Metropolitan Washington Council of Governments
National Capital Region Transportation Planning Board

Review of FTA Summit Software

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Executive Summary

The Metropolitan Washington Council of Governments, National Capital Region Transportation Planning Board (TPB) engaged Vanasse Hangen Brustlin (VHB) to review the Summit software program developed by the Federal Transit Administration (FTA) and provide guidance on what it is, and how it should be used by MWCOG as part of FTA New Starts Applications in the Washington Metropolitan Area.

Summit is an evolving tool currently used for all New Starts applications. It has become an important part of the planning process. Summit is useful for highlighting shortcomings in the mode choice model, but the process has resulted in little leeway for using different factors in mode choice models. The only real requirement for the model structure is that the mode choice model be an econometric choice model. Summit will not work on expected default coefficients and unless there is data to support different values, a New Starts applicant must use model coefficients and procedures that are consistent with these requirements. Summit has been applied using traditional four-step models as well as state-of-the-art activity-based models. In San Francisco County Summit was recently applied to the results of an activity based model. The application was viewed as a success.

The Summit software program developed by FTA is used to prepare information for evaluation of transit projects that are seeking funding under the New Starts program. Summit results are used as part of the evaluation for New Starts applications. Summit measures the difference in user benefits between different transit alternatives. It compares a baseline to a build alternative, which is usually, but not necessarily, a Transportation Systems Management (TSM) type alternative. The software is basically a matrix manipulation type of application. It focuses on the calculations used in the mode choice model at the traffic analysis zone (TAZ) level and calculates the benefits of the build scenario versus the baseline. It then aggregates this information into user-defined districts for the study area and allows for comparison between the build and baseline alternatives. Districts are generally defined as smaller and denser around the proposed transit project, while in outlying areas they include a larger area.

The objectives of this memo are to:

- Document the structure of Summit.
- Document some applications of Summit.
- Discuss some key factors affecting its successful application.
- Discuss its application in the current TPB forecasting framework.

Summit Structure

Summit currently has a Windows interface, but it was originally written to run in DOS. It can be run through the new Windows interface or via a command prompt. It is a FORTRAN-based program and there are control files the user can update with the necessary input file information and user options.

The input data includes:

- Mode choice model outputs.
- Zone attributes related to accessibility.
- Zone to district equivalence table.
- Control files for execution.

The required mode choice outputs include the logsum of the logit equation used in the model, the in-vehicle time coefficient, and the trip tables. The zone attributes include the type of transit access for each zone. There are three types of access markets for each zone: CW (can walk), MD (must drive), and NT (no transit). Zone-to-zone interchanges are referred to as the access market segmentation. The zone-to-district equivalence table is for aggregating the results. It is similar to the data required for a "data squeeze," which is an aggregation of the zone data. The control file syntax is listed in the user's guide. It designates the location and names of the input files and file prefixes for naming and identification. Most input files must be in a binary format. The Summit user's guide describes the file format and required headers for each file. The zone-to-district equivalence file is a text file, as are the control files.

Summit produces several important outputs. The products of a run are:

- A summary report file.
- User benefits file.
- A trip length file.
- Zone based vector files for geographic information systems (GIS) applications.

The user-benefits file is summed into the user-defined district level. There is also a user-benefits file by zone for productions and attractions. This file is useful for GIS applications. The trip length shows the change in trip length between the baseline and build. It is not overly useful because this data is difficult to interpret in relationship to user benefits. The file details trip length changes while user-benefits are calculated as a measure of time. A spreadsheet program can be used to manipulate and graph the trip length results.

