Unconventional Left-Turn Alternatives for Urban and Suburban Arterials

An Update

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ABSTRACT

Many arterials are hopelessly congested. In many places, engineers have done as much as they can with conventional improvements. Advances like intelligent transportation systems will not provide widespread assistance on arterials for many years. To help treat this impasse, the first author wrote a series for ITE describing seven unconventional design alternatives for arterials. The purposes of this paper are to review five of those alternatives—the median U-turn, bowtie, superstreet, jughandle, and continuous flow intersection—and to summarize new information about them. After presenting the advantages and disadvantages of each alternative, the paper suggests when analysts should consider one during feasibility studies and functional designs.

INTRODUCTION

Many urban and suburban arterials are congested with little immediate hope of relief. Access management and better coordination between land use and transportation offer long-term hope for developing areas but little short-term promise for developed areas. Transportation engineers in many places have done as much as they can with actuated signals, signal systems, multiple left turn lanes, right turn lanes, and other conventional measures. Good parallel streets to create one-way pairs rarely exist outside downtown areas. Intelligent transportation system efforts have concentrated on freeways. Public transportation will require shifts in land use before it provides major relief. Widening arterials, building overpasses and flyovers, upgrading arterial intersections to interchanges, and building bypasses are expensive and disruptive.

To help treat this impasse, the first author wrote a two-part series for ITE (*1,2*) describing seven unconventional alternatives that engineers may wish to consider for their urban and suburban arterials. The main purpose of the series was to entice engineers into considering one or more of these alternatives during feasibility studies and functional designs. Agencies have good tools, such as the Highway Capacity Software, SIDRA, Synchro, TRANSYT-7F, and CORSIM, to evaluate a wide range of alternatives with forecast traffic volumes at particular locations.

The purposes of this paper are to review five of those alternatives and to summarize new information on the alternatives that have been generated since the two-part ITE series was written. The five unconventional alternatives reviewed here are the

- Median U-turn,
- Bowtie,
- Superstreet,
- Jughandle, and
- Continuous flow intersection.

The paper presents significant new research or implementation on the median U-turn, superstreet, and continuous flow intersection. Space limitations in this paper prevented review of the other two alternatives (paired intersections and continuous green T intersections) discussed in the ITE series.

The unconventional alternatives share two major principles. First, the emphasis is on reducing delay to through vehicles. Serving through vehicles is the main purpose of the "arterial" functional class. Second, the unconventional alternatives try to reduce the number of conflict points at intersections, and separate the conflict points which remain. This usually means reducing the number of phases at signals from four (assuming no overlaps) to two, which reduces delay for through traffic and promotes progression along the arterial. This also usually means fewer threats to drivers, which promotes safety. The unconventional alternatives discussed in this paper reduce the number of conflict points by rerouting some left turns, and one reroutes cross street through movements. Agencies must have sufficient will, political backing, public relations resources, and (at times) enforcement resources to choose such an alternative and make it work.

By their nature as unconventional solutions, and by rerouting certain movements, the alternatives presented here all have the potential to cause more driver confusion than conventional arterials. However, newness is not a sufficient reason to ignore an otherwise superior alternative. In addition, two of the designs discussed in this paper have been in place at many locations in at least one state for a number of years. These older unconventional alternatives have shown that agencies can mitigate the confusion inherent in rerouting certain movements. In both cases, the agencies have developed understandable traffic control devices to guide drivers through the intersections. The agencies have also found that driver expectancies are best met if they use the alternatives at several intersections or on a whole section of arterial.

This paper presents each of the five unconventional alternatives with the same format: a description with a diagram, a summary of the new research or implementation if any, a list of the advantages and disadvantages relative to a conventional arterial, and a summary of where agencies should consider the unconventional alternative. To understand one unconventional alternative relative to another, compare the two lists of advantages and disadvantages.

MEDIAN U-TURN

Description

The median U-turn, shown in Figure 1, requires left turns to and from the arterial to use directional median crossovers. At a signalized intersection, left turns from the arterial proceed beyond the intersection, make a U-turn at the crossover, and make a right turn back at the main intersection. Left turns to the arterial first make a right turn at the main intersection and then make a U-turn at the crossover. Left turns are prohibited at the main intersection, so the signal there has two phases. The directional crossovers may be signalized or controlled by Stop signs, depending on the volumes and other usual considerations. A signal at a directional crossover should be coordinated with the signal at the main intersection, requiring arterial drivers to stop no more than once. The distance from the main intersection to the nearest crossover is a trade-off between preventing spillback and causing extra driving. Many agencies have found a distance of 600 feet to be optimum. Median widths depend on the design vehicle and the radius in which it can make a U-turn. For a large semi-trailer combination design vehicle AASHTO (*3*) recommends a median width of 60 feet on a four-lane arterial. A narrower median is possible with a smaller design vehicle, on six- or eight-lane arterials, or by providing a paved turning basin beyond the edge line. Placing the directional crossovers on the cross street instead of the arterial minimizes the right-of-way needed along the arterial and placing directional crossovers on both the arterial and the cross street increases the left turn capacity.

