travel modelling group

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TRANSIT ASSIGNMENT CONVERGENCE REPORT

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Transit Assignment Convergence

Background

Since the move to a congested Transit Assignment in GTAModel, the issue of convergence within the transit assignment has become more important. Convergence within the model would ensure that changes in ridership numbers and auto counts between scenarios are actually the result of network differences, rather than simply the difference between iterations. The GTAModel framework as currently prescribed by TMG has the maximum number of iterations of the congested transit assignment set to 5. The normal gap and the relative gap are both set to 0. The normal gap in this case refers to the difference between the previous iteration's average minimum trip impedance subtracted by the current generations average minimum trip impedance. The relative gap is the normal gap divided by the average impedance from the current iteration. This memo reports on work done by TMG to investigate the convergence of the transit assignment.

Setup

In order to investigate how converged the assignment is, it became necessary to extract out information between iterations for ease of comparison. Due to work on other projects, namely Surface Transit Speed Updating, it is now possible to write out csv files with the required information between iterations. The information extracted out includes gaps for each iteration, boardings per line, average v/c ratio per line, max v/c ratio, and line speed with congestion. For the purposes of this investigation, gaps and boardings are the main criteria for convergence. The number of max iterations for the purposes of this investigation was increased to 50.

Results

After performing 50 iterations, the gap values shown in Figure 1 and Figure 2 show that the congested transit assignment algorithm had not yet converged to the gaps of 0 that were specified. Since these gaps can be seen as unrealistic, the suggested INRO values of a normal gap of 0.01 and a relative gap of 0.001 can provide some guidance. Even when utilizing these values, the assignment still has not converged until the 36th iteration.

