The Travel Model Improvement Program

Summary Report

Dixie Metropolitan Planning Organization

Travel Demand Model Peer Review

Washington County, Utah
May 2009

Helping Agencies Improve Their Planning Analysis Techniques

TMIP
Travel Model Improvement Program

DISCLAIMER

The views expressed in this document do not represent the opinions of FHWA and do not constitute an endorsement, recommendation or specification by FHWA. The document is based solely on the discussions that took place during the peer review sessions and supporting technical documentation provided by the peer review host agency.

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Introduction

Report Purpose

A travel demand model peer review is conducted at the request of the agency hosting the peer review panel as a means of soliciting:

- External guidance on addressing identified issues
- The identification of possible model deficiencies
- Recommendations for potential model enhancements
- Experienced advice on model development and application

Moreover, as noted on the Travel Model Improvement Program (TMIP) website, "few individuals have had the opportunity to develop and apply more than one travel demand forecasting procedure. No individual can foresee all the issues that may arise in developing or applying a new model set. One approach to improving travel forecasting procedures has been the use of Peer Review Panels. These panels, composed of individuals who have "hands-on" experience with both developing and applying travel forecasting models, assist local agency staff in both identifying possible problems and in developing workable solutions".

After a peer review panel meeting has been conducted a summary report is prepared that documents the panel's findings, recommendations and suggested course of action. While this is the primary purpose of the report, a secondary purpose is equally valuable; that being to delineate the identified issues and workable solutions as a means of providing modeling practitioners concepts and approaches to consider for incorporation into their own model set. Ideally it should offer new perspectives to question our standard assumptions regarding model development.

Report Structure

To facilitate assessing whether any noted recommendation is worth implementing, the peer review summary report does not extensively document the reviewed model's current structure. Instead, a brief summary of the model component is offered to merely place the topic of discussion in context. The majority of discussion for a given topic will focus on summarizing the technical issue, its significance, and providing context for the recommended approach or solution. Thus, each topic of discussion will be structured as follows:

- Model Component
    - Issue Synopsis
    - Overview of Existing Model Structure
    - Issue Significance
    - Panel Recommendation

For the reader that desires a more comprehensive review of the existing model, Appendix A, Dixie MPO Model Documentation, lists relevant references that can be acquired.

Peer Review Panel Meeting and Recommendations

This report, *Summary Report Dixie Metropolitan Planning Organization Travel Demand Model Peer Review*, documents the travel demand model peer review panel meeting held at the Country Inn and Suites Hotel in Salt Lake City, Utah on August 26th and 27th of 2008. The two-day peer review panel meeting was held as part of the TMIP that is sponsored by the Federal Highway Administration (FHWA). The peer review panel consisted of four travel demand modeling experts (ref. Appendix B, List of Peer Review Panel Participants, for list of panel members and meeting participants).

Appendix C, Peer Review Panel Meeting Agenda, provides the meeting agenda. The meeting began with Utah Department of Transportation (UDOT) staff and Dixie Metropolitan Planning Organization (CMPO) staff presentations on existing model

structure and proposed model improvements. Peer review panel discussion was based on questions and answers occurring throughout staff presentations as well as model documentation provided prior to the meeting and a pre-defined set of goals provided at the inception of the meeting.

Apart from a brief model overview, the majority of this report summarizes the findings and recommendations of the peer review panel. Prior to discussing the identified issues and recommendations it should be noted that the Peer Review Panel was appreciative and complimentary of the effort involved in developing and calibrating the Dixie MPO travel demand model. Panel members commended Dixie MPO staff and their consultants for their responsiveness and openness in establishing the current travel model status.

Structuring the peer review panel report to primarily focus on issues and recommendations may leave one with an impression that the model was not entirely sound; that is not the case nor is it the intent of this report. Rather, it is assumed that the typical reader is more interested in identified issues and model nuances that required thoughtful consideration and that more can be learned from discussing aspects of a model with potential for enhancement as opposed to reviewing existing model structure and what works. To that end, Dixie MPO staff have been gracious enough to openly share their model's inner workings. Following the model overview the remainder of the report documents the identified issues and peer review panel recommendations.