The Michigan Department of Transportation (MDOT) is the most prominent user of median U-turns in the United States, with over 1000 miles in service. MDOT and other agencies in Michigan have used median U-turns for 30 years and continue to design them.

New Information

In recent years the authors have studied the capacity and efficiency of median U-turns. The capacity of a median U-turn relative to a conventional arterial at a signalized intersection is an interesting trade-off. The capacity increases for the median U-turn due to fewer signal phases with less lost time but decreases because there are typically fewer approach lanes and because left-turning vehicles pass through the intersection twice. Table 1 shows the second author’s (Reid’s) recent work, previously unpublished, on the intersection capacity

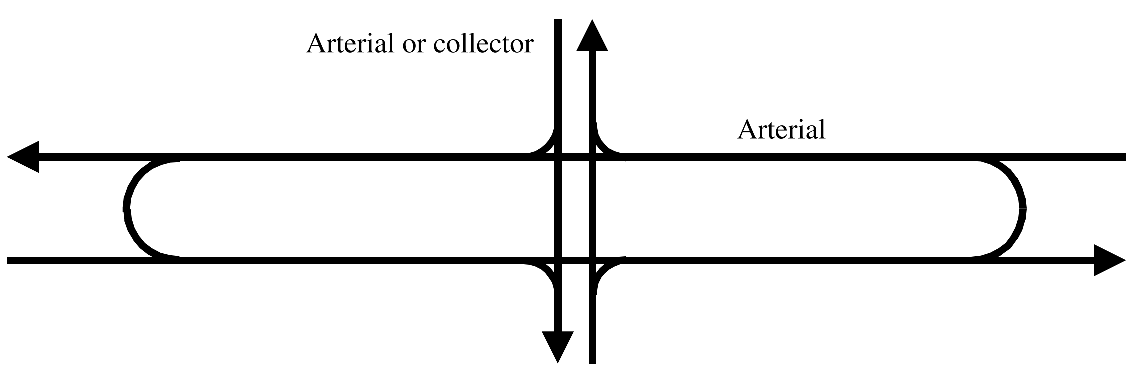

FIGURE 1 Median U-turn.

TABLE 1 Median U-Turn and Conventional Intersection Capacities

Arterial		Cross street	Critical v/c with 180-second cycle			
			20% turns		40% turns	
ADT	Dir. Split	ADT	Med. U-turn	Conv.	Med. U-turn	Conv.
15,000	60	15,000	0.49	0.56	0.61	0.69
		25,000	0.65	0.74	0.83	0.93
	70	15,000	0.58	0.69		
		25,000	0.77	0.91		
20,000	60	15,000	0.57	0.66	0.7	0.81
		25,000	0.73	0.84	0.93	1.05
	70	15,000	0.68	0.81		
		25,000	0.86	1.03		
25,000	60	15,000	0.66	0.76	0.79	0.81
		25,000	0.82	0.94	1.02	1.05
	70	15,000	0.77	0.93		
		25,000	0.96	1.15		
30,000	60	15,000	0.74	0.86	0.88	0.9
		25,000	0.9	1.04	1.11	1.14
	70	15,000	0.87	1.05		
		25,000	1.06	1.27		
35,000	60	15,000	0.63	0.78	0.98	0.99
		25,000	0.79	0.96	1.2	1.23
	70	15,000	0.74	0.95		
		25,000	0.93	1.17		
40,000	60	15,000	0.69	0.85	1.07	1.08
		25,000	0.84	1.03	1.29	1.32
	70	15,000	0.81	0.93		
		25,000	1	1.15		

of median U-turns relative to conventional arterials with protected left turns. The table shows the critical volume to capacity (v/c) ratio at the maximum cycle length, as calculated by the planning analysis technique in the 1997 update of the *Highway Capacity Manual* (*4*). The critical v/c at the maximum cycle length is a "pure" measure of the potential throughput of the intersection, removing the effects of signal timing from the computation. The assumptions made to arrive at the results in Table 1 included: a maximum cycle length of 180 seconds, lost times of six seconds for cross streets at median u-turns and four seconds otherwise, a directional split of 55/45 on the cross street, single exclusive right turn lanes, single exclusive left turn lanes for conventional arterials with less than 300 vph, dual exclusive left turn lanes for conventional arterials with 300 vph or higher, two through lanes in each direction for ADTs of 30,000 or below, three through lanes in each direction for ADTs of 35,000 and above, 10 percent of daily traffic in the peak hour, and a peak hour factor of 0.95. The table shows that median U-turns provide a higher critical v/c by 0.1 or more with 20 percent turns and by a smaller margin with 40 percent turns.

