ABM2+ Convergence Test Report

1. Background

In May 2019, SANDAG held the first ABM Technical Advisory Committee (TAC) meeting to help guide SANDAG through ABM2+ development. During the meeting, TAC members recommended the testing of global iteration convergence to evaluate its impact on model outputs and performance metrics. This memo documents the implementation of the test.

2. Methodology

Each standard ABM2+ run contains three global iterations with household sample rates of 20%, 50%, and 100% applied to each iteration, respectively. In the first two iterations, trip demand is expanded to full size using a scale factor before traffic assignment. ABM2+ implements traffic and transit assignment using EMME modeling software. It additionally uses a specified relative gap as the assignment convergence criteria. The relative gap is set to 0.0005 in a standard ABM2+ run. Three scenarios were created to conduct the convergence test; the main configurations are listed in Table 1. All the scenarios run in the base year of 2016.

Table 1 – Convergence Test Scenarios

Scenario	Sample Size	EMME Traffic Assignment Convergence Criteria
Standard Run	0.2, 0.5, 1.0	0.0005
Full Sample Run	1.0, 1.0, 1.0	0.0005
Small Convergence Criteria Run	0.2, 0.5, 1.0	0.0001

3. Convergence Analysis

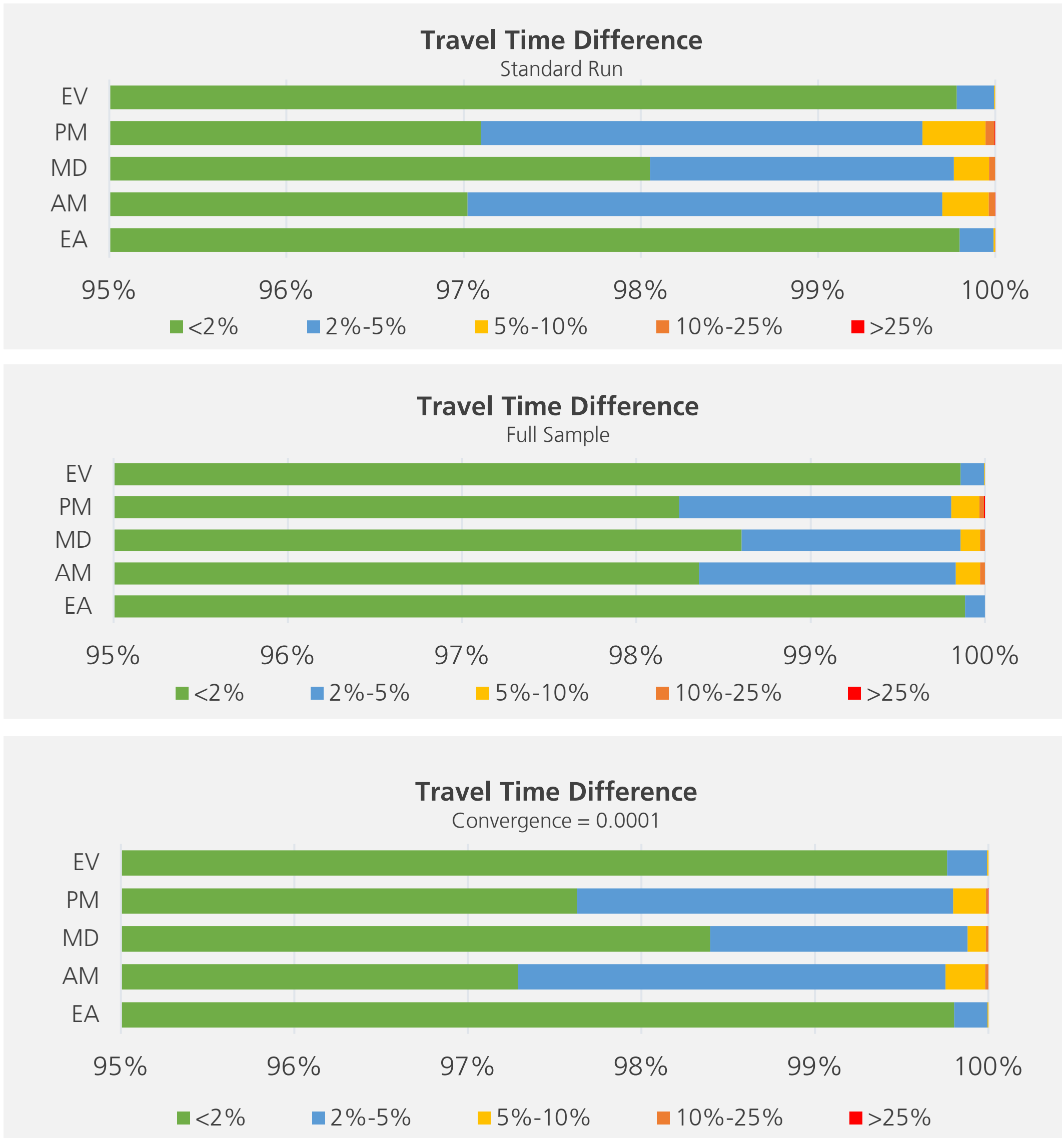
Two levels of statistics, which are described below, have been performed in this study.

