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**RESEARCH PROJECT TITLE**

Evaluation of Truck and Agricultural Vehicle Behavior at Reduced Conflict Intersections

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# Evaluation of Truck and Agricultural Vehicle Behavior at Reduced Conflict Intersections

tech transfer summary

This study evaluated truck and agricultural vehicle operational behavior at a set of Minnesota's reduced conflict intersections (RCIs) and found no evidence that validated concerns expressed about large vehicle operation at these intersections.

## Problem Statement

At-grade intersections along rural multi-lane roadways present challenging conditions for drivers in judging gaps between high-speed traffic from two different directions. Driver comprehension and understanding of whether to stop in crossing the median or cross the intersection in one movement have been shown to be problematic for drivers in rural settings.

## Background

In the US, some states have begun to address rural high-speed intersection crashes by physically restricting minor-road crossing movements (left and through turns) to simplify driver decision-making in terms of gap acceptance (the extent to which drivers will be able to utilize a gap in traffic of a particular size or duration). These treatments are referred to in Minnesota as reduced conflict intersections (RCIs).

Within Minnesota's rural corridors, introduction of RCI design has been successful in preventing severe crashes; however, the unusual design has been met with some apprehension from operators of agricultural equipment and large trucks. This, in combination with a resistance to the unfamiliar, has created a desire for more information regarding RCI configuration safety impacts for these types of vehicles.



*Video capture of large truck after U-turn maneuver at one of the reduced conflict intersections with driver in on-coming lane of traffic slowing down*

Even though RCIs eliminate right-angle crashes, which are the most severe crossing conflicts at rural high-speed intersections, concerns have been raised that, as large trucks are required to make U-turn maneuvers, they occupy the travel lanes for longer than would be required for a left-turn or through maneuver from the minor road, and, consequently, are exposed to on-coming high-speed vehicles for longer.

In response to these concerns, this study collected and evaluated large vehicle operational behavior at a set of RCIs and at similar standard control intersections in Minnesota. The researchers collected data in 2015 using a portable video trailer array and metrics on truck turning movements at three RCI intersections in Minnesota and three similar non-RCI intersections, which were proximate to the RCI intersections. The researchers compared travel time, conflicts, and other metrics for this study.

## Results

The research team reduced video data and compared metrics between RCI and control intersections as noted below.

## Exposure

One of the main concerns expressed about RCIs is that large trucks/vehicles would take a significant amount of time to enter the traffic stream during U-turn maneuvers. This may result in large trucks/vehicles occupying the oncoming travel lanes for an increased period of time, which could lead to conflicts.

The researchers evaluated exposure time (when a vehicle occupies a non-travel lane while waiting for a gap or to complete a maneuver) for both RCI and control intersections. They divided exposure into two parts for the RCI intersections (merge and U-turn).

At the Cologne, Minnesota locations, the average exposure time at the RCI was 6.7 seconds for the merge and 7.0 for the U-turn, while the average exposure time at the control intersection was 10.9 seconds. Collectively, the total exposure time at the Cologne RCI was 13.7 seconds, which was about 2 seconds more than at the control intersection. However, the two-stage movement (merge and U-turn) breaks the exposure into two stages, minimizing the duration that a vehicle is exposed at one time. In addition, truck exposure during the merging maneuver is more likely to result in a rear-end crash or sideswipe and exposure during the U-turn is more likely to result in a sideswipe, while a right-angle crash is the more likely result of a vehicle conflict for the control intersection. The average standard deviation time was also much greater for the control intersection, which suggests that a number of trucks had much longer exposure times.

The Vermillion and Wilmar, Minnesota sites had a much smaller sample size, but showed similar results. Consequently, concerns that the U-turn causes excessive exposure as large trucks complete the maneuver are unfounded. Anecdotal evidence also suggests that large trucks present a safety hazard at regular intersections because many were noted blocking lanes for an extended period as their drivers attempted to make through or left-turn maneuvers in two stages.

## Queuing and Travel Time

The researchers also evaluated time spent in the queue while a vehicle was waiting for a gap. Queue time at the Cologne RCI was about 9 seconds for both the merge and U-turn locations and about 18 seconds at the control. Although the collective queue time was similar for both types of intersections, queue time for each individual maneuver at the RCI was about half the queue time of the control intersection, and drivers waiting for a significant period before finding an acceptable gap are more likely to accept a smaller gap.

The researchers also computed travel time and included run time, queue time, merge time, and turning maneuver time. As expected, travel time was significantly longer at the Cologne RCI (72 versus 29 seconds). The researchers found similar results for the Wilmar and Vermillion locations.

## Evasive Maneuvers

Finally, the researchers compared evasive maneuvers (situations where an on-coming vehicle has to brake, slow, or change lanes to avoid the large vehicle crossing the intersection). The team recorded about 0.16 evasive maneuvers per large vehicle at the Cologne RCI merge point and 0.11 evasive maneuvers at the U-turn. At the Cologne control intersection, the researchers recorded 0.33 evasive maneuvers per large vehicle.



*Video capture of semi truck trailer blocking on-coming traffic for more than 20 seconds at one of the control intersections*

About 0.18 evasive maneuvers per large vehicle were reported at the Vermillion RCI merge and 0.15 evasive maneuvers per large vehicle at the U-turn. An average of 0.37 evasive maneuvers per large vehicle were noted at the Cologne control intersection. This included 5 near-crashes, while no near-crashes were noted at the RCI.

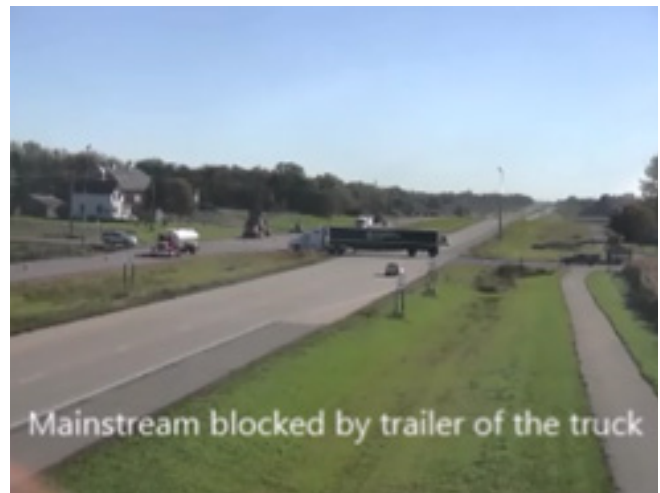
Opponents of RCIs had expressed the most concern about exposure and conflicts during the U-turn maneuver. As noted, the control intersections had a rate of evasive maneuvers that was almost double that of the U-turn locations.

## Conclusions

This study found no evidence that validated concerns expressed about large vehicle operation at RCIs. Exposure time was not increased at the U-turn locations and conflicts were lower than at control locations.

## Acknowledgments

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*Video capture of semi truck trailer blocking on-coming traffic for more than 30 seconds at one of the control intersections*