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Signals in Microsimulation-based analysis for Future Year Alternatives

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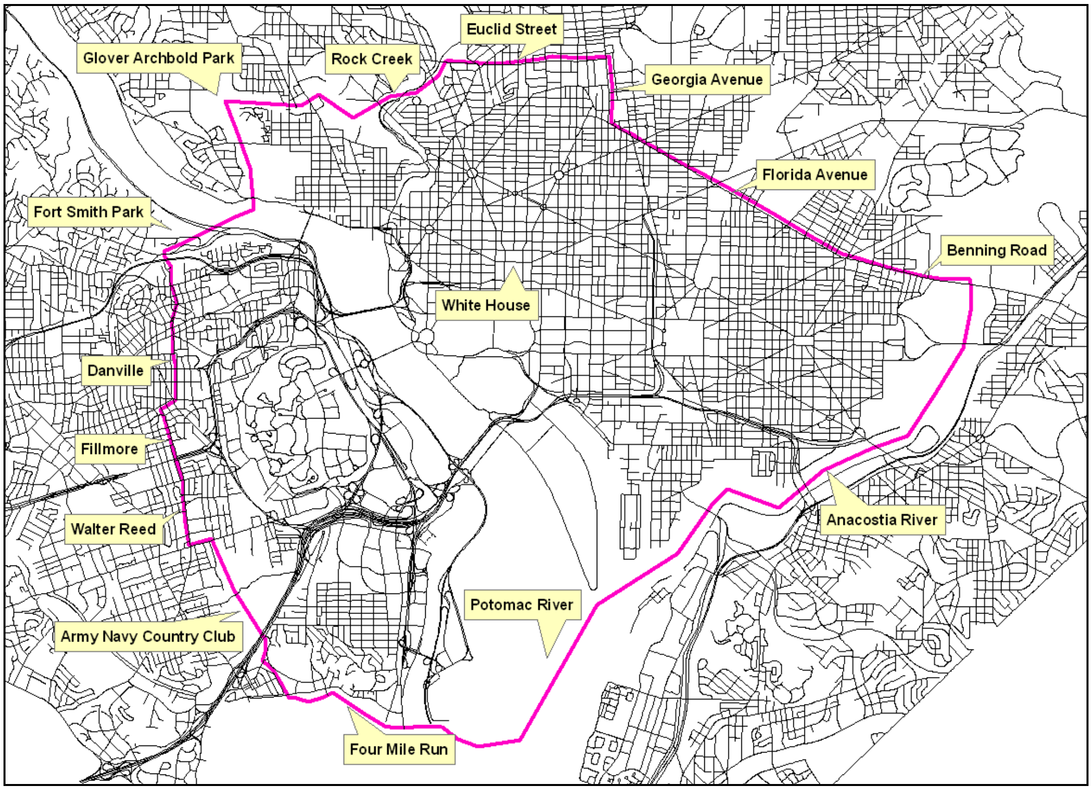
Abstract

Planning level models based on microsimulation using complex traffic signal timing plans are ever increasing in popularity. While the detailed signal coding brings them closer to the base-year reality, the need for the same can potentially take them away from accurate future year projections. This paper attempts to bring to light the issues relating to performing microsimulation for future year alternatives and in performing their comparative analysis. These issues need to be addressed as the work towards linking travel demand models and dynamic network models progresses. Signals play an instrumental role in the overall assignment results. And the assumptions made in terms of the signal systems for the future year alternatives greatly determines their performance.

As part of the White House Area Transportation Study (WHATS) we incorporated Synchro Signals from District Department of Transportation (DDOT) and Arlington County for the base year 2005. For the ten 2020 future year alternatives the base year signal system was used with alternative specific changes at portal entrances and exits. Four of them included tunnel options. We compared the cycle failure maps across the alternatives and found that they showed very different patterns. Several additional adjustments were required to the neighboring signals to relieve severe congestion. In the remaining part of the paper the methods adopted to address some of these issues are presented.

