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RESEARCH ARTICLE

Optimalization of road traffic with the applied of reversible direction lanes

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Abstract

Optimization of traffic on a large public road network is an undertaking and complex task. Reversible Direction Lane theory is an interesting and special method within this subject. This can completely support the fluctuation or alteration in existing congestional direction of traffic dynamics (time of day, seasonal, etc.) on existing road surfaces. In such case certain subsystems of the main network cease to exist, and subsystems working with new connections take their place. This type of routing therefore changes the system's structure „in an optimal direction", but many practical and safety questions arise. A number of studies prove that in areas this method is employed, travel time decreased by 30-40%, waiting time by 40-50%, number of stops by 30-40% compared to previous data. Its benefits were also shown in fuel consumption reduced by 15-25%, harmful substance emission HC by 15-25%, CO by 3-5%, and NO by 8-10%. We may not leave the application of this opportunity out of consideration in a case when a country's road infrastructure demands considerable developments otherwise.

Keywords

Reversible lane · road traffic · traffic control

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1 Introduction

The heavy increase of the traffic - among many other features - characterizes the developing national economies. At the same time, often limited resources do not make capacity increase of roads possible therefore congestions take shape increasingly more frequently because of this. In transport policy, congestion avoidance receives major importance, and a number of opportunities offer solutions. Here can be enumerated technical devices that form a complicated technical system like on-board, real-time, traffic dependent control of vehicles.

The principle of most favored innovations is the increased effective use of new and existing road networks, homogenization of vehicle traffic, increase in passengers in single vehicles (carpooling), or the use public transportation. One of the principles demanding plain technical backgrounds, which was used since the 1920s already in a number of states of The United States of America is the reversible lanes theory [1].We will introduce the historical background of this method in the second chapter. We would like to present the realization of the endeavors being aimed at the avoidance of the congestions in Chapter 2.2.

We will introduce two case studies made in the USA that prove the worth of reversible direction lanes in Chapter 2.3. Based on the measured values waiting time decreases by half, in this manner travel time is half as short as well. Besides decreasing waiting time the size of traffic has also decreased to its half on the road section. It is worth paying attention to not only waiting time, but to the number of stops made. Through this study it could be determined that continuous traffic flow forms since there is a 1/3 decrease in cars forced to make a stop. Based on these values harmful substance emissions, and fuel consumption reaches much more favorable levels.

Because of the centralized nature of cities traffic, congestion takes shape in the morning towards the center while in the afternoon roads leaving out of the city get more congested. In the afternoon traffic is less busy, and more distributed because of different sizes of destination areas and different working ours. Typically with improving lifestyles, people move out of cities to commute daily from near by towns. This process creates more commuters so traffic forms throughout larger destinations.

Taking advantage of the given vehicular traffic size of the directions differing in a time moment, it would be beneficial to create interchangeable direction lanes that would take into consideration current traffic flow, and provide optimum room for both directions. Reversible lanes must be designed based on environmental and social demands of a location. We present some procedures taking these claims into consideration, emphasizing the Hungarian conditions in the third Chapter.

2 Development and application of reversible lane system

2.1 Historical overview

The spread of vehicles conducived to formation of larger vehicular traffic size which caused congestions [3]. The use of reversible lanes was one of the primary methods of the last century used to handle peak period traffic flows.

It was first tested by Ralph T. Dorsey in Downtown Los Angeles in 1928. When the traffic was bad at the morning in one of the directions an extra lane was provided which was used during the afternoon by the opposite traffic. Metal-based stanchions were initially used to delineate the temporary division between opposing traffic flows during the early period, and after 1950 the new traffic cones were deployed. The Reversible Lane System (RLS) has been used all over the word which specific liens in that it can increase the capacity of roads [4]. The RLS can be used (see Fig. 1):

- against congestions (which are established in peak hours, during monumental events)
- temporary divert of traffic (respectively for evacuate of disaster area).

