SKINNY STREET BIG APPETITE: MERGING INNOVATION ALONG US 192

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ABSTRACT

Every so often engineers are presented with a challenge chockfull of constraints that a typical solution does not begin to scratch the surface of the problem. Whether it is Right-of-way, over-capacity intersections, or accommodation of the future implementation of an intermodal service, US 192 in Central Florida presented these and more.

Innovative intersections are becoming more common state by state as an effective solution to fiscal, Right-of-way, and capacity limitations; capitalizing on improvements within the constraints that exist. Diverging Diamond Interchanges, Median U-Turns, Super Streets, Continuous Flow Intersections; State DOTs and local agencies are more open to these types of alternatives considering their safety, operational, or economic benefits. Each of these alternative intersections provide a key facet serving a particular or site specific purpose. But what if a site has a multitude of particulars that a single innovative intersection cannot address.

US 192 presented this type of challenge and not just at one intersection but throughout the entire 22-mile corridor. Understanding the purpose each innovative element serves provides an opportunity to combine them; creating a new type of innovative intersection for the most constrained sites. This presentation will take a closer look at the geometry of the three intersections identified as critical breaking points and highlight how the unique elements of innovative intersections were taken apart and merged together to create a hybrid of solutions along the 22-mile corridor; providing sufficient capacity for the design year along with preserving the width for a future median busway bus rapid transit system.

Keywords: Hybrid Innovative Intersection, Continuous Flow Intersection, Median U-turn

INTRODUCTION

Every so often engineers are presented with a challenge chockfull of constraints that a typical solution does not begin to scratch the surface of the problem. Imagine a heavily congested six-lane corridor with minimal width to expand roadway capacity and a conceptual design for a median busway bus rapid transit (BRT) which would only exasperate the traffic operations even further. Whether it is right-of-way, over-capacity intersections, or accommodation of the future implementation of a premium transit service, US 192 in Central Florida presented these constraints and more.

US 192 is a heavily congested major arterial critical to the City of Kissimmee and Osceola County. The typical cross-section along the corridor varies. West of I-4, the cross-section is a high-speed six-lane divided highway with a wide grass median and at major intersections it is limited to a narrower median with long left turn lanes or a four to six-foot concrete separator with dual left turn lanes. East of I-4, the corridor is a six-lane divided roadway, with a raised grass median. There is little setback between the roadway and developed parcels, and dual left turn lanes and a four-foot concrete separator exist at major intersections. The furthest eastern portion of the corridor is a six-lane roadway with a center two-way left turn lane that becomes a left turn lane at intersections. This portion is mostly in the City of Kissimmee.

Most often, compromises are required for one mode of transportation to provide improvements or acceptable operations to another mode of transportation. This project however looked to minimize the required compromises through the development of an innovative corridor concept that will accommodate the future implementation of a median busway without degrading the future traffic operations and only require minimal roadway widening. This paper will describe the analysis and innovative concepts of three critical and highly constrained intersections along the 22-mile corridor.

John Young Parkway (Hybrid Displaced Left with Quadrant Road and Hook Turn Intersection)

John Young Parkway is a north/south arterial that runs through the region and the City of Kissimmee. The eastbound and westbound US 192 approaches to John Young Parkway both have three thru lanes and a left turn lane. The northbound and southbound approaches each have two thru lanes, a right turn lane, and dual left turn lanes. Table 1 below shows the no build traffic operations during the AM and PM peak hour for the design year (2040).

TABLE 1 No Build – US 192/John Young Parkway Traffic Operations (2040)

Design Year Peak Hour (2040)	Maximum V/C	Level of Service	Delay (sec/veh)
AM	1.71	F	246
PM	1.82	F	246

The analysis showed all left turn movements failing during the PM peak period experiencing between 350 and 420 seconds of delay per vehicle. All the thru movements failed as well, experiencing between 130 and 306 seconds of delay per vehicle during the PM peak period. With all movements failing, displacing one or two movements was not going to provide the capacity needed for acceptable operations during the design year.

Although the southeast parcel was identified as a possible right-of-way take, the constraints along US 192 at this intersection preclude any significant widening. Since adding capacity to the critical approaches was not an option, the intersection movements were pulled apart to allow heavy volume movements that typically oppose each other to run simultaneously. The constraints led to a hybrid innovative intersection that combined a quadrant road with a displaced left and hook turn. Figure 1 below shows the hybrid displaced left with quadrant road and hook turn concept.

