# Operational Effects of the Consolidated Intersection Design on Urban and Suburban Arterials

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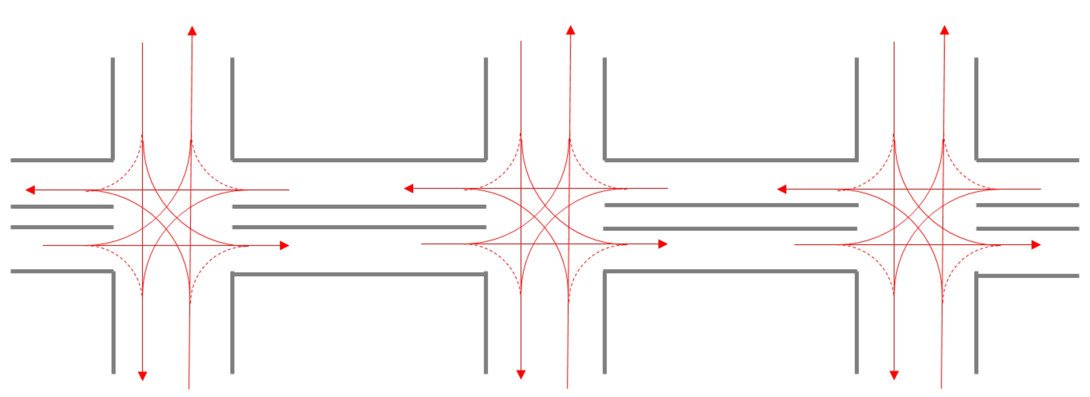
## Problem Statement

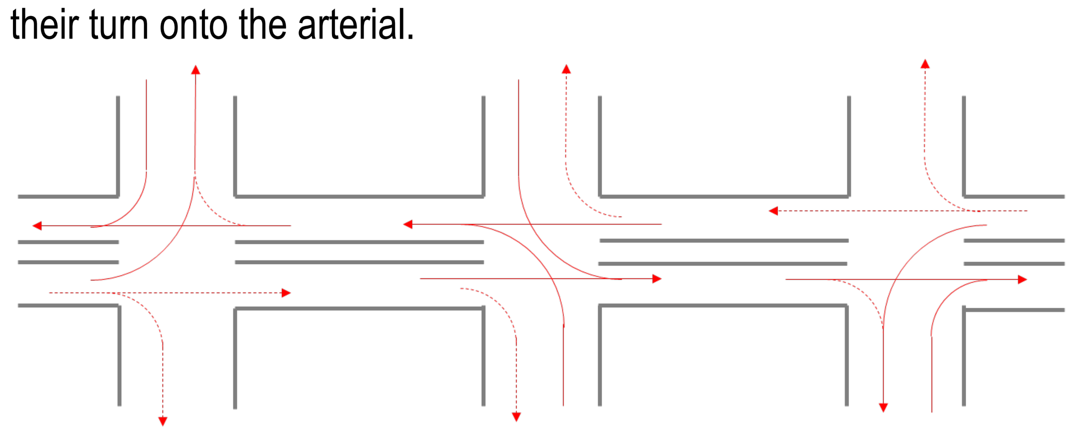
When large commercial centers flank both sides of an urban and suburban arterial and multiple (sometimes closely-spaced) signalized intersections are used to provide access to these developments, it becomes very difficult to provide adequate levels of service to the side street movements while at the same time providing bi-directional progression for the through traffic on the arterial. As these competing demands increase, cycle lengths and green splits are increased, often resulting in increased signal delay and longer queues.



Base Condition: Arterial with access to commercial developments

## Proposed Design Solution

The proposed design consolidates common movements together to eliminate many of the redundant turning movements. **This design requires that all traffic within the commercial development can access each of the three intersections via roadways internal to the commercial development, such as a frontage road or a ring road around a large mall.** Without proper internal circulation in the commercial development, the proposed design will not function properly because displaced routes will not be able to access the proper intersection to make their turn onto the arterial.