The authors presented a paper at the 1999 Transportation Research Board Annual Meeting with results from a CORSIM experiment on the efficiency of median U-turns relative to two-way left turn lanes (TWLTLs) and superstreets (*5*). The experiment used the geometry and traffic volumes from an actual median U-turn arterial in suburban Detroit, Michigan. The arterial was 2.5 miles long with five unevenly spaced signals, four to six through lanes, an ADT of 52,000 to 60,000, and a 50-mph speed limit. The authors simulated unsignalized side streets and major driveways. The authors used the SYNCHRO program to time the signals for all three alternatives, using protected left turn phases for the TWLTL alternative. In the experiment the authors varied the percentage of through traffic (10 to 25 percent over the corridor) and time of day. Table 2 summarizes the results. Each row in the body of the table is the mean from 12 half-hour simulation runs (four levels of through volume, replicated three times). The table shows that the median U-turn, relative to the TWLTL was:

- Superior in mean vehicle speed in all four time periods,
- Superior in total system time in the peak periods,
- Roughly equal in total system time in the off-peak periods,

TABLE 2 Simulation Results from Reid and Hummer (*5*)

Time of day	Major street geometry	Total system time, veh.-hrs.	Mean stops per veh.	Mean speed, mph
A.M. peak	TWLTL	302	1.95	14.5
	Median u-turn	254	1.98	22.4
	Superstreet	283	2.36	18.2
Noon	TWLTL	136	1.45	25.9
	Median u-turn	137	1.75	28.5
	Superstreet	142	1.84	27.4
Midday	TWLTL	162	1.53	24.6
	Median u-turn	159	1.82	27.3
	Superstreet	164	1.86	27
P.M. peak	TWLTL	403	2.08	13.3
	Median u-turn	280	2.19	19.2
	Superstreet	314	2.59	17.3
Mean, all times	TWLTL	251	1.75	19.6
	Median u-turn	208	1.94	24.4
	Superstreet	226	2.16	22.5

- Roughly equal in number of stops in the peak periods, and
- Inferior in number of stops in the off-peak periods.

Researchers from Michigan State University have also performed a recent CORSIM experiment on the efficiency of the median U-turn alternative relative to a TWLTL (*6*). Their experiment was on an “ideal” four-lane corridor with six signals spaced every 0.5 miles, no sidestreets or driveways, a free-flow speed of 45 mph, and a constant 80-second cycle. Four-lane cross streets at the signals carried two-thirds of the volume of the arterial. All intersection approaches had exclusive right turn lanes, and left turns from the arterial were protected. The researchers varied the major street entering volumes from 30 percent of saturated to 100 percent of saturated, varied the turning percentages at each intersection from 10 to 25 percent, varied the median width of the median U-turn design from 40 to 100 feet, and varied traffic control at the crossover from STOP sign to signal. The results from the simulations followed the same trends as seen in Table 2. For example, the researchers reported that the median U-turn saved about one minute per vehicle compared to the TWLTL for saturation levels above 50 percent with 10 percent left and right turns. The median width and crossover traffic control factors did not have large effects on the comparison between the median U-turn and TWLTL.

Michigan State University researchers have also published data recently on the collision rates for the median U-turn alternative relative to arterials with TWLTLs and arterials with medians and conventional left turns (*7*). Table 3 summarizes the data, from five years in Michigan. The sample sizes range from 36 to over 300 sections per category of

TABLE 3 Median U-Turn Collision Rates from Michigan (*7*)

Collision type	Reported collisions per 100 million vehicle miles					
	Unsignalized			Signalized		
	TWLTL	Conv. median	Median U-turn	TWLTL	Conv. median	Median U-turn
Rear end	150	40	100	490	360	340
Angle-Straight	30	10	0	120	20	20
Angle-turn	40	10	20	80	50	40
Head-on Left turn	20	10	10	130	70	20
Driveway Related	110	10	20	200	40	40
Other types	120	100	70	210	210	140
Total of above	460	180	220	1220	750	600

arterial, with almost 1,000 miles of roadway represented. Collision rates were significantly lower for sections with medians than TWLTL for almost all collision types. In general, compared to sections with medians and conventional left turns median U-turn sections had lower collision rates on signalized sections and higher collision rates on sections without signals. Readers must use the rates provided in Table 3 with caution due to possible confounding factors, such as roadside development density or cross street traffic volumes.

