

Raised Median versus TWLTL on Four Lane Roads in North Carolina

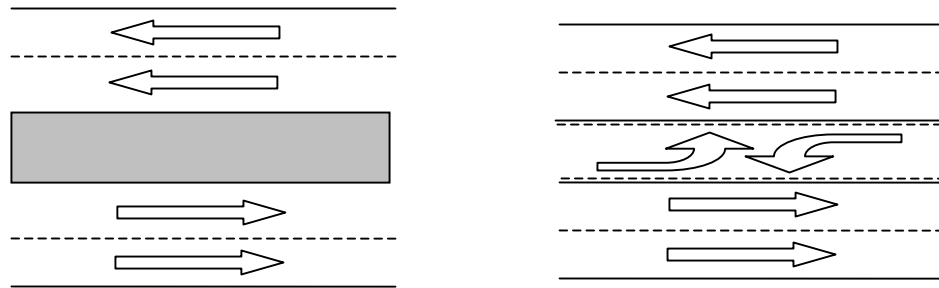
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2004
Raleigh, NC

Background

- Much controversy surrounds the issue of median-divided highways



- Solid research was needed to evaluate the ramifications of median designs

Project Objectives

- Midblock Segments
 - Collision Prediction Models
- U-Turns at Signalized Intersections
 - Safety Impacts
 - Operational Impacts

Objective – Midblock Segments

- To calibrate an empirical safety model for both four-lane median divided and five-lane with TWLTL segments
- Model based on:
 - Traffic Volume
 - Segment Length
 - Land Use
 - Driveway and Unsignalized Public Street Approach Density
 - Other parameters found to be significant

Site Selection

- NCDOT database containing all four-lane and five-lane segments in North Carolina
 - 5,917 total segments
- Filtered for desirable characteristics
 - 429 segments met requirements
- Randomly selected 200 segments for site visits
 - 100 of each cross-section

Desirable Characteristics

- Raised median or TWLTL
- Length of at least $\frac{1}{4}$ mile
- 35 – 45 mph speed limit
- ADT at least 20,000 vehicles per day
- No signalized intersections within segment
- No widening or major changes within last three years

