MARICOPA ASSOCIATION of GOVERNMENTS

Special Events Travel Forecasting Model and Collection of Special Events Data

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1.0 Introduction

The Maricopa Association of Governments (MAG) is the designated metropolitan planning organization (MPO) for transportation planning for the metropolitan Phoenix area. In collaboration with local transit agencies and local jurisdictions, MAG developed a successful proposal to compete for the Federal Transit Administration (FTA) Alternatives Analysis Discretionary Program Section 5339 funds. The proposal included collection of travel data related to special events and the development of a special event model. The importance of this project was further highlighted by the success of the light-rail transit recently introduced into the region. Other reasons for the launch of this project include: 1) necessity to better understand and forecast transit markets requires in-depth studying and modeling of planned special events in the region; and 2) special events' patrons constitute a very noticeable portion of the light-rail ridership in the region, and affect overall regional travel demand.

The MAG Regional Travel Forecasting Model is the main tool utilized at the agency for long-range planning and air quality conformity analyses. This model is a state-of-the-practice trip-based four-step model; and estimates travel demand for auto passengers and trucks for an average weekday. That is, it predicts weekday travel with emphasis on peak weekday time periods and work trip purposes. The model design does not account for weekend travel, and also does not explicitly consider planned special events' travel on weekdays.

Currently, there are more than 300 special events of regional significance that generate a total annual attendance of a few million people. In between 1999 and 2001, a number of data collection efforts and model development tasks were performed to estimate the potential Light-Rail Transit (LRT) ridership for special events along the proposed 20-mile LRT corridor, and to enhance the representation of LRT alternatives in the regional travel forecasts. After the new LRT service opened in early 2009, the ridership numbers started to exceed regional forecasts along all LRT lines. Subsequently, an LRT intercept survey was conducted to collect information on trip purposes and modes of access. This survey data indicated that a significant portion of LRT riders were noncommute trips occurring during off-peak hours and weekends. One of the main reasons for this phenomenon was utilization of LRT lines by special events patrons.

The nature and location of special events in the Phoenix region has also changed significantly since the last special events survey. In order for the regional planning agencies to continue using estimates of transit usage at special event locations, it has become necessary to update the special event database and conduct another survey of patrons. The importance of this data and models for the purposes of transit planning was recognized by the FTA, and the project was selected for the FTA Discretionary Programs allocations.

The travel associated with special events can produce significant, site-specific or even regional impacts. The special events-related travel is also an essential part of planning for some of the new transit projects. This has been long recognized by regional planners and the FTA. This project, which is conducted by MAG with Cambridge Systematics, Inc. (CS) as the prime consultant and WestGroup Research (WGR) as a subconsultant, focuses on identifying special events in the region that affect transit ridership, collecting data related to travel associated with these events, and developing a standalone special events model. This standalone model will enable MAG and its member agencies to predict and analyze planned special events travel with an emphasis on transit applications and requirements related to the FTA New Starts and Small Starts application processes.

The scope of work for this project included four tasks. The first task was creating a data collection and acquisition plan that describes what type of data collection will be employed, how the universe of special event venues and attendees will be identified (and how these data will be used to expand survey results), and where applicable, what the sampling units will be, what the sampling frame options are, how the samples will be stratified, required sample sizes, how the samples will be drawn, how participants (both venues and attendees) will be recruited, and what data will be collected. The second task implemented the data collection and acquisition plan by preparing, distributing, and processing surveys to event attendees at 20 special events. The third task used the data collected in Task 2 to develop, estimate, and calibrate a trip-based special events travel forecasting model. Finally, the last task, Task 4, involved the application and validation of the model developed in Task 3.

This report provides a description of the data collection plan that includes categorization of special events, short list of events to be surveyed, survey methodology, pretests and full surveys, sampling and data expansion procedures, Quality Assurance (QA)/Quality Control (QC) through the data collection process, and geocoding of survey records. It also includes an extensive descriptive analysis of all the travel data collected at key special events in the MAG region. The report describes the special event model development plan and the model estimation process, including the required model inputs, model estimation results for trip generation, time of day, origin choice and mode choice, and trip assignment procedures. Finally, the report discusses model application, sensitivity analyses, and some conclusions and recommendations for future consideration.

2.0 Special Events Data Collection Plan

This chapter describes the detailed data collection and acquisition plan that includes categorization of special events, short list of events to be surveyed, survey methodology, the type of data collection that was employed, QA/QC through the data collection process, how the universe of special event venues and attendees were identified (and how the data was used to expand survey results), and where applicable, what the sampling units were, what the sampling frame options were, how the samples were stratified, required sample sizes, how the samples were drawn, how participants (both venues and attendees) were recruited, and what data were collected.

2.1 Classification of Special Events

Special Event Types

The CS team collaborated with MAG staff to develop an exhaustive list of regional special events and special generators that occur or may occur throughout the base and forecast year(s). Special events in the MAG region vary from weekend festivals that attract local residents to large sporting events such as the Super Bowl, which bring thousands of visitors into the region for the one-day event. Given the large number of special events that occur in the MAG region each year, it is not feasible to collect data and create models for each individual event. Therefore, the CS team categorized special events in the region by salient characteristics that aid in data collection and model development. The special events were classified by the following nine distinguishing characteristics:

1. **Predicted Attendance.** The attendance or size of the event is an important factor in classifying a special event, as various sized events have differing impacts on the transportation system. However, if the special event does not result in increased travel demand on the transportation system or an interruption to the regional (but not local) transportation system, there is no reason to spend resources modeling the event. Therefore, special events were divided into events that have daily predicted attendance above 1,500 and special events that have a predicted daily attendance below 1,500. Events that are in the latter category were immediately discarded from further analysis and not included in the comprehensive list of special events.
2. **Event Frequency.** There are many special events in the Phoenix area that can be considered a *recurring event*. This would include professional and college sports home games, college bowl games, and many concerts, theater

productions, and conferences that occur at the same venue and have similar attendance levels. For example, while each concert or show at the U.S. Airways arena will not feature the same guest each time, all of the concerts can be grouped together as one event group (and named, for example, U.S. Airways Concerts), since they all occur at the same venue and have similar characteristics and attendance rates.

In contrast, some special events are a *one-time event* that has very unique attributes, making it impossible to group the event with others. These events do not occur on a yearly basis. For example, it is rare for Phoenix to hold the NFL Super Bowl. While the event has similar characteristics to a college football bowl game, in that it sells out the University of Phoenix Stadium and attracts many people from all over the country, it does not occur on a yearly basis like the Fiesta Bowl.

For the data collection effort, due to budget and time constraints, only one event within each group of *reoccurring* events will be chosen for surveying. In addition, since *one-time* events occur rarely and not on a regular yearly basis, the focus of the data collection effort will be on *reoccurring* events. For model development, knowledge of the number of times the event occurs per week and per year will be important for determining yearly forecast projections.

3. **Regular vs. Periodic Event.** Special events are categorized by *regular* events and *periodic* special events. The *regular events* are those that are typically available on an average weekday, and the travel associated with such events should be captured in the existing regional travel model. On the other hand, the *periodic* special events are those events that do not occur on a daily basis, such as conventions and sporting events. Travel to these types of events is not typically captured in a regional travel model. The focus of both data collection and model development is *periodic* events. *Regular* events will not be included in the comprehensive list of special events.

4. **Venue Type.** Special events take place at different types of venues. Most large sports and concert events take place at a *single venue*, such as a stadium, arena, or theater. The venue location does not change and is located at a single geographic location and within one Transportation Analysis Zone (TAZ). In contrast, some events are *multivenue* events since they take place at various locations throughout the region. An example of a multivenue event would be a conference that is spread across many hotels, or a music festival that is held at different music venues. Multivenue events occur at various geographical locations and, therefore, may occur within many TAZs. These events will have to be treated differently than single-venue events during the trip generation and trip distribution step of model development. For data collection, plans will be made to collect data at the events' various venues.

   A third venue type is the *temporary venue*. Temporary venues are constructed specifically for the event and dismantled following the end of the event.

Events that take place across city blocks normally open to traffic would be classified within this event type. Temporary venues may take place across multiple TAZs, and may be sufficiently large to require changes to the transportation network during model development. In addition, during data collection, surveys will be distributed at multiple locations.

5. **Event Start and End Time.** For data collection and model development, it is very important to distinguish if the special event has a *set start and end time*, where all attendees arrive during a set time before the event and leave immediately after the event; or if the event has a *continuous start and end time*, such that attendees come and go throughout the duration of the event. Examples of set start and end time events include sports games and concerts. Continuous start and end time events include festivals and conferences. Data collection during set start and end time events will occur within a few hours of the event start time; whereas, for a continuous time event, data collection will have to occur throughout the duration of the event. For model development, the type of event start and end time is important for time-of-day analysis.

6. **Single vs. Multiple Days.** Special events that occur on only one day, such as concerts and most sports games, are *single day events*. Multiple day events occur over the course of a few days or weeks. Many weekend festivals would be classified as a multiple day event, since they occur on both Saturday and Sundays, and possibly a weekday as well. Distinguishing between single and multiple day events is important for data collection, since data collection may occur over more than one day. Multiple day events are treated differently during model development, since in many cases multiple day events occur on weekdays, Saturdays, and Sundays, requiring separate consideration for each day of week.

7. **Day of Week.** *Weekdays*, *Saturdays*, and *Sundays* have different transportation system characteristics, and therefore, it is important to distinguish between special events that take place during the week versus on Saturdays or Sundays. For multiple day events or recurring single day events, it is important to note that data collected on one day of week may not be easily transferred to another day of week since the travel patterns to these events, time-of-day of attendance, and demographic characteristics of attendees may vary depending on the day of week. Multiple day and recurring events will also be modeled for each day of week (weekday, Saturday, and Sunday) to account for the different attendee and transportation characteristics of these days.

8. **Event Market Area.** Some special events have attendees that are mostly residents of the Phoenix area, such as small concerts and shows; whereas, other special events, such as large sports events and conferences, attract attendees from all over the State and Nation. *Local/regional events* will be simpler to model since we can most likely assume that all attendees have a home residence within the Phoenix area. For *statewide/national events,* many

attendees will be traveling from out of the region to attend the event, and will spend the night at a hotel. Model development for these events will take into account that many attendees may be traveling from outside of the MAG region or staying at a hotel. All surveys will ask out-of-town attendees about hotel accommodations. Data collected from the survey will help classify events into *local/regional* and *statewide/national* events.

9. **Local vs. Regional Attendance.** Certain special events attract attendees from all over the region, such as large sports games and concerts. These events can be categorized as *regional attendance* events. For these events, trips to and from the event will be distributed across the region. Other events are more localized in their attendance. Some shows, festivals, and sports events (i.e., college games) may attract attendees that originate (from home, work, hotel, or other location) closer to the event venue. For example, many conferences have a significant number of attendees that stay in hotels very close by to the conference event. This event would be characterized as a *local attendance* event. Distinguishing between local versus regional attendance is important for trip distribution model development. While initial classification of local vs. regional attendance will be made prior to data collection, the survey data results will provide additional insight into whether an event can be considered a *local* vs. *regional* attendance event.

Comprehensive and Short-List of Events

MAG provided to the CS team a list of events that occurred or are scheduled to occur between July 2009 and June 2010 in the MAG region. These were grouped and organized by the nine special event types.

Events occurring at the same venue, on the same day of week (Weekday, Saturday, or Sunday), and with similar predicted attendance size and start and end times were grouped into the same reoccurring event. For example, all Diamondback games occurring at Chase Field on Saturdays were considered one recurring event group with 13 recurring events each year. All Diamondback games occurring at Chase Field on weekdays were considered another recurring event group with 55 recurring events per year.

While the MAG region hosts several hundred special events each year, given resource constraints it was determined that it would only be possible to collect surveys spread over 15 to 17 special events. The number of events was later expanded to a total of 20 surveyed events in order to capture close to 6000 completed surveys, as per the contract.

The special events were chosen from the comprehensive list of events based on several criteria, as outlined below.

- It was very important to capture the impact of special events on the transit system, so priority was given to special events that are on the LRT line or have the potential to be connected by LRT in the future. Consideration was also given to those events that have other transit (bus) access as well. Over one-half of the events chosen was within one mile of an LRT station.

- There are several large stadiums and sports complexes in the MAG region. Therefore, at least one special event from each of these large complexes was chosen. Other events that were known to have a very large attendance size were also chosen.
- It was desirable to capture special events from a wide geographical range within the MAG region. The short list of events includes events in nine different cities.
- The group of events chosen included surveying weekday, Saturday, and Sunday events, including small local events, as well as large regional events, and including at least one temporary venue. A wide variety of events were chosen, including a marathon, a block party, concerts, festivals, conventions, and a variety of sporting events.
- The special events chosen were selected so as to spread the events over the course of a nine-month period from September 2009 through May 2010.

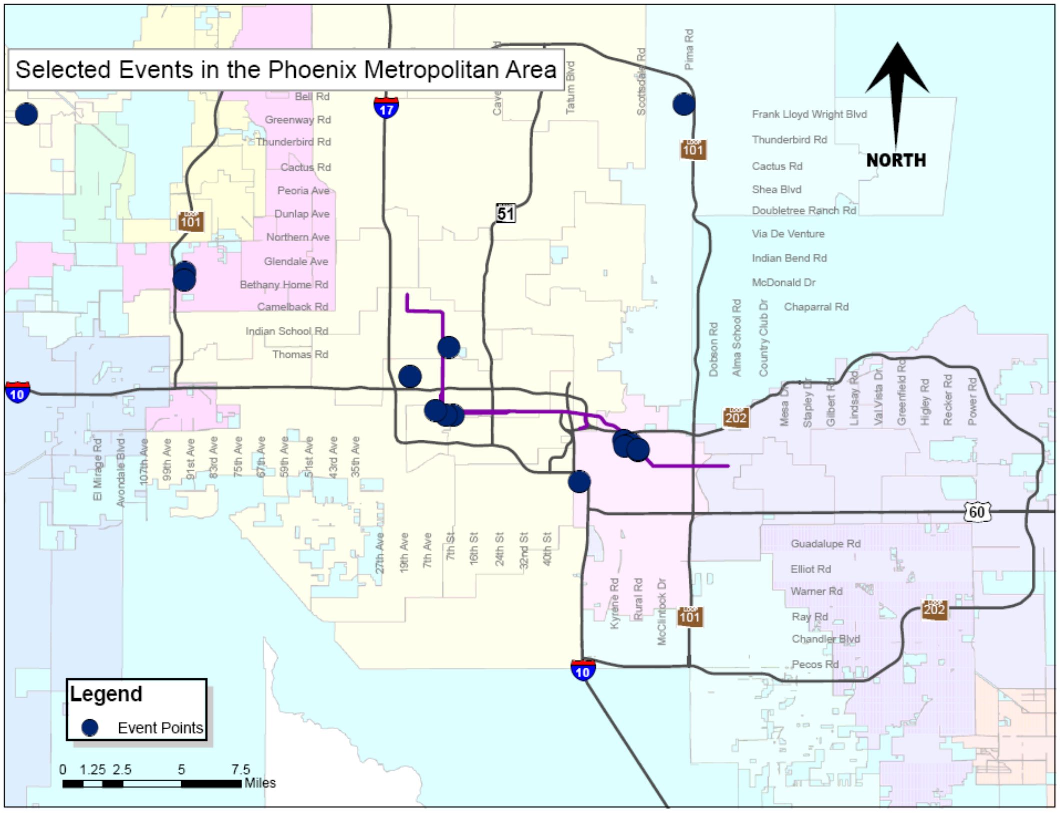
Using the above criteria, several decisions and tradeoffs were made to obtain a reasonable number of events. For example, only one of several concert event venues that all occurred within a similar distance to LRT and had similar attendance size was retained. In addition, it was desirable to survey at least one Scottsdale event for geographical diversity, but not more than one, since Scottsdale is not close to LRT. The decision was made to retain the PGA Tour FBR Open, but eliminate a Barrett Jackson Concert at West World. There are two major college bowl games that take place in Phoenix each year, the Insight Bowl and the Fiesta Bowl. Since the Mill Avenue Block Party takes place on the same day and in close proximity to the Insight Bowl, the Insight Bowl was eliminated from the list of events, and a special questionnaire for the Mill Avenue Block Party was created to inquire if the attendees also attended the Insight Bowl.

All of the above-described criteria led the project team to choose 20 events, as shown in Table 2.1. Figure 2.1 shows the geographical distribution of these surveyed special events.