3.1 Network-Level Comparison

Travel time difference – Figure 1

- Measures the difference in travel time between the second and third iteration. Links with zero volume from both iterations are excluded.
- All three model runs across all five time of day (TOD), namely early morning (EA), a.m. peak (AM), midday (MD), p.m. peak (PM), and evening (EV), converged well given the majority of link level time differences are below 5%.
- Standard and Small convergence criteria runs have similar convergence, with the latter having slightly better convergence.
- The Full sample model run outperforms the other two as it has the highest number of links with less than a 2% time difference.

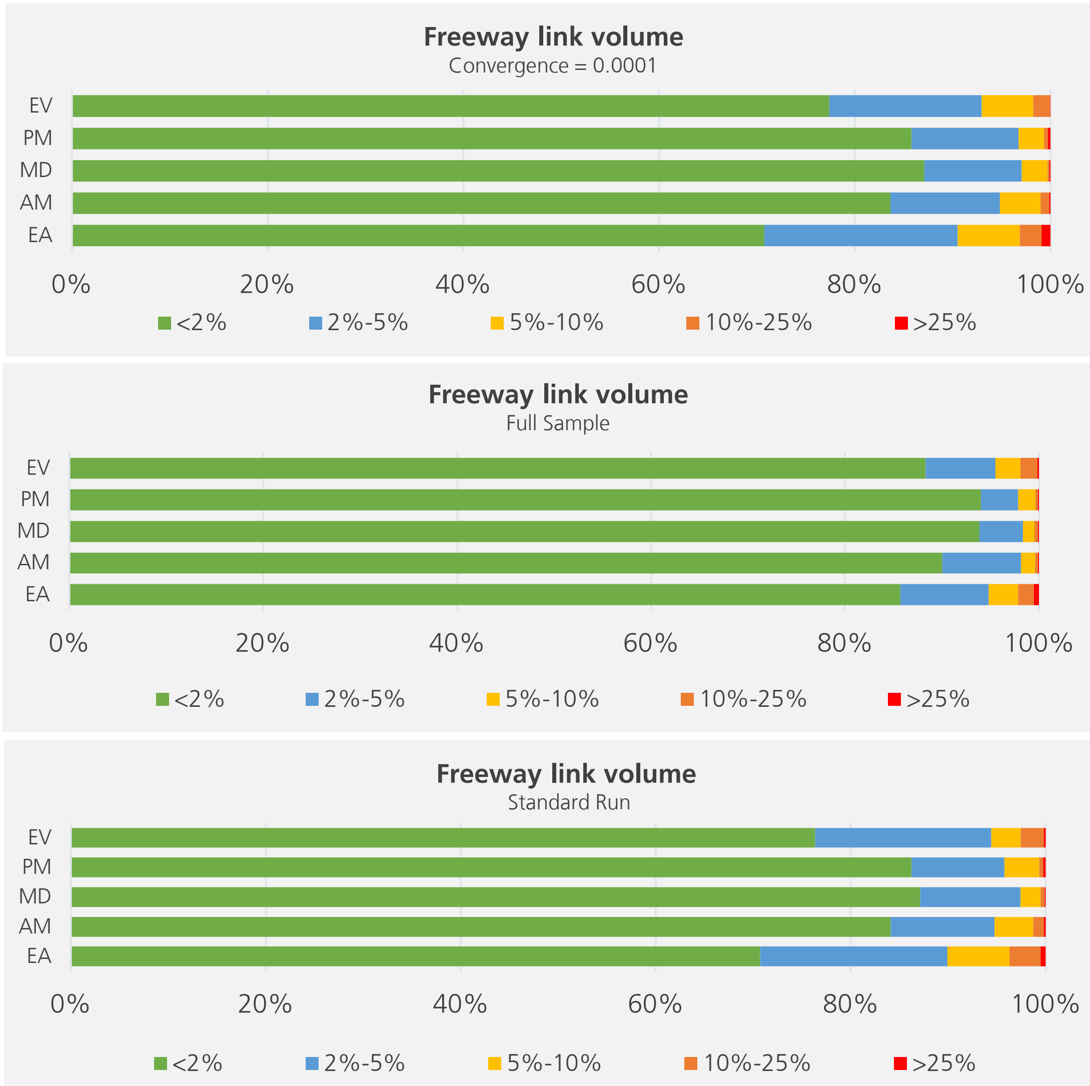
Figure 1 – Link Time Difference



Link volume difference – Figures 2, 3, and 4

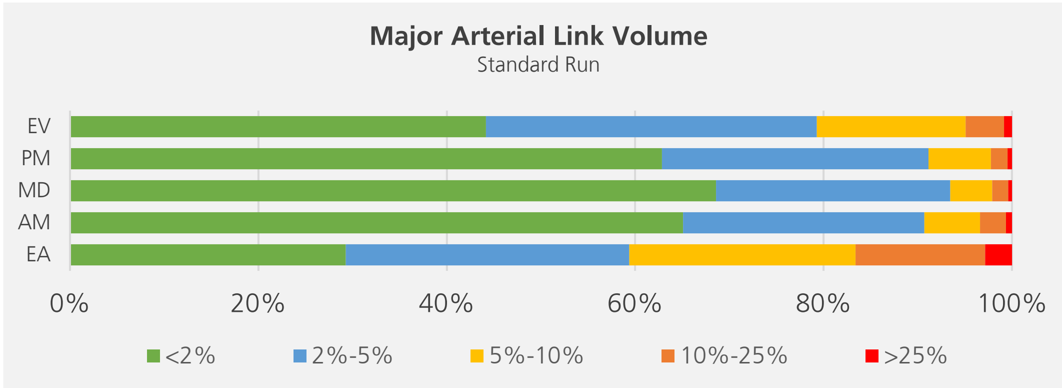
- Link volumes convergence were summarized into three categories by road type:
  - Freeways
  - Major arterials
  - Other roads
- Freeways (Figure 2)
  - The volume difference on most of the links was less than 5%.
  - The Full sample scenario has lower link volume difference when compared to the other two scenarios. All three tested scenarios demonstrated reasonable link volume convergence.

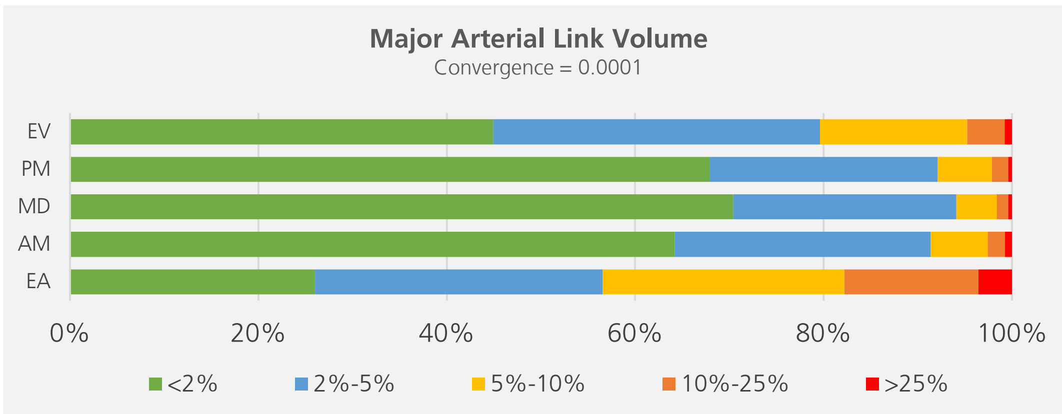
Figure 2 – Link Volume Difference – Freeway