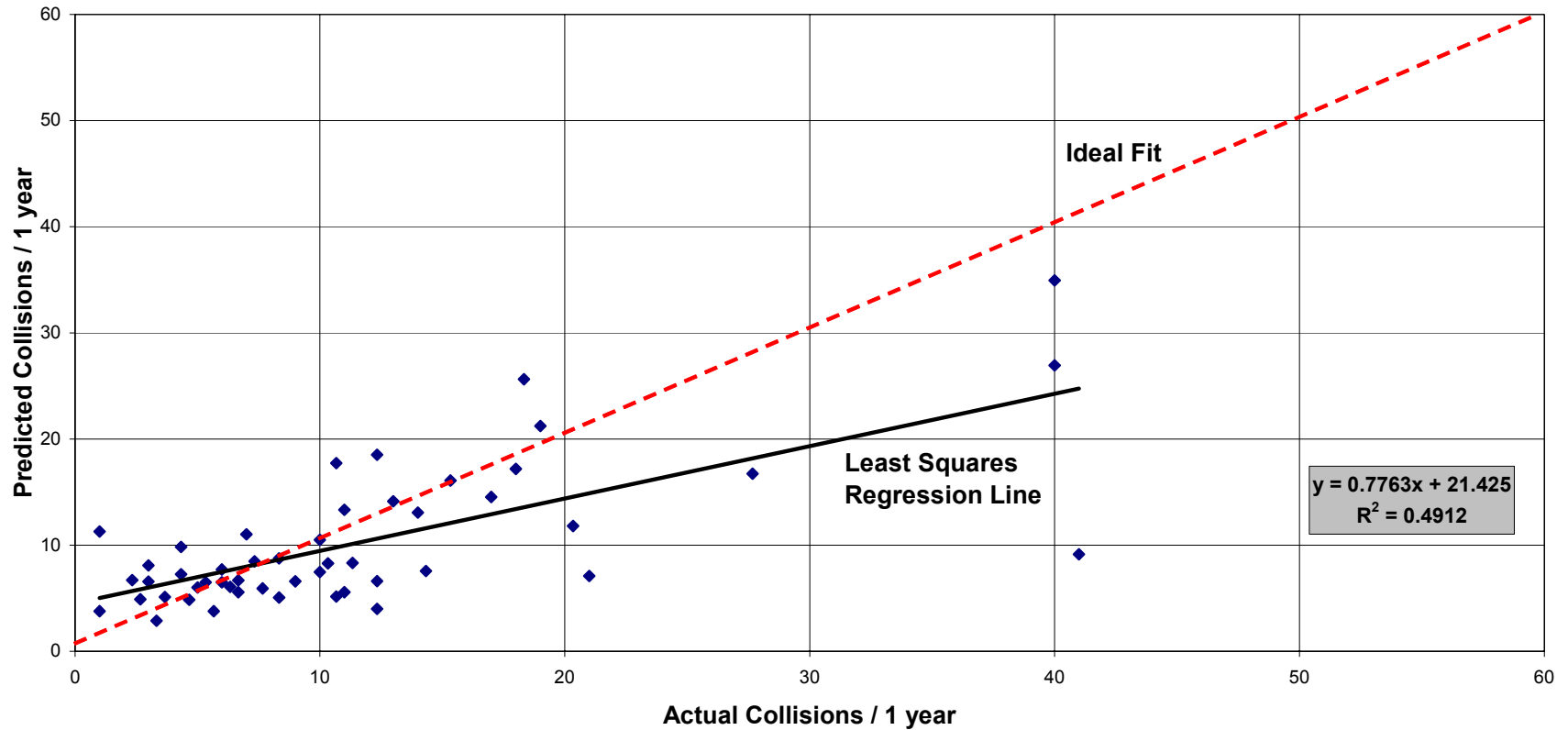
Collected Data

- 143 segments were include in the study
 - 62 raised median segments
 - 81 TWLTL segments
- Segments were rejected during site visits due to:
 - Incorrect cross-section
 - Speed limit too high or too low
 - Signal in middle of segment – segment too short