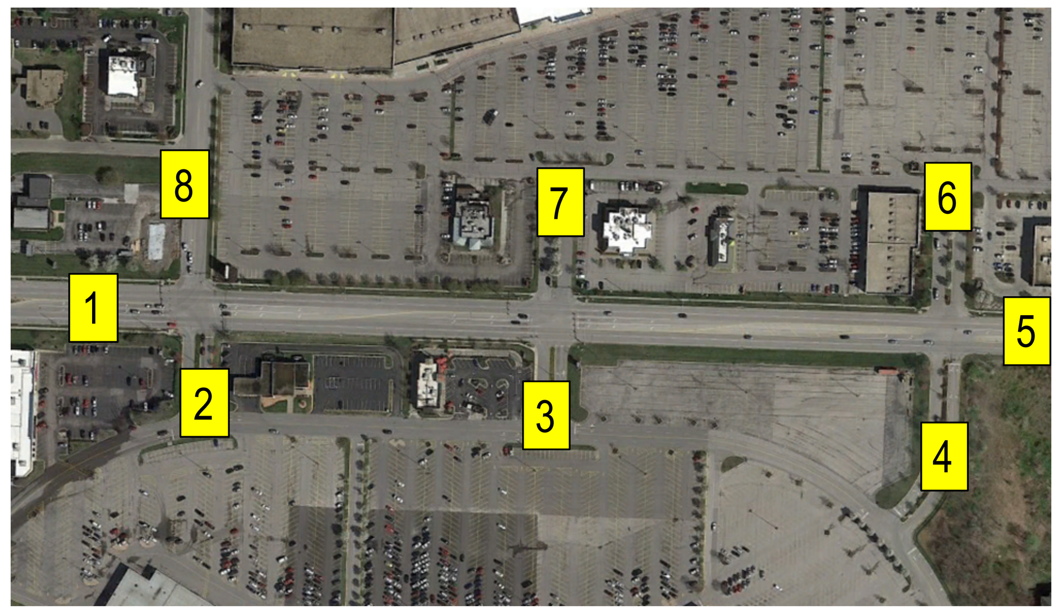
Proposed Design: The consolidated intersection design

## Methodology: Operational Analysis using Microsimulation

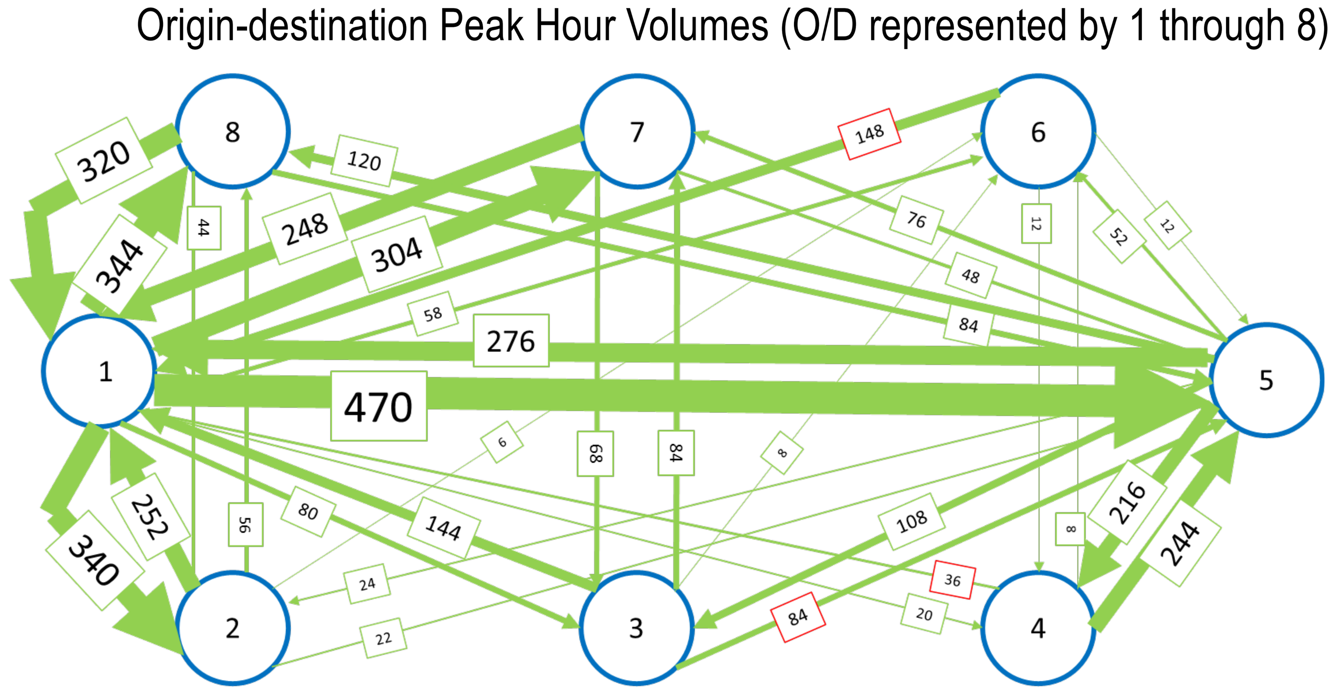
Microsimulation was used to test the hypothesized operational improvements of the consolidated intersection design. Vissim 8 was used as the microsimulation platform. A real-world site was selected to represent a baseline condition against which to test the proposed consolidated intersection. A calibrated microsimulation model was built for the base condition, and then a microsimulation model of the proposed design was built. The operational characteristics of each condition were gathered from the microsimulation and compared with a statistical analysis.