Table 2.1 List of Surveyed Special Events

	Event	Type of Event	Survey Date	Day of Week	Venue	TAZ
1	Arizona Fall Frenzy	Music Concert and Festival	9/19/2009	Saturday	Tempe Beach Park	1632, 1169
2	Diamondbacks game	Sports – MLB	9/27/2009	Sunday	Chase Field	850
3	Arizona State Fair	Fair	10/22 & 10/24/2009	Thursday & Saturday	Arizona Exposition & State Fair	758
4	AFL Rising Stars Game	Sports – Baseball	11/7/2009	Saturday	Surprise Stadium	182
5	ASU Football Game	Sports – College Football	11/28/2009	Saturday	Sun Devil Stadium	1635
6	KISS Concert	Music Concert	12/1/2009	Tuesday	Jobing.com Arena	425
7	Cardinals Game	Sports – NFL	12/6/2009	Sunday	University of Phoenix Stadium	425
8	Mill Avenue Block Party	Block Party	12/31/2009	Thursday	Downtown Tempe	1167
9	PF Changs Marathon	Sports – Marathon	1/17/2010	Sunday	Phoenix and Tempe roads	1635
10	FBR – WM Golf Open	Sports – Golf	2/27/2010	Saturday	TPC Scottsdale	1069
11	ASU Basketball Game	Sports – College Basketball	3/6/2010	Wednesday	Wells Fargo Arena	1635
12	NBA Phoenix Suns Game	Sports – NBA	3/12/2010	Friday	U.S. Airways Arena	847
13	Spring Training Game	Sports – MLB	3/15/2010	Monday	Tempe Diablo	1184
14	Wrestlemania	Sports – Wrestling	3/28/2010	Sunday	University of Phoenix Stadium	425
15	Pride Parade	Parade	4/17/2010	Saturday	Steele Indian School Park & Public Streets	777, 776, 781, 780
16	Crossroads of the West Gun Show	Gun Show	4/25/2010	Sunday	Arizona State Fairgrounds	758
17	Conan O'Brien Show	Comedy Show	4/30/2010	Friday	Dodge Theatre	839
18	First Friday	Art Festival	5/7/2010	Friday	Downtown Phoenix	845, 846, 849
19	Diamondbacks game	Sports – MLB	5/23/2010	Sunday	Chase Field	850
20	NBA Phoenix Suns Game	Sports – NBA	5/23/2010	Sunday	U.S. Airways Arena	847

Figure 2.1 Location of Special Events Surveyed



2.2 SURVEY METHODOLOGY

Survey Approach

The approach to the design of the survey instrument was driven by the need to maximize the response rate. As a result, the instrument was set up in a very concise format that can be completed in a maximum of three to five minutes. MAG and CS identified the critical survey elements. WGR staff constructed the survey instrument in a one-page, user-friendly format.

The survey instrument went through several iterations and reviews by staff members from MAG, CS, and WGR. The instrument was then tested through a pretest of more than 100 interviews at the Fall Frenzy in Tempe Beach Park. The data from the pretest was entered and evaluated, and a few subsequent changes to the instrument were made before it was finalized. Once the instrument was finalized, the survey was translated into Spanish.

Permissions

MAG staff worked to secure the necessary permissions for WGR interceptors to be near the entrances into the event. The parameters of the approved areas were communicated to WGR staff, along with any special instructions or exceptions. When possible, a contact name of the person providing the permissions was provided to WGR in case anyone challenged the interceptor presence at the event. WGR also provided assistance with permissions if it was determined that it has an influential contact that could provide assistance.

Conducting Surveys

As the events and venues were identified, WGR determined the staffing needs so the targeted number of completed interviews was successfully accomplished. Interceptors were scheduled for each event and trained on the unique attributes of the specific venue and event questionnaire. All interceptors carried copies of the survey instrument, a clipboard, writing utensils, a watch/clock, and a letter from MAG that explains the scope of the project.

For each event, other venue-specific details were also clarified, such as positioning of interviewers near the entrances into the event (sidewalks, LRT stops, at the venue, etc.); time needed to conduct surveys (few hours before, an hour before, just before/during the event, etc.); and another special needs (lights, clocks, etc.).

WGR interceptors arrived prior to the event (time prior to the event was determined by the event type and venue) and set up in the preidentified positions at the venue to allow for maximum access to attendees, as well as optimize the random selection of attendees. Surveys were completed using the identified tools. All completed surveys were returned to WGR.

WGR supervisors called at least 10 percent of the attendees who provided a first name/initials and a phone number to verify key data points on the survey as one of the QC processes.

Survey Instrument

A master survey instrument was developed for use at all events. However, the WGR/CS team worked with MAG staff to identify any event-specific, add-on questions that were added on a case-by-case basis. The instrument is included in Appendix A.

Data Entry

After the Field Supervisor and Project Manager have made a first QA "pass" through the completed surveys, the completed surveys were delivered to MAG, where staff "cleaned" the home address/cross-street information provided by respondents; filled in landmark addresses, when possible; and added missing city and zip code information that was identifiable. Then all of the data was entered into a master database for each event that also includes event-specific information: event time; event location; time of interview; interceptor initials; and respondent name and telephone number, when provided.

2.3 SAMPLING PLAN

The sampling frame for the special event surveys is the set of attendees to the various events in the MAG region. Different estimates of sample sizes were calculated based on the desired confidence level and accepted margin of error.

The sample sizes identified for each event on the project short list was determined by two primary criteria: relative size of the event (i.e., larger events = larger sample), as well as the overall importance to the model (i.e., events with less potential impact on the current or future light-rail and transit corridors have smaller sample sizes than events with lower projected attendance, but higher transit impact).

For the budget allocated to collect data at special events, the CS team aimed to collect about 6,000 completed surveys, spread over 20 special events. The number of event attendees to be interviewed, along with the confidence level and sampling error, was determined in consultation with MAG, as shown in Table 2.2. All the sample sizes were computed at the 95-percent confidence level, but the margin of error were varied depending upon the importance of the special event, based on its proximity to light rail. For example, based on a sample size of 300, the sampling error at 95-percent confidence level is +/-5.6 percent. However, if a greater sampling error is allowed, say close to +/-10 percent, then the required sample size is only about 100. Therefore, based on the relative importance of events, a higher margin of error was allowed for certain events, which allowed targeting more events. In addition, statistically, the margin of error varies slightly with extremely small populations (e.g., less than 1,500 attendance), but otherwise applies to all other populations, regardless of how large they may be.

Table 2.2 Sample Sizes at 95-Percent Confidence Level

	Event	Previous Attendance	Actual/Estimated Attendance	Sample Size	Confidence Level	Margin of Error
1	Arizona Fall Frenzy	4,000-15,000	15,000*	100	95.00%	9.80%
2	Diamondbacks game	20,000-49,033	30,018	300	95.00%	5.66%
3a	Arizona State Fair – Thursday	1,303,690 (whole 2-week event in 2006)	16,911	167	95.00%	4.38%
3b	Arizona State Fair – Saturday		32,800	333	95.00%	5.66%
4	AFL Rising Stars Game	4,000-6,000	4,550	100	95.00%	9.80%
5	ASU Football Game	20,000-60,000	55,989	500	95.00%	4.38%

	Event	Previous Attendance	Actual/Estimated Attendance	Sample Size	Confidence Level	Margin of Error
6	KISS Concert	8,000-17,799	10,876	300	95.00%	5.66%
7	Cardinals Game	40,000-63,400	64,121	500	95.00%	4.40%
8	Mill Avenue Block Party	100,000+	100,000	500	95.00%	4.38%
9	PF Changs Marathon	28,000+ Participants	102,556	500	95.00%	4.38%
10	FBR – WM Golf Open	538,356 (whole 4-day event in 2008)	122,000	500	95.00%	4.38%
11	ASU Basketball Game	13,000	9,040	100	95.00%	9.80%
12	NBA Phoenix Suns Game	8,000-16,210	18,422	300	95.00%	5.66%
13	Spring Training Game	9,600	8,854	100	95.00%	9.80%
14	Wrestlemania	72,047 (2008)	72,219	500	95.00%	4.38%
15	Pride Parade	12,500	12,000	100	95.00%	9.80%
16	Crossroads of the West Gun Show	9,000-12,000 (whole 3-day event)	5,000	100	95.00%	9.80%
17	Conan O'Brien Show	Not Available	5,500	200	95.00%	7.10%
18	First Friday	Not Available	10000	300	95.00%	5.66%
19	Diamondbacks game	20,000-49,033	23,148	300	95.00%	5.66%
20	NBA Phoenix Suns Game	8,000-16,210	18,422	300	95.00%	5.66%

2.4 Survey Procedure and QA/QC for Data Collection

The detailed survey procedure or process is described below, along with the QA/QC procedures that were employed: 1) before the event, 2) at the event, and 3) after the event.

Before the Event

As special event attendees do travel from all over the MAG region using different modes of travel, the arrival patterns to the event facility/venue will be very different. So in order to get a good mix of respondents, the CS team first established quotas for responses for different timeframes. These quotas were based on the flow of people arriving to the event. Quotas were set higher during times that have a higher concentration of people traveling to the event. These quotas are given to the lead supervisor of WGR.

MAG staff identified the exits and entry patterns of the venue through discussions with representatives from each venue. In addition, potential entry counts provided by the venues were used to establish the priority of the entrances for survey collection. WGR had interceptors stationed at all of these identified locations, where possible. The interceptors were placed proportionally to the priority of each entrance. For example, if a main entrance is identified and it is determined that 60 percent of the attendees will enter through that entrance, while the other 40 percent of attendees will enter through three other entrances, the WGR staff of interviewers would be distributed using the same proportions.

Prior to the event, surveys are printed and distributed evenly on clipboards for the interceptors. The lead supervisor gathered these materials and brought them to each event. The lead supervisor scheduled the interceptors for the event. Staffing was adjusted until it was determined that there is an appropriate balance of male and female interviewers, as well as bilingual (Spanish/English) interviewers at all of the entry locations. Prior to each event, all interceptors were briefed on the survey instrument, any unique event-related questions, as well as the specific logistics of each event.

At the Event

All supervisors and interceptors met at a predetermined location at the venue 30 minutes before the start of interviewing. At this time, the lead supervisor distributed clipboards and surveys to the interceptors. The lead supervisor rebriefed the interceptors on any details/changes that might have come up since their initial briefing of the event, as well as reemphasized important aspects of the interviewing process and venue.

The lead supervisor then dispersed supervisors and interceptors to the entry/ exit locations. There was at least one supervisor at each main intercept location. The ratio of supervisors and interceptors differed based on the number of entry/ exit locations; however, it was usually no more than 10 interceptors to one supervisor. In addition, at most events at least one MAG staff was on hand at the event to aid in survey collection and quality control.

The lead supervisor walked around to every intercept team during the event. They looked at the first few interviews from each interceptor to make sure they were being filled out correctly. They also monitored the approach of the interceptor and coached anyone who was having difficulty getting surveys.

All supervisors were required to carry a cell phone so they could communicate with the lead supervisor. The lead supervisor called each supervisor every 30 minutes to monitor the number of surveys they have completed. They were in charge of making sure the quotas are being met by the set timeframes. Also, if any issues or questions came up, the supervisors called the lead supervisor for an answer or clarification. If the lead supervisor did not have the answer, the lead supervisor then called the WGR project manager.

After the event, interceptors and supervisors met at their predetermined location. The interceptors and supervisors gave their surveys and clipboards to the lead supervisor. The WGR project manager debriefed with the lead supervisor after each event. In addition, MAG and CS staff reviewed the data file once all surveys were entered. Issues requiring potential retraining of interviewers, as well as questionnaire edits, were discussed after this review.

After the Event

After data collection was completed, each survey was stamped with an individual unique survey number for that event. Surveys were then quality checked as described below.

- The street address or intersections given by respondents were examined to make sure they are complete. If the address is missing information (i.e., the type of street, city, or zip code), data coders used Google maps to try to locate the information.
- Interview time and Departure time were also verified. For example, if it was known that the intercepts happened between the hours of 10:00 a.m. and 3:30 p.m. and the survey shows 11:00 p.m., data coders will then change it to a.m.
- Sometimes, Departure time was written as # of minutes ago (i.e., 40 min. ago). When this was the case, data coders looked at the interview time and go back XX minutes and record the time as XX: XX.
- Light-rail station names were also verified. The Valley Metro Light-Rail Legend is used to accurately describe the station name. If a respondent just says "University," the legend was consulted and made sure that only one station has "University" in the name. If it does, it was concluded that the station is "University Drive/Rural." Sometimes the staff was unable to decipher which station was used. For example, if it just says "Jefferson," it is impossible to determine which station was accessed because there are multiple stations with "Jefferson" in the name. When this is the case, data coders will just leave it as "Jefferson."
- If the Gender question was not marked, data coders looked at the name written down for verification purposes and infer the gender from that, if possible.
- If there were any other questions that arise while entering surveys, data coders conferred with WGR's data collection supervisors for clarification.

Validation Process

MAG staff performed an extensive review of the survey process. This included closely monitoring the survey procedures, and assisting throughout on all survey planning efforts, ranging from interviewer training, as well as positioning interviewers at the special events. MAG staff also worked closely with WGR staff on all data entry efforts, analyzing data and performing logical checks. MAG staff also reviewed all the geocoded results, especially those surveys that did not have specific addresses.

3.0 Special Events Survey Results

This chapter provides a description of the pretest that was undertaken, including approach, findings, and descriptive analysis of the collected data. In addition, the chapter discusses the expansion procedure applied to the full set of survey data, the geocoding procedure, and a descriptive analysis of all the full surveys.

3.1 Pretests

Approach

MAG's preference was to begin the data collection process in September 2009, as there were many events of significance, especially the Diamondbacks baseball games in September, which did not occur again until April 2010. Therefore, the CS/WGR team conducted the pretests quickly so that full surveys at the Diamondbacks game could be conducted in September 2009. The pretests were administered in order to test the survey process and instrument. The Fall Frenzy event at the Tempe Beach Park was chosen as the pretest venue. This is a three-day event featuring punk rock bands playing from about noon until midnight from September 18 to 20, 2009). The pretests were conducted on Saturday, September 19, 2009.

As the Fall Frenzy was a 12-hour event on September 19, survey interviewers were stationed at the event at different time slots, based on the type of band(s) playing in the early afternoon, late afternoon, and evening. This was done primarily to capture a variety of attendees as various bands have different fan bases (who differ in sociodemographic characteristics). The interviews were conducted in three distinct time slots: 1:00 p.m. to 3:00 p.m., 7:00 p.m. to 9:00 p.m., and a few surveys in-between the two time slots.

Findings

The pretest surveys took about three to five minutes to complete. A high cooperation rate was achieved during the daytime – about an average of one in every two to three requests. The nighttime interviewing was a problem for both interviewers and respondents. The interviewers were unable to find locations that provided enough light without being on the event property, but the bigger issue was that respondents were unwilling to participate in the dark. They were unable to see the interviewers clearly, and therefore, were suspicious about being approached by someone carrying something in the dark at the late hours. Some of the respondents would hurry past and not respond to all the questions. There was also an issue with increased incidence of drunkenness, which created some potential safety issues, particularly for the female interceptors. This problem prevented the survey team from surveying after 9:00 p.m. Overall, WGR was able to achieve about five interviews per hour, and this will be used to plan for other events accordingly.

Validation

After all surveys were entered into Excel, a random selection of interviews was validated. About 10 percent of the surveys were validated for this event. During the validation process, respondents were asked if they completed the intercept, and were asked again a few of the questions from the survey. The survey questions that they were asked again are questions related to mode of travel, party size and household size. Interviewers validating the process then recorded in an Excel spreadsheet the date, the survey record number, and the interceptor's initials. Interviewers also marked if the validation was successful or not successful. If it was not successful, they typed in the reason and alerted WGR data collection supervisors.

Data Analysis

In the pretests, 161 surveys were collected, well above the desired target of 100 surveys, so that even after cleaning and eliminating incomplete surveys, it would be over the target. An elaborate review of the pretest data was conducted to see if questions were answered logically, answers were coded correctly, there were any missing information, and the data summaries provided reasonable results with regard to special event travel and sociodemographic characteristics of travelers.

- **Origin and Destination Type.** The majority of respondents traveled from home to this event, as it was on a Saturday; and about the same percentage indicated that they were returning home after the event. No respondents reported going back to work, which makes sense for a Saturday event. The hotel share was twice as high for the return trip from the event. About one percent of survey records were missing this information.
- **Mode Choice.** About 75 to 80 percent of respondents reported using auto modes to and from the event. Six to 7 percent reported using light rail. Very few reported using public bus. The taxi share was about 5 to 6 percent. The walk/bike share was about 7 to 10 percent.
- **Access and Egress Modes.** Approximately 50 percent reported walking to access transit, while the other one-half reported driving or getting dropped off at the transit station or stop. However, on the way from transit, only 30 percent reported walking, with a much higher proportion driving from the transit stop.
- **Party Size.** There seems to be a slight increase in the party size as attendees leave the event.
- **Blocks/Minutes from Parking Lot.** About 80 percent of respondents reported the number of blocks, and about 60 percent responded in minutes.

