Fixed-Route Transit Ridership Forecasting and Service Planning Methods

DETAILS

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TRANSIT COOPERATIVE RESEARCH PROGRAM

TCRP SYNTHESIS 66

Fixed-Route Transit Ridership Forecasting and Service Planning Methods

A Synthesis of Transit Practice

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SUBJECT AREAS
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TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

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FOREWORD

By Staff
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Transit administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to the transit industry. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire transit community, the Transit Cooperative Research Program Oversight and Project Selection (TOPS) Committee authorized the Transportation Research Board to undertake a continuing study. This study, TCRP Project J-7, "Synthesis of Information Related to Transit Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute a TCRP report series, *Synthesis of Transit Practice*.

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

This synthesis documents the state of the practice in fixed-route transit ridership forecasting and service planning. It identifies forecasting methodologies, resource requirements, data inputs, and organizational issues. It also analyzes the impacts of service changes and reviews transit agency assessments of the effectiveness and reliability of their methods and of desired improvements. This report will be of interest to transit planners and managers as they develop and refine forecasting methodologies for their own agencies.

A survey was undertaken to acquire information on methodologies used in a variety of situations, satisfaction with these methods, and suggestions for improvements. Following a review of the survey results, case studies were developed that included transit agencies of various sizes and from different geographic regions, agencies with a variety of approaches and methods related to ridership forecasting, and agencies that could offer insight to the industry as a whole.

Daniel Boyle, Dan Boyle and Associates, San Diego, California, collected and synthesized the information and wrote the report, under the guidance of a panel of experts in the subject area. The members of the topic panel are acknowledged on the preceding page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

CONTENTS

FIXED-ROUTE TRANSIT RIDERSHIP FORECASTING AND SERVICE PLANNING METHODS

SUMMARY

This report documents the state of the practice in fixed-route transit ridership forecasting and service planning. A survey of transit agencies in North America identified methodologies used to analyze the effects of service changes and to forecast ridership. The survey included transit agency assessments of the effectiveness and reliability of their methods and desired improvements. An emphasis was placed on repeatable, timely, and transferable methodologies. Case studies provided additional details on innovative and successful practices. This report will be useful to transit planners and managers as they develop and refine forecasting methodologies for their own agencies.

A survey was distributed to 45 selected transit agencies in the United States and Canada. Twenty-five transit agencies were originally identified for inclusion in the survey sample. An additional 15 were randomly selected from the National Transit Database to make the sample more representative in terms of geographic region and system size. Five additional transit agencies, recommended by respondents, were also included bringing the total to 45. A total of 36 agencies completed and returned the survey.

Key findings included the following:

- A wide variety of data sources are used in ridership forecasting. Automated passenger counters (APCs) have become more popular, but are still the least likely source of ridership data among those listed. Origin/destination data, although frequently considered, are not a major component of ridership forecasting for a majority of respondents.
- A majority of responding agencies do not have the optimal amount of data available for forecasting ridership. The most common concern is availability of ridership data below the route level (by route segment or stop).
- Results regarding agency satisfaction with the reliability of input data are mixed, with 44% of respondents indicating general, but not complete, satisfaction. The greatest reliability concerns center on ridership data; however, the timeliness and level of detail for origin/destination and demographic data are also of concern.
- Simpler, less formal approaches are used for route-level and other small-scale service changes. The examples show that some of these “simpler” approaches have grown more sophisticated as geographic information system databases are used to assess demographic characteristics and identify similar routes, and as APCs and ongoing programs improve the accuracy of ridership data. More formal methods, including use of the four-step travel model, are used when either the change or the time frame is beyond the scope of the current system.
- The planning department is the most likely home within a transit agency for the forecasting function. However, it is not unusual for multiple departments to be involved in different levels of ridership forecasting. Responsibility for ridership forecasting is more likely to be part of general duties for all but major changes.
- Roughly one-third of responding agencies are satisfied with their current forecasting methods, one-third are partially satisfied, and one-third are not satisfied. The quality and availability of input data and accuracy of the forecasts are the most pressing concerns.

- Input data and methodology were the most frequently mentioned aspects of ridership forecasting procedures that transit agencies would like to change. Agencies reported a need for greater data availability, more current data, and more detailed data. Methodology needs were more diverse, because various agencies are at different stages regarding forecasting methods.
- The most commonly mentioned lessons learned included the need to interpret results carefully and simplify the approach to ridership forecasting.

Major conclusions included the following:

- Qualitative forecasting techniques relying on professional judgment and experience continue to be widely used by transit agencies, especially for small-scale and near-term changes. Some consider these too subjective and too dependent on the skill of the analyst. Examples cited throughout this synthesis demonstrate that qualitative procedures can involve consideration of a wide variety of factors, often directed toward identifying similar circumstances elsewhere in the transit system that can provide guidance for likely ridership response.
- Use of service and headway elasticities is widespread among transit agencies. Broad-based studies such as *TCRP Report 95: Traveler Response to Transportation System Changes* are very useful in providing information on "typical" elasticities; however, several agencies emphasized the need to adapt these to their service areas using their own experiences.
- Formal travel modeling expertise is found at the metropolitan planning organization (MPO), not usually at the transit agency. The literature review noted that several MPOs are actively engaged in development of forecasting methodologies at a more appropriate scale for transit needs than the traditional four-step travel model. At the same time, widespread use of new technologies such as geographic information systems and APCs allow transit agencies to develop more sophisticated ridership forecasting tools. These developments suggest the possibility of convergence in the near future.
- Transit agencies reported that a strong ongoing working relationship with their MPOs is beneficial to both parties. Modelers and transit planners often work in different time frames and geographic scales, and ongoing communication helps to bridge these gaps.
- Transit agencies reported value in ridership forecasting methodologies. Several noted that ridership forecasts provide a basis for prioritizing among competing proposals and, more generally, for decision making at the senior management and board levels. Internally, ridership forecasting can encourage discipline in the service planning process, particularly where there is ongoing interaction between modelers and service planners. This interaction can also result in improved methodologies. Sound ridership forecasting methodologies can also enhance a transit agency's credibility among stakeholders and peer local and regional agencies.
- At many agencies, forecasting is more of an art than a science and is likely to remain so in the near future. However, new technologies that provide more accurate ridership data and enhance the ability to summarize demographic and socioeconomic data at an appropriate level of detail are fostering continued development of ridership forecasting techniques and increasing the confidence level in forecasting results.

CHAPTER ONE

INTRODUCTION

BACKGROUND

Traditional transit ridership forecasting relies on a four-step travel demand forecasting model. This model has traditionally been used to compare and identify major travel investment policy choices.

Because the traditional forecasting process is data and labor intensive, transit agencies have developed and applied other methods for transit demand forecasting and service planning. Some methods may be used to estimate systemwide ridership for budgeting purposes and others to estimate the ridership impacts of new or revised services. These methods vary according to:

- Geographic scale (from a single route or route segment to the entire system),
- Scale of the service change (from a minor schedule adjustment to a major system restructuring), and
- Time frame for the ridership forecast (from one day to 10 years).

Given the wide variation in the purposes of a ridership forecast, it is not surprising that most transit agencies have not developed a single formal methodology. From the broader transit industry perspective, the transferability of a particular methodology to other transit agencies is uncertain. The end result is a widespread reliance on "back of the envelope" (improvised) methods, the accuracy of which depends on the knowledge and experience of the individual(s). Information on ridership forecasting approaches that bridges the gap between the back of the envelope and the four-step travel demand model would be very useful for transit agencies.

Technological changes have affected the forecasting process. One example is the increasing use of automated passenger counters (APCs) that enhance the quantity, reliability, and level of detail of ridership data. Another is the prevalence of geographic information system (GIS) tools that greatly simplify the process of summarizing demographic and employment data and relate these spatially to transit routes or route segments.

METHODOLOGY

This synthesis included a literature review, a survey of transit agencies, and telephone interviews with six agencies selected as case studies. A Transportation Research Information Services (TRIS) search was conducted to aid the literature review. In addition, a message was posted on the Travel Model Improvement Program (TMIP) e-mail list (see http://tmip.tamu.edu/email_list for additional information) describing the synthesis project and requesting assistance. Several respondents suggested studies for inclusion in the literature review.

The survey on transit ridership forecasting was designed to elicit information on methodologies in use in a variety of situations, satisfaction with these methods, and suggestions for improvements. A survey was sent to 45 selected transit agencies in the United States and Canada. Each agency was contacted by e-mail or telephone before the surveys were sent to ascertain interest and identify the correct recipient. Follow-up e-mails and telephone calls were placed approximately 6 and 10 weeks after the original survey to encourage responses.

The selection of agencies for the sample was guided by the existence of ongoing ridership forecasting activities, participation in similar studies, random selection of additional agencies to ensure adequate representation by size and location, and recommendations from other transit agencies. Initially, 25 transit agencies were identified for inclusion in the sample. An additional 15 agencies were randomly selected from the National Transit Database (NTD) to make the sample more representative in terms of geographic region and system size. At least 5% of agencies in each FTA district were included in the sample. Finally, respondents recommended five additional agencies for inclusion in the sample, bringing the total to 45 transit agencies. Thirty-six agencies completed the surveys, a response rate of 80%.

Table 1 presents the distribution of responding agencies by size.

Table 2 shows the distribution of responding agencies by FTA region. Figure 1 is a map of FTA regions.

ORGANIZATION OF REPORT

Following this introductory chapter, chapter two summarizes the findings of the literature review. Chapter three, the first of two chapters to present the results of the survey, focuses on forecasting methodologies, resource requirements, data inputs, and organizational issues. In the process of survey

TABLE 1
SAMPLE AND RESPONDING TRANSIT AGENCIES BY SIZE

No. of Vehicles Operated in Maximum Service	No. of Agencies Responding
1–50	5
51–100	4
101–250	11
251–500	3
501+	13
Total	36

TABLE 2
SAMPLE AND RESPONDING TRANSIT AGENCIES BY FTA REGION

FTA Region	No. of Agencies Responding
I	2
II	5
III	2
IV	4
V	3
VI	3
VII	2
VIII	1
IX	9
X	3
Canada	2
Total	36

development, the wide variety of circumstances that could generate the need for a ridership forecast became apparent. To address this issue, the survey provided seven specific scenarios and asked how the agency would forecast ridership under each scenario. This chapter includes agency responses.

FIGURE 1 Map of FTA regions.

Chapter four discusses the responding agencies' assessment of their own forecasting methods. This chapter summarizes perceptions of data reliability and accuracy, satisfaction with current methodologies, desired improvements, lessons learned, and advice for other transit agencies.

Chapter five reports detailed findings from each of the six case studies. Agencies were selected for the case studies for a variety of reasons. Some approaches can be characterized as "best practices." One case study presented a setting in which forecasting methodologies are not considered to be necessary. All six show a thoughtful response to the issues posed by ridership forecasting.

Chapter six summarizes the findings, presents conclusions from this synthesis project, and offers suggestions for further research. Findings from the surveys and particularly the case studies provide an assessment of strengths and weaknesses in current methods and likely future directions.

CHAPTER TWO

LITERATURE REVIEW

INTRODUCTION

This chapter summarizes findings from a literature review related to transit ridership forecasting. A TRIS search was conducted to aid the review. In addition, a message was posted on the Travel Model Improvement Program e-mail list (see http://tmip.tamu.edu/email_list for more information) describing the synthesis project and requesting assistance. Additional studies for inclusion in the literature review were suggested by several respondents.

OLDER STUDIES

Groundbreaking work on transit ridership forecasting goes back more than 30 years, with considerable activity in the 1970s and 1980s. The Urban Mass Transportation Administration sponsored several studies at specific transit agencies, including the Greater Cleveland Regional Transit Authority in Ohio (*1*). Other researchers in the 1980s developed techniques to forecast route-level or system-level ridership, either through regression models using some combination of service levels, fares, population, population density, employment, distance from the nearest stop, automobile ownership, gasoline price and supply, or through a modified four-step travel model (*2–5*).

A 1983 report summarized the use of route-level ridership prediction techniques (*6*). The authors identified eight different types of transit changes (seven service-related plus a fare change) that use ridership prediction techniques, and characterized four general techniques:

- Professional judgment;
- Noncommittal or stated-preference surveys;
- Cross-sectional models, ranging in sophistication from similar routes and rules of thumb to regression analyses; and
- Time-series models, including elasticity-based approaches and trend analysis.

The various techniques were ranked subjectively on a number of factors, but concluded that insufficient information was available to address accuracy and transferability.

Two broader works that encompassed examples from throughout the United States and the world were published and/or updated between 1977 and 1981. *Impacts of Changes in Fares and Services* (*7*) and *Traveler Response to Transportation System Changes* (*8,9*) served as key source documents for a generation of transit planners attempting to quantify the impacts of various types of service and fare changes.

MORE RECENT STUDIES

TCRP is sponsoring an update and expansion of the *TCRP Report 95: Traveler Response to Transportation System Changes*. Interestingly, one finding is that whereas much of the detailed information regarding transit service changes is old, it is not out of date. Several chapters have been finished and are available on the TCRP website, with the entire handbook scheduled for completion in 2006. The 19 chapters in the final handbook address the following subject areas (*10*):

- Multimodal/intermodal facilities,
- Transit facilities and services,
- Public transit operations,
- Transportation pricing,
- Land use and nonmotorized travel, and
- Transportation demand management.

Each chapter summarizes traveler responses to the specific type of change addressed, discusses underlying factors contributing to the traveler response, provides related information and impacts, and presents case studies and examples. The most relevant chapters for this synthesis, Chapter 9, "Transit Scheduling and Frequency," and Chapter, 10 "Bus Routing and Coverage," have been released.

Chapter 9, "Transit Scheduling and Frequency" (*11*), describes ridership response to changes in frequency in terms of service elasticity, with an average elasticity of +0.5. (Elasticities are generally used to estimate short-term changes in ridership in response to fare or service changes.) Higher elasticities are seen in cases where initial service levels are low (e.g., one bus per hour) and among higher-income riders. Recent examples show frequency elasticities grouping around either +1.0 or +0.3, with the higher elasticities seen in suburban systems and the lower elasticities in urban systems. It was noted that service reliability, clock face schedules that are easy to remember, the condition of the transit fleet, and timed transfers affect the response of riders to frequency changes, but are difficult to quantify.

Chapter 10, "Bus Routing and Coverage" (*12*), uses service elasticities as the measure of ridership response to service expansion and riders per hour or per capita as the measure of ridership response to successful new areawide transit systems. The authors report an average elasticity in the range of 0.6 to 1.0. First year ridership on new bus systems averages three to five trips per capita or 0.8 to 1.2 riders per bus mile. Service restructuring is more difficult to quantify, but several factors contributing to operating efficiencies and ridership growth are reported including high service levels on major routes, consistency in scheduling, enhancement of direct travel and ease of transferring, quantitative investigation of travel patterns, and favorable economic conditions. Among other findings, flexible service designs such as hub-and-spoke have a slight but not universal edge over grid systems. New bus routes take 1 to 3 years to realize their full ridership potential.

A study that examined service and fare changes in Europe found that long-run elasticities (from 3 to 7 years) are larger than short-term elasticities by a factor of 1.84 (*13*), although it is more difficult to isolate changes from a particular action over a long period of observation.

RAIL-ORIENTED STUDIES

Several studies published since the 1980s have addressed ridership forecasting for rail systems. Although the FTA's New Starts program mandates ridership forecasts, these forecasts are done in the context of a traditional four-step travel model. The Chicago Transit Authority developed a spreadsheet version of the Chicago Area Transportation Study's mode choice model on its West Corridor project to forecast ridership in response to service revisions (*14*). Model inputs included line-haul times and costs and access times and costs. Results confirmed the importance of transit access. An example of ridership forecasting for commuter rail included a methodology based on historical passenger rail travel patterns, origin/destination surveys, and population for an extension of passenger train service to San Luis Obispo, California (*15*). Rail passenger forecasters have also developed a quick-response approach using multivariate regression to examine the effect of station-level variables, including surrounding land use and service characteristics at a given station, on heavy rail, light rail, and commuter rail ridership (*16*).

ROUTE-LEVEL STUDIES

Two interesting papers addressed the issue of route-level ridership forecasting. Stopher (*17*) developed a model to predict ridership changes at route and time-of-day levels resulting from headway changes, route extensions, new routes, route shortenings, short-lines on existing routes, service span changes, or a combination of actions. Peng et al. (*18*) proposed a ridership model operating at the route segment level by time of day and direction. This model incorporated transit demand, supply, and inter-route effects in a simultaneous system. The study noted that, although a service improvement increases ridership on a given route, it is likely to later cause a ridership decrease on parallel or competing routes. Neither of these models, although theoretically appealing, has been widely adopted by transit agencies.

Several transit agencies have attempted to develop ridership forecasting procedures. Three procedures that have been published (and there are likely many more that are used internally) were prepared for Lane Transit District (LTD) in Eugene, Oregon; Metropolitan Transit Development Board (MTDB) in San Diego, California; and the Capital District Transportation Authority in Albany, New York. These attempts have all taken advantage of GIS programs to identify demographic and employment characteristics within walking distance of a given transit route.

