Operation Green Light Traffic Signal Coordination
Measures of Effectiveness Methodology

Introduction
Operation Green Light (OGL) is a regional effort to improve traffic flow and reduce vehicle emissions. Managed by the Mid-America Regional Council (MARC), Operation Green Light works with federal, state and local agencies to develop and implement a system that will coordinate traffic signal timing plans and communication between traffic signal equipment across jurisdictional boundaries.

This document is intended to describe the methodologies used by MARC staff to measure the effectiveness of coordination plan changes made to individual corridors that are part of the project.

Data Collection
One of the most common measures of effectiveness (MOE) for signal retiming projects is to perform main-line travel time and delay studies with visual observations of queue lengths on the side street approaches.1 MARC staff perform travel time runs using the floating car method, to the extent possible.2 Travel time runs on corridors first collected prior to spring of 2010 were completed starting from the beginning of the green interval at the first signal. Runs on new corridors following this time were completed using a random arrival technique, with the beginning of the run being upstream of the first signal. All runs, before and after, for a given corridor and signal timing cycle are collected using the same technique.

The runs are only completed on Tuesdays, Wednesdays, and Thursdays, with additional restrictions around holidays and school breaks where appropriate. The turning movement counts, which are used in the production of the signal timing plans and when estimating net benefits, are also collected with the same restrictions.

The travel data is collected in a vehicle equipped with a speed sensor and traffic data collector (TDC-8 by JAMAR Technologies Inc.), so as to take a recording of vehicle speed as a function of time. Several runs, (usually between six and eight in each direction of the corridor) are collected before the timing changes, and then again after the changes have been made to the signal timing. The respective speed profiles are then analyzed using software (PC Travel by Ridge Engineering Inc.) The software uses a mathematical model to estimate the fuel consumption and some harmful emissions based on second by second speed and acceleration data.

Raw Travel Time Data Description
The results of the travel time studies (as output from the analysis software) are the changes in travel time, number of stops, speed, fuel consumed, and harmful emissions for a single vehicle driving the length of the corridor once. In addition, a value for Travel Delay is calculated manually as the measured travel time minus the ideal travel time at speed limit.

It is important to remember that the magnitude of the benefits seen is directly related to how efficient the signal operation was before the changes were made. See the Perspectives section below for additional considerations to keep in mind.

The relative change of each MOE can be weighted by directional traffic volumes to give a volume-weighted-average improvement of each MOE, which is often more meaningful for corridors with uneven directional split.

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2 The floating car method may not be reasonable or even possible in all situations, for example, when there are lanes with un-even utilization. Floating car method, if followed strictly, may also result in overly aggressive driving style on signalized arterials, due to the relatively low and variable speeds as compared to freeway studies. Overly aggressive driving would result in un-realistic fuel consumption and emissions figures and should be avoided.
The effects of the timing changes for coordinated main-line travelers can be seen in the raw travel time data. The effects on the side street approaches and other non-coordinated movements is not measured in the field, except via visual inspection to ensure commensurate level of service as compared to pre-existing conditions and main-street operation. However, some non-coordinated movements are modeled with traffic signal coordination software (Synchro® by Trafficware®), as detailed in the following section, in order to capture changes in approach delay that may be significant as compared to changes in coordinated travel delay.

Calculating Net Benefits

The raw data from the travel time studies only tells the effects on one car, driving along one route, at one time. The benefits to that one route DO NOT apply to every vehicle on the corridor. In order to estimate the net benefits of the timing project to the entire travelling public, some additional calculations and extrapolations are made.

When quantifying these benefits several considerations must be remembered:

- The impact of the coordination changes on any particular trip with a unique origin and destination is not known, other than the trip that was measured.
- It is not known how many vehicles drive the entire length of the corridor.
- The origin and destination of each vehicle is not known.
- The changes made to the corridor will impact vehicles utilizing non-coordinated movements including side streets and main-street left turns. Some of these movements will perform better with the changes; others may perform worse than before.