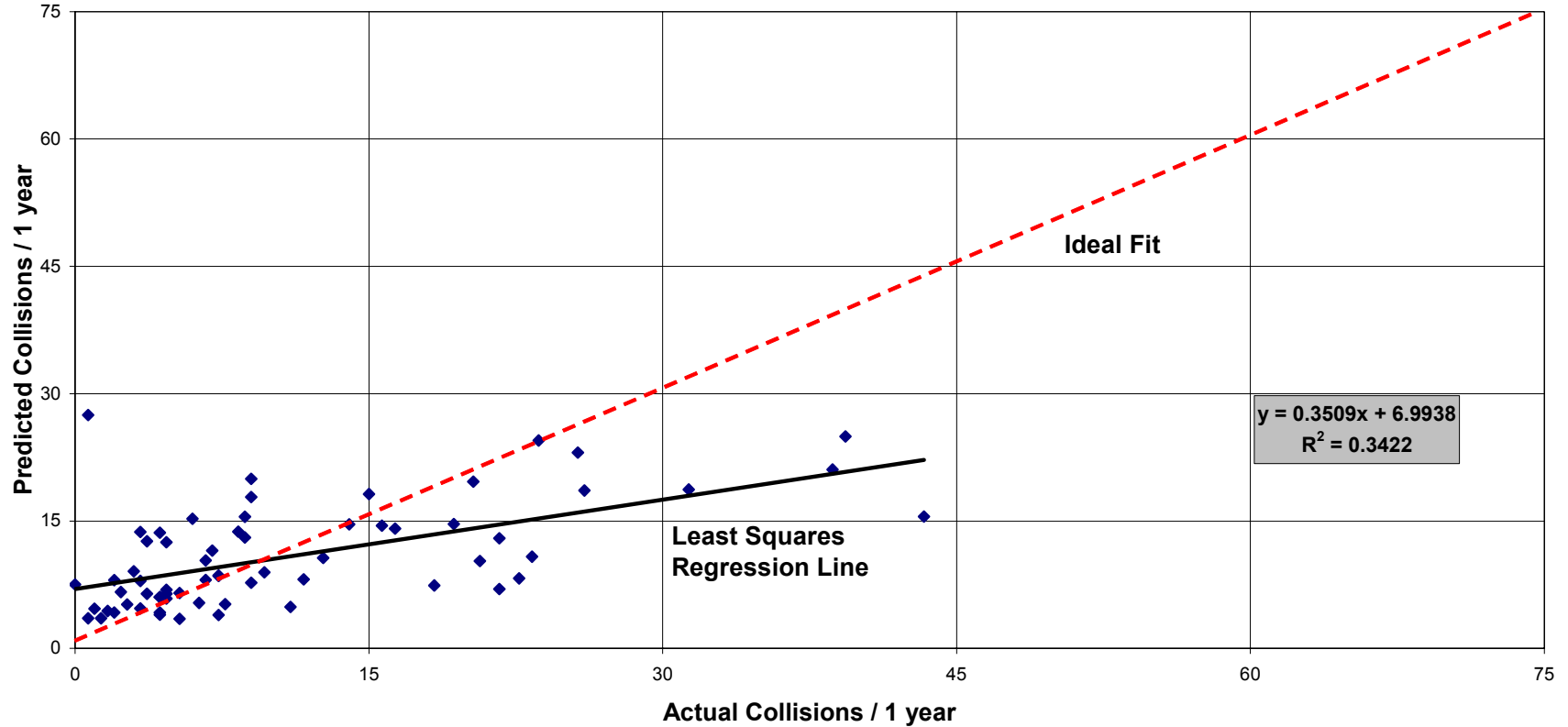
Significant Variables

- Using SAS[®], collisions were found to be significantly related to:
 - ADT, vehicles per day
 - Length, feet
 - Approach Density, approaches per mile (two-way total)
 - Only for Business / Office Land Use
 - Predominant Land Use
 - Residential / Industrial
 - Business / Office