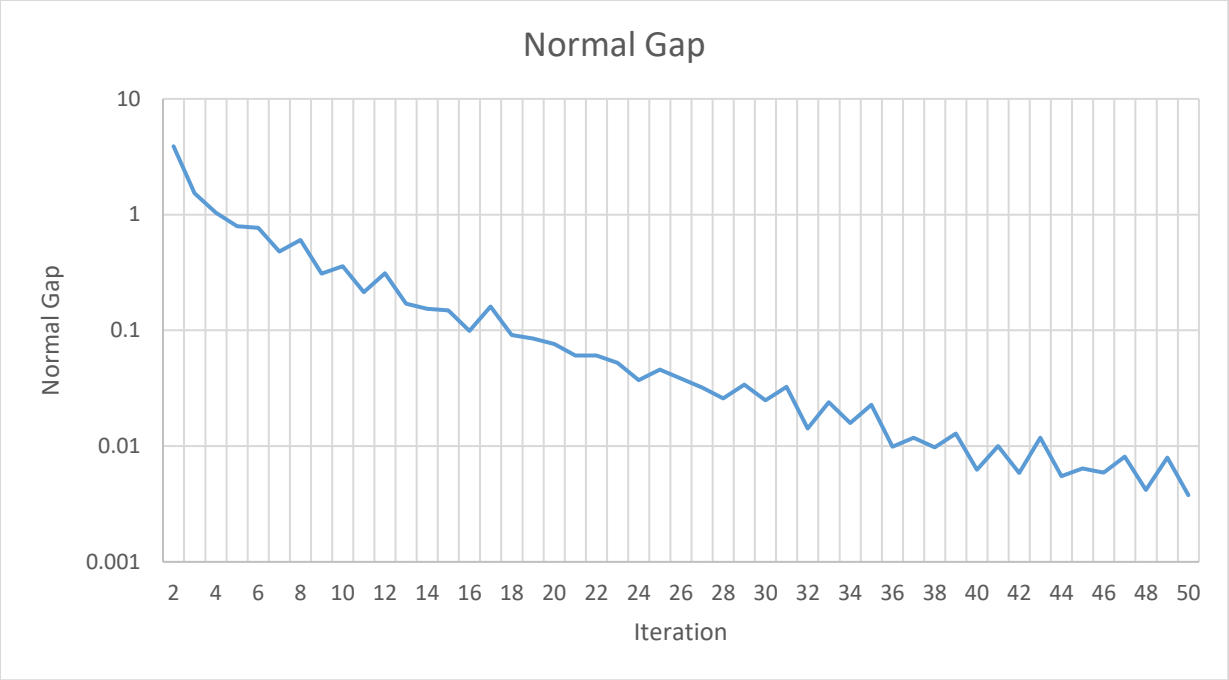

Figure 1 Normal Gap value across iterations

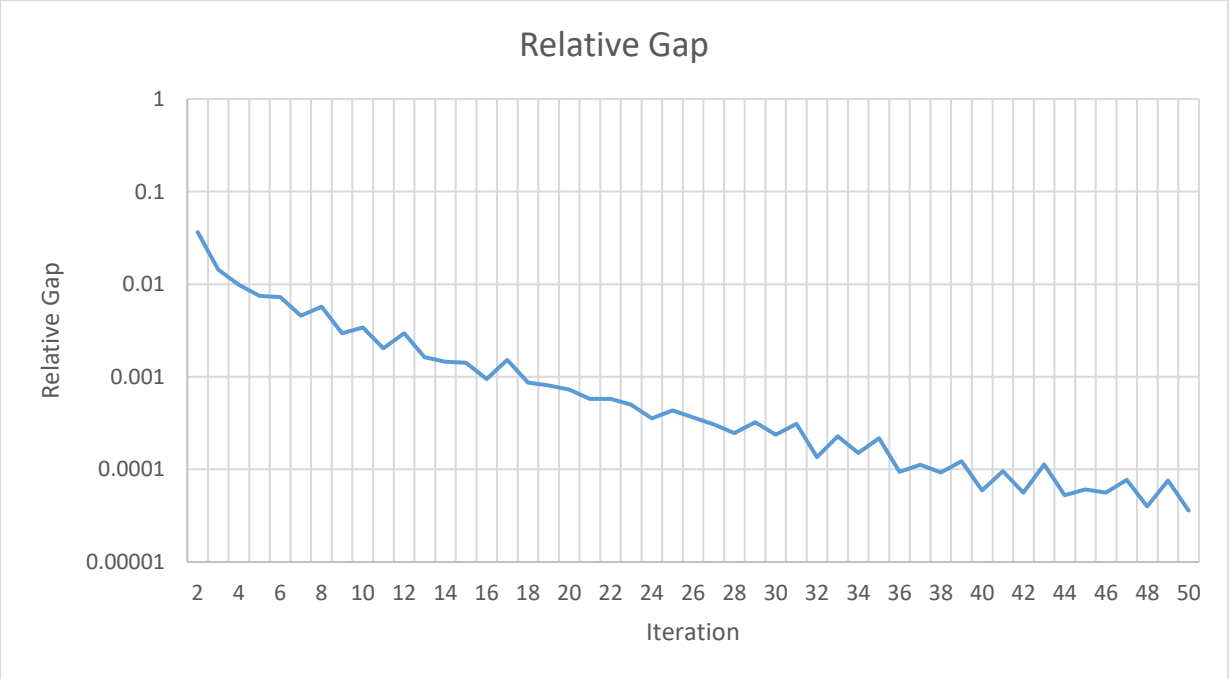

Figure 2 Relative gap value across iterations

When looking at how different the boarding numbers can be during each iteration, Figure 3 shows the average difference in boarding values (when comparing to the previous iteration) as well as the maximum difference in boarding values. This maximum value generally corresponds to the line with the highest volume, usually TTC Subway Line 1 (Yonge-University Spadina). It can be seen that the average difference is decreasing albeit slowly. Starting from the 9th iteration to the 40th iteration, the maximum

difference continues to remain approximately 100-200. It is only after the 40th iteration that the change decreases to below 100 consistently.