The LTD route-level ridership forecasting model used route ridership rates as the dependent variable and buffer-area demographics, service levels, and competition from other routes as independent variables (*19*). This effort developed separate least-squares regression models for four weekday time periods plus Saturday, and converted the models to elasticity form for use in forecasting. Median household income and vehicle service hours were the only variables to appear in more than one model. LTD is not currently using this model, citing difficulties in obtaining the required input data.

The second effort developed a preliminary ridership model for urban bus routes operated by the MTDB in San Diego (*20*). As at LTD, models were developed by time period (three daily time periods); however, an all-day model was also developed. This effort found that service-related variables tended to overwhelm demographic and employment factors. Also, the model was not transferable to other route types such as feeder routes or community circulators.

New transit modes can also stimulate ridership forecasting estimates. Capital District Transportation Authority developed ridership projections in the NY5 corridor as part of a bus rapid transit (BRT) study (*21*). The forecasting technique involved several steps, including a determination of which trips would be likely to shift to BRT and an assessment of the impacts of headway and travel time changes and other improvements on ridership. Headway elasticities were taken from Pratt and Coople (*9*), while the travel time elasticity was taken from Mayworm et al. (*7*). Other BRT case studies were used to estimate ridership impacts of branding, image, and amenity improvements.

METROPOLITAN PLANNING ORGANIZATION STUDIES

Not surprisingly, transit agencies are not the only agencies to prepare ridership forecasts. Several metropolitan planning organizations (MPOs), where modeling expertise is generally focused, and other regional agencies have developed transit ridership forecasting tools that are more user-friendly than formal four-step travel models.

As part of its Regional Transit Access Plan, the Georgia Regional Transportation Authority in Atlanta developed a sketch planning tool that produced ridership forecasts for various transit improvement scenarios (*22*). The flexible nature of this tool allowed for an iterative forecasting process in which refinements could be introduced to improve overall performance and effectiveness. Ridership forecasting using this sketch planning tool focused on rail, BRT, bus-only lanes, and streetcars running in traffic lanes.

The Maricopa Association of Governments in Phoenix, Arizona, created the Sketch Plan Model, which estimates light rail ridership (*23*). This model uses a set of trip rate factors developed from other light rail systems in the western United States. These factors are based on the number of households and the percentage of regional jobs within a given distance from a light rail station. Four geographic categories are used for access and egress distances, resulting in 16 average trip rate factors.

The North Central Texas Council of Governments has a transit analysis process integrated within its four-step travel demand model (*24*). Its major advantages are that it is simpler and faster than a full model run (4 h versus 12 h) and it uses the already available coded travel system. Although closer to a four-step model than a sketch planning tool, it results in faster model runs and is somewhat simpler to use.

The Knoxville Regional Transportation Planning Organization developed the Knoxville Transit Analysis Tool (KTAT) as an independent sketch-planning add-on to its regional travel demand model (*25*). Inputs to KTAT include a traffic analysis zone (TAZ) layer with socioeconomic data and a selection set on a line layer to define the route being tested. KTAT operates in TransCAD to produce an estimate of ridership per revenue hour based on a regression model with population density, mean household income, workers per vehicle, and retail employment density as independent variables. The independent variables are calculated for a one-quarter mile buffer around the route. The model resulted in an R-squared value of 0.835. The user guide cautions that the ridership per revenue hour is best viewed relative to other routes and not necessarily as an absolute forecast. However, this tool provides a means to test various routes to determine the most promising alternatives.

CURRENT STUDIES

A ridership forecasting tool that is still under development is Transit Boardings Estimation and Simulation Tool (T-BEST) (*26*), which is a model being developed for the Florida Department of Transportation (DOT) Public Transit Office that works with ArcGIS to simulate travel demand at the individual stop level. A resource paper in support of this effort presents a framework for forecasting stop-level transit patronage (*27*) and also provides a good overview of previous transit modeling efforts. The T-BEST model accounts for network connectivity, temporal and spatial accessibility, time-of-day variations, and competing and complementary routes through the use of a wide range of socioeconomic and service attributes. Results can be aggregated to time period, day of the week, route segment or route, sub-area, or the entire system from the individual stop level. The model distinguishes between direct and transfer boardings and therefore can quantify trip-linking and provide a means of analyzing the effects of transfer opportunities on ridership. An earlier version of this model has been documented in the literature (*28*) after calibration using data from Jacksonville, Florida. T-BEST is now being applied in Broward County, Florida. Florida DOT plans to use the T-BEST model statewide for transit ridership forecasting.

Research related to improved ridership forecasting techniques is continuing, as indicated by two papers presented at the TRB 85th Annual Meeting in January 2006. Lane et al. (*29*) presented a sketch-level ridership forecasting tool for light rail and commuter rail. This model improved on the 1996 *TCRP Report 16* (*30*) by taking into account reverse-commute trips to employment areas outside the central business district and by introducing service-related variables such as travel speed, fare, and midday headways. Marshall and Grady described a sketch transit planning model for the Washington, D.C., region that supports transit/land use scenario analysis (*31*). This model better matches suburban transit ridership, is sensitive to land use effects, and is less costly to use than the traditional four-step model. Transferability of this model to other regions is not clear.

SUMMARY

There are other ridership forecasting models. Several transit agencies have developed models for internal use and might not find it worthwhile or cost-effective to publish a report on the subject. The studies cited here provide a good cross section of work done in this area. The more straightforward approaches exemplified by Mayworm et al. (*7*) and Pratt and Coople (*9*) are more user-friendly and are appropriate for ridership forecasts resulting from small-scale changes. Efforts at the MPO or state levels to develop simpler and more usable sketch planning tools show promise. Transferability across different metropolitan areas has not been established and is an important factor inhibiting widespread use of ridership forecasting models. T-BEST development in Florida may provide insight into model transferability.

The intent of this synthesis is not to recommend one approach over another, but to catalogue the various forecasting procedures currently used by transit agencies. The following two chapters describe the results of a survey of more than 30 transit agencies in the United States and Canada.

CHAPTER THREE

RIDERSHIP FORECASTING METHODOLOGIES

INTRODUCTION

This is the first of two chapters presenting the results of a survey of transit agencies regarding ridership forecasting. The survey was designed to elicit information on methodologies in use in a variety of situations, level of satisfaction with these methods, and suggestions for improvements.

This chapter analyzes results related to data inputs, forecasting methodologies, organizational issues, and the use of forecasting methods for specific scenarios. A wide variety of circumstances can generate the need for a ridership forecast, suggesting that a variety of tools and techniques may be needed. To address this issue, the survey provided seven specific scenarios and asked how each agency would forecast ridership under each scenario.

TYPOLOGY: TIME, GEOGRAPHIC SCOPE, AND EXTENT OF CHANGE

Ridership forecasting varies from informal to formal or from simple to complex. Near-term changes are more likely to be evaluated informally, whereas most long-range transportation plans use a traditional four-step model. Changes affecting one or two routes or route segments do not receive the same level of analysis as a systemwide restructuring. Minor scheduling or route adjustments rarely call for the use of a formal model; however, the introduction of new modes such as light rail or BRT almost always does.

There is an inverse concern regarding the appropriateness of a particular method for a particular purpose. Traditional four-step travel models were not designed to measure the results of incremental changes to the transit network, are far too time consuming to use for such a purpose, and would be unlikely to yield an accurate answer because they are not sensitive to this level of change. Back-of-the envelope methods may be insufficient for forecasting the ridership impacts of a package of service changes.

The survey asked agencies under what circumstances they would prepare a ridership forecast (Table 3). A majority of the agencies reported that they would forecast ridership for a new route, major route changes, a new mode or type of service, for the next 5 or 10 years, and for the next fiscal year. Minor service changes or scheduling changes were much less likely to generate a ridership forecast. The most common "other" response was a fare change.

TABLE 3
REASONS FOR FORECASTING RIDERSHIP

Reason	No. Agencies Responding	Agencies Responding (%)
New routes	31	86
Route changes affecting 25% or more of a route	24	67
New mode/new type of service	24	67
The next 5 or 10 years	23	64
The next fiscal year	22	61
Route changes affecting less than 25% of a route	16	44
Minor adjustments to route segments	12	33
Scheduling changes	11	31
Other	5	14

Table 3 suggests that there may be a threshold in terms of the scale of service change that would trigger a ridership forecast. Table 4 shows that 66% of respondents have either a formal or informal threshold. Four agencies noted a threshold of a 25% change in miles, hours, or riders, whereas three reported 10%. Other factors that would require a ridership forecast include the need for board approval and significant cost impacts.

DATA INPUTS

Ridership forecasting can rely on various factors, including ridership at different levels, origin/destination information, demographic and land use factors, and economic trends. Myriad data sources are available for use. This section describes the factors and data sources used as input, with particular attention paid to origin/destination data.

TABLE 4
THRESHOLD FOR TRIGGERING RIDERSHIP FORECAST

Threshold	No. Agencies Responding	Agencies Responding (%)
Formal	13	41
Informal	8	25
None	11	34
Total responding	32	100

TABLE 5
FACTORS CONSIDERED AS INPUTS TO FORECASTING METHODOLOGY

Factors	No. Agencies Responding	Agencies Responding (%)
Existing route or route segment ridership	31	89
Ridership on similar routes	30	86
Existing system ridership	28	80
Demographic factors in the service area	27	77
Land use within the affected service area	25	71
Origin/destination information	24	69
Economic trends within the service area	21	60
Other	10	29
Total responding	35	100

Table 5 reveals that agencies use a wide variety of factors as inputs to ridership forecasts. Ridership factors are most frequently mentioned, followed by demographic characteristics, land use, origin/destination data, and economic trends. Several factors were mentioned in the “other” category, including travel time, fares, congestion levels, automobile ownership, land use changes, and market research survey results.

If a factor is involved for some types of changes or forecasts but not others, the agencies indicated this on the survey. Roughly half of the agencies noted the type of change or forecast for which a particular factor is used. Table 6 highlights the primary uses for each factor.

The most often used data sources include ridership data from the farebox and from recent ridechecks, existing and forecast land use, census demographic data, and origin/destination data from on-board surveys, as shown in Table 7. APCs have made inroads and are now used at 40% of responding agencies; however, APCs are still the least likely source of ridership data among those listed. In the “other” category, three agencies mentioned household travel surveys.

The use of origin/destination data was of particular interest, and a question addressing this was included on the survey. As Table 8 shows, the most common response was that origin/destination data are considered (43%), but are not a major part of ridership forecasting (29%). Nearly one-quarter of responding agencies (23%) do not consider origin/destination data.

TABLE 6
PRIMARY USES FOR INPUT FACTORS

Factors	Primary Use
Existing route or route segment ridership	Change in route
Ridership on similar routes	New route or corridor Change in route
Existing system ridership	Annual budget forecast Long-range plan
Demographic factors in the service area	Change in route
Land use within the affected service area	Change in route
Origin/destination information	New route or corridor Major new service Four-step travel model
Economic trends within the service area	No consensus

TABLE 7
DATA SOURCES FOR RIDERSHIP FORECASTS

Data Sources	No. Agencies Responding	Agencies Responding (%)
Ridership data from the farebox	30	86
Ridership data from recent ridechecks	28	80
Existing land use	25	71
Census demographic data	23	66
Origin/destination data from on-board surveys	22	63
Forecast land use	19	54
Ridership data from APCs	14	40
Origin/destination data from models	14	40
Economic forecasts	11	31
Economic trends	10	29
CTPP demographic data	9	26
Other	11	31
Total responding	35	100

APC = automated passenger counter; CTPP = Census Transportation Planning Package.

The findings in this section suggest that a wide variety of data sources are used in ridership forecasting. Certain sources may be very important across all forecasts, whereas others may be useful only for particular types of forecast. Subsequent sections explore how data are used in forecasting procedures.

ANALYTICAL TECHNIQUES

Ridership forecasting techniques can differ by mode, time frame, and scope of the change being analyzed. This section presents agency responses regarding analytical techniques used to forecast ridership.

Most agencies use more than one method of forecasting ridership, depending on the scope of the change and the purpose of the forecast (Table 9). The majority of responding agencies use different forecasting methods for long-range and short-range forecasts (Table 10). Interestingly, multimodal agencies are slightly more likely to use the same methodology for all modes (Table 11).

TABLE 8
ROLE OF ORIGIN/DESTINATION DATA IN RIDERSHIP FORECASTING

Role	No. Agencies Responding	Agencies Responding (%)
Considered, but not a major part	15	43
Major part	10	29
Not considered	8	23
Depends on time frame/level of detail	2	6
Total responding	35	100

TABLE 9
SINGLE VERSUS MULTIPLE METHODS OF RIDERSHIP FORECASTING

Methods	No. Agencies Responding	Agencies Responding (%)
Multiple	23	66
Single	12	34
Total responding	35	100

TABLE 10
FORECASTING METHODS: SHORT-RANGE VERSUS LONG-RANGE FORECASTS

Methods	No. Agencies Responding	Agencies Responding (%)
Different by time frame	22	71
Same by time frame	9	29
Total responding	31	100

The most frequently used techniques are qualitative in nature: professional judgment and rules of thumb/similar routes. At least half of responding agencies use elasticities and a traditional travel demand model to forecast ridership. Table 12 shows techniques included in agency methodology. Three of the "other" agency responses reflect trend line analysis; others mentioned Institute of Transportation Engineers trip generation rates, GIS, and an unspecified agency model.

It may be useful to distinguish among the qualitative techniques in Table 12, because they are referred to later in this chapter. "Similar routes" forecasts ridership on a given route based on the experiences on other routes with similar service areas and frequencies. An analyst might base a ridership forecast for a new crosstown route on the productivity of other crosstown routes or develop a ridership estimate for an extension of a route to a mall based on ridership on other routes at similar malls. "Rules of thumb" codify past experience in general rules. Examples can take the form of "new routes generate *x* riders per revenue hour," or "route extensions to suburban residential developments generate *y* riders per 100 households." "Professional judgment" relies on the judgment and experience of the analyst and is the most subjective qualitative technique. For example, an analyst might use professional judgment to adjust a ridership estimate developed by means of another technique upward or downward depending on the presence or absence of schools, retail centers, high-density residential development, or the general character of the neighborhoods along a particular route.

TABLE 11
FORECASTING METHODS: MULTIMODAL AGENCIES

Methods	No. Agencies Responding	Agencies Responding (%)
Different by mode	9	45
Same by mode	11	55
Total responding	20	100

TABLE 12
FORECASTING TECHNIQUES USED BY TRANSIT AGENCIES

Forecasting Technique	No. Agencies Responding	Agencies Responding (%)
Professional judgment	29	83
Rules of thumb/similar routes	28	80
Service elasticities	22	63
Four-step travel demand model	18	51
Econometric model	7	20
Regression analysis	7	20
Other	7	20
Total responding	35	100

If a technique is used for only certain types of changes or forecasts, the agencies indicated this on the survey. Roughly half of the agencies noted the type of change or forecast for which a particular technique is used. Table 13 highlights the primary uses for each factor. Professional judgment and rules of thumb/similar routes are most often used for route, service, and schedule changes. Service elasticities are used for these types of changes as well, whereas fare elasticities are used for fare changes. The four-step travel model is used most often for major new service.

Several agencies reported using a range of service elasticities, as suggested in national studies (*9,11*). Service elasticities were different depending on existing service frequency, service area density, time of day, or analyst judgment. For agencies reporting a single service elasticity value, this value was as low as +0.2 (in New York City) and as high as +0.5. Reported fare elasticities varied from −0.175 to −0.35.

Calculating ridership using passenger boardings (unlinked ridership) is common among transit agencies. Unlinked ridership is the reporting standard for the NTD, and APCs and fareboxes register boardings. For modeling purposes, knowledge of the number of linked trips is often desirable. Table 14 shows that transit agencies are much more likely to forecast ridership in terms of unlinked trips than linked trips.

TABLE 13
PRIMARY USES FOR FORECASTING TECHNIQUES

Forecasting Technique	Primary Use
Professional judgment	Any route or service change
Rules of thumb/similar routes	Any route or service change Change in route Headway/schedule change
Elasticities	Any route or service change Fare changes Headway/schedule change
Four-step travel demand model	Major new service
Econometric model	No consensus
Regression analysis	No consensus

TABLE 14
RIDERSHIP FORECASTS: LINKED VERSUS UNLINKED TRIPS

Type of Trip	No. Agencies Responding	Agencies Responding (%)
Unlinked	24	71
Both linked and unlinked	10	29
Total responding	34	100

The use of qualitative methods such as similar routes analysis or professional judgment is widespread among transit agencies for route, schedule, and fare changes. Service elasticities are the major quantitative method in use. Several transit agencies are satisfied with the use of qualitative techniques, noting their accuracy and simplicity of use.

ORGANIZATIONAL ISSUES

Transit agencies have different structures. This section explores where the ridership forecasting function is located within an agency and whether it is a dedicated function or part of a planner's overall responsibilities. This section also considers the time and effort required to prepare a ridership forecast and how forecasts are distributed.

Responsibility for Ridership Forecasts

Fourteen transit agencies reported more than one lead department in preparation of ridership forecasts. The transit agency's planning department is the most common location for the ridership forecasting function, as shown in Table 15. Among the "other" departments are Strategic Planning and Policy, Transit Research Section (under the Marketing Department), and Business Development. Twelve of the 20 agencies that reported a single lead department for ridership forecasting named Transit Planning.

