.

5.2.3 Final Satisfaction Model

To create a binary logit model for overall satisfaction, all other theoretically relevant survey question results were modeled as binary variables separated by each different response to the question as shown below for Question 2:

Question 2 – Most traveled toll road

Q2_A: 1 = Success (A), 0 = Failure (B, C, or D)

Q2_B: 1 = Success (B), 0 = Failure (A, C, or D)

Q2_C: 1 = Success (C), 0 = Failure (A, B, or D)

Q2_D: 1 = Success (D), 0 = Failure (A, B, or C)

Upon further analysis of the model, which included the creation of models with all variables from Table 27 and also different combinations of these variables, the following variables listed in Table 28 are found to be the most useful in developing a significant model for the satisfaction of traffic information on the OOCEA toll roads.

Table 28: Variables to be Included in the Final Overall Satisfaction Model

Label	Variable	Description	Mean of X (816)	# of Response
x_1	Seminole	Seminole County	0.316176	258
x_2	Q3_A	Number of Trips - <1 per week	0.355392	290
x_3	Q5_D	# Alternative Routes Known - 3	0.181373	148
x_4	Q5_E	# Alternative Routes Known - 4 or more	0.278186	227
x_5	Q8_B	Traffic Information Source - Radio	0.486520	397
x_6	Q8_C	Traffic Information Source - 511	0.060049	49
x_7	Q8_D	Traffic Information Source - Other	0.143382	117
x_8	Q12_AB	DMS Give Hazard Warning - All Agree	0.904411	738
x_9	Q13_AB	DMS Give Special Event Info - All Agree	0.688725	562
x_{10}	Q15_AB	DMS are Accurate - All Agree	0.839460	685
x_{11}	Q25_B	Rescheduling - Canceling Intended Stops	0.030637	25
x_{12}	Q30_CD	Age Groups - 36 to 50 and 51 to 65	0.667892	546
x_{13}	Q31_A	Education - High School or Less	0.177696	145
x_{14}	Q31_D	Education - Bachelor Degree	0.321078	262

The satisfaction model was then performed with these variables giving the following final overall satisfaction model as listed in Table 29:

- Question 9 Satisfaction with Traveler Information Provided on OOCEA Network
- Modeling the Responses of Q9 “Strongly Agree & Agree”
- Total Responses: 816
- Proportion of “Strongly Agree & Agree”: 84.19%, Number of “Strongly Agree & Agree”: 687
- Proportion of “Disagree & Strongly Disagree”: 15.81% , Number of “Disagree & Strongly Disagree”: 129

Table 29: Coefficients and Probability of Error from Binary Logit Satisfaction Model

Label	Variable	Description	Coefficient	Probability of Error
	Constant		-1.11286635	0.0085*
x_1	Seminole	Seminole County	0.42169438	0.0996**
x_2	Q3_A	Number of Trips - <1 per week	0.53622347	0.0383*
x_3	Q5_D	# Alternative Routes Known - 3	-0.47551534	0.1168
x_4	Q5_E	# Alternative Routes Known - 4 or more	-0.74413446	0.0042*
x_5	Q8_B	Traffic Information Source - Radio	-0.41881847	0.0808**
x_6	Q8_C	Traffic Information Source - 511	0.78240599	0.1910
x_7	Q8_D	Traffic Information Source - Other	-0.51459477	0.1058
x_8	Q12_AB	DMS Give Hazard Warning - All Agree	1.56226562	0.0000*
x_9	Q13_AB	DMS Give Special Event Info - All Agree	0.87274283	0.0004*
x_{10}	Q15_AB	DMS are Accurate - All Agree	1.84036855	0.0000*
x_{11}	Q25_B	Rescheduling - Canceling Intended Stops	-1.46910768	0.0064*
x_{12}	Q30_CD	Age Groups - 36 to 50 and 51 to 65	-0.38839314	0.1366
x_{13}	Q31_A	Education - High School or Less	0.60832315	0.0798**
x_{14}	Q31_D	Education - Bachelor Degree	0.41156404	0.1094

* = Statistically significant at 5% level. **=Statistically significant at 10% level.

Summary Statistics

Log likelihood function	-263.8094	Restricted log likelihood	-356.1727
Chi squared	184.7266	Degrees of freedom	14
Prob[ChiSqd > value] =	0.0000000	Pseudo R-squared	0.25932
Correct prediction	87.500%		

$$Logit(p(y=1)) = \ln\left(\frac{p_{(y=1)}}{1-p_{(y=1)}}\right) = \beta_0 + \beta_1 x_1 + \cdots + \beta_n x_n$$

$$\begin{aligned} Logit(p(y=1)) = &(-1.11286635) + (0.42169438\, x_1) + (0.53622347\, x_2) + (-0.47551534\, x_3) \\ &+ (-0.74413446\, x_4) + (-0.41881847\, x_5) + (0.78240599\, x_6) + (-0.51459477\, x_7) + (1.56226562\, x_8) \\ &+ (0.87274283\, x_9) + (1.84036855\, x_{10}) + (-1.46910768\, x_{11}) + (-0.38839314\, x_{12}) + (0.60832315\, x_{13}) \\ &+ (0.41156404\, x_{14}) \end{aligned}$$

where $y=1$ ("Strongly Agree & Agree")

p_1 = probability of "Strongly Agree & Agree"

$1- p_1$ = probability of "Disagree & Strongly Disagree"

Equation 5: Satisfaction Binary Logit Model

5.2.4 Analysis of Variables in the Final Satisfaction Model

In the model, if the coefficient corresponding to a variable is positive, it implies that this variable increases the likelihood of the commuters to be satisfied with the traffic information provided on the toll road. If the coefficient is negative, it implies that the corresponding variable decreases the likelihood of the commuters to be satisfied with the traffic information on the toll road. The magnitude of the likelihood is derived from the magnitude of the coefficient. The overall fit of the model is reasonable as indicated by the pseudo R-squared. Satisfactory pseudo R-squared values can range from 0.20 to 0.40 (43).

Table 30 summarizes the effect of each of the significant variables in the overall satisfaction model.

Table 30: Summary of the Effects of the Significant Explanatory Variables on Satisfaction

Variable	Coefficient	Explanation	A Priori Expectation
Constant	-1.11*	This implies that with the absence of other variables travelers are likely to not satisfied	
Seminole County	0.42**	Seminole county residents – variable has an increase effect on being satisfied	OOCEA toll roads are in Orange County. Orange County residents might have a different attitude towards DMS than residents of Seminole or Osceola Counties.
Number of Trips-<1 per week	0.54*	Infrequent travelers – variable has an increase effect on outcome of being satisfied	Frequency of travel might influence travelers' familiarity with the toll road, and therefore, influence them differently towards DMS.
# Alternative Routes Known-4 or more	-0.74*	More familiarity – variable has a decrease effect on outcome of being satisfied	Higher familiarity could be associated with the travelers' expectations for more information.
Traffic Information Source - Radio	-0.42**	Radio traffic reports - variable has a decrease effect on being satisfied	The source of traveler information could influence the travelers' satisfaction with information.
DMS Hazard Warning-All Agree	1.56*	Satisfied with hazard warning on DMS - variable has an increase effect on outcome of being satisfied	If travelers are satisfied with hazard warning messages on DMS on OOCEA toll roads, it is likely that their overall satisfaction improves.
DMS Special Event Info-All Agree	0.87*	Satisfied with special event information on DMS - variable has an increase effect on outcome of being satisfied	If travelers are satisfied with special event information on DMS on OOCEA toll roads, it is likely that their overall satisfaction improves.
DMS are Accurate-All Agree	1.84*	Satisfied with accuracy of information on DMS - variable has an increase effect on outcome of being satisfied	If travelers are satisfied with accuracy of information on DMS on OOCEA toll roads, it is likely that their overall satisfaction improves.
Rescheduling-Canceling Intended Stops	-1.47*	Rescheduling by canceling intended stops - variable has a decrease effect on outcome of being satisfied	If travelers feel that DMS helped them to reschedule their trips due to DMS on OOCEA toll roads, it is likely that their overall satisfaction improves.
Education - High School or Less	0.61**	Lower education level- this variable increase effect on outcome of being satisfied	The education level of the travelers might influence their likelihood to be satisfied.

* = Statistically significant at 5% level. **=Statistically significant at 10% level

Looking at the magnitudes of coefficients for DMS satisfaction questions (hazard warning, special event information and accuracy), the accuracy of information has the highest value (coefficient for All Agree = 1.84). This shows that travelers rate accuracy as the most important factor in satisfaction. To improve satisfaction with traveler information, OOCEA must facilitate the dissemination of accurate information.

The following variables were not found to be statistically significant at a 95% confidence interval for the overall satisfaction model, but were deemed theoretically relevant for the satisfaction model, thus were included in the final model. These following variables may surface as statistically significant in the post-deployment survey analysis:

- # of Alternative Routes Known – 3
- Traffic Information Source – 511
- Traffic Information Source – Other
- Age Groups – 36 to 50 and 51 to 65
- Education – Bachelor Degree

5.3 Logit Model Revealed Preference for Diversion

5.3.1 Theoretical Variable Selection

To model response to RP Diversion, Question (Q21) is targeted and modeled with 13 questions thought to be theoretically important. Only the surveys in the 500 sample who were asked Q21 (255 responses) are used in this analysis.

Using the results of the DMS Pre-Deployment Survey Version 14A, (500 sample), the results of Question 21 (What did you do in response to the unexpected congestion?) are modeled as a binary variable as shown below:

1 = Success (b. exited the toll road and got back on toll road, c. exited the toll road and continued all the way, d. abandoned journey and returned to origin),
0 = Failure (a. stayed on the toll road and waited it out).

The important explanatory variables that are theoretically relevant for explaining the propensity of the commuters to divert off toll roads when encountering unexpected delay are listed in Table 31.