The key Summit output is the table of user benefits. User benefits are a utility expressed in units of time. The development of this measure is based on the concept of consumer surplus. It measures the change in service and the change in price, which is represented as time for this calculation. It is similar to travel time savings but has several key advantages. It is sensitive to changes in both travel times and travel costs, and it recognizes benefits for both existing transit users and new users diverted from other modes. User benefits represent direct transportation

benefits as a single unit of measurement and permits them to be totaled. They reflect an overall measure of transportation benefits in the alternatives evaluation.[1]

Calculate the user benefits by converting the denominator of the logit model to equivalent minutes of in-vehicle time based on the locally determined coefficient. That product is then multiplied by the number of trips for that alternative. The user benefits are then equal to the difference of that product from the baseline alternative. The user benefits are expressed in terms of minutes and reflect all i-j interchanges.

$$\text{User Benefits} = \left(\frac{\text{Price}_{ALT}}{C_{IVT}} \times \text{Trips}_{ALT} \right) - \left(\frac{\text{Price}_{BAS}}{C_{IVT}} \times \text{Trips}_{BAS} \right)$$

Figure 1: Summit User Benefit Equation

$\text{Price}_{ALT} = \ln(\exp(U_{auto}) + \exp(U_{bus}) + \exp(U_{rail}))$ for the build alternative
$\text{Price}_{BAS} = \ln(\exp(U_{auto}) + \exp(U_{bus}) + \exp(U_{rail}))$ for the base alternative
C_{IVT} = coefficient on in-vehicle time
Trips_{ALT} = Trips for each i-j Interchange for the build alternative
Trips_{BAS} = Trips for each i-j Interchange for the base alternative

The user benefits are reported in terms of totals for access market segmentation as well as at the zonal and district levels for both production and attraction ends.

Summit Applications

Summit compares two transit alternatives and computes the change in user benefits for the build alternative versus the base. It allows for a quantitative analysis of transit alternatives and also for comparison of user benefits across different projects to help determine which projects should get FTA New Starts funding. For each project, Summit compares the user benefits from the build alternative to the user benefits from the baseline alternative. The baseline alternative is usually the TSM alternative, but it does not have to be. For New Starts submittals, the baseline alternative must have service coverage similar to the build alternative. For application submittals, the baseline alternative is approved after the submittal. The key difference between the baseline alternative and the build alternative for many New Starts applications is the baseline does not include a fixed guideway system; the build alternative does have a fixed guideway system.

The Summit results will show positive user benefits when the build alternative shows improved travel time. Currently, Summit only looks at transit-related benefits. It does not consider potential highway benefits resulting from a transit alternative. Transit-related highway benefits are not evaluated because of the instability in the application of the equilibrium highway assignment algorithm. This instability is related to issues with using an equilibrium assignment algorithm to reach convergence between iterations. Because of this instability, it is difficult to measure benefits from highway trips shifting modes to transit.

[1] Summit Users Guide, FTA, April 13, 2006, Washington, D.C.

Summit is a very useful tool for identifying coding and path problems with the transit networks. Summit will produce questionable and illogical results when there are problems in the access coding as well as the mode choice coefficients. The GIS plots of the user benefits by TAZ help to show where there are network or service issues. For example, if there is a new Light Rail Transit (LRT) line and zones adjacent to the LRT show negative user benefits, then it is useful to examine why with the new service and access to that specific zone user benefits decreased. In many cases these types of issues relate to the access coding for those zones. It could be that walk access links under the build alternative were not coded. It might be that the zone was previously drive-only access, and under the LRT scenario walk access links were not coded. The drive access under the build alternative then created a longer path than in the baseline. Summit is very good at highlighting these types of issues within the networks. The challenge is to examine those issues and determine what caused them.

Summit does not work well with step functions or cliffs. Cliffs are artificial barriers represented in the model, but which are not so clear in actuality. For example, in some models walk distance is determined to be a specific distance from the transit access node. For zones on the edge of this walk-shed, a change to a fixed guideway could force trips to go from “walk access to a direct bus” to “must drive to a rail station.” Under the baseline alternative, the bus served the neighborhood with greater access, but slower travel times. The new transit service is just slightly farther away, but provides faster service. Summit analysis often highlights these types of cliff issues.