- **Length of Stay.** Almost 90 percent of respondents planned to stay at the event for over three hours, which makes sense given the length of the event and the cost to attend the event.
- **Household Size**. About one-half of the respondents live in households of four or more persons.
- **Vehicle Availability.** Over 25 percent of respondents reported owning zero or one vehicles.
- **Household Income.** Over 75 percent of respondents reported income information, which is in line with expectations. There seems to be good distribution among the respondents.
- **Gender.** A majority of respondents (58 percent) were male.

3.2 DATA EXPANSION

The survey instrument, list of special events in the region, and a short list of events to be targeted in this project were shared with the FTA and the Technical Advisory Group (TAG) at the beginning of this project. The FTA reviewed these materials and, in general, was in agreement with the survey procedure and methodology being used for collecting special event travel data. The FTA suggested developing event-specific expansion factors, and wherever possible, collecting visitor arrival counts at the venues. Therefore, MAG made a decision to start collecting gate counts at all venues, wherever feasible, for all the upcoming special events starting from late October 2009.

Several expansion techniques were explored, and it was determined that the best method was to develop event-specific expansion factors, which were stratified further by time period, entry/gateway to the event, and party size. Party size was defined as the number of people, including the respondent who traveled to the event together. An expansion factor for each survey was obtained by weighting the number of surveys collected at each gate/entry during each time period by party size, and expanding the values to the total number of attendees entering the gate/entry during the time period.

Table 3.1 gives an example of how expansion factors were computed at one time period and gate. In this example, 10 surveys were collected and 150 attendees entered the venue. Of those 10 surveys, two had a party size of one, two had a party size of two, three had a party size of three, and three had a party size of four or more. The surveys with party size of one, two, three, and four or more (or 4.5) would represent two, four, nine, and 13.5 attendees, respectively. The 150 count total is weighted by the percentage of each party size represented in the surveys. These weights are then divided by the number of surveys of each party size in the sample to obtain final expansion factors for each survey by party size, gate, and time period. The expansion method is consistent with the FTA's recommendations on expanding the data by time period and entry point.

Table 3.1 Example of Expansion Factor Calculation

Party Size	Number of Surveys	Weighted Survey Numbers	Percentage of Weighted Survey	Expansion Factor for each Party Size	Expansion Factor for Each Survey
1	2	2	0.07	10.53	5.26
2	2	4	0.14	21.05	10.53
3	3	9	0.32	47.37	15.79
4+	3	13.5	0.47	71.05	23.68

In order to perform data expansion, accurate estimates of number of people entering the special event facility at every entry point or gate were required. In this approach, not only was it necessary to survey at all entry points or gates, but also to collect counts from start to finish at every entry or gate. This would have been an expensive process and required permission to survey and position counters to collect count data at all entry points. Therefore, this approach was only possible for those events where staff could easily be positioned at all entry points.

For those events where this approach could not be used, the total attendance on the day of the special event was used. Data on attendance collected from local agencies and event venues were used to expand the survey sample for such events, and party size information from the surveys was used to further weight the data.

3.3 GEOCODING

The geocoding of the survey records was mainly accomplished using the geocoding functions in ArcMap. The majority of geocoding was undertaken by MAG staff. Prior to geocoding, an extensive review and formatting of the survey data was undertaken to ensure consistency and usefulness for geocoding. Here is a checklist of data QA/QC procedure:

- The survey files provided by WGR had several column headings (the first row of a spreadsheet) that start with characters such as '/', '?', ']' and ')'. Since ArcGIS does not function properly on an excel file with such characters, such characters from column headings, were removed The column headings were also shortened so that the geocoded shapefile will not have an attribute table with excessively long field names.
- As a result of copying values from one spreadsheet into another, some of the cell formats used in the spreadsheet provided by WGR were somehow not compatible with ArcGIS. These caused issues while running 'Join attributes from a table' process in ArcGIS. In order to avoid this problem, while selecting and copying all the cells (including column headings into a new

spreadsheet), avoided using Ctrl+A as it copied many blank cells outside of the spread of records. Instead, selected and copied the cells within the spread of data only.

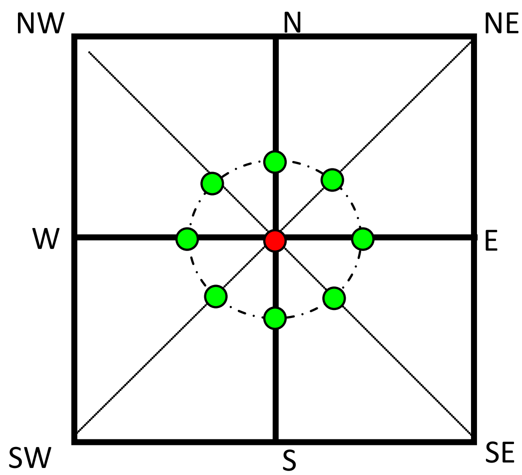
- Formatting the address information was a key step. Made sure cross streets were connected with '&' not with 'at', '/'. ArcGIS understands intersections defined using '&' better.
- Concatenated Q1b Address and Q1b CrossStreets. Inserted a new column after Q1b CrossStreets column, named it, for example, Q1bStreet (it can be anything, it just should be different from other column names). Populated this column with values resulting from CONCATENATE (Q1b Address, Q1b CrossStreets). The reason for doing this was to generate one single column with all street related information for each record collectively. Since each record either has Q1b Address or Q1b CrossStreets information, concatenation was to merge just these two columns. This saved time while running the ArcGIS geocoder as address and cross street both information were in one column.
- Made sure each record had a zip code. Zip code plays an important role while running ArcGIS geocoder. Most of the records in the received spreadsheet had a zip code. However, there were a few blank zip code fields, which were filled in by using Google Maps to locate those records by using other address-related information available, such as Q1b Address, Q1b CrossStreets, or Q1b Landmark. If a record was located on Google Maps, it provided the zip code information for that location. All the blank zip code fields were populated this way.

Two sets of data were required for this geocoding process: survey data with a list of addresses; and GIS data layer that was used as the reference layer (TIGER street layer from the Census). All GIS shapefiles were projected to "NAD 183 State Plane Central Arizona, International Feet" coordinates system. The reference TIGER network was prepared by creating what ArcGIS refers to as an "address locator." This process essentially indexes the reference layer; much like indexing a book. The Address Locator index was created in ArcCatalog in two geocoding styles: street address with and without zip code. Since most of the addresses in the survey file had intersection information instead of specific address information, the intersection option was enabled during the geocoding process. Also, the checkbox of add x- and y-coordinates was enabled so that the output file will contain the x- and y-coordinate information from the geocoding process. Nearly one-half of the survey data was geocoded using this method.

For the remaining survey data not geocodable using the above method, a manual procedure was used by looking up those addresses or landmarks on Google Maps and assigning a location on the map.

After every survey record (both origin Q1 and destination Q7) was geocoded, it was overlaid on the TAZ layer to identify the TAZ for both the origins and destinations. Many survey records with intersection information were located on the boundary of two or more TAZs, which made it hard to assign a particular TAZ. Therefore, after the pretest, WGR was asked to collect the directional information (E, W, N, S, NE, NW, SE, and SW) for each location. Using the directional information, it would become easier to shift the location to a unique TAZ, which helped in determining an appropriate TAZ for each location. This is graphically shown in Figure 3.1.

Figure 3.1 Shift Geocoding Location Based on Direction Provided in Survey



For survey respondents that did not provide direction, a small buffer (0.2 mile) was created around the survey location, and then overlaid that on the TAZ layer to find the multiple TAZs that fall within the buffer. This resulted in identifying more than one TAZ for a significant number of records.

For records that are geocoded within AZ, but are located outside the MAG TAZ boundary, the true lat/long of the location was located and assigned a dummy TAZ number -2 to these records. These records were then assigned to the closest external station TAZ.

There were also some records with some addresses information, but did not have full street location information. These records could not be correctly geocoded. A dummy lat/long (34, -112) and a dummy TAZ number (-1) were assigned to these records.

Table 3.2 provides a summary of the geocoding results for the first two surveys completed. As most of MAG TAZ boundaries line up with cross streets, and since many records have only cross-street information, we ended up with multiple TAZs for many survey records. Also, many respondents were comfortable giving cross streets rather than exact addresses. An improvement to this was to ask directional quadrant information (NW, SE, etc.) in the first full survey; and this was achieved with limited success.

Table 3.2 Geocoding Results from First Two Surveys

Geocoding Status	Pretests (Fall Frenzy)		First Full Survey (Diamondbacks Baseball Game)	
Missing address	14	9%	17	5%
One unique TAZ	85	53%	154	46%
Two or more TAZs	46	29%	139	42%
External TAZ	16	10%	24	7%
Grand Total	161	100%	334	100%

About 37 percent (60 out of 161) of the Fall Frenzy survey records had either more than one TAZ identified or missing address information. Similarly, about 47 percent (156 out of 334) of the Diamondbacks Game survey records had either more than one TAZ identified or missing address information. The survey records that do not have any address information, which were not geocoded, were discarded and the surveys considered incomplete. However, the survey records that have multiple TAZs were kept, but a unique TAZ had to be first identified.

CS and MAG discussed several options on how to best handle geocoded surveys that have more than one TAZ. The goal was two-fold: first, not to eliminate any these survey records that have multiple TAZs assigned; and second, limit the cases that result in multiple TAZs in future survey efforts. So the consensus of dealing with geocoding cross streets was to:

- Continue to collect information on directional quadrants. WGR will improve the collection of addresses and quadrants in future survey efforts so that the multiple TAZ issue can be eliminated.
- Clean the survey data based on chosen mode and accessibility. Another way of cleaning the data is to look into the chosen mode in the survey, determine which TAZ is most likely to have access to that mode, and then assign a TAZ. That is, if the chosen mode is light rail to the special event, and if only one TAZ among the multiple TAZs has direct access to LRT, then that TAZ will be the chosen TAZ.
- If the above methods are not successful for some survey records, then we will pick a TAZ randomly from records with multiple TAZs for estimation purposes. Though this method may seem arbitrary, there are several reasons for employing this method and not having to deal with a lot of error too. These are stated below.
  - TAZs that share boundaries are most likely going to have the same amount of transit accessibility, and so it does not matter which TAZ is ultimately chosen.

- Choosing a location or TAZ just across the street from the correct location did not introduce much error at all as the land use was relatively very similar.
- The special events model (SEM) has an origin choice model component, which has size variables that define the TAZ characteristics, and the model also estimates relative shares of trips for every TAZ.
- For mode choice model, this was not a huge problem as the skims are very similar among adjacent TAZs. Also, other major variables used in the model related to impedance did not vary much between adjacent zones.
- The surveys conducted have indicated very few instances of the same pairs of adjacent zones being geocoded in the data. Therefore, it was highly unlikely to cause any bias by selecting one TAZ over another.
- Discarding survey records with multiple TAZs will not only greatly reduce the sample for model estimation, but would actually bias the survey results geographically as trips originating from TAZs that share the same major cross streets as the adjacent TAZs would be eliminated. Therefore, many records were salvaged using the above steps.

3.4 FULL SURVEYS

Basic descriptive statistics were examined for the weighted survey data. The descriptive analysis is being used to guide model development and estimation. The following is an overview of important findings from the descriptive statistics.

Origin and Destination Location Type

The majority of respondents traveled from home to the event, and about the same percentage indicated that they were returning home after the event. With the exception of the PF Chang's Marathon and the Spring Training baseball game, between 75 and 98 percent of attendees traveled from home to attend each event. The low percentages of home origin locations for the PF Chang's Marathon and Spring Training game are due to the high percentage of out-of-town attendees at these events. Over 25 percent of attendees at these events traveled from a hotel. All other events have an average of 6.3 percent attendees originating from hotels. Trips from work make up only 2 percent of all special event trips. Not surprisingly, events taking place on a weekday evening had a much higher percentage of trips originating at work. On average, work trips comprised 6.3 percent of all trips to these events.

Mode Choice

Table 3.3 gives the percentage of attendees traveling by each of the nine aggregated modes for light-rail and non-light-rail accessible events. Party size and mode were used to further classify attendees by drive alone and size of carpool.

Table 3.3 Mode Used to Travel to Special Event

	Percentage of Event Attendees	
	Light-Rail Accessible	Non-Light-Rail Accessible
Drive Alone	4.90%	7.50%
2 Person Carpool	22.80%	28.90%
3+ Person Carpool	52.40%	60.80%
Light Rail – Walk	4.50%	0.10%
Light Rail – Drive	8.80%	0.00%
Bus – Walk	1.70%	1.40%
Bus – Drive	0.60%	0.00%
Nonmotorized	4.30%	1.20%

For the events with light-rail access, 80.1 percent of attendees traveled to the event by auto modes, 15.6 percent by transit, and 4.3 percent by nonmotorized modes. Of the auto travelers, 94 percent were in carpools. Overall, 13.3 percent of special event attendees traveled by light rail if the event was near light rail. For the events without light-rail access, 97.2 percent of attendees traveled by auto, while 1.6 percent of attendees took transit and 1.2 percent of attendees walked or biked. Of all transit riders, 44 percent walked to access transit, while the other 56 percent drove or were dropped off at the transit station or stop.

Party Size

Not surprisingly, the majority of attendees traveled in groups to the event. Only 6.1 percent of attendees traveled alone, while 45.2 percent traveled in groups of four or more. The Crossroads of the West gun show had a high number of attendees traveling alone. Given the nature of this special event, which could be viewed as similar to a shopping trip, this result was not surprising. Concerts with higher ticket prices such as the KISS concert and Conan O'Brian Tour, as well as the college and NBA basketball games, also had lower average party size compared to other events.

Length of Stay

Almost 80 percent of attendees planned to stay at the event for over three hours or for the whole event. Not surprisingly, all-day events or events with long durations had fewer attendees planning to stay at the event for the full duration. Shorter duration events, such as the NBA and ASU basketball games, had more than 87 percent of attendees planning to stay the entire length of the event.

Household Size

About 40 percent of the attendees reported living in households of four or more persons, while only 9 percent of attendees reported living in one-person households. The average household size of event attendees is much higher than for all households in the Phoenix region, where only 25 percent of households are composed of four or more persons, and 27 percent of households are composed of one person (U.S. Census Bureau, 2010). Average household size was highest for the Fall Frenzy Festival, which attracts a younger crowd of college and high school age groups; and the State Fair, which is a family-oriented event. Wrestlemania also had attendees from large households; most likely due to a significant number of attendees being of middle age, rather than retired or post-college.

Household Income

As shown in Table 3.4, compared to the general population in the Phoenix region, special event attendees have higher income.

Table 3.4 Household Income Distribution for Special Event Attendees and the MAG Area Population

Household Income	Survey	ACS 2006-2008 Data
Under $20,000	7.74%	14.24%
$20,001 to $40,000	13.15%	20.56%
$40,001 to $60,000	14.97%	18.41%
$60,001 to $100,000	31.67%	24.90%
$100,000+	32.46%	21.89%

Over 32 percent of event attendees have household incomes above $100,000, compared to only 22 percent in the general population (U.S. Census Bureau, 2010). This is not surprising, given that most special events charge a substantial admission price. Average household income was lowest for events with free or low-admission price, such as the Pride Parade, First Friday Art Festival, and the Arizona State Fair.

Vehicle Availability

Table 3.5 shows the vehicle availability distribution for surveyed event attendees compared against the general population of the MAG region. Over 74 percent of attendees reported living in households with two or more vehicles. This is higher than in the Phoenix region, where only 57 percent of households have two or more vehicles (U.S. Census Bureau, 2010).

Table 3.5 Vehicle Availability Distribution for Event Attendees and the MAG Area Population

Number of Vehicles	Survey	ACS 2006-2008 Data
0 Vehicles	3.5%	5.95%
1 Vehicle	21.8%	37.50%
2 Vehicles	40.3%	39.57%
3+ Vehicles	34.3%	16.98%

3.5 Challenges During Data Collection

The pretest provided invaluable insights into the way questions needed to be framed, response rates, survey techniques, and challenges faced during data collection. Subsequently, these findings were used to modify the survey methodology and instrument. Listed below are the main challenges that the project team faced throughout the survey process, and the measures that were taken to alleviate the corresponding problems.

- **Getting permissions from the event organizers to conduct surveys**. MAG officials were called upon to make the necessary contacts to obtain permissions directly with the event staff. If no permission was granted, the project team planned on conducting the surveys close to the event venue, but not on their property. This included sidewalks, public right-of-way and transit stops/stations. The feasibility of this type of solution depended on the particular layout of the venue and the nature of the event.
- **Differences in attendee profiles**. Each event is different and attracts a sociodemographic profile that depends on the type of the event, which makes it difficult to get a representative sample. Therefore, large enough samples were targeted so that the desired statistical significance could be achieved at a reasonably low margin of error. This issue also was reflected in patron counts for data expansion purposes. Different time periods and different approaches to venues some times were characterized by different modes of access and different socioeconomic characteristics of patrons. The expansion procedures were based on time period-specific and gate-specific patron counts.
- **Obtaining exact home addresses**. This was a big challenge since many respondents, for privacy reasons, would give only the closest cross-street information. Geocoding such responses and determining a unique zone for these locations proved difficult. Whenever cross-street information was obtained, respondents were also asked to provide the directional quadrants, which were used to assign the corresponding traffic zone associated with each respondent's origin and destination.