Table 16 shows a fairly even split in terms of whether ridership forecasting is the responsibility of a dedicated person or group. The results suggest that this responsibility is somewhat more likely to be part of general duties for all but major changes.

TABLE 15
DEPARTMENT OR AGENCY RESPONSIBLE FOR RIDERSHIP FORECASTS

Department or Agency	No. Agencies Responding	Agencies Responding (%)
Transit planning department	22	65
Transit operations planning department	9	26
Transit budget/finance department	8	24
MPO	6	18
Transit operations department	3	9
Other	4	12
Total responding	34	100

MPO = metropolitan planning organization.

TABLE 16
STRUCTURE OF RIDERSHIP FORECASTING FUNCTION

Structure	No. Agencies Responding	Agencies Responding (%)
Part of general duties	13	38
Depends on scale/extent of forecast	13	38
Dedicated person or group	8	24
Total responding	34	100

Time and Effort Required

A range of estimates were given for the time and effort required to prepare ridership forecasts. Table 17 shows that simple or short-range forecasts can generally be completed in 3 days or less, whereas complex or long-range forecasts can take much longer. The wide time range in long-range forecasts reflects the method used: trend line analysis takes much less time [one day or less was reported by seven respondents (Table 17)] than a four-step model run.

How Forecasts Are Used

Ridership forecasts are nearly always distributed and used internally. Most responding agencies also share the forecasts with their boards. Table 18 shows that it is less common to distribute these forecasts to other groups. Four respondents cited local stakeholders among "others" who receive ridership forecasts, whereas three mentioned the FTA.

RIDERSHIP FORECASTING UNDER A VARIETY OF SCENARIOS

Survey results in the previous sections shed light on how transit agencies go about the process of forecasting ridership. However, the very different types of circumstances under which a ridership forecast is needed or desired can be lost in an aggregation of overall responses. To better understand how ridership forecasts are generated and used, the survey included seven scenarios and asked transit agencies

TABLE 17
TIME REQUIRED FOR RIDERSHIP FORECASTS

Time	No. Agencies Responding	Agencies Responding (%)
Simple or Short-Range Forecasts		
Less than one day	8	32
One to three days	12	48
Two weeks or longer	5	20
Total responding	25	100
Complex or Long-Range Forecasts		
One day or less	7	47
One to three months	3	20
Longer than three months	5	33
Total responding	15	100

TABLE 18
DISTRIBUTION AND USE OF RIDERSHIP FORECASTS

Distribution and Use	No. Agencies Responding	Agencies Responding (%)
Internally	33	97
To board members	23	68
To the MPO	10	29
To elected officials	9	26
To others	10	29
Total responding	34	100

MPO = metropolitan planning organization.

to describe how they would forecast ridership under each scenario. Responses included data to be used and methodologies. This section summarizes data and techniques mentioned by at least 10% of respondents under each scenario. A complete list of responses is included in Appendix B. Each section also provides verbatim responses from selected agencies as examples of approaches to ridership forecasting. The case study chapter (chapter five) includes all responses to these scenarios from the six case study agencies

Percentages in the scenario tables are based on answers from all 36 responding agencies. One agency indicated that it would not forecast ridership under any of the scenarios, and others indicated that they would not forecast ridership for certain scenarios. "Would not analyze" characterizes these responses in the table for each scenario.

Scenario A: Half-Mile Rerouting of Existing Route to Serve a New Shopping Center

The most common approaches under this scenario were to evaluate similar conditions in terms of shopping centers elsewhere in the service area and to evaluate similar routes and previous service changes of this nature. Current route ridership is important, as is consideration of the impact of this detour on existing through ridership. Agencies also reported the use of trip generation rates and professional judgment. Table 19 summarizes responses.

TABLE 19
RIDERSHIP FORECASTING FOR SCENARIO A: REROUTING TO SERVE A NEW SHOPPING CENTER

Response	No. Agencies Responding	Agencies Responding (%)
Similar conditions/area	13	36
Similar routes/service change	11	31
Current route ridership	9	25
Consideration of through ridership	8	22
Trip generation rate	6	17
Professional judgment	5	14
Would not analyze	5	14

Examples of specific responses include:

> We would use the GIS to provide an integrated comprehensive market analysis using Census demographics, APC ridership by stop, and other land use data as available to compare this service with our current same type of service and project from there using professional judgment.

> Size of shopping center, demographics of current route ridership, level of current route ridership, proximity of transfers to/from other routes that have ridership that would be attracted by the shopping center, [and] number of existing riders adversely affected by the deviation.

> Impact on existing customers—travel time, access, egress, fare, etc.

> Trip generation/distribution based on size, type of shopping center.

> Prior experience.

> Quick spreadsheet analysis.

Scenario B: Extension of Existing Route for One Mile to Serve a New Residential Development

As with Scenario A, the most common approaches under this scenario were to evaluate similar routes and previous service changes of this nature and evaluate similar conditions in terms of residential developments elsewhere in the service area. The socioeconomic and demographic profile of the area is useful to know, as is the population and population density. Several agencies noted route productivity as a consideration; most would expect the same level of productivity for the extension, but would consider the productivity of similar route segments or of similar previous changes. Trip generation rates and professional judgment were also cited as tools in developing a ridership forecast. Perhaps the most interesting response was to assume that the extension would meet minimum performance standards in terms of boardings per revenue hour or other factors, with the implication that if performance fell short, the extension would be discontinued. Table 20 presents the responses.

TABLE 20
RIDERSHIP FORECASTING FOR SCENARIO B: ROUTE EXTENSION TO SERVE NEW RESIDENCES

Response	No. Agencies Responding	Agencies Responding (%)
Similar routes/service change	12	33
Similar conditions/area	11	31
Socioeconomic/demographic data	7	19
Route productivity	6	17
Trip generation rate	5	14
Assume minimum performance standard	5	14
Would not analyze	5	14
Population/population density/no. households	5	14
Professional judgment	5	14

Examples of specific responses include:

Would not prepare a specific forecast, but would ensure that the new development has a sufficient number and density of residents to ensure that it could support service meeting our transit service guidelines. Depending on the type of service, our guidelines call for (1) a minimum density of 20 to 30 residents per hectare (8 to 12 residents per acre) or 20 to 25 jobs per hectare (8 to 10 jobs per acre) over a minimum developed area of 10 hectares (four acres); (2) a road and pedestrian access system that permits safe access and efficient operation of transit service; (3) a minimum of 175 to 250 total person trips (by all modes) per additional bus service hour. Other factors such as the socioeconomic characteristics of the community and existence of travel demand management programs may also be considered in applying these guidelines.

I've used two different methodologies. Most commonly, I perform an analysis that compares community and service characteristics with similar parts of the route network. Typically, I'll consider headways, span of service, residential and employment densities, and family incomes. If there is a major generator along the extension, I'll consider it separately. For example, if we were considering an extension to a community college, I'd look at the number of students and apply a mode split. That mode split would vary depending on where students are coming from and whether we can coordinate bus schedules with class times and whether we will offer any fare incentive to customers.

The second approach I've used is a small sketch planning model that I originally developed in the 1990s. It considers residential and employment densities within TAZs along the route, family income, headways, and average travel time from each TAZ along the route to several different types of traffic generators (malls, hospitals, community colleges, etc.). The relative importance of each variable is then calibrated to achieve maximum consistency between projected and actual boardings on established routes. Doing this, I found that the model is about as reliable as if I make an informed guess. Accordingly, I seldom use it.

Scenario C: Change in Headway from 12 to 10 Minutes During Peak Hours

A typical approach to forecasting ridership in response to a change in headway is to use elasticities. Several respondents mentioned route productivity as a factor. One application of productivity is to use historical or comparable productivity changes elsewhere as the basis for the ridership forecast. Another is to forecast ridership changes only if the route's current load is above the maximum load factor. This scenario had the highest number of responses indicating that an agency would not perform a ridership forecast for this type of change (see Table 21).

Examples of specific responses include:

Work with MPO and use service elasticities from regional transportation model to forecast ridership increases.

We would generally not conduct such a forecast due to the inelasticity of our ridership. Over 70 percent are transit dependent and are not generally swayed if frequencies change by such a small amount in either direction. However, we would generally assume that any additional service hours would generate the same number of passengers per hour.

TABLE 21
RIDERSHIP FORECASTING FOR SCENARIO C: HEADWAY CHANGE

Response	No. Agencies Responding	Agencies Responding (%)
Elasticities	12	33
Route productivity	10	28
Would not analyze	8	22
Professional judgment	4	11
Similar routes/changes	4	11

Estimate the cost of more frequent service.

From ride counts, obtain existing boardings on the route during the AM peak.

From our transit assignment model, obtain the average 'weighted' travel time for customers who use this route (note that weighted travel time is the time for a customer's trip from the beginning of the trip at the origin to their final destination with each time component weighted; e.g., wait time weighted by a factor of 1.5, walk time weighted by 2.0, etc.).

Use elasticity model to estimate the number of new customers attracted due to the percentage decrease in their overall weighted travel time; e.g., TWTT [total weighted travel time] = 60 minutes, reduction in travel time will be 1 minute savings multiplied by wait weight of 1.5 = 1.5 minutes; therefore, percentage savings in travel time = 1.5/60 = 2.5%. Our AM peak weighted travel time elasticity is −1.5; therefore, number of new customers = number of existing customers * −1.5 * −2.5% (note 2.5% is negative because it represents a travel time savings).

Compute number of customers gained per dollar spent.

If greater than agency threshold of 0.23, then recommend for six month trial; [otherwise] do not recommend.

Note: more frequent service can also be recommended without any ridership forecast if current loads on the buses exceed agency standards.

Scenario D: Implementation of New Crosstown Route to Enhance Service Area Coverage and Provide More Direct Connections

An examination of other crosstown routes is the most common response. Evaluating transfer data and how connecting routes are used is also important. Respondents also mentioned the need to understand the demographics in the area to be served. Productivity was cited as the best metric to use in comparison with other routes and areas. Other approaches included using a four-step travel model (because this would be a new route), considering similar conditions or areas, evaluating trip generators and land use within one-quarter mile of the proposed route, and assuming that the new route would meet minimum performance standards for a cross-town route. Table 22 summarizes responses.

TABLE 22
RIDERSHIP FORECASTING FOR SCENARIO D: CROSSTOWN ROUTE

Response	No. Agencies Responding	Agencies Responding (%)
Similar routes/changes	15	42
Transfer data/connecting routes	8	22
Socioeconomic/demographic data	6	17
Productivity	5	14
Would not analyze	5	14
Four-step travel model	4	11
Similar conditions/area	4	11
Evaluate trip generators/land use within 0.25 mile	4	11
Assume minimum performance standard	4	11

Examples of specific responses include:

Would model using regional transportation model, but would interpret the results based on comparison with existing comparable routes given the inaccuracy of the regional model at the route level.

Population along proposed route, demographics of population, traffic generators along route, convenient transfers to other routes.

Review of all generators, attractions, service frequency, span, fares, competitive/complementary services in area, demographics, employment.

Scenario E: Implementation of New Mode such as Bus Route Transit

This scenario presents the most drastic change to the existing transit system and calls for the most formal analytical techniques to forecast ridership. Nearly half of all respondents indicated that they would rely on the four-step travel model. Several who mentioned that they would not analyze this type of change noted that there are no plans for a new mode of transit service and thus there would be no need to analyze ridership impacts. Many agencies would hire a consultant to develop a ridership forecast. Examination of travel time changes and application of appropriate elasticities were also mentioned (see Table 23).

TABLE 23
RIDERSHIP FORECASTING FOR SCENARIO E: NEW MODE SUCH AS BUS ROUTE TRANSIT

Response	No. Agencies Responding	Agencies Responding (%)
Four-step travel model	17	47
Would not analyze	7	19
Hire a consultant	6	17
Analyze travel times	4	11
Elasticities	4	11

Examples of specific responses include:

Code BRT service, modify models to add new mode, and use updated four-step model.

If BRT was being examined, we would likely use elasticities to examine how current ridership would be impacted based on incremental improvements over regular bus service. If a new rail line was being examined, the rigor of the analysis would be based on how the forecast is being used. For conceptual design purposes, ridership would likely be developed using rule of thumb methods. For projects beyond conceptual design, we would likely use the MPO's four-step model.

For a simple feasibility analysis (not one requiring environmental clearance) we would calculate additional service hours on the corridor, including any time savings resulting from the BRT improvements. We would then review the number of passengers per service hour on the existing service, and assume that the additional service hours would at least meet the existing threshold. Then, we would review the ridership trend analysis for any of the other BRT corridors we have implemented in order to make assumptions of similar performance. We have experienced a six percent increase in ridership on our first BRT corridor. That increase would be compared to other proposed corridors to determine whether similar increases could be anticipated. For BRT projects that would require environmental clearance [Environmental Impact Statement], we would perform a series of model runs using the countywide travel demand model.

Scenario F: Prediction of Next Year's Ridership as Part of Budget Process

Most agencies forecast next year's ridership using trend line analysis, with some consideration for expected service and fare changes and professional judgment. A few agencies do not forecast ridership one year ahead. Table 24 summarizes responses.

Examples of specific responses include:

Service evaluation uses an historical trend methodology comparing the ridership trends between consecutive months over time and disaggregating by weekday, Saturday, and Sunday. Service elasticities are used when evaluating service changes prior to implementation of the methodology. For FY 99 through FY 06, percentage differences between forecast and actual annual system ridership have ranged from −0.01 percent to −0.85 percent.

We use an econometric model for this.

TABLE 24
RIDERSHIP FORECASTING FOR SCENARIO F: RIDERSHIP FORECAST FOR NEXT YEAR

Response	No. Agencies Responding	Agencies Responding (%)
Trend line	21	58
Service level changes	13	36
Fare changes	5	14
Professional judgment	4	11
Would not analyze	4	11

Generally a fairly rough estimate based on change in overall service level plus some adjustment for expected population changes (regional plan assumed 1.5 percent population increase per year).

Our budget estimates have two very separate components. We generally apply an underlying system growth rate that is usually a conservative continuation of the previous year's trend. In this system, that is usually about one percent. We then add in the separate calculation of the impacts of any service changes we have programmed for the coming year, discounted to allow for a start-up period. We normally factor for a three-year start-up curve—50% of projected in the first year, 75% in the second, and 90% in the third.

Scenario G: A 10-Year Ridership Forecast as Part of a Long-Range Plan

This scenario shows a split between formal and informal ridership forecasting techniques (see Table 25). As in Scenario F, the need to consider planned service changes was cited, and several agencies do not prepare a 10-year forecast.

Examples of specific responses include:

Based on service levels, impact of any fare changes, and growth/loss rate trends from recent years.

We would start with this year's ridership and change it as needed for any planned improvements, service reductions, fare changes, or anticipated economic changes based on professional judgment. However, we would factor in any model-based projections from our MPO if we are introducing major new service.

TABLE 25
RIDERSHIP FORECASTING FOR SCENARIO G: 10-YEAR RIDERSHIP FORECAST

Response	No. Agencies Responding	Agencies Responding (%)
Four-step travel model	16	44
Trend line	12	33
Service level changes	8	22
Would not analyze	5	14

Develop ridership trend and develop a target based on demographic trends and professional judgment. Also work with MPO and use transit inputs into regional transportation model.

SUMMARY

Analysis of how transit agencies prepare ridership forecasting for seven scenarios supports and amplifies other survey responses. The findings included:

- A wide variety of data sources are used in ridership forecasting. The most often used data sources include ridership data from the farebox and from recent ridechecks, existing and forecast land use, census demographic data, and origin/destination data from on-board surveys. APCs have made inroads, but are the least likely source of ridership data among those listed. Origin/destination data, although frequently considered, are not a major component of ridership forecasting for a majority of respondents.
- The planning department is the most likely home for the forecasting function within a transit agency. However, it is not unusual for multiple departments to be involved in different levels of ridership forecasting.
- Simpler, less formal approaches are used for route-level and other small-scale service changes. The examples show that some of these "simpler" approaches have grown more sophisticated as GIS databases are used to assess demographic characteristics and identify similar routes and as APCs and ongoing programs improve the accuracy of ridership data.
- Use of elasticities is widespread for changes to existing service, particularly frequency changes.
- More formal methods, including use of the four-step travel model are used when either the change or the time frame is beyond the scope of the current system; for example, introduction of a new mode and forecasting over the next 10 years.

The next chapter summarizes agencies' assessments of their ridership forecasting methods.

CHAPTER FOUR

AGENCY ASSESSMENT OF FORECASTING METHODS

INTRODUCTION

This is the second of two chapters presenting the results of a survey of transit agencies regarding ridership forecasting. The previous chapter addressed the "nuts and bolts" of how agencies forecast ridership. This chapter's focus is on agencies' evaluations of their ridership forecasting techniques. Specific topics include data availability and reliability, data accuracy, impacts of technology, agency satisfaction with current methods, potential improvements, and lessons learned.

DATA AVAILABILITY AND RELIABILITY

Several survey questions dealt with data availability and reliability. For data availability, the survey asked if there was an optimal amount of data for the agency's forecasting and planning process, and if that data are available. Table 26 shows that 85% of respondents believed that an optimal amount of data should be available for forecasting and planning. A majority of respondents reported that they do not have this optimal amount of data available (Table 27). No respondent reported having too much data; the problem is inadequate data at the desired scale or level.