## Data Collection

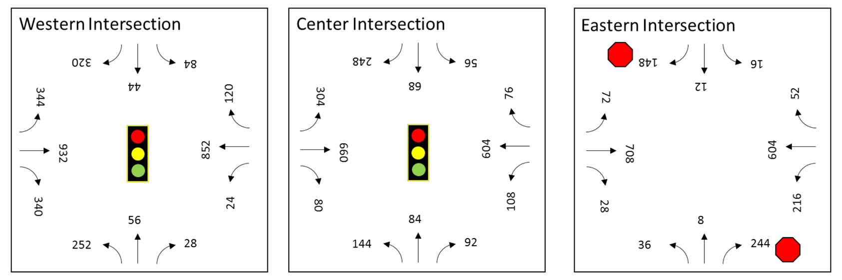
Test Site: 39th Street in Independence, Missouri




Origin-destination Peak Hour Volumes (O/D represented by 1 through 8)

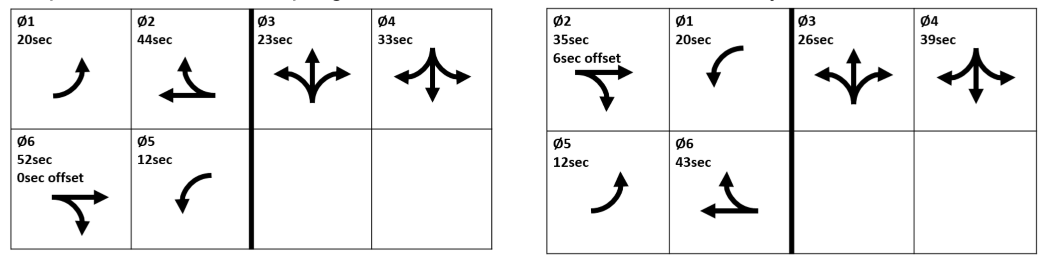


Balanced Turning Movement Counts: Peak Hour




Phasing Diagrams for Base Condition

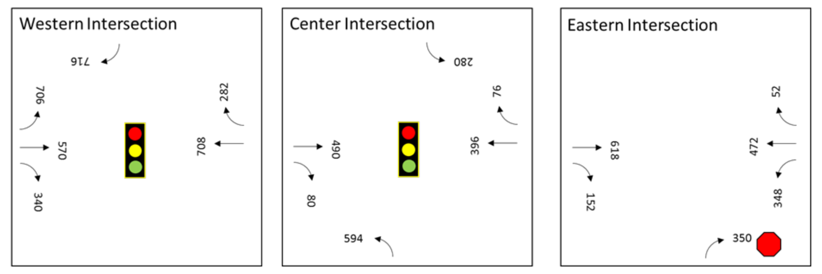
Signal timing plan was optimized using the peak hour demand volumes shown above to provide bidirectional progression and minimal side-street delay.



