An Update on Superstreet Implementation and Research

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ABSTRACT

Superstreets are promising solutions for arterials. They have the potential to move more vehicles efficiently and safely through the same amount of pavement as conventional arterials, at-grade, with minimal disruptions to the surrounding environment and businesses. A superstreet works by redirecting left turn and through movements from side streets. Instead of allowing those to be made directly through a two-way median opening, as in conventional design, a superstreet sends those movements to a one-way median opening 800 feet or so downstream.

Besides safety, capacity, and travel time, another profound change provided by a superstreet is in progression. With a superstreet, the signals that control one direction of the arterial can operate independently from the signals that control the other direction. This means that a superstreet can operate like a pair of one-way streets, and that perfect progression is possible at any speed with any signal spacing. This is an extraordinary capability; conventional arterials cannot approach this efficiency even with excruciating control of accesses and signal installations.

The superstreet concept was developed in the early 1980s. Maryland and North Carolina have led the world in superstreet development. The NC Department of Transportation (NCDOT) built its first superstreet in a rural area as a safety countermeasure in 2000. The NCDOT opened its first signalized version in a suburban area in June 2006. The NCDOT has also adopted the superstreet as an appropriate design for important segments of its Strategic Highway Corridor system. Maryland has had “j-turn” intersections in place since the early 2000s.

The purpose of this paper is to provide an update on recent work on superstreets. The paper concentrates on safety and reviews the performance of several recent superstreet installations in North Carolina and Maryland. The first superstreets have generally performed well. The rural applications in Maryland, in particular, have led to dramatic safety improvements. A rural superstreet application in NC has resulted in modest safety gains, and a signalized suburban application in NC has resulted in a collision rate below the statewide average for that type of roadway. The paper briefly reviews other experiences with superstreets. In general, agencies looking for alternatives for miserable stretches of arterial will benefit from learning about the experience with superstreets in North Carolina and Maryland.

INTRODUCTION

Many divided arterials in the U.S. operate very poorly these days. In urban and suburban areas they are often congested during peak hours and stressful places to drive at many times. In urban, suburban, and rural areas they experience far too many collisions. These efficiency and safety problems are due in large part to growing traffic demands that probably will not stop growing any time soon. Unfortunately, planners and engineers tasked with fixing arterials do not have many good solutions available. Conventional traffic engineering solutions like actuated signals, turn bays, and signal systems have generally been exhausted. Signal installations in rural areas disrupt traffic flow and may not provide much collision savings. Widening projects and bypasses are expensive and may be environmentally damaging. Flyovers and interchanges are expensive and unpopular with roadside businesses left in the shadows. Intelligent transportation, transit, demand management, and other possibilities have not yet proven helpful on urban and suburban arterials.

Superstreets, part of a menu of unconventional arterial designs that the lead author has worked on for the past 15 years, are a promising solution for arterials. They have the potential to move more vehicles efficiently and safely through the same arterial pavement as conventional arterials, at-grade, with minimal disruptions to the surrounding environment and businesses. Superstreets were invented by Richard Kramer, a traffic engineer in Huntsville, Alabama, in the early 1980s. Michigan has over 1000 miles of arterials with median u-turns, which is a closely related design. Many states make extensive use of one-way median crossovers that have some superstreet characteristics.

The purpose of this paper is to provide an update on recent work on superstreets. The paper will begin with a brief review of the advantages and disadvantages of a superstreet. The bulk of the paper will be a presentation of the latest collision data from recent superstreet applications in North Carolina and Maryland. The paper will also provide a brief discussion of other experiences with recent superstreet applications.

BASIC SUPERSTREET INTERSECTION

A superstreet works by redirecting left turn and through movements from side streets. Instead of allowing those to be made directly through a two-way median opening, as in conventional design, a superstreet sends those movements to a one-way median opening 500 to 1000 feet downstream, as Figure 1 shows. Thus, a left turn from a side street will be made by a right turn then a u-turn, while a side street through movement will be made by a right turn, a u-turn, and another right turn.