4.0 Special Events Model Development Plan

This chapter provides a description of the model development plan that includes special event trip generation, origin choice models for special event trips, mode choice of special event travelers, and assignment of special event trips.

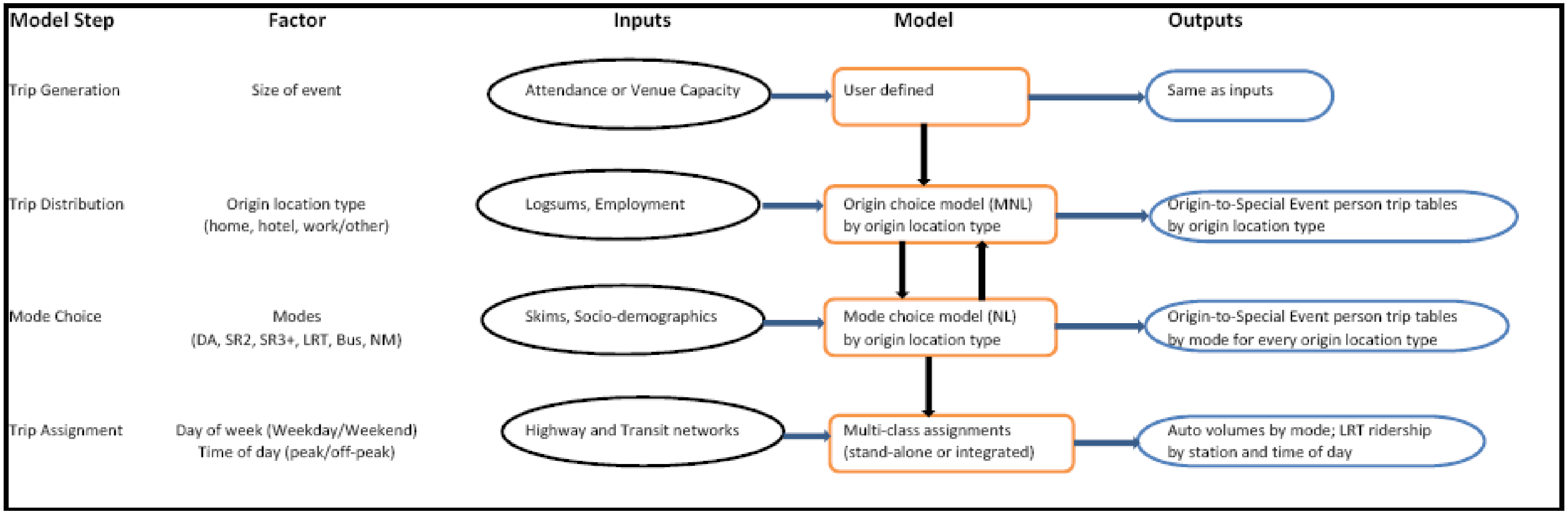
4.1 CONCEPT DEVELOPMENT

The objective of SEM is to forecast travel demand pertaining to different types of special events in the MAG region. The model will be able to predict the number of trips by location type (home-based, hotel-based, work/other-based); origin TAZs of these trips; mode choice of trips to special events; and vehicle-miles traveled (VMT) generated as a result of special events. All the data collected were used to develop a special events modeling framework that can be used to model different types of special events. Figure 4.1 provides a flowchart of the SEM model.

The SEM is a standalone model and is designed very similar to a daily model that can be applied separately to each type of special event and for each day of week (weekday, Saturday, or Sunday). The SEM components parallel the basic components of the Four-Step model that can be applied differently, depending on the event type or day of week. The following factors were considered while developing the structure for the SEM:

- **Size or attendance at an event.** The size or attendance at an event affects the trip generation characteristics of special event trips, which in turn affects the transit ridership to and from these events, especially large events that are in the vicinity of the light rail.
- **Origin type of special event trips.** The four major types of origins that were collected from the surveys are home-based, work-based, hotel-based, and other-based. It is important to consider these origin types while modeling special event travel, as this affects the origin choice or distribution of trips in the region. Also based on where the trip has started, the party size, mode choice, and time of day could change significantly.
- **Proximity to LRT.** This affects the choice of mode directly for trips to and from special events that are close to the LRT corridor. Almost one-half of the events surveyed has light-rail access, and so, as expected, survey results indicate high light-rail ridership to these events.

Figure 4.1 SEM Flowchart



- **Day of week and time of day.** The special events in the region happen on weekdays and weekends, and also during peak and off-peak periods. This is important to consider as it affects the time-of-day choice of special event trips. Also, for model estimation, it is necessary to attach the appropriate skims from the model (peak or off-peak) to the survey records, depending upon the time of day of the trip that occurred. For weekend special event trips, off-peak or free-flow skims will be used in the estimation.
- **Event market area.** Some special events draw a large portion of attendees from out of town (or external to the MAG modeling area). This will affect the percentage of trips that originate at a hotel and the socioeconomic characteristics of the event attendees.

4.2 Trip Generation

The objective of trip generation is to develop a procedure that predicts the number of person trips traveling to and from special events. The number of person trips is based on total anticipated attendance at the event.

Methodology

This is the first step in the special event modeling process; however, this is not a model, but a procedure to estimate number of person trips. This serves as a key input into the special event model, which is nothing but the estimated attendance at special events for each day of the event. For multiple day events, total event attendance will be divided into average daily attendance for each event date; most likely using an average attendance rate for each weekday, Saturday, and Sunday event, before being used as an input into the model. If actual attendance is unknown, the user can run different scenarios with different levels of estimated attendance. Number of person trips in the base year is equal to the attendance at the event. For the forecast year, attendance is predicted based on base year attendance, capacity at the event venue, and predicted population and employment growth between the base year and future year. The forecast year attendance will be capped at the venue capacity. The output from this step will be person trips for each event analyzed. Table 2.2 in Chapter 2 provides the actual attendance from the surveyed events, compared against the previous attendance. In all of these events, the actual attendance is very close to the previous attendance, indicating that under certain circumstances, historic data can be used with a good degree of confidence to predict future attendance.

Data Required for Estimation

The following data was used for estimation:

- Estimate of base year attendance for each modeled event for each day of event;
- Forecast year employment and population; and
- Venue capacity, where applicable.

Data Required for Application

The following data is required for application and will be supplied as input into the model by the user:

- Estimate of base year attendance for each modeled event for each day of event;
- Growth rate from base year to forecast year; and
- Venue capacity, where applicable.

4.3 TRIP DISTRIBUTION

The objective of trip distribution is two-fold. First, a procedure that predicts the probability of trips beginning or ending at home, work, hotel, or other location was developed. These probabilities were derived and applied at the TAZ level. Second, it predicts the location of these origins or the probabilities of such trips occurring in every TAZ in the region.

Methodology for Predicting Origin Type

The surveys gather information on origin type of trips destined to special events that are classified into home-based, work-based, hotel-based, and other-based. The origin type depends on the location of the special event venue, time of day of the event start time, and the day of week of the event. The weighted survey results were used to calculate the percentage of trips starting from different origin types by major special event category, as shown in Table 4.1. For example, the surveys indicate that a much higher percentage of trips originate at work places for an event on a weekday evening (e.g., KISS concert); and events with a large portion of out-of-town attendees (e.g., PF Chang's Marathon) have a high percentage of trips originating or ending at a hotel.

The percentages of origin type was determined for each event based on a set of event characteristics, including day of week, start and end time of event, and event market area. These percentages serve as rates or probabilities of special event trips that are home, work, hotel, or other-based. In the absence of data to provide alternate assumptions, these percentages are held constant for forecast years. A similar approach was used to allocate external trips to and from special events. The survey dataset was used to identify the most probable external stations that these trips originate from.

The surveys collected have indicated that there are instances where the final destinations, after the event, are different from the first origins of these trips. However, after examining the survey data from all the 20 special events, it is found that about 90 percent of special event travelers return the same location, that is, their final destination is same as their origin. About 80 percent of the surveyed trips are home-event-home, 8 percent are hotel-event-hotel, and a low 3 percent are work-event-home. Therefore, it will be assumed that all trips that originate at home, hotel or other location types will return to the same location, while all of the work-based trips will return to home location type.

Table 4.1 Table 4.1presents the percentage of special event attendees by event and origin location type from all the 20 special events that were surveyed. The origin location type is predominantly home-based, followed by hotel-based and other-based that is dependent on the type of the event. The work-based origin type is almost negligible in most of the events, but is significant for multiple and weekday events.

Table 4.1 Distribution of Origin Location Type by Special Event

	Event	Home	Work	Hotel	Other
1	Arizona Fall Frenzy	92.43%	3.70%	3.86%	0.00%
2	Diamondbacks game	95.67%	0.14%	3.90%	0.29%
3	Arizona State Fair	89.93%	3.52%	5.53%	1.02%
4	AFL Rising Stars Game	93.82%	0.00%	6.18%	0.00%
5	ASU Football Game	95.36%	0.38%	2.13%	2.13%
6	KISS Concert	93.50%	4.97%	1.51%	0.02%
7	Cardinals Game	90.22%	0.15%	7.17%	2.46%
8	Mill Avenue Block Party	75.75%	0.90%	21.56%	1.80%
9	PF Changs Marathon	66.40%	0.00%	27.26%	6.33%
10	FBR – WM Golf Open	83.97%	0.36%	10.54%	5.13%
11	ASU Basketball Game	92.14%	0.90%	5.06%	1.90%
12	NBA Phoenix Suns Game	79.11%	7.28%	11.78%	1.84%
13	Spring Training Game	47.42%	1.70%	41.24%	9.64%
14	Wrestlemania	71.71%	0.38%	25.27%	2.65%
15	Pride Parade	94.22%	1.08%	2.17%	2.53%
16	Crossroads of the West Gun Show	97.71%	1.03%	0.00%	1.27%
17	Conan O'Brien Show	90.84%	6.90%	0.70%	1.56%
18	First Friday	90.40%	7.98%	1.07%	0.55%
19	Diamondbacks game	94.27%	0.00%	5.50%	0.23%
20	NBA Phoenix Suns Game	91.24%	0.00%	7.06%	1.69%

Data Required for Estimation

The following data was used for estimation:

- Surveyed event characteristics, including location of event; whether event is accessible to light rail, day of week, start and end time event; and whether event is regional or national event. National events are those that draw a higher percentage of non-MAG residents who either drive or fly into the region.
- Weighted survey dataset indicating whether the attendees' prior and post event location was home, work, hotel, or other.
- Weighted survey dataset indicating whether origin or destination location was outside/external to the MAG region.

Data Required for Application

The following data is required for application and will be supplied as input into the model by the user:

- Event characteristics including event TAZ, day of week, start and end time of event, and whether event is regional or national event.

Methodology for Distributing Person Trips to Origin TAZs

The destination TAZ of all special event trips is the TAZ in which the special event venue is located. Therefore, the trip distribution procedure predicts the origin choice of trips to the event by origin type, that is, home, work, hotel, or other-based. Separate trip distribution or destination (or origin choice) models were estimated for trips with different location types (i.e., trips that begin at home, work, hotel, and other). In addition, person trips originating or ending at locations outside of the MAG region are assigned to the most probable external TAZ, as indicated by the surveys.

It was determined that there were enough survey samples to estimate robust multinomial logit origin choice models. For origin choice models, every internal TAZ in the MAG region was a potential choice in the estimation dataset. However, while estimating these models for each location type, TAZs that do not have the pertinent characteristic, such as residential population, employment, or hotels, were made nonavailable. For example, for the home-based location type, TAZs without residential population were not considered in the choice set. Many explanatory variables were examined in the origin choice model, including city or regional-area-based constants; mode choice logsums (which will be derived from mode choice models by home, work, hotel, and other location type) and other measures of travel impedance; various functional forms of distance from event, area type (i.e., suburban, urban, rural, CBD/downtown); and size variables, including number of households, hotel rooms, and/or employment by type of employment. The forecast year distribution will use the estimated model and forecast year zonal-level input variables.

For trips originating or ending outside of the MAG region, allocation factors based on surveyed events information were used to assign the person trips to each of the external stations or TAZs. The surveyed dataset was used to obtain a percentage of trips entering and exiting the MAG region at each external station for all events.

Data Required for Estimation

The following data was used for estimation:

- Survey data assigned to home, work, hotel, and other origin and destination.
- Weighted survey data providing origin and destination TAZs, including external TAZs, where applicable.
- Mode choice logsums, provided from the mode choice estimation results.
- Peak and off-peak skim data providing zonal level of service (LOS) characteristics. Peak data will be attached to weekday all-day and peak-period events, and off-peak data will be attached to weekend and off-peak weekday events.
- Zonal data for the base year, including area type, socioeconomic data, and hotel employment.

Data Required for Application

The following data is required for application:

- Mode choice logsums provided from the mode choice estimation results;
- Peak and off-peak skim data providing zone-to-zone LOS characteristics for the forecast year; and
- Zonal data for the forecast year, including area type and socioeconomic data.

4.4 MODE CHOICE

The objective of mode choice is to develop a procedure to predict mode of travel to and from special events. This model determines the probabilities of choosing different modes at the TAZ level by major special event category and origin location type.

Methodology

A nested logit model, consistent with MAG's current passenger mode choice model (at the higher level nests), was estimated. The major modes, as derived from the survey data, include drive alone, two-person carpool, three-person plus carpool, light-rail walk, light-rail drive, bus-walk, bus-drive, and nonmotorized (walk/bike). Tables 4.2 and 4.3 give the unweighted and weighted modal shares by event. Separate models for events with access to light rail and without access to light rail, as well as one joint model, were estimated. Many explanatory variables were examined in the mode choice model, including alternative-specific constants; LOS variables, including in-vehicle travel time (IVTT), out-of-vehicle travel time (OVTT), and cost; socioeconomic variables, including household income, household size, and number of vehicles; event characteristics, such as event type and location, time-of-day, and day of week; origin or destination zonal variables; and nesting coefficients. Different nesting structures, interaction variables, and various functional forms for the LOS variables were examined.

For trips originating or ending outside of the MAG region, allocation factors based on surveyed events were used to assign the person trips to modes. The surveyed dataset was used to obtain a percentage of trips entering and exiting the MAG region by each mode. Given the nature of these person trips, the modes will most likely be limited to auto modes, including drive-alone, two-person carpool, and three-person plus carpool. The same set of factors will be used in the base and forecast years. An estimate of trips that involve flying into the region and traveling directly to the event was derived; however, the small percentage of survey data indicated these trips could be ignored.

Data for Estimation

The following data was used for estimation:

- Weighted survey data with mode of travel to and from the event; origin and destination TAZs, including external TAZs, where applicable; and socioeconomic data.
- Peak and off-peak skim data providing zonal LOS characteristics. Peak data will be attached to weekday all-day and peak-period events, while off-peak data will be attached to weekend and off-peak weekday events.
- Zonal data for the base year, including area type and socioeconomic data.

Data for Application

The following data is required for application:

- Peak and off-peak skim data providing zonal LOS characteristics for the forecast year; and
- Zonal data for the forecast year, including area type and socioeconomic data.