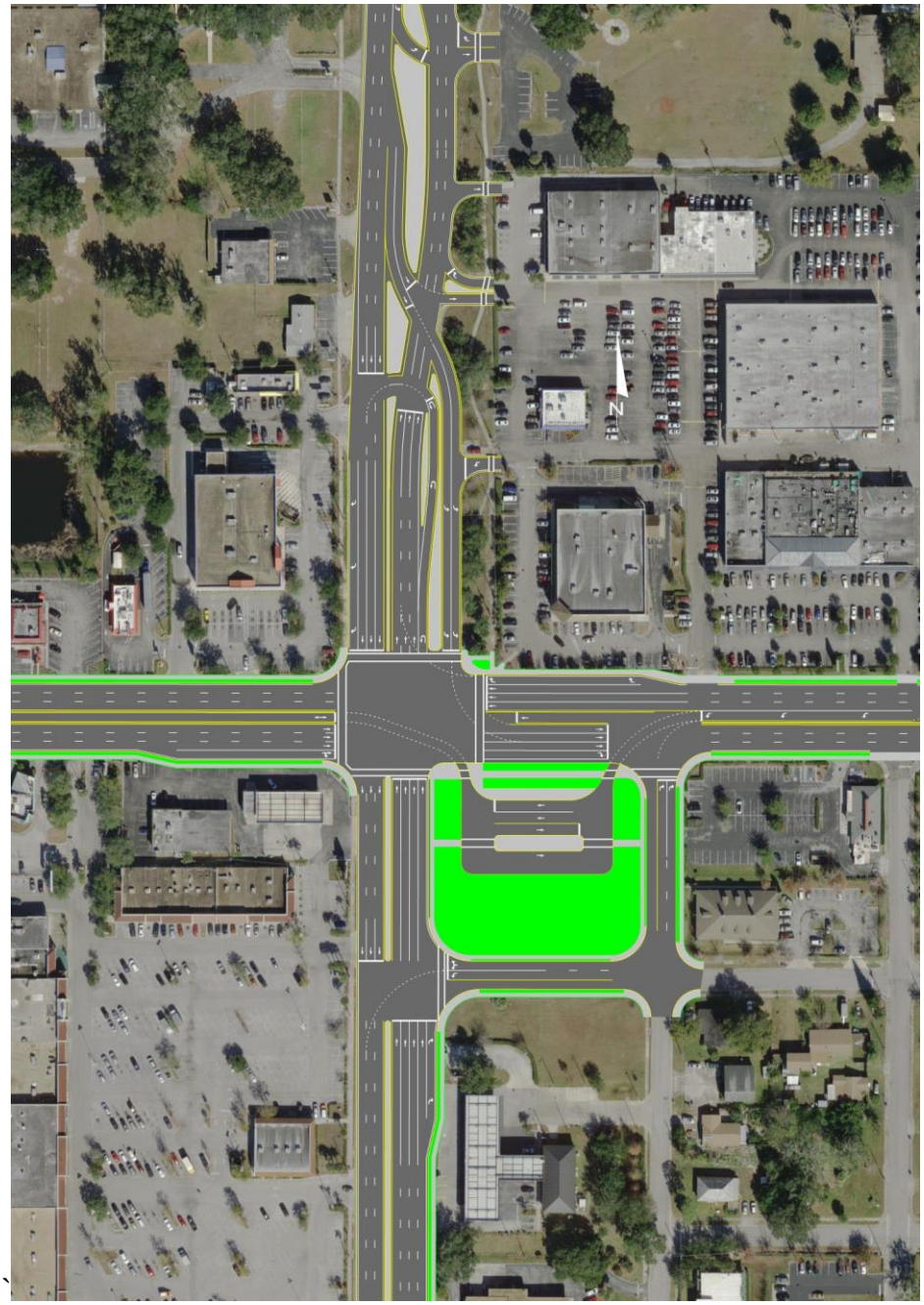

FIGURE 1 US 192/John Young Parkway conceptual layout

Left turns at this intersection use three different innovative treatments. The eastbound and westbound left turns along US 192 are routed through a quadrant road that also serves as a bus transfer station or super stop. The southbound left is displaced prior to the main intersection using geometry that more resembles a diverging diamond than a typical displaced left. The northbound left is sent through the main intersection and uses a signalized hook turn that runs during the same phase as the southbound displaced left.

