Quantifying Special Generator Ridership in Transit Analyses

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Abstract

In major investment analyses and transit corridor studies, the impact of conventions, sporting matches, and other special events on transit ridership is often of interest. In many locations, it is hypothesized that additional ridership to and from such sites can provide substantial additional revenue for the transit system at little additional cost. In addition, the transit system might be used to relieve traffic congestion around the venues used for these special events.

While some cities have used rigorous analyses to account for the non-home-based transit ridership that might be induced by fixed guideway facilities, the impact of special generators on regular or specially scheduled transit service is typically analyzed using ad hoc procedures and "rules of thumb." This paper describes an analysis process, developed as part of the "Gold Line" commuter rail study in Denver, Colorado, that introduces uniform procedures for analyzing the impact of regular and periodic special generators on transit services in the Denver area. These procedures can be readily generalized for use in other cities.

Local travel to sporting events, festivals and other special community events can contribute significantly to transit ridership and revenues. Seldom, however, is transit ridership from special events formally included in the four-step travel demand modeling process used for major investment studies. Typically, the evaluation level is little more than a comment that such functions would add to the transit ridership levels for the alternatives tested.

In 1995, the six-county Denver metropolitan Regional Transportation District (RTD) recognized the need to address this weakness in transit investment studies and funded a study to develop a consistent approach to analyzing the additional transit ridership that can be expected from "special generators."

The focus of the special generator assessment was a proposal for commuter rail service on the "Gold Line" — a freight rail corridor between downtown Denver and Golden, Colorado. In previous studies, RTD had examined the viability of this corridor for peak period only commuter rail service. Projected demand, however, was not sufficiently high (or cost effective) for inclusion in the Denver area's regional transportation plan. Recent new developments in the corridor including sporting venues and an amusement park have revived interest in the Gold Line.

The new developments which could potentially contribute to Gold Line ridership are of a special event variety, many of which occur during off-peak periods or weekends. RTD was asked to reconsider the Gold Line operating assumptions and re-estimate future ridership explicitly considering this off-peak, special generator ridership. The use of a traditional modeling approach, in which average daily trips and transit ridership are projected and then adjusted for special events by region-wide annualization factors, was believed to be underestimating potential transit demand in this particular corridor.

Research pertaining to public transportation patronage forecasting for special generators is limited. The literature is especially scant on the subject of the estimation of special generator mode

choice and the incorporation of the forecasts in the traditional four-step travel demand modeling process. Ergun and Stopher[1] developed transportation demand models for urban recreational trips. Their research focused on the impact of socioeconomic and locational variables on a person's recreational activity choice. Their study did not specifically deal with mode choice, nor did it fit within the standard urban travel demand forecasting process.

A study by Pol, Ponzurick, and Rakowski[2] is more typical of research regarding the use of public transportation to and from special events. Their study developed demographic profiles of potential users and non-users of public transportation to sporting events, and used the profiles to forecast overall public transportation use. Again, their research is not directly applicable in the standard urban travel demand forecasting process and is not useful for our purpose of estimating ridership differences for transit alternatives. A third area of related research deals with induced travel demand for fixed-guideway alternatives. This work is based on data summarized from the Washington Metro system and, in short, is used to forecast additional non-home-based trips made between major activity centers after a fixed guideway system linking the activity centers is built. This work is based on the observation that traditional methods for estimating non-home-based transit ridership focus only on shifts among motorized travel modes and, therefore, have no sensitivity to changes in trip frequency or destination choice for non-home-based trips resulting from fixed-guideway investments. This procedure has been used to forecast induced travel for proposed fixed- guideway systems in Honolulu and Cleveland[3, 4].

The analysis process developed as part of the Gold Line study introduces a consistent procedure for special generator analysis. Drawing on traditional analysis methods, the technique is consistent with the modeling process used for regional travel forecasts for the Denver region. Moreover, the analysis process provides line-specific forecasts of the boardings that will result for various alternatives due to the special generators.