Given the above considerations, the following describes the methods MARC staff use to quantify the results and give an approximate net change for each measure of effectiveness:

1. For each period (time of day which was analyzed):
   a. For each direction of coordinated main-line travel and for each link:
      i. Turning movement counts are used to calculate what percentage of vehicles continue, leave, and join the coordinated direction. Additionally, judgment and knowledge of the corridor are used to approximate what percentage will continue through each link’s non-signalized intersections. This will vary, perhaps link by link, depending on circumstances, and can be adjusted to better match what the actual counts show downstream.
      ii. The above figures and the turning movement counts are then used to approximate how many vehicles continue through this entire link and did NOT join the corridor at midblock or the previous intersection. (Those who just joined the corridor will likely not be in the coordinated platoon). Due to variations in traffic on the days when the turning movement counts were collected, the raw counts will not balance exactly between intersections. The counts are adjusted to closer match what would be a balanced set of counts to achieve more reasonable approximations.
      iii. The per-link MOE results are then applied to the adjusted number of vehicles that are estimated to have continued in the platoon at this link.
   b. Synchro® traffic signal coordination software is used to model some intersections (those likely to have significant changes in delay on non-coordinated movements) with before and after conditions. The net change in delay and the associated fuel usage and emissions
at these movements is combined with the main-line results from step a. to find the net results.3

2. Steps a. and b. are repeated for each other period during the day that is analyzed.

The output of the above steps is an estimate of the total change in travel time, stops, fuel consumed and harmful emissions from before to after the timing changes were made, for a single business day. If an off-peak plan was affected, more off-peak times will receive a benefit beyond that estimated here; however, since actual count data was not collected for all times of day, the reports do not attempt to quantify all those benefits. These steps may be altered slightly and/or the data tweaked in order to accommodate the specific corridor being analyzed.

**Economic Impact**

The daily net savings in travel time and fuel consumed are now easily assigned an economic value. The travel time savings is multiplied by $15.47, the hourly rate suggested by the Texas Transportation Institute’s Urban Mobility report4. The total savings in fuel is multiplied by the average price of a gallon of gas at the time the coordination changes were made.5 These daily economic benefits can be multiplied by 250 typical business days in a year to estimate a yearly benefit of the coordination plan changes. Non-business days may also receive significant benefit if, for example, an off-peak plan is utilized on these days, but without count data the reports do not attempt to quantify those benefits. OGL does not attempt to assign an economic value to pollutant emissions, travel time reliability, or any other benefits that could be quantified, other than travel time and fuel costs.

**Benefit to Cost Ratio**

Having quantified the benefits of the coordination project, it is important to compare this with the costs involved. In order to estimate a benefit to cost ratio, staff utilize the operations cost that OGL charges to member agencies. This will result in a conservative ratio, as those costs pay for more than just signal timing efforts, but since the signal timing is the primary source of quantifiable benefit from the OGL project, these reports ignore the other benefits and consider the entire project costs as going towards signal timing only.

**Perspectives**

- As time passes traffic patterns will change that could alter the travel profile along each corridor. The price of gasoline also can change dramatically. These changes will result in variations to the actual benefits to the travelling public.
- The benefits estimated are only meaningful from the perspective of comparing conditions before the timing changes were made to those after. Therefore the MOE reports attempt to document exactly what the before-conditions were.
- MARC staff sometimes “clean-up” existing signal timing prior to doing studies. This benefit is not measured.
- MARC staff attempt to retain only a reasonable number of significant figures in the results shown in the reports, however, staff do not perform formal propagation of error calculations, and do not know the amount of error in the output of the travel time data analysis software.

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3 It is assumed that the change in delay is time that the vehicle is stopped, and thus idling. The rates for fuel consumption and emissions for an idling vehicle are obtained from the formulas used by the PC-Travel. Synchro® does not track stops in a way that is comparable to the stops measured by PC-Travel, thus change in stops is not measured for non-coordinated movements.

4 [http://mobility.tamu.edu/](http://mobility.tamu.edu/).

5 For one source of this data see [http://www.kcgasprices.com/retail_price_chart.aspx](http://www.kcgasprices.com/retail_price_chart.aspx).
Conclusion

The methods outlined in this document are not perfect. These are the procedures used by MARC staff to collect, model, and analyze traffic data in order to measure and quantify the effectiveness of individual corridor retiming projects. The resulting benefits should reasonably reflect the benefits to the travelling public in the absence of more exhaustive data and more labor-intensive studies.

For more information please see:

www.marc.org/transportation/ogl