The signal phasing for this innovative intersection allows the main intersection and the adjacent intersections to the north and east run on two-phase controllers. With the southbound and northbound lefts no longer conflicting with the thru movements, all northbound and southbound traffic run on the same phase. The southbound displaced left and the hook turn will be coordinated to run with the east and westbound movements. Optimal signal timing will allow the displaced left turns arrive on green at the main intersection. Figure 2 provides a phasing schematic of how the three signals can be coordinated to optimize throughput and reduce overall delay.

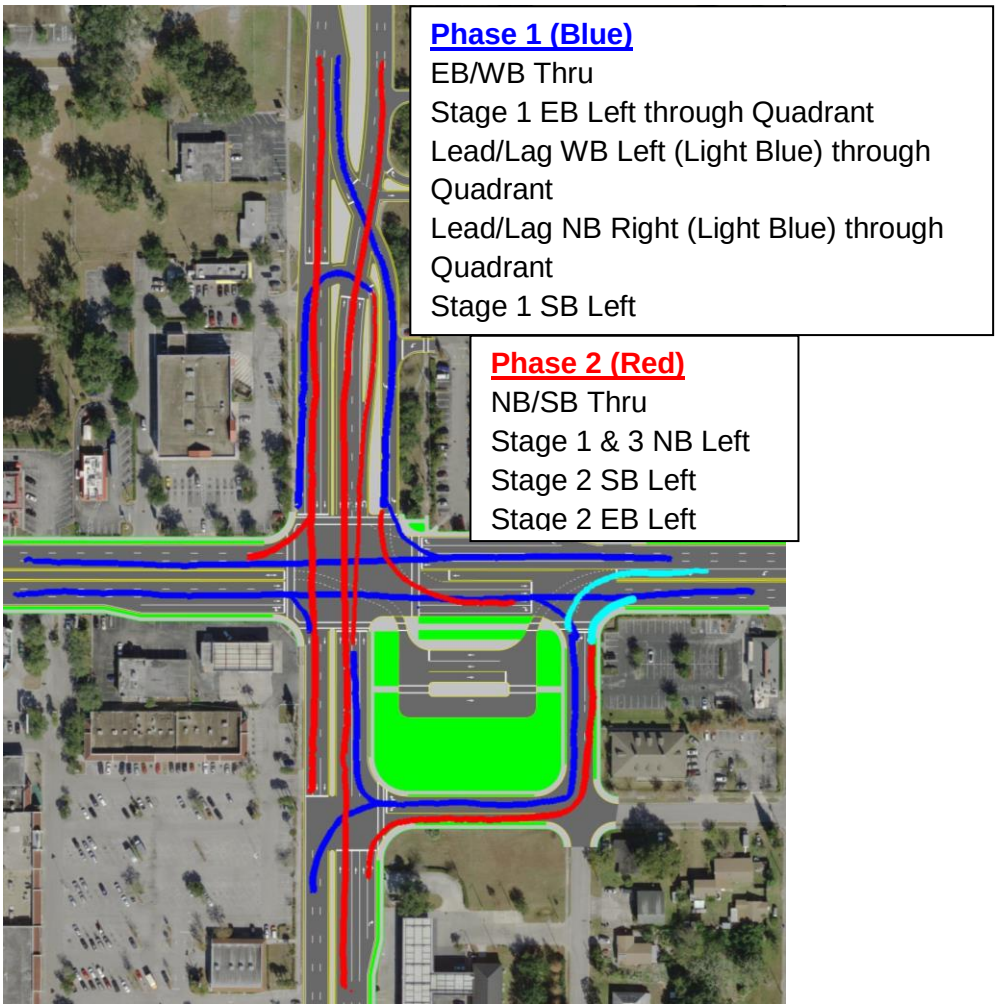

FIGURE 2 US 192/John Young Parkway Coordinated Signal Phasing Schematic

The combination of these three alternative treatments for handling left turns provides more time to the thru movements for all approaches. Table 2 shows the calculated traffic operations for the build alternative for the design year.

TABLE 2 Build Alternative - US 192/John Young Parkway Traffic Operations (2040)

Design Year Peak Hour (2040)	Maximum V/C	Level of Service	Delay (sec/veh)
AM	0.97	C	23
PM	1.00	C	31

SR 535 (Partial Diverging Diamond/Displaced Left Intersection)

SR 535 is a north/south arterial that tees into US 192. Opposite of SR 535 is a hotel with several driveways to US 192. The existing eastbound lane configuration is three thru lanes and a dual left turn lane. The westbound lane configuration has three thru lanes, a single left turn lane, and a free flow right turn lane with a large radius. The southbound lane configuration is a dual left turn lane that also serves as a thru to the hotel and a free flow dual right turn lane with a large radius. Table 3 below shows the no build traffic operations during the AM and PM peak hour for the design year (2040).