Summit is a very useful tool for analyzing networks and mode choice results. It catches errors that may have been overlooked in the past, but it requires familiarity with the inner workings of the mode choice model. There are issues with the mode choice model that can result in illogical user benefits. When there are multiple modes, the results can be very sensitive to slight changes in service. Summit uses paths for all modes and access markets. Small, unforeseen changes in access can create large changes in the user benefits. An example of this is with commuter rail, which in some models has larger bias coefficients. Changing a path from commuter rail to a new build alternative that might include a bus-to-rail transfer to access the new rail can show negative user benefits. The factoring of perceived time can show a shorter actual path being a longer path.

Figure 2 is a GIS plot of user benefits for a light rail extension project. This type of plot is one of the more useful Summit outputs. Summit produces files with user benefits by zone that can be input as a field into a GIS file. The files have production-end user benefits and attraction-end user benefits by zone. Summit is not GIS software, but reviewing the results using GIS is very useful and it is required for New Starts submission.

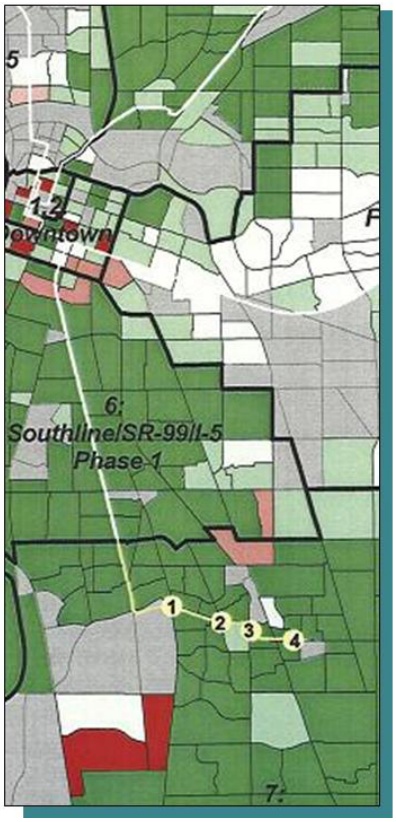

Figure 2: GIS Plot of User Benefits

The project in Figure 2 involves an extension of an existing LRT line by roughly 3 miles and the addition of four new stations. The GIS plot shows the user benefits at the zonal level for home-based work productions. Green shades show a gain in benefits; red shades show a loss in benefits. Review of the results raises some key questions for this application. For the zones to the southwest of the extension, why was there a loss in user benefits? It would be expected that the new service would provide those zones with increased user benefits. What happened is that with the extension of the light rail, under the build alternative, the project sponsor eliminated the express commuter bus service to the downtown area. Zones that previously had direct service to downtown on the commuter bus line now had to transfer to rail. Other corridor zones demonstrating lower gains in user benefits were caused by similar changes in service, as well as coding errors.

Review of these results raised another question about the gain in benefits on the other side of the downtown. These benefits are not likely to be related to the service extension. These benefits were related to the added service on the light rail continuing from the extended line to another existing line north of downtown. These benefits were questioned in the review because service could be increased on similar existing lines without the proposed extension. The analysis in Figure 2 was counting benefits not directly related to the extension being submitted for New Starts. The increase frequency on the other lines did not depend on getting the extension. This is an example of how Summit can be valuable as an analytical tool to identify potential problems with the coding and service being proposed.

These issues highlight the need to ensure user benefits are directly related to the proposed transit investment. The build alternative should not inadvertently reduce service. Figure 2 is a good example of this issue. The problem is common in outlying areas where commuter bus service suffers when new rail service is proposed and the commuter bus service is replaced with feeder service to the station. The new path represents not only a slower path, but also a transfer and additional wait time.

