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A Service Life Analysis of Roundabouts Retrofits for Signalized Intersections

Xinyi Yang[a,] *, Mark J. Magalotti[b]

[a]*Institute of Urban Environment, Chinese Academic of Sciences, 1799 Jimei Raod, Xiamen, Fujian, 361021, China*
[b]*University of Pittsburgh, Department of Civil and Environmental Engineering, 3700 O'Hara Street, Pittsburgh, PA 15261, USA*

Abstract

Roundabouts have long been regarded as an effective traffic control method. While this method is quite popular in some foreign countries like Australia, there are not as many existing roundabout sites in the U.S. According to foreign experiences and limited experience in the U.S., roundabouts can be good replacement alternatives where signalized intersections no longer function well. This research examined and monetized the potential benefits of converting signalized intersections to roundabouts under three different circumstances. To be specific, the potential benefits included crash reduction, delay time reduction, fuel efficiency improvement and air pollutant reduction. Then a benefit-cost analysis (BCA) was conducted. The monetization of environmental benefits was used to improve the BCA methodology that has been used by others. Three different intersections, that are currently signalized, were studied to determine the BCA. After a systematic evaluation, it was found that a five-way intersection with moderate traffic volume had the best benefit-cost ratio among all three intersections studied.

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Keywords: roundabout; retrofits; benefit-cost

* Corresponding author. Tel.: +86-13950106722
E-mail address: xinyiyang@iue.ac.cn

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1. Introduction

1.1. Background

Conventional signalized intersections and stop-controlled intersections are common throughout the United States. The public accepts them well and is familiar with them. So when agencies are making decisions to control a junction or improve traffic conditions, signalization of conventional intersections is usually a preferred alternative.

However, safety for both pedestrians and vehicles can be an issue in these intersections. There are 32 potential conflict points in a signalized intersection with one lane per approach. Some of the typical crash types are severe. Traffic signals can also be inefficient from an economic or environmental standpoint. Equipment often lacks periodic maintenance, technology changes, there are reoccurring maintenance costs, and traffic patterns may change over time. Moreover, when a traffic signal is not as efficient as it used to be, owners of the traffic signal don't always have the funding for upgrading of the equipment. Mostly, they only do updates of the timing plan, which may not bring significant savings for operating costs or environmental impacts. Also, traffic signals require replacement at the end of their useful life, which is a major construction cost.

An alternative to updating or replacing a traffic signal to other more efficient and safer control methods for those intersections should be considered. Roundabouts have been regarded as an effective traffic control method under specific traffic conditions for decades. Single lane roundabouts, the most common type, have only 8 potential conflict points. This is a significant reduction when compared to a signalized intersection. Vehicles are forced to reduce speeds as a result of the geometric design of roundabouts. These factors contribute to the safety advantages of roundabouts. So they can be applied to improve safety and calm traffic in most cases while sometimes applied in new intersections that have complex geometric features. However, the conversion of an existing signalized intersection to a modern roundabout is also worth considering in terms of economic and environmental benefit aspects in some urban areas with certain traffic volumes.

Based on the consideration of exploring an alternative control method both to the user and the operator, such a conversion is worth conducting research on to determine the service life benefits of the conversion.

1.2. Methodology

Three potential roundabout locations are selected on the basis of differing conditions related to traffic volumes, number of approaches to the intersection and the complexity of existing signal phasing. They are intersection of Bigelow Blvd- O'Hara ST-Parkman Ave, intersection of Fifth Ave- Morewood Ave and intersection of Forward Ave- Murray Ave- Poccusset ST. Two of these potential roundabouts are located in the Oakland section of the City of Pittsburgh, Pennsylvania, which has many congested signalized intersections. Another intersection located in Squirrel Hill, the City of Pittsburgh, was selected because it has five approaches, which are currently signalized. All three of the intersections have varying geometric conditions and existing timing plans.

There are few service life economic analyze tools available currently to perform the analysis. In this research, a benefit-cost analysis (BCA) methodology, specific to this traffic control change, was developed as the final task to test the hypothesis. Service life cost of such a conversion, and also monetized benefits of all factors were evaluated to calculate a benefit-cost ratio.

Operational performance is the first and most important criteria when considering a conversion from signalization to a roundabout. If operational benefits cannot be demonstrated then the service life comparison would not be needed. Such an analysis can confirm that if the conversion of the signalized intersections to a roundabout is completed, it will improve the level of service (LOS) and safety conditions. These operational benefits can be calculated using the Highway Capacity Manual (HCM) 2010 published by the Transportation Research Board. The Synchro version 8.0.804.795 software modeling package, which replicates the HCM method, was applied on all the three signalized intersections for existing LOS analysis under signalized conditions. The LOS for existing conditions was reported based upon an optimized timing plan, developed by Synchro version 8.0.804.795, and was used for the comparison. However, only control delay for roundabouts is included in the Highway Control Manual (HCM) currently. For the reason that SIDRA method, which is the most popular roundabout analyze tool in U.S, and it is used by various state agencies, was used to determine the appropriate design, performance characteristics and