TABLE 3 No Build – SR 535 Traffic Operations (2040)

Design Year Peak Hour (2040)	Maximum V/C	Level of Service	Delay (sec/veh)
AM	1.39	F	135
PM	1.56	F	197

The analysis showed the east, west, and southbound thru movements failing experiencing 192, 259, and 298 seconds of delay per vehicle, respectively. The southbound left was also failing with 292 seconds of delay per vehicle. Again, with the majority the movements failing, it was determined displacing one or two movements was not going to provide the capacity needed for acceptable operations during the design year.

The right-of-way constraints at this intersection also precluded any major widening along US 192. However, it was determined SR 535 could be widened to some extent while staying within the right-of-way. It was also determined critical to maintain access into and out of the hotel property to the south. These constraints led to a partial diverging diamond/displaced left intersection configuration, shown in Figure 3 below.

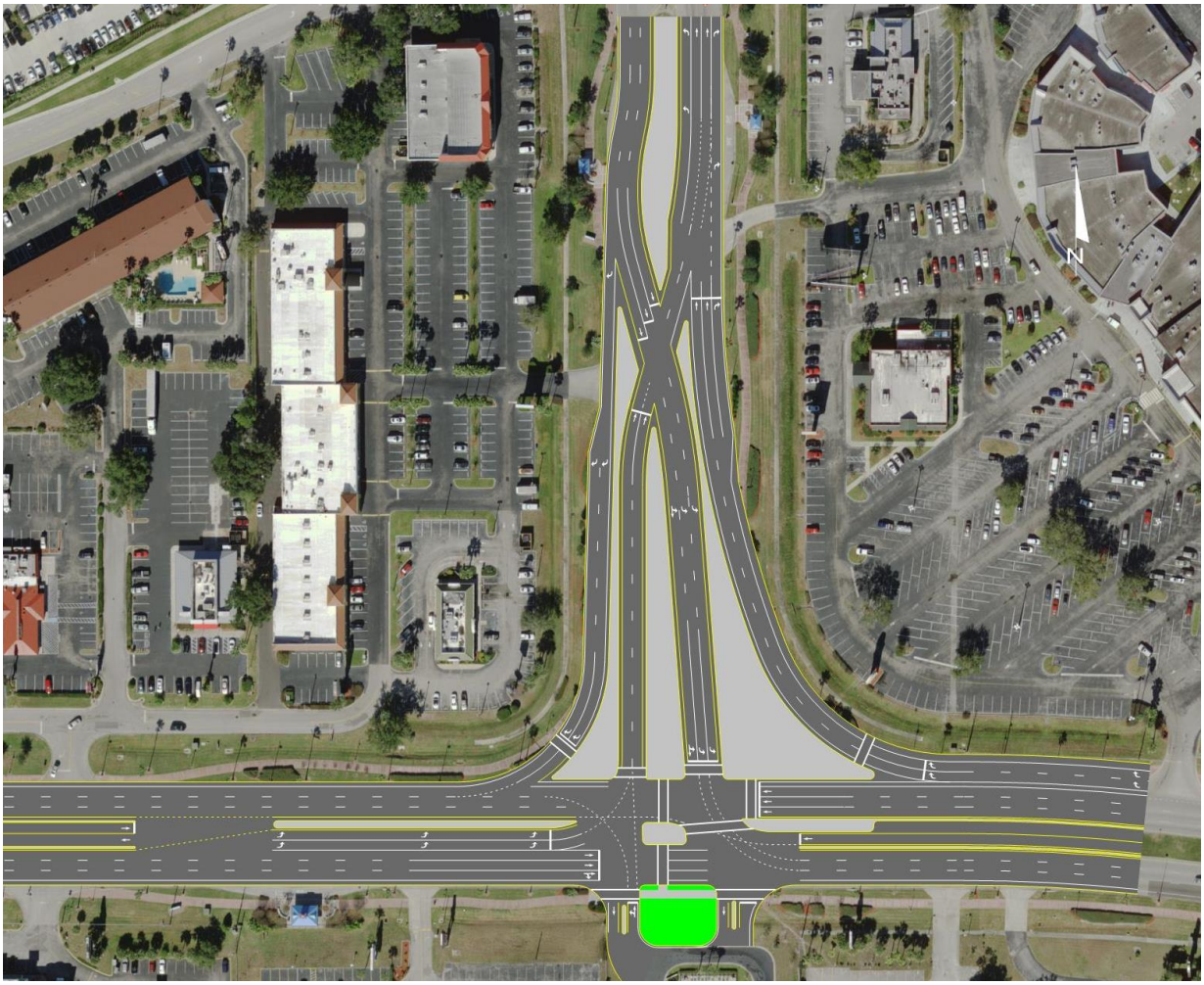

FIGURE 3 US 192/SR 535 conceptual layout

The southbound left and northbound thru lanes are realigned to allow for the southbound lefts to run on the same phase as the eastbound lefts. To achieve this, the geometry of a diverging diamond cross-over is used north of the intersection. The southbound right uses a bypass common with continuous flow intersections. Similarly, the westbound right also uses a bypass and ties in with the northbound thru lane at the cross-over, maintaining a two-phase signal at the cross-over.

The critical element controlling the coordination and timing of these two signals is the storage lengths for the southbound displace left and the eastbound left, both prior to the main intersection and between the main intersection and the intersection to the north. Care should be given to prevent spillback to the previous intersection. Figure 4 provides a phasing schematic of how the two signals can be coordinated to optimize throughput and reduce overall delay and queue lengths.