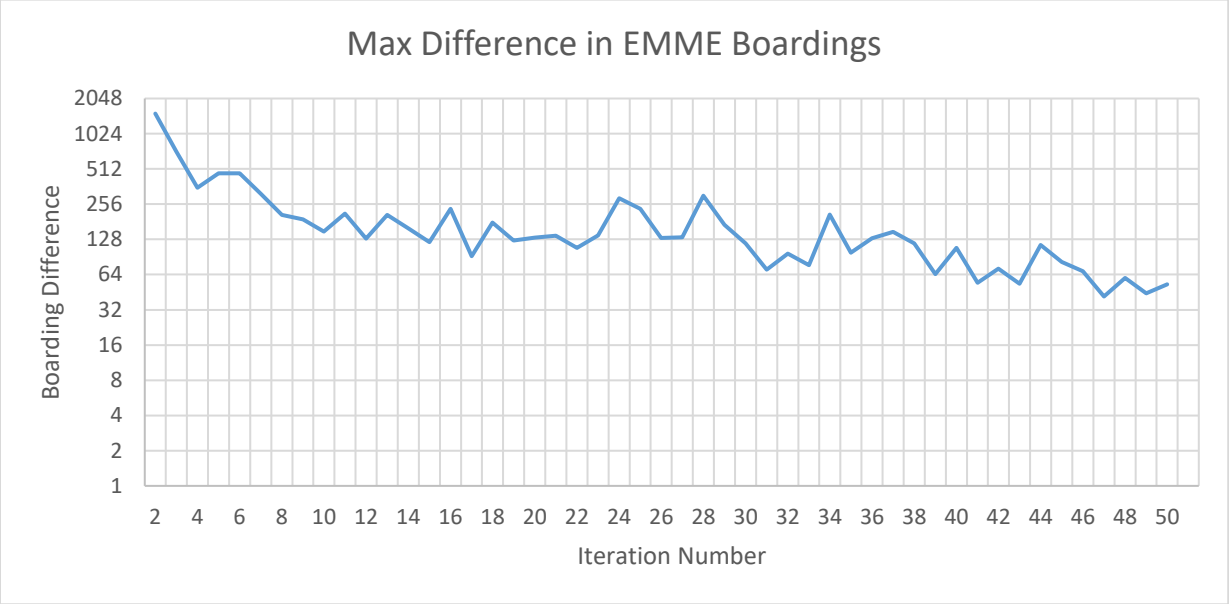

Figure 3 Maximum difference in EMME line boardings (from the Previous Iteration)

The maximum boarding difference also seems to decrease at a much lower rate, even when the gaps are tightening as shown in Figure 4. The relationship between it and the relative gap also paint a similar picture. Therefore, it would not be worth it to chase after a low maximum difference due to the very large computational requirements needed.

