



## RESEARCH SERVICES SECTION

# TECHNICAL SUMMARY

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### PROJECT COST:

\$167,886



This intersection at SR-371 and CR77/49 was monitored during peak time for turn lane queue length and traffic conditions.

# How to Determine Optimal Turn Lane Lengths

## What Was the Need?

A key task in designing roads is determining the optimal length for turn lanes at busy intersections. Mn/DOT designers typically rely on a combination of engineering judgment and the [Mn/DOT Road Design Manual](#) for guidance in performing the necessary calculations. While this approach has produced many successful projects through the years, designers now recognize a need to update the manual. Specifically, better guidance is needed regarding the variables that must be considered when calculating optimal turn lane lengths, such as traffic speed, traffic volume and heavy vehicle mixture.

It may be possible to economize turn lane construction, improve turn lane and intersection safety, and reduce travel delays and emissions in urban roadway networks by optimizing turn lane lengths based on these variables and additional parameters such as deceleration rates, vehicle classes, traffic behavior parameters, land availability, level of service and signal timing.

One difficulty in determining the optimal length of a turn lane, or, specifically, the storage bay portion of the lane where cars queue up while waiting to turn, is accurately predicting the expected queue length given the characteristics of the intersection and the traffic.

## What Was Our Goal?

One goal of this study was to validate and quantify the influence of eight variables on turn lane operation that were of particular interest to Mn/DOT designers: speed, through volume, opposing volume, turning volume, crossing volume, heavy vehicle through percent, heavy vehicle turning percent and grade.

Another objective was to develop tools for Mn/DOT that can factor in these variables to accurately predict the length of the turn queue at standard types of intersections.

## What Did We Do?

A key task for researchers was to develop tools for predicting the 95th percentile turn queue length, which has a 95 percent probability of not overflowing onto the main line during peak hours. This was posited as the target length for a turn lane's storage bay.

Researchers and Mn/DOT selected 10 intersections for study in the Minneapolis-St. Paul area and rural Minnesota that exhibited a variety of variables believed to influence turn lane operation. Researchers documented each intersection, then analyzed one hour of peak time traffic data from their video footage that included queue lengths and variables such as traffic volumes and number of heavy vehicles on through lanes and on left and right turn lanes. They computed average, 95th percentile and maximum queue lengths in two-minute intervals for all left and right turns. This data was tabulated and used to build computer models of each intersection that emulated traffic conditions.

Researchers then performed more than 14,000 simulations on the computer models to determine the mean value of the average, maximum and 95th percentile queue lengths for each intersection. The parameters used were combinations of the eight variables of interest to Mn/DOT designers. All data was tabulated, and researchers used a standard technique called multivariate regression analysis to assess the influence of each variable on queue length. Regression models were generated on the modeled intersections that predicted the average queue length for each turn lane with a high level of accuracy.

*“Data from this study will improve our ability to determine optimal turn lane length under differing types of conditions.”*

–Glen Ellis,  
Mn/DOT Metro District  
Design Engineer

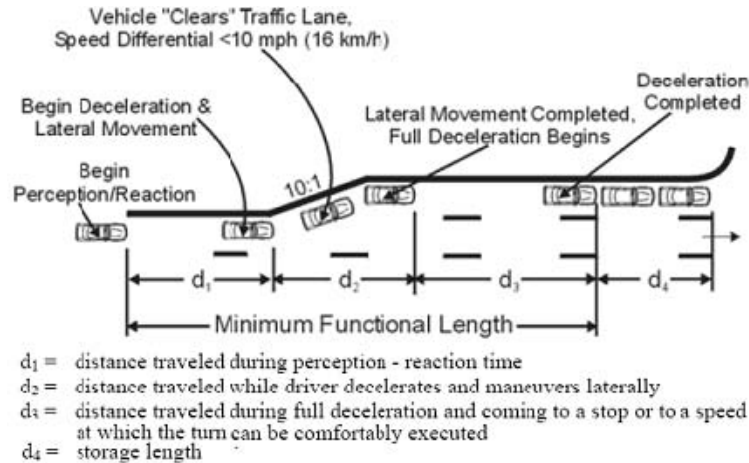
*“This research provides the practitioner with simple equations for solving the complicated problem of determining optimal turn lane length.”*

–Thomas Schnell,  
Associate Professor,  
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This diagram from the *Traffic Engineering Handbook* shows the parts of a right turn lane that a designer must consider: Not only must the storage bay where cars wait be long enough, but cars must have enough time to decelerate into it.

Based on the results of their analysis, researchers developed two toolkits of user-friendly equations for Mn/DOT designers. One calculates average queue length for 14 types of single-lane turns at two-lane and four-lane intersections. The other calculates the 95th percentile queue length (the target storage bay length) for seven types of single-lane turns at two-lane and four-lane intersections.

### What Did We Learn?

This study quantified the level of influence that several variables have on turn lane operation, and researchers used these to develop equations that should be helpful for future turn lane design.

The most significant factors were through volume, opposing volume (for left turns), crossing volume (for right turns), left and right turn volumes, heavy vehicle turn percent for left and right turns, and speed. Heavy vehicle through volume was not found to have a significant impact on turn lane operation, and no through volume appeared to significantly impact turn lane operation for free right turns at unsignalized intersections. The street's grade factor likewise did not appear to affect the left and right turn queue length.

### What's Next?

The project technical advisory panel performed a preliminary review of the study results and will next determine how Mn/DOT can best use the project report and what specific implementation steps are warranted. The goal will be to integrate the insights of this study into the *Mn/DOT Road Design Manual* to make it as easy as possible for design personnel to compute turn lane lengths at particular intersections.