Superstreet Advantages

The results from this redirection are dramatic. The superstreet intersection shown in Figure 1 only has 18 conflict points--places where vehicle streams cross, merge, or diverge—while a conventional intersection with a two-way median opening has 32. Since each conflict point adds another way for a vehicle to get hit, superstreets are likely to be safer.

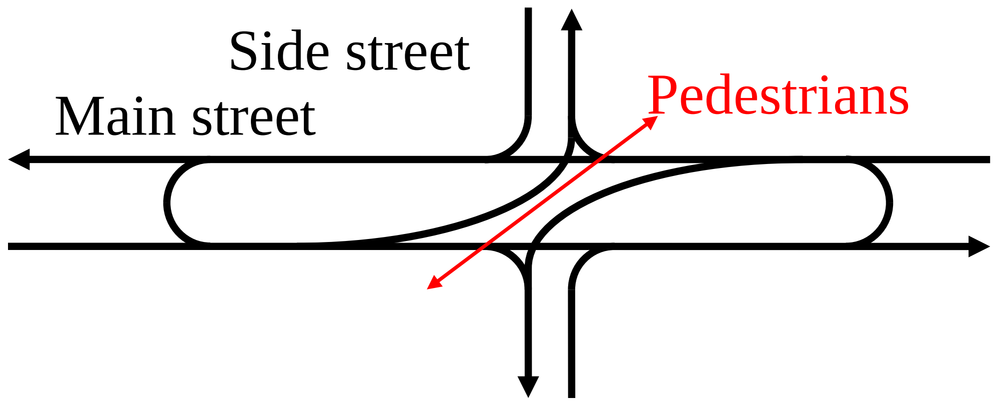

Figure 1. Superstreet schematic.

Traffic signals at a superstreet require only two major phases instead of the four or more phases—with green arrows for left turns from both streets--usually required at a busy two-way median opening. Since every signal phase introduces extra lost time for all motorists, this reduction in phases means significant time savings for everyone. Of course, related to travel time savings are other important variables like emissions and fuel consumption.

Another profound change provided by a superstreet is in progression. With a superstreet, the signals that control one direction of the arterial have little or nothing to do with the signals that control the other direction. This means that a superstreet will operate like a pair of one-way streets, and that **perfect progression is possible in both directions at any speed with any signal spacing**. This is an extraordinary capability; conventional arterials cannot approach this efficiency even with excruciating control of accesses and signal installations. On a superstreet agencies can set progression speeds as high or low as they wish (by location, direction, time, day of week, or any number of ways) without seriously affecting delay. Drivers will adjust quickly to the progression speed established, so as long as they obey traffic signals speeds will be controlled. Agencies can then reassign enforcement resources to duties other than speeding, enhancing safety and security elsewhere. A superstreet would also allow installation of any number of new traffic signals without changing the quality of progression, so engineers will no longer have to battle politicians and the public over signal installation.

The treatment of pedestrians is another superstreet advantage. Figure 1 shows that the pedestrian crossing can be completely signal-controlled—the only way a pedestrian can get hit is for the pedestrian or a driver to run a red signal. At a superstreet, crossing pedestrians do not have to play “a game of chicken” with turning drivers like at a conventional intersection.

Perceived Disadvantages Can be Mitigated

A superstreet has some perceived disadvantages. However, these can all be mitigated. The largest of these is the presence of heavy side street volumes. At some point, side street left and through volumes become so heavy that their extra travel times outweigh the savings of other vehicles. This is one of the issues we explored in a previous paper (1). In case of heavy side street through and left volumes, designers should turn to the median u-turn design mentioned above. A median u-turn redirects left turns but allows the side street through movement to be made directly. This design has most of the advantages of the superstreet and provides tremendous travel time savings over conventional design for most volume combinations even with heavy side street through movements (2,3).