Special Generator Analysis Methodology

Special Generator Types

Special generators can be subdivided into three groups for travel forecasting purposes: *"regular" special generators, "periodic" special generators,* and *"special" special generators*. *Regular special generators* are those special generators that produce trips on a regular, weekday basis. Typical examples of regular special generators are airports, regional shopping centers, hospitals, and schools. To qualify as a regular special generator, a site or establishment should be open during the work week. This distinction is made since most urban travel forecasting is performed to plan for weekday transportation needs, with the implicit assumption that the transportation infrastructure and services supplied for a weekday will provide sufficient capacity for weekend demand. If annual revenues from the transportation supply (e.g., transit fares or tolls) are required for cost effectiveness analyses, they are generally estimated by applying annualization factors that include the contribution of weekend travel as a percentage of weekday travel.

Periodic special generators are those generators that do not produce trips on a regular weekday basis. Typical examples of periodic special generators are convention centers, stadia and arenas, and fairs and festivals. Because they occur relatively infrequently, periodic special generators are not normally considered in the planning for transportation investments since traffic-carrying capacity is not generally added to regional facilities nor are additional transit vehicles purchased to serve infrequent events. Because of their infrequent scheduling, it is assumed for transportation

facility planning purposes that the transportation demands of periodic special generators can either (1) make use of available excess transportation system capacity (e.g., because they are scheduled at an off-peak time) or (2) create an acceptable short lived "breakdown" of the transportation system due to excess demand. While additional capacity is rarely added to the transportation system to serve periodic special generators, periodic special generators can be an important source of extra revenue for transit operators. This can result from event ridership using regularly provided transit service and from event ridership on specially provided service using surplus equipment (already available to serve normal peak demand). Of course, when special service is provided, revenues should be greater than operating costs in order for the provision of the service to be cost effective.

Special special generators include those sites or activities that cannot be easily classified as regular or periodic special generators. These special generators might include sites and activities outside of the modeling area. Travel on public transportation modes to and from external sites is often ignored because it is typically made on vehicles owned by private operators (e.g., intercity bus operators or charter buses). By definition, special special generators are unique and, thus, require individual analyses using ad hoc analysis procedures. In the Gold Line study, for example, the nearby ski areas and historic mountain community gaming districts west of Denver were considered as special special generators. The individual nature of special special generator analysis does not readily lend itself to the development of standard modeling procedures.

Regional travel models that include a special generator component for highway analyses also account for regular special generators for transit analyses. Regular special generators for highway analyses produce trips on a regular weekday basis and, due to differences in mode shares, impact auto travel forecasts long before they significantly impact transit ridership forecasts. Periodic special generators, however, often produce trips during periods that are not explicitly included in the regional modeling procedure. The focus of this paper will, therefore, be the evaluation of periodic special generators.

Periodic Special Generator Analysis Process

A principal reason for analyzing periodic special generators in a regional modeling sense is to determine additional revenue that would be generated for transit services. As stated previously, the travel demand associated with periodic special generators is not generally used to justify additional roadway or transit capacity. Trips from periodic special generators might, however, be considered in planning for the special generator site or special generator event. For example, transit and roadway improvements were considered in the planning for Coors Field in downtown Denver.

Periodic special generators of any size can be included in the analysis. Two practical considerations become important in determining size criteria: frequency of the event and size of the event. Large events, such as football games and baseball games are relatively infrequent, but are sufficiently important to receive special transit service. All large events should be included in the periodic special generator process. In Denver, using de facto criteria established in the region based on Colorado Rockies baseball attendance, large was defined as expected daily attendance of 40,000 or more. Smaller events (e.g., basketball and hockey games) typically do not receive specially provided transit service, but instead rely on regularly scheduled bus service. In Denver, the suggested size criteria for smaller events to be considered independently was 500,000 total annual

attendees, or 8,000 average individual event attendees, as described below. If either criterion was satisfied, the site was included for analysis as a periodic special generator.

The total attendance criterion was calculated by multiplying the average event attendance by the number of events during the year. When the generator did not meet the size criterion by itself, it was bundled with other events occurring at the same site. For example, individual concerts at McNichols Arena (or the proposed Pepsi Center arena) were too small to warrant individual analysis. However, grouping concerts and other special events occurring at the specific sites provided sufficient attendance to warrant consideration as a periodic special generator. Other sites or groups of events were considered on an exception basis if they had sufficiently high visibility.

