Quality Control Guidelines & Procedures

Contents

Introduction

1.1 Motivations

The purpose of the Transit Modeling Update project is to specify, within FSUTMS and associated support systems, the guidelines necessary to improve the preparation and quality of transit forecasts to a point consistent with federal expectations, and to incorporate supporting state of the practice techniques and tools. The focus of this memorandum is on a suggested set of analytical tests and comparisons that can be used as an integral part of the travel forecasting effort. A large portion of these tests pivot from the computation of user benefits generated using the FTA SUMMIT program. These analytical tests and comparisons are a precursor to drawing insights from the forecasts and constructing the Case for the Project.

2 Basic Quality Control Comparisons

Travel forecasting for Alternatives Analysis and New Starts requires some initial, fundamental quality control procedures, focusing on inputs to the model that have primary effects on transit ridership and outputs of the generation, distribution and mode choice model steps. This section focuses primarily on the examination of the changes from the base year to the future year forecasts and it will discuss the appropriate procedures associated with each key input. As a general note, the travel model should be set up to produce the measures discussed below on a regional basis. This allows quality and consistency checks to be made for both individual forecasts as well as for comparative forecasts of base and forecast year model runs. In all cases, the goal of the quality control procedures is to first identify both systematic and non-systematic errors that may arise from flawed input data, errors in model parameters or model application errors. Secondly, these procedures may also identify illogical or sub-optimal alternative specifications that can lead to inconsistent results for future forecasts. These procedures apply most particularly to the No-Build alternative in a New Starts analysis, since it is this alternative that creates the person-trip demand for all other future year build alternatives.

2.1 Land Use and Demographics

Land use and demographic data, usually consisting of population, households and employment by type for each zone, is one of the most basic inputs to the model. This data is usually obtained from locally-adopted comprehensive plans that take into consideration the expected social and economic growth and the capacity for expansion. The goal in the review of this data is to ensure that there are no errors or indefensible or unexplainable changes.

When reviewing these forecasts, the analyst should focus on growth by district and key activity centers, especially within the study corridor, including:

- Central Business District
- Outlying Employment Centers

- Suburban Residential Areas
- Urban Core

Compare the growth rates for these areas for both population and employment.   Region-wide, the growth rates for population employment should be consistent, which implies that the labor force participation rate will be stable.

The analyst should also check for outliers in the data. This includes:

- Zones with very large absolute or relative growth rates
- Zones which show large changes in average household size (based on population/household)
- Zones which change area type, or grow from a zero or negligible base – this may imply changes to assumptions about average income.

The growth in demographics should be documented and may be used as justification of trip growth produced by the model.

2.2 Person-Trip Changes

Person-trips produced by the model can be evaluated in terms of trip generation or distribution.

The trip generation changes from the base to the future year should be consistent with socioeconomic and demographic changes. That is, the rate of change for each should be very similar. Both trip productions and attractions should be examined at the district level to ensure that the growth in person-trips is reasonable. An imbalance between population growth and employment growth can lead to inconsistent growth rates between trip productions and population, or trip attractions and employment as a result of production or attraction normalization.

Other basic checks that should be made include the stability of the following measures over time on a regional basis:

- Trips per person,
- Trips per auto,
- Work Trips per employed resident,
- Work trips per job,
- Trips by purpose.

These measures can also be generated for the study area and major districts within the study areas.

Trip distribution changes from the base to the forecast year should reflect the growth patterns of specific areas with respect to others. For example, if suburban employment growth exceeds that of the CBD, we would expect to see the distribution model show a shift from CBD to Suburban orientation.