The most common concern is availability of ridership data below the route level (by route segment or stop), and many agencies anticipate that APC implementation will resolve this. Table 28 presents other comments regarding data availability as it relates to ridership forecasting.

Table 29 shows agency satisfaction with the reliability of input data. Reliability results are mixed, with 44% of respondents indicating general but not complete satisfaction. Table 30 summarizes reliability concerns by data type, with the greatest reliability concerns related to ridership data. Issues for ridership data include the accuracy of a limited number of manually collected samples, reliability of farebox data, and debugging issues associated with new technologies such as APCs. Issues for origin/destination data include timeliness, quality, and level of detail. Issues for demographic data include timeliness and level of detail.

MEASURING RELIABILITY AND VALUE OF FORECASTING METHODOLOGY

Table 31 shows that 94% of respondents compare actual ridership with ridership forecasts to assess the reliability and value of their forecasting methodologies. Board understanding and approval was mentioned by 27% of respondents, whereas "other" responses included professional judgment and "meeting expectations for growth."

TABLE 26
IS THERE AN OPTIMAL AMOUNT OF DATA NEEDED FOR RIDERSHIP FORECASTING AND PLANNING?

Optimal Amount of Data	No. Agencies Responding	Agencies Responding (%)
Yes	23	85
Depends on purpose	2	7
No	2	7
Total responding	27	100

IMPACTS OF TECHNOLOGY ON FORECASTING METHODOLOGY

The survey asked if technology has affected the agency's forecasting methodology. Most respondents have seen an impact from new technologies (Table 32). APCs and farebox upgrades or automated fare collection (AFC) were most frequently mentioned as new technologies that have had an effect. Strictly speaking, these technologies do not affect the forecasting methodology itself, but provide more and/or more accurate input data. Several off-vehicle technologies are also noted in Table 33.

Table 34 shows the effects of the new technologies. Improvements in data accuracy, reliability, and level of detail all rank highly, along with improved analytical tools. Many agencies also cite improvements in data availability and integration of data from different sources.

TABLE 27
AVAILABILITY OF OPTIMAL AMOUNT OF DATA

Data Available?	No. Agencies Responding	Agencies Responding (%)
Yes	8	26
Sometimes	6	19
No	17	55
Total responding	31	100

TABLE 28
DATA AVAILABILITY ISSUES

Issue	No. Agencies Responding	Agencies Responding (%)
Ridership data at route segment or stop level	10	59
On-board data collected infrequently/expensive to collect	3	18
No access to GIS data/demographic data at stop level	2	12
Question of priorities/balance	2	12
Rail data for new lines	2	12
Better farebox/APC data	2	12
Total responding	17	100

GIS = geographic information system; APC = automatic passenger counter.

SATISFACTION WITH RIDERSHIP FORECASTING

Table 35 shows transit agency satisfaction with current ridership forecasting methods. Responses to this open-ended question are distributed very evenly across the spectrum. Most respondents see a need for improvements to their current procedures.

Table 36 shows the types of improvements envisioned by respondents. Quality and availability of input data and accuracy of the forecasts are the most pressing concerns. Among other desired improvements were an automated short-range forecasting procedure, incorporation of *TCRP Report 95* into service guidelines, a greater commitment to high-quality input data throughout the region, and changes in FTA procedures for non-rail New Starts.

Respondents were asked, "If you could change one aspect of your agency's ridership forecasting methodology, what would you change?" Unlike the question regarding types

TABLE 29
SATISFACTION WITH RELIABILITY OF INPUT DATA

Input Data Reliability	No. Agencies Responding	Agencies Responding (%)
Satisfied	14	41
Somewhat satisfied	15	44
Not satisfied	5	15
Total responding	34	100

TABLE 30
RELIABILITY CONCERNS BY DATA TYPE

Input Data	No. Agencies with Concerns	Agencies Responding (%)
Ridership	13	65
Origin/destination	5	25
Demographic	5	25
General	5	25
Total responding	20	100

TABLE 31
MEASURING RELIABILITY AND VALUE OF FORECASTING METHODOLOGY

Method	No. Agencies Responding	Agencies Responding (%)
Comparison of actual and projected ridership	31	94
Board understanding and approval	9	27
Other	2	6
Total responding	33	100

TABLE 32
EFFECTS OF TECHNOLOGY ON RIDERSHIP FORECASTING

Technology Effects?	No. Agencies Responding	Agencies Responding (%)
Yes	22	63
No	13	37
Total responding	35	100

TABLE 33
SPECIFIC TECHNOLOGICAL CHANGES AFFECTING RIDERSHIP FORECASTING

Technology	No. Agencies Responding	Agencies Responding (%)
APC	10	56
Farebox upgrade/Automated Fare Collection	5	28
Travel model upgrade/new application	4	22
GIS	4	22
Improved personal computers/software	3	17
AVL/GPS	2	11
Data integration software	1	6
Total responding	18	100

APC = automatic passenger counter; GIS = geographic information system; AVL = automatic vehicle location; GPS = global positioning system.

TABLE 34
HOW TECHNOLOGIES HAVE AFFECTED FORECASTING METHODOLOGIES

Effect	No. Agencies Responding	Agencies Responding (%)
Data reliability/accuracy	7	30
Level of detail in data	7	30
Improved analytical tools	7	30
Data availability	6	26
Data integration from different sources	4	17
Origin/destination estimation possible	3	13
Faster analysis time	3	13
Better reporting	2	9
Total responding	23	100

TABLE 35
SATISFACTION WITH CURRENT RIDERSHIP FORECASTING METHODS

Level of Satisfaction	No. Agencies Responding	Agencies Responding (%)
Satisfied	11	31
Partially satisfied	12	34
Not satisfied	12	34
Total responding	35	100

of improvements desired, this question was open ended. Table 37 summarizes the results. Improvements to input data and methodology were most frequently mentioned. There is a need for greater data availability, more current data, and data at a more detailed level. Methodology needs were more diverse, reflecting that various agencies are at different stages regarding forecasting methods. Among the specific responses were greater sophistication, more consistency, and easier to apply models. "Approaches" is a catch-all category that includes adopting written guidelines, basing ridership forecasting on industry standards and best practices, and allowing alternate specific constants in FTA procedures.

LESSONS LEARNED

Roughly half of all survey respondents shared lessons learned from the process of developing and using ridership forecasting methodologies. The lessons learned can be grouped into seven broad categories, as shown in Table 38.

Responses are summarized by category below.

- Caution regarding results—be realistic in ridership estimates; use a range and confidence level—specific predictions are almost always wrong; review model results with peers, other corridors, and elasticities; temper with experience; a full understanding of current ridership behavior is critical for forecasting.

TABLE 36
DESIRED IMPROVEMENTS TO RIDERSHIP FORECASTING METHODS

Improvement	No. Agencies Responding	Agencies Responding (%)
Availability and/or accuracy of input data at the appropriate scale	22	81
Accuracy of the results	16	59
Inclusion of more predictive variables	11	41
Less time-intensive methodology	11	41
Flexibility to address a wider variety of situations	11	41
Simplification of the procedures	8	30
Other	7	26
Total responding	27	100

TABLE 37
ONE IMPROVEMENT TO RIDERSHIP FORECASTING METHODOLOGY

Improvement	No. Agencies Responding	Agencies Responding (%)
Input data	11	44
Methodology	10	40
Approaches	3	12
In-house staff expertise/understanding	2	8
Linkages (GIS, regional indicators)	2	8
Total responding	26	100

GIS = geographic information system.

- Simplify the approach—focus on one or two tools for synergy and absence of conflicting forecasts; trend forecasting and professional judgment can be as accurate as regression and econometric models; in-house expertise is more effective and less expensive than consultants.
- Caution regarding data and application—understand the limits of the data being used; use trip generation rates with care—these may not apply across the metropolitan area; use caution in applying regional model outputs at a different scale (e.g., route or station level); AFC data overcome limitations of survey/census-based origin/destination data, particularly the out-of-date issue.
- Communication and partnership—inform and cooperate with other local agencies (such as the MPO) and peers within the transit industry.
- Develop local factors—forecast models from external sources do not work well. They are complicated, time-intensive, data-intensive, and provide inferior results; local elasticities preferred over industry; use experience and results from the past.
- Simplify the model—car ownership and income do not provide enough improvement to warrant the time and difficulty in acquiring the data at the appropriate scale.
- Other:
  - Smaller versus larger agencies: for smaller agencies, trip rates and population and employment numbers can suffice; for larger agencies, network impacts are important—evaluate impacts on systemwide basis.

TABLE 38
LESSONS LEARNED

Lessons Learned	No. Agencies Responding	Agencies Responding (%)
Caution regarding results	7	37
Simplify the approach	4	21
Caution regarding data and applications	4	21
Communication and partnering	2	11
Develop local factors	2	11
Simplify the model	2	11
Other	7	37
Total responding	19	100

– Neither overly simple nor overly complex approaches work.
– GIS as data integration tool simplifies data management.
– Transferability: Institute of Transportation Engineers trip generation rates are very accurate; our mode split is very similar across our service area.
– Take the time to develop patronage forecasts.
– Interpretation and presentation in lay terms is as important as the forecasts themselves.
– Admitting that forecasts were wrong and finding out why is the best teacher.

SUMMARY

This chapter has described agency assessments of ridership forecasting methods. Findings include:

- Results regarding agency satisfaction with the reliability of input data are mixed, with 44% of respondents indicating general but not complete satisfaction. The greatest reliability concerns center on ridership data; however, the timeliness and level of detail for origin/destination and demographic data are also issues.
- Nearly all agencies measure the reliability and value of their forecasting methodologies through a comparison of actual ridership with ridership forecasts. Board understanding and approval is also a factor for 27% of respondents.
- A majority of responding agencies do not have the optimal amount of data available for forecasting ridership. The most common concern is availability of ridership data below the route level (by route segment or stop), and many agencies anticipate that APC implementation will solve this.
- New technologies have had an effect on agencies' forecasting methods. APCs and farebox upgrades or automated fare collection were most frequently mentioned among new technologies, but several off-vehicle technologies were also noted. Improvements in data accuracy, reliability, and level of detail are among the primary effects of new technologies. Many agencies also cite improvements in data availability and integration of data from different sources.
- The question regarding satisfaction with current forecasting methods yielded very interesting results: roughly one-third of responding agencies are satisfied, one-third are partially satisfied, and one-third are not satisfied with current forecasting methods. Quality and availability of input data and accuracy of the forecasts are the most pressing concerns.
- Input data and methodology were the most frequently mentioned aspects of ridership forecasting procedures that transit agencies would like to change. Agencies report a need for greater data availability, more current data, and data at a more detailed level. Methodology needs were more diverse, reflecting that various agencies are at different stages regarding forecasting methods. Among the specific responses were greater sophistication, more consistency, and easier to apply models.
- Roughly half of all survey respondents shared lessons learned from the process of developing and using ridership forecasting methodologies. The most commonly mentioned lessons included interpreting results cautiously and simplifying the approach to ridership forecasting. Responding agencies made several other important and useful observations.

The following chapter describes findings from six case studies that explore issues related to ridership forecasting in greater detail.

CHAPTER FIVE

CASE STUDIES

INTRODUCTION

Survey results provide a comprehensive overview of the major issues regarding transit ridership forecasting. Following a review of these results, six agencies were selected as case studies. Personnel directly involved with development and use of ridership forecasting methodologies agreed to be interviewed by telephone. In several cases, more than one person at an agency either participated in the interviews or reviewed the draft summary of the case study. The case studies are intended to provide additional details on innovative and successful practices.

The selection process for case studies had several criteria: (1) to include transit agencies of various sizes in different parts of the country, (2) to include a variety of approaches and methods related to ridership forecasting, and (3) to select agencies that could offer useful insights to the transit industry as a whole. Nearly 70% of responding agencies offered to serve as a case study and, as shown by examples from non-case study respondents in chapter three, these agencies offered very interesting responses based on their experiences. The six agencies chosen do not necessarily consider themselves as examples of best practices; however, together they provide a representative overview of the state of transit ridership forecasting.

The six case study agencies are:

- VIA (VIA Metropolitan Transit), San Antonio, Texas
- RTD (Regional Transportation District), Denver, Colorado
- GRTC (Greater Richmond Transit Company) Transit System, Richmond, Virginia
- NYCT (Metropolitan Transit Authority–New York City Transit), New York, New York
- OCTA (Orange County Transportation Authority), Orange, California
- TriMet (Tri-County Metropolitan Transportation District of Oregon), Portland, Oregon.

The case studies summarize survey responses and interview observations from each agency. The interviews explored issues raised by the survey responses in greater depth and also included a question regarding the value of passenger forecasting as experienced by each agency.

VIA METROPOLITAN TRANSIT (SAN ANTONIO, TEXAS)

One person in the operations planning department has responsibility for ridership forecasts. The data collection process previously relied on a staff of nine checkers with hand-held devices that could be linked directly to an Access database. VIA has acquired 50 APCs for its bus fleet; however, the APC data are not viewed as accurate. Ridership forecasts now use farebox data, available in 30-min increments and summarized by time of day and day of the week. This information is supplemented with origin/destination data gathered by means of an onboard survey every 5 years; also broken down by time of day and day of the week. VIA develops a ridership forecast for any type of service change other than very minor schedule adjustments as part of its service revision form. This form is circulated internally up to the Chief Executive Officer, who at his discretion may share it with board members. Board approval is only required when initiating new routes and discontinuing current routes.

VIA considers several factors in developing ridership forecasts. System ridership is used for annual forecasts tied to the budget process. Existing route or route segment ridership serves as input for any service change. Farebox data cannot provide ridership at the route segment level; therefore, either APC data are used to estimate the percentage of boardings along a given segment or checkers are sent out to collect the data. For new routes or added route segments, VIA looks at land use and economic trends within the new service area and relies on analysis of similar routes serving similar areas to forecast ridership. Origin/destination information and demographic factors are used primarily for service to new areas. Typically, a new development such as a major employment or retail center will generate analysis of a new route or a route extension.

The input data are considered reliable; however, VIA notes that the analyst needs to understand the limitations and accuracy of the data in terms of sample size and seasonal effects. Ideally, 3 days of ridership data should be available within the past 6 months. This is always the case for farebox data, usually for APC data, and usually not for onboard ridecheck data, especially on weekends.

The forecasting techniques include rules of thumb, similar route analysis, and professional judgment. A similar route analysis would examine productivity (in terms of passenger boardings per revenue hour) by time of day and day of the week for a similar route serving a similar area and would then apply the productivity values to the planned revenue hours of service by time of day and day of the week. For a headway change from 60 to 30 min, the expected productivity would be adjusted downward depending on type of route and reason for the change. VIA categorizes its routes as major radial, minor radial, crosstown, feeder/circulator, and express/limited stop, with different productivity standards for each category. All ridership forecasts are for 6 months after the service change, recognizing that it takes time for ridership to develop. Any new service is implemented on a 180-day trial basis and can be discontinued or altered if it does not meet the productivity standards for its service category. Short-range forecasts are made for a typical weekday/Saturday/Sunday, whereas long-range forecasts are at the more aggregate level of annual systemwide ridership.

VIA's goal for ridership forecasting is that all forecasts be within ±10% of actual ridership at the route or system level, and this goal has been met. The professional experience of the forecaster plays a significant role in understanding how trip productions and attractions, schools (especially middle schools), and timed transfers affect ridership. Field work is essential in developing and applying this experience. Signs of good transit potential can go beyond the obvious, such as high residential density and presence of major trip generators, to factors such as the presence of oil stains and transmission fluid leaks on residential streets.

Technology has made the forecasting process faster and more reliable, but has not changed the methodology itself. A ridership forecast for a simple route realignment can usually be generated within one hour.

Ridership forecasts would be developed under the scenarios included in the survey as follows:

- Half-mile rerouting of an existing route to serve a new shopping center: base the forecast on similar routes and trips generated by similar retail developments with the understanding that it may take time to develop new retail customers.
- Extension of an existing route for one mile to serve a new residential development: base the forecast on similar routes and trips generated per dwelling unit based on median value of homes. Residential areas must have at least 200 occupied homes before service begins.
- Change in headway from 12 to 10 min during peak hours: forecast would depend on load factors and overall usage in the transit corridor. A shift from five to six trips per hour would not increase ridership unless the route is at its maximum load factor and there are more potential riders in the corridor.
- Implementation of a new crosstown route: evaluate existing travel times and potential savings and extract origin/destination data for current riders. Obtain employee addresses from major employers along the proposed route.
- Implementation of a new mode such as BRT: evaluate existing travel times and potential savings. Look at station sites and potential for reroutes for transfers from other areas. Extract origin/destination data for current riders. Evaluate all trip generators within one-quarter mile of stations. Evaluate automobile drive times and traffic volumes.
- Prediction of next year's ridership as part of the budget process: base the forecast on the service plan included in the budget and past ridership trends.
- A 10-year ridership forecast as part of a long-range plan: base the forecast on past ridership trends, service revisions included in the plan, and expected growth and development.

VIA would not necessarily make any changes to its current methodology, but would like to obtain more data linked to GIS. Use of GIS has made it much easier to develop visual representations of ridership activity. Lessons learned include the need to understand the limitations of the data used in ridership forecasting.