Model Overview

This section of the report offers a brief overview of the Dixie Metropolitan Planning Organization (DMPO) model components to provide some context for the discussion comprising the remainder of the report.

The original Dixie MPO model was developed in 1994. In 2002 the model was calibrated to the year 2000 based on 2000 Census data. The model was subsequently updated and validated to 2007 conditions and a 2030 forecast application has been developed. The DMPO model is a Quick Response System II version 7 (QRS II) based three-step model (trip generation, trip distribution and trip assignment) used to predict average weekday traffic volumes.

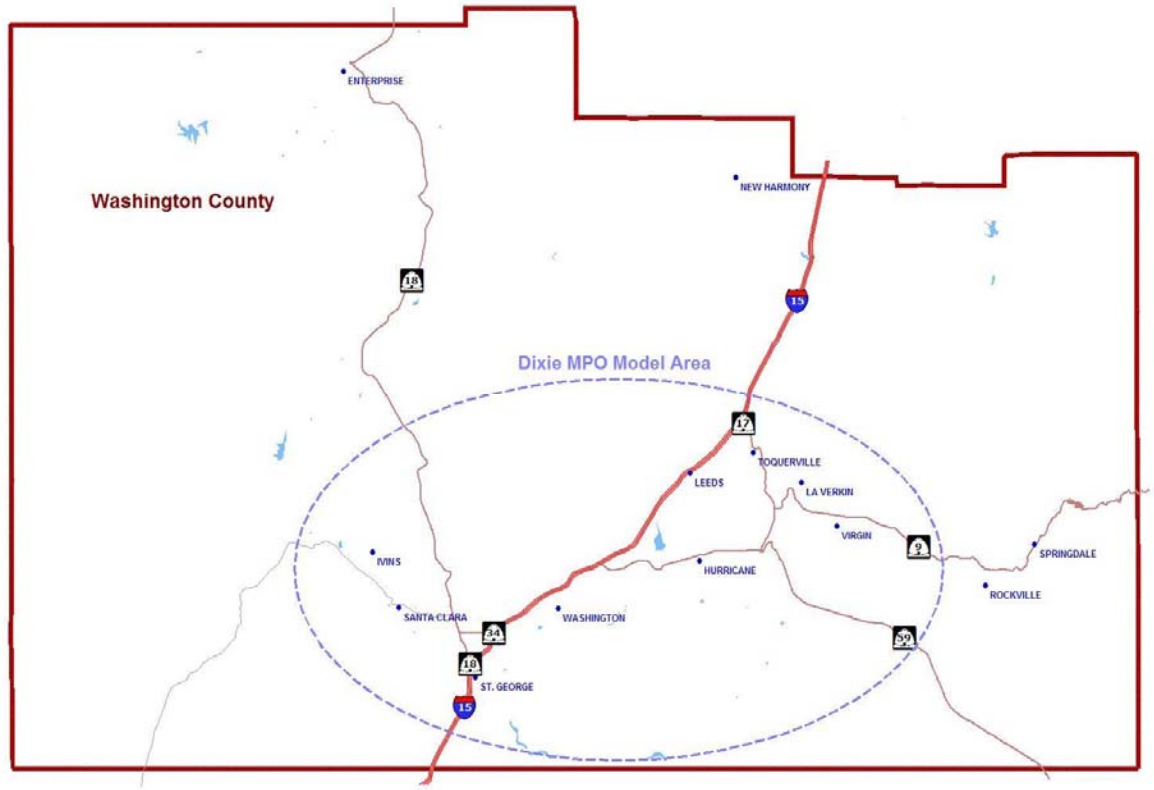
Study Area

In 1994 the Dixie study area was limited to the St. George, Utah area. In 2005 the model area was expanded to include Hurricane, Utah and surrounding areas, and resulted in the combined Washington County model. The Dixie MPO study area encompasses the southern central portion of Washington County (ref. Figure 1) which is located in south western Utah along the Utah-Nevada and Utah-Arizona state borders. There are several urban areas within the study area, the largest being St. George, Utah. The study area is divided into approximately 500 traffic analysis zones (TAZs). In addition there are eight external TAZs.