Fit of Raised Median Model



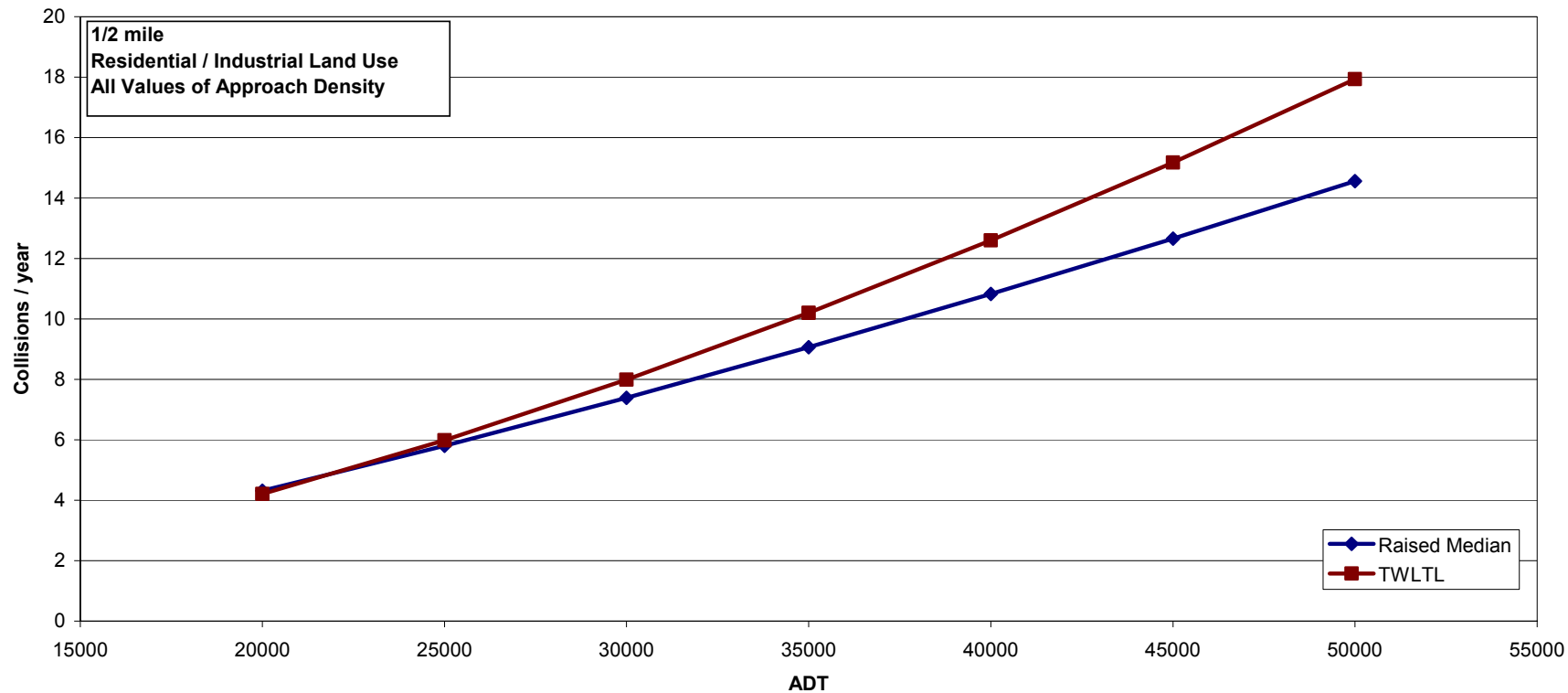
Fit of TWLTL Model



Limitations of Models

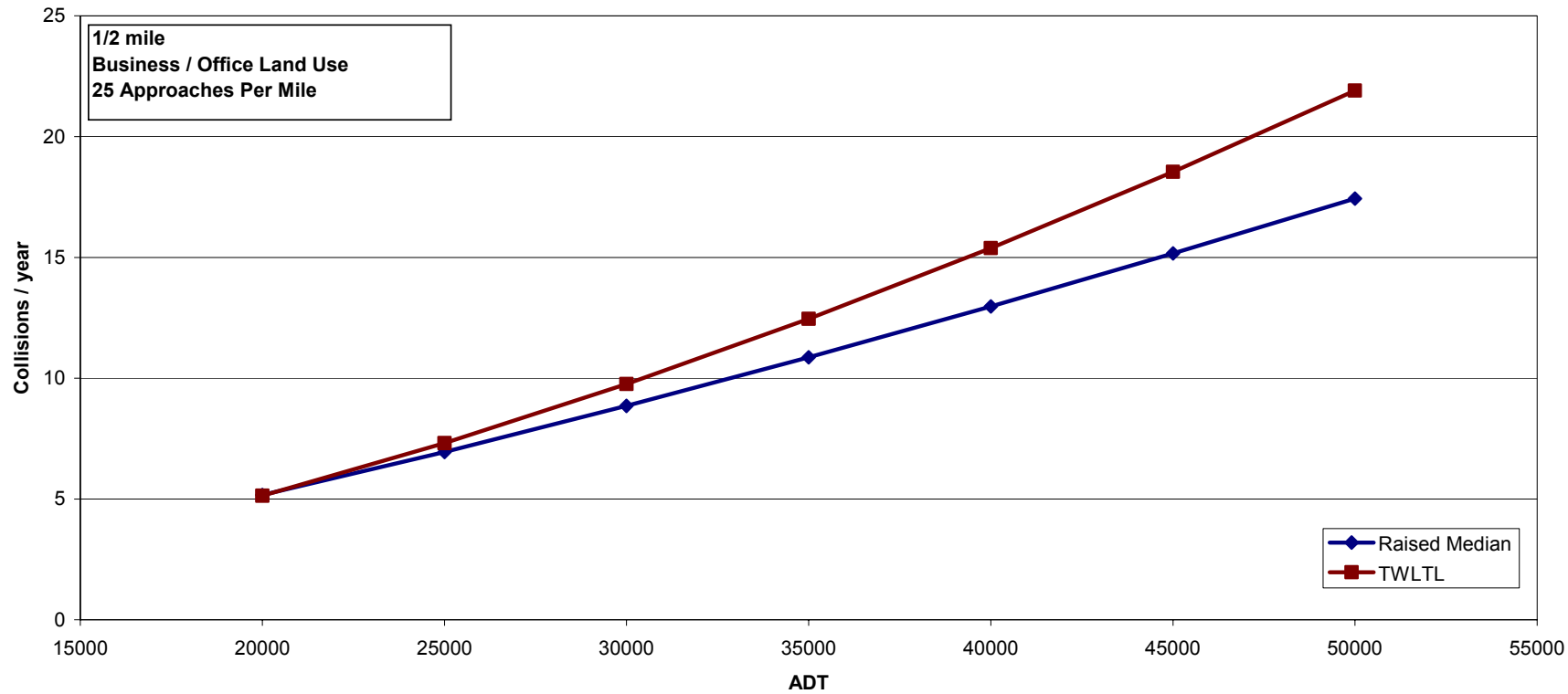
- ADT Range:
 - 20,000 – 50,000 vpd
- Land Uses:
 - Residential / Industrial
 - Business / Office
- Approach Density:
 - 0 – 90 approaches per mile
- Segment Length:
 - 1,320 – 6,000 feet