Trip generation, trip distribution, mode choice, and transit assignment models are required for periodic special generators. Modeling of periodic special generators is performed separately from the regional model. The periodic special generators require special files and model runs although some data and files from the regional model (e.g., auto "skim" trees) are used in the process.

Trip Generation

Trip generation for periodic special generators can be based on attendance projections. The normal daily trips to periodic special generator sites are accounted for in the regional modeling process. In Denver, for example, home-based work, home-based non-work, non-home-based, truck, and internal-external trips made to Mile High Stadium on an average weekday were based on the regular Mile High Stadium employment. However, travel to the stadium by "event" attendees has not been modeled in the normal regional travel forecasting process.

Estimates of attendees for most periodic special generators can be readily made. Attendance at sporting events, for example, can be estimated from past history. Attendance growth, in the case of sporting events, is often constrained by available seating. Two person trips can be modeled for each attendee to account for the trip to the event and the trip from the event.

Periodic special generator trips must be allocated to trip purposes. For events that occur on weekends, all trips can be assumed to be home-based non-work trips, although this assumption probably overstates the number of home-based trips and underestimates non-home-based trips since some attendees travel to or from the event to eating establishments, friends' homes, or work. For events that occur on weekdays, the attendee trips should be split between home-based non-work and non-home-based trip purposes. This split accounts for the higher likelihood of traveling to or from the event to or from work during the week. The split can be made in proportion to the regional shares of total trip ends by purpose (i.e., home-based non-work attractions, non-home-based productions, and non-home-based attractions). For events that occur on both weekdays and weekends, weighted averages for home-based non-work and non-home- based trips can be estimated.

Periodic special generator trips are projected on a daily basis. For sporting events, the daily basis is generally equivalent to one game. For other periodic special generators (such as an amusement park), a day is the appropriate time period for analysis. Each periodic special generator has a unique annualization factor. The annualization factor is simply the total number of annual events, or event days. For example, major league baseball teams play 81 home games each year, so the annualization factor is 81. The Taste-of-Colorado, an annual downtown Denver festival, is a three day event, so the annualization factor is three.

Trip Distribution

Home-based non-work and non-home-based trip attractions, and non-home-based trip productions are estimated for the periodic special generators. For home-based trips, the distribution of trips is somewhat simplified since they can be distributed from one attraction site (the special generator) to all production sites (i.e., home sites).

In the regional modeling process, symmetry between non-home-based trip productions and non-home-based trip attractions is assumed. In other words, non-home-based trip attractions are assumed to equal the non-home-based trip productions for each zone. For the periodic special generator process, this assumption of symmetry can be exploited to simplify the trip distribution process. Specifically, the non-home-based trip productions can simply be added to the non-home-based trip attractions at the special generator sites. This ensures that all periodic special generator trip "productions" take place at the non-special generator end of the trip, and all "attractions" take place at the special generator. The resulting distribution results can be used in the modeling process with no loss in generality.

Trip distribution of periodic special generators is simply a proportioning of trips from all parts of the region to a single site (for each periodic special generator). The basis for the proportioning will depend on the characteristics of each periodic special generator. For some sites, no sensitivity to travel time or distance in the region should be assumed. For example, there is no reason to assume that a resident of an outlying suburb is any more or less likely to attend a professional sporting event at Mile High Stadium than a resident of downtown Denver (if their socioeconomic characteristics are similar). Conversely, some special generator sites probably are sensitive to travel time or distance in the region. For example, residents of an outlying suburb are less likely to attend a downtown street fair than are residents of downtown Denver. Likewise, convention attendees at the Colorado Convention Center in downtown Denver are more likely to travel from downtown lodging establishments than from suburban hotels and motels.

Most special generator operators have little, if any, information regarding the spatial distribution of their attendees or consider the information to be confidential or proprietary. Since the information is not readily available, assumptions have been made regarding the basis for the distribution of trips to special generators. A basic choice must be made for each generator: the distribution should or should not be sensitive to time or distance traveled. The distribution can be considered to be independent of travel time or distance if there is no substitution event available. Thus, professional sporting events can be considered to be independent of travel time or distance. If a substitution event will be available, the distribution of trips to the site can be assumed to be affected by time or distance. Thus, events such as fairs and parades can be considered to be dependent on travel time since local jurisdictions provide similar events.