Data

Traffic Counts
A number of counts were collected to supplement the UDOT average daily traffic (ADT) counts and to support model validation. The 2007 counts that were collected included 40 count sites located throughout the Dixie MPO study area in addition to screenline and cordon area counts.

Figure 1 – Dixie MPO Study Area



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Demographics

The primary demographic data inputs to the DMPO model are dwelling units, referred to as households, and employment data. The 2007 household estimates were estimated based on 2000 Census figures and aerial photography. The base year employment estimates were derived using Utah Department of Workforce Services (DWS) employment data.

Base year 2007 household and employment estimates were 35,313 and 45,066 respectively. By the year 2030 the number of households is expected to increase approximately 237 percent, to 119,212. Total employment increases approximately 120 percent to 99,108 for 2030. Estimates for the two years are provided in Table 1 – Household Data for 2000, 2007 and 2030 and Table 2 – Employment Data for 2000, 2007 and 2030.

Networks

Highway Network

The 2007 base year model network is comprised of all facilities functionally classified as collector and above. The original St. George network used posted speeds as initial network link speeds and applied peak hour capacities based on a saturation flow rate of 1800 vehicles per lane per hour. The Dixie model documentation does not specify the speeds and capacities that are used in the expanded combined Washington County model.

Table 1 – Household Data for 2000, 2007 and 2030

Jurisdiction	2000	2007	2030
Hurricane	2,762	4,148	12,301
Ivins	1,435	2,042	6,525
La Verkin	1,053	1,194	4,155
Leeds	207	283	2,468
Santa Clara	1,225	1,850	6,824
St. George	17,367	19,219	74,201
Toquerville	282	446	1,439
Washington	2,614	6,131	11,299
Total	26,945	35,313	119,212

Source: Handout provided by Dixie MPO at Peer Review Panel Meeting

Table 2 – Employment Data for 2000, 2007 and 2030

Jurisdiction	2000	2007	2030
Hurricane	2,623	4,046	7,601
Ivins	526	890	918
La Verkin	243	765	1,220
Leeds	N/A	181	853
Santa Clara	294	2,462	2,900
St. George	22,497	31,431	70,803
Toquerville	N/A	49	1,087
Washington	1,864	5,242	13,726
Total	28,047	45,066	99,108

Source: Handout provided by Dixie MPO at Peer Review Panel Meeting

Transit Network
A local transit system comprised of four routes exists in St. George; however, a transit network was not coded for the Dixie MPO model.

Trip Generation

Zonal person trip productions are estimated using trip production rates cross-classified by income and household size. Production rates are stratified by nine household sizes (1 to 5+ in half increments; e.g. 1, 1.5, 2, 2.5) and 13 income categories ($0 to $65,000). The trip production rates have been carried over from the year 2000 St. George calibrated model.

Documentation for the trip attraction models was not available; however, it was noted that extensive use of special generators were employed in the Dixie QRS II model.

There are three internal trip purposes:

- Home Based Work (HBW)
- Home Based Non-Work Related (HBNW)
- Non-Home Based (NHB)

And one external trip purpose:

- External-internal (EI)

Travel between external stations (i.e. external-external trips) is not accounted for in the model.

For all trip purposes, trip attractions are scaled to equal trip productions.

Trip Distribution

The trip distribution model is a gravity model. Friction factors are derived using an exponential function. Modeled trip lengths are compared to national averages derived from Census and National Home Transportation Study (NHTS) data to assess trip distribution model performance. Based on graphical comparisons, trip length frequency distributions generally matched national averages.

The trip distribution model was calibrated for all three internal trip purposes: HBW, HBNW and NHB. It is not evident from the model documentation whether travel times or distance measured in miles is used as the impedance measure in the trip distribution model.

Mode Choice

A mode choice model is not included in the Dixie model chain.

Person trips are converted to vehicle trips using auto occupancy factors indicated in Table 3, Auto Occupancy Factors.