Table 31: Important Explanatory Variables for RP Diversion from Q21

Variables	Number of levels	Levels of explanatory Variables
County	3	Orange, Seminole, Osceola
Question 2 – Most traveled toll road	4	SR 408, SR 417, SR 429, SR 528
Question 3 - Number of trips on the most traveled toll road	4	<1, 1-5, 6-10, >10
Question 4 – Main purpose of most frequent trips	5	Work, Shopping, School, Recreational, Other
Question 5 – Number of alternate routes known	5	None, 1, 2, 3, 4 or more
Question 8 - Acquisition of traffic Information	5	DMS, Radio, 511, Other, None
Question 9 – Satisfied with traveler information provided on the toll roads	4	Strongly Agree , Agree, Disagree, Strongly Disagree
Question 10 – Knowledge of DMS on OOCEA Toll Roads	2	Yes, No
Question 19 - The cause of the unexpected congestion	6	Accident, Disabled Vehicle, Construction/road work, Weather Related, Other, Don't Know
Question 20 – How first learned of the unexpected congestion	5	DMS, Radio Traffic Reports, 511 Telephone, Direct observation of congestion, Other Means
Question 22 – Response to 30 minutes of unexpected congestion (SP)	4	Stay on toll road, Exit toll road & get back on at a different location, Exit toll road & continue all the way to destination, Abandon journey
Question 23A – Amount of delay the unexpected caused.	4	Up to 10 minutes, 10-20 minutes, 20-30 minutes, Over 30 minutes
Question 31 – Education Level	5	High School, Some College, Associate Degree, Bachelors Degree, Post Graduate Degree

5.3.2 A Priori Expectations for the Explanatory Variables for Diversion

Table 32 summarizes the a priori expectations for the explanatory variables for the RP diversion.

Table 32: A Priori Expectations for the Effect of Explanatory Variables for RP Diversion

Variables	A Priori Expectations
County	OOCEA toll roads are in Orange County. *Orange county residents might be more familiar with the OOCEA toll roads and would be more likely to divert.*
Q2 – Most traveled toll road	SR 408 is the most congested, and had the only DMS located on it in the pre-deployment period. *SR 408 travelers may see more congestion than travelers on SR 417, SR 429, or SR 528 making them more likely to divert*.
Q3 – Number of trips on the most traveled toll road	*Frequency of travel* might influence travelers' familiarity with the toll road, and therefore, influencing them differently towards diversion.
Q4 – Main purpose of most frequent trips	Work and School trips are bound by tighter time constraints than Shopping and Recreational trips. Travelers with *Work and School purposes might react differently to diversion.*
Q5 – Number of alternate routes known	As number of alternate routes known increases, familiarity of the traveler with the network increases. *Higher familiarity could be associated with the travelers' likelihood to divert*.
Q8 – Acquisition of traffic Information	The source of traveler information could influence the travelers' choice to divert. *The source of traveler information could be associated with the travelers' likelihood to divert.*
Q9 – Satisfied with traveler information provided on the toll roads	The travelers' *overall satisfaction with the travel information provided on the toll roads* could influence the travelers' decision to divert.
Q10 – Knowledge of DMS on OOCEA Toll Roads	The travelers' *knowledge of DMS on the toll roads* could influence their likelihood to divert.
Q19 – The cause of the unexpected congestion	*Different causes of unexpected congestion* could influence the travelers' likelihood to divert differently.
Q20 – How first learned of the unexpected congestion	*The source from which the traveler first heard of the unexpected congestion* could influence the travelers' likelihood to divert.
Q22 – Response to 30 minutes of unexpected congestion (SP)	*How the traveler would respond to a fictitious situation in which there is 30 minutes of unexpected delay* is likely to influence the likelihood to divert.
Q23A – Amount of delay the unexpected congestion caused.	Increasing delay would increase the likelihood to divert.
Q31 – Education Level	The education level of the travelers might influence their likelihood to divert.

5.3.3 Final Diversion Model

To create a binary logit model for the RP diversion question, the theoretically relevant survey question results are modeled as binary variables, or ordinal variables. The binary variables are separated by each different response to the question as shown below for Question 19:

Question 19 – Cause of unexpected congestion

Q19_A: 1 = Success (A), 0 = Failure (B, C, D, E, or F)

Q19_B: 1 = Success (B), 0 = Failure (A, C, D, E, or F)

Q19_C: 1 = Success (C), 0 = Failure (A, B, D, E, or F)

The ordinal variables are coded with numerical values by each different response to the question as shown below for Question 31.

Question 31 – Educational level

1 = High school diploma or less

2 = Some College

3 = Associate Degree

4 = Bachelor Degree

5 = Post Graduate Degree

Question 23A (additional time added due to unexpected congestion) was also used as ordinal variable. Table 33 shows the variables included in the final model.

Table 33: Variables to be Included in the Final RP Diversion Model

Label	Variables	Description	Mean of X (255)	# of Response
x_1	SEMINOL	Seminole County	0.32941176	84
x_2	Q2ASR4	SR 408	0.37254902	95
x_3	Q36GRE	6+ trips/wk	0.30980392	79
x_4	Q4BSHO	Purpose/Shop	0.09411765	24
x_5	Q4CREC	Purpose/Recreation	0.13333333	34
x_6	Q51ORLE	1 or less known alternate routes	0.27843137	71
x_7	Q8C511	Acquire info by 511	0.05882353	15
x_8	Q8ENONE	Acquire No Info	0.1372549	35
x_9	Q9ALLAG	Not Satisfied with given travel info on toll roads	0.20784314	53
x_{10}	Q10BINA	Acknowledged DMS on OOCEA	0.65490196	167
x_{11}	Q19AACC	RP Cause Accident	0.65882353	168
x_{12}	Q19BDIS	RP Cause Disabled Vehicle	0.02745098	7
x_{13}	Q19CCON	RP Cause Construction	0.18431373	47
x_{14}	Q20AMDS	RP Learned of Congestion by - DMS	0.30588235	78
x_{15}	Q20DDIR	RP Learned of Congestion - Direct Observation	0.46666667	119
x_{16}	Q22DIVER	SP Diverted	0.69803922	178
x_{17}	Q23AORD	Ordinal RP Amount of Delay	18.0588235	Ordinal
x_{18}	Q31ORDI	Ordinal values Education	3.26666667	Ordinal

The revealed diversion model was then run with these variables giving the final model in Table 34:

- Question 21 Revealed Diversion
- Modeling the Responses (Q21DIVER "Diverted")
- Total Responses: 255
- Proportion of "Diverted": 37.2549%, Number of "Diverted": 95
- Proportion of "Stayed": 62.7451%, Number of "Stayed": 160

Table 34: Coefficients and Probability of Error from Binary Logit Diversion Model

Label	Variables	Description	Coefficient	Probability of Error
	Constant		-2.40930945	0.0080*
x_1	SEMINOL	Seminole County	-0.79787111	0.0275*
x_2	Q2ASR4	SR 408	0.87252641	0.0104*
x_3	Q36GRE	6+ trips/wk	0.91673761	0.0120*
x_4	Q4BSHO	Purpose/Shop	1.04346013	0.0572**
x_5	Q4CREC	Purpose/Recreation	0.73087742	0.1271
x_6	Q51ORLE	1 or less known alternate routes	-0.54849865	0.1326
x_7	Q8C511	Acquire info by 511	1.38474047	0.0280*
x_8	Q8ENONE	Acquire No Info	-0.88541098	0.0767**
x_9	Q9ALLDI	Not Satisfied with given travel info on toll roads	0.71890612	0.0742**
x_{10}	Q10BINA	Acknowledged DMS on OOCEA	1.21643136	0.0011*
x_{11}	Q19AACC	RP Cause Accident	-1.24577798	0.0072*
x_{12}	Q19BDIS	RP Cause Disabled Vehicle	-2.6099093	0.0376*
x_{13}	Q19CCON	RP Cause Construction	-1.10672696	0.0489*
x_{14}	Q20ADMS	RP Learned of Congestion by DMS	-0.85812051	0.0582**
x_{15}	Q20DDIR	RP Learned of Congestion by Direct Observation	-0.62361735	0.1225
x_{16}	Q22ASTA	SP "Diverted"	1.11700948	0.0057*
x_{17}	Q23AORD	Ordinal RP Amount of Delay	0.02129351	0.1575
x_{18}	Q31ORDI	Ordinal Values Education	0.25458984	0.0393*

* = Statistically significant at 5% level. **=Statistically significant at 10% level.

Summary Statistics

Log likelihood function	-128.5997	Restricted log likelihood	-168.3761
Chi squared	79.55271	Degrees of freedom	18
Prob[ChiSqd > value] =	0.0000000	Pseudo R-squared	0.23624
Correct prediction	74.902%		

$$Logit(p(y=1)) = \ln\left(\frac{p_{(y=1)}}{1-p_{(y=1)}}\right) = \beta_0 + \beta_1 x_1 + \cdots + \beta_n x_n$$

$$Logit(p(y=1)) = (-2.40930945) + (-0.79787111 \cdot x_1) + (0.87252641 \cdot x_2) + (0.91673761 \cdot x_3) +$$
$$(1.04346013 \cdot x_4) + (0.73087742 \cdot x_5) + (-0.54849865 \cdot x_6) + (1.38474047 \cdot x_7) + (-0.88541098 \cdot x_8)$$
$$(0.71890612 \cdot x_9) + (1.21643136 \cdot x_{10}) + (-1.24577798 \cdot x_{11}) + (-2.60990930 \cdot x_{12}) + (-1.10672696 \cdot x_{13})$$
$$(-0.85812054 \cdot x_{14}) + (-0.62361735 \cdot x_{15}) + (1.11700948 \cdot x_{16}) + (0.02129351 \cdot x_{17}) + (0.25458984 \cdot x_{18})$$

where *y=1* (“Divert”)

p(*y*=*1*) = probability of “Divert”

1- p(*y*=*1*) = probability of “Stay”

Equation 6: RP Diversion Binary Logit Model

5.3.4 Analysis of Variables in the Final Diversion Model

In the model, if the coefficient corresponding to a variable is positive, it implies that this variable increases the likelihood of the commuters to “Divert” off the toll road. If the coefficient is negative, it implies that the corresponding variable increases the likelihood of the commuters to “Stay” on the toll road. The magnitude of the likelihood is given by the magnitude of the coefficient. The overall fit of the model is reasonable, as indicated by the pseudo R-squared. Satisfactory pseudo R-squared values can range from 0.20 to 0.40 (43).

Table 35 summarizes the effect of each of the significant variables in the RP diversion model.

