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On Comparing Aggregate Trip-Based and Disaggregate Tour-Based Travel Demand Models

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Introduction

In October 2001, the Mid-Ohio Regional Planning Commission (MORPC) contracted PB to develop a new set of regional travel forecasting models. The new model is a disaggregate tour-based model applied with the microsimulation of each individual household, person or tour, mostly using Monte Carlo realization of each possibility estimated by the models, with use of a random number series to determine which possibility is chosen for that record.

The new model is composed of nine separate models that are linked and applied sequentially. In order, these nine models are: Population Synthesis, Auto Ownership, Daily Activity Pattern (mandatory tour generation), Joint Tour Generation, Individual Non-Mandatory Tour Generation, Tour Destination Choice utilizing period level travel skims, Time of Day (TOD) Choice, Tour Mode Choice, and finally, Stops and Trip Mode Choice. Assignments are made at the period level (AM, Mid-day, PM, Night), and 2 feedback iterations are performed. Tours are synthesized by hour. This model was estimated from a 1993 Transit On-Board Survey, a 1995 External Cordon Survey and a 1999 Household Survey. (See Anderson et al for more information.)

In contrast, MORPC's prior aggregate trip-based model was comprised of the standard four steps: Trip Generation, Trip Distribution, Modal Choice, and Traffic Assignment. The Trip Generation model was performed on a 24-hour basis with a cross-classification model with 4 vehicle ownership categories. Trip Distribution was performed with a gravity model using uncongested highway skims. A nested logit model was used for Mode Choice. Traffic Assignment was conducted with a 24-hour highway network and trip tables. (See Anderson and Donnelly for more information.)

Current Project to Compare Aggregate Trip-Based and Disaggregate Tour-Based Travel Demand Models

The Ohio Department of Transportation (ODOT) has contracted with the University of Texas at Austin on a new research project to compare MORPC's trip- and tour-based models. This research project will compare model results and sensitivities with before and after conditions of major highway projects and transit service changes. Model years include 1990, 2000 and 2005. Originally, it was envisioned that MORPC's two existing models would be used in the comparisons. Several issues arose from discussions between ODOT, MORPC and research staff regarding the models' differences and potential ways these differences could skew the actual research results. Model differences include:

- Different model geographies, including area and zone structure
- Different estimation data sets
- Different external and commercial vehicle models
- Different transit networks (Tranplan UNET vs. TP+ Trnbuild)
- Different TOD periods, and hence traffic assignments.

Because it was hoped to limit the models' variances to the internal demand models, it was decided amongst ODOT and research staff to develop a new trip-based model for the MORPC area.

New Trip-Based Model

ODOT had contracted with various consults in 2003 to develop a new standard trip-based model for Ohio's small and mid-sized MPOs. This model was used as the basis for the new MORPC trip-based model. The model geography, zone structure and socio-economic variables and networks are identical to the tour-based model. Trip Generation is based on a series of cross-classification models for HBW, HB School, HB Shop, HBO, NHB-Work Based, and NHB-Other Based purposes. Travel is now generated for 3 income groups identical to the income groups in the tour-based model. Trip Distribution is performed with a gravity model on an uncongested network, as was in the old trip-based model.

The new model is using the old model's nested mode choice model, but it is being run by income group using both peak and off-peak travel skims for all purposes. Transit travel skims are now generated using the same TP+ Trnbuild networks and similar skim scripts from the tour-based model. However, the transit travel speeds differ between the trip- and tour-based models. Because the tour-based model performs two iterations of feedback, the final model iteration uses travel time skims that are based on AM and mid-day assigned highway travel times for the peak and off-peak, respectively. Because the new trip-based model does not have any feedback iterations, several options were considered.

The first option was to use the transit skims from the second iteration of the tour-based model. This had the advantage of both models using the same transit skims for the final mode choice calculations. The second option was to use the INET travel time curves from UTPS. This option is not necessarily consistent with the final highway impedances, however, it is consistent with typical four step modeling practice. A third option was to code line travel times on the transit lines to essentially create a UNET network, as was in the old trip-based model. This option was discarded because it is no longer acceptable standard practice.