Advantages

The advantages of the median U-turn over a conventional multi-phase signalized intersection include:

- Reduced delay for through arterial traffic,
- Increased capacity at the main intersection,
- Easier progression for through arterial traffic,
- Fewer stops for through traffic, particularly on approaches with Stop-controlled directional crossovers,
- Fewer threats to crossing pedestrians, and
- Fewer and more separated conflict points.

Disadvantages

The disadvantages of the alternative relative to conventional intersections include:

- Driver confusion,
- Driver disregard of the left turn prohibition at the main intersection,
- Increased delay for left-turning traffic,
- Increased travel distances for left-turning traffic,
- Increased stops for left-turning traffic,
- Larger rights-of-way along the arterial,
- Higher operation costs for extra signals, and
- Longer cross street minimum green times or two-cycle pedestrian crossing.

In addition, wider medians are generally considered to harm roadside businesses. To the extent that conventional arterials can safely and efficiently have narrower medians or two-way left turn lanes, roadside businesses may benefit.

When to Consider

Agencies should consider the median U-turn alternative where generally high arterial through volumes conflict with moderate or low left turn volumes and any cross street through volumes. If the left turn volume is too high, the extra delay and travel distance for those drivers, and the spillback potential, will outweigh the savings for through traffic. Arterials with narrow medians and no prospects for obtaining extra rights-of-way for widening are poor candidates for the median U-turn, with the exception of cases where agencies can build the wide median and crossovers on the cross street.

BOWTIE

Description

The bowtie alternative is a variation of the median U-turn alternative with the median and the directional crossovers on the cross street. To overcome the disadvantage of requiring a wide right of way on the cross street, the bowtie uses roundabouts on the cross street to accommodate left turns as Figure 2 shows. Left turns are prohibited at the main intersection, which therefore requires only a two-phase signal. Vehicles yield upon entry to the roundabout, but if the roundabout has only two entrances as shown on Figure 2 the entry from the main intersection does not have to yield. The roundabout diameter, including the center island and circulating roadway, varies from 90 feet to 300 feet depending on the speed of traffic on the approaches, the volume of traffic served, the number of approaches, and the design vehicle. The distance from the roundabout to the main intersection could vary from 200 to 600 feet, trading off spillback against extra travel distance for left-turning vehicles. The arterial may have a narrow median. U-turns on the arterial are difficult, having to travel both through roundabouts and through the main intersection three times, so the arterial should accommodate midblock left turns directly.

A few agencies have installed roundabouts on cross streets in an evolutionary manner, but no agency to the authors' knowledge has consciously designed a complete bowtie alternative. The first author and former student Jonathan Boone, inspired by the raindrop interchange common in Great Britain, conceived of the bowtie design in 1992 and published the idea and a simulation analysis of it in 1994 and 1995 (*8,9,10*). Raindrop interchanges are similar to diamond interchanges but with roundabouts instead of signalized or Stop-controlled ramp terminals. A few raindrop interchanges have been designed and built in the United States recently, most notably in Vail, Colorado.

Advantages

The advantages of the bowtie over conventional multi-phase signalized intersections include:

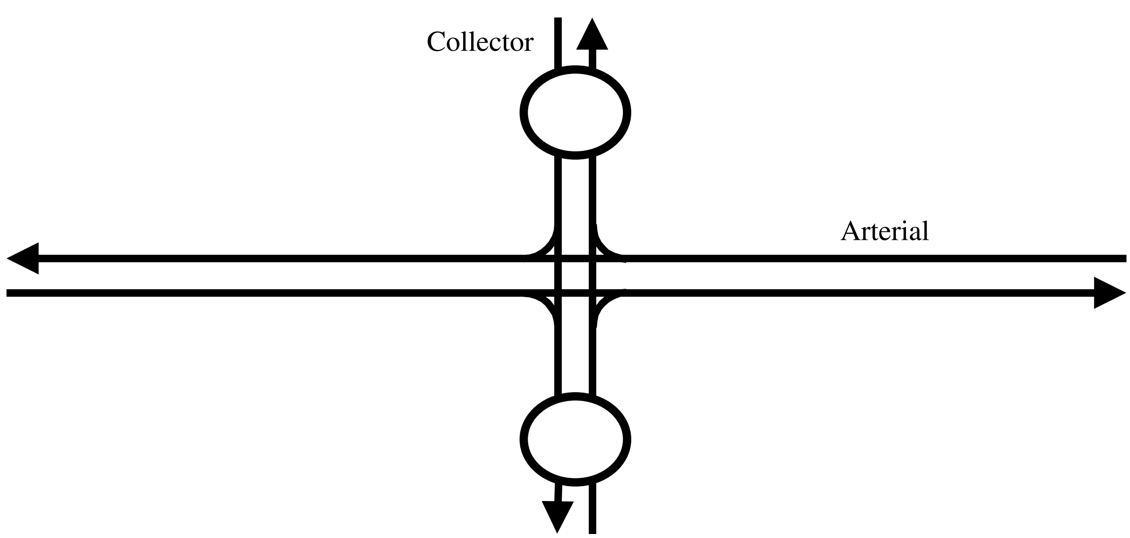

FIGURE 2 Bowtie.