Table 35: Summary of the Effects of the Significant Explanatory Variables on Diversion

Variables	Coefficient	Explanation	A Priori Expectations
Constant	-2.41*	All else being equal the travelers are likely not to divert.	
Seminole County	-0.80*	Seminole county residents – variable has a decrease effect on outcome of diversion	OOCEA toll roads are in Orange County. Orange county residents might be more familiar with the OOCEA toll roads and would be more likely to divert.
SR 408	0.87*	SR 408 travelers - variable has an increase effect on outcome of diversion	SR 408 travelers may see more congestion than travelers on SR 417, SR 429, or SR 528 making them more likely to divert
Number of Trips > 6 Trips per Week	0.92*	Frequent travelers - variable has an increase effect on outcome of diversion	Frequency of travel might influence travelers' familiarity with the toll road, and therefore, influencing them differently towards diversion.
Trip Purpose –Shopping	1.043**	Travelers with shopping trip purpose - variable has an increase effect on outcome of diversion	Travelers with Work and School purposes might react differently to diversion.
Acquire Info by 511	1.38*	511 users - variable has an increase effect on outcome of diversion	The source of traveler information could influence the travelers' choice to divert. The source of traveler information could be associated with the travelers' likelihood to divert.
Acquire No Info	-0.89**	Travelers not using any traveler information - variable has a decrease effect on outcome of diversion	
Not Satisfied with Given Travel Info	0.72**	Travelers dissatisfied with traveler information - variable has an increase effect on outcome of diversion	The travelers' overall satisfaction with the travel information provided on the toll roads could influence the travelers' decision to divert.
Acknowledged DMS on OOCEA	1.22*	Travelers who know of DMS on toll roads - variable has an increase effect on outcome of diversion	The travelers' knowledge of DMS on the toll roads could influence their likelihood to divert.
RP Cause Accident	-1.25*	RP Cause of congestion Accident / Disabled vehicle / Construction – variables have a decrease effect on outcome of diversion	Different causes of unexpected congestion could influence the travelers' likelihood to divert differently.
RP Cause Disabled Vehicle	-2.61*		
RP Cause Construction	-1.11*		
RP Learned of Congestion by DMS	-0.86**	Learning of congestion by DMS in Revealed Preference (RP)- variable has a decrease effect on outcome of diversion	The source from which the traveler first heard of the congestion could influence the travelers' likelihood to divert.
SP "Diverted"	1.12*	If travelers stated they would divert when faced with 30 minutes of congestion - variable has an increase effect on outcome of diversion	How the traveler would respond to a fictitious situation in which there is 30 minutes of unexpected delay is likely to influence the likelihood to divert.

Variables	Coefficient	Explanation	A Priori Expectations
Ordinal values Education	0.25*	As education level increases- this variable increase effect on outcome of diversion becomes larger	The education level of the travelers might influence their likelihood to divert.

* = Statistically significant at 5% level. **=Statistically significant at 10% level

The following variables were not found to be statistically significant at a 95% or 90% confidence interval for the diversion model, but were deemed theoretically relevant for the diversion model, thus were included in the final model. These following variables may surface as statistically significant in the post-deployment survey analysis:

- Trip Purpose – Recreation
- # of Alternative Routes Known – 1 or less
- RP Learned of Congestion – Direct Observation
- RP Ordinal Amount of Delay

5.4 Summary of the Satisfaction and Diversion Modeling Results

5.4.1 User's satisfaction with traveler information provided on OOCEA network

From the modeling results, all other things being equal, on average, travelers are more likely to be dissatisfied, since the constant displays a negative coefficient. There is an increase effect in probability of satisfied travelers with the presence of following variables:

- If the respondents is a resident of Seminole County
- If the number of trips per week on the preferred OOCEA toll road is less than one per week

- If the traveler “Strongly Agrees” or “Agrees” that DMS is helpful in showing hazard warnings
- If the traveler “Strongly Agrees” or “Agrees” that DMS is helpful in showing special event information
- If the traveler “Strongly Agrees” or “Agrees” that the information provided on DMS is accurate.
- If the traveler has an education level “High School Diploma or Less”.

5.4.2 Revealed Preference (RP) diversion

From the modeling results, on average, travelers are likely to stay on the toll road in the base case if all else being equal since the constant displays a negative coefficient. There is an increase effect in probability of diversion with the presence of following variables:

- If they traveled most frequently on SR-408 compared to other OOCEA roadways
- If they use the OOCEA toll road-network 6 or more times a week
- If their trip purpose is shopping
- If they acquire traffic information by means of 511 service on the phone while on OOCEA toll road network
- If they are not satisfied with the traveler information given on the OOCEA toll road network
- If they have knowledge of the DMS that are located on the OOCEA toll road network
- If they stated in the SP diversion question that they would divert when facing 30 minutes of unexpected congestion
- If the travelers are of higher educational levels

Also from the model, the variable of travelers who first learned of unexpected congestion by DMS showed a decreasing effect on diversion.

5.4.3 Final Comments on Satisfaction and Diversion Models

Overall, the results of the models are reasonable and show that higher levels of customer satisfaction may be achieved through improved and accurate travel information. It is also clear that route diversion could be affected under the circumstances when travelers acquire traffic information by means of 511 service or if they have knowledge of DMS.

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary of Findings

One of the objectives of this thesis was to measure the proportion of respondents who acknowledged DMS on the OOCEA toll road network. From the results of the pre-deployment analysis, 54.4% of those surveyed recalled seeing DMS on the OOCEA toll roads. From the categorical analysis, the results found that the highest percent knowledge of DMS is for the categories listed below:

- Age group “18-25” (61.3%)
- Education group “Some College” (56.63%)
- Most used OOCEA toll road “SR 408” (57.25%)
- Orange County (58.0%)

The satisfaction with DMS subject questions were measured using the grading system similar to a GPA. The DMS subject questions were only asked to those who recalled seeing DMS. The following question subjects are scored based on the average satisfaction as listed below in descending order:

1. Helpful about hazards
2. Easy to read while driving
3. Improves travel experience
4. Travel time accuracy
5. Helps save time
6. Helpful with special event information

With the subjects "Easy to Read While Driving," and "Travel Time Accuracy," the respondents "Over 65" on average were less satisfied. From the overall categories, the age groups "18-25", "26-35" had the highest satisfaction average and the lowest satisfaction average respectively. The categories "Most used toll road SR-408" and "Orange County" respondents did not rank highest in their categories, however the difference in satisfaction average was marginal.

The following formats were preferred by the majority of DMS respondents for DMS messages:

- Steady message (regular traffic conditions)
- I-Drive (As an acceptable abbreviation for "International Drive")

The message of travel time given on about "Orlando International Airport" was interpreted as travel time to the airport exit by the majority of respondents (54.2%).

The modeling of "satisfaction with traveler information on OOCEA toll roads" was performed to analyze and quantify the effects of various demographic, trip and DMS information related variables. Responses from Question 9 in the survey were used for the dependent variable. However, the sample was limited to the respondents who had recalled seeing DMS on the OOCEA toll roads (answered "yes" to Question 10). This was done to specifically examine the effect of DMS information related responses from the survey.

From the satisfaction modeling, it was inferred that the trip characteristics, familiarity of the traveler with the alternative routes in the network, source of acquisition of traffic information, satisfaction with the different aspects of information presented on DMS were significant in explaining the likelihood of the traveler being satisfied with traveler information on OOCEA toll roads. With different levels of network familiarity (when the number of alternative routes known changes between travelers), the likelihood of being satisfied with traveler information changes. When four or more alternative routes are known, the likelihood of being satisfied with the traveler information decreases. Importantly, satisfaction with some critical aspects of DMS, specifically, the hazard warnings, the special event information, and the accuracy of information on DMS tends to increase the likelihood of satisfaction with traveler information. However, it was found that when respondents used information from DMS to cancel intended stops on their trips the likelihood of satisfaction decreases.

The RP diversion behavior Question 21 showed that 37.25% of the respondents stated that they had diverted off an OOCEA toll road within the last six months because of unexpected congestion. For these respondents who answered RP Question 21 and SP Question 22, 69.80% of these respondents stated they would divert if facing 30 minutes of unexpected delay. In the model, the variable for Question 22 (SP diversion) proved to be significant for travelers' behavior. Seen from the model, the cause of the unexpected congestion, being an accident, disabled vehicle, or roadway construction, influenced the traveler's decision to stay and not divert of the toll road. With the presence of variable of respondents who acknowledged DMS on the OOCEA, this coefficient showed a positive effect on diversion, but the variable of those who learned of the congestion by DMS were showed a negative effect on diversion. The following variables were found to have a positive effect on diversion: those who use 511, travel 6 or more trips a week on the OOCEA toll road network, whose trip purpose is shopping, or who travel mostly on SR 408. The variables of those who are from Seminole County, and acquire no traffic information had decrease effect on diversion behavior. One finding that was not necessarily obvious, before the model results were completed, was that the variable of travelers who were not satisfied with travel information on the toll road network had an increase effect on diversion from the toll roads.

6.2 Implementation Plan

From this thesis, the results show that roughly a little more than half of the respondents acknowledged DMS on the OOCEA network. In the post-deployment analysis starting in 2008, it is expected that more travelers will acknowledge DMS on the OOCEA toll roads. With the addition of DMS on the toll road network, it would be likely that the travelers are more familiar with DMS. In the pre-deployment analysis, it was seen that travelers responded mostly in agreement with the DMS subjects investigated.

One concern that maybe of interest for the post-deployment study, is that with the addition of more respondents acknowledging DMS because of increased exposure, the satisfaction subjects with DMS have a possibility of scoring lower in satisfaction. Also, in consideration, the DMS satisfaction subjects could increase, or randomly increase and decrease across the different subjects. However, for now, it is important to meet the travelers' preferences and concerns for DMS. For example, DMS should be formatted as a steady message for normal traffic conditions, and use commonly recognized abbreviations such as I-Drive for International Drive.

The satisfaction modeling results show that the travelers' (who acknowledge DMS) satisfaction with traffic information provided on the network was influenced by the satisfaction agreement of the following DMS subjects:

- Hazard warnings
- Special event information

- Accuracy of information

To improve satisfaction of traveler information, the above subjects should be addressed. It was found that travelers agreed mostly that DMS was helpful for giving hazard warnings. It is obvious that travelers find it important to be informed on events that are related to personal safety. Special event information was found to be the least in agreement. This result could be because currently these types of messages are not displayed, and/or the fact that drivers might not find this information important enough to focus on while traveling, especially if the event information does not pertain to their destination. Accuracy of the information provided on DMS is also important to emphasize with traveler information satisfaction. If the travelers observe inaccurate travel time displayed on DMS, they may not trust the validity of future messages. It is important to provide the most accurate travel information available and update crucial information such as significant increase in travel times and/or hazard warnings. It was found that DMS messages that led to the travelers canceling their intended stops could decrease the likelihood of satisfaction of the traffic information provided. Therefore, it is important to ensure that the travelers are provided with accurate information, so as to enable them to make the right travel decisions.