Introduction

The WHATS study uses the regional-routing and subarea-microsimulation concept. The study is focused in identifying the methods of mitigating the traffic impacts caused due to the street closures near the White House. The routing network is the entire Metropolitan Washington Council of Government's (MWCOG) transportation planning network. The subarea for microsimulation included the downtown Washington DC and a portion of Arlington County, Virginia. The following figure shows the subarea boundary:



The downtown and the connecting freeways make a complex network including HOV restrictions and reversible streets. In addition there are several time of day based changes to turn restrictions and parking restrictions. TRANSIMS package was used for the WHATS modeling.

Conversion Process

DDOT maintains signal timing information in Synchro software for the downtown computerized system. This information is provided for four time periods for the weekday and three time periods for the weekend. For this study only the weekday data was considered.

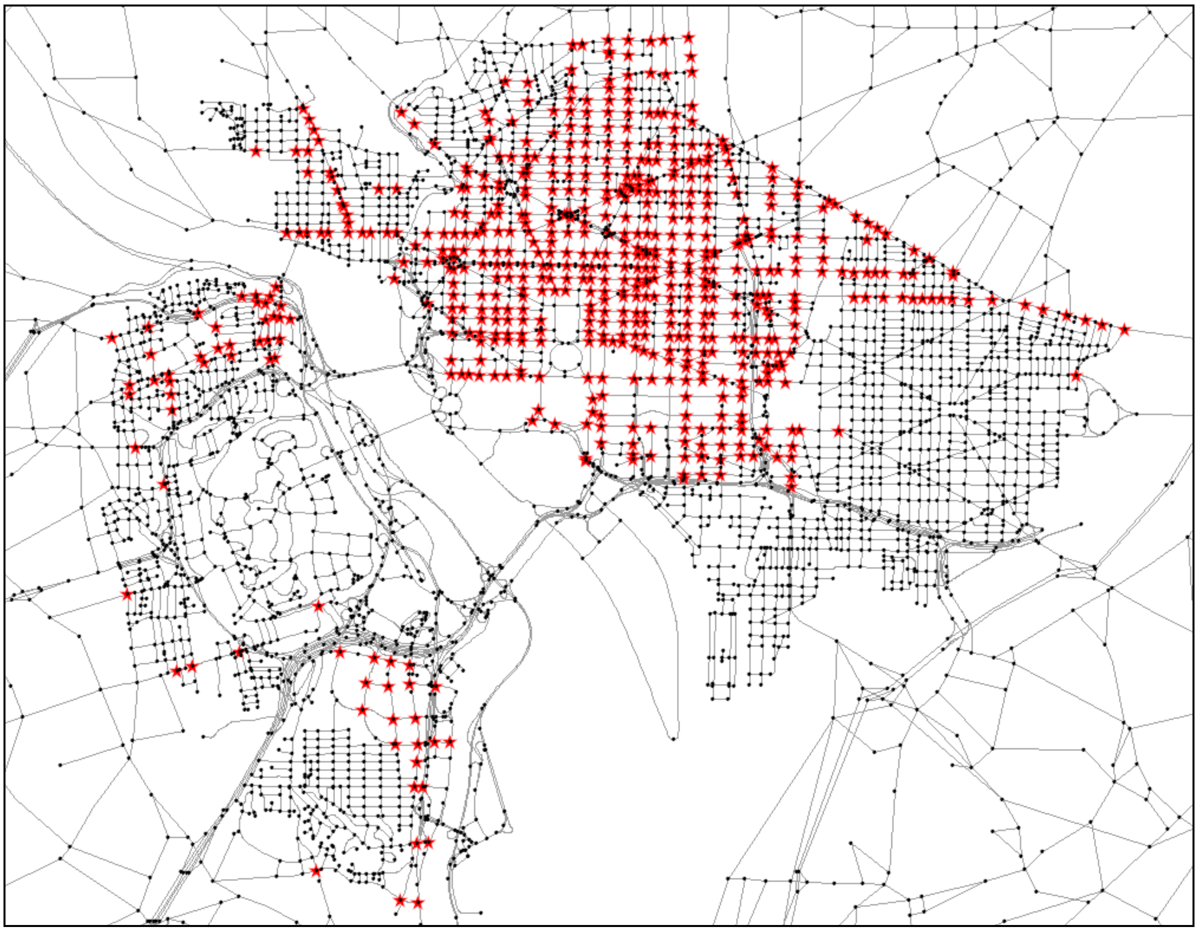
Weekday
5:30 am to 10:00 am – AM Peak (100 seconds cycle length)
10:00 am to 2:30 pm – Off Peak (100 seconds cycle length)
2:30 pm to 7:00 pm – PM Peak (100 seconds cycle length)
7:00 pm to 5:30 am – Off Peak (80 seconds cycle length)

The Synchro files contain information for 1,278 intersections. About 715 of these intersections were inside the simulation subarea. The information from these signals was converted to TRANSIMS format using custom software.