This case study provides an example of a traditional approach that relies heavily on professional judgment and an understanding gained through experience of the factors contributing to transit ridership. The value of ridership forecasting is perceived to have declined as a dedicated sales tax and other funding sources have lessened reliance on farebox revenue.

REGIONAL TRANSPORTATION DISTRICT (DENVER, COLORADO)

RTD prepares ridership forecasts for most service changes except for minor adjustments to schedules or route segments. There is no explicit threshold triggering the need for a ridership forecast; however, a change of more than 10% in service hours suggests ridership implications, and any service reduction indicates a potential loss of riders. Ridership forecasting is part of the general duties of staff members in the planning, operations planning, and budget departments, depending on the type of forecast being generated. Forecasts are distributed internally, to board members, and to stakeholders.

The most common change is in route frequency. RTD uses a service elasticity of +0.5 to forecast the ridership impact of frequency changes, based on the average value from *TCRP Report 95* (*11*). RTD calibrates this average elasticity upward or downward based on its previous experience, depending on existing route frequency, similar routes, and setting. For example, RTD has found a greater elasticity for headway improvements to infrequent service, with diminishing returns seen on headway improvements to frequent service. Also, headway improvements in response to overcrowding show a higher elasticity than improvements for other reasons. The inelastic nature of service elasticities has not been well understood in many communities served by RTD, and staff has been aided in educating policymakers by its documentation of prior experience and by summaries of experience in other areas.

RTD also relies on service standards. Although these do not forecast ridership, standards do set a minimum threshold of performance for existing routes and proposed new service. RTD also evaluates route sustainability by examining population and employment per acre.

RTD considers various inputs to its ridership forecasts depending on the type of change being analyzed. System ridership, ridership on similar routes, and demographic factors are considered for changes in span of service; timed transfers are an important component of RTD service, therefore consistency in span of service is important. A route deviation requires examination of route segment ridership. Ridership on similar routes, origin/destination information, and demographic and land use characteristics are important for new routes and route extensions, and most of these factors also bear on forecasts for a new mode or corridor. Economic trends are factored into annual ridership forecasts for budget purposes.

Along with service elasticities and service standards, RTD uses rules of thumb and similar route analysis in forecasting ridership impacts of most service changes. A significant change, such as a new mode or new corridor, calls for the regional four-step travel model, used for rail and long-range planning. Trend analysis is used for annual budget forecasting. Professional judgment is applied to all ridership forecasts to ensure reasonableness of the results.

RTD uses ridership, origin/destination, land use, and census demographic data in developing its forecasts. New technologies (including the introduction of APCs along with a focused effort to establish confidence in the APC data; new software that integrates ridecheck, supervisor point check, and APC data and converts it to a usable format for service planning purposes; GIS; and new, more reliable fareboxes) have improved the quality of ridership data. Having gone through a standard debugging period, RTD is now confident in the APC data and is developing new applications. For example, stop-level boardings, alightings, and loads are exported into GIS and are mapped along with population and employment density.

RTD views an optimum amount of data as a balance among data availability, methods to analyze the data appropriately, and the ability to present results in a meaningful way to decision makers. GIS has been very important in terms of presenting results. Service planners at RTD are moving toward the use of GIS in place of Microsoft PowerPoint in making presentations to the general public and to senior management. GIS can better represent the complexities not only of the transit network structure but also of the planning analysis. RTD has combined GIS with aerial photographs to develop presentations that clearly articulate its proposals and rationales, and reports very positive reception by the public. As an analytical and communications tool, GIS has helped to build support for RTD initiatives. RTD is now incorporating origin/destination data from household travel surveys conducted in the counties within its service area every 5 years on a rolling basis into GIS.

RTD assesses its ridership forecasting methods as generally adequate for short-term service planning and is now much better documented with the release of *TCRP Report 95*. Experience in applying these methods will result in additional refinements. Desired improvements include the availability and accuracy of input data at the appropriate scale, inclusion of more predictive variables, and incorporation of *TCRP Report 95* into service standards and guidelines.

Ridership forecasts would be developed under the scenarios included in the survey as follows:

- Half-mile rerouting of an existing route to serve a new shopping center: first assess current ridership; estimate new ridership based on similar routes and shopping centers.
- Extension of an existing route for one mile to serve a new residential development: estimate new ridership based on similar routes and developments.
- Change in headway from 12 to 10 min during peak hours: use an elasticity of +0.5 to estimate the ridership impact of the frequency improvement. This elasticity may be adjusted up and down as suggested in *TCRP Report 95* based on similar routes and settings and (more broadly) on existing frequency of service.
- Implementation of a new crosstown route: assess current ridership on related routes. Examine origin/destination data. Consider the performance of similar routes. Analyze transfer data and evaluate the setting of the proposed route.
- Implementation of a new mode such as BRT: run the four-step travel model.
- Prediction of next year's ridership as part of the budget process: base the forecast on a trend analysis.
- A 10-year ridership forecast as part of a long-range plan: run the four-step travel model.

In terms of one improvement to its forecasting methodology, RTD sees value in the adoption of written guidelines for how to do service planning, including ridership forecasting, in a rational way. These guidelines are not viewed as limiting planners to an inflexible approach, but rather as ensuring that key elements are addressed. Although these guidelines would be valuable internally, their primary value could be in helping potential partners such as city planning agencies in service area jurisdictions to understand transit planning and the importance of including the transit agency in activities such as development review and location of new sidewalks.

Lessons learned include the use of proven tools to develop realistic ridership forecasts and the value of integrating ridership and demographic data through GIS. An example of the latter is the inclusion in individual GIS layers of employment and population density by TAZ, boarding and alighting data by stop (presented as a pie chart whose size indicates level of activity and proportions represent boarding versus alighting activity at each stop), symbols representing total employment and total population by TAZ, and symbolic representation of passenger loads. A potential next step is the use of GIS network analysis tools to refine ridership forecasting methodologies.

In terms of value, forecasting changes to ridership as a result of changes in service brings discipline to the service development process and highlights its focus on the customer. Service changes are directed toward improving performance and sustainability as defined by service objectives and standards. RTD's objective is to serve the most riders for the budget dollar. Therefore, service changes that show improvements to subsidy per boarding or boardings per hour are beneficial. The forecast data needed are boardings, hours, and unit cost (less fare revenue). This information is (or should be) readily available internally and easily communicated to others.

This case study shows how new technologies such as APCs, integrated software, and GIS can improve the quantity and quality of ridership and other data, provide new methods for analyzing and forecasting ridership, and greatly enhance the ability to communicate results to stakeholders. At the same time, research projects such as *TCRP Report 95* provide invaluable documentation of experience elsewhere. RTD remains in the process of blending these factors to improve several aspects of its planning efforts, including ridership forecasting.

GREATER RICHMOND TRANSIT COMPANY (RICHMOND, VIRGINIA)

This case study is representative of many mid-sized and small transit agencies that do not prepare ridership forecasts. GRTC serves Richmond, Virginia, and the surrounding metropolitan area with 29 fixed routes and a peak bus requirement of 149 (based on 2003 NTD data). The majority of the routes are long-established and unchanging, and the nature of the system does not open up the need for ridership forecasting.

In most cases, requests for new service come from localities within the service area. Implementation depends on identification of a funding source. If the localities are willing to fund a demonstration project, GRTC will design and implement a new route or a route extension. At the end of the demonstration period, ridership and performance is evaluated and the locality makes a decision whether to continue funding the service.

Two recent examples of new service involve a new mall and a package of express bus and route-deviation local service to a locality that was previously not being served. No ridership forecasts were made for the mall service, but both the county and GRTC agreed at the outset that there was a good chance that ridership would justify the service. Evaluation of the new service to the mall was based on the county's perspective that the route worked to bring people to and from the mall.

The package of services was a more interesting example. A consultant for the locality had developed the service proposals and included ridership projections that GRTC accepted. Service proved to be successful, but was discontinued when the locality did not have money to fund the routes beyond the demonstration period. Funding for the express service has been restored, and GRTC was scheduled to reinstitute express service in late February 2006.

GRTC recently received a request from an elected official to begin a new route serving a small area of the city. Staff developed the parameters for the proposed service (including basic route design, frequency, and span of service) to be able to estimate the cost. Implementation is dependent on identification of a funding source to begin a demonstration project.

When GRTC brainstorms ways to improve service to its riders, ridership forecasts are not a significant part of the equation. Identifying the service concept and assessing how riders would respond (based on professional judgment) are the key elements. As GRTC notes, the best analysis in the world would make no difference without a local funding source.

GRTC periodically undertakes a comprehensive operational analysis (COA) of its transit network. The upcoming COA will dovetail with a regional mass transit needs study led by the MPO. GRTC is considering the development of a ridership forecasting tool as an element of the upcoming COA. The agency recognizes that, as it develops GIS expertise, it will be better able to analyze demographic factors at the route level. Thus, a ridership forecasting tool could be very useful in the future. For the present, GRTC has managed its transit system well without such a tool, noting its high ranking among all transit agencies of its size in terms of cost-efficiency.

This case study shows that there may not be a real need for a ridership forecasting methodology at all transit agencies. The decision-making process at many small and mid-sized agencies is driven more by politics and funding availability than by ridership analysis. Although many agencies can see the value of employing a forecasting methodology, it may not rank highly in terms of current needs. This is a valid assessment in many cases and is a useful point to keep in mind for this synthesis project.

MTA–NEW YORK CITY TRANSIT (NEW YORK, NEW YORK)

MTA–New York City Transit (NYCT) prepares ridership forecasts for most service changes except for minor service adjustments and scheduling changes. There is no specific threshold triggering the need for a ridership forecast. Significant subway service changes, especially during peak hours, are likely to require a forecast. Bus service changes are less likely to trigger ridership forecasts. Management decides whether a ridership forecast is needed. There is a dedicated group that generates ridership forecasts, but they work primarily on major projects such as the Second Avenue subway, the Manhattan Bridge reconstruction, and BRT. Forecasts for other changes are sometimes done by transit analysts as part of their regular duties.

The Operations Planning Department takes the lead for preparing most ridership forecasts, although the Office of Management and Budget typically prepares annual forecasts for budget purposes. Forecasts are distributed and used internally. MTA–NYCT considers a wide variety of inputs for its forecasts, although system-level ridership is used primarily for annual forecasts.

MTA–NYCT maintains and uses a detailed network model of all subway and bus routes in New York City and walking links for access and transferring. This network model is used to analyze current travel patterns by assigning subway origin/destination trip tables estimated from MetroCard farecard transactions. It is also used to model future major service changes or additions by using census-based trip tables projected into the future. Shifts between bus and subway modes are estimated using this model; however, there is no provision within this model for attracting automobile or taxi users because the existing transit share is generally already high. Mode share modeling as well as regional impacts is addressed by a regional transit forecasting model that is maintained by the MTA, which is MTA–NYCT's parent agency. It incorporates most of MTA–NYCT's bus and subway network model. A service elasticity of +0.2 is used primarily to estimate the impacts of contingency service reductions. The Operations Planning Department and Office of Management and Budget work together to mine MetroCard data.

Introduction of the MetroCard has proven to be very useful for both subway and bus ridership analysis. The MetroCard provides a record of subway station usage by time of day and bus route usage by direction and time of day. Linked trips and transfer locations can be inferred through analysis of individual MetroCard use (MetroCard captures boarding data only). MTA–NYCT recently contracted with a private firm to construct subway and bus trip tables from raw MetroCard data; a significant undertaking given that the database holds more than 7 million transaction records for each weekday.

In the interim, the agency has been using a subway-only method for inferring destination stations for each station entry and then using the resulting trip table with the network model to estimate subway travel patterns and route usage. For bus trip patterns, MTA–NYCT designed an iterative probability model to predict alightings at bus stops based on total boardings and alightings from ridechecks, the travel time between stops, and total passengers alighting at a specific bus stop. This model produces an acceptable result within a few iterations. The resulting stop-to-stop origin/destination trip tables are being used to estimate ridership on proposed BRT lines. Recent efforts focus on integrating subway origins with feeder bus alightings and combining MetroCard and census journey-to-work data. The analysis of expected transfer levels to the new Second Avenue subway line has been used in some station designs.

MTA–NYCT uses a variety of data sources beyond the MetroCard in developing ridership forecasts. The agency does not have APCs, but uses a large contingent of trained traffic checkers to gather data through ridechecks and pointchecks at peak load points and central business district cordon points. MTA–NYCT also relies on farebox/turnstile data, origin/destination data from travel models, census and Census Transportation Planning Package demographic data, existing and forecast land use, and economic trends and forecasts. GIS programs have helped in organizing large collections of data. New York City has developed a new GIS base map (NYCMAP) with high-quality aerial photographs, and MTA–NYCT is making increasing use of this map. The city has also developed a land use database in GIS.

Technology has clearly had an impact on forecasting methodology. AFC equipment provides ridership boarding data in 6-min increments, which allows for origin/destination estimation. Improved personal computers and software permit more detailed methodologies that can be applied more quickly. Input data reliability is a problem in terms of the accuracy of pointchecks for on-board train volumes, along with the labor-intensive nature of collecting enough samples to compensate. Ridechecks are practical on buses, but not on subways.

Short-term forecasts are based on ridership trends and known land uses, whereas long-range forecasts use detailed socioeconomic forecasts. Short-term forecasts can be completed within 1 to 5 days by service planners, including time for supplementary ridechecks. A simple long-term forecast can be completed in one week; however, more complex forecasts of alternatives can take up to a year. Typically, one-quarter to one-half the time of two analysts is needed to forecast the ridership impacts of major subway service changes or additions, either line-specific or at major station complexes. Ridership forecasting models are often used as tools to test various scenarios, and this can be an open-ended process until a satisfactory service plan is selected.

MTA–NYCT is satisfied with the ridership forecasting methods in use and under development, but hopes to make these methodologies faster and easier to use. Needed improvements include the availability and accuracy of input data at the appropriate scale, fewer time-intensive methodologies, simplification, enhanced accuracy, and flexibility to address a wide variety of situations.

Ridership forecasts would be developed under the scenarios included in the survey as follows:

- Half-mile rerouting of an existing route to serve a new shopping center: ridership forecasts are generally not prepared for this scale of change.
- Extension of an existing route for one mile to serve a new residential development: ridership forecasts are generally not prepared for this scale of change to the bus system. A proposed one-mile westward extension of the #7 subway line in Manhattan was analyzed using MTA–NYCT's a.m. peak-hour network assignment model and MTA's regional travel forecasting model. The former uses a stochastic user equilibrium procedure, whereas the latter uses a Pathfinder procedure with capacity constraint added.
- Change in headway from 12 to 10 min during peak hours: this change is usually too small to model. However, one additional peak-hour train does add capacity.
- Implementation of a new crosstown route: new crosstown routes have not been implemented for at least the past 10 years.
- Implementation of a new mode such as BRT: MTA–NYCT is treating BRT in similar fashion to limited-stop service in its transit trip assignment model (bus, subway, and walk network); however, for the first time the agency is estimating stop-to-stop origin/destinations using ridecheck data (see above for a description of this process). New or induced transit travel resulting from the "attractiveness" of BRT will be based on careful and realistic quantification of expected time and reliability benefits. These will be converted to added riders using elasticity-type methods from the literature and experienced BRT planners and operators.
- Prediction of next year's ridership as part of the budget process: base the forecast on year-to-date ridership trends at the time the forecast is being prepared. The next year's ridership change applies forecasts of New York City employment to the current year's estimate, with minor adjustments to account for calendar differences. Additional changes are made as needed to account for planned service or fare changes.
- A 10-year ridership forecast as part of a long-range plan: begin by forecasting an origin/destination trip table based on existing trips and socioeconomic forecasts by the MPO. The calibrated network model of all subway, bus, transferring, and walk options in New York City is further calibrated as needed and then modified to reflect the long-range plan. A trip assignment model (shortest path/stochastic user equilibrium) is run to predict ridership for the long-range plan scenario by route and station/stop. Predictions of any significant shifts from or to automobile are obtained from the MTA model.

The one improvement to forecasting methodology would be to make it easier to apply.

MTA–NYCT reports several lessons learned from their experience:

- Neither overly simplistic nor overly complex approaches work. MTA–NYCT has tried to make its model as comprehensive and realistic as possible without getting bogged down in unnecessary details.
- By having a very good representation of existing and proposed services, the model serves two purposes: (1) as a structuring tool that allows service planners to better understand the details of scenarios and interaction with existing services and (2) for the production of actual ridership forecasts by scenario.
- AFC (MetroCard) data are a valuable source of current transit usage and transit information, including inferred origins and destinations. This overcomes some of the limitations of survey/census-based origin/destination data, particularly their tendency to be out of date.
- Care should be used when applying transit trip rates. A recent study of downtown Brooklyn revealed that transit trip generation rates typically used for site-specific environmental analysis needed adjustment to produce accurate results using current data.
- An additional factor that emerged in the case study discussions is the benefit of physical proximity between modelers and service planners. Both groups are part of Operations Planning, but being housed in the same building has encouraged interaction and in the process has improved the model. The model as a tool may be more important than the model as a producer of specific results.
- There is a need for a modified software package that can allow smaller systems to conduct the types of analysis done at MTA–NYCT while being easy to use and understand.

