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USE OF ALTERNATIVE INTERSECTIONS IN ORDER TO IMPROVE TRAFFIC SAFETY

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RESEARCH ARTICLE

ABSTRACT: The intersection of two or more roads represents the possibility of a conflict between vehicles. Alternative intersection designs can improve intersection performance by changing the configuration of conflict points by redirecting traffic, reducing the number of signal phases, as well as significantly reducing time losses at intersections. The use of alternative intersections such as continuous flow intersections (CFI) (also known as shifted left turns or DLT), divergent diamond loops (DDI), superstreets (also known as J-turns, restricted crossing U-turns, or RCUTs, reduced conflict intersections, or RCIs, reduced conflict U-turns, and synchronized streets), median U-turns (MUTs) became more common, as traffic demand increases. They are usually more complex than conventional design intersections and they are used when conventional intersection designs do not allow adequate safety improvements or adequate traffic flow. Alternative intersection designs have fewer points of conflict resulting in increased safety for both, drivers and pedestrians.

KEY WORDS: *alternative intersections, traffic safety, divergent diamond loops (DDI), continuous flow intersections , restricted crossing U-turns, median U-turns , superstreets*

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KORIŠĆENJE ALTERNATIVNIH RASKRSNICA U CILJU POBOLJŠANJA BEZBEDNOSTI SAOBRAĆAJA

REZIME: Raskrsnica dva ili više puteva predstavlja mogućnost sudara vozila. Koncepti alternativnih raskrsnica mogu poboljšati performanse raskrsnice: promenom konfiguracije tačaka konflikta preusmeravanjem saobraćaja, smanjenjem broja faza signala, kao i značajnim smanjenjem gubitka vremena na raskrsnicama. Upotreba alternativnih raskrsnica kao što su raskrsnice sa kontinualnim protokom (CFI) (poznate i kao pomerena leva skretanja ili DLT), divergentne dijamantske petlje (DDI), superulice (poznate i kao J-krivine, ograničena polukružna skretanja ili RCUTs, smanjena je konfliktne raskrsnice, ili RCI, smanjena konfliktna polukružna skretanja i sinhronizovane ulice), srednja polukružna skretanja (MUT) su postale sve češće, kako se potražnja za saobraćajem povećava. Obično su složenije od raskrsnica konvencionalnog koncepta i koriste se kada konvencionalni projekti raskrsnica ne dozvoljavaju adekvatna poboljšanja bezbednosti ili adekvatan protok saobraćaja. Koncept alternativnih raskrsnica ima manje tačaka konflikta što dovodi do povećanja bezbednosti i vozača i pešaka.

KLJUČNE REČI: *alternativne raskrsnice, bezbednost saobraćaja, divergentne dijamantske petlje (DDI), raskrsnice sa kontinualnim tokom, polukružna skretanja sa ograničenim ukrštanjem, srednje polukružno skretanje, superulice*

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INTRODUCTION

Traffic problems are more complex than ever. Engineers have a complex task, to meet the needs of a growing population with limited resources. At many intersections, traffic jams are increasing, which results in drivers and pedestrians are wasting a lot of time waiting at such intersections, with an increased risk of being involved in a traffic accident. It is considered that conventional intersection designs are insufficient to alleviate existing transportation problems. Consequently, many engineers are researching and implementing innovative solutions in an attempt to improve both, the mobility of road users and their safety. One of the ways to solve this complex problem is precisely alternative ways of managing intersections.

Traffic is an extremely complex, stochastic phenomenon that cannot be modeled, because it depends on a number of parameters that affect the volume of traffic, and this later entails a number of problems arising from this.

Alternative intersections can reduce the number of major conflict points by redirecting traffic flow, especially left turns and turns at multi-arm intersections. Reducing the number of conflict points leads to the realization of operational and safety advantages for alternative intersections compared to conventional intersection designs under certain traffic and location conditions, often at significant cost savings compared to other more conventional alternatives, such as adding a turning lane or replacing the intersection with a loop, etc.

In the world, one of the most famous and widespread alternative ways of managing intersections is the roundabout. In addition, there are Superstreet, Median U-Turn, Continuous flow intersection, Continuous green-T, Jughandle, Quadrant roadway intersection, Single point diamond interchange, Diverging diamond interchange, etc.