The distribution of trips to and from the periodic special generators can be made using a gravity model formulation. The gravity model is typically used to distribute trips from one origin to all destinations, not from one destination (i.e., the special generator) to all origins. However, the model can be applied in either direction. Zonal home-based non-work or non-home based productions can be used along with the periodic special generator attractions for the generator in question in the model application. The fact that the sum of the home-based non-work or non- home-based productions for the region do not match the special generator attractions for the special generator in question is not a problem in the application. The gravity model is "self normalizing" to

the total attractions modeled for each special generator. Note that in the periodic special generator process, the model is applied independently for each special generator.

The values used for the friction factors in the gravity model determine the type of distribution performed. For a non-distance based distribution, all of the friction factors are set to 1.0, making the distribution independent of spatial separation and sensitive to only the relative distribution of trip productions in the production zones. For distance based distributions, the friction factors can be based on the home-based non-work and non-home-based trip distribution friction factors calibrated for the regional travel model.

Care must be used in the application of the gravity model to ensure that all inputs (i.e., productions, attractions, travel time matrices or friction factors) are consistent in terms of directionality. If special routines are used for the distribution, they can account for the fact that attractions are being distributed to productions while travel time matrices are from production zone to attraction zone. If a set gravity model program is "tricked" by inputting the special generator attractions as productions and the productions as attractions, travel time matrices should be transposed prior to the implementation of the gravity model, and the output trip matrices should be transposed (prior to the mode choice step) if normal mode choice procedures are used.

The distributions for each periodic special generator are, in effect, independent of each other. Distributions for multiple sites can be performed simultaneously, provided there are not two sites within one zone and provided that special travel time matrices are not subsequently required for mode choice. Note that for each periodic special generator, two distributions are performed— one for home-based non-work trips and one for non-home-based trips.

Mode Choice

Mode choice for periodic special generators can be accomplished through the use of the regional models for home-based non-work and non-home-based trips. The model must be run for each trip table created by the trip distribution step for the periodic special generators. Prior to the application of the mode choice model, the trips can be annualized by multiplying the appropriate trips for a periodic special generator by the appropriate annualization factor. This step simplifies the subsequent mode choice and trip assignment procedures.

Special transit path-building runs might be required for periodic special generators with special service such as professional baseball or football games. In this case, the special service must be coded into the network. Auto access to transit services can be assumed to be available for both home-based and non-home-based trips to the special generators. This will account for attendees that travel to events from eating establishments or friends' homes. Coded fares should reflect the service used. In other words, if a special service is used, the special service fare should be coded. Otherwise, normal fare policy should be coded for regularly scheduled services.

A number of changes to zonal data input to the mode choice program might be required. First, average event parking costs at the attraction zone should be coded for each periodic special generator. The parking costs should be adjusted to account for the average auto occupancy noted for each event. In addition, auto terminal times should be modified to reflect average walk times from parking lots to each of the periodic special generators.

Table 1: Sample periodic special generators for 2015

Site or Event	Assumed annual growth	Event days per year	Visitors/day	
			1995	2015
Colorado Convention Center / Currigan Hall	1.0%	250	3,420	4,170
Coors Field-Rockies Baseball	0.0%	81	48,000	48,000
Elitch Gardens Amusement Park	2.5%	121	7,470	12,240
Taste of Colorado	1.6%	3	116,700	160,30

Transit Assignment

Annual transit assignments can be performed for the periodic special generators. Since each periodic special generator can have a unique annualization factor, an annual transit assignment is a logical common time period available for the assignment process. Assigning the trips on an annual basis eliminates the need to perform separate transit assignments for each special generator. Since transit assignments are not capacity restrained, the assignment of annual trips does not cause any problems with the assignment process.

Example Application Results

Trip Generation

Table 1 summarizes the year 2015 trip generation results for four of the periodic special generators included in the Gold Line study. The annual growth factors listed in Table 1 are based on information provided by operators of the special generators, when available, or on the average annual percent growth in the region's population. The 1.6 percent rate assumes that attendance at special generator events will grow at a pace equal to the projected growth in population. Zero percent growth rates are for events that are currently constrained by seating capacity. Growth rates greater than 1.6 percent are based on information provided by operators of events. As previously discussed, each visitor was assumed to make two trips.