Another perceived disadvantage of the superstreet is the wide median needed to accommodate large vehicles making u-turns. Larger but still common trucks have turning radii of up to 45 feet (4), which could mean superstreet medians 42 to 66 feet wide to accommodate those vehicles within the travel lanes. However, designers should be aware of several ways to minimize that width, including:

- Every median opening does not have to accommodate the largest design vehicle,
- Strengthened paved shoulders, and
- Bulb-outs or loons, as Figure 2 shows.

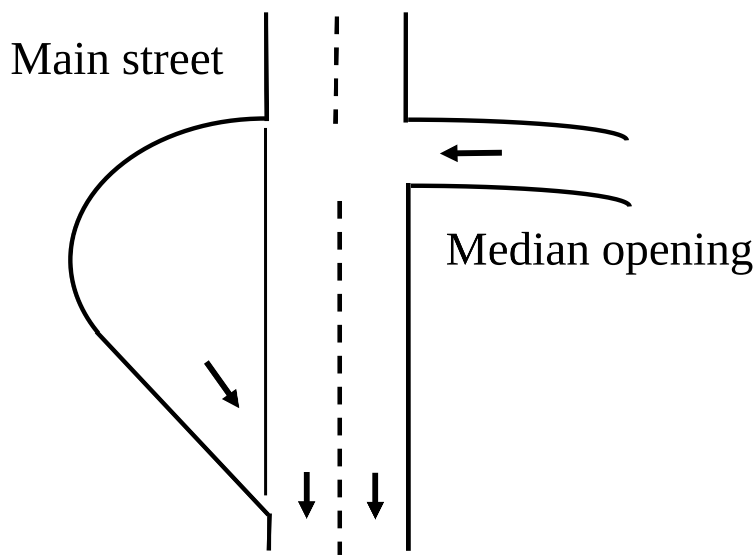

Figure 2. Bulb-out schematic.

Driver confusion is a concern with any new design. However, there are several reasons for believing that drivers will quickly adapt to superstreets. First, similar designs like the median u-turn have been successful in parts of the US for years. Second, in recent years drivers have adapted quickly to new designs like roundabouts and single point interchanges. Third, good traffic control devices are available, such as the devices Michigan uses for its median u-turns.

Finally, like many designs with wider medians, superstreets may be perceived to harm roadside businesses, particularly businesses not at median openings that attract left turn pass-by trips (5). These effects should be mitigated for superstreets in several ways, however, including that:

- The business impact perception during project planning is typically worse than the reality after an improved arterial opens,
- There is typically no net communitywide impact,
- Travel time savings mean more happier customers getting to more businesses quicker, and
- Perceptions of safety, slower speeds, and better pedestrian access should all help.

SAFETY DATA

The major concern regarding superstreets is safety. The literature appears to show that superstreets will offer significant safety advantages over conventional arterials. Good evidence comes from Florida, where research showed that a right turn followed by a u-turn was much safer than a direct left turn out of a side street (6). In addition, research in North Carolina found very few collisions caused by u-turns on main streets with medians (7). The best evidence, though, is from Michigan. Studies show lower collision rates on Michigan's signalized arterials for median u-turns (closely related to superstreets) compared to conventional designs (8).

To this point, superstreets have been installed in North Carolina and Maryland. Some of these installations have been in place long enough for decent collision sets to be collected. This section provides a summary of those collision data sets.

North Carolina

The North Carolina Department of Transportation (NCDOT) has recently become convinced of the virtues of superstreets in urban and rural areas. In fact, the NCDOT has adopted the superstreet design as an option for its higher classes of arterials in its "Strategic Highway Corridors" plan (9). To this point, at least five superstreets have been completed on segments of NCDOT highways. At least three of these were completed in rural areas primarily for safety purposes, while two were completed in suburban areas for safety and efficiency purposes. All are on divided four-lane roads.