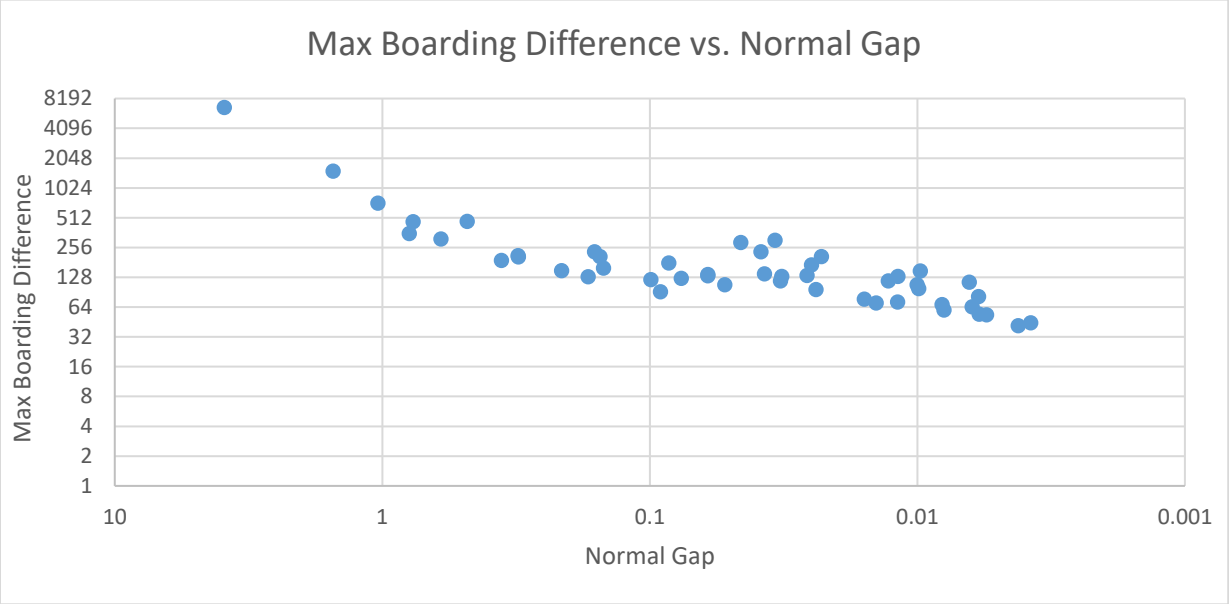

Figure 4 Change in maximum EMME boarding difference as compared to the Normal Gap

The average boarding difference decreases much more steadily as shown in Figure 5 and Figure 6 (which compares it to the Normal Gap). The relationship between the average change in boardings and the relative gap is similar to the normal gap.