Table 3 – Auto Occupancy Factors

Trip Purpose	Auto Occupancy Factor
HBW	1.1
HBNW	1.5
NHB	1.5

Source: InterPlan Co. "The Dixie Model Validation", July 2007

Trip Assignment

A daily 24-hour assignment is applied. The 24-hour assignment procedure uses the QRS II default all-or-nothing assignment process. Assignment results were compared to the 40 count sites located throughout the Dixie MPO study area in addition to the screenline and cordon area counts that were available.

Issues and Recommendations

The Issues and Recommendations chapter concentrates on examining each of the technical issues that arose during the peer review meeting, its significance, and providing context for the peer review panel's recommendations.

TAZ and Network Structure

TAZ Structure

Issue Synopsis
The TAZ structure is incompatible with the network and Census tract boundaries.

Overview
There are a number of network and TAZ coding issues that were highlighted during the MPO's overview of the model structure. Several of the problems seem to have arisen during the expansion of the St. George model to incorporate Hurricane and other surrounding communities and are attributed to different model developers having worked on the expansion of the model. The issues noted include the following:

- TAZs are not compatible with Census tracts
- TAZs are defined inconsistently across the region
- TAZs are incompatible with the network structure

Issue Significance
TAZ incompatibility issues with Census tracts make it more challenging to summarize Census data at the TAZ level and to compare and contrast TAZ population and household data to comparable Census data.

Inconsistent TAZ definitions can lead to varying TAZ sizes and TAZs that are not compatible with the network.

TAZs that are incompatible with the network tend to impede proper loading of trips on to the network.

Panel Recommendation
The peer review panel recommended that the TAZ structure be revised and updated.

Network Structure

Issue Synopsis
There are network coding errors and incompatibilities between the network and TAZ structure.

Overview
The DMPO network is comprised of all facilities functionally classified as collector and above. One of the Dixie model strengths noted during the panel peer review was the coding and use of delay at network nodes. Unfortunately it was also noted that intersection delay was improperly coded at a number of intersections, predominantly in the Hurricane portion of the region.

The DMPO expressed concerns regarding the accuracy and quality of the regional network. A notable issue is that over the years the network has been developed and coded by several firms with minimal MPO oversight. Additional network issues mentioned included network coding errors, such as incorrect number of lanes and inaccurate location of network facilities. In addition the network editing process was characterized as rather cumbersome.

Issue Significance
Accurate network distance, speeds and resulting travel times are an important foundation for appropriate trip distribution and trip assignment results.

Panel Recommendation
The peer review panel recommended that the network be revised and corrected.

Travel Survey Data

Data Availability and Application

Issue Synopsis
There is a lack of travel survey data to support local model estimation and model calibration and validation.

Overview
The peer review panel noted that some of the MPO model strengths lie in their data collection effort. For example, the MPO has instituted a respectable traffic data collection program. In addition aerial photography and suitable employment data are available to support the development of the trip generation model. Nevertheless, during the course of the peer review it was also noted that available data appears to not have been utilized to its fullest extent due to data management issues. For example, data from travel time studies that were conducted do not appear to have supported the development of network speeds or to have been utilized to assess the validity of network travel times.

A more pressing issue was the lack of available household survey data to support the development of the DMPO model. Currently national default values are applied in the trip generation and trip distribution models.

Issue Significance
The unavailability of household survey data and the use of national default values may impede or hinder the development of a sound and defensible model. For example, if the base year trip assignment model is over-assigned compared to observed counts and vehicle miles traveled (VMT) it cannot be properly attributed to trip generation or trip distribution issues without having relevant household survey data to evaluate model inputs and outputs.

Panel Recommendation
Given the importance of adequate data, the peer review panel recommended that the Dixie MPO develop and outline a data collection program to support model development. The panel also recommended that the MPO better utilize existing collected data.

A long-term recommendation is that the DMPO initiate a home interview survey when adequate financial resources are available.

Trip Generation

Trip Production Models

Issue Synopsis
The trip production models are not reflective of local conditions.