Good collision data sets are available for one rural and one suburban superstreet. The other superstreets in NC are too new at this point to provide any meaningful collision data. The rural location is on US-23/74 in Haywood County in the mountainous western part of the state. The US-23/74 superstreet is unsignalized, about 2.5 miles long, includes three complete sets of crossovers, and was retrofit from an existing conventional arterial in 2000.

Table 1 shows the collision frequencies and rates in the US-23/74 corridor during the six years before and six years after superstreet installation in 2000. The superstreet was installed as a safety countermeasure to combat a perceived problem at the unsignalized intersections, so an analysis of the collision data must take into account the possibility of regression to the mean. Traffic volumes have been rising fairly steadily on US-23/74 throughout the period covered in Table 1, so collision rates were computed to account for that. Considering all of this, it is apparent from Table 1 that the superstreet installation has likely been helpful. The collision frequency has dropped somewhat since superstreet installation in 2000 and the injury collision frequency has been lower. There has been a shift from left turn and angle collisions (the types most susceptible to correction with a superstreet) to other types of collisions, primarily sideswipe and rear-end collisions. The collision rates have been lower with the superstreet by a substantial margin. The NC statewide collision rates for divided, four-lane, US highways in rural areas with partial access control were 0.97 collisions per million vehicle mile (mvm) for total collisions and 0.38 collisions per mvm for fatal and injury collisions in 2003-2005 (10), so the collision rates on the superstreet are now well below the statewide averages for this facility type.

Table 1. Collision data from the superstreet segment of US-23/74.

Year	Number of reported collisions					Total Crash Rate (per million vehicle miles)	Fatal + Injury Crash Rate (per million vehicle miles)
	By Severity		By Type				
	Total	Fatal + Injury	Left Turn	Angle	Other		
Annual average "Before" ('94 - '99)	16.0	10.7	4.5	3.5	8.0	1.07	0.71
Annual average "After" ('01 – '06)	13.3	6.3	2.0	0.5	10.8	0.69	0.32
Difference "After" - "Before" (Percent Difference)	-2.7 (-16.8%)	-4.4 (-41.1%)	-2.5 (-62.5%)	-3.0 (-85.7%)	+2.8 (+35%)	-0.38 (-35.5%)	-0.39 (-54.9%)

The suburban superstreet location for which collision data are available is US-17 in Brunswick County, just south and west of Wilmington, in the flat terrain near the Atlantic Ocean. The US-17 superstreet, pictured in Figure 3 in the later stages of construction, includes three sets of signalized crossovers over a segment less than one mile long and was opened in mid-2006. A large retail development along the US-17 superstreet opened in early 2007, and the area continues to develop. The opening of the large retail establishment made any comparison between collision data sets 'before' and 'after' the superstreet irrelevant. However, 1.5 years of collision data are available with the superstreet operating that show:

- 38 total collisions,
- 0 fatal collisions,
- 15 injury collisions,
- 1 left turn collision, and
- 6 angle collisions.

Twelve of the 38 total collisions occurred at the u-turn crossovers. Most of the reported collisions were rear-end or sideswipe. As at the US-23/74 site, this site did not have many left turn or angle collisions.

Figure 3. US-17 superstreet late in construction phase.
Photo courtesy of the NCDOT.

Based on the best available AADT estimate from the NCDOT, the total collision rate from the data shown above is 2.4 collisions per mvm while the rate of fatal and injury collisions is 0.95 collisions per mvm. By comparison, the 2003-2005 NC statewide collision rates for urban, four-lane, divided US highways with medians and partial access control were 2.5 collisions per mvm for total collisions and 0.79 collisions per mvm for fatal and injury collisions (10). Thus far the US-17 superstreet has had a total collision rate that is slightly under the best available comparison for total collisions and just above for injury collisions (based on a very small sample size).