Residential / Industrial Land Use



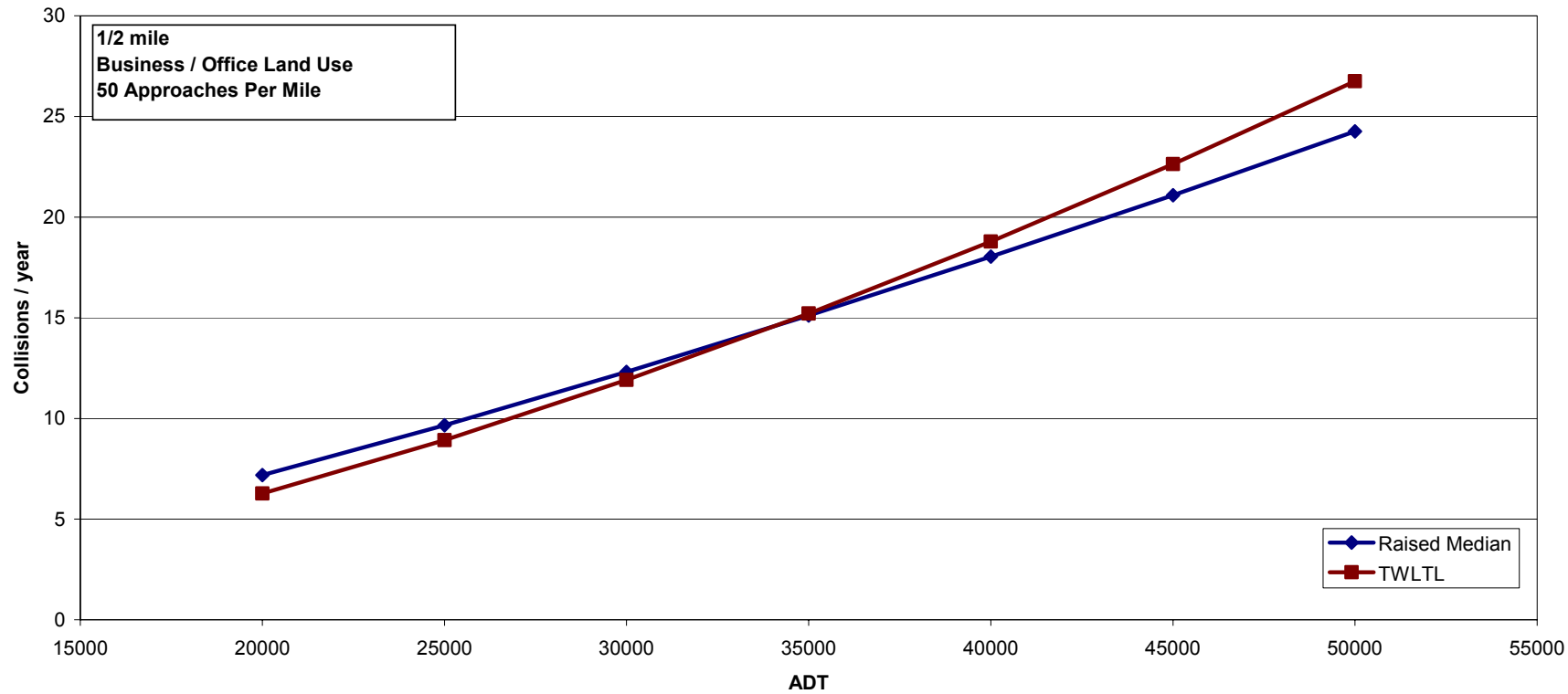
1/2 Mile Segment, All Values of Approach Density

Business / Office Land Use



1/2 Mile Segment, 25 Approaches per Mile

Business / Office Land Use



1/2 Mile Segment, 50 Approaches per Mile

Results

- For predominantly residential or industrial land uses, raised median segments are safer regardless of volume or approach density
- For predominantly business or office land uses, it depends on ADT and approach density
 - Raised median improves with higher ADT
 - TWLTL improves with higher approach density

Conclusions

- Segments with raised medians are generally associated with fewer collisions than those with TWLTLs
- For business and office land uses with low traffic volumes and high approach densities, TWLTL segments may be slightly safer

U-Turns at Signalized Intersections

- Operational impacts
- Safety impacts

Operational Impacts: Site Selection

- Criteria
 - Located in North Carolina
 - Sufficient percentage of U-turns
 - Sufficient queue length
- Visited over 100 sites
- Final selection was 14 intersections in Raleigh, Cary, Chapel Hill, Winston-Salem, and Charlotte

Operational Impacts: Studies

- Team of 3 observers
 - Headway measurement
 - Volume count and conflict observation
 - Delay measurement
- Each site was observed for 6 to 9 hours
- Average of 400 eligible left turn queues observed per site

U-Turn Adjustment Factor to Saturation Flow Rate

- Average change in saturation flow was calculated for each site

$$\text{Adjustment Factor} = \frac{\text{Average Observed Saturation Flow Rate}^*}{\text{Comparison Saturation Flow Rate}^{**}}$$

* Average observed rate was calculated using headways of vehicles in positions 5 or greater.

** Comparison saturation flow rate was calculated using headways of vehicles positions 5 or greater **and** unaffected by U-turns.

Significance of Intersection Characteristics on U-turn Adjustment Factor

- Significant
 - Presence of protected right turn overlap
 - Number of left turn lanes
- Insignificant
 - Median width
 - Receiving width
 - Conflicting right turn volume
 - Number of lanes receiving

Significance of characteristics was analyzed using t-tests and linear regression analysis at a 90% confidence level.