The Time of Day model proportions trips by the same four time periods as is used in the tour-based model. These proportions were calculated from the Household Survey and are static; there is no peak spreading. A GPS Correction model is also included in the new trip-based set-up. Household Surveys for Ohio, exclusive of Columbus, Cleveland and Cincinnati, included a GPS subset. As expected, it was found that trips are under-reported in surveys. The GPS Correction model factors trips by purpose by trip length in relation to the under-reporting found in the Ohio surveys. In the tour-based model, only Individual Non-Mandatory trips were increased to account for this effect.

Traffic assignment is identical to the tour-based model, with only the internal travel trip-tables varying across alternatives. Because it was decided amongst the research team to limit the variances to the internal travel demand models, the trip-tables for I-E, E-E, and commercial vehicle models are read directly from the last iteration of the tour-based model.

Special Considerations in Comparing Different Models

As previously mentioned, the goal of this research project is to document the differences between the internal demand models of an aggregate trip-based and a disaggregate tour-based model using several before and after studies. ODOT, MORPC and the Research Team felt that several special considerations needed to be addressed for a successful project.

Geography and Traffic Analysis Zones – The geography of the comparison area should be identical. This can be accomplished by either cutting identical sub-areas or by making the entire model geography identical. In the conduct of before and after studies, the change should be sufficiently far enough away from the model boundary to allow changes to be related to the internal models and not the external models.

Networks – Networks should be identical to limit any discrepancies due to network coding errors, or differences in included network links.

External and Commercial Vehicle Models – Because this project is to compare the aggregate and disaggregate methods of demand estimation, the aggregate external and commercial models remain identical for both models. Due to highway skims being a required input to these aggregate models, it was decided to read the trip tables from the tour-based model directly, as it includes 3 feedback iterations. Thus the new four step model is currently not wholly independent of the tour base model.

Highway Assignment – Every effort to limit model differences due to the supply models is being made, including the use of identical traffic assignment procedures. Several possibilities were considered, including a three-iteration capacity restrained assignment with 40%, 40%, 20% weights, as was standard in Ohio 15 years ago. Currently, it has been decided to use an equilibrium assignment, however the convergence criteria have not yet been agreed upon. During a Build/No-Build User Benefits comparison for another project, it was found that hundreds of iterations were required to obtain assigned networks that were converged well enough to isolate user benefits due to a specific project. The current MORPC implementation converges well enough for most uses between 6-20 iterations, depending on time period, however, no the number necessary to compare alternatives in a detailed sensitivity analysis is yet to be determined. The current assignment will be evaluated to determine its acceptability, in light of the user benefits project.

Transit and Mode Choice – Because the trip-based model uses a nested-logit structure with different local and premium skims, and the tour-based model uses a multinomial-logit model using only the best transit skims, the premium modes are being favored during the generation of the trip-based model's walk to premium transit paths. Variables in the two mode choice models are different, as the tour-based model include person and household level variables, and modes are potentially restricted as in the case of Household tours and At-Work subtours. The mode choice coefficients were made to be as consistent as possible for level-of-service attributes, such as IVT and OVT. This effort was made because the same path building parameters are being used to generate the transit skims, and the old trip-based model's coefficients do not fall within current FTA guidelines.

Models that Could Have Been Included in a More Robust Trip-Based Model

Realizing that limited time and resources were available for creating a new validated aggregate model for this research project, several models that are State of the Practice for large urban areas are unfortunately missing from the new trip-based model. They are noted here as these models should potentially be considered for other research projects.

Peak-Spreading – The new four step model uses static time of day factors. However, large urban areas typically experience peak-spreading, and therefore peak-spreading models are a part of many large urban area travel forecasting models. The inclusion of this model would enhance the aggregate model by moving trips to other model periods as the peak periods become increasingly congested.

Vehicle Ownership – The new four step model uses base year household vehicle ownership patterns. A model of vehicle ownership based upon relative modal accessibilities would be more appropriate for a large urban area.

Feedback – Several constraints in the new trip-based model were encountered due to lack of congested and uncongested travel times for early models. Different period level travel times would be useful for the trip distribution and mode choice models. Several methods of performing feedback are being considered by other researchers.

Model Validation

This section will be updated as the new trip-based model is finalized.