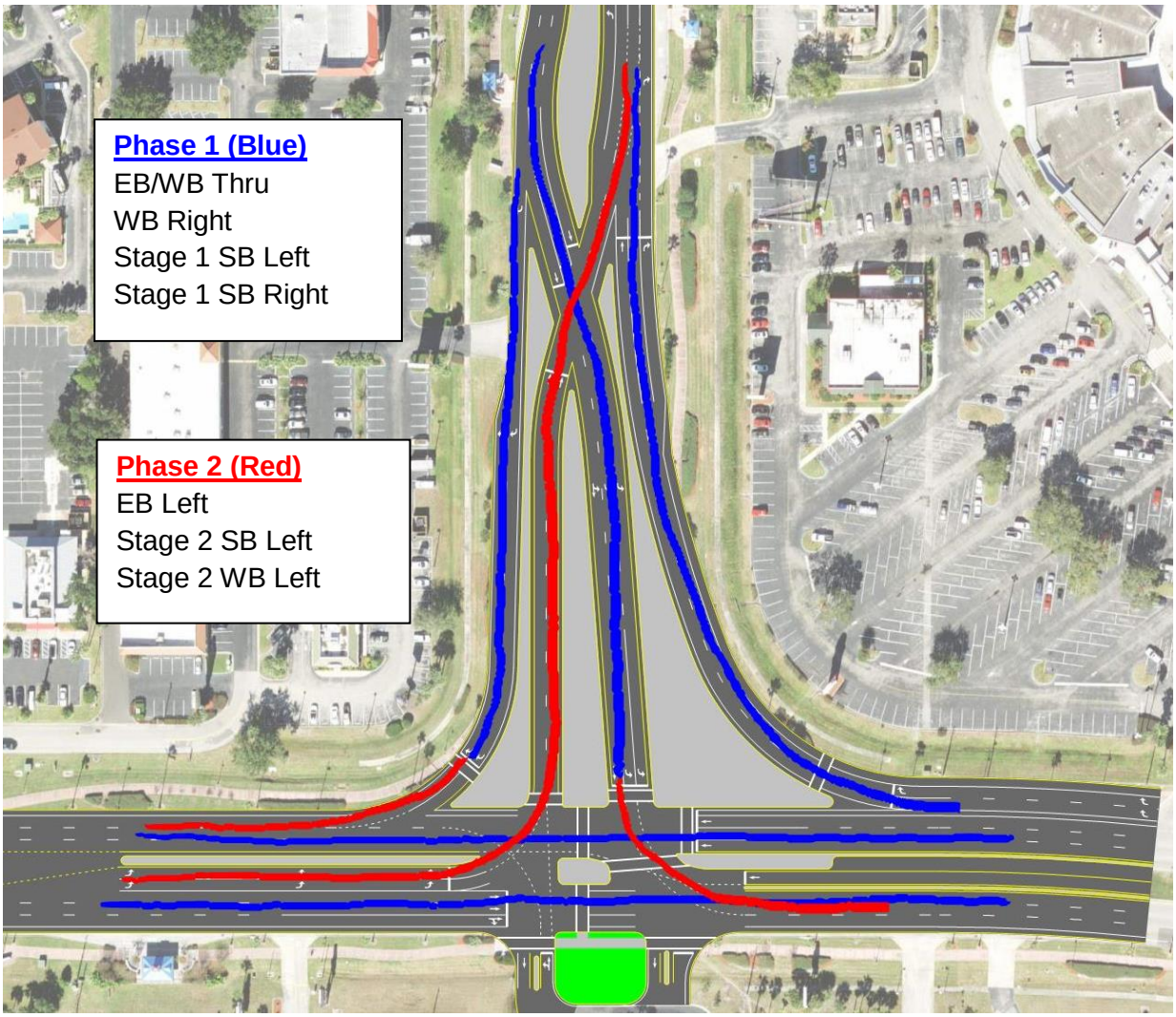

FIGURE 4 US 192/SR 535 coordinated signal phasing schematic

This innovative lane configuration allows all traffic opposing the westbound thru movement to run on the same phase, adding time to the eastbound and westbound movements. Table 4 shows the calculated traffic operations for the build alternative for the design year.

TABLE 4 Build Alternative – US 192/Shady Lane Traffic Operations (2040)

Design Year Peak Hour (2040)	Maximum V/C	Level of Service	Delay (sec/veh)
AM	0.95	C	26
PM	0.99	D	44

Shady Lane (Hybrid-Continuous Flow Intersection with Median U-Turns)

Shady lane is a minor arterial south of US 192 that aligns with the entrance to Florida's Turnpike which is north of US 192. The existing eastbound lane configuration is three thru lanes, a dual left turn lane, and a right turn lane. The westbound lane configuration has three thru lanes, a single left turn lane, and a low speed free flow right turn lane. The southbound lane configuration is a single thru lane, a dual left turn lane, and a low speed free flow right turn lane. The northbound lane configuration is a shared thru-right turn lane and a dual left turn lane. Table 5 below shows the no build traffic operations during the AM and PM peak hour for the design year (2040).

TABLE 5 No Build – US 192/Shady Lane Traffic Operations (2040)

Design Year Peak Hour (2040)	Maximum V/C	Level of Service	Delay (sec/veh)
AM	1.47	F	135
PM	1.36	F	113

The analysis showed all left movements during the AM peak period experiencing between 87 and 261 seconds of delay per vehicle. The northbound and westbound thru movements delays of 221 seconds per vehicle and 176.5 seconds per vehicle during the AM peak period. Again, with all movements failing, it was determined displacing one or two movements was not going to provide the capacity needed for acceptable operations during the design year.

Existing right-of-way limited making any major modifications to the northbound approach. Additionally, access to the southeast parcel precluded displacing the westbound left. It was determined widening to the north at the intersection and adjacent to the southbound approach along Shady Lane was feasible. This led to a continuous flow intersection configuration with two median U-turns. Figure 5 below shows the hybrid-continuous flow intersection with median U-turns.