Table 4.2 Unweighted Modal Shares by Special Event

	Event	Drive Alone	Carpool 2	Carpool 3+	LRT – Walk Access	LRT – Drive Access	Bus – Walk Access	Bus – Drive Access	Nonmotor	Other	Total
1	Arizona Fall Frenzy	17	35	52	7	2	1	0	9	2	125
2	Diamondbacks game	36	128	96	5	19	5	0	4	1	294
3	Arizona State Fair	100	192	265	0	0	31	3	3	4	598
4	AFL Rising Stars Game	18	39	27	0	0	0	0	0	0	84
5	ASU Football Game	21	106	171	12	30	7	2	32	6	387
6	KISS Concert	46	172	95	0	0	3	0	2	8	326
7	Cardinals Game	28	158	245	0	0	3	0	5	7	446
8	Mill Avenue Block Party	44	109	183	46	90	28	7	27	31	565
9	PF Changs Marathon	51	111	147	15	13	5	5	13	114	474
10	FBR – WM Golf Open	79	244	195	0	0	4	0	13	42	577
11	ASU Basketball Game	23	41	24	2	3	2	0	9	5	109
12	NBA Phoenix Suns Game	38	113	85	19	13	1	0	12	9	290
13	Spring Training Game	18	51	61	0	0	0	0	9	4	143
14	Wrestlemania	22	121	170	3	0	10	2	9	28	365
15	Pride Parade	25	34	33	4	7	3	0	14	1	121
16	Crossroads of the West Gun Show	25	28	12	0	0	1	0	0	0	66
17	Conan O'Brien Show	25	141	33	9	11	0	0	5	6	230
18	First Friday	48	71	89	39	17	7	1	29	10	311
19	Diamondbacks game	20	85	72	10	15	0	1	6	1	210
20	NBA Phoenix Suns Game	31	76	45	9	17	0	0	7	9	194
Total		715	2,055	2,100	180	237	111	21	208	288	5,915

Table 4.3 Weighted Modal Shares by Special Event

	Event	Drive Alone	Carpool 2	Carpool 3+	LRT – Walk Access	LRT – Drive Access	Bus – Walk Access	Bus – Drive Access	Nonmotor	Other	Total
1	Arizona Fall Frenzy	761	3,090	8,575	851	224	90	0	1,231	179	15,001
2	Diamondbacks game	1,435	10,205	15,009	359	1,734	598	0	419	179	29,938
3	Arizona State Fair	6,047	11,155	30,107	0	0	2,103	47	103	138	49,700
4	AFL Rising Stars Game	431	1,414	2,705	0	0	0	0	0	0	4,550
5	ASU Football Game	1,384	10,115	32,229	1,574	3,698	835	239	5,057	811	55,942
6	KISS Concert	645	4,610	4,573	0	0	15	0	130	902	10,875
7	Cardinals Game	822	15,734	45,849	0	0	277	0	288	1,135	64,105
8	Mill Avenue Block Party	1,841	9,321	46,729	5,264	18,212	3,214	926	3,121	11,372	100,000
9	PF Changs Marathon	4,959	18,810	46,597	3,591	2,650	898	769	1,924	21,759	101,957
10	FBR – WM Golf Open	12,236	38,889	60,884	0	0	1,110	0	1,275	7,265	121,659
11	ASU Basketball Game	1,682	4,264	1,749	107	116	61	0	452	610	9,041
12	NBA Phoenix Suns Game	1,391	5,615	7,878	1,198	623	17	0	470	1,214	18,406
13	Spring Training Game	562	2,403	5,076	0	0	0	0	620	194	8,855
14	Wrestlemania	2,231	16,811	44,790	310	0	1,057	98	1,467	5,106	71,870
15	Pride Parade	1,079	2,935	5,266	410	777	173	0	1,230	86	11,956
16	Crossroads of the West Gun Show	1,214	2,110	1,638	0	0	4	0	0	0	4,966
17	Conan O'Brien Show	348	2,738	1,455	366	395	0	0	96	51	5,449
18	First Friday	632	1,860	4,602	1,010	577	112	61	823	301	9,978
19	Diamondbacks game	965	7,135	12,403	672	1,385	0	126	336	126	23,148
20	NBA Phoenix Suns Game	1,363	6,432	6,985	894	1,533	0	0	426	788	18,421
Total		42,028	175,646	385,099	16,606	31,924	10,564	2,266	19,468	52,216	735,817

4.5 TRIP ASSIGNMENT

The objective of trip assignment is to assign special event trips to the MAG highway and transit network, along with rest of the passenger autos and commercial vehicles.

Methodology

The special event trip tables from the mode choice procedure are fed into the existing highway and transit assignment model of MAG's travel model. For weekday events, the existing weekday highway and transit skims are used. The special event trips can be assigned along with other passenger and commercial vehicles to account for congestion. For weekend events, the nonpeak weekday skims should be used as weekend skims are not available. The weekend-based special event trips will be assigned separately, as there is no need to account for congestion during weekends. For temporary events, modifications to the highway or transit network should be made before implementation to account for event-related street closures. It is also important in considering the impact of weekday events ending (or starting) during peak periods. In addition, for air quality analysis, it is important for running the assignment process. The LRT ridership by station and time period will also be estimated based on transit assignments. Any duplication of special event trips, as a result of the passenger model, which may have accounted for these from the household surveys, will be discounted prior to running the assignments.

The special events are designed for projection on a daily basis, and therefore, each individual event is modeled. However, it may be desirable to obtain yearly trip totals. This is especially important for transit revenue projections. For recurring events, instead of modeling each event separately, an annualization factor can be assigned to determine yearly passenger and vehicle trips. The annualization factor is simply the total number of annual events, or event days. For example, the Arizona Cardinals play approximately 8 to 10 home weekend games each year (including preseason and depending on the number of weekday night games scheduled), and so the annualization factor would be between 8 and 10 for the weekend games. The annualization factor will depend on the number of weekday, Saturday, and Sunday events that occur each year, since different models will be developed depending on the day of week.

The SEM models are developed as standalone procedures in TransCAD. The model was implemented using TransCAD GISDK script. This allowed us to take advantage of the existing databases of the MAG TransCAD based model, and to assign the trip tables to the TransCAD networks.

The SEM was designed to be easily customized with different special events activated for a particular travel scenario and day of week. For example, for short-term forecasts, MAG may want to model one individual special event. For transit forecasting, MAG may choose to select only events that occur in one geographical area (such as a transit corridor), and model those events simultaneously. The model can also be run for all special events predicted to occur over a set time period (such as a week, month, or year). This would be desirable for revenue projections. In addition, the model can be run for any base or forecast year as long as model inputs, such as event and venue information, sociodemographic data, and highway and transit networks are available.

Data for Application

The following data is required for application:

- MAG passenger auto and truck trip tables; and
- MAG highway and transit network.

5.0 Special Events Model Estimation Results

This chapter provides a description of the required model inputs and model estimation results, including trip generation, time of day, origin choice, mode choice, and trip assignment procedures and models. The application of these models was developed in TransCAD GISDK.

5.1 MODEL OVERVIEW

The objective of the special events model (SEM) is to forecast travel demand pertaining to different types of special events in the MAG region. The model estimates the number of trips by location type (home-based, hotel-based, work/other-based); origins of these trips (identified by TAZ from the MAG travel demand model); mode choice of trips to special events; and VMT generated as a result of special events.

The SEM is a standalone model and is designed similarly to a daily travel demand model. It can be applied separately to each type of special event and for each day of week (weekday, Saturday, or Sunday). The SEM components parallel the basic components of the Four-Step model that can be applied differently, depending on characteristics of the event or day of week.

5.2 MODEL INPUTS

The SEM model requires as input data the event and forecast-year information. Event-level inputs are unique to each special event that is modeled, while forecast-level inputs are specific to the forecast year and are identical for all special events that are modeled within that year.

Event-Level Inputs

1. **Base Year Daily Attendance**. Base year (year 2010) daily attendance for the event is an input into trip generation. For multiple day events, event attendance should be inputted by the user as the daily attendance for each event date; most likely using an average attendance rate for each weekday, Saturday, and Sunday event. If actual attendance is unknown, the user can run different scenarios with different levels of estimated attendance.
2. **Forecast Year Daily Attendance**. The attendance to the event can be input directly, rather than relying on the model to forecast attendance. This input should be left blank or recorded as zero if Base Year Daily Attendance is to be

used in conjunction with Annual Population Growth Rate and Venue Capacity to predict forecast year daily attendance.

3. **Venue Capacity.** For an event that takes place in a set venue, the venue capacity is entered into the model. Venue capacity is used to cap future year daily attendance at the event. If attendance is directly input (via Forecast Year Daily Attendance), this input is not used in the model.
4. **Event TAZ(s) location**. The TAZ in which the event takes place is an input into the model and used for calculating LOS and accessibility variables for the mode choice and destination choice models. For events taking place over more than one TAZ, multiple TAZs can be entered.
5. **Day of Week of Event**. Information on whether the event takes place on a weekday or weekend is used for calculating location type (i.e., home, work, hotel, or other origin location); distribution of event attendees; peak and off-peak LOS data; and for implementation within assignment. Events falling on weekday holidays can be treated as a weekday or weekend event at the user's discretion.
6. **Start and End Time of Event**. The start and end time of the event is used for calculating location type distribution of event attendees, peak and off-peak level-of-service data, and for implementation within assignment.
7. **Set vs. Continuous Start and End Time**. Distinguishing if the special event has a set start and end time, where all attendees arrive during a set time before the event and leave immediately after the event, or if the event has a continuous start and end time, such that attendees come and go throughout the duration of the event is important for calculating location type distribution of event attendees and time-of-day analysis.
8. **Parking Cost**. The event parking cost is used to compute the cost of traveling to the event by automobile modes for mode choice. Parking cost is assumed the same for all travelers for an event.
9. **Event Market Area.** Some special events have attendees that are mostly residents of the Phoenix area; whereas, other special events attract attendees from all over the State and Nation. Surveyed events were classified into categories based on the number of hotel-based attendees at the event. Event market area is used for calculating location type distribution of event attendees, and for determining the socioeconomic make-up (i.e., household income-level and vehicle availability) of event attendees. Each event will be classified as either regional, multiregional, or national event using the following definitions as a guide:

Regional Event. These events draw an audience mostly from the MAG region. In general, these events occur regularly and occur frequently in cities in the MAG region. For these regional events, hotel-based trips make up to 6 percent of trips to the surveyed event.

i. Regional Events from Survey. Fall Frenzy, Diamondbacks Major League Baseball (MLB) game, State Fair, Arizona Fall League Rising Stars game, Arizona State University (ASU) football game, KISS concert, ASU basketball game, Pride Parade, Crossroads Gun Show, Dodge Theatre, and First Friday.

Multiregional Event. These events draw an audience beyond the MAG region, typically occur only a few times per year, and infrequently take place in other nearby cities (e.g., a sporting event in which the opponent is from a nearby city such as Los Angeles, a sporting event that does not occur in nearby areas, or a sporting event with a high-ranked team). For multiregional events, hotel-based trips make up 7 to 12 percent of trips to the surveyed event.

ii. Multiregional Events from Survey. Cardinals National Football League game, Waste Management Golf Tournament, and Suns National Basketball Association game.

National Event. These events most likely attract a nationwide audience, occurring very few times per year, and are only held in Phoenix or very few other areas. These events also draw a high number of hotel-based attendees, and therefore may include events in which event attendees stay in hotels even if their home residence is in the MAG region (i.e., Mill Avenue Block Party). For national events, hotel-based trips make up 22 to 41 percent of trips to the surveyed event.

iii. National Events from Survey. Mill Avenue Block Party/Insight Bowl, PF Chang's Marathon, MLB Spring Training, and Wrestlemania.

Forecast-Level Inputs

1. **Forecast Year.** This is nothing but the calendar year that is used as an input in trip generation for determining forecast year attendance.

2. **Annual Population Growth Rate.** Annual population growth rate between the base year (year 2010) and the forecast year is used as an input in trip generation for determining forecast year attendance.

3. **Forecast Year Time-of-Day Skims.** Skims by time of day are used to calculate LOS variables and accessibility measures for the mode choice and origin choice models. Though the current skims are developed for four time periods (i.e., those currently in the MAG model: AM peak, mid-day, PM peak, night), hourly skims, if prepared in the future, can also be used as an input into the SEM.

4. **Forecast Year Zonal Data.** Zonal data is used for calculating land-use and accessibility measures around the event and origin/destination trip TAZ for use in mode choice and origin choice models.

5. **Forecast Year Hotel Employment.** Hotel employment at the TAZ level is used for forecasting origin and destination of trips made to and from hotels.

6. **Auto Operating Cost.** The operating cost is used to compute the cost of traveling to the event by automobile modes for mode choice. If an operating cost is not input by the user, then a default value of $0.15 will be used. The default value (for year 2010) is $0.15 per mile traveled. This conservatively reflects a $3.00 per gallon fuel cost and 20-mile per gallon average fuel economy. If the user inputs a value, then the user input value will override the default value.

5.3 TRIP GENERATION

Model Overview

The trip generation procedure predicts the number of person trips traveling to and from special events. The number of person trips is based on total anticipated attendance at the event.

Methodology

This is the first step in the special event modeling process. The trip generation procedure estimates the number of person trips for each event. The number of person trips in the base year is equal to the attendance at the event. The number of person trips traveling to the event is assumed equal to the number of person trips traveling from the event. For the forecast year, the number of person trips is predicted based on base year attendance, capacity at the event venue, and predicted population growth between the base and forecast year. The forecast year attendance will be capped at the venue capacity.

$$\text{Forecast Year Person Trips} = \min \{ A * (1+G)^T, V\}$$

Where:

A = Base Year attendance;

G = Population annual growth rate;

T = Forecast Year – Base Year; and

V = Venue capacity.

As an alternative, the forecast year attendance to the event can be input directly, rather than relying on the model to forecast attendance.

The output from trip generation for each event is the number of person trips traveling to and from the event. The segmentation of trips by origin location type is discussed under trip distribution below.

5.4 TIME OF DAY

Model Overview

The time-of-day procedure determines arrival and departure time distribution of person trips, and determines the number of trips traveling within each of the four time periods within the MAG model.

Methodology

While each of the surveyed events has unique attendee arrival patterns, simplifications were made to assign arrival times within the SEM. Arrival time distributions were determined based on the most common arrival time distributions for set start and end time events and continuous start and end time events. Departure times were based on information pertaining to how long event attendees planned to stay at the event.

For set start and end time events, arrival times for events were determined based on averaging the arrival time patterns for each event. Table 5.1 shows the arrival patterns for the set start and end time events. Departure time at events were estimated based on the planned length of time distributions for each event survey participants planned to stay at the event compared to the event duration. Table 5.2 shows the planned duration distributions for the set start and end time events. Note the Pride Parade was considered a set start and end time event; however, due to the festival following the event, it can also be considered a continuous start and end time event. Therefore, it was not used for determining start and end time event arrival and departure patterns.

Table 5.3 shows the distribution of arrival times and departure times used in the SEM model in 30-minute increments. All event attendees are assumed to arrive between three hours before the event and one-half hour after the event start time, and leave between one hour before the event and one-half hour after the event end time.

For continuous start and end time events, arrival time is distributed uniformly (using one-half hour increments) between the event start time and three hours before the event end time. Each trip is assigned an event duration with 20 percent of attendees staying at the event for two hours, 30 percent of event attendees staying for three hours, 30 percent of event attendees staying for four hours, and 20 percent of event attendees staying for five hours. This was derived from the survey data shown in Table 5.4. Departure time is determined based on arrival time and event duration with all event attendees leaving at or before the event end time.

Table 5.1 Set Start and End Time Arrival Time Distributions

	Dback	AFL	ASU	KISS	Cardinals	ASU BB	Suns	Spring Training	Wrestlemania	Dodge Theater	MLB	NBA
4 hours before event start time	0%	0%	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3.5 hours before event start time	0%	0%	11%	0%	1%	0%	0%	0%	0%	0%	0%	2%
3 hours before event start time	0%	0%	14%	3%	2%	0%	0%	0%	4%	0%	1%	1%
2.5 hours before event start time	4%	0%	17%	3%	4%	0%	2%	0%	5%	0%	8%	11%
2 hours before event start time	13%	5%	15%	7%	3%	0%	5%	14%	10%	1%	18%	26%
1.5 hours before event start time	24%	5%	15%	10%	4%	4%	7%	9%	18%	4%	19%	10%
1 hour before event start time	28%	23%	11%	9%	26%	19%	25%	22%	22%	5%	25%	19%
0.5 hour before event start time	17%	16%	8%	33%	28%	66%	39%	21%	23%	17%	15%	17%
At event start time	14%	51%	5%	27%	30%	11%	19%	19%	6%	51%	10%	11%
0.5 hour after event start time	0%	0%	0%	6%	3%	0%	3%	15%	9%	22%	5%	4%
1 hour after event start time	0%	0%	0%	1%	0%	0%	0%	0%	3%	0%	0%	1%

Table 5.2 Set Start and End Time Distributions of Stated Planned Duration at Event

	Dback	AFL	ASU	KISS	Cardinals	ASU BB	Suns	Spring Training	Wrestlemania	Dodge Theater	MLB	NBA
0-2 hours	4%	12%	4%	2%	5%	1%	4%	12%	1%	66%	9%	3%
2-3 hours	16%	19%	3%	3%	2%	1%	4%	7%	1%	26%	7%	2%
whole event	81%	71%	94%	95%	94%	98%	91%	82%	98%	8%	84%	95%

Table 5.3 Arrival and Departure Time Distribution for Set Start and End Time Events

Arrival and Departure Time	Percentage of Trips
Arrival Time	
3 hours before event start time	4.00%
2.5 hours before event start time	4.50%
2 hours before event start time	9.70%
1.5 hours before event start time	10.70%
1 hour before event start time	19.50%
0.5 hour before event start time	24.90%
At event start time	21.00%
0.5 hour after event start time	6.00%
Departure Time	
1 hour before event end time	5.50%
0.5 hour before event end time	5.50%
At event end time	71.20%
0.5 hour after event end time	17.80%

Table 5.4 Continuous Start and End Time Distributions of Stated Planned Duration at Event

	Fall	SF-Thur	SF-Sat	MillAve	PF Chang	WaMo	Gun	First Fri
0-2 hour	5%	6%	8%	15%	36%	3%	44%	36%
2-3 hour	2%	19%	24%	12%	8%	6%	32%	27%
3 or more hours	94%	75%	68%	73%	62%	91%	24%	38%

The number of trips traveling within each of the four time-of-day periods (AM Peak – 6:00 a.m. to 9:00 a.m.; Midday – 9:00 a.m. to 3:00 p.m.; PM Peak – 3:00 p.m. to 6:00 p.m.; and Night – 6:00 p.m. to 6:00 a.m.) is assigned based on the arrival time and departure time at the event. It is assumed that if a trip is scheduled to arrive or happen during the PM peak period, then the trip is made within the PM peak period. At least 30 minutes prior to the event start time would be considered to identify the most appropriate time period in which the special event trip occurs. Similar methodology is used for the other periods. Trips made to weekday events during the AM or PM peak period are assigned peak skims, while all other events are assigned off-peak skims.