This paper will show the operation of most commonly used listed alternative intersections, their advantages and disadvantages, as well as how each of them influence on traffic safety.

1. ROUNDABOT

A roundabout is an alternative intersection where vehicles move in a counter-clockwise direction around the central island. Although roundabouts have been in use since the early 1900s (USA), the modern roundabout can be traced back to the 1960s in the United Kingdom. What characterizes modern roundabouts is that they can have one or more traffic lanes, and their regulation can be done in several ways. A circular traffic sign is placed on each entrance leg.

The first way to regulate traffic in a roundabout is to place a sign for crossing the road with the right of way along with the sign for the roundabout. This means that the vehicle entering the roundabout is obliged to wait vehicles that are already in this roundabout, and when they pass it can enter in roundabout.

If there is no “crossing the road with right-of-way” sign on the entrance branch, the usual rules apply, namely that vehicles in an intersection that is not regulated by light signals or

traffic signs must follow the "right-hand rule" or, as it is otherwise called, the "left-turn rule".

As many alternative intersections, roundabouts move left turns to achieve better operation.

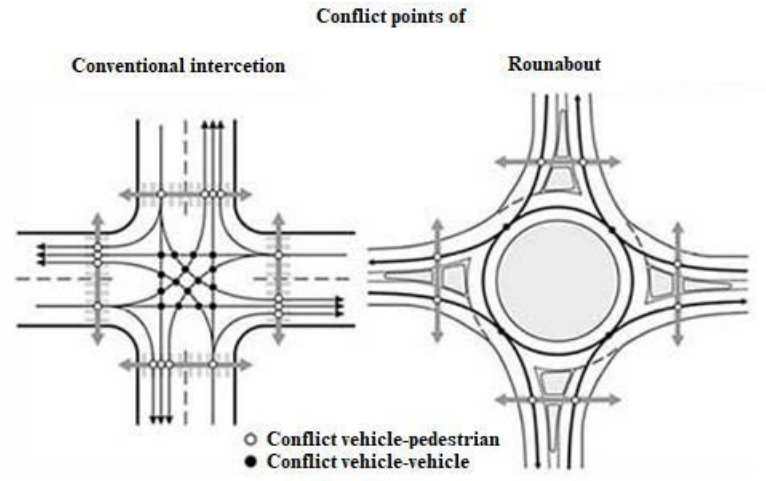

Figure 1. Conflict points: Left - Conventional intersection; Right - Roundaboat

As already mentioned, roundabouts can have one or more traffic lanes. Roundabouts that have only one traffic lane (so-called mini-roundabouts) are extremely safe, because there are no conflicting intersection points, while roundabouts with two or more traffic lanes also have conflicting intersection points due to improper use of the traffic lane and inadequate maneuver conflicts arise.

Advantages of roundabout are improved safety, fewer conflict points (all vehicles within roundabouts travel in the same direction, there are fewer conflict points and the vehicle-to-vehicle contact is limited to the “front-to-back” crashes. A conventional 4-legged signalized intersection has 32 conflict points, whereas a single-lane roundabout has only 8. Roundabout reduces travel speeds (before entering roundabouts, drivers must slow down (speeds in roundabouts often between just 25-40 km/h) and collisions that do occur are generally minor and cause far fewer injuries. Beside that the driver is made more aware of the surroundings with slower speeds. Enhanced efficiency is also one of the advantages of roundabouts (roundabouts provide a more efficient way to move traffic through intersections, since they are continuously flowing, and yield-controlled, they can handle a larger amount of traffic in the same amount of time than a conventional intersection. Roundabouts also reduce congestion on approaching roads and help drivers get to where they need to go in quick timing.). No traffic lights is one of the advantages, too, because there is no flow interrupttion. Since traffic is constantly moving through these intersections, drivers don’t feel the need to accelerate to make it through a traffic light and through the intersection, which made roundaboats safier. Vehicle pollution is decreased because vehicles entering the intersection aren’t required to stop. This opportunity for free-flowing traffic eliminates the stop-and-go movements associated with stop signs or intersections controlled by traffic signals. Reduced stop-and-go traffic leads to fewer idling vehicles and decreased vehicle pollution overall. Reduced maintenance costs is also one big advantage, because traffic signals require electricity 24/7 and the maintenance cost associated with it can become expensive and require a lot of equipment in order to function. If a signal blacks

out, the intersection can cause chaos. Increased aesthetic opportunities roundabout, because typical intersections controlled by traffic signals require large, unsightly paved areas to accommodate the full range of turning movements needed. A roundabout provides a welcome opportunity for landscaping and artwork with central space [1].