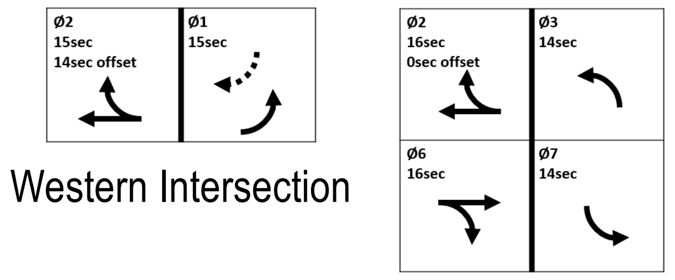
Western Intersection

Center Intersection

Turning Movement Counts Adjusted for Consolidated Intersection Design




Phasing Diagrams for Consolidated Intersection

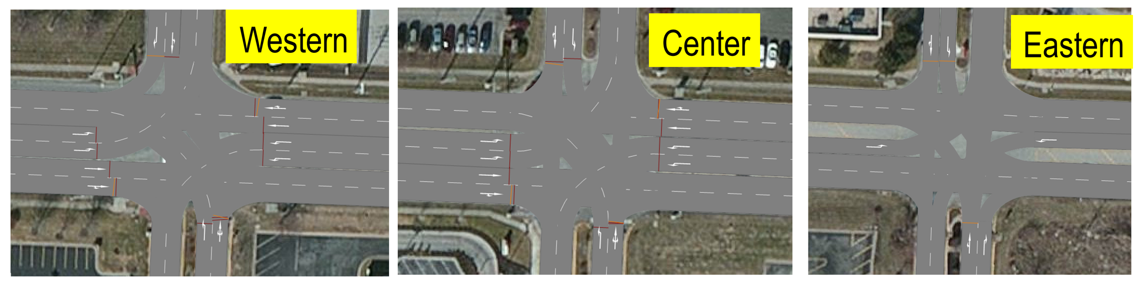


Western Intersection

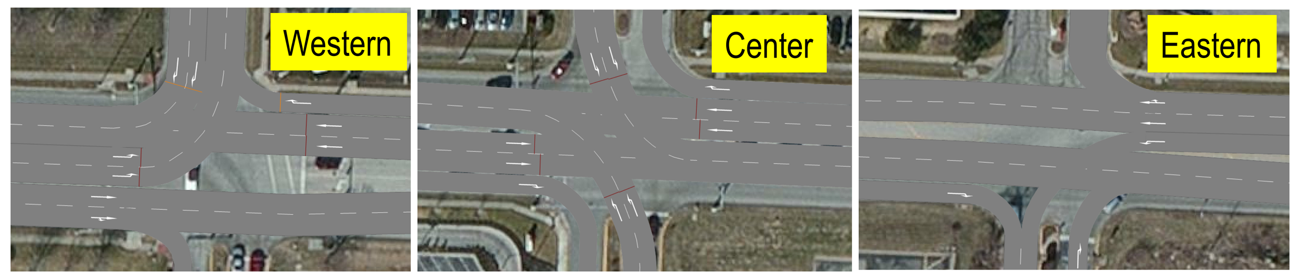
Center Intersection

## Microsimulation Models

### Base Design




### Consolidated Intersection Design




Each simulation model was run 100 times with different random seeds. Each model ran for 4,500 seconds, but data was collected only for the time period 900 to 4,500 seconds (1 hour). Travel time and delay data were collected for each vehicle and grouped by each route. Travel time for each vehicle started at a point 240 ft upstream of the first intersection traversed on the route, and the travel time ended for each vehicle at a point 120 ft downstream of the last intersection traversed.