5.5 ORIGIN CHOICE MODEL

Model Overview

The trip distribution model is composed of three separate procedures. First, trips beginning and ending at a location external to the MAG region are identified and distributed to external stations from the MAG travel demand model. Second, a procedure that predicts the probability of trips beginning or ending at home, work, hotel, or other location is implemented. As part of this procedure, income and vehicle segmentation is applied to trips originating at home. Third, the trip distribution model estimates the location TAZ of home, work, hotel, and other-based trips through multinomial logit destination choice models.

Methodology for Predicting External Trips

The weighted survey data indicated that 8.7 percent of attendees for all events originate from a location outside of the MAG region. This percentage does not vary significantly based on event market area or weekday versus weekend events. Therefore, 8.7 percent of attendees to each event will be assumed to travel from outside of the MAG region. Out of these external-based trips, 91.9 percent of person trips will be assumed to return after the event to outside the MAG region as indicated by in the surveys. The remaining 8.1 percent of person trips will be converted to hotel-based trips, and will be assigned a post-event hotel destination through the hotel-based destination choice model. It is also found that the percentage of external travel is not very different by event types, and so the aforementioned averages will be considered for all event types.

The specific external stations from which these trips enter the MAG region was also determined using the survey data. External station percentages were examined by event location (i.e., northwest, southeast, northeast, and downtown). However, the external station percentages did not differ significantly based on region, and so the percentages assumed in the SEM do not vary by event location, and were derived from all surveyed events. Table 5.5 shows the allocation of external trips to external stations. In the absence of data to provide alternate assumptions, these percentages will be held constant for forecast years.

Note regarding airport trips. Trips originating at the airport constitute 18 out of 5,943 records in the survey data. This is 0.3 percent of special event trips. Therefore, airport trips will not be modeled separately in the SEM.

The output from this procedure is the number of person trips for the event originating and ending at each external station

Table 5.5 Percentage Allocation of External Trips to External Stations

External Station	Percentage of External Trips
1	0.2%
2	2.5%
3	11.5%
4	0.3%
5	4.4%
6	21.3%
7	4.7%
8	0.2%
9	7.0%
10	1.0%
11	47.0%

Methodology for Predicting Location Type

This procedure determines the percentages of special event trips that are home, work, hotel, or other-based. The percentage of each location type (home, work, hotel, and other) to each event is determined based on event market area (national, multiregional, regional); and event time of day and day of week combination (weekday evening, all-day, other). Weekday evening events are weekday events beginning in the PM peak period or later. All-day events have a continuous start and end time, and take place throughout the day or evening on either a weekday or weekend. Other events are set start and end time events, or short duration continuous events taking place during the day on a weekday or at any time on the weekend. The weighted survey data was used to determine the percentages for each event type combination.

Event market area of the event drives the number of attendees who stay at hotels or other locations (i.e., friend's houses, RV parks) for the event. Hotel and other location type percentages were first calculated based on averaging hotel and other location type percentages from surveyed events for each of three event market areas. The remainder of the locations types is allocated to home- and work-based on observed percentages from all the surveys by time of day and day of week of the event. Work location type percentages are calculated based on averaging work location type percentages for each set of surveyed events with the same time of day and day of week combination. These percentages were calculated from home and work trips only. Table 5.6 shows the distribution of home, work, hotel, and other location types based on event market area and day of week and time-of-day combination. In the absence of data to provide alternate assumptions, these percentages will be held constant for forecast years.

Table 5.6 Location Type Percentages Based on Event Market Area and Day of Week – Time-of-Day

Event Market Area	Day of Week – Time of Day	Home	Work	Hotel	Other
National	Weekday Evening	61.3%	4.8%	28.8%	5.1%
	All Day	64.7%	1.4%	28.8%	5.1%
	Other	65.7%	0.4%	28.8%	5.1%
Multiregional	Weekday Evening	81.8%	6.3%	9.1%	2.8%
	All Day	86.2%	1.9%	9.1%	2.8%
	Other	87.6%	0.5%	9.1%	2.8%
Regional	Weekday Evening	89.0%	6.9%	3.1%	1.0%
	All Day	93.9%	2.0%	3.1%	1.0%
	Other	95.3%	0.6%	3.1%	1.0%

For location type from the event, all percentages are the same, except that work location types are assigned to the home location types, increasing the home percentage and decreasing the work percentage to zero.

Methodology for Predicting Socioeconomic Segmentation for Home Location Type

The SEM requires the event attendees originating at home to be classified as low, middle, or high household income, as well as by whether the attendee's household has zero, one, two, or more vehicles available. These socioeconomic characteristics are inputs into the mode choice and destination choice models.

Weighted survey data, based on event market area, was used to determine the percentage of home origin event attendees in each income and vehicle availability group. Multiregional and national events attract higher income households with more vehicles (see Table 5.7), and regional events contain attendees with lower household incomes and less vehicles (see Table 5.8). In the absence of data to provide alternate assumptions, these percentages will be held constant for forecast years.

Event attendees originating at work, hotel, other, or an external location are not assigned to an income-vehicle segment. Only trips originating at home use income and vehicle availability information for determining home TAZ location and mode to and from the event.

Table 5.7 Distribution of Multiregional and National Event Attendees Within Each Household Income and Household Vehicle Availability Group

	Low Income	Middle Income	High Income	Total Within Household Vehicle Availability
Zero Vehicles	0.90%	0.50%	0.10%	1.50%
One Vehicle	9.00%	8.60%	1.90%	19.50%
Two or more vehicles	7.60%	38.00%	33.30%	79.00%
Total with Household Income	17.50%	47.20%	35.30%	

Table 5.8 Distribution of Regional Event Attendees Within Each Household Income and Household Vehicle Availability Group

	Low Income	Middle Income	High Income	Total Within Household Vehicle Availability
Zero Vehicles	3.90%	0.40%	0.30%	4.60%
One Vehicle	11.90%	11.50%	3.00%	26.40%
Two or more vehicles	14.00%	35.90%	19.20%	69.10%
Total with Household Income	29.70%	47.70%	22.50%	

Methodology for Distributing Person Trips to Internal Origin TAZs

The destination TAZ of each special event trip is defined as the TAZ(s), in which the special event venue is located. Therefore, the trip distribution model predicts the origin choice of trips to the event by origin type; that is, home, work, hotel, or other-based. Separate destination (or origin) choice models were estimated for trips originating from home and hotel. A combined model was estimated for work and other trips.

For origin choice models, each internal TAZ in the MAG region is included in the choice set used in model estimation. The models are specified in the multinomial logit form; and each model employs two types of variables: 1) size variables and 2) utility variables. Size variables essentially reflect the quantity of an alternative (rather than the quality). For instance, a zone with high employment will have more opportunity to attract work trips. Size variables are introduced to the models in such a way that choice probabilities are proportional to the size of the zone (as predicted by the size function).

Utility variables tested in the origin choice models include various functional forms of distance between the origin and event zones (e.g., distance, distance^2, distance^3); mode choice logsums (which represent accessibility); and area type indicators for the origin zone, plus retail employment for hotel-based trips.

Various size variables were also examined. For home-based origins, this included number of households by income category and number of home-based nonwork (HBNW) trips produced in the zone (computed from MAG's Regional Travel Demand Model). For hotel-based trips, hotel employment was considered. For work-based/other-based trips total employment, retail employment, and total households were evaluated, along with number of home-based work (HBW) attractions and total attractions. As trip generations should best represent the quantity of trips originating in particular zone, these were found to have the most important impact on model fit for the home-based and work- and other-based models.

Home-Based Origin Choice

Home-based trips (i.e., those originating at one's home) constitute the majority of special event trips. A single home-based model was estimated, although segmentation by household income level (low, middle, or high income as defined above) and household vehicle ownership (0 vehicles or 1 or more vehicles) was used. Unfortunately, a large number of records in the data (about 20 percent) did not have valid income levels recorded (due to respondent refusal). To accommodate such records, a missing income category was added (for a total of four income segments).

Size variables used for the home-based model are the number of home-based nonwork (HBNW) trips produced in a zone (excluding school trips). The low-income segment uses only those HBNW trips produced by the lowest income quintile households, the high-income segment uses HBNW trips produced by the highest income quintile households, and the middle-income segment uses HBNW trips produced by the middle three income quintile households. For missing income segment, all HBNW trip productions are used. The number of households within each income quintile was also tested as a size variable, but was removed from the final model due to its high level of correlation with HBNW trips produced by income quintile (correlations of over 0.95 in each case). With such high correlation between two variables, statistical identification of parameter values becomes an issue.

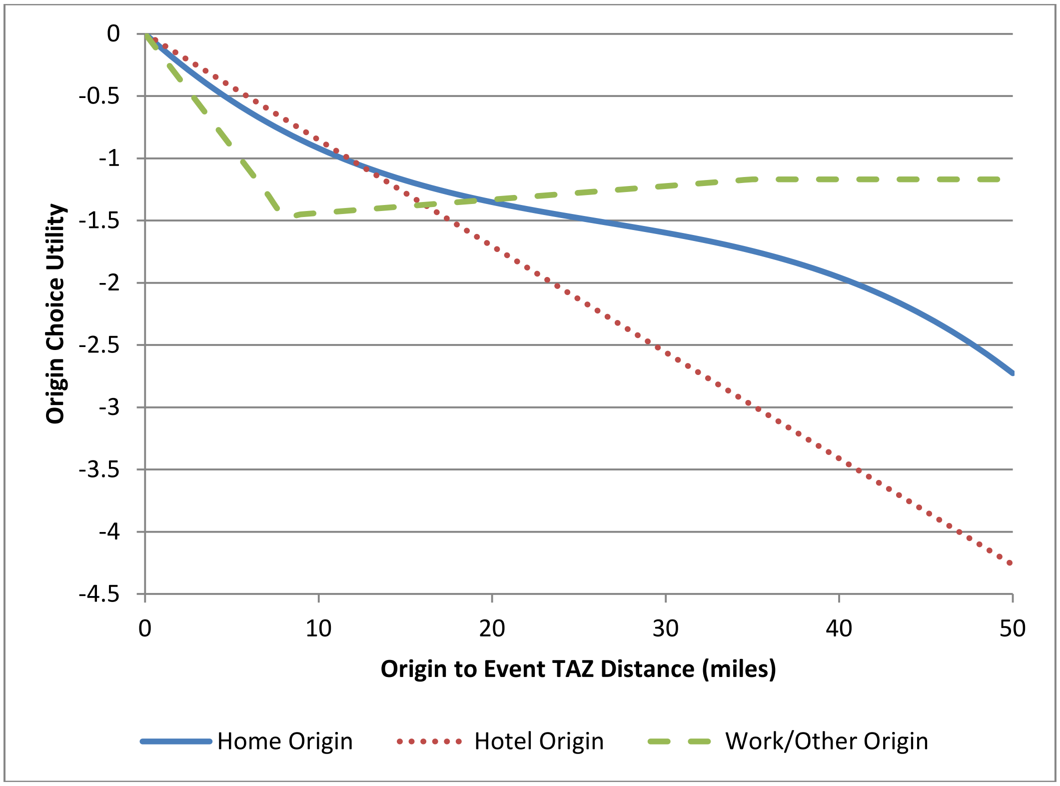
Table 5.9 presents the parameter estimates of the home-based model. Note that the coefficient of each size variable is constrained to be exactly 1.0. Also, note that one size variable must be constrained per segment used. Since each segment employs only one size variable each, all of the size variables are constrained. Since very few individuals traveled more than 50 miles to an event from home, the distance variable was set to 50 for any distance over 50 miles. Figure 5.1 shows the effect of distance on the utility function for the home-based model.

Table 5.9 Home-Based Origin Choice Model

Variable	Coeff.	t-stat
Size Variables		
ln(HBNW Productions, for households in income quintile 1) – Low Income	1.000	Constr.
ln(HBNW Productions, for households in income quintiles 2-4) – Middle Income	1.000	Constr.
ln(HBNW Productions, for households in income quintile 5) – High Income	1.000	Constr.
ln(HBNW Productions, for all households) – Missing Income	1.000	Constr.
Utility Variables		
Distance (miles)	-0.126	-8.2
Distance^2	0.00393	6.6
Distance^3	-0.000050	-6.2
CBD Origin – Middle/High Income	-0.173	-3.7
CBD Origin – Missing Income	-0.514	-5.4
Urban Origin – Low Income	0.374	5.0
Urban Origin – Missing Income	-0.310	-3.6
Mode Choice Logsum – 0-Vehicles	0.927	4.5
Mode Choice Logsum – Low Income, 1+ Vehicle	0.102	0.8
Mode Choice Logsum – Middle Income, 1+ Vehicle	0.129	1.1
Mode Choice Logsum – High Income, 1+ Vehicle	0.186	1.5
Mode Choice Logsum – Missing Income, 1+ Vehicle	0.272	2.1

Observations	4,257
Log Likelihood	-30,030.1
Log Likelihood at Zero	-32,346.4
Pseudo Rho-Squared	0.072

Figure 5.1 Effect of Distance on Origin Choice Model Utilities



A variety of area type indicator variables were tested for each income segment, with area types of CBD, urban, suburban, and rural. However, only a few of these variables were found to have statistical and practical significance in the model.

Hotel-Based Origin Choice

Hotel-based trips (i.e., those originating at a hotel) represent the second largest group of trips. The hotel-based model is not segmented, and hotel employment is used as the size variable. It was found that 68 hotel-based records (about 11 percent of the 620 total) originated in zones with no hotel employment (according to MAG's 2010 hotel employment database). Because hotel employment must be present in the chosen zone for size variables to be appropriate, these 68 records were not used to estimate the model.

Table 5.10 shows the estimation results of the hotel-based model. As before, the size variable must be constrained for statistical identification purposes. For hotel-based trips, retail employment is introduced as a utility variable to reflect that individuals may be more likely to stay at hotels near areas with shopping, which is exactly what the positive coefficient on the variable indicates. The urban area type indicator variable was found to be statistically insignificant. Like the home-based model, the distance variable was capped at 50 miles. A single distance variable was used, since estimates with additional distance terms (i.e., $distance^2$ and $distance^3$) created undesirable effects of distance as a whole (e.g., higher utilities at large distances compared to smaller distances). As shown in Figure 5.1, the effect of distance on the utility function for the hotel-based model is consistent with expectations.

Table 5.10 Hotel-Based Origin Choice Model

Variable	Coeff.	t-stat
Size Variables		
Ln(Hotel Employment)	1.000	Constr.
Utility Variables		
Distance (miles)	-0.0806	-5.1
Retail Employment at Origin	0.000152	1.7
CBD Origin	0.476	3.8
Suburban Origin	-0.780	-3.4
Mode Choice Logsum	0.732	1.7
Observations	552	
Log Likelihood	-2907.1	
Log Likelihood at Zero	-4,194.3	
Pseudo Rho-Squared	0.307	

Work- and Other-Based Origin Choice

Because so few trips originated at either work or other locations, these two origin types were combined for origin choice estimation, although the two origin types are segmented across a number of key variables.

For the work-based segment, home-based work (HBW) attractions are used as the size variable; and for the other-based segment, total trip attractions are used as the size variable. Other size variables that were tested (including total and retail employment) were not found to be statistically or practically significant.

Table 5.11 presents the parameter estimates for the work- and other-based model. As before, one size variable must be constrained for each segment. Unlike the other models, a slightly different specification for distance was used here. It was found that the effect of distance tends to level off after about 8 miles. In other words, utility decreases as the distance grows from zero to 8 miles, but the difference in utility between 8 miles and anything more than 8 miles is approximately equal. Because very few individuals traveled more than 35 miles to these origin types, the distance variable was set to 35 for any distances more than 35 miles. The effect of distance on the model's utility functions is shown in Figure 5.1.

Like the other two origin choice models, a number of area type indicator variables were tested. A CBD origin was found to be more likely for work trips (all else being equal), which makes sense, since the CBD offers many work centers. For other-based trips, urban and suburban zones were found to be more likely origins than CBD or rural zones.