U-Turn Adjustment Factor

- Multivariate linear regression

$$f_{\text{uturn}} = 1.0 - 0.0018 \cdot \text{UTURN} - 0.0015 \cdot \text{UTURN} \cdot \text{OVERLAP}$$

where:

- f_{uturn} = saturation flow reduction factor for an exclusive left turn lane with protected phasing
- UTURN = average U-turn percentage in the exclusive left turn lane (or inside turn lane if double left turn lanes)
- OVERLAP = yes/no variable, 1 if conflicting right turn is protected overlap, 0 if no protected right turn overlap

U-Turn Adjustment Factor

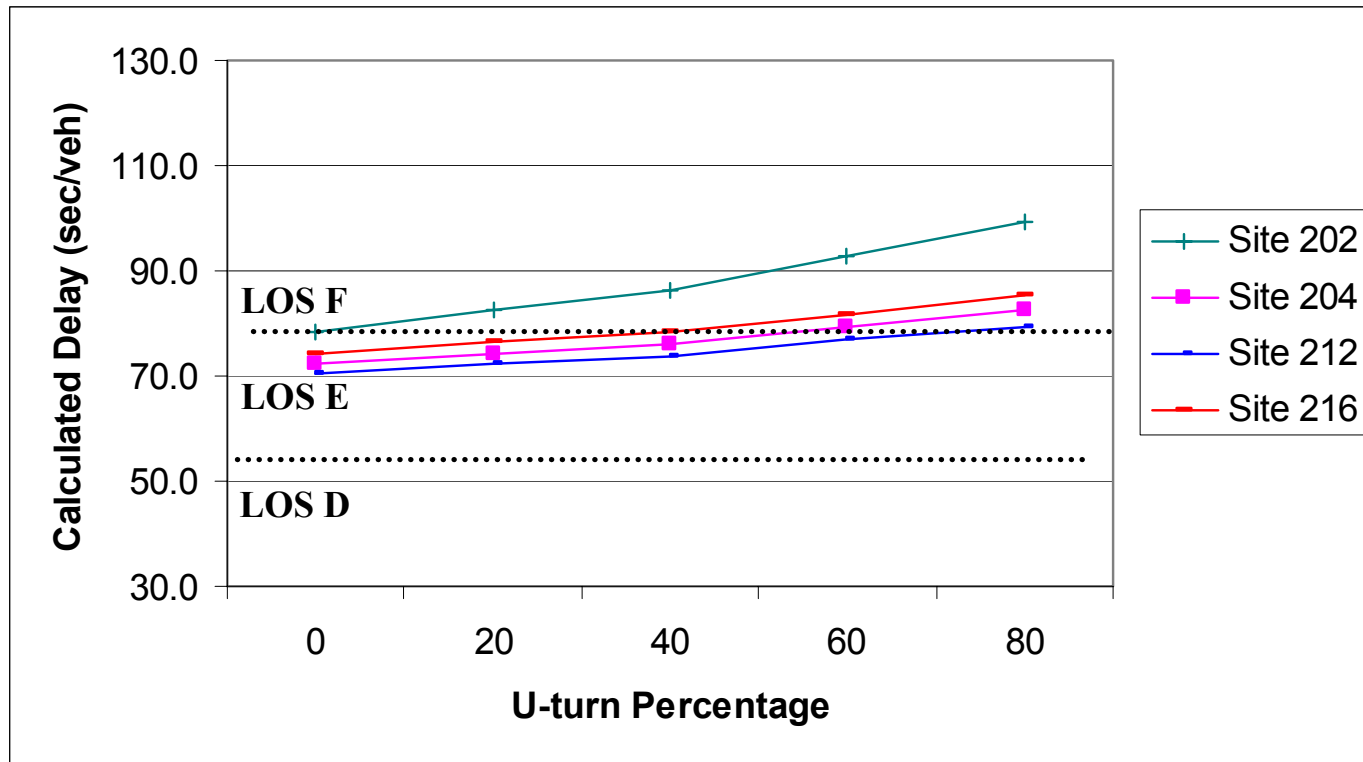
- Regression equation has adjusted R^2 of 0.75
- Coefficients significant at 99% confidence

Using the U-turn Adjustment Factor

- Use for analysis of an exclusive left turn lane with protected phasing
- Calculate f_{uturn} using regression equation
- If double left turn lane, use weighted f_{uturn}
 - Weight according to lane usage
- Include f_{uturn} in delay/LOS calculations
 - Does not replace HCM factor of 0.95 for exclusive left turn lane