This summary shows the highway validation statistics, including some of the standard reports as suggested in the ODOT Traffic Assignment Procedures. It also shows the validation of the work purpose travel distribution when compared to the CTPP.

Trip Distribution

To explore the reliability of the work-component of the distribution model, the simulated 2000 year work tour distribution was compared to the 2000 Census Transportation Planning Package (CTPP).

The modeled work tour distribution is shown in **Table 1**. The CTPP journey distribution is shown in **Table 2**. **Table 3** displays the ratio of the modeled to the observed distribution.

Table 1: 2000 Modeled Work Tours

District	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
1 - CBD	277	154	47	34	53	7	8	338	167	293	170	5	12	1,565
2 - OSU	3,646	3,586	1,270	1,077	1,138	200	270	5,846	3,061	2,752	1,854	48	165	24,913
3 - Clintonville	3,706	2,565	1,612	1,447	1,686	233	418	5,346	3,281	1,966	1,181	65	144	23,650
4 - Worthington	4,085	1,903	1,434	2,557	3,575	536	929	5,621	5,278	1,842	983	141	213	29,097
5 - Crosswoods	3,197	1,534	1,228	2,086	5,144	1,094	1,597	5,883	4,940	1,498	826	178	293	29,498
6 - Polaris	625	294	216	382	1,235	464	830	1,478	963	285	146	42	120	7,080
Corridor Total	15,536	10,036	5,807	7,583	12,831	2,534	4,052	24,512	17,690	8,636	5,160	479	947	115,803
7 - Delaware	2,820	1,241	831	1,565	4,431	1,851	12,350	7,650	5,210	1,613	865	630	1,635	42,692
8 - NW	15,631	8,178	4,407	3,957	7,360	1,467	3,150	49,480	8,067	6,606	8,857	212	2,895	120,267
9 - NE	11,676	5,134	2,846	4,207	6,472	1,148	2,423	10,431	22,156	10,979	3,146	1,444	906	82,968
10 - SE	17,249	6,414	1,972	1,981	2,496	391	705	12,093	17,788	36,222	8,876	1,485	3,228	110,900
11 - SW	7,265	4,542	1,182	1,025	1,230	234	436	20,153	4,420	9,439	14,984	113	1,923	66,946
12 - Licking	2,645	811	407	721	1,094	253	1,202	1,781	6,342	5,713	822	46,456	1,606	69,853
13 - Other	4,877	1,570	615	585	1,173	263	1,536	7,709	4,166	10,641	3,476	2,830	11,161	50,602
Non-Corridor Tot	62,163	27,890	12,260	14,041	24,256	5,607	21,802	109,297	68,149	81,213	41,026	53,170	23,354	544,228
Regional Total	77,699	37,926	18,067	21,624	37,087	8,141	25,854	133,809	85,839	89,849	46,186	53,649	24,301	660,031

Table 2: CTPP 2000 Journeys (scaled to modeled work tours)

District	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
1 - CBD	535	243	33	33	47	7	15	335	182	195	88	15	24	1,752
2 - OSU	4,008	6,094	833	1,030	1,023	127	296	4,887	2,755	1,778	926	174	104	24,036
3 - Clintonville	3,609	3,001	2,256	1,127	1,517	311	416	4,201	2,827	1,695	816	94	99	21,969
4 - Worthington	3,761	2,509	1,380	3,745	3,499	505	542	5,125	4,760	2,107	963	244	182	29,322
5 - Crosswoods	3,730	1,633	1,051	1,733	6,194	1,192	1,083	5,255	5,280	1,792	859	210	130	30,142
6 - Polaris	698	321	240	312	995	995	934	1,340	794	350	170	16	58	7,223
Corridor Total	16,341	13,801	5,793	7,982	13,275	3,137	3,286	21,142	16,598	7,917	3,823	753	597	114,444
7 - Delaware	3,318	1,524	844	1,012	3,887	2,948	13,648	6,970	5,695	1,907	789	385	860	43,788
8 - NW	16,883	9,268	3,567	2,517	6,983	1,469	2,256	55,319	8,268	7,483	7,429	561	1,787	123,790
9 - NE	11,278	3,910	1,849	3,469	6,704	1,253	1,925	10,901	29,014	9,764	2,769	1,255	530	84,620
10 - SE	16,179	4,264	1,495	1,948	3,585	477	902	14,371	19,233	35,442	7,513	1,340	1,867	108,616
11 - SW	7,675	2,338	1,104	950	2,191	315	390	19,977	4,790	7,996	18,272	316	1,049	67,365
12 - Licking	2,437	667	310	642	1,429	268	722	3,111	7,698	5,144	1,010	39,761	716	63,914
13 - Other	4,594	1,221	524	621	1,395	283	574	8,767	5,521	9,164	3,425	1,539	15,868	53,494
Non-Corridor Tot	62,364	23,192	9,693	11,159	26,174	7,012	20,417	119,416	80,219	76,901	41,207	45,157	22,677	545,587
Regional Total	78,704	36,993	15,486	19,141	39,449	10,149	23,703	140,558	96,817	84,817	45,029	45,910	23,274	660,031