There are several other disadvantages of roundabouts and they are: As the flow increases and reaches the capacity, weaving generally gives way to a stop and go motion as vehicles force their way into the roundabout, being followed by vehicles waiting in the queue behind them. Under such conditions vehicles, once having got into the rotary, may not be able to get out of it, because the vehicles across their path and the roundabout may lock up. When used on high speed roads, roundabout requires extremely large size. Where the angle of intersection between the two roads is too acute, it becomes difficult to provide adequate weaving length. When provided at close intervals, they make travel troublesome. Traffic turning right has to travel longer distance. A roundabout requires many warning and directional signs for safety. The central island and entrance and exits must be well lighted at night. This tends to make it costly. Roundabouts have a particularly poor safety record for cyclists and motorcyclists because of the geometric design of roundabouts is a major factor in the type of accidents that take place. The design of roundabouts is generally based on maximizing traffic throughput, which often leads to multi-lane approaches with poor entry path curvature and wide circulatory carriageways, encouraging high speed onto and circulating the roundabout) [2].

Very large roundabouts lead to high circulating speeds and cause problems for entering traffic.

2. SUPERSTREET

Unsigned J-turns, limited intersection U-turns, reduced conflict intersection U-turns, reduced conflict U-turns and synchronized streets. Everything listed belongs to Superstreets.

A reduced number of conflicts on Superstreets are achieved by diverting vehicles going straight or turning left to a minor street. Vehicles that want to turn left or want to continue straight cannot do that immediately, they must make so-called U-turn, by turning right, making a U-turn and continuing straight on the main street (if they wanted to turn left) or turn right again (if they wanted to continue straight), as shown in the figure 2). Vehicles turning left and traveling on main street move through the intersection as a conventional intersection, if the median is left open. In a variant of this type of intersection, the median is closed, and vehicles turning left from the main street are redirected to the U-turn section, as indicated.

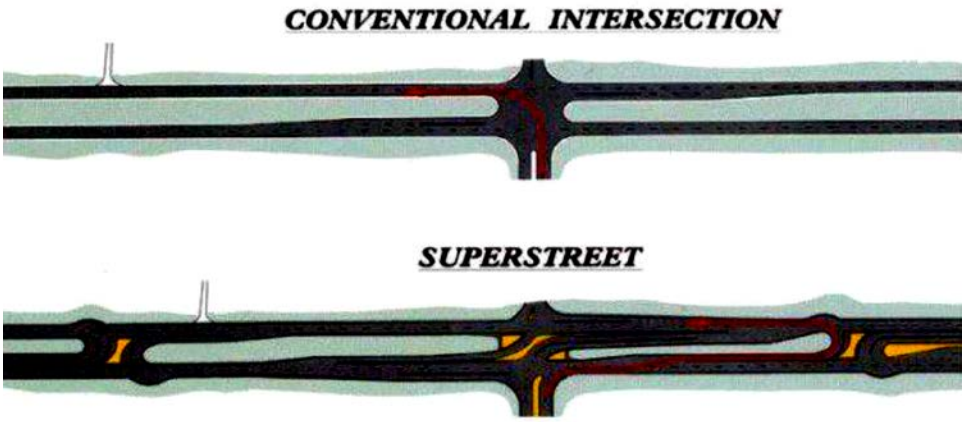

Figure 2. Left turn in conventional intersection (up) and superstreet (down)

The Superstreet design looks complicated, but it doesn't leave drivers much of a choice. This alternative type of intersection guiding them through the intersection by minimizing intersection conflict points. A typical intersection can have as many as 32 potential conflict points, while a Superstreet has only 14 conflict points, so they are therefore safer for pedestrians.

In addition to these significant advances in increasing the safety of both drivers and pedestrians, there are many other things that make these intersections a good alternative. This type of intersection is efficient, because the number of conflicting points is reduced, there are fewer traffic lights, which allows more vehicles to be served and less waiting time. Also, Superstreets are economically profitable because they require less space compared to interchanges, which are an excellent alternative. The smaller areas required for this type of intersection and the reduced waiting time mean that they are more favorable from an environmental point of view.