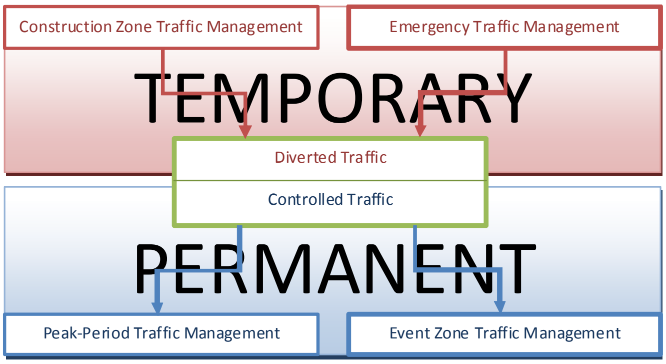

Fig. 1. Characteristics of applications of Reversible Lanes

During the use of RLS the basic principle is simple; nevertheless it requires clear planning and operation. The traffic signals and marks have to give appropriate information to driver about actual conditions and must not allow going in the face of direction of the traffic under any circumstances.

2.2 Use of Reversible Direction Lanes

One of the most current ways around the world of the usage of RLS is the construction work zone. Reversible lanes are well suited for bridges and within tunnels because at these areas it is desirable to maintain adequate capacity within the restricted right-of-ways of work zones.

In Illinois, a 6,000 ft movable concrete barrier was used during the rehabilitation of the McClugage Bridge. The barrier which could be realigned in about 25 min with only minor disruptions to traffic was used to serve directionally unbalanced volumes during the morning and afternoon peak periods [4].

The second most recent usage of RLS has been the purpose of emergency traffic management. Largely the result of the traffic jams was associated with natural disasters as hurricanes (15 states have developed plans for the use of contraflow for hurricane evacuation) and manmade hazards, including various nuclear, biological, chemical, and terrorist threats.

One of the advantages to reversing flow on a freeway is the restricted access into the travel lanes. Freeway operating speeds are typically much higher than arterial roadways, which limits the required manpower and quantity of control elements required for the reversal, however that is the major drawback. As a result, transition period and points become more critical element of the design and management plan.

The frequency of the largest cultural or sport events, that occur annually or seasonally, typically does not warrant the construction of additional lanes or complex control systems (Fig. 2). There are some exceptions to this rule, particularly for arenas in urban areas. The scheduling of more frequent events justified the added expense of a permanent system in these instances.

Unlike in Event Traffic Management (where events occur annually or seasonally), at Peak Period Management these events are ordinary.

The management of peak hour traffic are particularly effective and most commonly used on arterial roadways and freeways (like in Washington, DC where reversible lanes have been both popular and successful), rather than local traffic. Typical for Peak Period Management that the direction of traffic in lanes is routinely converted during the morning and evening commute periods.

On this freeway, two lanes between the directional lanes are dedicated for inbound transit in the morning, then outbound in the afternoon. At the reversible lanes traffic can enter and depart at several points. Between the reversible and directional freeway lanes the access is controlled by gated ramp crossovers and by signal controlled reversible ramps between the reversible freeway lanes and grade separated arterial roadways (see Fig. 3).

These segments are relatively short (about two to three miles in length) and operate on a one-way in basis from 7:00 to 9:00 a.m. and a one-way out basis from 4:00 to 6:00 a.m.

With assistance from DC Park Police the movements into and out of the segments are controlled at signalized intersections [4].

An other unique example of RLS used on a roadway that is operated as a balanced four-lane corridor that works out a smart idea that allows residents to on-street parking during non-peak hours, then as a 4:2 reversible roadway during the peak periods.

Fig. 2. Channelized access for Reversible Direction Lanes [5]

