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# Designing the required changes in the bus network after performing limited traffic zone in Mashhad, Iran

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ABSTRACT

After performing Limited Traffic Zone (LTZ), an approach to limit the number of vehicles entering a zone or street in Mashhad, Iran, a change in the share of public transportation happens. In some routes, the share of public transportation decreases during peak hour because some users shift the time of their trips to other hours. Alternatively, the use of private cars on most routes shifts toward public transportation and as a result, these routes experience more demand. Supposing that the current system is based on current demand, after performing an LTZ, transit systems need to be modified based on new demand. This modification can be done in regards to route configuration, frequency and timetables. In this paper, a methodology is proposed to modify the bus transit system to determine required changes in the system. This method is easy to implement in large cities, especially cities that have seasonal demand changes and need to adjust their system with minimum changes in route configuration. The objective function of this method is based on covering the increased demand in the system. The methodology includes a GIS-based heuristic approach and is performed in Mashhad, Iran.


## 1. Introduction

Limited Traffic Zone (LTZ) is an approach to limit the number of vehicles entering a zone or street. This method of travel demand management (TDM) has been practiced in Mashhad for more than 10 years.

Studies show that around 20 million pilgrims visit the Holy Shrine of Imam Reza in the center of Mashhad each year. Most of these pilgrims come to Mashhad during summer (July to end of September) and two weeks at the beginning of spring (March 21 to April 4). Therefore, the majority of pilgrims visit a small zone in the city (Holy Shrine of Imam Reza) in a short period of time. Also, the daily travel demand is higher at noon and sunset since most prayers at the Holy Shrine are during these times of the day.

Summer and spring holidays are based on the solar calendar so they happen on the same dates each year. However, some religious dates that attract pilgrims to Mashhad are based on the lunar calendar and therefore, travel each year happens on different dates. Both these solar and lunar holidays are called special days. Of course in some years, lunar occasions fall on solar-based holidays, so the city experiences an extreme peak period.

To manage crowded traffic on these special days, the Mashhad Traffic and Transportation Organization (MTTO) decided to implement two LTZs: one for summer and spring holidays and another one for normal days on which lunar occasions may happen. Fig. 1 demonstrates the border of these two LTZs. During normal days, only the smaller LTZ operates while during special days, both of them operate with a different control scheme. On normal days, LTZ operates based on a license plate scheme. During odd days, only vehicles with plates ending with an odd number can enter this LTZ. The same applies to even days for even-numbered plates. On Fridays (formal weekend in Mashhad), all vehicles can enter the LTZ. On special days, LTZ operates based on zone pricing. Each vehicle that enters this LTZ is charged a fee and if it has the appropriate license plate for that day, it can also enter the inner LTZ. In order to determine the borders and restricted areas, an LTZ Comprehensive Study (LTZCS) was conducted by MTTO. The study also estimated the new demand of trips during special and normal days. This paper summarizes the findings of the public transit section of LTZCS.

The emphasis of this research is to modify the current bus system without introducing a new bus network. There are several reasons for keeping the current bus system and avoiding a new system that is significantly different from the current system. Introducing a new bus line usually does not have negative social effects, but removing or even partially changing it usually produces a lot of public complaints. Previous experience in Mashhad shows

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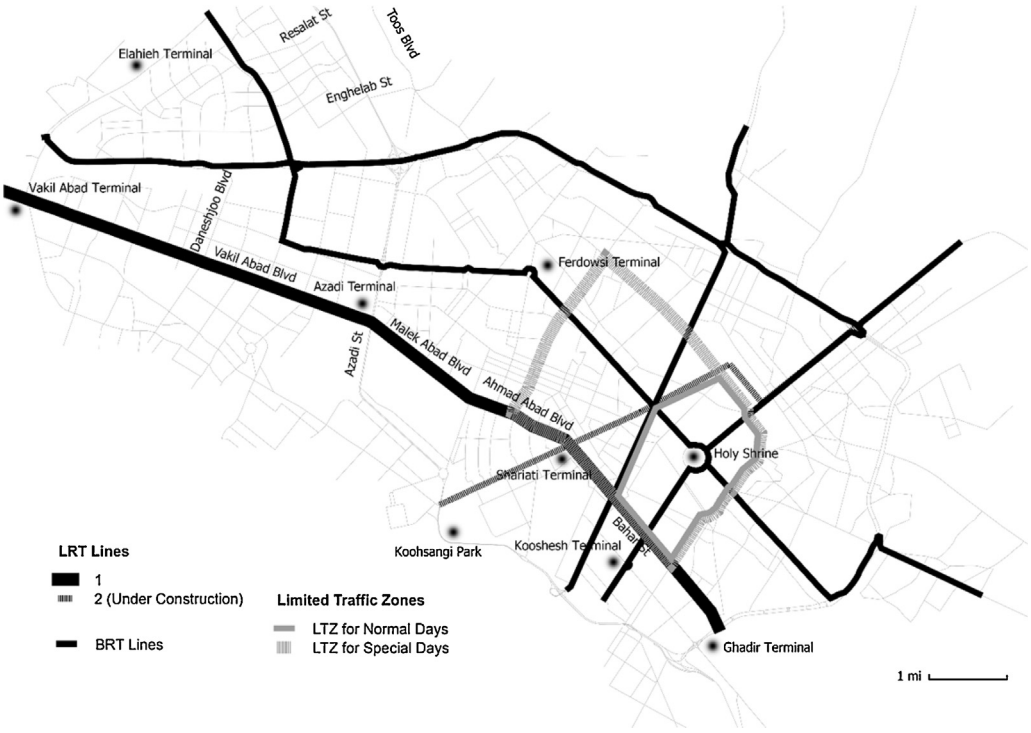