Table 2: Average travel times for trips to sample periodic special generators for 2015

Site or Event	Distribution basis	Average travel time in minutes	
		Home-based non-work trips	Non-home-based trips
Colorado Convention Center/Currigan Hall	Distance	22.6	22.6
Coors Field-Rockies Baseball	Non-Distance	34.5	32.5
Elitch Gardens Amusement Park	Distance	25.1	24.9
Taste of Colorado	Distance	23.2	22.9

Table 3: Annual transit trips and transit mode shares to sample periodic special generators for 2015

Site or Event	No-Build		Build	
	Trips	Share	Trips	Share
Colorado Convention Center / Currigan Hall	437,100	21.2%	447,600	21.7%
Coors Field-Rockies Baseball	1,208,100	15.5%	1,219,800	15.7%
Elitch Gardens Amusement Park	865,200	29.3%	881,200	29.8%
Taste of Colorado	372,900	38.8%	372,900	38.8%

Trip Distribution

Table 2 summarizes the average travel times to the periodic special generators. The distribution basis (distance based or non-distance based) is also shown. As can be seen, the distance based average travel times are shorter than the non-distance based distributions.

Mode Choice

Mode choice is dependent on numerous items including auto and transit travel times and costs. The regional home-based non-work and non-home-based mode choice models were used to project periodic special generator mode shares. Several changes were made to the models in order to replicate base mode shares. Specifically, parking costs were adjusted in the special generator zones to reflect weekend, nighttime, and event parking costs as appropriate, as well as assumed and observed auto occupancy rates. Auto terminal times were also modified for Colorado Rockies Baseball games. The revised auto terminal times reflect longer walk distances from parking to Coors Field and increased congestion approaching and leaving the venues. Finally, special transit services for Rockies games were also coded.

Table 3 summarizes the overall mode choice results for the example periodic special generators for two of the alternatives tested. As can be seen in the table, transit mode shares to the periodic special generators are relatively high. In comparison, general home-based non-work and non-home-based transit mode shares for the region average about 11.5 percent in the CBD and 1.2 percent outside of the CBD. The high mode shares are due, in large part, to the CBD or CBD fringe location of many of the events along with the relatively high parking costs charged for many of the events.

Transit Assignment Results

Table 4 summarizes the results of the transit assignments of the annual periodic special generator trips for the Gold Line study. The results summarized in Table 4 include only periodic special generator trips by event attendees. Table 4 also shows projected annualized weekday boardings as a basis for comparison.

The annualized weekday boardings implicitly include the periodic special generator boardings through the annualization factor, 302. That factor is based on historical data comparing annual system wide boardings to average weekday boardings. However, the projected annual periodic special generator boardings for the build alternative range from about 4 percent of the annualized estimate for Limited/Rapid Transit Feeder service to about 9 percent for the Regional/Express

Table 4: Regional transit assignment results for 2015

Type of transit service	Annual periodic special generator boardings		Annualized boardings[a]
	No-Build	Build	
Local Bus	4,055,300	4,060,300	52,805,300
Limited/Rapid Transit Feeder	305,300	311,900	8,324,000
Regional/Express Bus	688,200	628,500	6,872,000
Light Rail/Air Train	2,489,100	2,523,300	30,455,800
Gold Line Rail	n/a	130,000	1,774,300
Total	7,537,900	7,654,000	100,231,400

a. Annualized boardings are summarized from 2015 projections for regular weekday transit.

Bus service. This implies that the explicit modeling of periodic special generator ridership can produce more realistic forecasts of annual boardings and revenues. Of course, adjustments to the annualization factor are required to avoid double counting in annualized totals.

Summary

An analysis process for assessing the impact of special generators on transit ridership projections has been developed and demonstrated in a study performed for the Regional Transportation District in Denver, Colorado. The special generator analysis process provides a consistent and rigorous method for comparing special generator ridership projections between alternatives and corridors.

The special generator process works within the regional transportation planning process used for the Denver region. In the future, it might be desirable to collect data and calibrate trip distribution and mode choice models unique to the special generators. However, since those data are currently not available, assumptions that travelers react to travel options in a similar manner as for normal weekday travel have produced reasonable results.

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