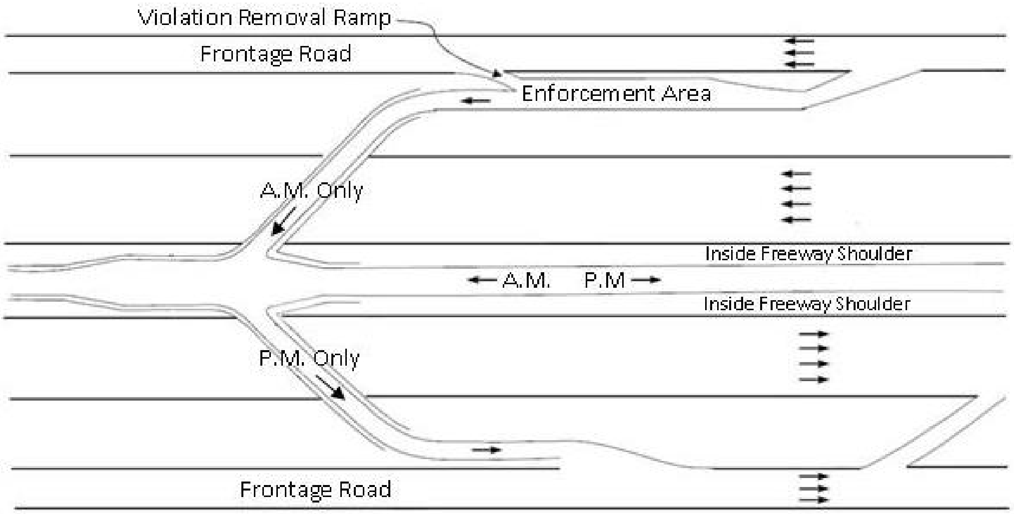

Fig. 3. Flyover ramp to single-lane Reversible Flow Managed lane [6]

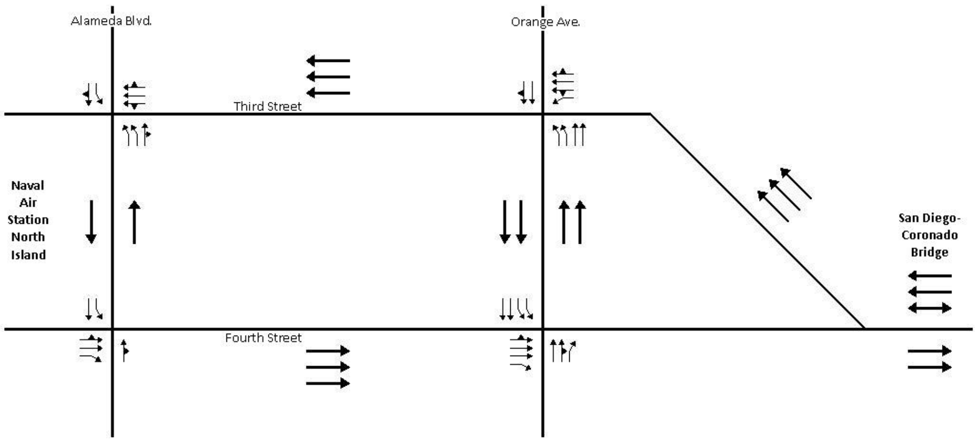

Fig. 4. No-build strategy 2030 lane configuration [7]

The roadway might feature numerous at grade intersections and driveways into adjacent properties. During the reversal period, priority is given to through traffic as left turns are prohibited.

2.3 A study from North America

Finally we would like to introduce an American study [7]. On State Route 75 bridge leading to North Island San Diego in California there are reversible direction lanes. On the island's two main roads (Third Street and Fourth Street) 3 lanes each are dedicated to the method as further demonstrated on Fig. 4.

The study was carried in 2003 and it prepared predictions for 2030. With the basic strategy the situation in which no change will take place was examined. In the other two cases (B and C strategy – see Fig. 5), the two main roads, Third Street and Fourth Street, were changed to use reversible lanes.

At strategy B they would stop making major roads into one way avenues, and on Fourth Street they would integrate 3 reversible direction lanes. At plan C both main streets would stay one way roads and on Fourth Street they would build 2 reversible direction lanes, the number of existing lanes would not change.