Maryland

The Maryland State Highway Administration (MDSHA) had opened four superstreet (or J-turn, as they are called in Maryland) intersections as of 2007. All four were at unsignalized intersections on rural sections of US-301 on the Eastern Shore. US-301 is a four-lane divided highway with a posted speed limit of 55 mph and partial access control that serves as an important through route between the Baltimore and Washington areas and Delaware. The minor streets are undivided two-lane roads with low volumes. The MDSHA installed the superstreet intersections as safety countermeasures where intersection-related collisions were occurring (so regression to the mean is a possible bias to the results shown below) in an effort to avoid signals on the US-301 corridor and to avoid the high cost of interchanges. Two of those superstreet intersections have been in place long enough for collision data to show trends related to the installation of the intersection designs.

Table 2 shows the relevant collision data for the intersection of US-301 and MD-313 near Galena in Kent County, which was installed in 2001. The reduction in collisions was dramatic, from an average of 8 collisions per year during 1997 to 2000 to only two collisions total during 2004 to 2006. There were 22 injury collisions from 1997 to 2000, while there were none from 2004 to 2006. There were 22 angle collisions from 1997 to 2000, whereas there have been none during 2004 to 2006. Other collision types during 1997 to 2000 included six opposite direction collisions, two fixed-object collisions, and three ‘other’ collisions, while the two collisions in 2004 were a rear-end collision and an ‘other’ collision. Readers should note that Table 2 includes only collisions reported to be within 250 ft of the main intersection. However, since there were no reported collisions at the u-turn crossovers during the “after” period the reduction in collisions at the main intersection appears impressive.

Table 2. Collision data from the superstreet intersection of US-301 and MD-313.

Year	Number of reported collisions				All Reported Crash Rate (per million entering vehicles on major road)	Fatal + Injury Crash Rate (per million entering vehicles on major road)
	By Severity		By Type			
	Total	Fatal + Injury	Angle	Other		
Annual average "Before" ('97 - '00)	8.3	5.8	5.5	2.8	2.18	1.51
Annual average "After" ('02 - '06)	0.8	0.0	0.0	0.4	0.20	0.00
Difference "After" - "Before" (Percent Difference)	-7.5 (-90.4%)	-5.8 (-100%)	-5.5 (-100%)	-2.4 (-85.7%)	-1.98 (-90.8%)	-1.51 (-100%)

Table 3 shows the relevant collision data for the intersection of US-301 and MD-456 near Queenstown in Queen Anne’s County, which was installed in approximately 2005. The reduction in collisions was also significant at this intersection, from an average of four collisions per year during 1997 to 2004 to only one collision during 2005 and 2006. There were 19 injury collisions from 1997 to 2004, while there were none during 2005 and 2006. During 1997 to 2004, there were 23 angle collisions, whereas there was one during 2005 and 2006. Other collision types during 1997 to 2004 included two opposite-direction collisions, four rear-end collisions, one fixed-object collision, and two ‘other’ collisions.

Table 3. Collision data from the superstreet intersection of US-301 and MD-456.

Year	Number of reported collisions				All Reported Crash Rate (per million entering vehicles on major road)	Fatal + Injury Crash Rate (per million entering vehicles on major road)
	By Severity		By Type			
	Total	Fatal + Injury	Angle	Other		
Annual average "Before" ('97 - '04)	4.0	1.5	2.9	1.1	0.52	0.32
Annual average "After" ('06)	0	0	0	0	0.00	0.00
Difference "After" - "Before" (Percent Difference)	-4.0 (-100%)	-1.5 (-100%)	-2.9 (-100%)	-1.1 (-100%)	-0.52 (-100%)	-0.32 (-100%)

OTHER OBSERVATIONS

The recent North Carolina superstreet installations provide lessons that other agencies contemplating superstreets can use. One of the big lessons is that superstreets are likely to cost more than conventional arterials, at least to start. The US-17 superstreet upgrade cost about two million dollars, which is perhaps twice as high as a project to add three conventional signalized intersections to a suburban arterial would cost. One of the surprisingly high cost items during this project was the cost of signals. The designers chose to use individual controllers at each of the twelve signals (a fully signalized superstreet intersection has four signals at each four-legged side street intersection). The authors of this paper believe that one could design fully signalized superstreet intersections with three, two, or even one controller to save money, although one controller would sacrifice the ability to have independent timing for the two directions of the major street. The US-17 case has also raised a policy issue regarding who should pay for the upgrade to a superstreet. In this case, a large retail developer paid for the superstreet improvements. The concern is that later developers along the segment will get a “free ride” benefiting from the development-friendly configuration without having to bear any of the burden.