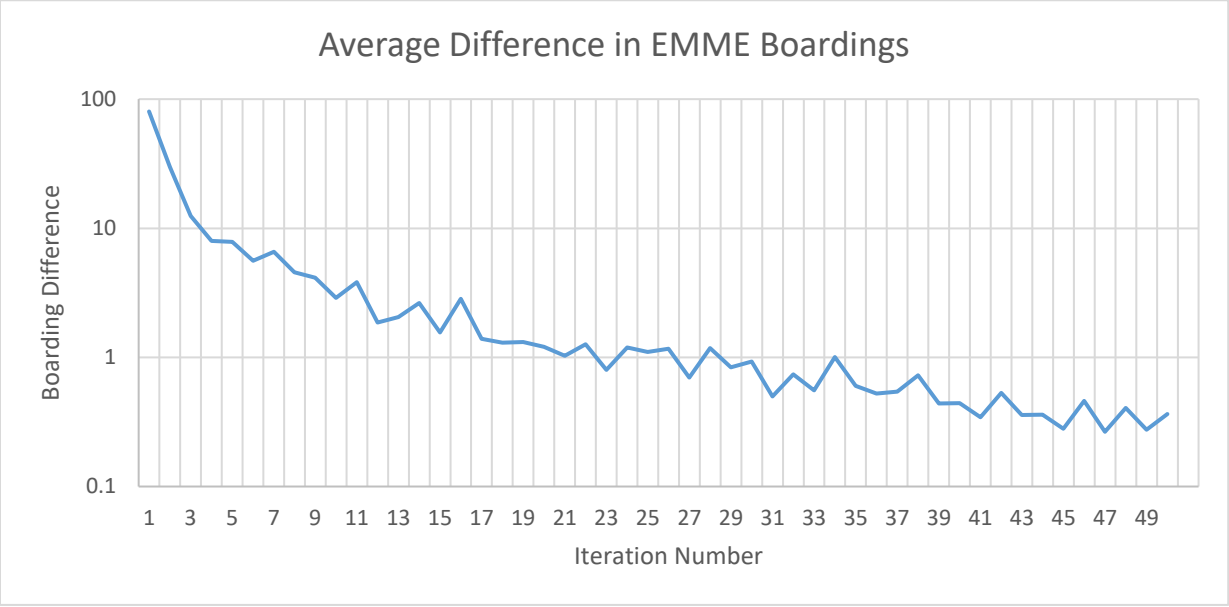

Figure 5 Average Difference (from the previous iteration) of EMME line boardings

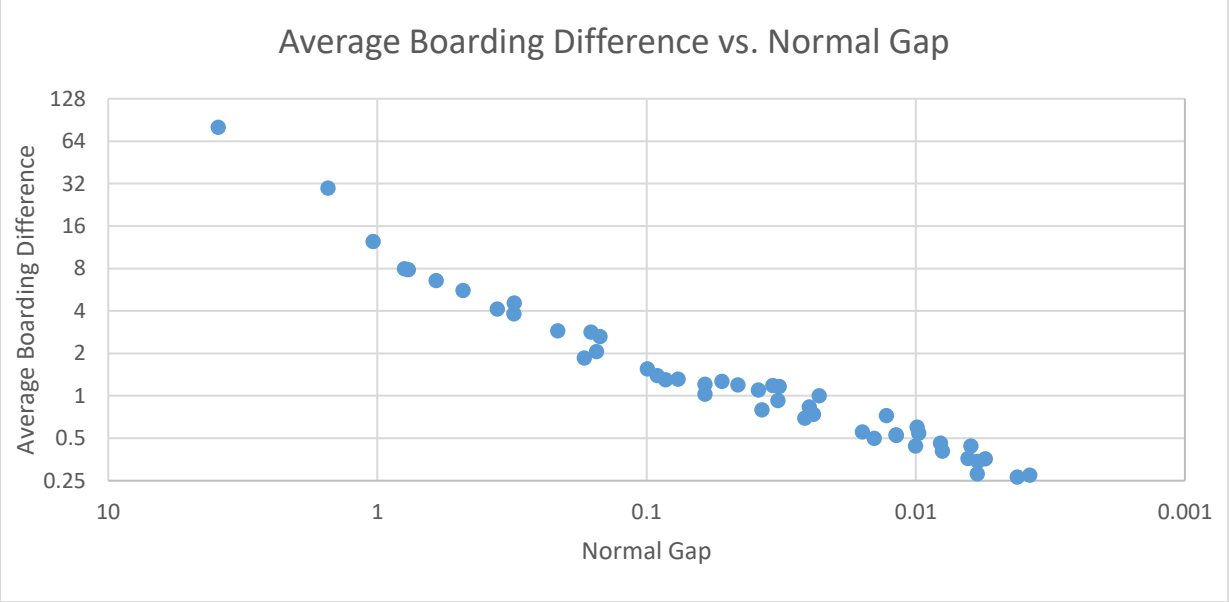

Figure 6 Average EMME line boardings difference as compared to the Normal Gap

The boarding difference might not matter so much when looking at large lines with very large capacities. For this reason, EMME GTFS lines were aggregated into TTS lines and then the change in boardings divided by the capacity of the line can help to determine how much the line is changing between iterations as a function of its capacity. As can be seen in Figure 7, the current convergence criteria of 5 iterations has some lines changing by up 25% of its capacity, a not insignificant figure. Until the 17th

iteration, TTS line boardings can vary by more than 10% of their capacity between iterations. However the average change in boardings divided by capacity drops below the 1% mark by the 7th iteration.