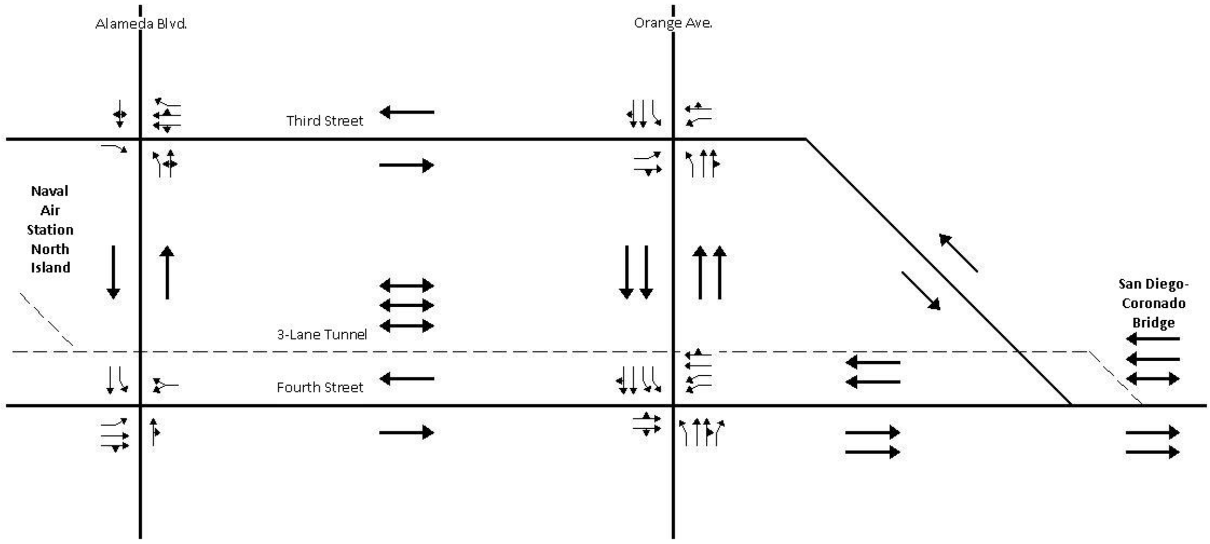

Fig. 5. Strategy B and C 2030 Lane Configuration [7]

Each given strategy's road sections usability clearly show that with reversible direction lanes the road could welcome more vehicles than the expected traffic increase will be. This area was examined in afternoon and morning traffic so these results prove themselves better with reversible lanes.

Let us look at another study where a road was observed with and without reversible lanes [8]. This road was using RL since 1981, and then later RL was cancelled in 2001. In the study called City of Tucson 2004 they took the growing traffic flow in account (see Table 1). The following criterion has grown with stopping reversible lanes on this road: waiting time doubled because of more traffic jams, harmful substance emissions, and fuel consumption. As a result in 2004 the major and city council have voted unanimously (7-0) to reinstate their earlier reversible direction road network.

Tab. 1. Positive effects of Reversible Lane [8]

Network Statistics	With Reversible Lane	Without Reversible Lane	% Change
Travel time (hr)	1942.6	3283.7	+69.0
Total delay (hr)	1299.4	2674.4	+105.8
Delay/vehicle (sec)	182.4	386.8	+112.1
Total stops	50187	81503	+62.4
Fuel used (gal)	2285.9	2918.8	+27.7
HC emissions (g)	6173	7721	+25.1
CO emissions (g)	219526	225223	+2.6
NOx emissions (g)	17696	19370	+9.5

3 Possible applications in Hungary

3.1 Introduction

In Hungary, traffic lanes with changing directions are mentioned as the integrated line regulating system's sub function [2].

During domestic integration of this practice we could take into consideration EU goals aimed at the improvement of systems directed towards traffic flow. We also have to look at the fact that presently we have more improved technological resources available than what the Americans had at the time of their first trials. Currently Hungary is the continuously vehicular traffic size's stage which can be easily followed with modernized routing systems.

With the use of reversible direction lanes we have to separate urban and highway traffic. At their design we also have to take into consideration whether the system will be used with existing or a new road network. The earlier mentioned way is most common in urban, the later with highway planning. At highways, safety has to be provided at higher speeds so similar safety standards require more attention and spending that can be easier realized with new developments. There are cases where a wide area is available, but at a shorter section we are forced to decrease the width of the road. At this narrow width it is worth employing reversible direction lanes if it is demanded by vehicular traffic size. In short if vehicular traffic size varies greatly in both ways and this variance happens with changing traffic jam patterns between directions.