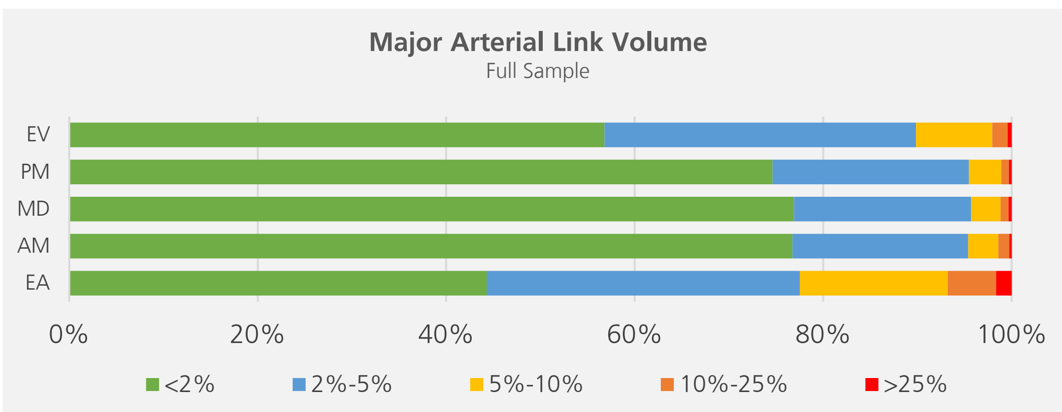


- Major Arterials (Figure 3)
  - Compared with freeways, major arterial links with less than a 2% volume difference are less prevalent, and the proportion of links with volume differences between 2–5% is noticeably higher.
  - Most of the link differences fell in the less-than-10% range. The Standard and Small convergence criteria runs have similar link volume convergence. The Full sample scenario has noticeably better convergence.