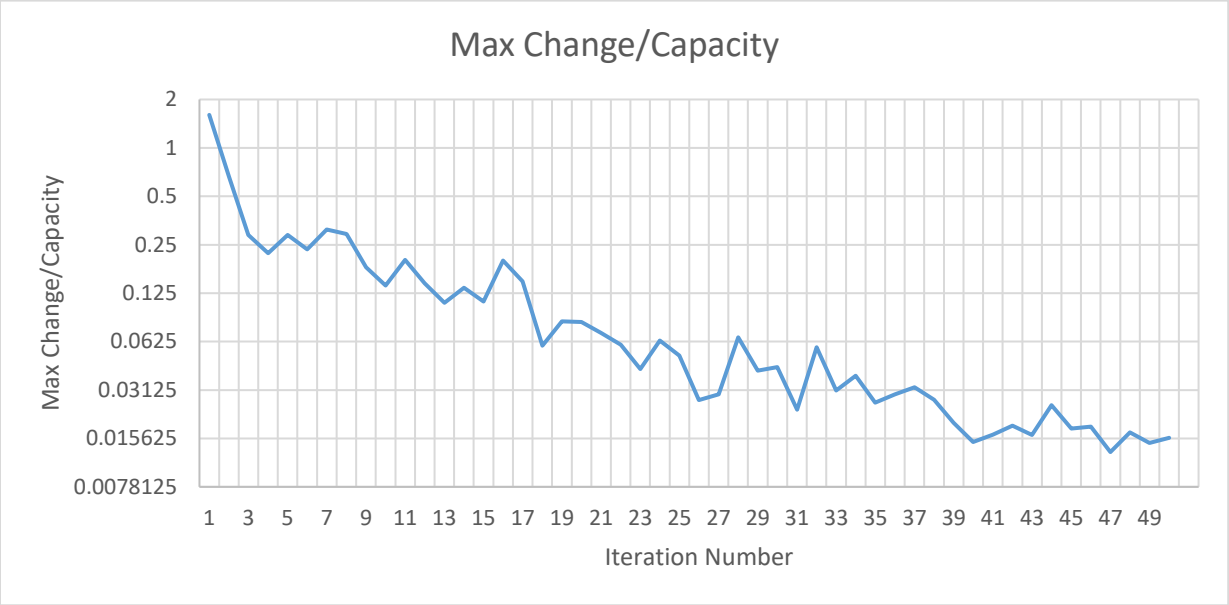

Figure 7 Maximum change in TTS line boardings as a function of its capacity

This value also converges steadily when the gaps start tightening as seen in Figure 8. The relationship between it and the relative gap also show a similar trend.

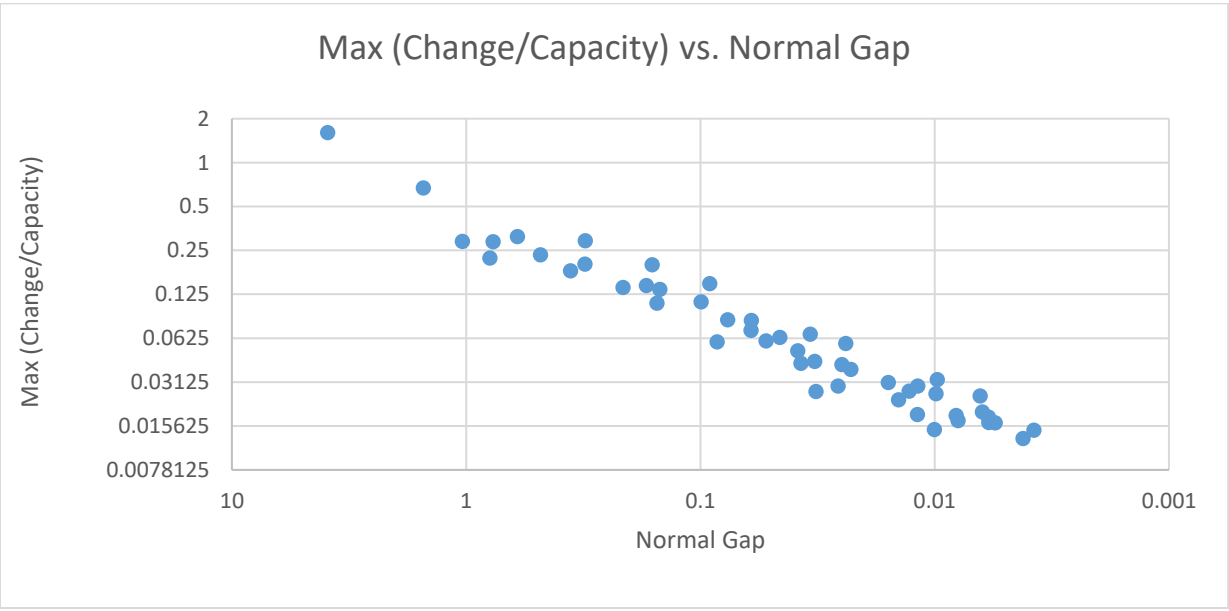

Figure 8 Maximum change in TTS line boardings as a function of its capacity when compared to the Normal Gap

Lastly, the boarding numbers can be compared to the TTS boarding values and a Root Mean Squared Error can be calculated. This value is shown in the Figure 9.