3.2 Undertaking on highways

Traffic flow of highways near cities is greater in the morning with the incoming, and in the afternoon with the outgoing flow. There can be differences in both directions near recreation areas seasonally. This change mostly shows in weekend traffic, or on long weekends with national holidays.

Even if only for a short time we would like to increase the number of lanes we have to make sure that with the increased section traffic, the end of the section can handle the increase without newer jams, meaning the network of roads after the interchangeable lanes is able to handle such increases. Because of this reason we do not only have to pay attention to the designing of these lanes, but also to vehicle destinations to provide appropriate down channeling.

In case of a new concept it is worth planning the freeway with at least one reversible direction lane to save on the costs of one lane, since it is important that instead of 6 lanes for example only 5 have to be built. With this its usability is increased however it is an expensive and complex task to solve the problem of routing the traffic on and off the fifth lane. It has to be thought through what length of freeway is worth saving on lanes. This train of thought is necessary with roads passing by historical sights, or existing freeway lane additions. An economic solution could be during new concepts or during additions to build one less lane. This way the inner lane's traffic change could be needed as well, with the change in traffic flow.

Case study: Stage common of M1-M7 One of the large traffic of Budapest happens on common part of the M1 and M7 motorways. In case of fashion of Reversible Lane we have to take care of the increased traffic.

Directed to Pest of this traffic can be conduct to Egér Road. This route is two lanes, but the exit ramp from the motorway is only one lane and the modification of this to duple lanes would not demand for large investment. During the peak period hours the users of exit ramp would have priority opposite to traffic of Egér Road. During non-peak hours the present formation would remain, consequently, the change would be signalled by LEDs. Fig. 6 shows the practical changing – direct or bending – lane on the mentioned road-section.

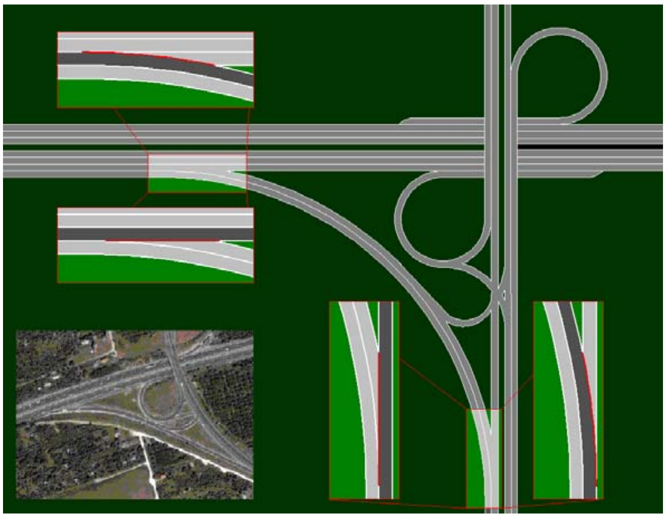

Fig. 6. Junction of Stage common of M1-M7 and Egér Road [2]

3.3 Examples for possible urban undertakings

Inside a downtown city area we have limited opportunities for brand new roads therefore we can only economize existing roads which width can not be increased so we need other capacity increasing methods. There could be areas available for lane additions where existing lanes are wider than demanded.

Usually typical city traffic flows on major avenues or on circularly structured main roads. Peak time congestion of these roads vary in the morning or in the afternoon so on such sections it is worth planning reversible direction lanes. Most cities have centralized traffic therefore it is much harder to get inside the city than to get out of it since outgoing traffic distributes easier on different sub roads of largely distributed destinations. This way inside a city it is not necessary to build new lanes instead just to take a lane from outgoing traffic for the incoming.

Since average speed is less inside of a city, it is a factor so safety requirements will be different. There are one way bus lanes since lane width gives room for only one. On these road sections the direction of the bus lane could be changed. Streets could be modified similar to one way streets, or the direction of a one way street could be changed.

Bus lanes with changeable directions will be used by experienced bus drivers and taxi drivers. Once such regulation takes effect we can demand testing among users of the lane, so only certified drivers could use them. Such education could bring attention to actual misleading signs too, and in this case could help the driver make the proper decision.