Table 3: Ratio of Model over Scaled CTPP

District	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
1 - CBD	0.52	0.63	1.40	1.02	1.13	0.96	0.55	1.01	0.92	1.50	1.93	N/A	0.50	0.89
2 - OSU	0.91	0.59	1.52	1.05	1.11	1.58	0.91	1.20	1.11	1.55	2.00	0.28	1.59	1.04
3 - Clintonville	1.03	0.85	0.71	1.28	1.11	0.75	1.01	1.27	1.16	1.16	1.45	0.69	1.45	1.08
4 - Worthington	1.09	0.76	1.04	0.68	1.02	1.06	1.71	1.10	1.11	0.87	1.02	0.58	1.17	0.99
5 - Crosswoods	0.86	0.94	1.17	1.20	0.83	0.92	1.47	1.12	0.94	0.84	0.96	0.85	2.26	0.98
6 - Polaris	0.90	0.91	0.90	1.22	1.24	0.47	0.89	1.10	1.21	0.82	0.86	2.67	2.08	0.98
Corridor Total	0.95	0.73	1.00	0.95	0.97	0.81	1.23	1.16	1.07	1.09	1.35	0.64	1.59	1.01
7 - Delaware	0.85	0.81	0.98	1.55	1.14	0.63	0.90	1.10	0.91	0.85	1.10	1.64	1.90	0.97
8 - NW	0.93	0.88	1.24	1.57	1.05	1.00	1.40	0.89	0.98	0.88	1.19	0.38	1.62	0.97
9 - NE	1.04	1.31	1.54	1.21	0.97	0.92	1.26	0.96	0.76	1.12	1.14	1.15	1.71	0.98
10 - SE	1.07	1.50	1.32	1.02	0.70	0.82	0.78	0.84	0.92	1.02	1.18	1.11	1.73	1.02
11 - SW	0.95	1.94	1.07	1.08	0.56	0.74	1.12	1.01	0.92	1.18	0.82	0.36	1.83	0.99
12 - Licking	1.09	1.22	1.31	1.12	0.77	0.94	1.66	0.57	0.82	1.11	0.81	1.17	2.24	1.09
13 - Other	1.06	1.29	1.17	0.94	0.84	0.93	2.68	0.88	0.75	1.16	1.01	1.84	0.70	0.95
Non-Corridor Tot	1.00	1.20	1.26	1.26	0.93	0.80	1.07	0.92	0.85	1.06	1.00	1.18	1.03	1.00
Regional	0.99	1.03	1.17	1.13	0.94	0.80	1.09	0.95	0.89	1.06	1.03	1.17	1.04	1.00

Highway Assignment Validation

Model validation refers to the comparison of estimated and observed individual highway link loadings and transit route boardings. The purpose of model validation is to gauge how accurately the model predicts observed base year travel patterns and to identify potential model shortcomings. The MORPC model was validated against traffic counts that have been processed to represent directional Average Annual Daily Traffic, for year 2000. The criteria used to assess the adequacy of the model validation were: percent VMT error, percent VMT root mean square error and percent volume root mean square error, by facility type and volume group. Highway assignment validation was geographically structured by districting schemes – Rings, Sectors and Super Districts.