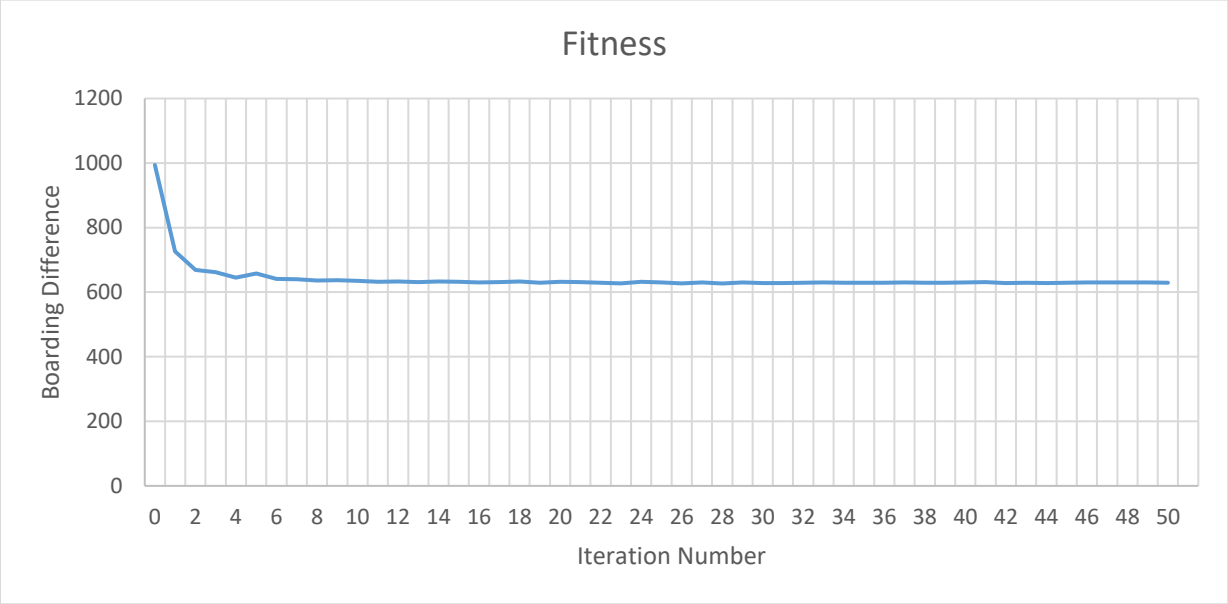

Figure 9 Fitness value compared across iterations

The other aspect to the number of iterations is the increase in time required for additional iterations. The time for various iteration numbers are shown in Table 1. Please note that is the time on a regular Workstation PC and not a server.

Table 1 Assignment Run Time

Iterations	Raw Time (mins)	Base Score
5	7.53	1.00x
10	15.22	2.02x
15	23.35	3.10x

Based on these numbers, it can be seen that increasing the number of iterations to 15 will increase the time by about 15 minutes for a single time period assignment. Any increase in the number of iteration also roughly corresponds to linear increase in time. However, due to GTAModel doing parallel assignments of the time periods across multiple EMME data banks, the total time will only increase by that 15 minutes as well.

Recommendations

Therefore, TMG then recommends the following changes.

1. Input gaps of 0.01 for the normal gap and 0.001 for the relative gap
2. Increasing the number of iterations of the transit assignment to 10.