## Statistical Analysis of Simulation Results

| Base O-D Route | CID O-D Route | Travel Time Change (s/veh) | Percent Change | P-value | Delay Change (s/veh) | Percent Change | P-value |
|---|---|---|---|---|---|---|---|
| 4 to 6 | 3 to 8 | 22.5 | 70.8% | <.01 | 4.1 | 26.7% | <.01 |
| 6 to 4 | 7 to 4 | 19.0 | 69.8% | <.01 | -0.1 | -0.8% | 1 |
| 4 to 1 | 3 to 1 | -37.0 | -40.0% | <.01 | -25.9 | -53.9% | <.01 |
| 4 to 5 | 4 to 5 | -5.0 | -20.5% | <.01 | -3.0 | -48.2% | <.01 |
| 6 to 5 | 7 to 5 | 14.3 | 53.9% | <.01 | -1.3 | -11.3% | 0.51 |
| 6 to 1 | 8 to 1 | -68.9 | -77.7% | <.01 | -38.7 | -83.6% | <.01 |
| 3 to 5 | 4 to 5 | -52.4 | -73.2% | <.01 | -36.5 | -91.9% | <.01 |
| 3 to 6 | 4 to 5 | -23.3 | -30.0% | <.01 | -23.6 | -54.6% | <.01 |
| 3 to 7 | 3 to 8 | -22.0 | -28.8% | <.01 | -35.9 | -64.7% | <.01 |
| 3 to 1 | 3 to 1 | -74.3 | -57.2% | <.01 | -74.0 | -77.0% | <.01 |
| 7 to 5 | 7 to 5 | -35.3 | -46.3% | <.01 | -35.6 | -78.1% | <.01 |
| 7 to 4 | 7 to 4 | -33.5 | -42.0% | <.01 | -34.5 | -74.7% | <.01 |
| 7 to 3 | 7 to 4 | -19.8 | -30.0% | <.01 | -37.6 | -76.3% | <.01 |
| 7 to 1 | 8 to 1 | -59.6 | -75.1% | <.01 | -43.9 | -85.3% | <.01 |
| 2 to 5 | 4 to 5 | -107.6 | -84.8% | <.01 | -77.3 | -96.0% | <.01 |
| 2 to 6 | 3 to 8 | -73.1 | -57.4% | <.01 | -59.3 | -75.1% | <.01 |
| 2 to 8 | 3 to 8 | -23.9 | -30.5% | <.01 | -38.3 | -66.1% | <.01 |
| 2 to 1 | 3 to 1 | -18.2 | -24.7% | <.01 | -31.3 | -58.6% | <.01 |
| 8 to 5 | 7 to 5 | -74.7 | -64.6% | <.01 | -63.8 | -86.5% | <.01 |
| 8 to 2 | 7 to 4 | -18.7 | -28.7% | <.01 | -41.6 | -78.1% | <.01 |
| 8 to 1 | 8 to 1 | -5.6 | -22.0% | <.01 | -5.5 | -42.2% | <.01 |
| 5 to 4 | 5 to 4 | 1.8 | 8.4% | <.01 | 1.0 | 20.0% | <.01 |
| 5 to 6 | 5 to 6 | 0.1 | 0.3% | 1 | -0.02 | -2.3% | 1 |
| 5 to 3 | 5 to 4 | -69.2 | -75.3% | <.01 | -52.6 | -90.0% | <.01 |
| 5 to 7 | 5 to 7 | -23.2 | -40.7% | <.01 | -23.2 | -96.0% | <.01 |
| 5 to 2 | 5 to 4 | -89.6 | -79.8% | <.01 | -59.8 | -91.1% | <.01 |
| 5 to 8 | 5 to 8 | -28.1 | -33.4% | <.01 | -27.9 | -71.6% | <.01 |
| 5 to 1 | 5 to 1 | -27.5 | -33.6% | <.01 | -27.4 | -72.3% | <.01 |
| 1 to 2 | 1 to 2 | -14.3 | -42.0% | <.01 | -14.3 | -88.4% | <.01 |
| 1 to 8 | 1 to 8 | -44.7 | -64.1% | <.01 | -44.8 | -82.8% | <.01 |
| 1 to 3 | 1 to 3 | -23.3 | -41.0% | <.01 | -23.8 | -90.6% | <.01 |
| 1 to 7 | 1 to 8 | -58.8 | -70.2% | <.01 | -43.9 | -82.5% | <.01 |
| 1 to 4 | 1 to 4 | -22.5 | -29.4% | <.01 | -23.1 | -74.1% | <.01 |
| 1 to 6 | 1 to 8 | -54.2 | -68.5% | <.01 | -25.1 | -73.0% | <.01 |
| 1 to 5 | 1 to 5 | -22.9 | -31.5% | <.01 | -22.8 | -75.3% | <.01 |

With the exception of unsignalized right turns at the periphery of the study area, all non-displaced routes showed a statistically significant reduction in travel time and delay. Travel time and delay changes are reported for displaced routes, but these measures only take into account the "in-network" portion of the trips. The in-network reduction of travel time was 31.9 s/veh (-48.5%), and the in-network reduction of delay was 29.1 s/veh (-76.4%).