- Reduced delay for through arterial traffic,
- Increased capacity at the main intersection,
- Reduced stops for through arterial traffic,
- Easier progression for through arterial traffic,
- Fewer threats to crossing pedestrians, and
- Reduced and separated conflict points.

Disadvantages

The disadvantages of the alternative relative to conventional intersections include:

- Driver confusion,
- Driver disregard for the left turn prohibition at the main intersection,
- Increased delay for left-turning traffic and possibly cross street through traffic,
- Increased travel distances for left-turning traffic,
- Increased stops for left-turning and cross street through traffic,
- Additional right-of-way for the roundabouts, and
- Difficult arterial U-turns.

When to Consider

Agencies should consider the bowtie alternative where generally high arterial through volumes conflict with moderate to low cross street through volumes and moderate or low left turn volumes. If the left turn volume is too high, the extra delay and travel distance for those drivers, and the spillback potential, will outweigh the savings for arterial through traffic. Likewise, if the cross street through volume is too high delays caused by the roundabout will outweigh the savings for the arterial through traffic. Arterials with narrow or nonexistent medians and no prospects of obtaining extra right-of-way for widening are good candidates for the bowtie. Developers may be convinced with certain incentives to build roundabouts into site plans. The distances between signals should be long so that the extra right-of-way costs for the roundabouts do not overwhelm the savings elsewhere.

SUPERSTREET

Description

A superstreet is another extension of the median U-turn. The superstreet provides the best conditions for through arterial movements short of interchanges. The superstreet, shown in Figure 3, requires cross street through movements and left turns to and from the arterial to use the directional crossovers. Four-approach intersections become two independent three-approach intersections. This independence allows each direction of the arterial to have its own signal timing pattern, including different cycle lengths if desired, so that engineers can achieve “perfect” progression in both directions at any time with any intersection spacing. Pedestrians can make a relatively safe but slow two-stage crossing of the arterial as Figure 3 shows. Other design details of the superstreet are identical to median U-turns.

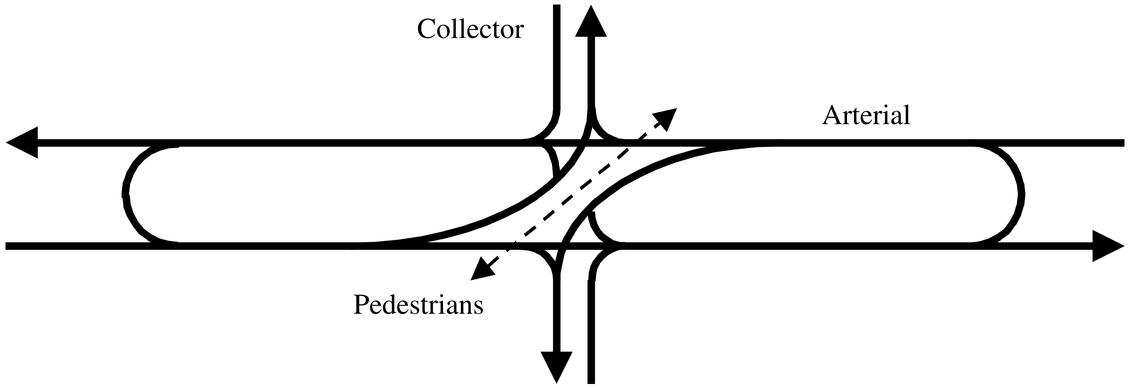

FIGURE 3 Superstreet.

At an intersection with a low volume cross street a designer could dispense with the crossovers at the intersection. Another variation is to reverse the direction of the crossovers at the intersection to allow left turns to the arterial in cases where those are the heavier volume movements. However, these crossovers create difficult merges from the left on the arterial. Researchers have shown that forcing cross street traffic to turn right onto an arterial first, and then turn left back onto the cross street, is generally superior to a left then right pattern (*11*).

Richard Kramer conceived of the superstreet alternative and published a paper on it in 1987 (*12*). No one to the authors' knowledge has implemented the full superstreet alternative, but some agencies have severed cross street through movements and built directional crossovers on arterials in a piecemeal fashion.