Table 5.11 Work- and Other-Based Origin Choice Model

Variable	Coeff.	t-stat
Size Variables		
ln(HBW Attractions) – Work	1.000	Constr.
ln(Total Attractions) – Other	1.000	Constr.
Utility Variables		
Distance (miles)	-0.183	-4.4
Max (Distance – 8, 0)	0.193	5.1
CBD Origin – Work	0.301	1.5
Urban/Suburban Origin – Other	0.860	4.5
Mode Choice Logsum – Work	0.308	0.6
Mode Choice Logsum – Other	0.834	1.6

Observations	280
Log Likelihood	-1,710.4
Log Likelihood at Zero	-2,127.6
Pseudo Rho-Squared	0.196

5.6 MODE CHOICE MODEL

Model Overview

The mode choice model determines the probabilities of choosing different modes at the TAZ level. Trips originating at locations external to the MAG region will have set mode choice percentages for all events. The probabilities of choosing different modes for trips originating within the MAG region are determined by a nested multinomial logit model.

Methodology for Determining Mode of External Trips

From the weighted survey data, it was found that 96.9 percent of the individuals traveling from outside of the region travel via a motorized mode. Therefore, it was assumed that all attendees traveling from outside of the region travel by drive alone or shared ride. The weighted data indicate that 3.5 percent, 30.7 percent, and 65.8 percent travel by drive alone, shared ride 2, and shared ride 3+, respectively. These percentages are used to assign mode to these trips. In the absence of data to provide alternate assumptions, these percentages will be held constant for forecast years.

The output from this procedure is the number of person trips traveling by drive alone, shared ride-2, and shared ride-3 from each of the external stations.

Methodology for Determining Mode of Internal Trips

Two types of discrete choice models are widely used for the estimation of mode choice models. They are multinomial logit and nested logit. Both were investigated for application in the SEM.

MNL models and various nesting structure nested logit mode choice model were estimated from the weighted survey data for trips originating within the MAG region. The major modes as derived from the survey data include drive alone, two-person carpool (shared ride-2), three-person+ carpool (shared ride-3), light rail-walk, light rail-drive, bus-walk, bus-drive, and nonmotorized (walk/bike).

The highway and transit skims were appended to the dataset prior to estimation. If the arrival time at the event was between 6-9am or 3-6pm on weekdays, then peak-period skims were used; otherwise off-peak skims were used. For auto modes, cost is equal to per person operating cost ($0.15) times distance plus per person event parking cost. For transit, cost is equal to transit fare, while the nonmotorized cost is set to zero.

A multinomial logit structure was tested first to explore the basic model structure, introduce new variables incrementally, and test the quality of the data. The more complex nested logit structure was introduced later in the process, investigating a number of different nesting structures.

The acceptance of variables and alternative structures was decided by the following criteria:

- Reviewing the magnitude and sign of coefficients and their relationship to other variables (The FTA's guidelines were followed here, where the expected range for IVTT is -0.01 to -0.03, OVTT is two to three times that of IVTT, value of time is in the $5.00 range.)
- Significance of t-statistics.
- Log likelihood ratio tests.
- Magnitude of nesting coefficients (A value of 1.00 suggests that the modes in the lower tier and the upper tier are equally competitive, and that no nesting is necessary.).
- The importance of the presence of certain variables in the model. In general, reaching the final structure of the model was an empirical process achieved through a number of trial-and-error runs.

The mode choice model was finalized through a series of rounds of estimation. Separate models for events with access to light rail and without access to light rail, as well as one joint model, were estimated. Separate models were also tested by location type (i.e., home, work, hotel, other). Many explanatory variables were examined in the mode choice model, including alternative specific constants; LOS variables including IVTT, OVTT, and cost; socioeconomic variables including household income, household size, and number of vehicles; event characteristics such as event market area and location, time-of-day, and day of week; origin or destination zonal variables; and nesting coefficients. Different nesting structures, interaction variables, and various functional forms for the LOS variables were also examined.

Round 1

- Separate MNL models were tested for trips with and without light-rail access. The coefficients on the variables were similar, and it was decided to estimate one joint model that set availability to zero for observations without light rail-access.
- A wide variety of explanatory variables were tested, including socioeconomic variables (income, vehicle availability, and household size); origin and event location land-use types; event-specific variables (time of day and day of week); event type (sports, music, or other type); event market area, including regional, multiregional, or national event; and origin location type, including home, hotel, work, and other.
  - Event-specific variables were not significant in any models, and were subsequently dropped from further estimation.
  - All other variables were carried into the next round of estimation. However, household size was later dropped from the model due to decisions regarding market segmentation in relationship to the destination choice models.

Round 2

- Constrained and unconstrained LOS variables were tested:
  - Unconstrained IVTT resulted in coefficient values much lower than the .01- to .03-range recommended by the FTA;
  - Constraining IVTT, but unconstraining OVTT, led to OVTT values higher than three times IVTT; and
  - Constraining IVTT and OVTT, but unconstraining cost, led to high value of time estimates of about $18.
- Decision was made to constrain IVTT to -.015, OVTT to two times IVTT, and cost to -0.18, which results in a $5 value-of-time.

Round 3

- Various constrained and unconstrained nesting structures were tested:
  - Two-level nesting structure with transit and auto modes in separate nests was tested with unconstrained nesting coefficients. Nesting the auto modes together into a nest did result in a valid nesting coefficient; however, the transit nest was not significant.
  - Three-level nesting structure with the higher-level nest constrained and the auto nest further divided into a shared ride nest and drive alone nest was tested with unconstrained lower nest, but the nesting coefficient was not significant.
  - Three-level nesting structures were tested with the higher-level nest constrained and the transit nest further divided into subnests. One model tested subnests containing drive-access and walk-access in separate nests, and the second model tested subnests containing light-rail and bus in separate nests. Both models resulted in nonsignificant nesting coefficients.
- Decision was made to retain a three-level nesting with fully constrained nesting structures with auto, transit, and nonmotorized modes at the first level. The second level contains an auto nest consisting of drive alone, shared ride-2, and shared 3+, as well as a transit nest consisting of drive-access, and walk-access. The third-level nests the light-rail and bus walk-access and light-rail and bus drive-access modes. Figure 5.2 shows this nesting structure.

Round 4

- Finalize the explanatory variables used in the model. The final explanatory variables used in the model include income, vehicle availability, land-use at the origin location, and origin location type. The final model specification is shown in Table 5.19 and described below.

Figure 5.2 Nested Logit Mode Choice Model Structure

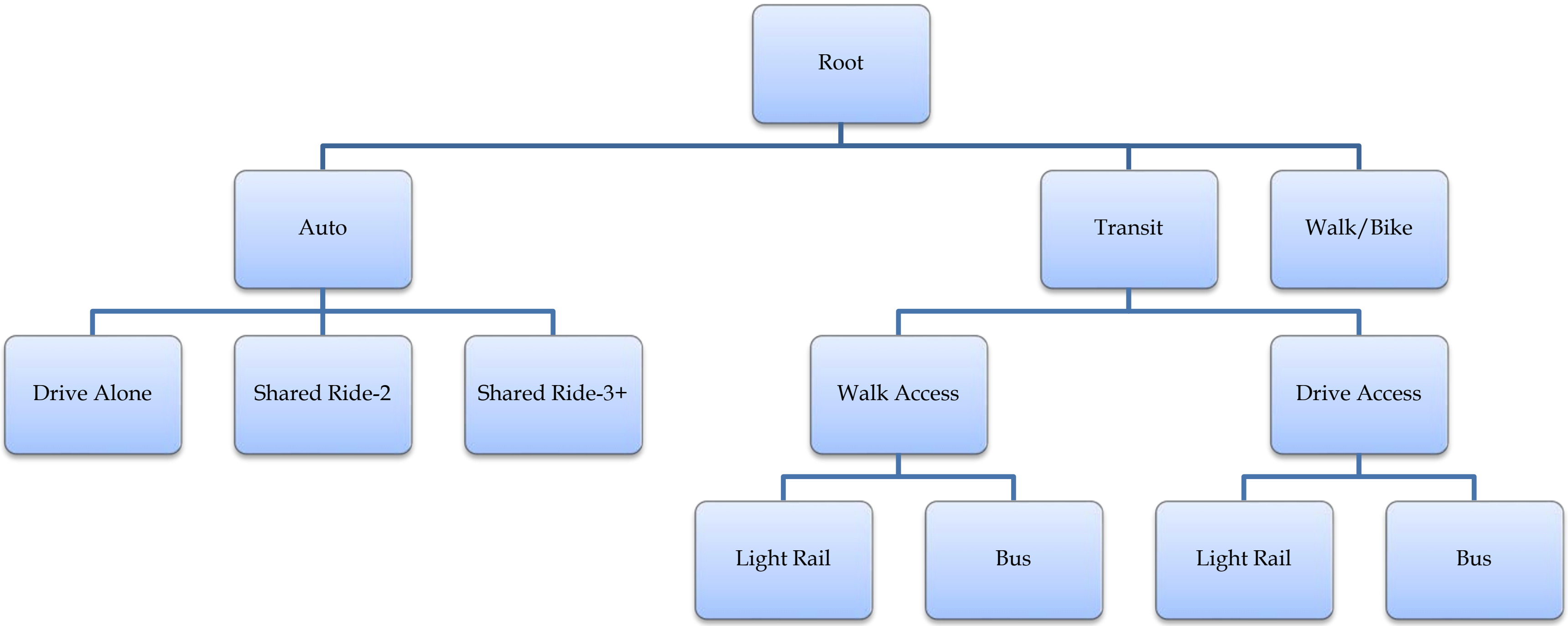


Table 5.12 Final Nested Logit Mode Choice Model

	DA		Shared Ride -2		Shared Ride -3		LRT- Walk		LRT-Drive		Bus-Walk		Bus-Drive		Nonmotorized	
	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat
Constants	0.373	1.907	0.748	4.26	1.021	5.936	-0.093	-0.631	-0.559	-2.72	-0.055	-0.383	-0.76	-4.377		
Level of Service																
Cost ($)	-0.18	Constr	-0.18	Constr	-0.18	Constr	-0.18	Constr	-0.18	Constr	-0.18	Constr	-0.18	Constr		
IVTT (mins)	-0.015	Constr	-0.015	Constr	-0.015	Constr	-0.015	Constr	-0.015	Constr	-0.015	Constr	-0.015	Constr		
OVTT (mins)	-0.03	Constr	-0.03	Constr	-0.03	Constr	-0.03	Constr	-0.03	Constr	-0.03	Constr	-0.03	Constr		
Distance															-0.249	-13.515
Income for Home Origin																
Middle income (quintile 2-4)	0.347	1.898	0.338	2.248	0.338	2.248	0.273	3.004	0.522	3.482						
High income (quintile 5)	1.164	5.069	0.781	3.868	0.781	3.868			0.522	3.482						
Missing income	-0.22	-1.181	-0.272	-1.843	-0.272	-1.843	0.104	1.236	0.269	1.579						
Vehicle Availability for Home Origin																
1 vehicle	0.921	5.054	0.716	5.18	0.267	1.954										
2+ vehicles	0.511	2.774	0.716	5.18	0.509	3.804			0.322	2.555						
Land-Use																
CBD at origin	-0.2	-1.875	-0.2	-1.875	-0.2	-1.875			-0.359	-2.809						
Origin Location Type																
Work	1.087	5.899														
Hotel									-1.027	-3.738			-0.988	-2.725		
Nesting Coefficients (thetas)																
Auto	0.6	Constr														
Transit	0.6	Constr														
Transit – Walk	0.24	Constr														
Transit – Drive	0.24	Constr														
Likelihood	-6105.349															
r-squared	0.372															

Final Model

The final nested logit mode choice model is composed of a three-level nesting structure with auto, transit, and nonmotorized modes at the first level. The second level contains an auto nest consisting of drive alone, shared ride-2, and shared 3+, as well as a transit nest consisting of drive-access and walk-access. The third-level nests the light-rail and bus walk-access and light-rail and bus drive-access modes. Figure 5.2 shows a flowchart of the nesting structure.

The final nested logit mode choice model is presented in Table 5.12. The model contains constrained LOS variables for cost, IVTT, and OVTT. At the highest level, the IVTT coefficient is equal to -0.015, the OVTT coefficient is set to two times IVTT, and the cost coefficient is set to -0.18 so that the implied value of time is $5 per hour. The nesting coefficients are also constrained to normalized coefficients of 0.6 for the second-level nest and 0.24 for the third-level nest. Please note that the coefficients presented in Table 5.12 have been scaled by thetas (nesting coefficients); that is, the coefficients have been multiplied by 0.6 * 0.4 = 0.24.

The income coefficients indicate that individuals living in middle- and high-income households are more likely to use auto modes, with the high-income households even more likely than middle-income households. Both middle- and high-income households are more likely to drive to light rail compared to low-income households, while middle-income households are more likely to walk to light rail compared to both low- and high-income households. A missing income category was included in the model to account for missing income records. Individuals living in households with at least one vehicle are more likely to use auto modes as well as drive to light rail.

Individuals living within the central business district or outer central business district are less likely to use auto or drive to light rail compared to those living elsewhere. Individuals traveling from work to the special event are more likely to drive alone, while individuals traveling from a hotel are more likely to walk to transit.

The output from this model is the number of person trips traveling by drive alone, shared ride-2, shared ride-3+, light rail-walk, light rail-drive, bus-walk, bus-drive, and nonmotorized mode from each TAZ by each time-of-day period

5.7 MULTICLASS ASSIGNMENT

Model Overview

The assignment procedure is not part of the SEM standalone model, but the special event trips output from the SEM model is assigned to the MAG highway and transit network, along with the rest of the passenger autos and commercial vehicles using MAG's current assignment procedure.

Methodology

The special event person trip tables from the mode choice procedure are converted to vehicle trips by taking into account the number of drive-alone, shared ride-2, and shared ride-3 person trips that are made. One drive-alone person trip is equivalent to one drive-alone vehicle trip. One shared-ride 2 person trip is equivalent to 0.5 shared ride-2 vehicle trips. One shared-ride 3 person trip is equivalent to 0.29 shared ride-3 vehicle trips. For weekday events, the existing weekday highway and transit skims are used for each time-of-day period. The special event trips are assigned along with other passenger and commercial vehicles to account for congestion. For weekend events, the nonpeak weekday skims should be used, as weekend skims are not available. The weekend-based special event trips are assigned separately, as there is no need to account for congestion during weekends. For temporary events, modifications to the highway or transit network should be made before implementation to account for event-related street closures. The LRT ridership by station and time period can also be estimated based on transit assignments.

6.0 SEM Application

6.1 APPLICATION

The SEM is designed as a standalone model. It is able to serve as a forecasting and scenario-testing tool for current and future planned special events. The model is a standalone forecasting procedure, but it can be integrated within weekday trip-based modeling framework. One of the long-term goals includes utilization of the developed SEM approaches and collected data for the activity-based modeling framework. As the SEM is designed to handle all types of events, the application can also be applied to a subset of events. That is, if MAG desires to analyze different future LRT alignments for a particular event, then the SEM for that event can be executed and integrated with the MAG's travel model. The SEM application can also be applied based on the day of the week as special events occur on both weekday and weekends.

The SEM is applied in TransCAD using GISDK scripting language. The script implements each of the model components, as discussed in Chapter 5, based on forecast year and special event inputs defined by the user. The forecast year inputs include the forecast year, annual population growth rate (measured from the base year), and auto operating cost for the forecast year. Event inputs include the base year daily attendance for the event, event capacity, forecast year daily attendance, the TAZ ID for the event, day of week, start time, end time, an indicator for a set start and end time event versus continuous start and end time event, parking cost, and event market area. If forecast year daily attendance is left blank or given a value of zero, the base year daily attendance is inflated using the population growth rate, with a maximum value equal to the event capacity input. Otherwise, the forecast year daily attendance is used as the event attendance. The event input file allows the user to run multiple events for the forecast year at the same time by entering each event's inputs on a separate line in the file.

The SEM script also takes as inputs the weekday skim matrices for the forecast year and socioeconomic variables for the forecast year. These are essentially inputs coming from MAG's regional travel model. The script allows for three different time resolutions of the skim matrices. These are peak versus off-peak, AM peak, midday, PM peak, and night, or one-half-hour skims. The script automatically searches for the highest resolution skims first (i.e., if one-half-hour skims are available, it will use those). For weekend events, off-peak, midday, or 11:30 a.m. to noon skims are used, depending on the time resolution.

Several other input files are also used, which contain the parameters of the models used for SEM application. In general, these other input files need not be changed by the user. The reason these parameters were not hard-coded in the model was to provide MAG the ability to easily change certain model settings and parameters if needed.