Overview
As noted previously, zonal person trip productions are estimated using trip production rates cross-classified by income and household size. The trip production rates are originally based on rates from the National Cooperative Highway Research Program 365 Report (NCHRP 365), *Travel Estimation Techniques for Urban Planning*, and have been carried over from the year 2000 St. George calibrated model. Since the production trip rates are borrowed rates, one of the primary concerns expressed by the DMPO was that the trip rates do not reflect local demographics; principally, the number of retirement communities as well as the amount of second home ownership within the urban area. The main issue cited by the peer review panel was that instead of households, dwelling units inventoried from aerial photography and treated as households were used to estimate the number of trip productions.

Two other issues regarding the trip production model were noted by the peer review panel as well:

- 2000 census income was deflated to 1990 income
- Person trip rates and vehicle trip rates appeared to be intermixed

Issue Significance
The person trip production models are actually structured to use households instead of dwelling units. Households rather than dwelling units are typically used as a production variable since a number of dwelling units may actually be vacant depending on the vacancy rate for a given urban area. By substituting dwelling units for households in the application of trip production rates the estimate of person trip productions by trip purpose may be inadvertently over estimated and consequently yielding higher vehicle miles traveled (VMT) than observed conditions indicate. This issue is further underscored by the amount of second home ownership that occurs in the DMPO urban area.

Panel Recommendation
The panel recommended that households instead of dwelling units be used in the trip production models.

Trip Attraction Models

Issue Synopsis
There is an over-reliance on special generators to estimate zonal attractions by trip purpose.

Overview
The DMPO model documentation does not address trip attraction models and consequently does not specify the trip attraction rates that were applied or indicate how trip attraction rates were derived. The model documentation does note however that the DMPO trip generation model has used special generators extensively. For example, all local schools and post offices have been treated as special generators. Though estimated trips for special generators are based on the Institute of Transportation Engineers (ITE) *Trip Generation* manual, it was noted during peer review panel discussions that the development of trip estimates for special generators were not treated in a coherent fashion.

Issue Significance
As is standard with many urban models, the DMPO model scales trip attractions to equal trip productions. If a large number of employer sites are treated as special generators however, fewer overall trip attractions by trip purpose are scaled if special generator trips are held constant. Thus for a given trip purpose, depending on whether trip productions exceed trip attractions or vice versa, the non-special generator attractions may not be scaled up or down enough such that the final scaled attractions are representative of the amount of travel that occurs at their respective employment sites since a substantial number of attractions have already been allocated to the special generators. As the peer review panel noted, trips to commuter markets are independent of the magnitude of resulting attractions so the scaling of attractions is an issue of concern.

Panel Recommendation
The panel recommended removing some of the special generators and returning the relevant employment data to the land use files.

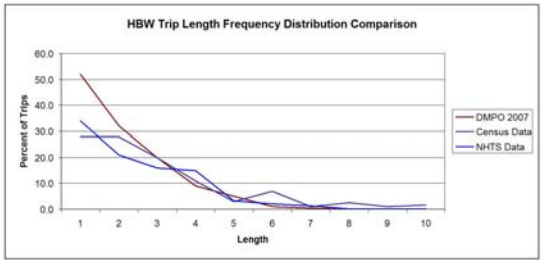
Trip Distribution

Model Validation

Issue Synopsis
Lack of observed data hinders trip distribution model calibration and validation.

Overview
In the absence of home interview survey data, the Dixie MPO does not have the available data to derive trip length frequency data and average trip lengths by trip purpose to support trip distribution model calibration and validation. The existing model derives friction factors using an exponential function and resulting trip length frequencies by trip purpose are graphically compared to national average trip length frequency distributions as illustrated in Figure 2 – Trip Length Frequencies. Resulting model average trip lengths by trip purpose do not appear to be assessed to ascertain their validity.

Figure 2 - Trip Length Frequencies



Source: InterPlan Co. "The Dixie Model Validation", July 2007

Issue Significance
Friction factors represent the propensity to travel between zone pairs based on the impedance between zone pairs expressed in time. Trip length frequency distributions and average trip lengths are key indicators as to how well the trip distribution model is performing and replicating observed travel conditions. Consequently, it becomes rather challenging to determine whether trip distribution model results are reasonable when applying friction factors and not having available relevant survey data.