Another Summit output is the summary of user benefit calculations, which is a very useful data table. It can be used to evaluate whether there are any issues in the process and where the benefits are by access market segmentation. The user-benefits table summarizes 50 tables produced by Summit. Tables 1 through 10 show the total trips for the baseline alternative. Tables 11 through 20 show the number of total trips for the build alternative. Tables 21 through 30 show the number of transit trips for the baseline, and Tables 31 through 40 show the number of transit trips for the build alternative. Tables 41 through 50 show the user benefits by access market segmentation. Table 1 is an example summary table:

Table 1: Sample Output from Summit

Summary of User Benefit Calculations

Table	Contents	Conditions	Markets		Total
1	trips	all	BASE	CW-CW	928474 trips
2	trips	all	BASE	CW-MD	0 trips
3	trips	all	BASE	CW-NT	0 trips
4	trips	all	BASE	MD-CW	0 trips
5	trips	all	BASE	MD-MD	1177997 trips
6	trips	all	BASE	MD-NT	0 trips
7	trips	all	BASE	NT-CW	22 trips
8	trips	all	BASE	NT-MD	0 trips
9	trips	all	BASE	NT-NT	2621413 trips
10	trips	all	BASE	TOTAL	4727935 trips
11	trips	all	ALT	CW-CW	928474 trips
12	trips	all	ALT	CW-MD	0 trips
13	trips	all	ALT	CW-NT	0 trips
14	trips	all	ALT	MD-CW	0 trips
15	trips	all	ALT	MD-MD	1177997 trips
16	trips	all	ALT	MD-NT	0 trips
17	trips	all	ALT	NT-CW	22 trips
18	trips	all	ALT	NT-MD	0 trips
19	trips	all	ALT	NT-NT	2621413 trips
20	trips	all	ALT	TOTAL	4727935 trips
21	trips	trn	BASE	CW-CW	260444 trips
22	trips	trn	BASE	CW-MD	0 trips
23	trips	trn	BASE	CW-NT	0 trips
24	trips	trn	BASE	MD-CW	0 trips
25	trips	trn	BASE	MD-MD	61372 trips
26	trips	trn	BASE	MD-NT	0 trips
27	trips	trn	BASE	NT-CW	0 trips
28	trips	trn	BASE	NT-MD	0 trips
29	trips	trn	BASE	NT-NT	0 trips
30	trips	trn	BASE	TOTAL	321816 trips
31	trips	trn	ALT	CW-CW	261477 trips
32	trips	trn	ALT	CW-MD	0 trips
33	trips	trn	ALT	CW-NT	0 trips
34	trips	trn	ALT	MD-CW	0 trips
35	trips	trn	ALT	MD-MD	61439 trips
36	trips	trn	ALT	MD-NT	0 trips
37	trips	trn	ALT	NT-CW	4 trips
38	trips	trn	ALT	NT-MD	0 trips
39	trips	trn	ALT	NT-NT	0 trips
40	trips	trn	ALT	TOTAL	322920 trips
41	userbens	total		CW-CW	90931 minutes
42	userbens	total		CW-MD	0 minutes
43	userbens	total		CW-NT	0 minutes
44	userbens	total		MD-CW	0 minutes
45	userbens	total		MD-MD	2835 minutes
46	userbens	total		MD-NT	0 minutes
47	userbens	total		NT-CW	218 minutes
48	userbens	total		NT-MD	0 minutes
49	userbens	total		NT-NT	0 minutes
50	userbens	total		TOTAL	93983 minutes

It is important to ensure that total number of person trips remains constant. The total number of trips in the build alternative must equal the total trips in the baseline alternative. The build alternative cannot have a different land-use. Land-use assumptions related to transit-oriented development cannot be assumed for the build alternative and excluded in the baseline alternative. A mode shift is expected with the build alternative, because the build alternative should provide better service resulting in a higher mode share over the baseline.