The designers of the US-17 superstreet reported that drainage in the median proved challenging. The ability of the designers to shift the u-turn crossovers was quite helpful in allowing solutions to be found. Along these lines, the optimal distance from the main intersection to the u-turn crossover remains somewhat controversial: the Michigan DOT generally uses 600 feet or so on its median u-turns, NCDOT guidelines call for a minimum of 800 feet, and some have called for a spacing as low as 400 feet for more efficient operations. It is clear that giving the designer the ability to shift the crossover location for better drainage, to better accommodate driveways and side streets, to better fit alignments, or for whatever reason is a positive feature of the superstreet.

The authors' observations are that in all NC cases bulb-outs are working well. Bulb-outs were needed on all NC superstreets because the medians were not wide enough to accommodate u-turns by large trucks and buses without them. The authors have observed large trucks making u-turns without difficulty, and in fact have observed that the bulb-out dimensions (based on "Green Book" vehicle dimensions (4)) are generous for most large trucks making u-turns. One minor difficulty the authors have observed with bulb-outs is the tendency of drivers to occasionally use them to rest and park. Perhaps agencies need signing and occasional enforcement to eliminate this difficulty.

Figure 4 shows the signal locations for the US-17 superstreet. The post-mounted signal for the u-turn in the median is a good idea, but the view to this signal is sometimes blocked by a queue. More experimentation on signal locations seems warranted.

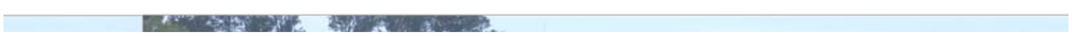

Figure 4. Signal locations at the US-17 superstreet.
Photo courtesy of Joe Bared, FHWA.

Most observers agree that drivers seem to have adjusted quickly to all new superstreets in North Carolina. The authors have observed a few wrong way movements through crossovers at rural intersections and a few red lights run at crossovers on US-17, but overall traffic seems to flow smoothly. One of the concerns in all several areas before installation was that they were areas with high concentrations of tourists and retirees who might be surprised or slower to adapt to new traffic patterns. Those concerns have generally subsided.

CONCLUSION

Superstreets offer a promising solution to the mess on many arterials. They offer more efficient and safer travel, at-grade, in an atmosphere of controlled speeds that welcomes pedestrians. The potential drawbacks, like heavy side street through volumes, wider medians, driver confusion, and lost business, can all be mitigated. Those looking at alternatives for arterials owe it to the drivers and taxpayers to at least examine this promising alternative.

This paper provided an update on recent developments on superstreets, particularly related to safety. Sufficient collision data were available to spot trends from two superstreet segments in North Carolina and two superstreet intersections in Maryland. The rural segment in North Carolina has been in place the longest and shows a considerable reduction in collision frequency and rate after superstreet installation. The suburban segment in North Carolina did not provide a before-and-after comparison, but since the superstreet opened the collision rates are near the statewide averages for similar facilities. Both intersections in Maryland showed huge reductions in collision frequencies and rates after superstreet installation. Overall, one must conclude that the safety record of superstreets thus far is promising.

The authors recommend that research continue on superstreets. There are still many unanswered questions about superstreets including on safety, efficiency, environmental benefits, design details, business impacts, and other aspects. The authors also recommend that superstreets continue to be built on arterials where they look beneficial. Software and models can only show so much; at some point the profession needs actual operating superstreets to examine and learn from. North Carolina and Maryland have led the way in this regard, and it is time for other states to step forward and demonstrate this terrific arterial design.

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