Public Abstract

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A top priority of transportation agencies in the United States is to improve safety of transportation facilities through the use of latest technology, innovative designs, procedural methods, and training practices to decrease fatalities, injuries, and property damage.

In order to continue improving roadway safety, different approaches such as alternative designs have been considered. Alternative designs for roadway facilities include J-turn for minor roads and high-speed expressway intersections, the Diverging Diamond Interchange (DDI) for freeway interchanges, or red light cameras for signalized intersections. There is limited research evaluating the safety effectiveness of recently implemented alternative designs and enforcement strategies. This dissertation focused on developing jurisdiction specific crash prediction models, calibrating existing models, and applying rigorous statistical methods to study the safety effectiveness of these new alternative treatments.

This dissertation found that the DDI design replacing a conventional diamond decreased crash frequency for all severities. Fatal and injury (FI) crashes experienced a 62.6% reduction. Property damage only (PDO) crashes reduced by 35.1% and total (TOT) crashes decreased by 47.9%. The collision diagram analysis of the DDI showed that the top two crash types were: 1) rear end collisions between right turning movements on the exit ramp at the intersection, and 2) rear end collisions on the outside crossroad approach leg to the ramp terminal. The DDI design traded a severe crash type, right angle left turn crash, with less severe rear end, sideswipe, and loss of control crash types. Wrong way crashes inside the crossroad between ramp terminals accounted for 4.8% of the FI crashes occurring at the DDI. This dissertation also examined the DDI safety effect on two adjacent facilities: speed change lanes and major signalized intersections. There is no strong evidence that DDIs impacted the safety of adjacent roadway facilities, either positively or negatively.

Another alternative intersection design studied in this dissertation was the J-turn intersection. The safety evaluation of the implementation of the J-turn replacing two-way stop-controlled intersections was effective at decreasing FI crashes by 63.8% and TOT crashes by 31.2%. The collision diagram analysis showed that the most recurrent crashes were sideswipe with 31.6% and rear end with 28.1% on the main road.

Red light running was also evaluated in this dissertation. The implementation of red light running cameras in Missouri resulted in a reduction of FI crashes by 7.4% and increase in PDO crashes by 3.8%. Additionally, right angle crashes were reduced across all severities, including 14.5% for FI crashes. Rear end crashes increased by 16.5% overall. The crash cost benefit results showed a positive net economic benefit of $35,269 per site per year in 2001 dollars (approximately $47,000 in 2015 dollars). It translated into an overall 5.0% economic crash cost benefit.

In addition to roadway safety, this dissertation also evaluated airfield safety. In the field of aviation, runway incursions are the incorrect presence of and aircraft, vehicle or person on an active runway designated for takeoff and landing. Runway incursions can result in property damage or loss of life through incidents leading to aircraft collisions or avoidance maneuvers. Efforts are on the rise to reduce the risk of runway incursions at airports. However, guidance is mostly qualitative and does not provide specific quantitative measures to predict runway incursion frequency and evaluate the effectiveness of treatments. This dissertation adapted statistical roadway safety modeling to airport airfield operations. The transferability of roadway safety modeling theory was possible because airfield operations share similar measures of exposure and hazard concepts. Thus, models were developed to estimate runway incursion frequency for

hub airports in the United States. Assessing runway incursion frequency and treatment effectiveness with quantitative measures enables a more straightforward comparison of different facilities, alternatives, and treatments. The models developed in this dissertation contribute to decision making and the implementation of cost effective countermeasures to mitigate runway incursions.