New Information

The authors presented simulation results on the efficiency of the superstreet relative to the median U-turn and conventional arterial at the 1999 Transportation Research Board Annual Meeting (*5*). Table 2 (provided above in the "Median U-turn" section) summarized the results. The table showed that the superstreet, relative to the TWLTL, was:

- Superior in mean vehicle speed in all four time periods,
- Superior in total system time in the peak periods,
- Roughly equal in total system time in the off-peak periods, and
- Inferior in number of stops in all four time periods.

The median U-turn design was consistently better than the superstreet design during the experiment. Readers must remember, however, that the experiment was on an existing median U-turn corridor with relatively high cross street through volumes.

Advantages

The advantages of the superstreet over a conventional multi-phase signalized intersection include:

- Reduced delay for through arterial traffic and for one pair of left turns (usually left turns from the arterial),
- Reduced stops for through arterial traffic,
- "Perfect" two-way progression at all times with any signal spacing for through arterial traffic,
- Fewer threats to crossing pedestrians, and
- Reduced and separated conflict points.

Disadvantages

The disadvantages of the alternative relative to conventional intersections include:

- Driver and pedestrian confusion,
- Increased delay for cross street through traffic and for one pair of left turns (usually left turns to the arterial),
- Increased travel distances for cross street through traffic and for one pair of left turns,
- Increased stops for cross street through traffic and for one pair of left turns,
- A slow two-stage crossing of the arterial for pedestrians, and
- Additional right-of-way along the arterial.

When to Consider

Consider a superstreet where high arterial through volumes conflict with moderate to low cross street through volumes. This will be the case for many suburban arterials where roadside development generates most of the conflicting traffic. One should also consider a superstreet where close to 50/50 arterial through traffic splits exist for most of the day but uneven street spacings remove any chance of establishing two-way progression. As for median U-turns, arterials with narrow medians and no prospects for obtaining extra rights-of-way for widening are poor candidates for the superstreet.

JUGHANDLE

Description

The jughandle alternative uses ramps diverging from the right side of the arterial to accommodate all turns from the arterial. In the four-approach jughandle intersection shown in Figure 4, the ramps are prior to the intersection. Left turns from the arterial use the ramp, then turn left on the cross street at the ramp terminal. Ramp terminals are typically STOP-controlled for left turns and Yield-controlled for channelized right turns. In modern jughandles ramp terminals are several hundred feet from the main intersection to insure that queues from the signal on the cross street do not block the terminal. Since no U-turns or left turns are allowed directly from the arterial, the median may be narrow. The signal at the main intersection may need a third phase, for left turns from the cross street, if the volume is heavy. The New Jersey Department of Transportation has used jughandles for years on hundreds of miles of heavy-volume arterial and continues to build new jughandle intersections.

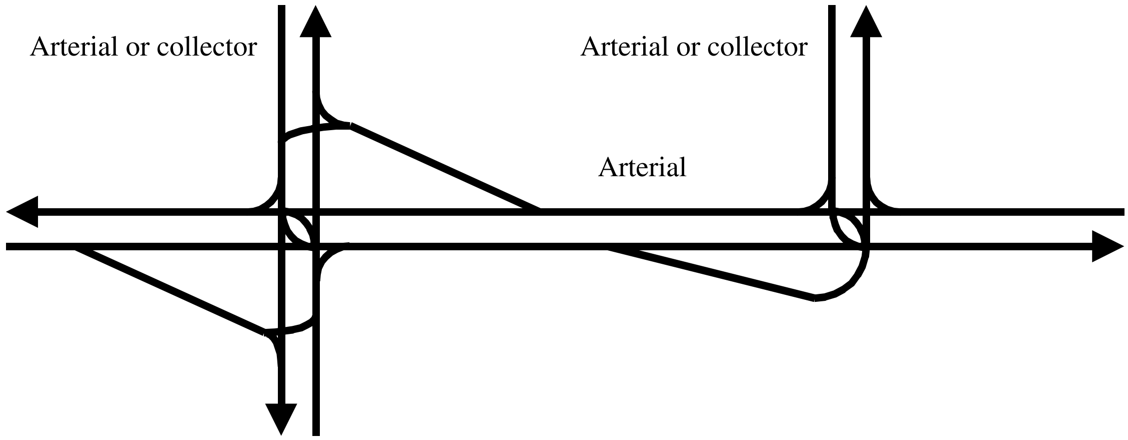

FIGURE 4 Jughandle.

If agencies use jughandles as the only way drivers can make left turns and U-turns along a section of arterial, all turns will be made from the right lane. This could decrease driver confusion, decrease lane changes, and increase travel speeds in the left lane.