The validation by volume group is shown in **Figure 4**. All volume groups, except 0-500, fall below the maximum allowable percent RMSE. (Maximum Allowable %RMSE per ODOT Traffic Assignment Procedures, page 30.)

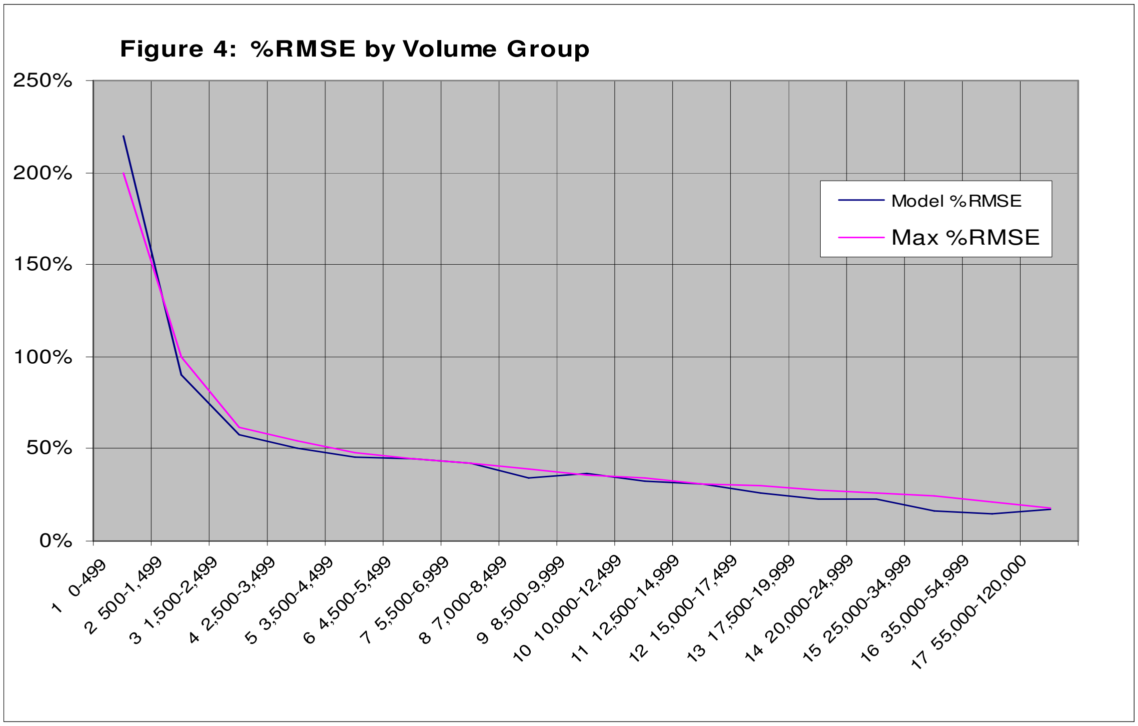

Table 5 shows validation statistics by facility type. Total VMT is within one percent of the observed data, and total volume is within two percent of the observed volumes.

Table 5: Counts vs. Model Volume Validation – by Facility Type

	Observed Traffic			Modeled Traffic		Percent Difference			
FACTYPE	# Links	Count	Count VMT	Volume	Model VMT	Volume	VMT	Max. % VMT	% RMSE
1 Interstate	144	6,776,143	7,093,162	6,993,800	7,060,835	3%	0%	7%	17%
2 Major Arterial	200	3,405,379	2,227,072	3,547,900	2,339,286	4%	5%	10%	22%
3 Minor Arterial	843	9,462,496	2,431,483	10,160,500	2,533,349	7%	4%	10%	31%
4 Major Collector	1,960	12,341,296	3,743,390	12,031,545	3,485,721	-3%	-7%	15%	42%
5 Minor Collector	1,012	3,137,166	1,111,915	2,816,063	990,219	-10%	-11%	15%	55%
6 Local	1,050	1,228,257	518,832	1,044,427	464,212	-15%	-11%	15%	93%
Total	**5,209**	**36,350,737**	**17,125,853**	**36,594,235**	**16,873,623**	**1%**	**-1.5%**	**3%**	**40%**

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