Figure 3 – Link Volume Difference – Major Arterial

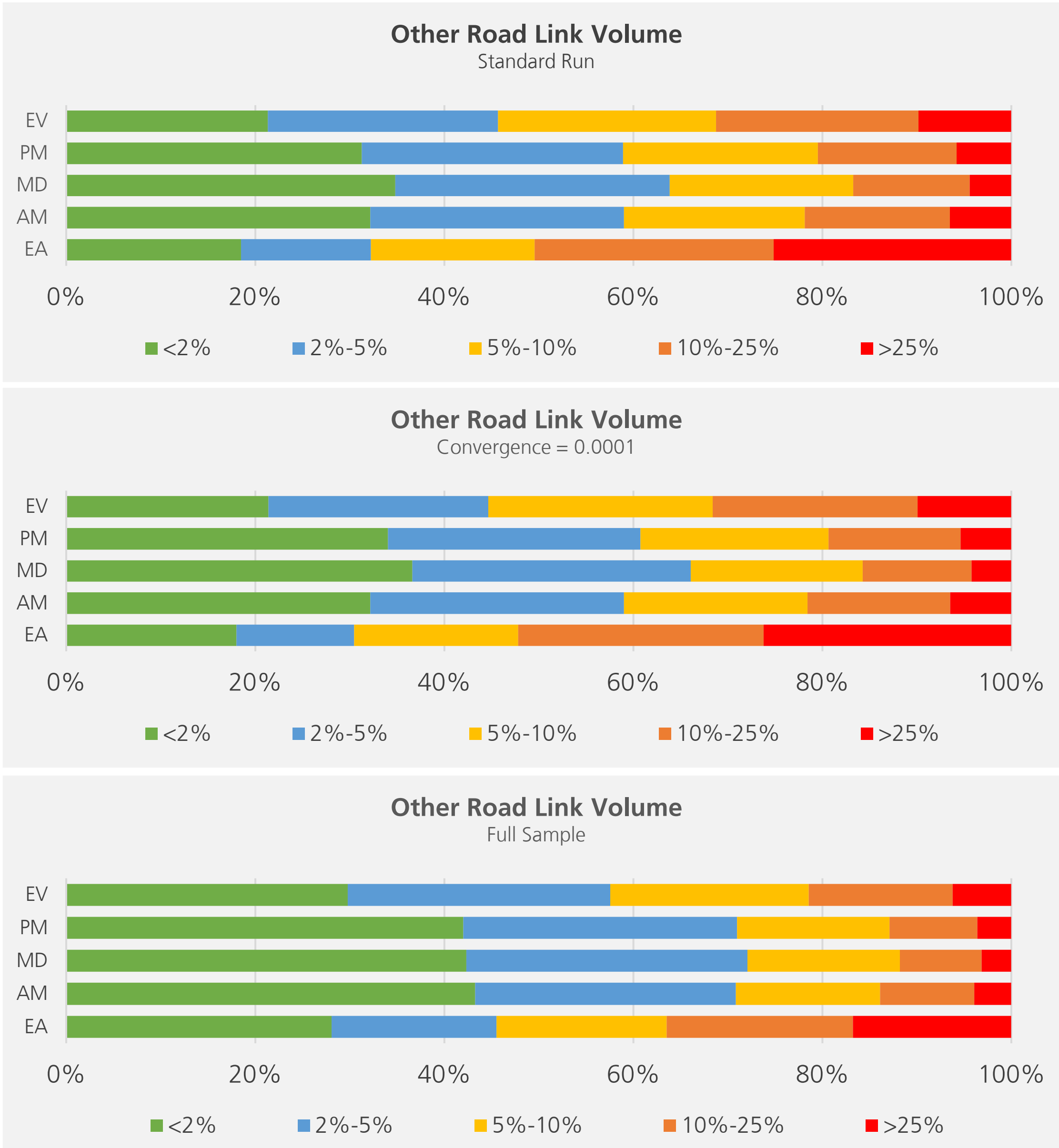






- Other road types (Figure 4)
  - Compared with freeways and major arterials, other road types have the worst link volume convergence as expected, primarily due to the small vehicle volumes on these roads.
  - Most of the link differences still fall in the less-than-10% range. The Full sample run outperformed Standard and Smaller convergence criteria runs.

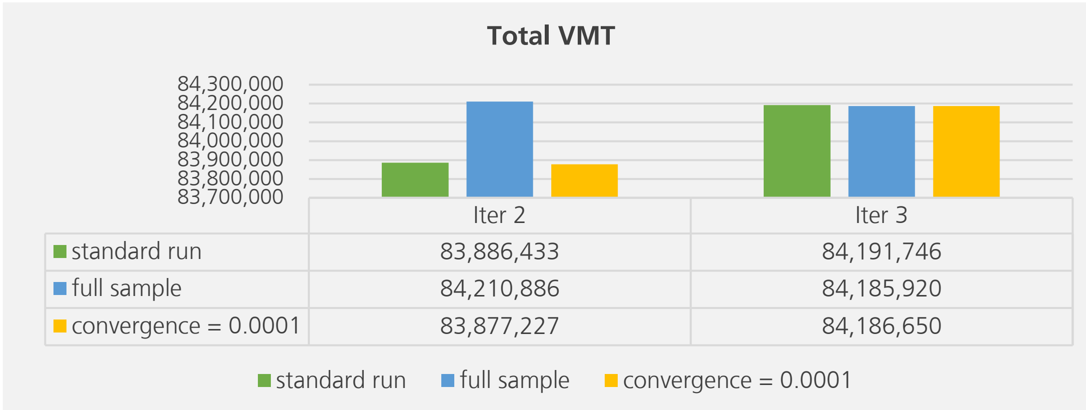
Figure 4 – Link Volume Difference – Other Roads



<u>VMT and VHT difference - Figures 5, 6 and 7</u>

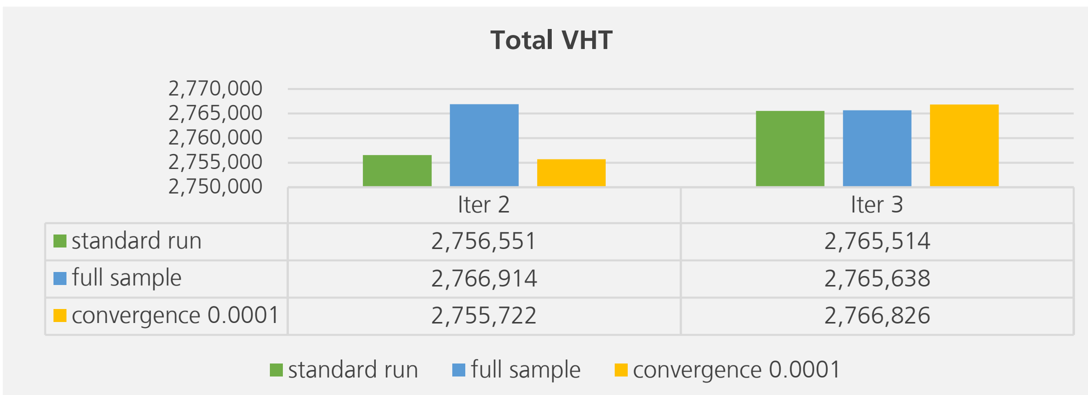
- The Standard and Small convergence criteria runs have similar performance. The Full sample scenario outperformed the other two scenarios.
- The VMT and VHT convergence, measured in % difference, in the Full sample run is approximately ten times lower than the other two test runs (Figure 7).