In the absence of observed data from home interview surveys the only data available to assess the validity of the trip distribution model is Census journey to work data; however, it is limited to evaluating home-based work trip purpose district to district flows.

Panel Recommendation
The peer review panel recommended comparing home-based work model results to Census Transportation Planning Package (CTPP) flow tables.

Trip Assignment

Trip Assignment Model Adjustments

Issue Synopsis
Adjustments in assignment process overcompensate for upstream model uncertainties.

Overview
A daily 24-hour assignment is applied. The 24-hour assignment procedure uses the QRS II default all-or-nothing assignment process. Consequently, from an assignment perspective, link capacities are irrelevant. The network coding errors mentioned previously have made it difficult to calibrate network speed and capacity look-up tables. To improve trip assignment model results, ad hoc adjustments have been made on a link by link basis. These network or assignment modifications have included individual link speed adjustments and factoring of link assigned volumes.

Issue Significance
Correcting an apparent model deficiency without investigating the underlying cause does not necessarily improve the overall model structure or model defensibility. In this instance, it appears that for some network links the model was yielding assigned volumes that varied significantly from available traffic count data. The approach taken to correct the problem was to reduce network speeds and factor link assigned volumes.

While the corrective action taken may have improved model results from a model validation perspective, the inherent problem continues to exist and will be carried forward in future year model applications where the impact of correction factors may be less well understood.

Panel Recommendation
The peer review panel recommended that the MPO consider using an equilibrium assignment process. The panel also recommended that network speeds and capacities be reevaluated and that the MPO eliminate speed adjustments and the factoring of link level volumes.

Additional Recommendations

In addition to the recommendations noted above the peer review panel also offered the following observations and comments.

Future Model Development and Administration

It was suggested that for all future model development and applications that the MPO ensure consultant delivery of all required products including the following:

- Model users manual
- Model calibration report
- Model estimation data set
- Control mechanism for usage

The panel noted that a dedicated staff person should be available to run the model and that access to an up-to-date computing environment be provided. The Dixie MPO does not currently have staff available to run the travel demand model. As a result, the DMPO is reliant on consulting firms to develop, update and apply their travel model. In addition to being without in-house modeling resources, the DMPO lacks the needed resources and expertise to evaluate modeling results and products provided by consultant firms.

Model Software Application

A brief discussion was held regarding whether QRS-II features have been used to their fullest extent by the MPO. For example, QRS-II offers an equilibrium assignment procedure yet all-or-nothing assignments were typically applied by the DMPO. The peer review panel recommended that the DMPO fully investigate the use of the QRS-II software.

It was also noted that the current model has limited regional forecasting capabilities and a long-term recommendation was for the DMPO to consider adopting a software platform consistent with the rest of the state of Utah.

Long-term Model Recommendations

The peer review panel pointed out that the DMPO urban area is too large and growing too fast to continue relying on national default values for model development. In conjunction with the long term recommendation of initiating a home interview survey, the peer review panel recommended that the Dixie MPO consider developing a locally estimated model based on data specific to the urban area. A follow-on recommendation was that the MPO should establish model calibration and validation guidelines based on a survey of peer agencies.

A final long-term recommendation was that the DMPO consider the use of the Utah statewide model as a source of data for addressing model data deficiencies. The existing travel demand model does not account for truck trips in the urban area and the Utah statewide model freight and commodity flow movements could support the development of a truck trip purpose. Likewise, inadequate treatment of external-internal trips and the lack of external-external trip movements were cited as an issue and data extrapolated from the statewide model could also assist in improving the function of those trip purposes.

Appendix A

Dixie MPO Model Documentation

1. InterPlan Co. “The Dixie Model Validation”, July 2007.

2. Project Engineering Consultants, Ltd. “St. George Area QRS II Travel Demand Forecasting Model Year 2000 Calibration and Validation Report”, June 2003.