One difficulty the authors have observed with bulb-outs is the tendency of drivers to occasionally use them to rest and park [3].

2. 1 Restricted crossing U-turn intersection (RCUT)

Restricted crossing U-turn (RCUT) is among the alternative intersection design used to improve the operation and safety of conventional signalized intersections. It allows larger movements (right turns, through and left turns) on the main road, while prohibiting all these movements for smaller volumes, as well as U-turns (for vehicles on the main and minor roads) on the main intersection. U-turns in the main direction are made downstream of the intersection using U-turn lanes. All vehicles on the secondary road must first turn right and then use the U-turn lanes if the driver wants to pass, turn left or U-turn. Figure 3 shows an example of a signalized RCUT intersection.

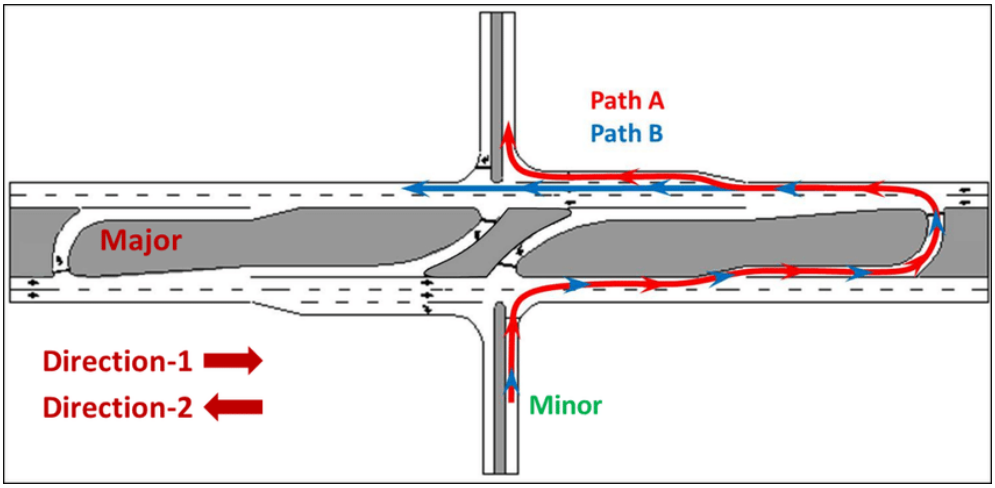

Figure 3. Restricted crossing U-turn (RCUT)

In one of the studies, thirteen RCUT intersections were compared to twenty conventional intersections. Using the cross-sectional method, it was determined that RCUT intersections significantly increase the rush of individual vehicles. On the other hand, the before-and-after method found that RCUT intersections significantly reduced other types of crashes (except vehicle crashes) that did not change significantly with the implementation of the RCUT design [4].

Advantages of RCUT are reduced number and severity of conflicts, reduced signal phases and shorter cycle length (results in decreased intersection delay, congestion, and queuing), – increased intersection capacity, allows installation of additional midblock crossing pedestrian signals, significant cost benefit over grade separation solution.

On the other side disadvantages of RCUT are that without special facilities, crossing bicyclists may have challenges, it increases travel time and distance for movements that are redirected, may require additional right-of-way for loons or wider medians and higher construction cost than conventional intersection due to additional pavement, signs, and signals [5].

2.2. Median U-turn (MUT)

RCUT intersections are a variant of median U-turn (MUT) intersections. Median U-turns (MUT) are the most common type of alternative intersections in Michigan, Florida and Louisiana.

A MUT intersection involves the elimination of direct left turns from major and/or minor approaches (usually both). Vehicles wishing to turn left from the main road onto the intersecting minor road must first pass through the main at-grade intersection and then make a U-turn at the median opening downstream of the intersection. These drivers then turn right at the intersection. Vehicles on the side street who wish to turn left onto the main road must first turn right at the main intersection, make a U-turn at the downstream median and proceed back through the main intersection.