Similar information was provided by Arlington County. About 114 signals for three time periods (AM peak, PM peak and Off-peak) were used for the study. The data was available for three time periods:

6:00 am to 9:30 am – AM Peak (60-210 seconds cycle length)
9:30 am to 3:00 pm – Off Peak (55-140 seconds cycle length)
3:00 pm to 7:00 pm – PM Peak (60-150 seconds cycle length)

The Figure below shows the location were signal information was provided by either DDOT or Arlington County. For other locations, the TRANSIMS signal warrant process was used to identify signal locations and the signal timing plans for these locations.



Unfortunately, the process of converting Synchro signals to TRANSIMS was not as easy as it might have been. The DDOT database included many coding errors or ill-defined timing plans.

The signal data for each time period were first exported by Synchro in Universal Traffic Data Format (UTDF). The custom software then translated this data into TRANSIMS format and network link and node numbers. The conversion process worked well and was complete for intersections were the network configuration matched between Synchro and TRANSIMS. For other locations, several workarounds were utilized to correct transformation problems. Several of the more significant transformation problems are listed below:

1. The Synchro node and TRANSIMS node did not match

   The total number of nodes and the node numbers in the Synchro file for a particular location were not always the same for each time period. This of course complicates the equivalence between Synchro nodes and TRANSIMS nodes. The network representation and coding differences between Synchro and TRANSIMS required special attention at several places. For instance, at many locations, only a single TRANSIMS node represented the location whereas there would be two nodes to represent the location in Synchro and vice-versa.

2. The network geometry did not match

   Synchro does not include link numbers, but stores link-related data in directional format (e.g., north-bound lanes: NB, southeast-bound lanes, SEL etc.). The difference in orientation of the approach and departure links between Synchro and TRANSIMS required careful scrutiny. In addition, two-way streets that were coded with two one-way links in TRANSIMS or Synchro also needed supervision. When the number of approach or departure streets at an intersection were not equal due to differences in the network coding manual adjustments were needed.

3. Data file errors

   Inconsistency between the different data files that comprised the Synchro signal database prevented a number of signals to be exported by the software.

4. Actuated-coordinated signals

   These types of signals could not be translated because the TRANSIMS signal system currently does not support coordinated actuation.

