The main goal of this dissertation is to have better understanding of design and operation of the Continuous Flow Intersection (CFI) and Diverging Diamond Interchange (DDI) and the different factors that affect signalized intersection and interchange performance due to increased left-turn demand. The dissertation attempts to assess the need and justifications to redesign the intersections and interchanges to improve their efficiency and safety. For this purpose, an extensive literature review of existing studies was done to understand the principles of these innovative designs and determine the methodology that is needed to be followed to achieve the aim of the study. Accordingly, several DDI and CFI locations were selected to be candidate locations that already have implemented the designs and collect the required data to calibrate and validate the models. The microsimulation software (VISSIM 8.0) was utilized to simulate, calibrate and validate the existing conditions through several steps which include signal optimization and driving behavior parameter sensitivity analysis. Afterwards, an experiment was designed for each design to examine the different factors that affect the efficiency of each design. The experiments involved 180 and 90 different scenarios of CFI, DDI and their conventional designs, respectively. Two measures of effectiveness were identified to analyze the results; the average delay and the capacity. The analyses of the results were performed to detect the thresholds of switching from the conventional designs to the innovative designs. In addition, performance comparison studies of the CFI and DDI with their conventional designs were performed. The results and findings of this research will act as guidelines for decision makers as to when they should consider switching from conventional to innovative design. Finally, decision support systems were developed to accelerate finding which design is superior to other.