**Fig. 1.** Mashhad Street, LRT, and BRT networks.

that in some cases, it could generate protests. Another reason is the practical difficulties. A bus system takes years to form, including the habits on both the side of operators and users. Most cities start their bus system with a few lines and as the population of the city increases, more lines are added. Changing a network, or even a line, requires a lot of energy and cost in the system. LTZ produces considerable friction in changing the habits in a city, it does not seem wise to create more friction by changing the current bus network altogether.

This paper is organized as follows. The next section provides a literature review. Methodology to design required changes in the bus network after performing limited traffic zone is provided in Section 3. The case study section and its results are presented at the end.

## 2. Literature review

Various methods cast restrictions on vehicles entering roadways in an effort to manage traffic congestion and demand, including Area Licensing Scheme (ALS), Traffic Restricted Area and Congestion Charging Zone. Much research has been conducted on traffic restriction measures in different cities. In Athens, vehicle entry was regulated according to the last digit of the license plate of the vehicle, such that each vehicle is banned on alternate days Monday to Friday. Some studies show up to 50 percent reductions in traffic with this scheme (Argyrakos, 1986; Matsoukis, 1985). More recently, Grange and Troncoso (2011) and Han et al. (2010) also have investigated the effect of these restrictions on urban transport flows. However, some other studies such as Behbehani et al. (1984) in Singapore, and Harrison (1986) in Hong Kong indicate that road user fees can work more effectively to reduce private car usage only if fees are set significantly high. Olszewski et al. (1995) and Olszewski and Xie (2005) developed models for the Singapore CBD (Central Business District) with the aim of providing an analytical framework for the evaluation of traffic management measures for Singapore Restricted Zone. Also Jones and Hervik (1992) have summarized other methods for restraining car traffic in European cities and assessing the potential of a road pricing measure as a demand management tool in the future.

Another interesting method to reduce entrance of vehicles in some zones is called road diet. In this method, capacity can be restricted through reallocating part of the carriageway to bus lanes, which limits the space for private cars. This kind of restriction can also be done by transit signal priority that allows bus lanes to bypass the traffic signals and as a result, imposes delays on other vehicles. Some early studies proposing this method were Cracknell et al. (1975) for London, Vincent Layfield (1977) for Nottingham, and Small (1983). Later, Huang (2000) evaluated the transit fares and highway tolls and Basso et al. (2011) analyzed dedicated bus lanes in addition to congestion pricing and transit subsidies. Various research such as Watters et al. (2006) and Li et al. (2009) have also been done to reduce traffic congestion using public transportation priority systems.

Palma and Lindsey (2011) review the methods and technologies for congestion pricing of roads. Liu et al. (2012) developed a simple equilibrium model for a linear mono-centric city to investigate the effects of both restriction measures and pricing on morning commuters' travel cost and modal choice behavior and found that a Pareto-improving rationing and pricing scheme might be obtained as a combination of the rationing degree and the toll associated with rationing. Wang et al. (2010) analyzed the effect of road rationing on the original traffic assignment model. Shi et al. (2014) introduced an optimization method for alternate traffic restriction (ATR) schemes in terms of both their restriction districts and the proportion of restricted automobiles. Under ATR, a certain proportion of automobiles are prohibited from entering predetermined ATR districts during specific time periods. Other methods can be summarized as credit-based congestion pricing (Kara and Kalmanje, 2005), vehicle quota systems (Chin and Smith, 1997; Seik, 1998), and travel credit systems (Yang and Wang, 2011).

Most of the research is focused on restriction of private vehicles to manage congestion in an area. Usually in these studies, the effect