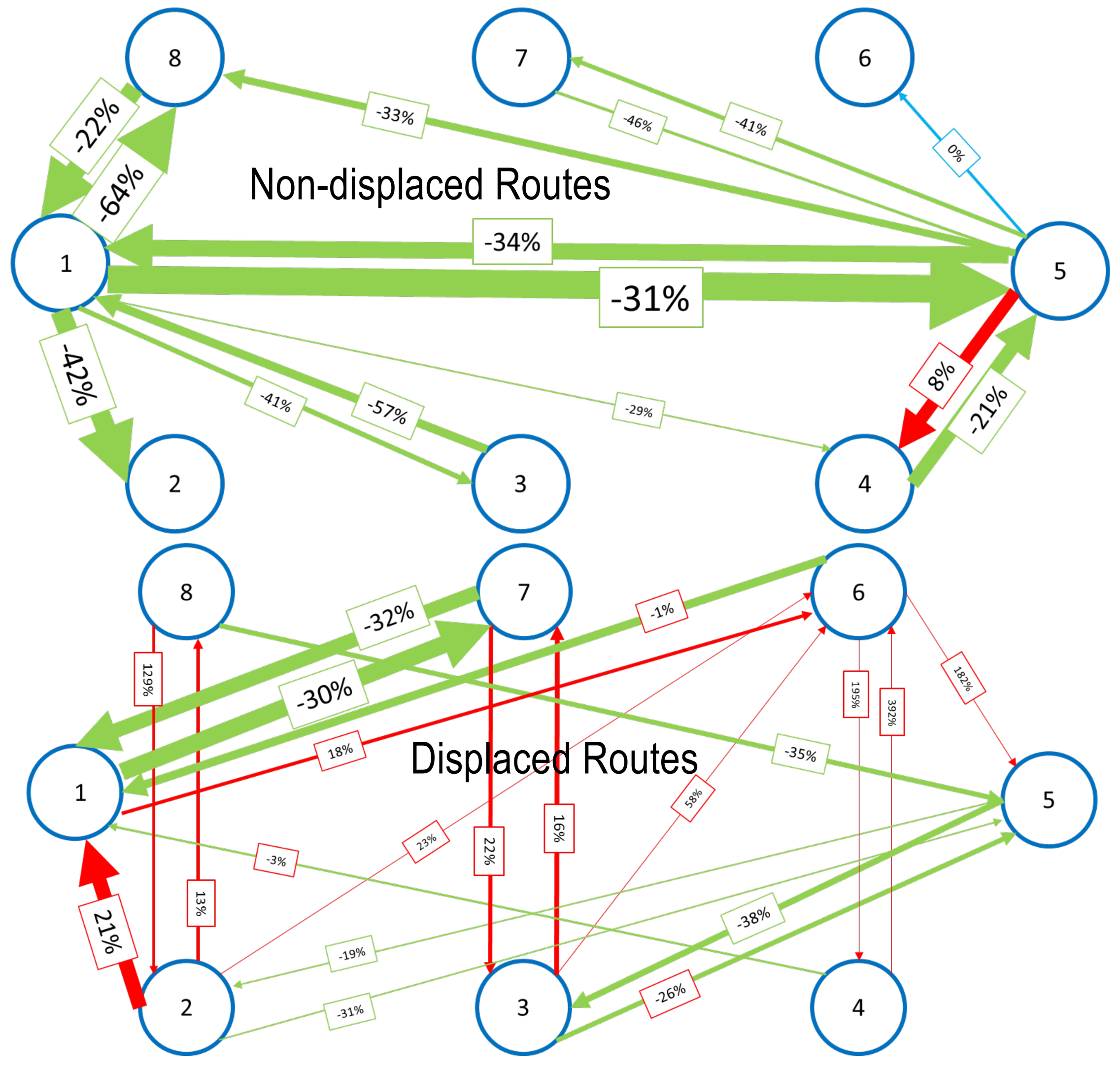
Displaced routes must travel within the commercial development, but the simulation did not model this. The travel time and delay of vehicles within commercial developments is highly variable, but some common ground must be established in order to compare the before condition to the proposed design. An average speed of 15 mi/h within the commercial development was used to adjust the travel time of displaced routes (see below).

Non-displaced routes: The results can be interpreted from this table directly

Change in travel time or delay was not statistically significant

## Adjusted Change in Travel Time

Percent change in travel time adjusted to include extra travel time within commercial developments. Assume average speed within commercial development of 15 mi/h. Wider lines represent higher volume routes.




## Conclusions and Future Research

| Overall Effectiveness based on Travel Time Reduction | | Commercial Development Speed | |
|---|---|---|---|
| Weighted Average Travel Time, Base Condition | In-network | Assume 15 mi/h | Assume 10 mi/h |
| Weighted Average Change in Travel Time | -31.9 s/veh | -16.2 s/veh | -8.3 s/veh |
| Percent Change | -48.5% | -24.6% | -12.6% |
| Weighted Average Change in Delay | -29.1 s/veh | -- | -- |
| Percent Change | -76.4% | -- | -- |

**The overall reduction of in-network travel time is 31.9 s/veh (48.5%), and 29.1 s/veh (76.4%) for in-network delay. The overall reduction in adjusted travel time, assuming a 15 mi/h speed of vehicles within commercial developments, is 16.2 s/veh, resulting in a 24.6% decrease in travel time. Even if a 10 mi/h speed is assumed, travel time is reduced by 8.3 s/veh (12.6%).**

More research is needed to understand travel time and delay incurred by the extra travel required for displaced routes within commercial developments. A sensitivity analysis is currently in progress to determine the applicability of the consolidated intersection design for specific site conditions, however it seems that this design may not be suited for sites with heavy cross-corridor volume.

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