THE COST-BENEFIT ANALYSIS FOR UNCONVENTIONAL ALTERNATIVE INTERSECTION DESIGNS (UAIDs)

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Although the Unconventional Alternative Intersection Designs (UAIDs) have been proposed since the last decade as an innovative at-grade signalized intersection treatment to alleviate congestions, the issue of Cost-Benefit Analysis (CBA) has not been estimated for such schemes. Hence, the purpose of this article is to compare the CBA of the existing conventional signalized intersections with two alternative schemes. These alternatives include two UAIDs proposed schemes namely; the Displaced Left-Turn (DLT) intersection and Superstreet Median (SSM) intersection, as well as the grade-separated intersection, as another alternative. This context aims to produce enough information about the performance of the alternatives scheme and to ascertain whether these alternatives should be undertaken. The research objective is accomplished by identifying, valuing and comparing the private and external costs and benefits of the proposed alternatives.

Keywords: *Unconventional Alternative Intersections, Cost-Benefit Analysis.*

1. BACKGROUND

Worldwide, the transportation experts have been challenged by the rapid travel needs. As a result of the ever-increasing traffic demands, the corresponding congestions in the performance of the conventional traffic signalized intersections were influenced dramatically. The total travel time of the urban networks, the intersections' level of service indicators such as the overall delays, as well as the intersections throughputs, experienced adverse considerable impacts. The traditional measures which target signal system improvements such as the use of the actuated signal, signal timing optimization or adding more through lanes and exclusive turning pockets to increase the approach capacity, failed to provide a significant enhancement. Therefore, constrained by the limited resources, the need for innovative approaches to overcome the serious traffic dilemma, mitigate congestion and improve the intersections' level of service has become highly required. Although the higher capacities provided by the grade separation intersection approach, it is costly and aesthetically unpleasing[2),11)]. Hence, the use of (UAIDs) has been proposed as an innovative at-grade signalized intersection treatment as a promising solution for more dominant flow on arterials and main corridors. The innovation of these schemes' basically is to enhance the operational performance by reducing the delay as well as to improve the entire intersection safety conditions. They share two fundamental concepts; facilitating traffic movements to ensure a smooth traffic along the arterial and increasing the intersection capacity by reducing the number of signal phases. Also, the safety performance is improved by reducing the number of conflict points in the main intersection. Re-routing one or more of the traffic movements results in unusual movement structure is provided through these designs to achieve their objectives[2),3),4)]. In the current study, two UAIDs schemes namely; the Displaced Left-Turn (DLT) intersection that is also known as Continuous Flow Intersection (CFI) and the Superstreet Median (SSM) intersection that is also referred to Restricted Crossing U-Turn (RCUT) intersection are proposed. The innovation of DLTs design is the allowance of the operation of both through movements and left-turns simultaneously by using a two-phase signal. Unopposed left-turns at intersections are provided a few hundred meters in advance by crossing traffic over to the edge of the other side of the road. Through this scheme, drivers cross over to the left of the road into an exclusive left-turn lane by rerouting the left-turn movements[7),8),9)]. Thus, left-turns are allowed to move simultaneously with through traffic, resulting in a significant operational efficiency. Four additional secondary intersections in major and minor approaches upstream the primary intersection are created as a result of the left-turn displacements create as **Fig.1** illustrates. As its name implies, the CFI design succeeds to keep and maintain the traffic moving along the corridors[7)]. A significant reduction in the total cycle length is achieved for the two-phase system. Shorter average queues, as well as shorter storage bays with an overall significant improvement, are the main achievements for this design[2),7)]. Consequently, with shorter travel times on the main roadway, more traffic flow is processed efficiency and an obvious progression along the corridor is enhanced[3),4)].

The Super Street Median (SSM) intersection, that is also referred to as Restricted Crossing U-Turn (RCUT) intersection is proposed to alleviate congestions at signalized intersections. By adding an additional break for the through-moving traffic flows, SSM intersection separate the directions of travel on the main artery with two different traffic signal controllers as shown **Fig.2**. The two one way streets that provided with a two-phase signal system emphasizes independent operations on the arterial streets to achieve an efficient smooth traffic flow[5),6)]. The main approach traffic can continue to progress as through, turn left or turn right, as the SSM handles vehicles entering or crossing the main highway from the minor road approaches. The SSM is channelized