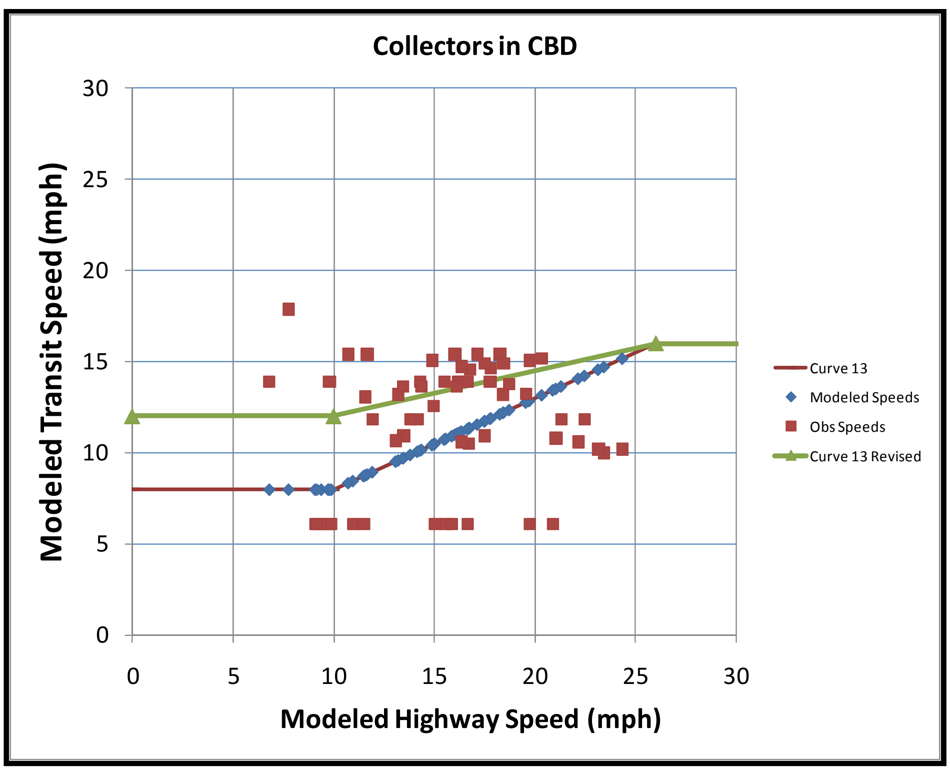
Regional statistics such as average trip length and the trip length distribution by trip purpose should be compared between the base and forecast year. In general, these values should not change radically. In some cases however, they may show valid shifts as growth patterns in the region become more dispersed (implying longer trip lengths) or more concentrated (implying shorter trip lengths).

If large discrepancies are evident in these comparisons, the analyst should examine both the input socioeconomic data for obvious errors and the model procedures. The latter should include checking to make sure both the base and forecast year model runs use the same model parameters, and are run using the same application procedures. An inspection of the data for outliers at the zone and zone interchange level is often very useful in identifying non-systematic errors.

2.3 Transit Travel Times, Transit Trips and Trip Mode Shares

Transit travel times form a key input into the ultimate user benefits for alternatives. As such, it is important to ensure that the base and future year transit travel times are consistent with the anticipated change in congestion levels of the system. Typically, transit travel times for buses in mixed traffic are derived from a transit travel time function which relates transit speeds to model-generated highway congested speeds. Quality control for these functions starts with a validation of the base year model run with observed speeds. Often, Automatic Vehicle Locator, or AVL data is available for transit buses, and this data can be used directly in the model network. From this, the observed and estimated transit speeds can be computed within the model skim processes and compared as a function of model-generated highway speeds. Adjustments to the transit travel time function can then be made to improve the observed and estimated transit speeds. Figure 2-1 shows an example from the OUATS model (Orlando regional model) of a plot of observed and estimated transit speeds as a function of model-estimated highway speeds. It illustrates a revised transit speed function (in green) based on observed transit speed data.

Figure 2-1: Example of Observed and Estimated Transit Speed Values



Forecast transit speeds should reflect changes to congestion on the highway network. Comparison of base and future transit speeds can be done at a variety of levels, including:

- Average link transit speeds by area type and facility type, as well as for the study area
- Average end-to-end transit times by route
- Transit travel time distributions for the overall region as well as to and from key activity centers within the study area
- Graphic representation of transit and highway time changes from the base to the future year using isochrones.

The change in transit trips and associated mode shares can be obtained from a comparison of the mode choice output. Transit trip changes can be the result of:

- Growth in person-trips
- Change in the nature of the travel market (i.e., more transit dependants)
- Changes in transit level of service (i.e., headways and travel times)
- Changes in transit service coverage
- Changes in real values of parking costs, auto operating costs and/or transit fares
- Changes in congestion and delay for autos

With regard to basic quality control procedures, the analyst should look for any large changes in transit trips that cannot be tied to one of the factors above. Evidence such as this may indicate inconsistency in model application, inconsistent mode choice parameters, or simply errors in input data, such as transit accessibility shares. Inconsistency in model application or model parameters will lead to systematic errors, while input data errors will often lead to specific, isolated transit trip demand errors.