Figure 5 – Total VMT



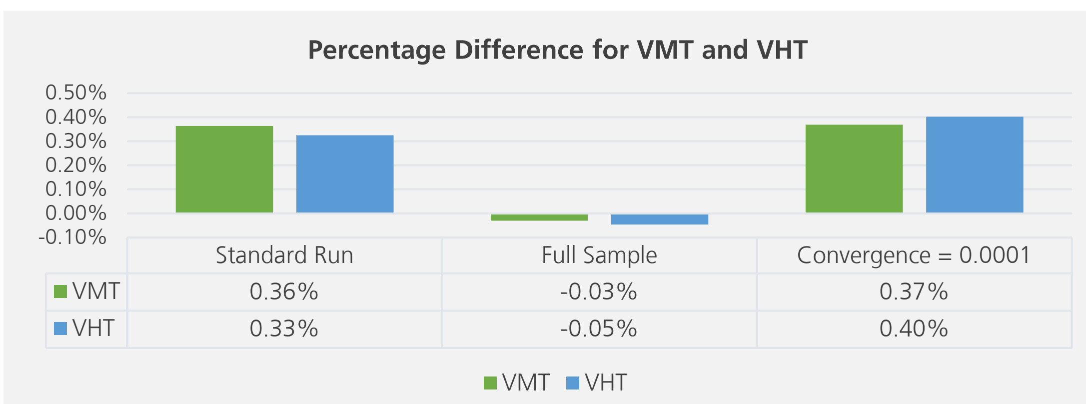
	Iter 2	Iter 3
standard run	83,886,433	84,191,746
full sample	84,210,886	84,185,920
convergence = 0.0001	83,877,227	84,186,650

Figure 6 – Total VHT



	Iter 2	Iter 3
standard run	2,756,551	2,765,514
full sample	2,766,914	2,765,638
convergence 0.0001	2,755,722	2,766,826

Figure 7 – Percentage Difference for VMT and VHT

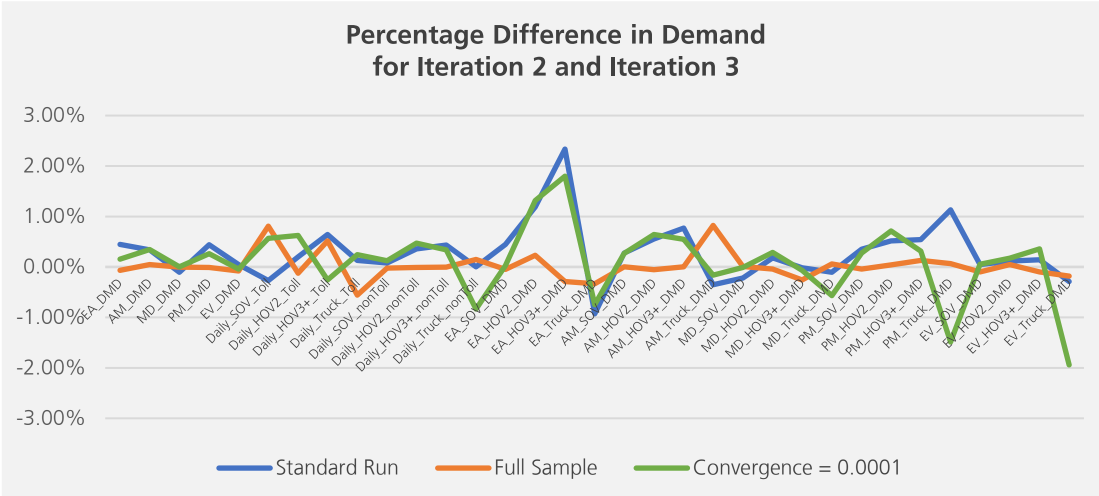


	Standard Run	Full Sample	Convergence = 0.0001
VMT	0.36%	-0.03%	0.37%
VHT	0.33%	-0.05%	0.40%

3.2 Travel Demand Matrix Comparison

This section describes the comparison of travel demand by TOD and mode between second and third iterations. Overall, 33 trip demand matrices were compared. The total variance, percentage variance, and maximum and minimum difference were calculated for comparison purposes. In general, Standard and Small convergence criteria runs have similar performance with variances largely within ±1.5%. As expected, the smaller the total trips in a demand matrix, the larger the variance is. The Full sample run outperformed the other two scenarios. Figure 8 shows travel demand analysis with respect to convergence criteria.