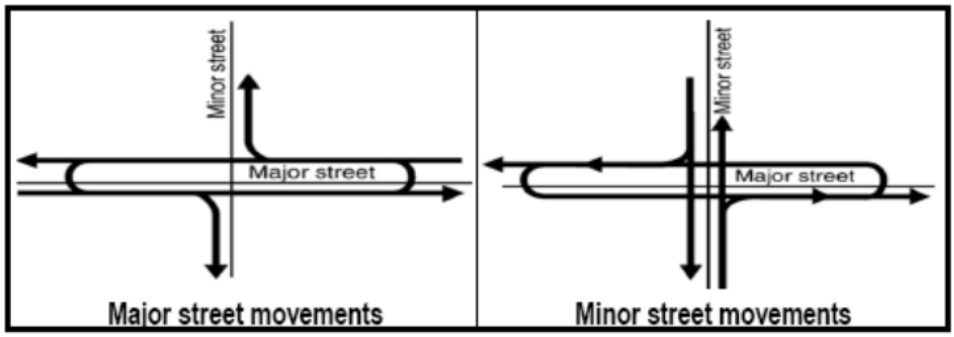

Figure 4. Median U-turn (MUT) movements on major and minor streets

MUT intersection have fewer conflict points compared to conventional intersections with double left turn lanes. An information guide from FHWA shows the number of conflict points at a four-way signalized intersection (32 in total) compared to MUT intersections (16 in total). The MUT intersection, compared to a conventional intersection, reduces crossing conflict points by 75%.

These alternative intersections are sometimes classified as U-turn based intersections. For these reasons, the safety effects of RCUT implementation are somewhat similar to those of MUT intersections.

MUT intersections are often more effective in reducing total, property damage and rear-end crashes; however, RCUT have shown greater effectiveness in reducing minor injuries, fatal injuries, frontal crashes, and corner crashes. Compared to partial MUTs, RCUTs are more effective in reducing the total number of traffic accidents, but less effective in reducing accidents with less material damage.

It should also be noted that MUT intersections are significantly more dangerous for traffic accidents which are involving non-motorized users [4].

3. CONTINIOUS FLOW INTERSECTIONS (CFI OR DLT)

Continuous flow intersections (CFI) are also known as Displaced left turns (DLT) and crossed displaced left turns. They reduce number of conflicts at the main intersection by directing left-turning vehicles to the crossing at a location upstream of the main intersection. In this way, vehicles turning left do not encounter oncoming traffic at the main intersection, that is, they do not have a conflict. In fact, the conventional intersection is split to allow more traffic to flow continuously, as left turns and oncoming vehicles occur simultaneously at the main flow intersection.

In terms of safety, full and partial DLT intersections have 28 and 30 conflict points, respectively, compared to a conventional intersection, which has 32. One of the studies was at Airline Highway and Siegen Lane in Baton Rouge, LA. The results of a simple before-after DLT intersection study showed is a 24 percent reduction in total crashes and a 19 percent reduction in fatal and injury crashes over 2 years after installing a partial DLT.

All of the above referred to vehicle-vehicle conflicts. At DLT intersections, pedestrian and bicycle flows are separated, i.e. there is no pedestrian-vehicle conflict, which significantly increases safety at this type of alternative intersection [6].

Other advantages of DLT are that increases lane capacity by 30 to 70 percent, reduced number of signal phases improves progression and significant cost benefit over grade separation solution.

Disadvantages are potential for wrong-way movements, larger footprint than conventional intersection and longer pedestrian crossing distances and time [5].

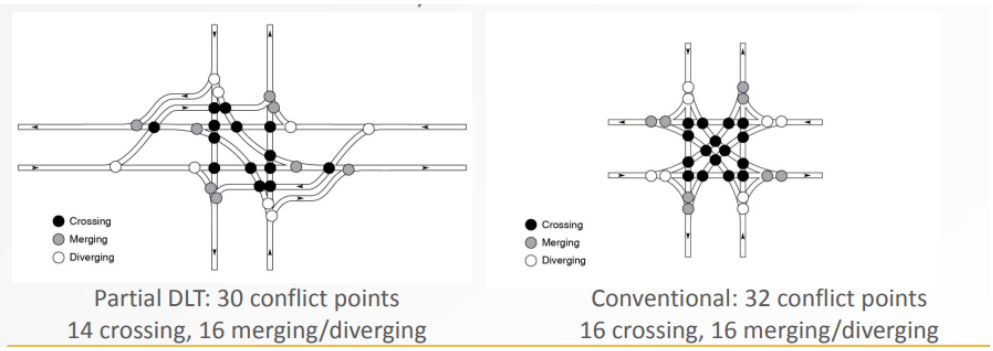

Figure 5. Conflict points of Partial DLT and Convential intersection

There are limited safety-related studies for a small number of existing DLT intersections to infer safety performance based on observed data, so special attention should be paid to this type of alternative intersections.