Finally, mode shares should be examined not only in terms of overall mode shares, but as shares of eligible or available person-trips. For example, mode choice models for walk-access transit trips typically reduce the total person-trips available for transit by the percent of trips within walking distance of both the production and attraction zone. Therefore, a zone to zone interchange may seem to produce a reasonable mode share of overall trips might actually reveal an extreme mode share of available trips. The mode choice model can easily be updated to produce these statistics, showing mode shares of available trips. Extremely high available trip mode shares often reveal errors in trip distribution which can distort forecasts and complicate model calibration and validation.

3 Standard SUMMIT Outputs

3.1 User Benefit Summary

Table 4 in the User Benefit Analysis Guidance[1] provides the definition of the 80 tables generated by SUMMIT. The person trip values in tables 1-10 and 11-20 should be identical. If not, then the person trip input matrices are not identical and need to be checked. And at least one of the alternatives rerun.

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[1] Task 04, Transit Modeling Update, Technical Memorandum 9, "User Benefit Analysis Guidance", September 2011.

Similarly, the user benefit values contained in tables 51-60 (highway user benefits) and tables 71-80 (trip asymmetry) should also be zero. Given that the No-Build highway level-of-service matrices should be used for all subsequent alternatives (low cost and all build alternatives) highway user benefits should be zero. If the input person trip matrices are identical, not only in aggregate, but at the individual zone level, then both record and trip asymmetry will not be present. If there are record or trip asymmetry benefits (or dis-benefits), then it may also be that the creation of the user benefit file is in error. Or the values contained in the user benefit file have not been measured at the proper level of the model.

Of particular interest in evaluating aggregate benefits is the proportion of transit dependent or low income riders. Standard SUMMIT reporting should include tables and reports for each of the market segments contained in the model. The reporting of transit dependent or low income benefits are required as input to the New Starts templates.

3.2 District Level Deltas

Deltas (between the base and alternative scenario) provide useful insight to the magnitude and geographical distribution of transit trips and user benefits. If the change (either positive or negative) in transit trips and/or user benefits do not occur in expected locations, then more detailed analysis of the source of these unexpected changes in merited. Both SUMMIT and UserbenC provide the tools necessary to conduct these investigations. There is no need for speculation if these tools are used effectively.

3.3 Thematic Mapping of User Benefits

FTA has provided detailed guidance for the generation of user benefit thematic maps[2]. Zonal level maps are created for each trip purpose for both productions and attractions. The pattern of the benefits should be logical, both in terms of magnitude and geographical distribution. Any zones which are red in color (negative user benefits) should be carefully investigated. The presence of negative user benefits may very well be the logical consequence of the physical or operational definition of an alternative, but must be understood and explained. For example, implementation of a new fixed-guideway facility may require some travelers to encounter an additional transfer, and therefore be worse off compared with the base alternative. However, more detailed analysis may reveal that a network coding error has occurred or possibly that the model has responded illogically to a change in level-of-service changes.

3.4 Changes in Transit-Access Opportunities

An important input to the mode choice model is the percent walk values by individual zone. In general, they remain identical for all alternatives. Any differences in individual zone level values need to be based upon explainable changes in accessibility between alternatives. If the Low Cost and Build alternatives are designed appropriately, such differences are not likely to occur. However, the placement of a fixed-guideway station could conceivably improve accessibility for some zones and decrease accessibility for other zones.

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[2] "Reporting Instructions for the Section 5309 New Starts Criteria", August 2011, U.S. Department of Transportation, Federal Transit Administration.

4 Understanding Service Level Changes

Well before the travel model is run for a set of alternatives, analysis of level-of-service changes can provide helpful insight to the likely implications on ridership and user benefits. These tests can be performed with (weighted by) transit demand matrices (either No-Build or alternative) or independent of demand. Performing this analysis prior to running the models may highlight or identify network coding errors or unintended implications of the physical and operational definition of the alternatives.

4.1 Coverage Differences

Coverage in this context refers to the geographic coverage provided by each of the alternatives examined in the study. This is not the same as percent walk values. For example, is there a subset of zones without transit accessibility in only one of the alternatives? Or is the frequency of service offered in one alternative substantially better or worse than in another. If either of these conditions occur, then once again the definition of alternatives and/or network coding needs to be examined.

4.2 Fares

The specification of transit fare levels is a function of policy. As such, there should be no difference in fare structure or assessment levels between alternatives. Under certain circumstances, there could a difference in total fare if the number of transfers or mode use varies between alternatives. An analysis of fares, at a trip interchange level, can identify these differences. Assuming the total fare is correct, when the model is run an estimate of the impact of these fare differences on user benefits should be developed.