The value of ridership forecasting at MTA–NYCT can be seen in several ways. Modeling provides a structure for planning, and this is even truer with complex projects. For example, in the ongoing BRT work, modelers need details that force service planners to think through their plans in greater detail, to the benefit of the plans and the models. The model

TABLE 39
OCTA FORECASTING METHODS

Purpose	Method	Time Frame	Geography
Budgeting	Trend line, group consensus	Annual	Countywide
New starts (bus/rail)	Traditional four-step	Up to 20+ years	Regionwide
Short-term service planning	Service elasticities	Up to 5 years	Route specific
Special purpose/commuter rail	Apply specific mode choice components	Varies	Route specific with broader service area
Special purpose/paratransit	Time series regression	Varies	Countywide

also provides an accounting system that can identify any inconsistencies in underlying systems. As noted earlier, the process has fostered interaction between service planners and modelers and encouraged new ideas about model uses.

MTA–NYCT is often not used as a case study because of its size relative to other transit agencies. This case study shows how application of new data collection techniques (AFC) and tools such as TransCAD can improve ridership forecasting procedures. Successful exploration of new analytical methods (such as inferred origins and destinations) as ridership data become more reliable is an important finding that can be applied elsewhere. Encouraging interaction between modelers and end-users through organizational structure and location of the departments ultimately results in model improvements and greatly increases the likelihood of its being trusted and used on a consistent basis. MTA–NYCT maintains and regularly uses an in-house network model specifically for analyzing and forecasting transit usage in New York City, whereas regional transit agency and the MPO maintain larger and more complex demand forecasting models that include suburban transit services and non-transit modes. This allows MTA–NYCT to focus on its transit service planning needs while improving and updating its route coding, which is passed along to the larger models.

ORANGE COUNTY TRANSPORTATION AUTHORITY (ORANGE, CALIFORNIA)

OCTA prepares ridership forecasts for virtually every service change. There is no specific threshold triggering the need for a ridership forecast; however, changes in route alignment or in the number of daily trips generate a forecast. Forecasts are used internally and are part of the general planning and modeling duties.

The Operations Planning Department prepares ridership forecasts related to short-term service changes. The Planning Department forecasts long-term ridership as well as ridership changes for major service changes. The Finance Department, in consultation with the Operations Planning Department, prepares annual forecasts for budget purposes.

OCTA uses systemwide ridership in its annual forecasts. Changes to routes or service spans use route and route segment data as well as ridership on similar routes. A similar routes approach is also used for new routes. Origin/destination information and demographic factors are used in the mode choice model.

Table 39 summarizes OCTA forecasting methods.

For short-term service planning, similar routes and professional judgment are used along with elasticities. OCTA uses a range of service elasticities depending on the extent of the service change, but within each category the analyst has some leeway. Table 40 shows guidelines for service elasticity factors.

Choice of elasticity within a category can be based on knowledge of the route, reason for the service change (e.g., to add service at a major activity center), other market considerations, or time of day. Interestingly, OCTA used its long-range model to estimate service elasticities and found an elasticity of +0.56 for peak-period headway changes. Then, by holding service levels constant, it estimated the elasticity of ridership with respect to demographic changes at +0.19.

OCTA uses an extensive array of input data, but does not currently use APC data. The Operations Department has questioned the reliability of APC data; therefore, OCTA continues to rely on ridecheck and especially farebox data. The automatic vehicle location (AVL) system supplies GPS coordinates with every farebox transaction, thus greatly enhancing the reliability of farebox data (good at the bus stop level, very accurate at the TAZ level). This has been the primary impact of technology on ridership forecasting. One advantage

TABLE 40
OCTA GUIDELINES FOR SERVICE ELASTICITY FACTORS

Percent Increase in Service Level (buses/hour)	Recommended Elasticity Factor
20% or less Examples: 30 min to 25 min 15 min to 12 min	+0.50 to +0.70
More than 20% to 50% Examples: 60 min to 45 min 45 min to 30 min	+0.50 to +0.75
More than 50% to 100% Examples: 60 min to 30 min 30 min to 15 min	+0.75 to +0.90

of relying on farebox data is that it is available every day from every bus. Getting to the point where farebox data are usable not only at the route level but also at the stop level has been the primary objective for many years. OCTA is also exploring the development of origin/destination trip tables through the use of the APC data.

OCTA is satisfied with the accuracy of its input data, with the caveats that improvements in the reliability of APC data through field verification and calibration would be useful, and that demographic data are not always available at the desired geographic scale. More accurate APC ridership data would go a long way toward ensuring that an optimal amount of data is available. Constructing an origin/destination trip table with APC data would be a significant improvement over use of on-board surveys, which are difficult and expensive.

OCTA would like to see several improvements in its ridership forecasting methods, including the availability and accuracy of input data at the appropriate scale, less time-intensive methodologies, inclusion of more predictive variables, simplification of procedures, enhanced accuracy, and flexibility to address a wide variety of situations. The ideal next step would be to develop an automated methodology for short-range ridership forecasting. Also, the long-range model predicts ridership for 2030; however, demographic variables are available in 5-year increments. A spreadsheet model that could predict interim year ridership (say at 5-year intervals) would complement and not compete with the long-range model, which requires too much work to generate interim year forecasts.

Ridership forecasts would be developed under the scenarios included in the survey as follows:

- Half-mile rerouting of an existing route to serve a new shopping center: (1) determine interest level based on public comments, (2) look at similar shopping centers, (3) analyze whether this change would affect existing customers, and (4) consider improved transfer opportunities and connections.
- Extension of an existing route for one mile to serve a new residential development: estimate the additional revenue vehicle-hours required and multiply by the minimum productivity standard to project the ridership needed to meet the minimum productivity standard.
- Change in headway from 12 to 10 min during peak hours: multiply the peak-hour change in service hours by the current productivity of the route by the appropriate elasticity from Table 40 (within the range of +0.5 to +0.7).
- Implementation of a new crosstown route: analyze ridership, productivity, and transfer points of similar routes with a crosstown alignment. Use the long-range model to analyze further.
- Implementation of a new mode such as BRT: use the mode choice model.
- Prediction of next year's ridership as part of the budget process: analyze past and current ridership trends; use the annual ridership goal as defined by the Authority. The operations planning department tracks ridership compared with the goal, and will send up red flags to senior management and other departments when the trends do not match the goal.
- A 10-year ridership forecast as part of a long-range plan: use a combination of the mode choice model and trend line analysis.

The one improvement to forecasting methodology would be to develop a more automated approach. This would involve the use of new technologies and tools, and would result in forecasts based on a choice of methodology from a wide variety of proven and accurate methods that best fits the goal.

OCTA reports two main lessons learned from its experience:

- Use experience and results from the past to justify ridership forecasts.
- Carefully review mode choice model results with those obtained by peers and in other corridors and to elasticity-based forecasts.

OCTA sees ridership forecasting methodologies adding value in three areas:

- Budget: good forecasts provide more accurate information regarding ridership and revenue for budgeting purposes.
- Service planning: forecasts help to prioritize potential service improvements by quantifying the benefits (increased ridership) of each improvement.
- Long-range planning: forecasts also quantify benefits attributable to transit in the long-range model, including increased ridership, decreased vehicle-miles traveled, and net reduction in travel delay.

This case study indicates that GIS programs, formal modeling efforts, use of elasticities, and professional judgment can together provide a menu of ridership forecasting methodologies for use as appropriate. The various departments that require ridership forecasts are comfortable with the methodologies and confident in the results. Additional work is ongoing to enhance accuracy and simplify the use of these methodologies; however, OCTA has achieved a high level of confidence in its ridership forecasts in a wide variety of situations.

TRIMET (PORTLAND, OREGON)

TriMet prepares ridership forecasts for virtually every service change. There is no specific threshold triggering the need for a ridership forecast. Forecasts are used internally and distributed to interest groups and stakeholders in response to service requests, as needed. One employee handles the ridership forecasting for bus changes. Light rail is evaluated using the four-step travel model.

The Operations Planning and Planning Departments prepare ridership forecasts related to short-term service changes. Ridership and demographic data, including population, employment, and retail employment are the primary inputs. APCs provide current ridership, supplemented as needed with ridecheck data. TriMet uses census data and origin/destination data gathered through on-board surveys. Employment data are available from the 2000 Metro Employment Database.

TriMet first looks for similar routes and uses professional judgment to forecast ridership for most service changes. If there are no similar routes, it implements a two-step process using regression and service elasticities to predict ridership. The first step involves regression equations developed in-house for three different types of service and calibrated using TriMet routes:

- For regional routes: Ridership1 = 0.06704 * population + 0.0018 * non-retail employment + 0.02 * retail employment.
- For local routes: Ridership1 = 0.00984 * population + 0.004 * non-retail employment + 0.008 * retail employment.
- For employer shuttles: Ridership1 = 0.01 * non-retail employment + 0.0135 * retail employment.

All population and employment values are calculated within one-quarter mile of the route using GIS. Specifically, all census blocks with a centroid within one-quarter mile of the bus route are included in the route buffer.

Results of the regression model are for a "typical" route; the second step of the model adjusts the regression-based forecast using service elasticities that vary based on the proposed level of service. The equation is in logarithmic form. For regional routes, the equation is:

Ridership = Exp (((LN (# daily trips) − LN (62)) * Elasticity) + LN (Ridership1))

For local routes and employer shuttles, the equation is:

Ridership = Exp (((LN (# daily trips) − LN (36)) * Elasticity) + LN (Ridership1))

A daily total of 62 trips for regional routes and 36 trips for other routes represent service at 30 min headways for a typical service span. Service elasticities (Table 41) were taken from the *Traveler Response to Transportation System Changes* study (*10*) and calibrated using TriMet data. These service elasticities are also used to forecast ridership based on all service changes involving changes in headway only.

TABLE 41
SERVICE ELASTICITIES USED BY TRIMET IN ITS' RIDERSHIP FORECASTING MODEL

Change in Headway	Elasticity Factor
New service or new time period	+1.00
60 min to 15 min	+0.58
60 min to 30 min	+0.80
30 min to 15 min	+0.73
20 to 15 min; 15 to 10 or 12 min	+0.20
12 to 10 min; 10 to 7.5 min; 7.5 to 5 min	+0.10

TriMet calibrated each of the three models (for regional, local, and employer shuttle routes) using data from 12 regional routes, 12 local routes, and 5 employer shuttles. Calibration minimized the differences between predicted and actual ridership for the group of routes as a whole. Elasticity factors of 1.0 were used for very frequent service outside the scope of changes shown in Table 41 and for local service and employer shuttles, based on the calibration efforts and because this high number of trips is usually associated with an increase in the span of service.

TriMet is satisfied with the reliability of ridership data collected through its APC/AVL system. Numerous samples are obtained for each trip and the data have proven to be both detailed and accurate down to the trip and stop levels. Census data and origin/destination data are not quite so reliable. Census data becomes dated relatively quickly. Origin/destination data do not provide a large enough sample to work with below the route level.

Technology has had a significant effect on ridership forecasting. The APC/AVL systems have greatly improved the accuracy and reliability of ridership data. GIS has allowed TriMet to associate census data more accurately with routes and ridership.

Ready availability of more detailed data, such as vehicle ownership and income, at the stop level would be welcome. The ridership models were designed to use population and employment because data for both is readily available at the census block level. TriMet is satisfied with its current forecasting methods.

Ridership forecasts could be developed under the scenarios included in the survey as follows:

- Half-mile rerouting of an existing route to serve a new shopping center: (1) identify existing service with comparable headways to a shopping center that is similar in terms of land use, population, retail employment, and nonretail employment, and assume similar ridership; (2) if no similar service is identified, then enter population and employment data into the ridership model; and (3) consider added travel time for existing customers as a result of the deviation and, if deemed significant, apply a travel time elasticity from Pratt (*10*).

- Extension of an existing route for one mile to serve a new residential development: (1) look at comparable existing service and (2) if no similar service is identified, apply the ridership model.
- Change in headway from 12 to 10 min during peak hours: apply a headway elasticity of +0.1 (see Table 41).
- Implementation of a new crosstown route: (1) look at comparable existing service and (2) if no similar service is identified, apply the ridership model.
- Implementation of a new mode such as BRT: the MPO would use its travel model to forecast ridership.
- Prediction of next year's ridership as part of the budget process: generally, TriMet does not forecast next year's ridership.
- A 10-year ridership forecast as part of a long-range plan: no experience with 10-year forecasts.

TriMet lists the following lessons learned from its experience:

- Forecast models from external sources that the agency has experimented with in the past are complicated, require substantial staff time, are data intensive, and provide results that are often inferior to a simple analysis of similar routes. One regression model, for example, relied heavily on service levels as an independent variable. The projections suggested unreasonable ridership response to potential service improvements in low-density areas.
- Using population, retail employment, and nonretail employment as the independent variables in a ridership model results in accurate estimates. Other variables such as vehicle ownership and income do not provide enough improvement in accuracy to warrant the time and difficulty in acquiring and compiling the data at the appropriate scale.
- If sufficient data are available, derive elasticities from local experience, not industry-wide averages.

The value of ridership forecasting for TriMet is that it provides a sound basis for making decisions. In most cases, ridership is the bottom line in the evaluation of existing and proposed service. Ridership forecasts aid TriMet in making an informed choice among competing alternatives.

This case study provides an example of a ridership forecasting model in use at a transit agency. It is noteworthy that TriMet's first choice of methodology for incremental service changes is similar-route analysis, but the model is useful in addressing unique situations. TriMet also relies heavily on service headway elasticities to assess the impact of changes in frequency. TriMet believes that its model and approach could be used at other transit agencies, once calibrated with that agency's ridership data.

CHAPTER SIX

CONCLUSIONS AND SUGGESTIONS FOR FURTHER STUDY

INTRODUCTION

This chapter summarizes the findings, presents conclusions from this synthesis project, and offers recommendations for further research. Findings from the surveys and particularly the case studies provide an assessment of strengths and weaknesses in current methods and likely future directions. The chapter is organized in six sections:

- Data
- Methodology
- Organizational Issues
- Reliability and Accuracy
- Lessons Learned
- Conclusions and Further Research Needs

At the outset, this study noted the need for ridership forecasting methodologies that fall between "back-of-the-envelope" methods and a formal four-step travel demand model. During the process of survey development for this synthesis, the wide variety of circumstances under which a ridership forecast may be required became apparent, supporting the need for intermediate methodologies.

The conclusions offered here attempt to place these findings in a larger context of how ridership forecasting methodologies are evolving and might continue to evolve at transit agencies.

DATA

- A wide variety of data sources are used in ridership forecasting. The most often used data sources include ridership data from the farebox and from recent ridechecks, existing and forecast land use, census demographic data, and origin/destination data from on-board surveys. Automated passenger counters (APCs) have made inroads but are still the least likely source of ridership data among those listed. Origin/destination data, although frequently considered, are not a major component of ridership forecasting for a majority of respondents.
- Most responding agencies do not have the optimal amount of data available for forecasting ridership. The most common concern is availability of ridership data below the route level (by route segment or stop). Many agencies anticipate that APC implementation will solve this issue.
- Results regarding agency satisfaction with the reliability of input data are mixed, with 44% of respondents indicating general but not complete satisfaction. The greatest reliability concerns center on ridership data; however, the timeliness and level of detail for origin/destination and demographic data are also issues.

METHODOLOGY

- The literature review provided a good sampling of previous work related to ridership forecasting. The more straightforward approaches exemplified by Pratt et al. and Mayworm et al. are more user-friendly (given that modeling expertise is not necessarily present at many transit agencies) and are appropriate for ridership forecasts resulting from small-scale changes. Efforts at the metropolitan planning organization (MPO) or state level to develop simpler and more usable sketch planning tools are promising. Ongoing work with the T-BEST (Transit Boardings Estimation and Simulation Tool) model in Florida should provide insight into model transferability.
- Simpler, less formal approaches are used for route-level and other small-scale service changes. The examples show that some of these "simpler" approaches have grown more sophisticated as geographic information system (GIS) databases are used to assess demographic characteristics and identify similar routes and as APCs and ongoing programs improve the accuracy of ridership data.
- Use of elasticities is widespread for changes to existing service, particularly frequency changes.
- More formal methods, including the use of the four-step travel model, are used when either the change or the time frame is beyond the scope of the current system (e.g., introduction of a new mode and forecasting over the next 10 years).
- New technologies have had an effect on agencies' forecasting methods. APCs and farebox upgrades or automated fare collection were most frequently mentioned among new technologies; however, several off-vehicle technologies were also noted. Improvements in data accuracy, reliability, and level of detail are among the primary effects of new technologies. Many agencies also cite improvements in data availability and integration of data from different sources.

ORGANIZATIONAL ISSUES

- The planning department is the most likely home for the forecasting function within a transit agency. However, it is not unusual for multiple departments to be involved in different levels of ridership forecasting.
- Responsibility for ridership forecasting is more likely to be part of general duties for all but major changes.
- A range of estimates were given for the time and effort required to prepare ridership forecasts. Simple or short-range forecasts can generally be completed in 3 days or less. A wide time range in long-range forecasts reflects the method used; a trend line analysis takes much less time than a four-step model run.
- Ridership forecasts are nearly always distributed and used internally. A majority of responding agencies also share the forecasts with their boards.