4. CONTINUOUS GREEN-T INTERSECTIONS (CGT)

Continuous green-T (CGT) intersections, also known as Continuous-T, Turbo-T, High-T, Florida-T, Florida green-T, or Seagull intersections, are usually implemented at three-arm intersections, although there may be a fourth arm in driveway.

This alternative intersection design is controlled by traffic lights, and traffic is traveling in the direction on the upper side of the "T" passes through the intersection without stopping, while the other direction is typically signaled. Vehicles turning left onto main street use the channelized receiving lane to merge onto the main street. By allowing free flow of the main street through one-way traffic, the efficiency of the entire intersection is improved.

Channeling vehicles turning left from a side street reduces the possibility of corner collisions, which is extremely important for safety. Angled collisions are known as having major consequences for drivers, because due to the force acting on the driver from a side impact, the most common injuries drivers sustain are neck injuries, which are mostly fatal.

For example, in Florida, this type of intersection has been used for decades, and certain studies have been conducted and have shown that this type of intersection has proven to be extremely safe for drivers who are not Florida residents. For this reason, the studies conducted in the period from 2003 to 2008 refer to traffic accidents that occurred at Continuous Green-T (CGT) intersections and only in the main lane, where vehicles must stop at the light signal. It was noted that the continuous flow lanes had a statistically significant higher proportion of side impact crashes than the stop lanes. This was probably due to the swerving of vehicles merging into the continuous flow lanes. This analysis did not take into account the overall frequency of collisions or any potential confounding factors. The results of this analysis were based on a comparison of crashes between lane

groups, and therefore have limited practical value, as they did not include the types of injuries, which is much more important.

Another study was conducted in Florida between 2000 and 2003 involving five Continuous Green-T (CGT) intersections, where a total of 117 traffic accidents occurred, of which 10 were rear-end collisions caused by the driver's inadvertent stopping in lanes for continuous flow, which, together with side collisions, constitute the most common type of collision at this type of alternative intersection. The side court was reached when drivers turning left from the smaller arm of the intersection turned or merged with passing traffic on the main road [7].

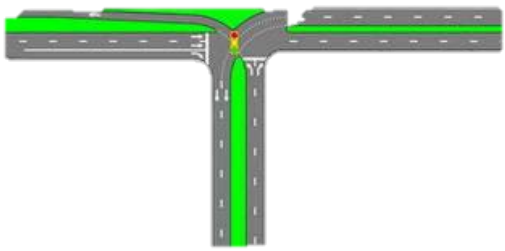

Figure 6. Continuous green-T (CGT) intersection

These data are of great importance when designing this type of alternative intersections because they directly indicate the biggest problems that significantly affect the reduction of safety. Adequate projecting of light signals at this type of intersection and knowledge of pressing problems can have a significant impact on increasing safety.

CGT intersections need to be considered only at intersections with three approaches, which have a moderate or low volume of left turns from the side street and a high flow on the main stream.

One good example of adequate management of Continuous Green-T (CGT) intersections is a study conducted at two rural T-intersections in Colorado (in Grand Junction and Durango), with a high incidence of injuries and angle crashes. The crash reduction results are based on a review of "before and after" data from these intersections over a four-year period. The "before" and "after" observation period was 24 months at both intersections. At both intersections, a large number of crashes were observed, especially at an angle and many with injuries, due to the limited stopping distance. In order to solve these two problems, and thereby improve the efficiency of the intersection. Converting the intersection (US-50 and SH 141, Grand Junction, CO) to a CGT intersection reduced cornering crashes from 16 to 0 (a 100 percent reduction); accidents with injuries reduced from 12 to 2 (a reduction of 83.3 percent); the total number of collisions was reduced from 16 to 7 (a reduction of 56.3 percent).