Figure 8 – Percentage Difference in Demand between Iteration 2 and Iteration 3



4. Model Performance Analysis

4.1 Model Run Time

- Table 2 describes the model run time breakdown.
- As expected, the Full sample scenario has the longest run time (close to 46 hours).
- Small convergence criteria scenario has the longest traffic assignment time, four hours longer than the Standard run.
- Since the models ran at different times with slightly different configurations, the time breakdown is not always consistent. Nonetheless, the runtime summary serves as a general guidance for balancing between convergence and model run time.

4.2 Server Specifications

All the three servers used for the model runs had the same specifications:

- Processor: Intel(R) Xeon(R) CPU E5-2690 v4 @ 2.60Hz 2.60 GHz (2 processors)
- Memory (RAM): 256 GB (256 GB usable)
- System Type: 64-bit Operating System, x64-based processor

5. Summary

- The convergence study suggests that the three tested scenarios all converged reasonably well.
- The Full sample scenario outperformed the Standard and the Small convergence criteria scenarios. However, for the base year 2016, the Full sample run took 10.5 hours, or 30% longer, than the Standard run time. The Full sample run is only recommended when link level travel time and volume accuracy is important.
- The Small convergence criteria scenario is not recommended since it achieves similar performance as the Standard scenario but takes a few hours longer to run.

Table 2 – Model Run Time Comparison

Total Run time	Standard Run 35:14:00	Full Sample 45:46:00	Convergence = 0.0001 39:14:00
Model setup and initialization	**0:21**	**0:20**	**0:20**
Iteration 1	**7:43**	**13:27**	**8:03**
Start matrix manager, JPPF Driver, HH manager, and nodes manager	0:01	0:01	0:01
Traffic assignment and skims	1:23	1:44	1:44
Transit assignments and skims	0:12	0:13	0:12
Java-Run CT-RAMP	3:20	7:44	3:15
Java-Run airport, cross border, visitor model	1:53	2:51	1:55
Export Skims for commercial vehicle model	0:02	0:03	0:02
Commercial vehicle model	0:26	0:26	0:27
Truck model	0:08	0:07	0:07
External-internal model	0:04	0:04	0:05
External-external model	0:01	0:01	0:01
Create TOD auto trip tables	0:14	0:14	0:15
Iteration 2	**9:04**	**12:22**	**9:21**
Start matrix manager, JPPF Driver, HH manager, and nodes manager	0:01	0:01	0:01
Traffic assignment and skims	1:35	1:34	1:55
Transit assignments and skims	0:15	0:15	0:14
Java-Run CT-RAMP	4:30	6:59	4:27
Java-Run airport, cross border, visitor model	1:57	2:36	1:57
Export Skims for commercial vehicle model	0:03	0:03	0:03
Commercial vehicle model	0:26	0:31	0:27
Create TOD auto trip tables	0:17	0:23	0:18
Iteration 3	**11:57**	**11:53**	**13:16**
Start matrix manager, JPPF Driver, HH manager, and nodes manager	0:01	0:01	0:01
Traffic assignment and skims	1:40	1:48	2:11
Transit assignments and skims	0:17	0:18	0:17
Java-Run CT-RAMP	7:00	6:45	7:07
Java-Run airport, cross border, visitor model	2:13	2:15	2:53
Export Skims for commercial vehicle model	0:03	0:03	0:02
Commercial vehicle model	0:26	0:27	0:28
Create TOD auto trip tables	0:17	0:17	0:18
Iteration 4	**6:09**	**7:43**	**8:13**
Final traffic assignments	0:27	0:27	0:49
create TOD transit trip tables	0:03	0:02	0:02
final transit assignments	0:23	0:26	0:23
export network results for data loader	0:11	0:16	0:11
export matrices for data loader	0:35	0:48	0:34
export core ABM data	2:10	2:06	2:11
copy project data to remote drive	2:20	2:21	3:59