RELIABILITY AND ACCURACY

- Nearly all agencies measure the reliability and value of their forecasting methodologies through a comparison of actual ridership with ridership forecasts. Board understanding and approval is also a factor for 27% of respondents.
- The question regarding satisfaction with current forecasting methods yielded interesting results. Roughly one-third of responding agencies are satisfied, one-third are partially satisfied, and one-third are not satisfied with current forecasting methods. Quality and availability of input data and accuracy of the forecasts are the most pressing concerns.
- Input data and methodology were the most frequently mentioned aspects of ridership forecasting procedures that transit agencies would like to change. Agencies reported a need for greater data availability, more current data, and data at a finer level. Methodology needs were more diverse, because various agencies are at different stages regarding forecasting methods. Among the specific responses were greater sophistication, more consistency, and easier to apply models.

LESSONS LEARNED AND CASE STUDY RESULTS

- Approximately half of all survey respondents shared lessons learned from the process of developing and using ridership forecasting methodologies. The most commonly mentioned included interpreting results cautiously and simplifying the approach to ridership forecasting. Responding agencies made several other important and useful observations.
- Each of the case study agencies was very different in terms of approach to ridership forecasting, response to local issues and concerns, and use of various methods and techniques. All showed a thoughtful response to the issues posed by ridership forecasting.
- The VIA Metropolitan Transit (San Antonio) case study provides an example of a traditional approach that relies heavily on professional judgment and an understanding gained through experience of the factors contributing to transit ridership.
- The Regional Transit District (RTD) (Denver) case study shows how new technologies such as APCs, integrated software, and GIS can improve the quantity and quality of ridership and other data, provide new methods for analyzing and forecasting ridership, and greatly enhance its ability to communicate results to stakeholders. At the same time, RTD relies on research projects such as *TCRP Report 95* to provide invaluable documentation of experience elsewhere.
- The Greater Richmond Transit Company (GRTC) case study shows that there may not be a real need for a ridership forecasting methodology at all transit agencies. The decision-making process at many small and mid-sized agencies is driven more by politics and funding availability than by ridership analysis. Although many agencies can see the value of employing a forecasting methodology, it may not rank highly in terms of current needs.
- The Metropolitan Transit Authority–New York City Transit (MTA–NYC) case study shows how application of new data collection techniques (automated fare collection) and GIS analytical tools can improve ridership forecasting procedures. Successful exploration of new analytical methods (such as inferred origins and destinations) as ridership data become more reliable is an important finding that can be applied elsewhere. Encouraging interaction between modelers and end-users through organizational structure and location of the departments can ultimately result in model improvements and greatly increases the likelihood of its being trusted and used on a consistent basis.
- The Orange County Transportation Authority (OCTA) case study indicates that GIS programs, formal modeling efforts, use of elasticities, and professional judgment can together provide a menu of ridership forecasting methodologies for use as appropriate. The various departments that require ridership forecasts are comfortable with the methodologies and confident in the results. Additional work is ongoing to enhance accuracy and simplify the use of these methodologies; however, OCTA has achieved a high level of confidence in its ridership forecasts in a wide variety of situations.
- The Tri-County Metropolitan District of Oregon (TriMet) case study provides an example of a ridership forecasting model in use at a transit agency. It is noteworthy that TriMet's first choice of methodology for incremental service changes is similar-route analysis, but the model is useful in addressing unique situations. TriMet also relies heavily on service headway elasticities to assess the impact of changes in frequency. TriMet believes that its model and approach could be used at other transit agencies once calibrated with that agency's ridership data.

CONCLUSIONS AND FURTHER RESEARCH NEEDS

- Qualitative forecasting techniques relying on professional judgment and experience continue to be widely used by transit agencies, especially for small-scale and near-term changes. Some consider these too subjective and too dependent on the skill of the analyst. Examples cited throughout this synthesis demonstrate that "qualitative" does not equal "simplistic." Qualitative procedures can involve consideration of a wide variety of factors, often geared toward identifying similar circumstances elsewhere in the transit system that can provide guidance for likely ridership response.
- Use of service and headway elasticities is widespread among transit agencies. Broad-based studies such as *TCRP Report 95* are very useful in providing information on "typical" elasticities; however, several agencies have emphasized the need to adapt these to their service areas using their own experiences.
- Formal travel modeling expertise is found at the MPO, not usually at the transit agency. The literature review noted that several MPOs are actively engaged in the development of forecasting methodologies at a more appropriate scale for transit needs than the traditional four-step travel model. At the same time, widespread use of new technologies such as GIS and APCs allow transit agencies to develop more sophisticated ridership forecasting tools. These developments suggest the possibility of convergence in the near future.
- Transit agencies reported that a strong, ongoing working relationship with their MPOs is beneficial to both parties. Modelers and transit planners often work in different time frames and geographic scales, and ongoing communication helps to bridge these gaps. The New York City case study findings emphasize the benefits of interaction between modelers and planners within large transit agencies.
- Transit agencies reported value in ridership forecasting methodologies. Several noted that ridership forecasts provide a basis for prioritizing among competing proposals and, more generally, for decision making at the senior management and board levels. Internally, ridership forecasting can encourage discipline in the service planning process, particularly where there is ongoing interaction between modelers and service planners. This interaction can also result in improved methodologies. Sound ridership forecasting methodologies can also enhance a transit agency's credibility among stakeholders and peer local and regional agencies.
- Does the state of the art in transit ridership forecasting justify the high value that transit agencies place on this function? At many agencies, forecasting is more of an art than a science and is likely to remain so in the near future. However, new technologies that provide more accurate ridership data and enhance the ability to summarize demographic and socioeconomic data at an appropriate level of detail are fostering continued development of ridership forecasting techniques and are increasing the confidence level in forecasting results. There will always be a role for professional judgment and experience, particularly in understanding the underlying factors affecting ridership behavior. The continued integration of ridership, service, demographic, and other data will provide new tools to assist in this understanding.

Findings from this synthesis suggest five major research needs:

1. Transferability of ridership forecasting methodologies. How well does a methodology developed at one transit agency work at another agency? Calibration to local conditions is a given; however, how extensive is the needed calibration and how accurate are the resulting forecasts? Ongoing work with the T-BEST model in Florida, sponsored by the Florida Department of Transportation, has as one of its purposes calibration and use of this model at all transit agencies within the state, and should offer interesting findings regarding transferability.
2. GIS applications in ridership forecasting. The use of GIS by transit agencies continues to increase. Although many GIS applications are oriented toward simple mapping functions, the true value of GIS in transit may be as a data integration platform that simplifies data management. Additional research in this area should have a positive return.
3. Easy-to-use methodologies. As previous experience has shown, forecasting procedures relying on data that are not readily available to transit agencies are unlikely to be used. User acceptance should be a primary focus of future research efforts in this field.
4. Implementation of new technologies. Transit agencies in the process of acquiring APC systems anticipate that the use of APCs will solve problems with the availability of ridership data at the route segment or stop level. However, APC implementation has not always been successful. Several agencies, including VIA and OCTA among the case studies, have experienced problems in obtaining usable data from APCs and/or in convincing all departments within the agency that APC data are equally or more reliable than farebox or manually collected data. Other agencies, including RTD and TriMet among the case studies, are very confident in and rely extensively on their APC data. Future research into factors affecting successful implementation would be useful not only in relation to APCs but also for the variety of ITS applications that will come on line in the near future.
5. The need for cost-effective and reliable data collection efforts. Quality and availability of input data continue to be among the primary concerns of transit agencies. Research geared toward reliable data collection at the appropriate level and at an affordable price could have enormous practical value.

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APPENDIX A

Survey Questionnaire

FIXED-ROUTE TRANSIT RIDERSHIP FORECASTING AND SERVICE PLANNING METHODS

Project purpose: This TCRP synthesis project will document the state of the practice in fixed-route transit ridership forecasting and service planning. Ridership forecasting takes place in a wide variety of circumstances, and different methods may be used depending on the scale of a proposed change or the time frame involved. The survey contains questions about forecasting methods, data inputs and requirements, use of the forecasts, organizational responsibility for forecasting, reliability, and potential improvements. The survey questions try to address as many situations as possible, but given the variety of circumstances and transit systems, not all questions may be appropriate for all agencies. If any question does not apply to your system, please answer "N/A." Unless otherwise noted, more than one response is acceptable for multiple-choice questions.

The last portion of the survey asks you to describe how your agency would forecast ridership for seven different scenarios. We also ask for recommendations for other agencies to be included in our sample and for your willingness to participate in a telephone interview if your agency is selected for a more detailed case study.

The final report, to be published by the Transportation Research Board, will identify forecasting methods in use along with agency assessments of their effectiveness and reliability. This report will be extremely useful to all transit agencies as they consider how best to develop future ridership estimates in a variety of contexts. All survey responses will be confidential.

Thank you for taking the time to participate. Instructions on returning the survey are included on the last page. To begin, hit the TAB key or the down arrow. Type your answer (or mark an X in a multiple-choice question), and use TAB, up and down arrows, or mouse controls to move back and forth through the questions.

RESPONDENT INFORMATION

Date:
Name and Title of Respondent:
Agency Name:
Respondent Telephone Number:
Respondent e-Mail Address:

GENERAL RIDERSHIP FORECASTING

1. Do you forecast ridership for:

- ☐ Minor adjustments to a route segment
- ☐ Scheduling changes
- ☐ Route changes affecting less than 25% of a route
- ☐ Route changes affecting 25% or more of a route
- ☐ New routes
- ☐ New mode/new type of service
- ☐ The next fiscal year
- ☐ The next five or ten years, or other long-term forecast
- ☐ Other (please describe):

2. Is there a threshold in terms of the scale of service change that triggers a ridership forecast? If so, what is the threshold?

3. Do you have more than one method of forecasting ridership, depending on the scope of the change (check only one)?

- ☐ Yes
- ☐ No

4. How are these forecasts distributed and used?

- ☐ Internally
- ☐ To board members
- ☐ To the MPO
- ☐ To elected officials
- ☐ Other (please specify):

5. Is there a dedicated person or group responsible for ridership forecasts, or do planners or other personnel estimate future ridership among their other duties (check only one)?

- ☐ Dedicated person/group
- ☐ Not dedicated —part of general duties
- ☐ Depends on the scale and extent of the ridership forecast

6. Which department or agency has the lead for preparing ridership forecasts?

- ☐ Transit operations planning department
- ☐ Transit operations department
- ☐ Transit planning department
- ☐ Transit budget/finance department
- ☐ MPO
- ☐ Other (please specify):

7. Do you consider the following as inputs in your methodology? If a factor is involved for some types of changes or forecasts but not others, please indicate.

<u>FACTOR</u> <u>TYPE OF CHANGE OR FORECAST</u>

- ☐ Existing system ridership
- ☐ Existing route or route segment ridership
- ☐ Ridership on similar routes
- ☐ Origin/destination information
- ☐ Demographic factors within the service area
- ☐ Land use within the affected service area
- ☐ Economic trends within the service area
- ☐ Other (please specify):

8. What techniques are included in your methodology? If a technique is involved for some types of changes but not others, please indicate.

<u>TECHNIQUE</u> <u>TYPE OF CHANGE</u>

- ☐ Econometric model
- ☐ Four-step travel demand forecasting model
- ☐ Regression analysis
- ☐ Service elasticities
- ☐ Rules of thumb or similar route analysis
- ☐ Professional judgment
- ☐ Other (please specify):

9. What data sources do you use in developing ridership forecasts?

- ☐ Ridership data from APCs
- ☐ Ridership data from recent ridechecks
- ☐ Ridership data from the farebox
- ☐ Origin/destination data from on-board surveys
- ☐ Origin/destination data from models
- ☐ Census demographic data

- ☐ CTPP demographic data
- ☐ Existing land use
- ☐ Forecast land use
- ☐ Economic trends
- ☐ Economic forecasts
- ☐ Other (please specify):

10. Are you satisfied with the reliability of the input data? If not, why not?

11. How is origin/destination data included in your forecasting methodology (check only one)?

- ☐ Major part
- ☐ Considered, but not a major part
- ☐ Not considered

12. Do you forecast linked or unlinked ridership?

- ☐ Linked ridership
- ☐ Unlinked ridership
- ☐ Both linked and unlinked ridership

13. Has technology affected your forecasting methodology? If so, how?

14. If your system operates more than one mode, do you use different methods to develop forecasts for each mode?

15. Do you use different methods for long-range and short-range forecasts?

16. Is there an optimal amount of data for your forecasting and planning process? Do you have that amount of data available?

17. How long does it take to prepare a ridership forecast? What is involved in terms of resources/staff?

18. Are you satisfied with the current ridership forecasting methods?

18A. If not, what would you like to see improved?

- ☐ Availability and/or accuracy of input data at the appropriate scale
- ☐ Less time-intensive methodology
- ☐ Inclusion of more predictive variables
- ☐ Simplification of the procedures
- ☐ Accuracy of the results
- ☐ Flexibility to address a wider variety of situations
- ☐ Other (please specify):

19. How do you assess the reliability and value of the methodology?

- ☐ Comparison of actual and projected ridership
- ☐ Board understanding and approval
- ☐ Other (please specify):

20. Please describe how your agency would forecast ridership for the following scenarios:

A. A half-mile rerouting of an existing route to serve a new shopping center
B. Extension of an existing route for one mile to serve a new residential development
C. Change in headway from 12 to 10 minutes during peak hours
D. Implementation of a new crosstown route to enhance service area coverage and provide more direct connections
E. Implementation of a new mode such as BRT
F. Prediction of next year's ridership as part of the budget process
G. A 10-year ridership forecast as part of a long-range plan

21. If you could change one aspect of your ridership forecasting methodology, what would you change?

22. Please describe any “lessons learned” that would benefit other transit agencies that are considering changes to their ridership forecasting methods.

23. Is there another transit system that you suggest we contact for this synthesis project?

24. Would you be willing to participate further as a case study, involving a telephone interview going into further detail on your forecasting methodology, if selected by the TCRP panel for this project (check only one)?

☐ Yes
☐ No

Please return by December 31, 2005 to:

Daniel Boyle
President, Dan Boyle & Associates, Inc.
4511 Falcon Ridge Court
San Diego, CA 92130
858-259-6515 phone
858-259-2305 fax
dboyle34@pacbell.net e-mail

We encourage you to return your completed survey via e-mail. If you have any questions on the survey or the project, feel free to contact Dan Boyle by e-mail or phone.

APPENDIX B

Summary of Survey Results

FIXED-ROUTE TRANSIT RIDERSHIP FORECASTING AND SERVICE PLANNING METHODS

The sum of the number of responses does not equal the total number of respondents, because many questions allowed multiple answers. The number of responses is listed first, followed by the percentage of total respondents for that question. Responses to open-ended questions have been summarized into categories. A number next to an answer in the "Other" category indicates that more than one transit agency listed this response; if there is no number, the response was mentioned once.

GENERAL RIDERSHIP FORECASTING

1. Do you forecast ridership for:

Minor adjustments to a route segment	12	33%
Scheduling changes	11	31%
Route changes affecting less than 25% of a route	16	44%
Route changes affecting 25% or more of a route	24	67%
New routes	31	86%
New mode/new type of service	24	67%
The next fiscal year	22	61%
The next five or ten years, or other long-term forecast	23	64%
Other (please describe):	5	14%

Other includes fare changes (3), contingency service reductions, new or extended fixed guideway, New Starts projects, park-and-ride lots, economic/demographic shifts, rolling stock/facility/capacity needs.

2. Is there a threshold in terms of the scale of service change that triggers a ridership forecast? If so, what is the threshold?

Formal	13	41%
Informal	8	25%
None	11	34%
Total responding	32	100%

Thresholds include:

- Greater than 10% change in platform miles/hours
- Any change that significantly (by 10% or more) affects the resources required to deliver service on a route
- 25% change in miles/hours, less for Title VI analysis
- 25% change in ridership (required by city ordinance)
- 25% of route unless number of riders affected is moderate
- Action required by Board
- Added cost
- Any fare change
- Anything other than minor schedule adjustments
- Change in resource allocation
- Changes in route alignment and number of trips
- Significant enough to be part of service change program
- When transit agency requests

3. Do you have more than one method of forecasting ridership, depending on the scope of the change?

Yes	23	66%
No	12	34%

4. How are these forecasts distributed and used?

Internally	33	97%
To Board members	23	68%
To the MPO	10	29%
To elected official	9	26%
Other (please specify):	10	29%

Others include FTA (3), interest groups/stakeholders/general public (4), other agency/external departments (3), consultants.

5. Is there a dedicated person or group responsible for ridership forecasts, or do planners or other personnel estimate future ridership among their other duties?

Dedicated person/group	8	24%
Not dedicated—part of general duties	13	38%
Depends on scale/extent of ridership forecast	13	38%

6. Which department or agency has the lead for preparing ridership forecasts?

Transit operations planning department	9	25%
Transit operations department	3	9%
Transit planning department	22	65%
Transit budget/finance department	8	24%
MPO	6	18%
Other (please specify):	4	12%

Other includes strategic planning and policy, transit research section (marketing department), business development, consultant (for BRT), service evaluation section, systems analysis section.

7. Do you consider the following as inputs in your methodology? If a factor is involved for some types of changes but not others, please indicate.