If left turns from the ramp terminal are difficult, agencies can use loop ramps beyond the main intersection to accommodate left turns from the arterial. The travel distances for the left-turning vehicles are longer with a loop ramp, but loop ramps allow an easier right turn onto the cross street at the ramp terminal. Agencies can also employ loop ramps beyond the intersection for left turns from the cross street to avoid the third signal phase. Jughandles for three-approach intersections and jughandles exclusively for U-turning traffic use ramps that curve back to meet the arterial as Figure 4 shows.

Advantages

The advantages of the jughandle alternative over conventional multi-phase signalized intersections include:

- Reduced delay for through arterial traffic,
- Reduced stops for through arterial traffic,
- Easier progression for through arterial traffic,
- Narrower right-of-way needed along the arterial, and
- Reduced and separated conflict points.

Disadvantages

The disadvantages of the alternative relative to conventional intersections include:

- Driver confusion,
- Driver disregard for left turn prohibitions at the main intersection,
- Increased delay for left turns from the arterial, especially if queues of cross street vehicles block the ramp terminal,
- Increased travel distances for left turns from the arterial,
- Increased stops for left turns from the arterial,

- Pedestrians must cross ramps and the main intersection,
- Additional right-of-way for ramps,
- Additional construction and maintenance costs for ramps, and
- Lack of access to arterial for parcels next to ramps.

When to Consider

Designers should consider jughandles on arterials with high through volumes, moderate to low left turn volumes, and narrow rights-of-way. The distances between signals should be long so that the extra right-of-way and other costs for the ramps do not overwhelm the savings elsewhere.

CONTINUOUS FLOW INTERSECTION

Description

The continuous flow intersection features a ramp to the left of the arterial upstream of the main intersection to handle traffic turning left from the arterial, as Figure 5 shows. Usually, high volumes will justify a signal at the crossover where the ramp begins. Engineers can easily coordinate this two-phase signal with the signal at the main intersection so that arterial through traffic stops no more than once. The left turn ramp remains along the arterial and meets the cross street near the main intersection. A single signal controls the main intersection and the left turn ramp-minor street intersection. The major breakthrough with this design is that arterial through traffic and traffic from this left turn ramp can move during the same signal phase without conflicting. This allows, in effect, protected left turns with a two-phase signal. The cross street stop bar must be set back beyond the left turn ramp, which probably means more lost time and longer clearance intervals for the cross street signal phase(s). Right turns are removed from conflicts near the intersection with ramps. U-turns on the arterial are possible at the left turn crossover if the median is wide enough. Without provision for U-turns the arterial median may be narrow. The left turn ramp usually crosses the opposing traffic 300 or so feet from the cross street to balance the various higher costs of a longer ramp against the chance of spillback from the main

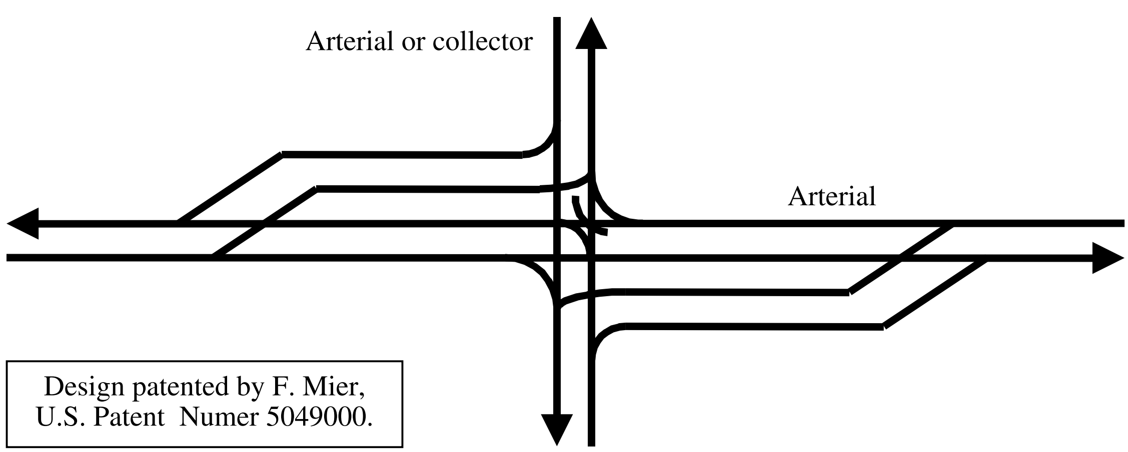

FIGURE 5 Continuous flow intersection.

intersection blocking the signal at the crossover. If left turns to the arterial are heavy at the continuous flow intersection shown in Figure 5, a third signal phase may be needed at the main intersection. To avoid the third phase, designers can use left turn ramps in three or all four quadrants of the intersection.