4.3 Travel Time Comparisons

Travel time comparisons, for simplicity purposes, can be performed using a single “best” transit path for each production/attraction zone pair. As such, the analysis is independent of the mode choice model structure. Creating a single “best” path simply means setting all in-vehicle weights (for the various modes) equal to 1. Both a weighted and unweighted total transit travel time can be computed for each interchange. A weighed travel time considers the relative influence of each variable on overall “utility” or mobility. A simple example of an equation for computing an unweighted travel time might be:

$$wtt_{i,j} = 1.0 * invtt + 2.5 * ovtt + 0.2 * fare$$

Where:

$wtt_{i,j}$ weighted transit travel time for each production (i) and attraction zone (j)

invtt in-vehicle time

ovtt out-of-vehicle time (which might include wait, wait, etc).

Fare transit fare (in cents)

There are wide variety methods to display the results when comparing weighted and unweighted travel times between alternatives. One of the more common methods is to develop an isochronal map that thematically displays incremental degrees of travel time differences from all zones to an individual zone or from an individual zone to all zones. In addition, frequency distribution plots of the differences, along with means and the standard deviation, is another analysis method.

4.4 Park-and-Ride Service Areas

If different coding rules for creating drive access connectors to transit differ by primary transit mode, illogical ridership and user benefit results can occur. In particular, if the search distant varies by transit mode, such illogical results will definitely occur. Comparing weighted and unweighted travel times for drive access paths will reveal this problem.

4.5 Number of Transfers

Implementation of a fixed-guideway system can often result in increased number of transfers for some segment of travelers. A key question to be understood is the extent to which existing riders might be worse off given the need to make an additional transfer. And to determine if reductions in parallel service, if made, should be reviewed and/or revised. Graphically displaying and summarizing changes in the number of transfers can utilize the same techniques as described in section 4.3.

5 Capped Benefits

If the level of capped benefits exceeds ± 20%, then an investigation into the source of those capped benefits becomes essential. The UserbenC program can be used to identify trip interchanges that exceed a user specified threshold for change in transit price. The FTA standard is 45 minutes. A trace (or detailed) reporting capability within the mode choice can be used to evaluate and identify the source of higher than acceptable user benefits (positive or negative). Typical sources are unexpected values in the transit skim matrices, coding errors, or illogical properties of the mode choice model.

It is conceivable, however, that the source of capped benefits may stem directly from savings in <u>in-vehicle</u> travel time that are in excess of 45 minutes. There are not many corridors where this level of in-vehicle savings is achievable, but in that instance, a case could be made to increase the default 45 minute threshold value to a higher value consistent with the findings of the analysis.

6 Understanding the Source of User Benefits

6.1 Coverage Related

The SUMMIT program considers three basic access markets – walk/drive, drive only, and no transit. When comparing a base and build alternative, SUMMIT summarizes benefits by 10 categories, the combination of the three access markets for each alternative and total. The diagonal of this 3x3 matrix is walk/drive to walk/drive, drive only to drive only, and no transit to no transit. The off-diagonal are cells where benefits (or riders) shift markets between alternatives. If the level of off-diagonal benefits exceeds more than 10% of total benefits, support for this result needs to be developed. As outlined earlier, changes in the percent walk values and/or geographic coverage typically are the source of off-diagonal benefits.

6.2 In-Vehicle Time Contribution

If the low cost and build alternatives have been designed correctly, a majority of benefits will result from improvements in in-vehicle time. If in-vehicle time benefits are not at least 80% of the total, then a logical explanation is required.

6.3 Project Related Benefits

Similar to the contribution of in-vehicle benefits, at least 80% of the project benefits should be in interchanges where the proposed investment is present (used). In most project corridors, this percentage should be very close to 100%. Benefits in interchanges where the project is not present should be investigated to determine if benefits are derived from unexpected sources.

7 User Benefits per Project Trip

One of the most powerful measures used to inform development of the Case for the Project is user benefits per project trip. User benefits per project trip should be market specific, as the value will undoubtedly vary across markets. In the Case for the Project, the sources of those benefits are key to describing the mobility benefits of the project. If within a market the number of user benefits is 30 minutes per project trip, then what components constitute the 30 minutes? It might be, for example, that 20 minutes are in-vehicle time savings, 4 minutes are savings in wait time due to the removal of a transfer, 8 minutes are the contribution of un-included attributes, and there is a loss of 2 minutes due to longer wait times to reach the station. As indicated earlier, if a vast majority of the benefits are not due to in-vehicle time savings, then there may be a question surrounding the definition of the alternatives.