The fifth column of this report shows access market segmentation. The first two letters refer to the access market in the baseline alternative. The second set of letters refers to the access market in the build alternative. Thus in Tables 21 through 30, there can be no trips where the first access market segmentation is NT. For Tables 31 through 40, there can be no trips where the second access market segmentation is NT. If there are trips in these tables, there is a problem with the network or input data. These market segmentations provide information on how the access markets shift between alternatives.

In the previous table, the build alternative moved few trips from one access market segmentation to another. This shows that the baseline alternative provides equal access to the build alternative. Table 37 shows that the build alternative did provide transit access to four new trips. As can be expected, the build alternative did attract most of the new transit trips from the CW-CW access markets.

A review of Tables 41 through 50 shows the total user benefits. In the current software release this is equal to the transit-user benefits because there are no highway-user benefit calculations. Here, the user benefits should correspond to access markets that included trips. The four new trips from the NT-CW access market produced 218 minutes of user benefits, but most of the benefits came from the CW-CW access market segmentation. This report came from an analysis of a transitway for a relatively high-density urban setting. Therefore, it is expected to show large increases in the CW-CW market. If it was a commuter rail alternative, then changes in the MD-MD might show the highest benefits. In reviewing the user-benefit results, it helps to have a good understanding of what type of system is being tested and what the expected access market segmentation benefits might be.

When examining where user benefits occur, it is useful to look at the zonal level GIS plots and review the district-to-district tables. These tables provide, at an aggregate level, the user benefits by purpose for production and attraction ends, and they can help identify potential problems related to network errors or service deficiencies. They are useful in conjunction with the GIS data.

Good Practice - Key Factors Affecting Successful Application

Summit is a useful tool for many reasons, but if a mode choice model does not fit the parameters expected by FTA, then the modeler needs to supply supporting data to FTA showing why the model is designed and calibrated a certain way. FTA will review model assumption or calibration parameters and may accept them when there is adequate supporting data.

There are key factors to emphasize in FTA’s reviews of Summit runs:

- Consistency between alternatives is very important. The access and coverage of the build alternative must be matched with the baseline alternative. If this is not so, then questions will be raised when the access market segmentation is reviewed.

- The trip tables must be consistent. The number of trips cannot change between the baseline and build alternative. Trips can shift modes, but the total number of trips can not change.

- Land use has to be held constant. Project sponsors or others may use Summit to test differences in land use, but FTA evaluations are based on consistent land use.

Because the trip tables must be held constant, the final trip table from the trip distribution should reflect the build alternative and any proposed highway improvements that would complement the system (e.g., direct access ramps into stations, etc.). The productions and attractions for zone pairs cannot change, but the mode shares for each interchange can shift. It is beneficial to use the trip table that best reflects the build alternative in the Summit-based analysis.

The in-vehicle time coefficients for all modes must be the same in path building. There cannot be different coefficients for highway modes and rail modes. The weighted time, including wait time, access time, and in-vehicle time, must be the same for all modes. This also includes any transfer penalties. The access-sheds for rail and bus must be the same. Rail cannot have a longer walk access than bus – unless, as stated above, the engineer or planner responsible for the model has data to support it.

The transit coding and networks should be clean. There should be equivalent access points in both the build and baseline alternatives. Summit will quickly identify issues with coding. Therefore, to save cost, debug those issues at the start of the modeling.

Applications in the Current TPB Framework

TPB's current mode choice model (sequential multinomial logit) could be used with Summit, although it could be a challenge to get the results accepted. The current mode choice model does not have different transit modes, and it only develops shares for transit, auto, and high-occupancy vehicles (HOVs). The model does have access-market segmentation, although there is a problem with the different walk-sheds for rail and bus. The sheds would have to be changed to be equal. The mode-specific weighted times for path building would have to be consistent. Bus and rail can not have different weighted times for in-vehicle or out-vehicle components. Currently there is an adjustment to bus in-vehicle time, which is based on a static set of factors that are designed to reflect the effect of congestion. However the relationship of these factors to the highway skims is not clear, and they could be construed as weights for in-vehicle bus time. Also, the current mode choice model would have to produce the output files required for input to Summit. The required file format is outlined in the Summit User's Guide and could be easily added to the mode choice executable.