At another intersection (US-160 and US-550, Durango, CO2) corner crashes decreased from 15 (including 1 fatality) to 1 (average crash reduction of 93.3 percent); injury crashes were reduced from 8 to 4 (an average crash reduction of 50 percent); and the total number of crashes was reduced from 19 to 7 (an average crash reduction of 63.2 percent) [8].

Some of other advantages of CTG are that maximizes throughput, primarily by improving signal efficiency (the use of green time), provides physical separation and a safer and quicker left-turn from a side street, allows installation of a signalized intersection at

locations that otherwise couldn't have one, such as intersections that are too close to one another, uses a half-signal (no extra distance driven) and allows one lane of traffic to not stop.

Main disadvantages of CTG are lack of driver familiarity and use due to few installations, left-side merge is a major concern and other safety issues (truck acceleration, pedestrian crossing, traffic control devices etc.) [9].

5. DIVERGING DIAMOND INTERCHANGE (DDI)

Intersections with turnouts are what make DDI different and are very intuitive for the driver, who claim that in cities where DDI is built, they don't even notice this type of alternative intersection. Turnouts gently cross or separate traffic from the right side of the road to the left side of the road and join it again. As traffic flows on the left between intersections, all left turns are made without the need to cross traffic from the opposite direction. Road geometry, road signs and markings help make this very easy.

DDI is worth considering as an alternative especially in locations with the following characteristics: a large number of left turns on and off the freeway ramps; moderate but unbalanced traffic volume at the intersection through the loop, safety issues related to left turns at intersections and when there is a need for additional capacity without roadway and bridge widening.

A separate study comparing DDI designs with conventional diamond interchange designs compared a range of combinations of high and low traffic volumes. For higher traffic volumes, DDI designs showed better overall performance, reducing latency by 15-60 percent and increasing throughput by 10-30 percent. The DDI could accommodate twice as much left-turn traffic as the conventional design.

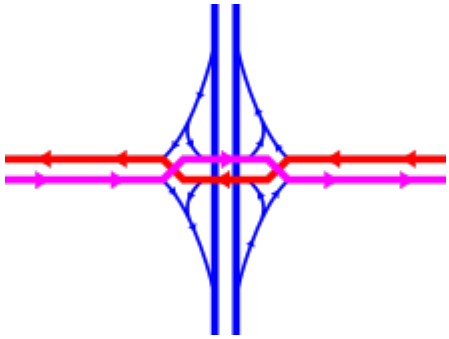

Figure 7. Diverging diamond interchange

A potential collision exists every time a vehicle, pedestrian, or bicycle crosses or turns across the path of another direction of traffic. Compared to a conventional diamond-shaped intersection, DDI reduces collision points between vehicles by nearly 50 percent and eliminates many of the most severe types of collisions. A DDI evaluation in Springfield, Missouri, compared crashes from the first year after construction to the five-year average before DDI and found the following:

- Left turn accidents are completely eliminated,
- Right angle shots are reduced by 72 percent,
- Rear impacts are reduced by 29 percent,
- The total number of crashes was reduced by 46 percent.

For example in 2009 it was opened DDI in Springfield, Missouri, and it was the first in the United States. After that, dozens of others were built in several states and quickly became a popular option. Where they are built, travelers save time, agencies save money, and they are significantly safer.

DDI can cost less – in some cases up to 75 percent less – than a conventional diamond or e.g. one city loop. DDI often require fewer lanes than conventional designs to handle the same amount of traffic. A smaller footprint means less land is needed, resulting in less impact on neighboring areas. All this makes the DDI alternative cheaper, easier and faster to build than some conventional solutions [10].

Disadvantages of DDI are bus stops must operate outside of the interchange, traffic signals in opposite directions will never be green simultaneously, DDI require more pedestrian crossings because of their design, drivers may be confused by driving on the "wrong side" of the road, leading to inadvertent lane changes [11].

6. ADVANTAGES AND DISADVANTAGES OF ALTERNATIVE INTERSECTIONS

Alternative ways of managing intersections, as everything else, are not perfect and they have their advantages and disadvantages. Depending on what is to be achieved, the most adequate alternative solution can be chosen. For this reason, Table 1 shows the good sides, that is, what can be found as a problem when considering the introduction of some of the listed alternative intersection solutions.