The RP traveler diversion behavior modeling results showed that when travelers' educational level is of the higher levels the likelihood of diversion is greater. Most interesting, is that travelers who were not satisfied with travel information provided on the toll road network had an increase in likelihood to divert, and travelers who learned of the revealed delay by means of DMS had a decrease in likelihood to divert.

From these findings, it is important to note that satisfaction of travel information provided on the OOCEA toll road network plays a crucial role in allowing the traveler to experience a journey of high quality.

APPENDIX A: IRB HUMAN SUBJECTS PERMISSION LETTERS

Approval of Survey 14 (Sample Size – 1000)

Revised 09/05

UCF IRB Addendum/Modification Request Form

This addendum form does NOT extend the IRB approval period or replace the Continuing Review form for renewal of the study.

INSTRUCTIONS: Please complete the upper portion of this form and attach all revised/new consent forms, altered data collection instruments, and/or any other documents that have been updated. **The proposed changes on the revised documents must be clearly indicated by using bold print, highlighting, or any other method of visible indication. Attach a highlighted and a clean copy of each revised form.** This Addendum/Modification Request Form may be emailed to IRB@mail.ucf.edu or mailed to the IRB Office: ATTN: IRB Coordinator, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or campus mail 32816-0150. Phone: 407-823-2901 or 407-882-2276, Fax: 407-823-3299.

- **DATE OF ADDENDUM:** **_October 26, 2006_** to IRB# 3745   IRB Addendum # 3953
- **PROJECT TITLE:** EVALUATING THE IMPACT OF OOCEA'S DYNAMIC MESSAGE SIGNS (DMS) ON TRAVELERS' EXPERIENCE
- **PRINCIPAL INVESTIGATOR:**

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http://www.catss.ucf.edu/tsi

- Employee ID: 0114408

- **MAILING ADDRESS: See above**
- **PHONE NUMBER & EMAIL ADDRESS: See above**
- **REASON FOR ADDENDUM/MODIFICATION: To modify pre-deployment survey instrument, minor but important changes are included with some additional questions.**
- **DESCRIPTION OF WHAT YOU WANT TO ADD OR MODIFY: Need approval of the revised survey instrument before the random digit dialing phone interview can be conducted. See revised survey.**

SECTION BELOW - FOR UCF IRB USE ONLY

√ Approved ____ Disapproved   Tracy Dietz (signature)   10/27/06
IRB Chair Signature   Date

____ Full Board X Chair Expedited
____________ IRB Member/Designated Reviewer   ____ Date

1

Approval of Survey 14A (Sample Size – 500)

Revised 09/05

UCF IRB Addendum/Modification Request Form

This addendum form does NOT extend the IRB approval period or replace the Continuing Review form for renewal of the study.

INSTRUCTIONS: Please complete the upper portion of this form and attach all revised/new consent forms, altered data collection instruments, and/or any other documents that have been updated. **The proposed changes on the revised documents must be clearly indicated by using bold print, highlighting, or any other method of visible indication. Attach a highlighted and a clean copy of each revised form.** This Addendum/Modification Request Form may be emailed to IRB@mail.ucf.edu or mailed to the IRB Office: ATTN: IRB Coordinator, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or campus mail 32816-0150. Phone: 407-823-2901 or 407-882-2276, Fax: 407-823-3299.

- **DATE OF ADDENDUM:** _**November 14, 2006**_ to IRB# 3745 IRB Addendum # 3994
- **PROJECT TITLE:** EVALUATING THE IMPACT OF OOCEA'S DYNAMIC MESSAGE SIGNS (DMS) ON TRAVELERS' EXPERIENCE
- **PRINCIPAL INVESTIGATOR:**

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- **MAILING ADDRESS: See above**
- **PHONE NUMBER & EMAIL ADDRESS: See above**
- **REASON FOR ADDENDUM/MODIFICATION: To modify pre-deployment survey instrument, minor but important changes are included with changes and sequence of some existing questions.**
- **DESCRIPTION OF WHAT YOU WANT TO ADD OR MODIFY: Need approval of the revised survey instrument before the random digit dialing phone interview can be conducted for and a new sample of 500 responses. See revised survey version 14.**

SECTION BELOW - FOR UCF IRB USE ONLY

_X_ Approved ____ Disapproved [signature] IRB Chair Signature 11/16/06 Date

____ Full Board _√_ Chair Expedited ____ IRB Member/Designated Reviewer ____ Date

1

APPENDIX B: DMS PRE-DEPLOYMENT SURVEYS

Version 14 (Sample Size – 1000)

Survey (Survey Conductor should make the decision if the participant is Male or Female)

WE ARE CONDUCTING A SURVEY OF PEOPLE WHO USE THE ORLANDO-ORANGE COUNTY EXPRESSWAY AUTHORITY'S TOLL ROADS. WE ARE NOT SELLING YOU ANYTHING. WE ARE SIMPLY TRYING TO GET YOUR IMPRESSIONS ABOUT TRAVEL EXPERIENCES ON TOLL ROADS IN THE CENTRAL FLORIDA AREA AND MORE SPECIFICALLY ABOUT THE DYNAMIC MESSAGE SIGNS ON TOLL ROADS. YOUR RESPONSES ARE VERY IMPORTANT AS THEY WILL HELP US IMPROVE THE QUALITY OF TRAFFIC INFORMATION AND MAY LESSEN TRAFFIC CONGESTION ON THE TOLL ROADS. ALL ANSWERS ARE STRICTLY CONFIDENTIAL AND THE SURVEY WILL ONLY TAKE A FEW MINUTES OF YOUR TIME.

WOULD YOU LIKE TO PARTICIPATE IN THIS SURVEY?

Are you 18 years old or older? (Yes, No) (if "NO" terminate survey)

[Note to Survey Conductor: If asked about Dynamic Message Signs then read the introduction to Question 9 next page]

Survey Questions

1) In the past 6 months, did you travel on any of the following toll roads: State Road 408 (East-West Expressway), State Road 417 (Central Florida GreeneWay), State Road 429 (Western Expressway), or State Road 528 (Beach Line)?
   a) Yes
   b) No **(if "NO" terminate survey)**

2) Which of these toll roads do you travel on the most? (Only one selection)
   a) State Road 408 (East-West Expressway)
   b) State Road 417 (Central Florida GreeneWay)
   c) State Road 429 (Western Expressway)
   d) State Road 528 (Beach Line)

3) How many one-way trips do you make on your most traveled toll road?
   a) Less than one a week
   b) Between 1 to 5 trips a week
   c) Between 6 to 10 trips a week
   d) More than 10 trips a week

4) What is the main purpose of your most frequent trips on this toll road?

a) Work
b) Shopping
c) Recreational
d) School
e) Other

5) How many alternate routes to this toll road do you know?

a) None
b) 1 Route
c) 2 Routes
d) 3 Routes
e) 4 Routes or more

6) How do you pay tolls?

a) Cash
b) E-PASS or SUN-PASS

7) What type of vehicle do you travel in most of the time?

a) Motorcycle
b) Car/Light Truck/SUV
c) Semi-Truck
d) Commercial Truck or 18-wheeler

8) How do you acquire traffic information while traveling on the toll road, select all that apply?

a) Dynamic Message Signs
b) Radio Traffic Reports
c) 511 through Mobile Phone
d) Other
e) None

9) Do you agree or disagree that you are satisfied with traveler information provided on the toll roads?

a) Strongly Agree
b) Agree
c) Disagree
d) Strongly Disagree

10) A Dynamic Message Sign is an electronic traffic sign used on roadways to give travelers information about travel times, traffic congestion, accidents, disabled vehicles, AMBER ALERTS, or special events. The particular dynamic message signs referred to in this survey are large rectangular signs installed over the travel lanes. These are not the orange, portable trailer mounted signs you see on the side of the road during construction. For the purpose of this survey, please limit your comments to dynamic message signs on Central Florida toll roads only, not those found on local roads or interstate highways.

Do you recall seeing a Dynamic Message Sign during your travel on State Road 408 (East-West Expressway), State Road 417 (GreeneWay), State Road 429 (Western Expressway), State Road 528 (Beach Line)?

a) Yes
b) No **(if "NO" skip the yellow highlighted questions)**

11) Do you agree or disagree that Dynamic Message Signs improve your traveling experience on the toll roads?

a) Strongly Agree
b) Agree
c) Disagree
d) Strongly Disagree

12) Do you agree or disagree that Dynamic Message Signs have been helpful for giving you warnings on hazards on toll roads?

a) Strongly Agree
b) Agree
c) Disagree
d) Strongly Disagree

13) Do you agree or disagree that Dynamic Message Signs have been helpful for giving you special event information?

a) Strongly Agree
b) Agree
c) Disagree
d) Strongly Disagree

14) Do you agree or disagree that it is easy to read a Dynamic Message Sign while driving?

a) Strongly Agree
b) Agree
c) Disagree
d) Strongly Disagree

15) Do you agree or disagree that travel time information displayed on Dynamic Message Signs are accurate?

a) Strongly Agree
b) Agree
c) Disagree
d) Strongly Disagree

16) On Dynamic Message Signs what do you prefer?

a) Steady Message
b) Alternating Messages

17) On Dynamic Message Signs what style of message do you prefer to see in case of abnormal traffic conditions?

a) All Flashing Message
b) One Line Flashing Message
c) Non-Flashing Message

18) Within the past 6 months, did you ever become aware of unexpected congestion, due to an accident or a disabled vehicle, while traveling on any of the toll roads?

a) Yes **(if "YES" ask the green highlighted questions)**
b) No **(if "NO" ask the pink highlighted question)**

19) What was the cause of this unexpected congestion?

a) Accident
b) Disabled vehicle
c) Construction/road work
d) Weather Related
e) Other
f) Don't know