Appendix B

List of Peer Review Panel Participants

Peer Review Panel Members:

Name	Affiliation
MaryAnn Waldinger	Community Planning Association (COMPASS)
Guy Rousseau	Atlanta Regional Commission (ARC)
Mick Crandall	Utah Transit Authority (UTA)
Eric Pihl	Federal Highway Administration (FHWA) Resource Center

Supporting Staff to Peer Review Panel Members:

Name	Affiliation
Phillip Reeder	Texas Transportation Institute (TTI)

Local Agency Staff:

Name	Affiliation
Walt Steinvorth	Utah Department of Transportation
Jeff Gilbert	Cache Metropolitan Planning Organization (CMPO)
Tim Boschert	Utah Department of Transportation
Curt Hutchings	Dixie Metropolitan Planning Organization (DMPO)
Lowell Elmer	Dixie Metropolitan Planning Organization (DMPO)
Kelly Lund	Federal Highway Administration
Stephen Law	Resource Systems Group, Inc.
Chad Worthen	Resource Systems Group, Inc.
John Lobb	Resource Systems Group, Inc.
Ivan Hooper	Resource Systems Group, Inc.
Matt Riffkin	Interplan
Michael R. Brown	WCEC Engineers, Inc.

Appendix C

Peer Review Panel Meeting Agenda

Travel Model Improvement Program (TMIP)
Cache MPO – Logan, UT and Dixie MPO, St. George, UT

August 26- 27, 2008
UDOT Region Two, 2010 South 2760 West Salt Lake City, UT 84104
Hurley Conference Room

AGENDA

August 26, 2008

I. Welcome / Introductions	Steinvorth	8:00 - 8:20 a.m.

TMIP participant introductions
Panel Introductions

- MaryAnn Waldinger, Community Planning Association (COMPASS)
- Mick Crandall, Utah Transit Authority (UTA)
- Guy Rousseau, Atlanta Regional Commission (ARC)
- Eric Pihl, Federal Highway Administration (FHWA)

II. Organization Structure / Model history	CMPO - Jeff Gilbert DMPO – Lowell Elmer	8:20 - 9:00 a.m.
III. Peer Review Key Objectives	Steinvorth / Panel	9:00 - 9:45 a.m.

- Model Uses
  - LRP / TIP Development
  - Infrastructure Growth
  - Air Quality / SIP
  - Project Analysis / NEPA
  - other

Break 9:45 - 10:00 a.m.

IV. Travel Demand Model Investigation	(CMPO)	10:00-12:00 p.m.

- Study Area
- Network Development
- Data Inputs and structure (demographics)
- Trip Generation / Trip Purpose
- Trip Distribution
- Mode Choice

Lunch		12:00-1:00 p.m.
V. Travel Demand Model Investigation ❖ Trip Assignment ❖ Daily / Peak Hour ❖ Transit Assignment/ other	(CMPO) continued	1:00 - 2:30 p.m.
Break		2:30 - 2:45 p.m.
VI. Travel Demand Model Investigation ❖ Study Area ❖ Network Development ❖ Data Inputs and structure (demographics) ❖ Trip Generation / Trip Purpose ❖ Trip Distribution ❖ Mode Choice	(DMPO)	3:00 - 5:00 p.m.

Adjourn 5:00 p.m.

<u>August 27, 2008</u>

Welcome Day Two		8:00 - 8:30 a.m.
VII. Travel Demand Model Investigation ❖ Trip Assignment ❖ Daily / Peak Hour ❖ Transit Assignment/ other	(DMPO) continued	8:30 - 10:30 a.m.
Break		10:30 - 10:45 a.m.
VIII. Current Model and Future Enhancements	(CMPO & DMPO)	10:45 - 12:00 p.m.
Lunch		12:00 - 1:00 p.m.
IX. Question and Answer – follow up ideas	(CMPO & DMPO)	12:00 - 1:00 p.m.

(Lunch work session to address any additional questions or discussion items from the current and previous day's information.)

X. PANEL CAUCUS – (PANELISTS ONLY)	1:00 - 3:00 p.m.
XI. PANEL REPORT AND DISCUSSION CMPO 3:00-4:00 p.m. DMPO 4:00-5:00 p.m.	3:00 - 5:00 p.m.
XII. WRAP-UP	5:00 p.m.

Dress is business casual