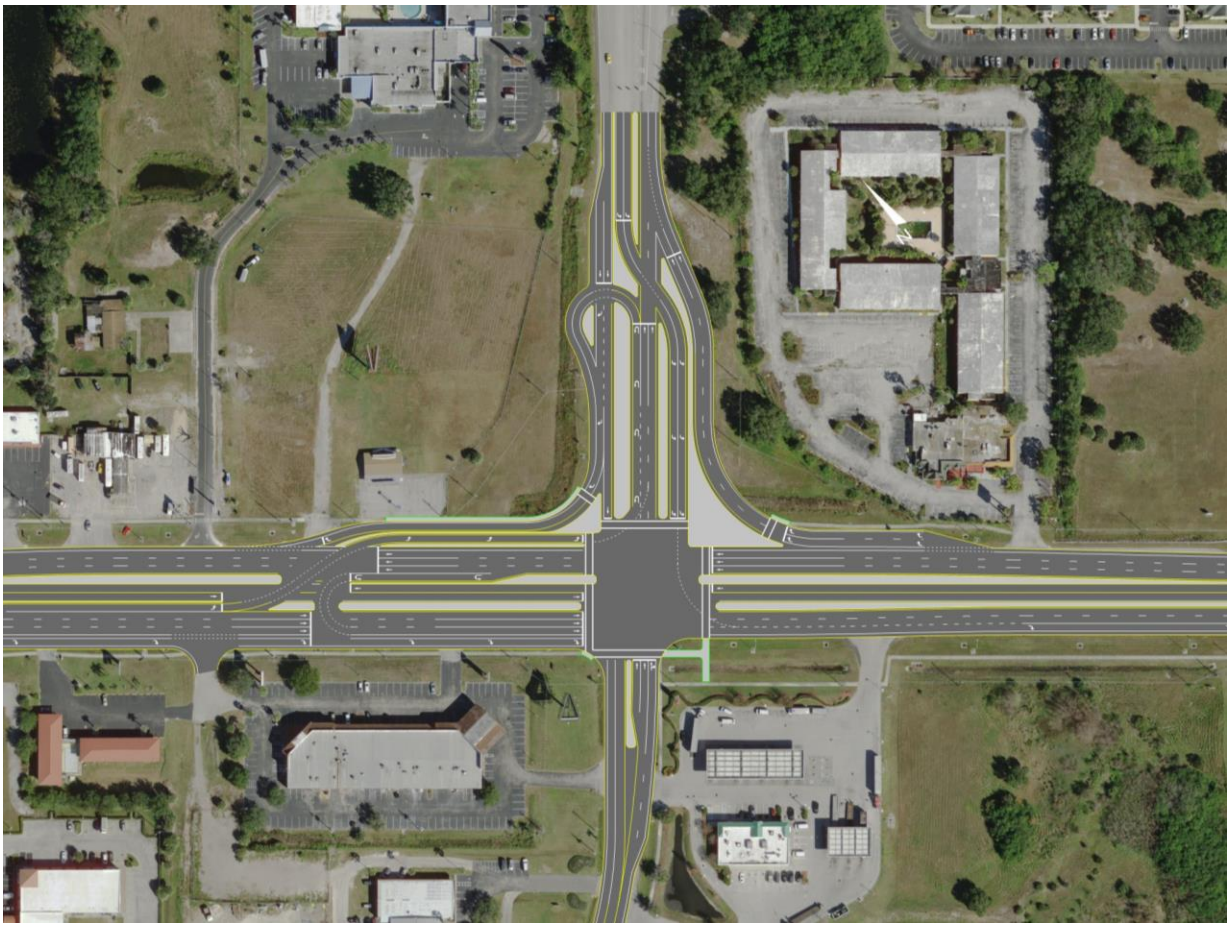

FIGURE 5 US 192/Shady Lane conceptual layout

Since displacing the westbound left and the northbound left was precluded due to right-of-way and access constraints, these movements were sent through the main intersection and U-turned. The eastbound and southbound lefts did not have the same constraints and were both displaced prior to the main intersection. The displaced eastbound left is placed at the westbound U-turn to allow for these movements to be ran on the same phase, maintaining the need for only two phases. Additionally, the westbound right turn bypasses the main intersection and ties into the northbound thru at the north signal and would run on the same phase as the southbound displaced left.

Careful coordination of these three signals will optimize maximum flow through the intersection, pairing movements together to minimize queue and delay, increase arrival on green, and maximize throughput. The northbound U-turn that is already queued north of the intersection will flush the queue while the east and westbound thru is running at the main intersection. This will allow the U-turn movement to arrive on a green at the signal to the east when the eastbound displaced left is crossing the westbound traffic. Similarly, the eastbound displace left will only experience a small amount of red time at the main intersection before it is released along with the east and westbound thru. Figure 6 provides a phasing schematic of how the three signals can be coordinated to optimize throughput and reduce overall delay.