The continuous flow intersection is the only patented and copyrighted design covered in this paper. Francisco Mier of El Cajon, California, has held the U.S. patent, number 5049000, since 1987. Agencies wishing to implement the design must obtain the rights from Mr. Mier. With co-authors, Mier has published articles (*13,14*) evaluating the concept in general and has written several reports evaluating the concept in particular locations. The first continuous flow intersection in the United States, with ramps in a single quadrant at a T-intersection, was opened in 1994 on Long Island, New York, at an entrance to Dowling College.

New Information

In recent years additional continuous flow intersections have been built in Mexico, bringing the total open as of February 1999 to seven. Primarily, these installations have been left turn ramps in one or two quadrants at oversaturated intersections. Early qualitative findings are that the projects have resulted in huge delay savings with no obvious safety or motorist understanding difficulties. Ten more continuous flow intersections are in the planning or design stages in Mexico. In the United States, the State of Maryland is designing a continuous flow intersection that may be open by the time of the conference (June 1999).

Advantages

The advantages of the continuous flow intersection over a conventional multi-phase signalized intersection include:

- Reduced delay for through arterial traffic,
- Reduced stops for through arterial traffic,
- Easier progression for through arterial traffic,
- Narrower right-of-way needed along the arterial, and
- Reduced and separated conflict points.

With ramps in three or four quadrants these advantages may extend to the cross street as well.

Disadvantages

The disadvantages of the alternative relative to conventional intersections include:

- Driver and pedestrian confusion,
- Increased stops for left turns from the arterial,
- Restricted U-turn possibilities,
- Pedestrians must cross ramps and the main intersection (and pedestrians must cross the four-quadrant design in a slow two-stage maneuver),

- Additional right-of-way for ramps,
- Additional construction, maintenance, and operation costs for ramps and extra signals,
- Lack of access to the arterial for parcels next to ramps, and
- The costs of obtaining the rights to use the design.

Left turns from the arterial may experience more delay than at comparable conventional intersections, but the extra delay is likely to be small in magnitude.

When to Consider

Agencies should consider the continuous flow intersection on arterials with high through volumes and little demand for U-turns. The designer must have some right-of-way available along the arterial near the intersection and must be able to restrict access to the arterial for parcels near the intersection. Like the bowtie and jughandle alternatives, the extra right-of-way and other costs will be hard to justify if installations are too close together.

SUMMARY

The purpose of this paper was to review five of seven unconventional alternatives for arterials which, under certain circumstances, move traffic more efficiently than conventional arterials with fewer negative impacts than widening, bypasses, or interchanges. The paper summarized new information on three of the alternatives. Three of the seven alternatives were older, and four were relatively new. The two major principles of the unconventional arterials were that they reward arterial through traffic and that they reduce the number of conflict points and separate those that remain.

Table 4 summarizes when analysts should consider an unconventional alternative. Some alternatives only make sense at limited numbers of intersections. Three alternatives—the median U-turn, jughandle, and continuous flow—may apply

TABLE 4 Summary

Alternative	Applicable traffic volume			Extra right of way needed
	Left turns from arterial	Left turns from minor street	Minor street through	
Median U-Turn	Low-Medium	Low-Medium	Any	30' wide along arterial
Bowtie	Low-Medium	Low-Medium	Low-Medium	2 circles up to 300' diameter on minor st.
Superstreet	Any	Low-Medium	Low-Medium	30' wide along arterial
Jughandle	Low-Medium	Low-Medium	Any	Two 400' by 300' triangles at int.
Continuous Flow	Any	Any	Any	Two 40' by 300' rectangles at int.

to intersections between two major streets. There is no single universally applicable alternative, and there are arterials where no unconventional alternative will work. However, there is probably at least one alternative worth analyzing to improve an arterial with heavy through traffic. Use your present or forecasted volumes with one of the good available analysis tools to examine travel efficiency. Today's improved microscopic simulation models allow detailed analysis of most conventional and unconventional arterial alternatives. Safety will be more difficult to analyze, but the reduction in unprotected conflict points offered by some unconventional alternatives makes them theoretically safer than conventional arterials. Valid collision reduction factors or collision models will have to wait until agencies build more unconventional alternatives.

Consider implementing unconventional alternatives consistently along an entire section of arterial rather than in a piecemeal or isolated fashion. Consistent design along a section is important in reducing driver confusion and minimizing driver judgment errors.

More coordinated land use planning, ITS and/or public transportation may provide a permanent solution for our congested suburban arterials some day. In the meantime, we do not have to subject our motorists to delays of minutes per mile, and we may not have to spend millions on widening, bypasses, or interchanges. Use Table 4 and at least consider an unconventional alternative.

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