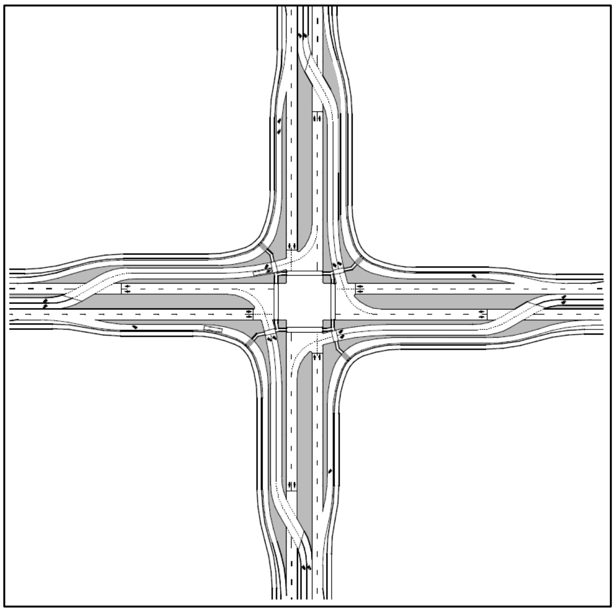

Fig.1 Displaced Left-Turn Intersection (FHWA, 2014)

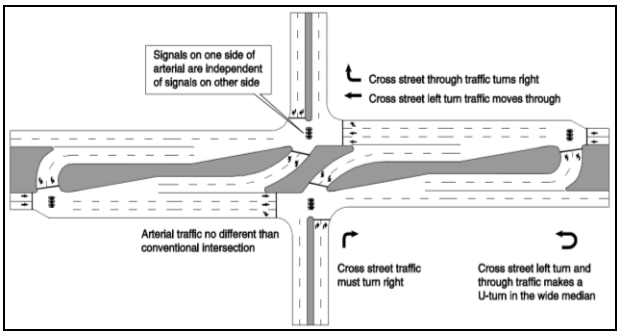

Fig.2 Supestreet Vehicular Movement (FHWA, 2014)

through the major street median at specific locations to achieve the independent operation for the arterials' movements. By channelizing islands at the intersections, the minor traffic flow enters or crosses the main highway is experienced indirect left-turns relying on a combination of right turns followed by U-turns provided on the main corridor that allows minor flow to proceed in the opposite direction as an equivalent of a left-turn, then turning right and continue traveling along their original minor route as shown in **Fig.2**[5),6),12)].

The main objective of this study to produce enough information about the alternatives schemes and to evaluate whether these alternatives should be undertaken. Based on the CBA approach, a comparison is done between the entire existing conventional signalized intersections with the other two proposals.

2. RESEARCH METHODOLOGY

To accomplish this study objective, the CBA approach is considered and employed. Based on the straightforward principles of CBA approach, a comparison is done between the three entire existing conventional signalized intersections with the alternatives proposed; UAIDs and the grade-separated intersection. The CBA is done following certain basic steps as follow: first, identifying all cost and benefits for the base-case as well as for the other alternatives by developing basic cost factors. Second, determining beneficiary and identify the cost and benefit items. Third, measuring these costs and benefits by a monetary term. Fourth, calculating the Net Present Value (NPV) of both cost and benefit and estimating the future rates of interest and use them to discount the future value of costs and benefits to the today's values. Fifth, calculating user benefits and extrapolate benefits to all alternatives by evaluating the indices in different external conditions. Finally, comparing the costs and benefits of total current values to decide the best alternative.

The cost analysis considers the construction cost, the running cost, and the maintenance cost. The construction cost includes the new extra lanes construction cost, the new signal heads as well as the right of way needed for the UAIDs proposed schemes, and the grade-separated inter-section. As it mentioned earlier in the previous section, the proposed UAIDs requires extra lanes and new signal controller heads for the new up-stream crossover in case of DLTs and for the new U-turns in case of RCUTs. The cost analysis of the grade-separated intersection takes into account the right of way needed for the ramps and construction costs for the structures required for the elevated dicks. The running cost includes the electricity consumption needed for the new signal controller heads, while the maintenance cost considers the painting needed for the lane line markings and the signal controller heads and other equipment maintenance cost.

On the other hand, the benefits analysis includes the travel time improvements, the fuel consumption, and the safety conditions. The previous studies results based on the microsimulation analysis are employed to estimate the travel time and the fuel consumption benefits. The safety conditions can be evaluated using a safety assessment based on micro-simulation. Also, the previous studies related to the driver confusion and human behavior studies can be taken into account to evaluate the safety aspects benefits.

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