Traffic safety has been considered one of the most important issues in the transportation field. Crashes have caused extensive human and economic losses. According to the World Health Organization, the world still lost 1.24 million lives from road traffic crashes in the year of 2013. And without action, traffic crashes on the roads network are predicted to result in deaths of around 1.9 million people, and up to 50 million more people suffer non-fatal injuries by the year 2020.

Freeways and expressways are considered an important part of any successful transportation system. These facilities carry the majority of daily trips on the transportation network. Although expressways (Toll Roads) offer high level of service, and are considered the safest among other types of roads, traditional toll collection systems may have both safety and operational challenges. The traditional toll plazas still experience many crashes, many of which are severe. Therefore, the main focus of the research in this dissertation is to provide an up-to-date safety impact of using different toll collection systems, as well as providing safety guidelines for these facilities to promote safety on expressways.

In this study, an extensive data collection was conducted that included a hundred mainline toll plazas located on approximately 750 miles of expressways in Florida. Multiple sources of data available online maintained by Florida Department of Transportation were utilized. Different methods of Observational before-after and Cross-Sectional techniques were used to evaluate the safety effectiveness of applying different treatments on the expressways. A set of safety performance functions which predict crash frequency as a function of explanatory variables were developed. The results of this study proved that safety effectiveness was significantly improved across all locations that were upgraded from Traditional Mainline Toll Plazas (TMTP) to the Hybrid Mainline Toll Plazas (HMTP) system. It was also proven that there is a significant difference between the different designs of HMTP, and there is an indication that the majority of crashes occurred at diverge-and-merge areas before and after these facilities. In addition, the results indicated significant relationships between the crash frequency and toll plaza types, annual average daily traffic, and drivers’ age. Moreover, the conversion from TMTP to the All-Electronic Toll Collection (AETC) system resulted in an average crash reduction of 77 and 76 percent for total and Fatal-and-Injury (F+I) crashes, respectively. And the conversion from HMTP to AETC system enhanced traffic safety by reducing crashes by an average of 23 and 29 percent for total and F+I crashes, respectively. Therefore, the use of AETC system changed toll plazas from the highest risk sections on expressways to be similar to regular segments. This study also evaluates the safety effectiveness of the implementation of High-Occupancy Toll lanes (HOT Lanes) as well as adding roadway lighting to expressways. Overall, this study provided for the first time an up-to-date safety impact of using different toll collection systems, and also developed safety guidelines for these systems which would be useful for expressway authorities and roadway users.