7.1 Defining Project Trips

Computing project trips in the context of a new mode (within a region) is straightforward and can be easily placed into a trip matrix. If the proposed project is an extension of an existing line, then a method will need to be developed, similar to highway selected link analysis, to isolate transit trips which use the project. The mechanics of the method will depend largely upon the software platform and the structure of the mode choice model.

7.2 Project Trip Characteristics

A matrix of project trips can also be used to examine a wide variety of characteristics of those project trips beyond user benefits per trip. For example, how does the average trip length of the project compare with the total length of the project? What does the geographic distribution of projects look like? And does each of these evaluations make sense in the context of the project?

8 Uncertainties

Explicit consideration of uncertainties as part of the travel forecasting process improves the quality of the forecasts, provides additional information for decision makers, and sets the stage for future comparisons of predicted and actual outcomes. The result of an uncertainty analysis is a range of forecasts that have upper and lower bounds and a most likely estimate for both the opening and horizon years. For each specific source of uncertainty, the analysis should consider the underlying basis for the uncertainty, the current forecasting assumption, and describe the alternative outcomes, likelihoods, and implications. Documentation of uncertainty analysis is logically contained in the travel forecasting results report.

8.1 Candidate Sources

There are two fundamental sources for uncertainty analysis, predictions that are inputs to the model and new items beyond the model's experience. Typical categories of model inputs are:

1. Demographics – population, employment, and income levels. With emphasis on the location and magnitude of those changes, particularly within the corridor.
2. Transportation Context – On the highway system, typical inputs would be congestion levels, parking or gasoline prices. For transit, it would be background service levels and possibly fares.
3. Project Related – the physical scope of the project including stations, park-and-ride lots, and degree of grade separation. Or the service plan, including the guideway and integration with bus system levels of service.

Items beyond the model's experience fall into two primary categories:

1. New transit modes and parameters. The introduction of a new transit mode requires assumptions regarding the contribution of un-included attributes as well as possible changes in one or more coefficients on variables. Depending upon the structure and formulation of the mode choice model, nesting coefficients could be impacted as well.
2. New Behaviors. The introduction of a new mode or new service may influence behavior in ways not currently understood by the model. Examples might include attractiveness to choice riders, provision of formal park-and-ride facilities, free-fare riders, or circulation travel on fixed guideways.

8.2 Stepwise Buildup of Forecasts

A stepwise buildup of forecasts seeks to isolate the contribution of key model inputs on ridership and user benefits. The basic dimensions considered in a stepwise buildup of forecasts are:

1. Person Travel
2. Highway Speeds
3. Bus Speeds
4. Transit Network
5. Transit Demand

A stepwise buildup of forecasts can provide helpful insights when comparing the future year No-Build alternative to base year conditions, and when comparing the locally preferred alternative to the low cost alternative.

As the analysis proceeds, it may highlight changes which require more detailed analysis to evaluate and understand. For example, in Honolulu, the contribution of highway service levels over time contributed very little to ridership levels. After careful investigation it became clear that the Regional Long Range plan included over $3 billion dollars in highway investment. This insight leads to part of the uncertainty analysis that evaluated the impact of reduced levels of highway investment on ridership.

8.3 Presentation of Uncertainty Analysis Results

A simple table that summarizes the results of the uncertainty analysis would like the following example from Honolulu:

Summary of Results

- Initial estimate: 87,000 rail trips per day
- Upper bound: 105,000 rail trips per day
- Best estimate: 95,000 rail trips per day
- Lower bound: 80,000 rail trips per day

Upside Uncertainties	Downside Uncertainties
1. Unmeasured attributes	1. Unhappy TSM riders
2. Drive access behavior	2. Rail headways
3. Highway congestion levels	3. 2+ car households bus access
4. West End employment	4. West End employment

Documentation that would accompany this table would describe the details that support the formulation of each uncertainty test, the insights and conclusions drawn from each test, and the corresponding implications on ridership. It all ultimately leads to summarizing ridership in the four categories shown at the top of the table.

The conduct of uncertainty analysis represents a new way of thinking about forecasting. It has a strong direct connection to the real world and offers very valuable insights. It not about model mechanics, but rather is a learning process that has a direct connection to the Case for the Project.