20) How did you first learn about the unexpected congestion? (Only Select One)

a) Dynamic Message Signs
b) Radio traffic reports
c) 511 Telephone
d) Direct observation of congestion
e) Other means

21) What did you do in response to the unexpected congestion? (Only Select One)

a) Stayed on the toll road and waited it out **(if the answer is "a" ask the blue highlighted question)**

b) Exited the toll road and got back on toll road at a different location

c) Exited the toll road and continued all the way to destination on an alternate route

d) Abandoned journey and returned to origin/home **(if the answer is "b, c, or d" ask the gray highlighted question next page)**

22) Suppose that you encounter a 30-minutes of unexpected congestion due to an accident or disabled vehicle on a toll road, what would you do? (Only Select One)

a) Stay on the toll road and wait it out **(if the answer is "a" ask the blue highlighted question)**

b) Exit the toll road and get back on toll road at a different location

c) Exit the toll road and continue all the way to destination on an alternate route

d) Abandon journey and return to origin/home **(if the answer is "b, c, or d" ask the gray highlighted question next page)**

23) What amount of unexpected delay would cause you to divert your route off the toll road?

a) up to 10 minutes
b) 10 to 20 minutes
c) 20 to 30 minutes
d) Over 30

24) What would be the main reason that you would stay on the toll road and wait it out? (Choose One Answer)

a) Unfamiliar with alternate routes
b) Do not trust accuracy of travel time information
c) It would still be faster to stay on toll road
d) Combination of any of the above
e) None of the above

25) If you received information from Dynamic Message Signs, would you say it helped you reschedule your travel by:

a) Adding unintended intermediate stops, e.g., to run errands
b) Canceling intended intermediate stop(s)
c) Informing someone that you are running late
d) Other
e) It did not help with rescheduling

26) By helping you select the most appropriate routes, Dynamic Message Signs have saved you time, do you:

a) Strongly Agree
b) Agree
c) Disagree
d) Strongly Disagree

27) Do you agree or disagree that I-Drive is a good abbreviation for International Drive?

a) Strongly Agree
b) Agree
c) Disagree
d) Strongly Disagree

28) Which do you prefer for identifying a roadway?

a) State Road Number (for example State Road 50)
b) Street Name (for example Colonial Drive)

29) Assume you are traveling on the toll roads and you see a Dynamic Message Sign displaying a travel time to a destination named "International Airport". How would you interpret the travel time given?

a) The travel time is the amount of time it takes to get to the airport exit
b) The travel time is the amount of time it takes to get to the airport terminal

30) Which of the following best describes your age?

a) 18-25
b) 26-35
c) 36-50
d) 51-65
e) Over 65

31) What is your education level?

a) High School Diploma or Less
b) Some College
c) Associate Degree
d) Bachelor Degree
e) Post Graduate Degree

32) What is your current zip code?

THANK YOU FOR PARTICIPATING IN THIS SURVEY!

END OF SURVEY

Version 14A (Sample Size – 500)

Survey (Survey Conductor should make the decision if the participant is Male or Female)

WE ARE CONDUCTING A SURVEY OF PEOPLE WHO USE THE ORLANDO-ORANGE COUNTY EXPRESSWAY AUTHORITY'S TOLL ROADS. WE ARE NOT SELLING YOU ANYTHING. WE ARE SIMPLY TRYING TO GET YOUR IMPRESSIONS ABOUT TRAVEL EXPERIENCES ON TOLL ROADS IN THE CENTRAL FLORIDA AREA AND MORE SPECIFICALLY ABOUT THE DYNAMIC MESSAGE SIGNS ON TOLL ROADS. YOUR RESPONSES ARE VERY IMPORTANT AS THEY WILL HELP US IMPROVE THE QUALITY OF TRAFFIC INFORMATION AND MAY LESSEN TRAFFIC CONGESTION ON THE TOLL ROADS. ALL ANSWERS ARE STRICTLY CONFIDENTIAL AND THE SURVEY WILL ONLY TAKE A FEW MINUTES OF YOUR TIME.

WOULD YOU LIKE TO PARTICIPATE IN THIS SURVEY?

Are you 18 years old or older? (Yes, No) (if "NO" terminate survey)

[Note to Survey Conductor: If asked about Dynamic Message Signs then read the introduction to Question 9 next page]

Survey Questions

1) In the past 6 months, did you travel on any of the following toll roads: State Road 408 (East-West Expressway), State Road 417 (Central Florida GreeneWay), State Road 429 (Western Expressway), or State Road 528 (Beach Line)?

a) Yes
b) No **(if "NO" terminate survey)**

2) Which of these toll roads do you travel on the most? (Only one selection)

a) State Road 408 (East-West Expressway)
b) State Road 417 (Central Florida GreeneWay)
c) State Road 429 (Western Expressway)
d) State Road 528 (Beach Line)

3) How many one-way trips do you make on your most traveled toll road?

a) Less than one a week
b) Between 1 to 5 trips a week
c) Between 6 to 10 trips a week
d) More than 10 trips a week

4) What is the main purpose of your most frequent trips on this toll road?
  a) Work
  b) Shopping
  c) Recreational
  d) School
  e) Other

5) How many alternate routes to this toll road do you know?
  a) None
  b) 1 Route
  c) 2 Routes
  d) 3 Routes
  e) 4 Routes or more

6) How do you pay tolls?
  a) Cash
  b) E-PASS or SUN-PASS

7) What type of vehicle do you travel in most of the time?
  a) Motorcycle
  b) Car/Light Truck/SUV
  c) Semi-Truck
  d) Commercial Truck or 18-wheeler

8) How do you acquire traffic information <u>while traveling</u> on the toll road, select all that apply?
  a) Dynamic Message Signs
  b) Radio Traffic Reports
  c) 511 through Mobile Phone
  d) Other
  e) None

9) Do you agree or disagree that you are satisfied with traveler information provided on the toll roads?
  a) Strongly Agree
  b) Agree
  c) Disagree
  d) Strongly Disagree

10) A Dynamic Message Sign is an electronic traffic sign used on roadways to give travelers information about travel times, traffic congestion, accidents, disabled vehicles, AMBER ALERTS, or special events. The particular dynamic message signs referred to in this survey are large rectangular signs installed over the travel lanes. These are not the orange, portable trailer mounted signs you see on the side of the road during construction. For the purpose of this survey, please limit your comments to dynamic message signs on Central Florida toll roads only, not those found on local roads or interstate highways.

Do you recall seeing a Dynamic Message Sign during your travel on State Road 408 (East-West Expressway), State Road 417 (GreeneWay), State Road 429 (Western Expressway), State Road 528 (Beach Line)?

a) Yes
b) No **(if "NO" skip the yellow highlighted questions)**

11) Do you agree or disagree that Dynamic Message Signs improve your traveling experience on the toll roads?

a) Strongly Agree
b) Agree
c) Disagree
d) Strongly Disagree

12) Do you agree or disagree that Dynamic Message Signs have been helpful for giving you warnings on hazards on toll roads?

a) Strongly Agree
b) Agree
c) Disagree
d) Strongly Disagree

13) Do you agree or disagree that Dynamic Message Signs have been helpful for giving you special event information?

a) Strongly Agree
b) Agree
c) Disagree
d) Strongly Disagree

14) Do you agree or disagree that it is easy to read a Dynamic Message Sign while driving?

a) Strongly Agree
b) Agree
c) Disagree
d) Strongly Disagree

15) Do you agree or disagree that travel time information displayed on Dynamic Message Signs are accurate?

a) Strongly Agree
b) Agree
c) Disagree
d) Strongly Disagree

16) On Dynamic Message Signs what do you prefer?

a) Steady Message
b) Alternating Messages

17) On Dynamic Message Signs what style of message do you prefer to see in case of abnormal traffic conditions?

a) All Flashing Message
b) One Line Flashing Message
c) Non-Flashing Message

18) Within the past 6 months, did you ever become aware of unexpected congestion, due to an accident or a disabled vehicle, while traveling on any of the toll roads?

a) Yes **(if "YES" ask the green highlighted questions)**
b) No **(if "NO" ask the pink highlighted question 22, note that if the answer to question 22 is b, c, or d then question 24 should be skipped and NOT asked. Also, anytime the answer to questions 21 or 22 is b, c, or d then question 24 should not be skipped and NOT asked. Question 24 is intended only for those who answer "a" to questions 21 and/or 22 since it is meant to find out why travelers did not divert off (and stayed on) the toll road and wait it out?)**

19) What was the cause of this unexpected congestion?

a) Accident
b) Disabled vehicle
c) Construction/road work
d) Weather Related
e) Other
f) Don't know

20) How did you first learn about the unexpected congestion? (Only Select One)

a) Dynamic Message Signs
b) Radio traffic reports
c) 511 Telephone
d) Direct observation of congestion

e) Other means

23) How much time did you expect it to add to your trip?

a) up to 10 minutes
b) 10 to 20 minutes
c) 20 to 30 minutes
d) Over 30 minutes

21) What did you do in response to the unexpected congestion? (Only Select One)

a) Stayed on the toll road and waited it out **(if the answer is “a” ask the blue highlighted question, then after asking the blue highlighted question you need to go back and ask Question22 before you continue)**

b) Exited the toll road and got back on toll road at a different location

c) Exited the toll road and continued all the way to destination on an alternate route

d) Abandoned journey and returned to origin/home

22) Suppose that you encounter a 30-minutes of unexpected congestion due to an accident or disabled vehicle on a toll road, what would you do? (Only Select One)

a) Stay on the toll road and wait it out **(if the answer is “a” ask the blue highlighted question)**

b) Exit the toll road and get back on toll road at a different location

c) Exit the toll road and continue all the way to destination on an alternate route

d) Abandon journey and return to origin/home

24) What would be the main reason that you would stay on the toll road and wait it out? (Choose One Answer)

a) Unfamiliar with alternate routes

b) Do not trust accuracy of travel time information

c) It would still be faster to stay on toll road

d) Combination of any of the above

e) None of the above

(If the answer to Question 21 was (a), then you need to ask Question 24 and after you ask Question 24 you need to go back and ask Question 22 before you proceed to the next Question 25.

If the answer to Q 21 was (b) (c) or (d), ask Q 22. If Question 22 answer was (a) then you need to ask Question 24 and continue afterwards to the next Question 25). Note that Question 23 has been re-worded and moved to be before Question 21.