The current approach for using the MWCOG model for New Starts projects is to apply a post-process mode choice model, as shown in Figure 3. The current model applied in this post-process has been used for Summit submissions. This model provides a nested-logit structure for different transit modes, although Summit does not require a nested-logit structure to be executed. Summit can work with a multinomial logit structure. The important element in the post-process mode choice model is the representation of different transit modes in the transit nest and the output of the required input data for Summit.

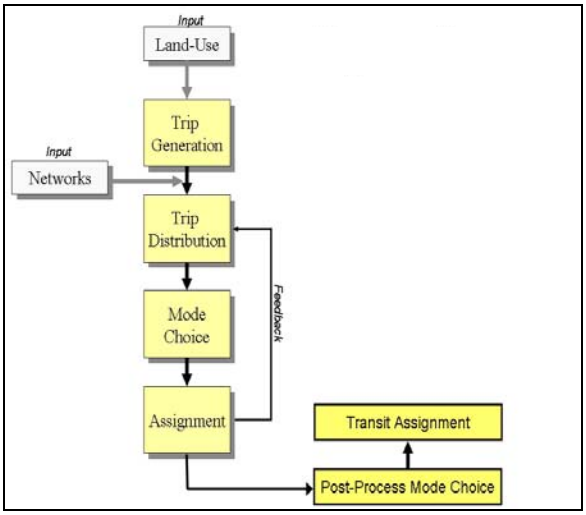

Figure 3: TPB Approach for New Starts Forecasts

An issue with the post-process mode choice approach is the lack of any feedback into the model chain. By taking the initial mode choice results and applying another mode choice model after the highway assignment is completed, there is no reflection of mode shifts given the new transit service. There may not be a significant impact on LOV trips, but if the build transit service competes with HOV facilities, then there could be a significant impact on HOV with a shift of HOV trips to transit modes. This mode shift is not addressed with the post-process application of the mode choice model.

A potentially greater issue is the interaction of the transit system with the model chain. By redoing the mode choice as a post-process after the model is completed, problems in the model chain can be overlooked until Summit identifies them. As the mode choice is a post-process, the user trying to fix a problem related to an earlier step in the model chain will not address the real issue. An example of this is when transit times are not given the proper weight for individual interchanges in the trip distribution model. In this case a potential transit trip interchange from a suburb to a downtown CBD would not be identified as a potential transit interchange. This is a trip distribution problem that cannot be addressed by changing mode coefficients and bias constants in the post-process mode choice model in order to achieve reasonable simulated to observed transit boardings.

The easy solution to these issues is to include the post-mode choice model in the model chain, which TPB is currently attempting to accomplish. The post-process mode choice model is currently not developed for the region, but it has been applied for localized areas within the boundaries of the regional model. The post-mode choice model needs to be refined and

calibrated for the region before it is applied as part of the regional travel demand model. This can be a very challenging task. Having a post-process mode choice model is essentially rearranging the four-step sequential process, and the benefit of doing this is questionable. It may be a stopgap measure, but the correct action for TPB is to incorporate a better mode choice model in the four-step process. As they review and calibrate the new mode choice model, staff should note the items identified in the "Good Practice" section of this memo.

Summary

Summit is an evolving tool currently used for all New Starts applications. It has become an important part of the planning process. Summit is useful for highlighting shortcomings in the mode choice model, but the process has resulted in little leeway for using different factors in mode choice models. The only real requirement for the model structure is that the mode choice model be an econometric choice model. Summit will not work on expected default coefficients and unless there is data to support different values, a New Starts applicant must use model coefficients and procedures that are consistent with these requirements. Summit has been applied using traditional four-step models as well as state-of-the-art activity-based models. In San Francisco County Summit was recently applied to the results of an activity based model. The application was viewed as a success.