At the direction change of city buses we have to take into account the frequency of stops as well as the opening of doors. This is the reason why we have to take care of bus stop designs, and their approachability.

Case study: Formation of bus lane on the Kerepesi Road In front of the certain junction we find different solutions of development or cessation of bus lane depending on whether, how large surface is available and what kind of turning possibilities are in the junction. I have examined three kinds of formation to realization of the bus lane which is in the centre of road [2]. The formations depend on the position of stopping-place:

– duple street island (Fig. 7/a)

– the stopping-place next to the bus lane (Figs. 7/b and c)

– lock-gate to buses (Fig. 7/d)

4 Conclusions and future work

With the application of Reversible Lane System we may reduce the development of congestion and may ensure shorter travel time for vehicles. The causes of wait nervousness would be reduced with this measure and consequently the number of accident issue from inattentions would reduce too.

In the first place the Reversible Lane System would be work out expedient on the anew under construction road, because we depend least on the local addition in the course of these planning, we would be in possession of the most liberty.

The expectation against safety of this system may be greater because it is a new system, while it may be sufficient if the system can guarantee the level of safety which can be guaranteed by every other management systems on the public road.

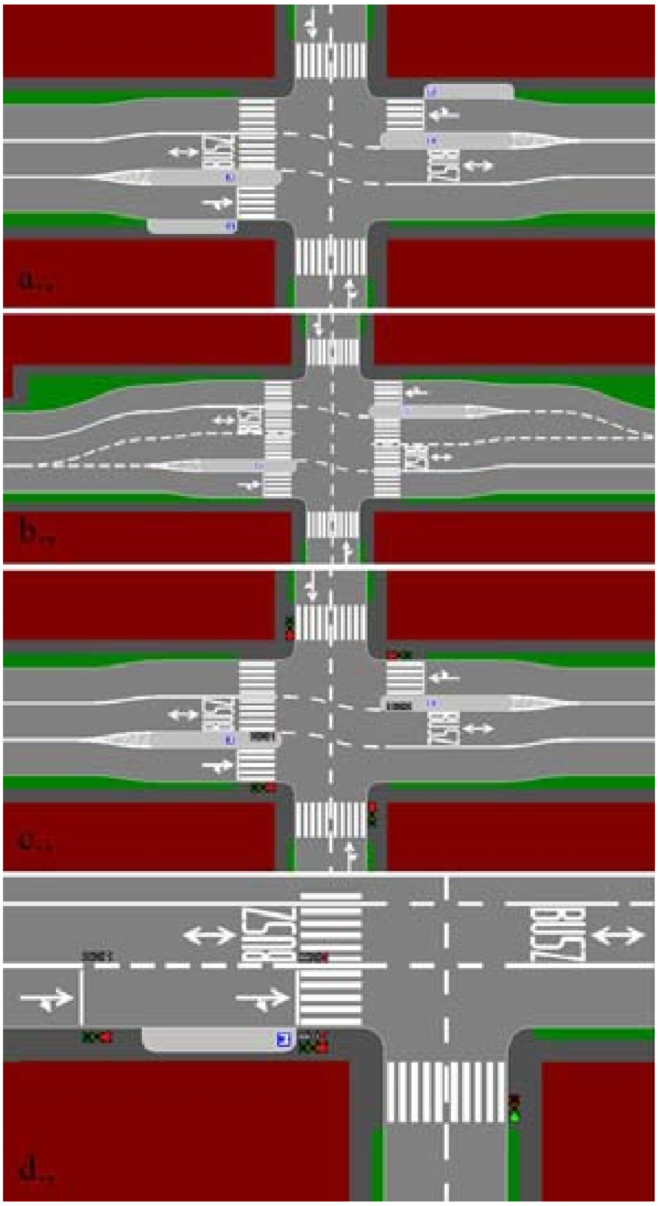

Fig. 7. a|b|c|d: Realization of Bus Lane in the Centre [2]

In excuse of this, the safety analyses of the road systems, the research of employed appliances and the estimation of social expectation are necessary. By the aid of this procedure justness of user of the reversible lane as well as opposite to the controlling appliances of the requirement would be determinable.

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