25) If you received information from Dynamic Message Signs, would you say it helped you reschedule your travel by:

a) Adding unintended intermediate stops, e.g., to run errands

b) Canceling intended intermediate stop(s)

c) Informing someone that you are running late

d) Other

e) It did not help with rescheduling

26) By helping you select the most appropriate routes, Dynamic Message Signs have saved you time, do you:
   a) Strongly Agree
   b) Agree
   c) Disagree
   d) Strongly Disagree

27) Do you agree or disagree that I-Drive is a good abbreviation for International Drive?
   a) Strongly Agree
   b) Agree
   c) Disagree
   d) Strongly Disagree

28) Which do you prefer for identifying a roadway?
   a) State Road Number (for example State Road 50)
   b) Street Name (for example Colonial Drive)

29) Assume you are traveling on the toll roads and you see a Dynamic Message Sign displaying a travel time to a destination named "International Airport". How would you interpret the travel time given?
   a) The travel time is the amount of time it takes to get to the airport exit
   b) The travel time is the amount of time it takes to get to the airport terminal

30) Which of the following best describes your age?
   a) 18-25
   b) 26-35
   c) 36-50
   d) 51-65
   e) Over 65

31) What is your education level?
   a) High School Diploma or Less
   b) Some College
   c) Associate Degree
   d) Bachelor Degree
   e) Post Graduate Degree

32) What is your current zip code?

THANK YOU FOR PARTICIPATING IN THIS SURVEY!

END OF SURVEY

APPENDIX C: SUMMARY DISTRIBUTION-RESPONSES TO QUESTIONS

#	**Question Summary**	*variable*	Frequency	Percent (%)	Mode 1	Mode 2
q2	most used toll road	A) SR 408	524	34.9%		A) SR 408
		B) SR 417	723	48.2%	B) SR 417	
		C) SR 429	91	6.1%		
		D) SR 528	162	10.8%		
		ALL q2	1500	100.0%		

#	**Question Summary**	*variable*	Frequency	Percent (%)	Mode 1	Mode 2	cumulative %
q3	number trip a week	A) <1 trip a week	558	37.2%		A) <1 trip a week	37.2%
		B) 1-5 trips a week	597	39.8%	B) 1-5 trips a week		77.0%
		C) 6-10 trips a week	192	12.8%			89.8%
		D) >10 trips a week	153	10.2%			100.0%
		ALL q3	1500	100.0%			

#	**Question Summary**	*variable*	Frequency	Percent (%)	Mode 1	Mode 2
q4	trip purpose	A) Work	607	40.5%	A) Work	
		B) Shopping	196	13.1%		
		C) Recreational	260	17.3%		
		D) School	40	2.7%		
		E) Other	397	26.5%		E) Other
		ALL q4	1500	100.0%		

#	**Question Summary**	*variable*	Frequency	Percent (%)	Mode 1	Mode 2	cumulative %
q5	number of known alternate routes	A) None	160	10.7%			10.7%
		B) 1 Route	271	18.1%			28.7%
		C) 2 Routes	423	28.2%	C) 2 Routes		56.9%
		D) 3 Routes	244	16.3%			73.2%
		E) 4 Routes or more	402	26.8%		E) 4 Routes or more	100.0%
		ALL q5	1500	100.0%			

#	**Question Summary**	*variable*	Frequency	Percent (%)	Mode 1
q6	payment method	A) Cash	537	35.8%	
		B) E-PASS or SUN-PASS	963	64.2%	B) E-PASS or SUN-PASS
		ALL q6	1500	100.0%	

#	**Question Summary**	*variable*	Frequency	Percent (%)	Mode 1	Mode 2
q7	vehicle type	A) Motorcycle	6	0.4%		
		B) Car/Light Truck/SUV	1451	96.7%	B) Car/Light Truck/SUV	
		C) Semi-Truck	12	0.8%		
		D) Commercial Truck or 18-wheeler	31	2.1%		D) Commercial Truck or 18-wheeler
		All q7	1500	100.0%		

#	Question Summary	*variable*	Frequency	Percent (%)	Mode 1	Mode 2
q8(Totaled)	traffic info used	A) Dynamic Message Signs	408	23.9%		A) Dynamic Message Signs
		B) Radio Traffic Reports	697	40.8%	B) Radio Traffic Reports	
		C) 511 through Mobile Phone	96	5.6%		
		D) Other	224	13.1%		
		E) None	283	16.6%		
		ALL q8R(TotaledDMS)	1708	100.0%		

#	Question Summary	*variable*	Frequency	Percent (%)	Mode 1	Mode 2
q9	satisfaction traveler information	A) Strongly Agree	324	21.6%		A) Strongly Agree
		B) Agree	873	58.2%	B) Agree	
		C) Disagree	204	13.6%		
		D) Strongly Disagree	99	6.6%		
		ALL q9	1500	100.0%		

#	Question Summary	*variable*	Frequency	Percent (%)	Mode 1
q10	recall seeing DMS on toll road	A) Yes	816	54.4%	A) Yes
		B) No	684	45.6%	
		ALL q10	1500	100.0%	

#	**Question Summary**	*variable*	Frequency	Percent (%) (not including unanswered)	Percent (%) (including unanswered)	Mode 1	Mode 2
q11	DMS improve travel experience	A) Strongly Agree	341	41.8%	22.7%		A) Strongly Agree
		B) Agree	353	43.3%	23.5%	B) Agree	
		C) Disagree	90	11.0%	6.0%		
		D) Strongly Disagree	32	3.9%	2.1%		
		ALL Answered q11	816	100.0%	54.4%		
		ALL Unanswered q11	684		45.6%		
		ALL q11	1500		100.0%		

#	**Question Summary**	*variable*	Frequency	Percent (%) (not including unanswered)	Percent (%) (including unanswered)	Mode 1	Mode 2
q12	DMS helpful informing about hazards	A) Strongly Agree	374	45.8%	24.9%	A) Strongly Agree	
		B) Agree	364	44.6%	24.3%		B) Agree
		C) Disagree	57	7.0%	3.8%		
		D) Strongly Disagree	21	2.6%	1.4%		
		ALL Answered q12	816	100.0%	54.4%		
		ALL Unanswered q12	684		45.6%		
		ALL q12	1500		100.0%		

#	**Question Summary**	*variable*	Frequency	Percent (%) (not including unanswered)	Percent (%) (including unanswered)	Mode 1	Mode 2
q13	DMS helpful giving special event information	A) Strongly Agree	229	28.1%	15.3%		A) Strongly Agree
		B) Agree	333	40.8%	22.2%	B) Agree	
		C) Disagree	200	24.5%	13.3%		
		D) Strongly Disagree	54	6.6%	3.6%		
		ALL Answered q13	816	100.0%	54.4%		
		ALL Unanswered q13	684		45.6%		
		ALL q13	1500		100.0%		

#	**Question Summary**	*variable*	Frequency	Percent (%) (not including unanswered)	Percent (%) (including unanswered)	Mode 1	Mode 2
q14	easy to read DMS while driving	A) Strongly Agree	352	43.1%	23.5%		A) Strongly Agree
		B) Agree	391	47.9%	26.1%	B) Agree	
		C) Disagree	50	6.1%	3.3%		
		D) Strongly Disagree	23	2.8%	1.5%		
		ALL Answered q14	816	100.0%	54.4%		
		ALL Unanswered q14	684		45.6%		
		ALL q14	1500		100.0%		

#	**Question Summary**	*variable*	Frequency	Percent (%) (not including unanswered)	Percent (%) (including unanswered)	Mode 1	Mode 2
q15	travel time on DMS accurate	A) Strongly Agree	226	27.7%	15.1%		A) Strongly Agree
		B) Agree	459	56.3%	30.6%	B) Agree	
		C) Disagree	103	12.6%	6.9%		
		D) Strongly Disagree	28	3.4%	1.9%		
		ALL Answered q15	816	100.0%	54.4%		
		ALL Unanswered q15	684		45.6%		
		ALL q15	1500		100.0%		

#	**Question Summary**	*variable*	Frequency	Percent (%) (not including unanswered)	Percent (%) (including unanswered)	Mode 1	Mode 2
q16	on DMS what is preferred	A) Steady Message	518	63.5%	34.5%	A) Steady Message	
		B) Alternating Message	298	36.5%	19.9%		B) Alternating Message
		ALL Answered q16	816	100.0%	54.4%		
		ALL Unanswered q16	684		45.6%		
		ALL q16	1500		100.0%		

#	Question Summary	*variable*	Frequency	Percent (%) (not including unanswered)	Percent (%) (including unanswered)	Mode 1	Mode 2
q17	style message on DMS preferred abnormal conditions	A) All Flashing Message	256	31.4%	17.1%		A) All Flashing Message
		B) One Line Flashing Message	212	26.0%	14.1%		
		C) Non-Flashing Message	348	42.6%	23.2%	C) Non-Flashing Message	
		ALL Answered q17	816	100.0%	54.4%		
		ALL Unanswered q17	684		45.6%		
		ALL q17	1500		100.0%		

#	Question Summary	*variable*	Frequency	Percent (%)	Mode 1	Mode 2
q18	last 6 months ever aware on unexpected congestion on toll road	A) Yes	736	49.1%		A) Yes
		B) No	764	50.9%	B) No	
		ALL q18	1500	100.0%		

#	**Question Summary**	*variable*	Frequency	Percent (%) (not including unanswered)	Percent (%) (including unanswered)	Mode 1	Mode 2
q19	the cause of unexpected congestion	A) Accident	476	64.7%	31.7%	A) Accident	
		B) Disabled vehicle	22	3.0%	1.5%		
		C) Construction/road work	142	19.3%	9.5%		C) Construction/road work
		D) Weather Related	11	1.5%	0.7%		
		E) Other	51	6.9%	3.4%		
		F) Don't know	34	4.6%	2.3%		
		All Answered q19	736	100.0%	49.1%		
		All Unanswered q19	764		50.9%		
		All q19	1500		100.0%		

#	**Question Summary**	*variable*	Frequency	Percent (%) (not including unanswered)	Percent (%) (including unanswered)	Mode 1	Mode 2
q20	how first learned of unexpected congestion	A) Dynamic Message Signs	205	27.9%	13.7%		A) Dynamic Message Signs
		B) Radio Traffic Reports	104	14.1%	6.9%		
		C) 511 Telephone	8	1.1%	0.5%		
		D) Direct observation of congestion	385	52.3%	25.7%	D) Direct observation of congestion	
		E) Other means	34	4.6%	2.3%		
		ALL Answered q20	736	100.0%	49.1%		
		ALL Unanswered q20	764		50.9%		
		ALL q20	1500		100.0%		