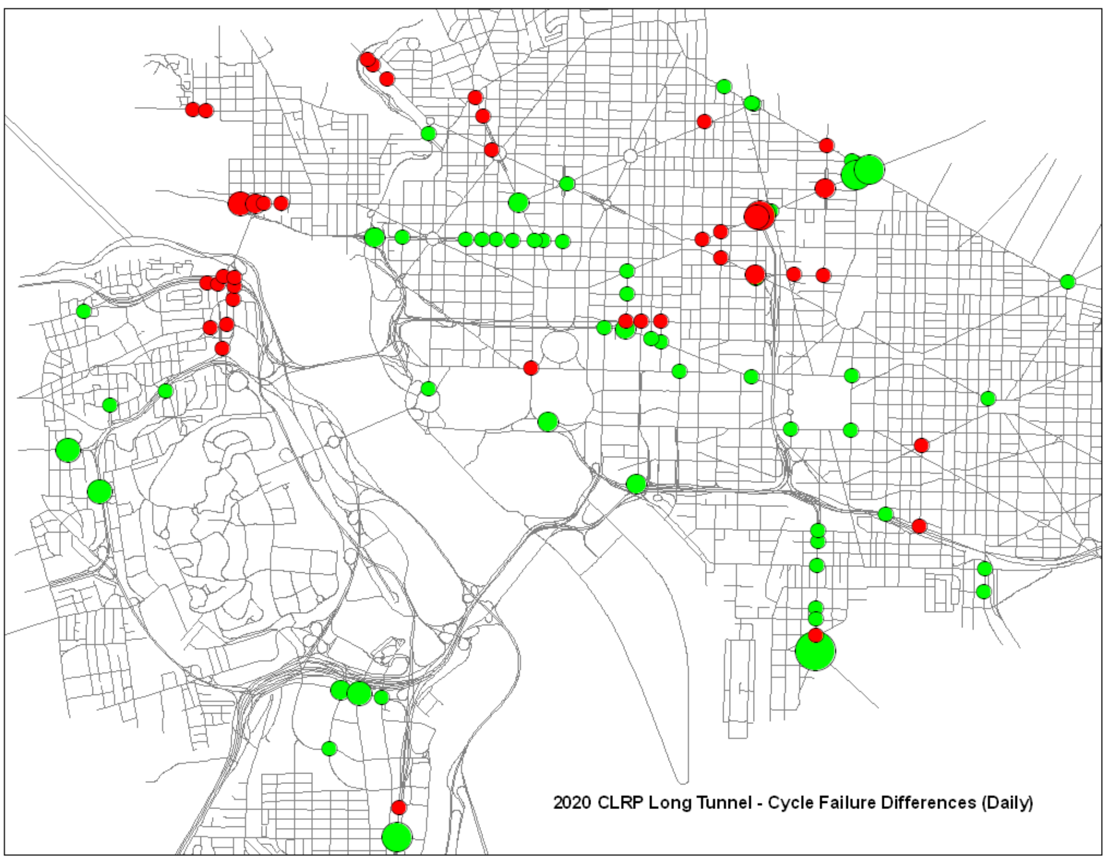
Effectively 632 signals from the DDOT database could be matched logically to the TRANSIMS network. Of these, 538 signals were match automatically by the software. Similarly, 82 signals from the Arlington database were translated and 63 signals could be translated using the software. The remaining signals and the signals that failed in the conversion process were then manually coded or synthesized using IntControl program.

Impacts on Microsimulation

The presence of real-world signal information for the base year was found very useful in the calibration process by obtaining the right assignments on streets due to accurate intersection controls. However, in the future year application, after the initial stabilization process, the plots of the cycle failures by time periods were compared for the future alternatives were found to be varying beyond what could be logically explained. Amongst others the following more significant steps were taken for adjusting the signals:

1. Signal progression was set for major arterials and corridors which had both converted and synthetic signals for smoother flow of traffic.
2. The initial set of 15-turning movement volumes were utilized to update the signal timings.
3. Several signals had to be individually tweaked for reducing queues observed in microsimulation.
4. The neighboring and slightly far away signals to portal entrances and exits required adjustments for improved traffic flow.

One or more of the above steps was repeated during further stabilization. The following images shows an example from of the alternatives: E Street Long Tunnel, showing the changes in daily cycle failures obtained as a result of adjustments. The green dots a reduction and red dots show an increase. The size of the dots shows a relative to the magnitude of change. Many intersections increased in cycle failures, even though they were operating as best as they could, because of changes in traffic patterns resulting from the operational changes mentioned above.



Lessons Learned

The important lessons learned from this study are:

1. Signals systems are very important in determining assignments.
2. External signal systems are beneficial in calibration but require careful scrutiny.

3. Several adjustment iterations are necessary over and above the alternative definitions to obtain a logical pattern of cycle failures.

Conclusion

The signal system for a network with detailed phasing and timing plans can not be determined for a twenty or thirty year future network. They are too uncertain. In presence of such a un-certainty the base-year signal system is usually adapted with alternative specific changes. Traffic engineers continually monitor and update the signals based on the observed queues, volumes and delays. It is safe to assume that in the future also, for instance a tunnel alternative's portal specific intersections and other nearby intersections will be monitored and updated. However, those changes are based on volumes which are not yet know or are dependent on the way these future year signals are coded. This becomes a circular reference. Some set of guidelines could be developed to define how many and how much should signals be adjusted for future years and for future year alternatives. The linkage of external signal softwares with travel demand models is found to help in improving the assignments, but the practical implications of such an interaction needs to be studied more and quantified.

References

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