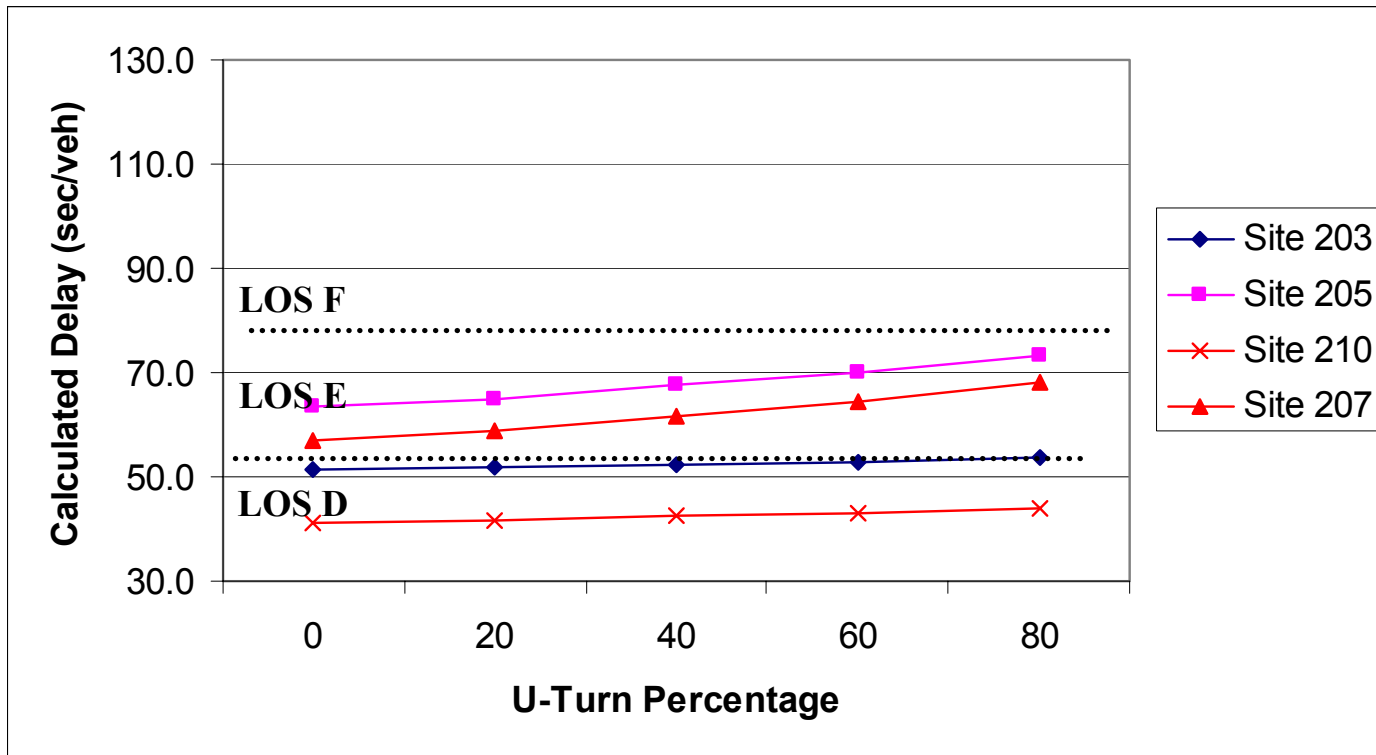
Sensitivity of Lane Performance to U-turn Percentage

- Sites with *no* protected right turn overlap, single left turn lane



Sensitivity of Lane Performance to U-turn Percentage

- Sites *with* protected right turn overlap, double left turn lane



Safety Impacts: Site Selection

Selection Criteria:

- Located in North Carolina
- Signalized
- Protected or permitted left turn
- Median divided
- Two lanes receiving
- No U-turn prohibition

Selected Sites:

- 54 sites randomly selected
 - 24 sites recommended as U-turn “problem sites”
-
- 78 total sites

Collision Form

14 DIAGRAM *Toward McCullough Dr*

Indicate North

N Tryon St.

U-turn must yield sign

Harris Blvd.