#	**Question Summary**	*variable*	Frequency	Percent (%) (not including unanswered)	Percent (%) (including unanswered)	Mode 1	Mode 2
q21	response to unexpected congestion	A) Stayed on toll road	445	60.5%	29.7%	A) Stayed on toll road	
		B) Exited toll road and got back on	54	7.3%	3.6%		
		C) Exited toll road and continued on alternate route	222	30.2%	14.8%		C) Exited toll road and continued on alternate route
		D) Abandoned journey	15	2.0%	1.0%		
		ALL Answered q21	736	100.0%	49.1%		
		ALL Unanswered q21	764		50.9%		
		ALL q21	1500		100.0%		

#	**Question Summary**	*variable*	Frequency	Percent (%) (not including unanswered)	Percent (%) (including unanswered)	Mode 1	Mode 2
q21	response to unexpected congestion	A) Stayed on toll road	160	62.7%	32.0%	A) Stayed on toll road	
		B) Exited toll road and got back on	17	6.7%	3.4%		
		C) Exited toll road and continued on alternate route	72	28.2%	14.4%		C) Exited toll road and continued on alternate route
		D) Abandoned journey	6	2.4%	1.2%		
		ALL Answered q21	255	100.0%	51.0%		
		ALL Unanswered q21	245		49.0%		
		ALL q21	500		100.0%		

**The above table is from the question in the 500-sample survey, and are values that were used for modeling revealed preference diversion.*

#	**Question Summary**	*variable*	Frequency	Percent (%) (not including unanswered)	Percent (%) (including unanswered)	Mode 1	Mode 2
q22	suppose 30 minutes of unexpected congestion	A) Stayed on toll road	268	26.3%	17.9%		A) Stayed on toll road
		B) Exited toll road and got back on	236	23.2%	15.7%		
		C) Exited toll road and continued on alternate route	486	47.7%	32.4%	C) Exited toll road and continued on alternate route	
		D) Abandoned journey	29	2.8%	1.9%		
		ALL Answered q22	1019	100.0%	67.9%		
		ALL Unanswered q22	481		32.1%		
		ALL q22	1500		100.0%		

#	**Question Summary**	*variable*	Frequency	Percent (%) (not including unanswered)	Percent (%) (including unanswered)	Mode 1	Mode 2	cumulative %
q23	amount of unexpected delay that would cause you to divert	A) up to 10 minutes	194	22.9%	12.9%		A) up to 10 minutes	22.9%
		B) 10 to 20 minutes	314	37.0%	20.9%	B) 10 to 20 minutes		59.8%
		C) 20 to 30 minutes	193	22.7%	12.9%			82.6%
		D) Over 30 minutes	148	17.4%	9.9%			100.0%
		ALL Answered q23	849	100.0%	56.6%			
		ALL Unanswered q23	651		43.4%			
		ALL q23	1500		100.0%			

#	**Question Summary**	*variable*	Frequency	Percent (%) (not including unanswered)	Percent (%) (including unanswered)	Mode 1	Mode 2	cumulative %
q23A	how much time did you expect it to add to your trip?	A) up to 10 minutes	66	25.9%	13.2%		A) up to 10 minutes	25.9%
		B) 10 to 20 minutes	94	36.9%	18.8%	B) 10 to 20 minutes		62.7%
		C) 20 to 30 minutes	46	18.0%	9.2%			80.8%
		D) Over 30 minutes	49	19.2%	9.8%			100.0%
		ALL Answered q23	255	100.0%	51.0%			
		ALL Unanswered q23	245		49.0%			
		ALL q23	500		100.0%			

**The above table 23A was asked in the 500 survey only to those who were asked question 21.*

#	**Question Summary**	*variable*	Frequency	Percent (%) (not including unanswered)	Percent (%) (including unanswered)	Mode 1	Mode 2
q24	main reason to stay on the toll road and wait it out	A) Unfamiliar with alternate routes	139	21.4%	9.3%		
		B) Do not trust travel time information	8	1.2%	0.5%		
		C) It would be faster to stay on the toll road	230	35.4%	15.3%	C) It would be faster to stay on the toll road	
		D) Combination of any of the above	162	24.9%	10.8%		D) Combination of any of the above
		E) None of the above	111	17.1%	7.4%		
		ALL Answered q24	650	100.0%	43.3%		
		ALL Unanswered q24	850		56.7%		
		ALL q24	1500		100.0%		

#	**Question Summary**	*variable*	Frequency	Percent (%) (not including unanswered)	Percent (%) (including unanswered)	Mode 1	Mode 2
q25	DMS helped reschedule travel by:	A) Adding unintended intermediate stops	57	7.0%	3.8%		
		B) Canceling intended intermediate stops	25	3.1%	1.7%		
		C) Informing someone that you are running late	469	57.5%	31.3%	C) Informing someone that you are running late	
		D) Other	80	9.8%	5.3%		
		E) It did not help with rescheduling	185	22.7%	12.3%		E) It did not help with rescheduling
		ALL Answered q25	816	100.0%	54.4%		
		ALL Unanswered q25	684		45.6%		
		ALL q25	1500		100.0%		

#	**Question Summary**	*variable*	Frequency	Percent (%) (not including unanswered)	Percent (%) (including unanswered)	Mode 1	Mode 2
q26	DMS have helped you save time	A) Strongly Agree	224	27.5%	14.9%		A) Strongly Agree
		B) Agree	415	50.9%	27.7%	B) Agree	
		C) Disagree	128	15.7%	8.5%		
		D) Strongly Disagree	49	6.0%	3.3%		
		ALL Answered q26	816	100.0%	54.4%		
		ALL Unanswered q26	684		45.6%		
		ALL q26	1500		100.0%		

#	Question Summary	variable	Frequency	Percent (%)	Mode 1	Mode 2
q27	I-Drive good abbreviation for International Drive	A) Strongly Agree	586	39.1%		A) Strongly Agree
		B) Agree	673	44.9%	B) Agree	
		C) Disagree	153	10.2%		
		D) Strongly Disagree	88	5.9%		
		ALL q27	1500	100.0%		

#	Question Summary	variable	Frequency	Percent (%)	Mode 1	Mode 2
q28	prefer for identifying a roadway	A) State Road Number	821	54.7%	A) State Road Number	
		B) Street Name	679	45.3%		B) Street Name
		ALL q28	1500	100.0%		

#	Question Summary	variable	Frequency	Percent (%)	Mode 1	Mode 2
q29	interpretation of travel time to International Airport	A) airport exit	813	54.2%	A) airport exit	
		B) airport terminal	687	45.8%		B) airport terminal
		ALL q29	1500	100.0%		

#	Question Summary	variable	Frequency	Percent (%)	Mode 1	Mode 2	cumulative %
q30	age range	A) 18-25	75	5.0%			5.0%
		B) 26-35	214	14.3%			19.3%
		C) 36-50	595	39.7%	C) 36-50		58.9%
		D) 51-65	421	28.1%		D) 51-65	87.0%
		E) Over 65	195	13.0%			100.0%
		ALL q30	1500	100.0%			

#	**Question Summary**	*variable*	Frequency	Percent (%)	Mode 1	Mode 2	cumulative %
q31	educational level	A) High School Diploma or Less	267	17.8%			17.8%
		B) Some College	362	24.1%		B) Some College	41.9%
		C) Associate Degree	148	9.9%			51.8%
		D) Bachelor Degree	471	31.4%	D) Bachelor Degree		83.2%
		E) Post Graduate Degree	252	16.8%			100.0%
		ALL q31	1500	100.0%			

#	**Question Summary**	*variable*	Frequency	Percent (%)	Mode 1	Mode 2
county	county	ORANGE	519	34.6%	ORANGE	
		OSCEOLA	480	32.0%		
		SEMINOLE	501	33.4%		SEMINOLE
		ALL county	1500	100.0%		

APPENDIX D: DATA SET-UP LOGIT MODELING SAMPLE

Respondent #	county (Orange)	county (Osceola)	county (Seminole)	q21 (Divert)	q23a (Ordinal expected delay)
1007	0	0	1	0	35
1008	1	0	0	0	15
1010	1	0	0	1	35
1014	1	0	0	1	15
1015	0	0	1	0	5
1017	1	0	0	1	15
1021	0	0	1	0	5
1022	0	1	0	1	25
1023	0	1	0	0	5
1024	0	1	0	0	35
1026	0	0	1	1	25
1027	1	0	0	0	15
1030	0	1	0	0	15
1034	0	1	0	0	25
1036	0	1	0	0	35
1037	1	0	0	0	5
1038	1	0	0	1	35
1039	0	1	0	0	35
1041	0	1	0	0	25
1042	1	0	0	1	25
1044	0	1	0	0	5
1045	0	0	1	0	35
1048	0	1	0	0	5
1049	0	1	0	0	25
1053	0	1	0	0	15
1054	0	1	0	0	15
1055	1	0	0	1	5
1057	0	0	1	1	35
1059	0	0	1	0	15
1061	0	0	1	0	15
1066	0	1	0	1	15

APPENDIX E: LIMDEP/NLOGIT FINAL MODELING OUTPUTS

Model Output for Satisfaction

```
+--------------------------------------------+
| Multinomial Logit Model                    |
| Maximum Likelihood Estimates               |
| Model estimated: Oct 30, 2007 at 03:49:20PM.|
| Dependent variable                  Q9     |
| Weighting variable                None     |
| Number of observations             816     |
| Iterations completed                 6     |
| Log likelihood function      -263.8094     |
| Restricted log likelihood    -356.1727     |
| Chi squared                   184.7266     |
| Degrees of freedom                  14     |
| Prob[ChiSqd > value] =        .0000000     |
| Hosmer-Lemeshow chi-squared =   7.64018    |
| P-value=  .46938 with deg.fr. =       8    |
+--------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
	Characteristics in numerator of Prob[Y = 1]				
Constant	-1.11286635	.42308751	-2.630	.0085	
COUNTY_S	.42169438	.25610202	1.647	.0996	.31617647
Q3_A	.53622347	.25882046	2.072	.0383	.35539216
Q5_D	-.47551534	.30317615	-1.568	.1168	.18137255
Q5_E	-.74413446	.26001958	-2.862	.0042	.27818627
Q8_B	-.41881847	.23984920	-1.746	.0808	.48651961
Q8_C	.78240599	.59831768	1.308	.1910	.06004902
Q8_D	-.51459477	.31814377	-1.617	.1058	.14338235
Q12_AB	1.56226562	.31481794	4.962	.0000	.90441176
Q13_AB	.87274283	.24806857	3.518	.0004	.68872549
Q15_AB	1.84036855	.25457496	7.229	.0000	.83946078
Q25_B	-1.46910768	.53833319	-2.729	.0064	.03063725
Q30_CD	-.38839314	.26089438	-1.489	.1366	.66789216
Q31_A	.60832315	.34724769	1.752	.0798	.17769608
Q31_D	.41156404	.25707502	1.601	.1094	.32107843