The first step of SEM application in the model script is trip generation. This step computes the event's attendance, and distributes the corresponding inbound and outbound person trips to each of 13 segments. There is one segment each for external, hotel-based internal, work-based internal, and other-based internal trips. Home-based trips are segmented by income level (low, middle, and high) and vehicle ownership (0, 1, or 2+ vehicles) for a total of nine home-based trip segments. The shares of attendance within each segment are determined using the event input parameters for day of week, market area, and set or continuous start and end time event type.

The next step of SEM application is that of time-of-day split. In this step, arrival and return time-of-day shares are computed at the one-half-hour level for each relevant one-half-hour interval. The event start and end time inputs, along with the time-of-day model inputs, determine the relevant intervals. Time-of-day model parameters differ based on whether the event is input as a set or continuous start and end time event.

SEM application then proceeds to mode and origin choice models. First, for each traveler segment (excluding externals, which are handled separately), mode choice logsums and probabilities are computed at the zonal level. The mode choice logsums are used to compute origin choice probabilities across zones, and these origin choice probabilities are multiplied by mode choice probabilities to arrive at combined origin-mode choice probabilities.

Next, the combined origin-mode choice probabilities for each segment are multiplied by the segment attendance and arrival and return time-of-day splits, yielding person trips by segment, time of day, mode, and origin (or destination in the case of return trips). External trips are then distributed by time of day using the computed time-of-day splits, and are distributed by mode and origin based on the fixed proportions as described in Chapter 5.

Finally, some processing is needed to aggregate trips in a variety of ways for output preparation. Data file outputs include person trips by mode, person trips by segment, and person trips by one-half-hour interval. In each data file, there is a single field for each event created in the event input file. In addition, each event will have a data file with person trips by mode and segment, and a data file with vehicle trips to each zone by time-of-day period (AM, midday, PM, and night periods). Two matrix files per event are also output by the script. The first contains person trips with one matrix table per mode and time-of-day period. The second contains vehicle trips with one matrix table per automobile mode (drive along, shared ride 2, and shared ride 3+) and time-of-day period.

6.2 SENSITIVITY TESTS

MAG performed a variety of model runs testing the sensitivity of the SEM to user inputs. The user inputs that were varied include the day of week on which the event occurs, the event market area, and set versus continuous start and end time events. In addition, the sensitivity to light-rail fare and parking costs was tested.

The first test examined events occurring on a weekday versus those on a weekend. It should be noted that the only difference between weekdays and weekends in the models is for the location type (i.e., home, hotel, work, or other) distribution of event attendees. These distributions are only different for set start time events occurring in the evening. All-day events have the same distribution of location type on weekdays and weekends, as do set start and end time events occurring prior to the PM peak period. Another difference between weekday and weekend events is the skims that are used. For weekday events, both peak and off-peak skims are utilized, while on weekends, the SEM reads only from the off-peak skims. The sensitivity tests show that location type distributions do not change, except for set start and end time events occurring in the PM peak hours or later. It was also found that nonautomobile mode trips increase (by about 7 percent), on average, for weekend events compared to those on weekdays, as shown in Table 6.1.

Table 6.1 SEM Sensitivity Test 1

Summary	Weekday	Weekend	% Difference
Trips by Auto	280,114	274,315	-2.1%
Trips by Non-Auto	84,585	90,384	6.9%
Low Income category trips	56,380	56,798	0.7%
Medium Income category trips	138,618	139,287	0.5%
High Income category trips	98,248	98,563	0.3%

The second test investigated the effect market area has on event travel. In particular, regional events were compared with multiregional and national events. Event market area has an impact on the distribution of trips by location type and the distribution of home-based trips by household segment. The most important difference being that many more hotel- and other-based trips will be forecast for multiregional and national events. The test results show this, and the added hotel- and other-based event attendees result in increased nonautomobile trips (about 18 percent), on average (Table 6.2), since these attendees are more likely to originate in zones with accessible transit and less likely to have accessibility to an automobile. In addition, the number of low-income event attendees drops considerably for multiregional and national events (by 50 percent), while high-income event attendees grow modestly (by 15 percent).

This makes sense given that multiregional and national event tickets are likely to be priced higher.

Table 6.2 SEM Sensitivity Test 2

Summary	Weekday (Regional events)	Weekday (Multiregional & National Events)	% Difference
Trips by Auto	270,350	252,965	-6.4%
Trips by Non-Auto	94,348	111,734	18.4%
Low Income category trips	94,467	40,324	-57.3%
Medium Income category trips	151,211	108,760	-28.1%
High Income category trips	71,326	81,339	14.0%

The third test compared set start and end time events to all-day events. Unfortunately, it is a bit difficult to isolate the effect this has on event travel in the models. The reason is that, by definition, an all-day event will be of relatively long duration (e.g., 8 hours), while a set start and end time event will typically be much shorter (e.g., 2 to 3 hours). Thus, these two types of events cannot be given identical start and end times, meaning multiple inputs must be changed to compare the event types.

The final two tests examined the effects of parking cost and light-rail fare on event travel. In the SEM model, these variables will have the most impact on mode choices, and to a lesser degree, origin choice. Not surprisingly, it was found that a doubling of parking cost (from $5 to $10) increases nonautomobile trips (by 5 percent, on average), as shown in Table 6.3. However, a 20-percent reduction in light-rail fare (from $0.75 to $0.60) has very mild effects, with nonautomobile trips increasing by less than 0.1 percent, on average.

Table 6.3 SEM Sensitivity Test 4

Summary	Weekday ($5 Parking Cost)	Weekday ($10 Parking Cost)	% Difference
Trips by Auto	280,114	276,095	-1.4%
Trips by Non-Auto	84,585	88,604	4.8%
Low Income category trips	56,380	56,380	0.0%
Medium Income category trips	138,618	138,618	0.0%
High Income category trips	98,248	98,248	0.0%

Overall, the sensitivity tests appear to show that the model is working properly. The model was shown to predict the correct types of travel shifts in all sensitivity tests.

7.0 Conclusions and Recommendations

7.1 Conclusions

Here are some key conclusions drawn from the overall study:

- The collected special events data proved to be a very valuable dataset in a variety of analytical applications that MAG has already embarked upon;
- The collection of gate counts was very useful in computing proper expansion factors for most of the surveys;
- Special events do constitute a large share of light-rail ridership in the MAG region, especially during off-peak hours and weekends;
- The SEM, designed as a standalone model, can be easily integrated with the passenger model system at the assignment step; and
- The special event travel demand can either be assigned using a multimodal assignment, or can be assigned to a preloaded network.

7.2 Recommendations

The developed SEM is in the process of being calibrated and validated. It is recommended to validate this model using sources of data that differ from those used for model development and estimation. The following are four independent data sources that will be used to validate the SEM:

1. **Special event venue parking data.** For the purposes of validation, any data available on parking capacity and usage information for the events should be used. Usage data and capacity information can be used as a validation measure to check how many autos access the facility. This information can be compared against the number of auto trips predicted by the SEM. The parking data may also be used to conduct sensitivity analysis on forecast years to see how varying parking costs and availability will impact transit ridership.
2. **Transit boarding counts.** Transit boarding counts from Valley Metro on major bus routes serving special events, as well as light-rail ridership data is another source to validate SEM assignment results. Transit data on nonspecial event days can be compared to transit data on special event days to determine the effect of the special event on transit ridership. These counts can also be used to validate the transit assignment results for the base year.

3. **Percentage of survey data.** The SEM results can also be compared to that of the survey results as a reasonableness check. The weighted survey estimates of person trips and mode shares can also be compared against for reasonableness.

4. **Review of other studies.** Literature and data can be obtained from other regions that have developed special events models, or can provide information on travel to special events. Information collected from other regions can be used for reasonableness testing of the SEM. While every region has unique travel characteristics, comparing the SEM results to other regions will help identify if the model is producing reasonable results.

The datasets identified are recommended to be used to validate the SEM, and be used for sensitivity and reasonableness testing for the base and future years. Based on the results of model validation, the SEM model can be adjusted and recalibrated, where necessary.

A. SEM Survey

Location/Event: ________ **Gate**____ **Date:**_______ **Time:** ______**AM/PM** **Int:** ____

S1 [IF NOT OBVIOUS] Are you here today to see **[NAME OF EVENT]**?
☐ Yes – **GO TO Q1** ☐ No – **THANK & END**

S2 Hello, my name is _____________ from WestGroup Research. I am conducting a brief transportation survey about how people traveled to this event. It will only take a few minutes of your time.

***1.** Which of the following locations did you come from to attend **[NAME OF EVENT]**? (**READ LIST**).
☐$_1$ Home ☐$_2$ Work ☐$_3$ Hotel ☐$_4$ Other: SPECIFY______________

***1A. (ASK If Q1=4,5)** Where were you prior to stopping there?
☐$_1$ Home ☐$_2$ Work ☐$_3$ Hotel

***1B.**What is the street address **[Home, Work, or Hotel]**? ASK FOR OR A NEARBY INTERSECTION OR LANDMARK IF REFUSED/DK ADDRESSES

Address/Cross Street: ____________________________________ N W E S

City: ______________________________ Zip Code: ______

***2.** What time of day did you start at [**Home, Work, or Hotel**]?
Departure Time: _________ AM/PM **ASK FOR APPROXIMATE IF DK**

***3.** How did you travel from **[Home, Work, or Hotel]** to the **[NAME OF EVENT]** today? Did you travel by…? **(MULTIPLE RESPONSES ALLOWED)** PROBE: Take event Shuttle?

☐$_1$ Drive alone ☐$_4$ Walked ☐$_8$ Light Rail : **STATION:** _______________
☐$_2$ Carpool ☐$_5$ Biked ☐$_9$ Charter Bus
☐$_3$ Motorcycle ☐$_6$ Taxi ☐$_{10}$ Limousine
☐$_{13}$ Dropped off ☐$_7$ Public Bus ☐$_{11}$ Other **(SPECIFY)**_________________
☐$_{12}$ **(DO NOT READ)** Don't know

AUTO TRAVELERS AND WALK (*1,2,3,4*) – CONTINUE WITH Q4
TRANSIT TRAVELERS (*7,8*)– SKIP TO Q5
EVERYONE ELSE (*5,6,9,10,11,12,13*)– SKIP TO Q6

***4.** About how many minutes and blocks away did you park or need to walk?
\# of minutes: _____ # of blocks ____ ☐ Dropped off/Didn't park ☐ Don't know

4A.How much did you pay to park?
Parking Cost: _______ Dollars ☐ Nothing/Free ☐ Don't know

***5. (ASK If Q3 = 7 or 8)** How did you get to the bus stop or light rail stop from **[Home, Work, or Hotel]**?

☐$_1$ Walked ☐$_2$ Drove ☐$_3$ Dropped-off ☐$_4$ Biked ☐$_5$ Public Bus

***6A. (ASK ALL)** Including yourself, how many people traveled from **[Home, Work, or Hotel]** TO **(NAME OF EVENT)** with you? ☐$_6$ Same HH ☐$_7$ Different HH

☐$_1$ 1 person ☐$_2$ 2 people ☐$_3$ 3 people ☐$_4$ 4 +

***6B.(ASK ALL)** Including yourself, how many people will travel FROM the **(NAME OF EVENT)** with you back to **[Home, Work, or Hotel]**? ☐$_6$ Same HH ☐$_7$ Different HH

☐$_1$ 1 person ☐$_2$ 2 people ☐$_3$ 3 people ☐$_4$ 4 +

***7.** Where will you be going to after this [NAME OF EVENT]?

☐$_1$ Home ☐$_2$ Work ☐$_3$ Hotel ☐$_4$ Other: SPECIFY_____________

****7A.ASK FOR ADDRESS ONLY IF DIFFERENT LOCATION THAN IN Q1:*** What is the street address place where you will be going to after the **[NAME OF EVENT]**? ASK FOR A NEARBY INTERSECTION OR LANDMARK IF REFUSED/DK ADDRESSES

Address/Cross Street: _______________________________________ N W E S

City: ______________________ Zip Code: ________

***8.** How will you travel when you leave **(NAME OF EVENT)**? (**READ LIST; PROBE FOR MULTIPLE RESPONSES)**

☐$_1$ Drive alone ☐$_4$ Walked ☐$_9$ Charter Bus
☐$_2$ Carpool ☐$_5$ Biked ☐$_{10}$ Limousine
☐$_3$ Motorcycle ☐$_6$ Taxi ☐$_{11}$ Other **(SPECIFY)**________
☐$_{13}$ Picked up ☐$_7$ Public Bus ☐$_{12}$ **(DO NOT READ)** Don't know
☐$_8$ Light Rail: STATION: ______________________

***9. (ASK If Q8 = 7 or 8)** How will you get back to **[Home, Work, or Hotel]** from the bus stop or light rail stop?

☐$_1$ Walk ☐$_2$ Drive ☐$_3$ Get Picked-up ☐$_4$ Bike ☐$_5$ Public Bus

***10.* (ASK ALL)** How long do you plan on staying at this **(NAME OF EVENT)** ?

☐$_1$ For the whole event ☐$_2$ 1 hour or less ☐$_3$ 1-2 hours
☐$_4$ 2-3 hours ☐$_5$ 3 or more hours ☐$_6$ Don't know ☐$_7$ Refused

***11.* (ASK ALL)** Including yourself, how many people live in your household?
☐$_1$ 1 person ☐$_2$ 2 people ☐$_3$ 3 people ☐$_4$ 4 + ☐$_5$ Refused ☐$_6$ Other _______

****12.*(ASK ALL)** How many registered cars, trucks, or motorcycles are available to your household?
☐$_1$ None ☐$_2$ 1 vehicle ☐$_3$ 2 vehicles ☐$_4$ 3 + vehicles ☐$_5$ Refused

***13.* (ASK ALL)** What was your total combined household income last year?
☐$_1$ Under $20,000 ☐$_2$ $20,001 to $40,000 ☐$_3$ $40,001 to $60,000
☐$_4$ $60,001 to $80,000 ☐$_5$ $80,001 to $100,000 ☐$_6$ $100,000+ ☐$_7$ Refused

****14.*** Which of the following describes your employment status?
☐$_1$ College Stdnt ☐$_2$ FT Emplyd ☐$_3$ PT Emplyd ☐$_4$ Retired ☐$_5$ Other ☐$_6$ HS Stdnt

****15.*** (**RECORD GENDER. DO NOT ASK**)
☐$_1$ Male ☐$_2$ Female

Name ___________________________ ***Phone*** ________________________

B. SEM User Guide

To run the GISDK script for SEM application, a single project folder must be used. This project folder corresponds to the forecast year folder of MAG's regional model, and should contain subfolders "tripgen" containing the socioeconomic data at the zonal level and "Out" containing the skim matrix files and trip generation files from the forecast year regional model application. In addition, a subfolder named "SEM" should be created in this main project folder, and all SEM input files should be placed there. The path to the project folder should be entered at the beginning of the GISDK script before running. If a different format for the folders is to be used, the script can accommodate this. The user must simply enter the path directories for the four sets of files: socioeconomic data, skim matrices, trip generation files, and all SEM inputs.

The SEM inputs needed to run the script are as follows:

- ctrl_file.csv
- Event_inputs.csv
- FY_inputs.csv
- mc_model.csv
- dc_model.csv
- tod_model.csv
- hh_composition.csv
- location_type.csv
- external_inputs.csv

Before running, the user should open the files named Event_inputs.csv and FY_inputs.csv. The latter contains forecast year information with three fields and a single data row. This is where the forecast year, annual population growth rate, and automobile operating cost (in $/mile) should be input by the user.

Event_inputs.csv contains all event inputs. There are a total of 13 fields for the user to enter for each event. Events should be entered one per row of the file with no empty rows. The first field in the file is simply an integer ID value for the event. This can be any integer, but each event should have a unique ID value. The second, third, and fourth fields are the base year daily attendance, forecast year daily attendance, and event capacity. The TAZ ID of the event should be entered in the fifth column. The remaining fields for the user to fill (from left to right in the data file) are day-of-week (integers from 1 to 7 correspond to Monday through Sunday, 0 can be entered for a generic weekday, and 8 can be entered for a generic weekend); start hour of the event (integers from 0 to 23); start minute (integers from 0 to 59); end hour (integers from 0 to

23); end minute (integers from 0 to 59), whether the event is a set start/end time event (0 for continuous start/end time, 1 for set start/end time), parking cost of the event (in dollars); and event market area (1 for regional, 2 for multiregional, or 3 for national).

Once all events are entered into the input file, the script can be run in TransCAD. Output files include three data files with total person trips by mode, by segment, and by time of day. Each of these files contains one field for each event in the event input file. In addition, two data files are created for each event. The first contains person trips by segment and mode; and the second contains vehicle trips across all zones by broad time-of-day period (AM, midday, PM, night). Finally, two matrix files are created per event. The first contains person trips with one table for each pairing of mode and transit-oriented development (TOD). The second contains vehicle trips with one table for each pairing of automobile mode and TOD, as well as 24-hour vehicle trips by automobile mode.