Table 1. Advantages and disadvantages of alternative intersections

Name of intersection	Advantages	Disadvantages
Roundabout	–Mini roundabout are extreamly safe. –Improved safety. –Fewer conflict points. –Reduced travel speeds. –Enhanced efficiency –No traffic lights. –Decreased vehicle pollution. –Reduced maintenance costs. –Increased aesthetic opportunities.	Can be blocked when there is a large amount of traffic. Requires extremely large size. Difficult to provide adequate weaving length between two roads. When provided at close intervals, they make travel troublesome. Traffic turning right has to travel longer distance. A roundabout requires many warning and directional signs for safety. The central island and entrance and exits must be well lighted at night. Roundabouts have a particularly poor safety record for cyclists.
Superstreet	Has only 14 conflict points. There are fewer traffic lights. Economically profitable because they require less space compared to	With bulb-outs is the tendency of drivers to occasionally use them to rest and park.

	interchanges. The smaller areas required for this type of intersection and the reduced waiting time mean that they are more favorable from an environmental.	
RCUT/MUT	MUT intersections are effective in reducing total, property damage and rear-end crashes. RCUT have shown greater effectiveness in reducing minor injuries, fatal injuries, frontal crashes, and corner crashes. Compared to partial MUTs, RCUTs are more effective in reducing the total number of traffic accidents.-Reduced signal phases and shorter cycle length (results in decreased intersection delay, congestion, and queuing). Increased intersection capacity. Allows for installation of additional midblock crossing pedestrian signals. Significant cost benefit over grade separation solution.	Without special facilities, crossing bicyclists may have challenges. Increased travel time and distance for redirected movements. May require additional right-of-way for loons or wider medians. Higher construction cost than conventional intersection due to additional pavement, signs, and signals. MUT intersections are significantly more dangerous for traffic accidents which are involving non-motorized users. RCUT is less effective in reducing accidents with less material damage.
Continious flow intersection (CFI) of Displaced left turn (DLT)	Full and partial DLT intersections have 28 and 30 conflict points, respectively. Reduction in total crashes and in fatal and injury crashes after installing a partial DLT (vehicle-vehicle conflicts).Pedestrian and bicycle flows can be separated, i.e. there is no pedestrian-vehicle conflict, which significantly increases safety. Increased lane capacity by 30 to 70 percent. Reduced number of signal phases improves progression and significant cost benefit over grade separation solution.	Potential for wrong-way movements. Larger footprint than conventional intersection. Longer pedestrian crossing distances and time.
Continuous Green-T	Reduced cornering crashes, accidents with injuries an the total number of collisions. Maximizes throughput, primarily by improving signal efficiency (the use	Lack of driver familiarity and use due to few installations. Left-side merge is a major concern. Other safety issues (truck

	of green time). Provides physical separation and a safer and quicker left-turn from a side street. Allows installation of a signalized intersection at locations that otherwise couldn't have one, such as intersections that are too close to one another. Uses a half-signal (no extra distance driven) and allows one lane of traffic to not stop	acceleration, pedestrian crossing, traffic control devices and driveways).
DDI	Reduced collision points between vehicles and eliminates many of the most severe types of collisions. Left turn accidents are completely eliminated. Right angle shots, rear impacts and the total number of crashes is also reduced. Travelers save time. Costs less – in some cases up to 75 percent less. Require fewer lanes than conventional designs to handle the same amount of traffic. A smaller footprint means less land is needed, resulting in less impact on neighboring areas. All this makes the DDI alternative cheaper, easier and faster to build than some conventional solutions.	Bus stops must operate outside of the interchange. Traffic signals in opposite directions will never be green simultaneously. Require more pedestrian crossings because of their design. Drivers may be confused by driving on the "wrong side" of the road, leading to inadvertent lane changes.

7. CONCLUSION

As shown in this paper, each alternative intersection has its advantages and disadvantages. Depending on the location, intersection geometry, traffic flow structure and traffic conditions, the most favourable solution can be chosen. When everything is summed up, all intersections have the same goals, which are to reduce the number of conflict points, reduce waiting time and, most importantly, increase the safety of road users (drivers, pedestrians, motorcyclists and cyclists). In the Republic of Serbia, roundabouts are the only type of alternative intersections that is represented.

This paper showed a high potential for alternative intersections in order to improve safety in Republic of Serbia by turning some of conventional safety critical intersections into alternative ones.

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