```
+---------------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.                   |
|                            M=Model MC=Constants Only   M0=No Model  |
| Criterion F (log L)     -263.80936        -356.17265    -565.60810  |
| LR Statistic vs. MC      184.72658            .00000        .00000  |
| Degrees of Freedom        14.00000            .00000        .00000  |
| Prob. Value for LR          .00000            .00000        .00000  |
| Entropy for probs.       263.80936         356.17265     565.60810  |
| Normalized Entropy          .46642            .62972       1.00000  |
| Entropy Ratio Stat.      603.59747         418.87089        .00000  |
| Bayes Info Criterion     621.48053         806.20711    1225.07800  |
| BIC - BIC(no model)      603.59747         418.87089        .00000  |
| Pseudo R-squared            .25932            .00000        .00000  |
| Pct. Correct Prec.        87.50000            .00000      50.00000  |
| Means:        y=0    y=1    y=2    y=3    yu=4   y=5,    y=6   y>=7  |
| Outcome     .1581  .8419  .0000  .0000  .0000  .0000  .0000  .0000  |
| Pred.Pr     .1581  .8419  .0000  .0000  .0000  .0000  .0000  .0000  |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).      |
|        Normalized entropy is computed against M0.                   |
|        Entropy ratio statistic is computed against M0.              |
|        BIC = 2*criterion - log(N)*degrees of freedom.               |
|        If the model has only constants or if it has no constants,   |
|        the statistics reported here are not useable.                |
+---------------------------------------------------------------------+
+----------------------------------------+
| Fit Measures for Binomial Choice Model |
| Logit    model for variable Q9         |
+----------------------------------------+
| Proportions P0= .158088   P1= .841912  |
| N =     816 N0=     129   N1=     687  |
| LogL =  -263.80936 LogL0 =  -356.1727  |
| Estrella = 1-(L/L0)^(-2L0/n) = .23053  |
+----------------------------------------+
|     Efron |  McFadden  |  Ben./Lerman  |
|    .28335 |     .25932 |       .80834  |
|    Cramer | Veall/Zim. |      Rsqrd_ML  |
|    .28001 |     .39605 |       .20259  |
+----------------------------------------+
| Information  Akaike I.C. Schwarz I.C.  |
| Criteria          .68336    628.18494  |
+----------------------------------------+
Frequencies of actual & predicted outcomes
Predicted outcome has maximum probability.
Threshold value for predicting (Y=1) = .5000
            Predicted
------  ----------  +  -----
Actual      0    1  |  Total
------  ----------  +  -----
  0        45   84  |    129
  1        18  669  |    687
------  ----------  +  -----
Total      63  753  |    816
```

```
======================================================================
Analysis of Binary Choice Model Predictions Based on Threshold =  .5000
----------------------------------------------------------------------
Prediction Success
----------------------------------------------------------------------
Sensitivity = actual 1s correctly predicted                    97.380%
Specificity = actual 0s correctly predicted                    34.884%
Positive predictive value = predicted 1s that were actual 1s  88.845%
Negative predictive value = predicted 0s that were actual 0s  71.429%
Correct prediction = actual 1s and 0s correctly predicted     87.500%
----------------------------------------------------------------------
Prediction Failure
----------------------------------------------------------------------
False pos. for true neg. = actual 0s predicted as 1s          65.116%
False neg. for true pos. = actual 1s predicted as 0s           2.620%
False pos. for predicted pos. = predicted 1s actual 0s        11.155%
False neg. for predicted neg. = predicted 0s actual 1s        28.571%
False predictions = actual 1s and 0s incorrectly predicted    12.500%
======================================================================
```

Model Output for Diversion

```
+---------------------------------------------+
| Multinomial Logit Model                     |
| Maximum Likelihood Estimates                |
| Model estimated: Aug 15, 2007 at 00:50:43AM.|
| Dependent variable             Q21DIVER     |
| Weighting variable                 None     |
| Number of observations              255     |
| Iterations completed                  6     |
| Log likelihood function       -128.5997     |
| Restricted log likelihood     -168.3761     |
| Chi squared                    79.55271     |
| Degrees of freedom                   18     |
| Prob[ChiSqd > value] =         .0000000     |
| Hosmer-Lemeshow chi-squared =  10.90918     |
| P-value=  .20690 with deg.fr. =       8     |
+---------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
Characteristics in numerator of Prob[Y = 1]					
Constant	-2.40930945	.90897950	-2.651	.0080	
SEMINOL	-.79787111	.36192876	-2.204	.0275	.32941176
Q2ASR4	.87252641	.34040167	2.563	.0104	.37254902
Q36GRE	.91673761	.36498043	2.512	.0120	.30980392
Q4BSHO	1.04346013	.54877793	1.901	.0572	.09411765
Q4CREC	.73087742	.47908104	1.526	.1271	.13333333
Q51ORLE	-.54849865	.36474500	-1.504	.1326	.27843137
Q8C511	1.38474047	.63034967	2.197	.0280	.05882353
Q8ENONE	-.88541098	.50022111	-1.770	.0767	.13725490
Q9ALLDI	.71890612	.40269158	1.785	.0742	.20784314
Q10BINA	1.21643136	.37243796	3.266	.0011	.65490196
Q19AACC	-1.24577798	.46383902	-2.686	.0072	.65882353
Q19BDIS	-2.60990930	1.25549618	-2.079	.0376	.02745098
Q19CCON	-1.10672696	.56201886	-1.969	.0489	.18431373
Q20ADMS	-.85812051	.45305022	-1.894	.0582	.30588235
Q20DDIR	-.62361735	.40384627	-1.544	.1225	.46666667
Q22DIVER	1.11700948	.40391317	2.765	.0057	.69803922
Q23AORD	.02129351	.01506276	1.414	.1575	18.0588235
Q31ORDI	.25458984	.12351624	2.061	.0393	3.26666667

```
+----------------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.                    |
|                            M=Model MC=Constants Only   M0=No Model   |
| Criterion F (log L)     -128.59973        -168.37609    -176.75253   |
| LR Statistic vs. MC       79.55271            .00000        .00000   |
| Degrees of Freedom        18.00000            .00000        .00000   |
| Prob. Value for LR          .00000            .00000        .00000   |
| Entropy for probs.       128.59973         168.37609     176.75253   |
| Normalized Entropy          .72757            .95261       1.00000   |
| Entropy Ratio Stat.       96.30560          16.75288        .00000   |
| Bayes Info Criterion     356.94221         436.49492     453.24781   |
| BIC - BIC(no model)       96.30560          16.75288        .00000   |
| Pseudo R-squared            .23624            .00000        .00000   |
| Pct. Correct Prec.        74.90196            .00000      50.00000   |
| Means:       y=0    y=1    y=2    y=3    yu=4   y=5,    y=6   y>=7   |
| Outcome     .6275  .3725  .0000  .0000  .0000  .0000  .0000  .0000   |
| Pred.Pr     .6275  .3725  .0000  .0000  .0000  .0000  .0000  .0000   |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).       |
|        Normalized entropy is computed against M0.                    |
|        Entropy ratio statistic is computed against M0.               |
|        BIC = 2*criterion - log(N)*degrees of freedom.                |
|        If the model has only constants or if it has no constants,    |
|        the statistics reported here are not useable.                 |
+----------------------------------------------------------------------+
+---------------------------------------+
| Fit Measures for Binomial Choice Model |
| Logit    model for variable Q21DIVER   |
+---------------------------------------+
| Proportions P0= .627451   P1= .372549  |
| N =      255 N0=     160   N1=      95 |
| LogL =  -128.59973 LogL0 =  -168.3761  |
| Estrella = 1-(L/L0)^(-2L0/n) = .29945  |
+---------------------------------------+
|     Efron |  McFadden  |  Ben./Lerman  |
|    .26869 |     .23624 |       .66096  |
|    Cramer | Veall/Zim. |      Rsqrd_ML |
|    .27480 |     .41785 |       .26800  |
+---------------------------------------+
| Information  Akaike I.C. Schwarz I.C.  |
| Criteria        1.15764    362.48347   |
+---------------------------------------+
Frequencies of actual & predicted outcomes
Predicted outcome has maximum probability.
Threshold value for predicting (Y=1) = .5000
            Predicted
------  ----------  +  -----
Actual      0    1  |  Total
------  ----------  +  -----
  0       135   25  |    160
  1        39   56  |     95
------  ----------  +  -----
Total     174   81  |    255
```

```
======================================================================
Analysis of Binary Choice Model Predictions Based on Threshold =  .5000
----------------------------------------------------------------------
Prediction Success
----------------------------------------------------------------------
Sensitivity = actual 1s correctly predicted                   58.947%
Specificity = actual 0s correctly predicted                   84.375%
Positive predictive value = predicted 1s that were actual 1s  69.136%
Negative predictive value = predicted 0s that were actual 0s  77.586%
Correct prediction = actual 1s and 0s correctly predicted     74.902%
----------------------------------------------------------------------
Prediction Failure
----------------------------------------------------------------------
False pos. for true neg. = actual 0s predicted as 1s          15.625%
False neg. for true pos. = actual 1s predicted as 0s          41.053%
False pos. for predicted pos. = predicted 1s actual 0s        30.864%
False neg. for predicted neg. = predicted 0s actual 1s        22.414%
False predictions = actual 1s and 0s incorrectly predicted    25.098%
======================================================================
```

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