Unit 1 was Traveling Parked Facing N S E W on *N Tryon St.*

Unit 2 was Traveling Parked Facing N S E W on *N Tryon St.*

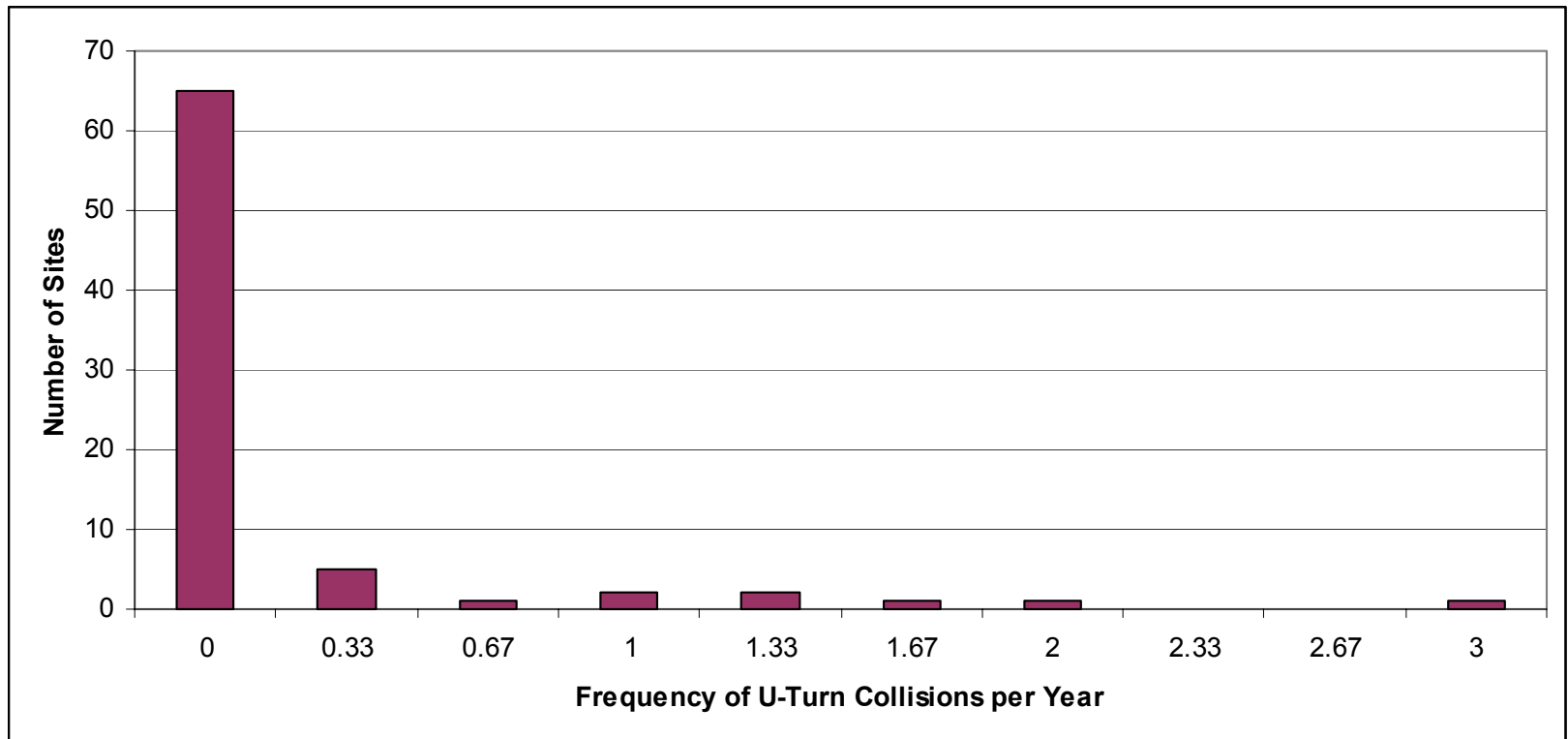
15 NARRATIVE Include pertinent and unusual aspects, which are not listed elsewhere on the form.

The driver of veh #1 states that she was making the U-turn and didn't see veh #2 making a right turn & they struck. XRD

The driver of veh #2 states that as he was making the right turn veh #1 made a u-turn & they struck. XRD.

Safety Impacts: Results

- 65 out of 78 sites had no U-turn collisions in spite of biased selection



Safety Impacts: Results

- Significant factors in U-turn collisions
 - Protected right turn overlap
 - Double left turn lanes
 - High turning volumes

Conclusions

- Operational Impacts of U-Turns
 - Most strongly affected by U-turn percentage in left turn lane and right turn overlap from cross street
 - Slight saturation flow decrease for increases of 20-30% U-turns
 - Increase in U-turns by 70% or more will generally cause a drop in performance by one level of service

Conclusions

- Safety Impacts of U-Turns
 - Minimal overall impact on safety
 - Most sites had no U-turn collisions
 - Significant factors were right turn overlap, double left turn lane, and high turning volumes

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