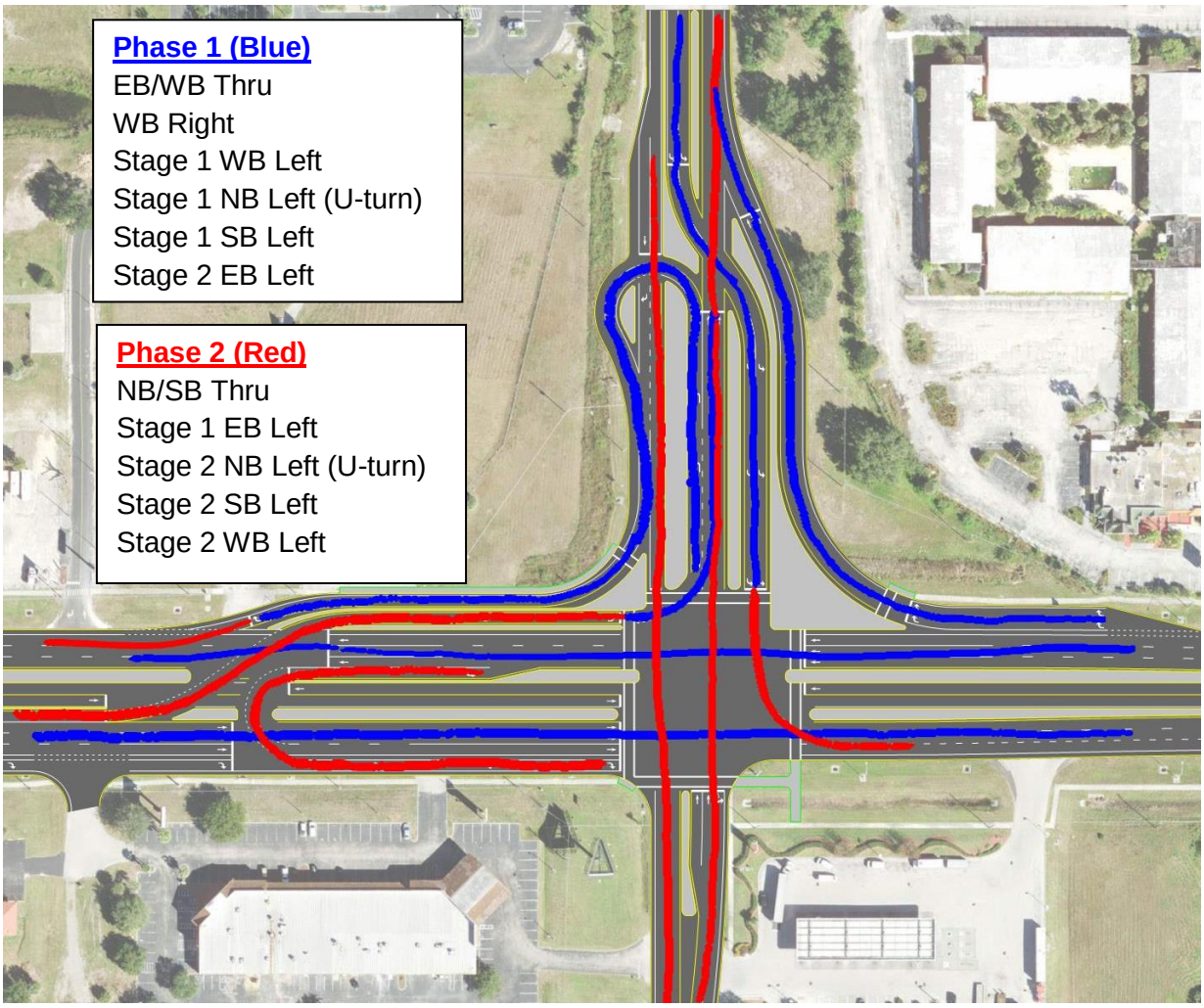

FIGURE 6 US 192/Shady Lane coordinated signal phasing schematic

This innovative lane configuration creates a hyper-continuous flow intersection. Table 6 shows the calculated traffic operations for the build alternative for the design year.

TABLE 6 Build Alternative - US 192/Shady Lane Traffic Operations (2040)

Design Year Peak Hour (2040)	Maximum V/C	Level of Service	Delay (sec/veh)
AM	0.98	C	22
PM	0.98	C	32

CONCLUSION

The 22-mile corridor concept for US 192 provided an opportunity to use typical innovative intersections accepted and in use today not as a cookie cutter solution but as building blocks to develop hybrid innovative intersections. Specific elements of a diverging diamond, continuous flow intersection, median U-turns and hook turns were broken apart and rebuilt to achieve not only acceptable operations for the design year but acceptable operations while accommodating the future implementation of a bus only center-running guideway. It is only through innovative geometry and creative signal phasing could this be achieved within the tight-of-way and other constraints presented.

Each innovative intersection serves a site-specific purpose. A diverging diamond allows an interchange to process a higher left turn volume typically within the same or smaller footprint of a diamond interchange. A continuous flow intersection displaces left turns in advance of the main intersection to allow the lefts to run during the same phase with movements a left turn typically conflicts with. This reduces loss time and allows more green time for the heavier movements. A median U-turn accomplishes a similar result. Understanding the purpose each innovative element serves provides an opportunity to combine them; creating a new type of innovative intersection for the most constrained sites.