Existing system ridership	28	80%
Existing route or route segment ridership	31	89%
Ridership on similar routes	30	86%
Origin/destination information	24	69%
Demographic factors within the service area	27	77%
Land use within the affected service area	25	71%
Economic trends within the service area	21	60%
Other (please specify):	10	29%

Other includes auto ownership, travel time (2), congestion level (2), distance from major activity centers, fare/pricing information (2), modal competition, service frequency, transfer activity, access mode (2), egress mode, market research surveys, new employment/retail development, trip generators in affected area.

7A. Type of change or forecast for existing system ridership.

Annual budget/forecast	5
Long-range plan	3
Four-step travel model	2
Fare changes	2
For system ridership	2
5-year plan	2
Major new service, including fixed guideway extensions	1
Span of service	1
Change in scheduled service level	1
All	1
Any route or service change	1

Elasticities	1
Model validation	1

7B. Type of change or forecast for existing route/route segment ridership.

Change in route	3
Span of service	2
Change in scheduled service level	2
All	2
Any route or service change	2
Elasticities	2
Major new service, including fixed guideway extensions	1
Four-step travel model	1
Timed transfer	1
New route or corridor	1
Model validation	1
Significant service changes	1

7C. Type of change or forecast for ridership on similar routes.

New route or corridor	7
Change in route	4
Span of service	2
Major new service, including fixed guideway extensions	1
Annual budget/forecast	1
All	1
Any route or service change	1
5-year plan	1

7D. Type of change or forecast for origin/destination information.

Major new service, including fixed guideway extensions	3
Four-step travel model	3
If available	2
Long-range plan	2
Change in route	2
Timed transfer	1
New route or corridor	1
Service to new areas	1
Used to plan, not forecast	1

7E. Type of change or forecast for demographic factors.

Change in route	3
Major new service, including fixed guideway extensions	2
New route or corridor	2
Service to new areas	2
Four-step travel model	1
Span of service	1
All	1
Long-range plan	1
Used to plan, not forecast	1
Title VI analysis	1
Large-scale projects that may require environ. analysis	1
Mode choice in model	1
5-year plan	1
Significant service changes	1

7F. Type of change or forecast for land use.

Change in route	4
New route or corridor	3
Major new service, including fixed guideway extensions	2
Four-step travel model	2
Long-range plan	2
Activity centers	1
All	1
For system ridership	1
Used to plan, not forecast	1
For planning area level forecasts	1
At gross level (residential vs. commercial vs. industrial)	1
Significant service changes	1

7G. Type of change or forecast for economic trends.

Major new service, including fixed guideway extensions	2
Four-step travel model	2
Annual budget/forecast	2
Long-range plan	2
New route or corridor	1
All	1
Emerging markets	1
Change in route	1
5-year plan	1

7H. Type of change or forecast for other.

Four-step travel model	2

8. What techniques are included in your methodology? If a technique is involved for some types of changes but not others, please indicate.

Econometric model	7	20%
Four-step travel demand forecasting model	18	51%
Regression analysis	7	20%
Service elasticities	22	63%
Rules of thumb or similar route analysis	28	80%
Professional judgment	29	83%
Other (please specify):	7	20%

Other includes trend analysis (3), GIS/similar routes, internal model based on actual experience, trip generation rates from ITE.

8A. Type of change or forecast for econometric model.

Major new service, including fixed guideway extensions	1
New route or corridor	1
Fare changes	1

8B. Type of change or forecast for four-step travel demand model.

Major new service, including fixed guideway extensions	8
Four-step travel model	5
Annual budget/forecast	1
For system ridership	1

Large-scale projects that may require environ. analysis	1
Capital projects	1
Modified travel model, not standard approach	1
Long-range plan	1

8C. Type of change or forecast for regression analysis

For system ridership	2
Change in route	2
New route or corridor	1
Any route of service change	1
Annual budget/forecast	1
Long-range plan	1
5-year plan	1

8D. Type of change or forecast for service elasticities

Any route or service change	9
Fare changes	6
Headway/schedule changes	3
For system ridership	1

8E. Type of change or forecast for rules of thumb/similar routes

Any route or service change	5
Change in route	4
Headway/schedule changes	3
Span of service	2
New route or corridor	2
Major new service, including fixed guideway extensions	1
Long-range plan	1
Significant service change	1

8F. Type of change or forecast for professional judgment

Any route or service change	5
New route or corridor	2
All	2
Change in route	2
Span of service	1
Headway/schedule changes	1
Check on all forecasts	1
Significant service change	1

8G. Type of change or forecast for other

New route or corridor	1
Annual budget/forecast	1
Fare changes	1
Long-range plan	1
For system ridership	1

9. What data sources do you use in developing ridership forecasts?

Ridership data from APCs	14	40%
Ridership data from recent ridechecks	28	80%
Ridership data from the farebox	30	86%
Origin/destination data from on-board surveys	22	63%

Origin/destination data from models	14	40%
Census demographic data	23	66%
CTPP demographic data	9	26%
Existing land use	25	71%
Forecast land use	19	54%
Economic trends	10	29%
Economic forecasts	11	31%
Other (please specify):	11	31%

Other includes household surveys (3), driver trip counts, special event surveys, on-board ridership surveys, distance walked, frequency of use, point checks for volume at peak load points/CBD cordon points, regional model, FTA Summitt software for BRT, service characteristics (2), fare levels, traffic condition, type of fare paid (if available).

10. Are you satisfied with the reliability of the input data? If not, why not?

Satisfied	14	41%
Partially satisfied	15	44%
Not satisfied	5	15%
Total responding	34	100%

Issues with data reliability:

Ridership	13	65%
Origin/destination data	5	25%
Demographic data	5	25%
General	5	25%
Total responding	20	100%

11. How is origin/destination data included in your forecasting methodology?

Major part	10	29%
Considered, but not a major part	15	43%
Not considered	8	23%
Depends on time frame/level of analysis	2	6%

12. Do you forecast linked or unlinked ridership?

Linked ridership	0	0%
Unlinked ridership	24	71%
Both linked and unlinked ridership	10	29%

13. Has technology affected your forecasting methodology? If so, how?

Yes	22	63%
No	13	37%

Specific technology:

APC	10	56%
Farebox upgrade/AFC	5	28%
Upgrade/new use for travel model	4	22%
GIS	4	22%
Improved PCs/software	3	17%
AVL/GPS	2	11%
Data integration software	1	6%

Effect of technology:

Data reliability/accuracy	7	30%
More data	7	30%
Improved analytical tools	7	30%

Greater detail in data	6	26%
Data integration from different sources	4	17%
Makes origin/destination estimation possible	3	13%
Faster analysis time	3	13%
Better reporting	2	9%

14. If your system operates more than one mode, do you use different methods to develop forecasts for each mode?

Yes	9	45%
No	11	55%

15. Do you use different methods for long-range and short-range forecasts?

Yes	22	71%
No	9	29%

16. Is there an optimal amount of data for your forecasting and planning process? Do you have that amount of data available?

Optimal Amount of Data			Is Optimal Amount of Data Available?		
Yes	23	85%	Yes	8	26%
Sometimes	2	7%	Sometimes	6	19%
No	2	7%	No	17	55%

17. How long does it take to prepare a ridership forecast? What is involved in terms of resources/staff?

Time and Effort Required—Short-range			Time and Effort Required—Long-range		
Less than one day	8	32%	One day or less	7	47%
One to three days	12	48%	One to three months	3	20%
Two weeks or longer	5	20%	Four months or longer	5	33%

18. Are you satisfied with the current ridership forecasting methods?

Yes	11	31%
Partially	12	34%
No	12	34%

18A. If not, what would you like to see improved?

Availability and/or accuracy of input data at the appropriate scale	22	81%
Less time-intensive methodology	11	41%
Inclusion of more predictive variables	11	41%
Simplification of the procedures	8	30%
Accuracy of the results	16	59%
Flexibility to address a wider variety of situations	11	41%
Other (please specify):	7	26%

Other includes actually having a forecasting process; automated methodology for short-range to minimize steps needed; FTA should allow non-rail to use alternative specific constants; improved accuracy for local bus routes; incorporate *TCRP Report 95* into guidelines; more commitment to input data in region and by other operators; more effective methodology—fare and short-term good, long-term and New Starts poor.

19. How do you assess the reliability and value of the methodology?

Comparison of actual and projected ridership	31	94%
Board understanding and approval	9	27%
Other (please specify):	2	6%

Other includes meet expectations for growth; pre/post-implementation review plus professional judgment.

20. Please describe how your agency would forecast ridership for the following scenarios:

A. A half-mile rerouting of an existing route to serve a new shopping center

Similar conditions/area	13	36%
Similar routes/changes	11	31%
Current route ridership	9	25%
Consideration of through ridership	8	22%
Trip generation rate	6	17%
Professional judgment	5	14%
Would not analyze	5	14%
Transfer data/connected routes/ridership shift	3	8%
Productivity	3	8%
Socioeconomic/demographic data	3	8%
Local mode share	2	6%
Current/planned development	2	6%
Elasticities	2	6%
Regression/sketch planning mode	2	6%
No. employees	1	3%
Population/population density/no. households	1	3%
Consultant	1	3%
Four-step travel model	1	3%
Assume minimum performance standard	1	3%
Service level changes	1	3%
Travel time	1	3%
Understanding it takes time to reach ridership forecast	1	3%
Evaluate trip generators/land use within 1/4 mile	1	3%
Rider input (public comments/on-board survey)	1	3%
Change made to provide access	1	3%

B. Extension of an existing route for one mile to serve a new residential development

Similar routes/changes	12	33%
Similar conditions/area	11	31%
Socioeconomic/demographic data	7	19%
Productivity	6	17%
Trip generation rate	5	14%
Assume minimum performance standard	5	14%
Would not analyze	5	14%
Population/population density/no. households	5	14%
Professional judgment	5	14%
Local mode share	3	8%
Current ridership	2	6%
Consideration of through ridership	2	6%
Current/planned development	2	6%
Regression/sketch planning model	2	6%
Four-step travel model	2	6%
Evaluate trip generators/land use within 1/4 mile	2	6%
Elasticities	1	3%
Consultant	1	3%
Understanding it takes time to reach ridership forecast	1	3%
Rider input (public comments/on-board survey)	1	3%
Change made to provide access	1	3%
Origin/destination data	1	3%

C. Change in headway from 12 to 10 minutes during peak hours

Elasticities	12	33%
Productivity	10	28%
Would not analyze	8	22%

Professional judgment	4	11%
Similar routes/changes	4	11%
Assume minimum performance standard	3	8%
Current ridership	3	8%
Socioeconomic/demographic data	2	6%
Four-step travel model	2	6%
Similar conditions/area	1	3%
Evaluate trip generators/land use within 1/4 mile	1	3%
Consultant	1	3%
Service level changes	1	3%
Travel time	1	3%

D. Implementation of a new crosstown route to enhance service area coverage and provide more direct connections

Similar routes/changes	15	42%
Transfer data/connected routes/ridership shifts	8	22%
Socioeconomic/demographic data	6	17%
Productivity	5	14%
Would not analyze	5	14%
Four-step travel model	4	11%
Similar conditions/area	4	11%
Origin/destination data	4	11%
Evaluate trip generators/land use within 1/4 mile	4	11%
Assume minimum performance standard	4	11%
Elasticities	3	8%
Professional judgment	2	6%
Consultant	2	6%
Travel time	2	6%
Trip generation rate	2	6%
Population/population density/no. households	2	6%
Local mode share	2	6%
Regression/sketch planning model	2	6%
No. employees	2	6%
Current ridership	1	3%
Service level changes	1	3%
Consideration of through ridership	1	3%
Current/planned development	1	3%
Understanding it takes time to reach ridership forecast	1	3%
Roadway congestion	1	3%

E. Implementation of a new mode such as BRT

Four-step travel model	17	47%
Would not analyze/would not implement	7	19%
Consultant	6	17%
Travel time	4	11%
Elasticities	4	11%
Origin/destination data	3	8%
Similar routes/changes	2	6%
Assume minimum performance standard	2	6%
Experience in other cities	2	6%
Econometric model/new or refined model	2	6%
Transfer data/connected routes/ridership shifts	1	3%
Productivity	1	3%
Evaluate trip generators/land use within 1/4 mile	1	3%
Professional judgment	1	3%
Service level changes	1	3%

Roadway congestion	1	3%
FTA new starts methodology	1	3%

F. Prediction of next year's ridership as part of the budget process

Trend line	21	58%
Service level changes	13	36%
Fare changes	5	14%
Professional judgment	4	11%
Would not analyze	4	11%
Economic/employment/sales tax revenue changes	3	8%
Demographic trends	3	8%
Elasticities	3	8%
Four-step travel model	2	6%
Current/planned development	2	6%
Understanding it takes time to reach ridership forecast	2	6%
Regression/sketch planning model	2	6%
Consultant	1	3%
Econometric model/new or refined model	1	3%
Done elsewhere in agency	1	3%

G. A 10-year ridership forecast as part of a long-range plan

Four-step travel model	15	43%
Trend line	12	34%
Service level changes	8	23%
Would not analyze	5	14%
Demographic trends	3	9%
Fare changes	2	6%
Professional judgment	2	6%
Economic/employment/sales tax revenue changes	2	6%
Consultant	2	6%
Elasticities	1	3%
Current/planned development	1	3%
Understanding it takes time to reach ridership forecast	1	3%
Econometric model/new or refined model	1	3%
Done elsewhere in agency	1	3%
Origin/destination data	1	3%
Similar routes/changes	1	3%
Productivity	1	3%
Population/population density/no. households	1	3%
No. employees	1	3%

21. If you could change one aspect of your ridership forecasting methodology, what would you change?

Input data	11	44%
Methodology	10	40%
Improved linkages (GIS, regional indicators)	2	8%
Staff expertise/understanding	2	8%
Written guidelines	1	4%
Allow alternate specific constants	1	4%
Based on industry standards and best practices	1	4%

22. Please describe any "lessons learned" that would benefit other transit agencies that are considering changes to their ridership forecasting methods.

Caution regarding results	7	37%
Simplify the approach	4	21%

Caution regarding data and application	4	21%
Communication and partnering	2	11%
Develop local factors	2	11%
Simplify the model	2	11%
Smaller vs. larger agencies	1	5%
Neither overly simple nor overly complex approaches work	1	5%
GIS as data integration tool simplifies data management	1	5%
Transferability	1	5%
Take the time to develop ridership forecasts	1	5%
Interpretation/presentation as important as results	1	5%
Admit when forecasts are wrong—it's the best teacher	1	5%

23. Is there another transit system that you suggest we contact for this synthesis project?

Yes	10	28%
No	26	72%
Total responding	36	100%
Total agencies named	14	
Of named agencies, included in survey	10	71%

24. Would you be willing to participate further as a case study, involving a telephone interview going into further detail on your forecasting methodology, if selected by the TCRP panel for this project?

Yes	25	69%
No	11	31%

APPENDIX C

Participating Transit Agencies

1.	Albany, NY	Capital District Transportation Authority
2.	Ames, IA	Ames Transit Agency (CyRide)
3.	Bridgeport, CT	Greater Bridgeport Transit Authority
4.	Buffalo, NY	Niagara Frontier Transportation Authority
5.	Charlotte, NC	Charlotte Area Transit System
6.	Chicago, IL	Chicago Transit Authority
7.	Cleveland, OH	Greater Cleveland Regional Transit Authority
8.	Concord, CA	Central Contra Costa Transit Authority
9.	Dallas, TX	Dallas Area Rapid Transit
10.	Denver, CO	Regional Transportation District (RTD)
11.	Eugene, OR	Lane Transit District (LTD)
12.	Hartford, CT	Connecticut Transit
13.	Houston, TX	Metropolitan Transit Authority of Harris County
14.	Jacksonville, FL	Jacksonville Transportation Authority
15.	Lancaster, PA	Red Rose Transit Authority
16.	Livermore, CA	Livermore/Amador Valley Transit Authority (WHEELS)
17.	Los Angeles, CA	Los Angeles County Metropolitan Transportation Authority
18.	Montgomery, AL	Montgomery Area Transit System
19.	New York, NY	MTA–New York City Transit (MTA–NYCT)
20.	Newark, NJ	New Jersey Transit
21.	Oakland, CA	Alameda–Contra Costa Transit District (AC Transit)
22.	Oceanside, CA	North County Transit District
23.	Orange, CA	Orange County Transportation Authority (OCTA)
24.	Phoenix, AZ	Valley Metro
25.	Portland, OR	Tri-County Metropolitan Transit District of Oregon (TriMet)
26.	Richmond, VA	Greater Richmond Transit Company (GRTC)
27.	San Antonio, TX	VIA Metropolitan Transit
28.	San Diego, CA	San Diego Association of Governments (SANDAG)
29.	St. Cloud, MN	St. Cloud Metropolitan Transit Commission
30.	St. Louis, MO	Metro
31.	Syracuse, NY	CNY Centro, Inc.
32.	Tacoma, WA	Pierce Transit
33.	Tallahassee, FL	Star Metro
34.	Toronto, ON	Toronto Transit Commission
35.	Tucson, AZ	SunTran
36.	Vancouver, BC	Greater Vancouver Transportation Authority (Trans Link)

Abbreviations used without definitions in TRB publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation