

1 **U-5710: CONNECTING THE COAST TO THE CITY – A CASE STUDY ON ALTERNATIVE**  
2 **INTERSECTION DESIGN AT EASTWOOD ROAD AND MILITARY CUTOFF ROAD**

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17 Word Count: 2,752 + 10 figures x 250 words (each) = 5,252 words

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25 May 15, 2017

**ABSTRACT**

Developing a solution to improve a failing intersection can sometimes be as easy as adding a few lanes or adjusting signal timing. In today's world of limited right-of-way (ROW) and other design restrictions, however, it is often necessary to think creatively and consider more atypical intersection design alternatives. But what happens when a critical design criteria is to maintain connectivity between the coast and a nearby hurricane evacuation route, and what if that route has significantly less traffic than the cross street?

This presentation will take a closer look at the concept development and alternative intersection design on the U-5710 project in Wilmington, North Carolina. Working closely with the North Carolina Department of Transportation (NCDOT) Division 3, the project team developed alternatives for the intersection at Eastwood Road (Eastwood Road) and US 76/SR 1409 (Military Cutoff Road); taking into consideration access and ROW impacts, traffic operations, bicycle and pedestrian accommodations, constructability, and minimizing impacts on Eastwood Road, which provides connectivity between the coast and a designated hurricane evacuation route.

A number of concepts were developed and put through an initial qualitative screening followed by a high-level, proof-of-concept quantitative analysis. The goal of this initial screening was to limit the number of alternatives to be carried forward into a more detailed geometric design and analysis.

Alternatives considered included quadrant roads, Continuous-flow Intersections (CFIs), an Echelon intersection, and some form of tight urban interchange such as a Tight Urban Diamond Interchange (TUDI) or Single Point Urban Interchange (SPUI). A shortlist of alternatives will be selected by the NCDOT and presented to the public for additional feedback.

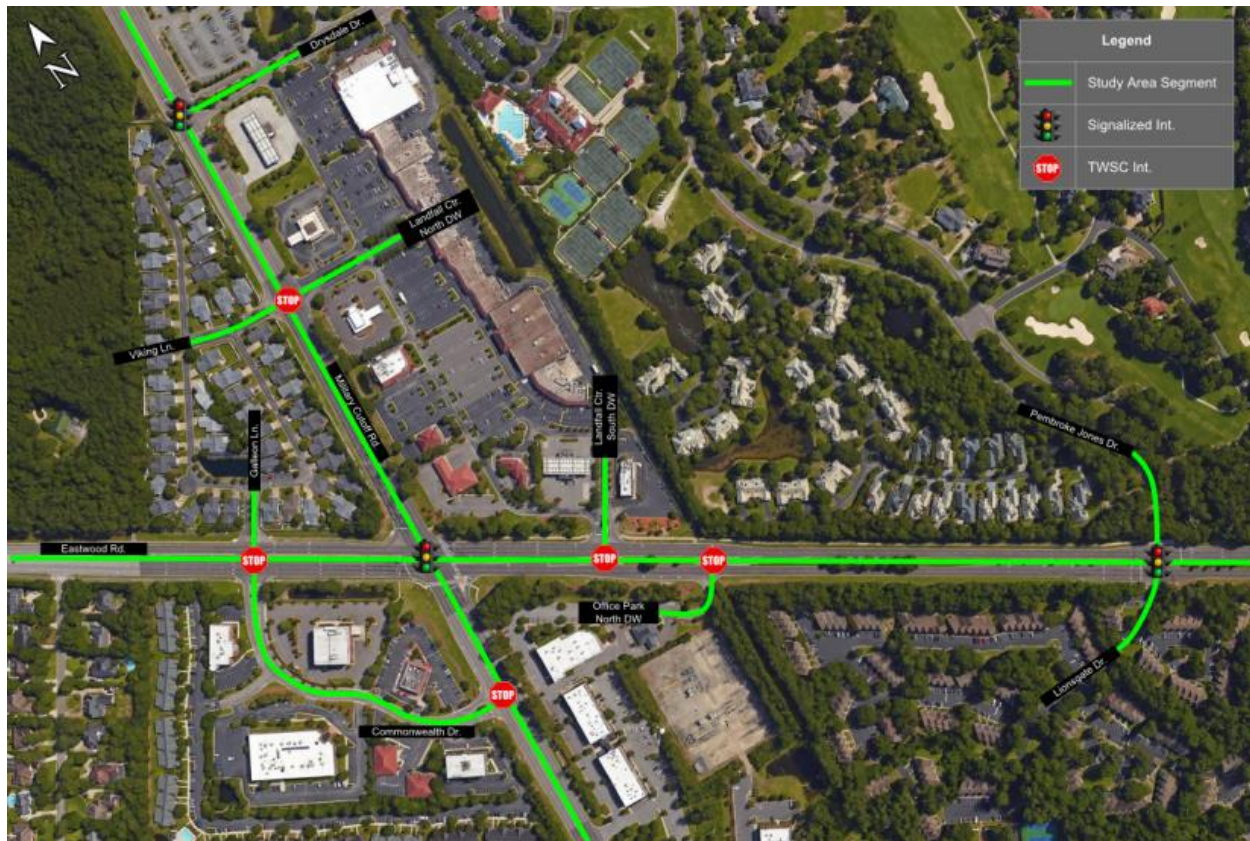
## INTRODUCTION

At the request of the North Carolina Department of Transportation (NCDOT), HDR completed a capacity and simulation analysis of the proposed alternatives for Statewide Transportation Improvement Program (STIP) Project U-5710. The project, located in Wilmington, North Carolina, involves improvements to the existing at-grade intersection of US 74 (Eastwood Road) at US 76/SR 1409 (Military Cutoff Road), in addition to several adjacent intersections and driveways in the intersection's vicinity (Figure 1). This project is anticipated to begin right-of-way (ROW) acquisition in 2019 and let for construction in 2021.

Eastwood Road, a principal arterial, serves as the primary east-west connector between the city of Wilmington and the town of Wrightsville Beach. The route is heavily utilized by visitors and tourists destined for the Atlantic coast, particularly during off-peak hours and weekends. Military Cutoff Road, also a principal arterial, serves as part of the "outer loop" encompassing Wilmington's urban area. This route, aligned as north-south within this study area, serves primarily local commuters and, thus, carries the higher peak-hour demands of the two major routes being studied. The intersection currently operates at near-failing operations and is expected to worsen as peak-hour traffic demands in the area increase in the coming years. It can be objectively concluded, therefore, that the existing intersection configuration will, at some point in time, no longer be equipped to handle the expected future-year peak-hour traffic volumes. However, residential communities, office parks, and shopping plazas occupy the four "quadrants" adjacent to the intersection, putting significant restrictions on potential ROW expansion or realignment of the roadways as part of the proposed improvements.

The intersection of Military Cutoff Road and Eastwood Road is roughly 2.5 miles to the west of the North Carolina coast. Situated between the Atlantic coast to the east and I-40 to the west, Eastwood Road serves as a connection to a preferred hurricane evacuation route along I-40. This consideration ultimately played a large role in the final screening for preferred alternatives.

In addition to vehicular traffic, the Cross-City Trail (CCT) also adds pedestrian and bicycle traffic across the south and east legs of the intersection. Since this trail is a popular route to the coast, it became a major design consideration for the project. With the atypical concepts being considered, accommodation of the CCT movements were of critical importance and sometimes very difficult to accomplish. The development of the conceptual alternatives assumed that all possible access would be maintained, although diversion of access would be allowed.



**FIGURE 1 - Existing Intersection and Adjacent Roads.**

## METHODOLOGY

Two analysis programs were used in various stages of the project: Synchro and VISSIM. Synchro is a traffic operations and signal optimization software that emulates the methodology from the Highway Capacity Manual (HCM) and provides level of service (LOS) metrics. VISSIM is a widely-used, behavior-based multi-purpose traffic microsimulation program that tracks individual vehicle movements and interactions and quantifies the performance of individual movements and overall intersection delays and queue lengths more realistically than typical HCM methods.

The initial analysis included modeling in Synchro for operational feasibility. These synchro models primarily focused on the main intersection of Military Cutoff Road and Eastwood Road as well as the adjacent intersections of Commonwealth Drive at Military Cutoff Road and Eastwood Road. As alternatives were developed, the use of Synchro was expanded to evaluate various changes to other adjacent intersections.

In order to model interactions among signalized intersections along the Military Cutoff Road and Eastwood Road corridors, VISSIM models were developed and included the intersections at Military Cutoff Road & Viking Lane, Military Cutoff Road & Drysdale Drive, and Eastwood Road & Pembroke Jones Drive and the two entrances to the adjacent shopping and office plazas. This was in addition to the intersections that were modeled in Synchro, namely those at Eastwood Road & Military Cutoff Road, Eastwood Road & Commonwealth Drive, and Military Cutoff Road & Commonwealth Drive. Driveways were also modeled and included the Landfall Center driveway at Eastwood Road and Galleon Lane at Eastwood Road. One driveway along each direction of Commonwealth Drive was also included to balance network volumes.



## ALTERNATIVES

Eight alternatives were initially screened and evaluated, which considered overall traffic operations in addition to ROW impacts, structural impacts, and access management in terms of benefits and drawbacks.

### Single Point Urban Interchange (SPUI) along Military Cutoff Road

The SPUI with Military Cutoff Road as the free-flowing movement assumes the crossroad and ramp terminals would be on ground level and the free flow movement would be grade separated. This option is better for pedestrian/bike treatment and has a smaller footprint than elevating the interchange. Operationally, the interchange would require dual turn lanes from the ramps, dual left turns to the ramps, and single right turns to the ramps. A preliminary geometric layout showing proposed lane configurations (without ramp-to-ramp movements) and potential right of way (ROW) impacts is provided in **Figure 2**.



**FIGURE 2 – Geometric Layout of SPUI along Military Cutoff Road.**

1           The SPUI is not a true interchange in terms of access control. Driveways and intersections  
2 impacted by the SPUI are restricted to right-in-right-out access to the ramps as they can be treated as  
3 frontage roads. Access modifications on Eastwood Road and Military Cutoff Road would be required as  
4 access patterns are altered to reflect the change of Military Cutoff Road access points to right-in-right-out.  
5 The rerouting of some movements to Drysdale Drive from Landfall Center/Viking Lane would require  
6 improvements to that intersection as well.

7           To facilitate movements impacted by the ramps, through (ramp to ramp) movements are required.  
8 Ramp to ramp movements at a SPUI are unconventional but can be accommodated in several ways;  
9 traditional split phasing with shared left/through movements (each ramp operates independently) or  
10 dedicated through movements and an additional signal phase. A Synchro analysis indicated that a through  
11 movement can only be accommodated via a single exclusive lane. The addition of a through lane to the  
12 ramps will result in a larger (5-lane) ramp cross section with signalized dual left and right-turn  
13 movements. Providing a free right turn to Eastwood Road with an add lane would reduce the ramp cross  
14 section to 4-lanes but will require an additional acceleration lane on Eastwood Road. These large ramp  
15 concepts proved to be a critical flaw as there was very little ROW to accommodate the lanes needed for  
16 the intersection to operate at an acceptable level.

### Single Point Urban Interchange (SPUI) Eastwood Road

While the SPUI with the north-south free movement addressed many project considerations, it had significant ROW impacts and stopped through traffic along Eastwood Road. Being that Eastwood Road is the connection to the hurricane evacuation route, it was preferred that this traffic receive priority as opposed to the traffic on Military Cutoff Road. With more space along Eastwood Road to widen, a SPUI alternative with an east-west free flow movement was evaluated. **Figure 3** shows the geometric layout for this alternative.



**FIGURE 3 – Geometric Layout of SPUI along Eastwood Road.**

Design benefits and drawbacks for the SPUI in this direction are similar to those for the SPUI along Military Cutoff Road. As previously mentioned, the most significant benefits to shifting the free movement to Eastwood Road are the reduction in ROW impacts as well as the access to the hurricane evacuation route. Some of the access issues that occurred in the Military Cutoff SPUI option were addressed and corrected in the Eastwood Road SPUI option including all access points to the mall in the NE quadrant. This option also forces the CCT to cross Military Cutoff Road at a signal with Commonwealth Drive. The SPUI along Eastwood Road is one of the two preferred alternatives that is moving into further analysis.



## Echelon

An echelon divides an intersection into an upper and lower level, reducing the number of conflicting phases at the intersection. The example echelon interchange shown in **Figure 4** has two conflicting phases on the lower level, and three conflicting phases on the upper level.



**FIGURE 4 - Example of an Echelon Intersection in Aventura, FL.**

The echelon alternative at Eastwood Road & Military Cutoff Road could be designed with only two conflicting phases per level. The configuration in **Figure 5** was carefully arranged so that nearby driveways would not cause weaving sections. It avoids weaving by placing all northbound departures on the same level and all southbound departures on the same level. The northbound and eastbound movements intersect on one level, as well as the westbound right turn movement. The southbound and westbound movements intersect on the other level. Note that the eastbound right turn is routed through Commonwealth Drive to simplify the structures at the intersection and to maintain the same level for the southbound departures.





**FIGURE 5 - Geometric Layout of Echelon.**

This option is by far the most expensive option as it has structures in all four directions. Due to the construction of these structures, the CCT would be closed during most of the improvements. In addition, the use of Commonwealth Drive for the eastbound right movement with heavy volume already on Commonwealth Drive may put the road over capacity. Although the echelon performed well from a strictly traffic operations standpoint, the potential cost and the impacts proved to be too much and it was ultimately removed from the short list of preferred alternatives.

## Quadrant Road at Grade

Where a secondary road exists in one or more quadrants of the intersection, left turns can be eliminated from the main intersection by routing them onto the quadrant road. With the reduction in the number of phases at the main intersection, use of a quadrant road allows all movements to be at grade. This is shown in the schematic in **Figure 6**.



**FIGURE 6 - Geometric Layout of Quadrant Road at Grade.**

The quadrant road at grade addresses many of the considerations for this project. It has acceptable operations, maintains most access, and is relatively inexpensive. One of the major drawbacks to this alternative, however, is that Commonwealth Drive would need to be expanded to a 5-lane cross-section. This would take away some parking for the adjacent businesses and make access to these businesses and nearby housing very difficult. A variation of this alternative is explored later which is why this version of the quadrant road was dismissed.



### Quadrant Road with Overpass

The addition of an overpass on Eastwood Road to the quadrant road alternative eliminates one signal that potential hurricane evacuation traffic would encounter. This also addresses some of the operational flaws that the at-grade quadrant experienced, such as a westbound left turn bay to replace the trap left turn lane in the at-grade option. The schematic in **Figure 7** shows how this could be accomplished in combination with an east-west overpass to further reduce conflicts with the through movements.



**FIGURE 7 - Geometric Layout of Quadrant Road with Overpass.**

The proximity of the Commonwealth Drive and Eastwood Road intersection to the main intersection created a dilemma with the structure design. The distance between the two intersections was too small to safely connect the upper level at Military Cutoff Road and the lower level at Commonwealth Drive. Instead of extending the structure to allow Commonwealth Drive to travel under the structure, the decision was made to build Commonwealth Drive up to meet the structure as it was connecting the two levels. In other words, the elevation where Commonwealth Drive met Eastwood Road was between levels 1 and 2. This created a few access issues as well as the removal of parking in the business plaza. In addition, this design did not address the fact that Commonwealth Drive was to be a 5-lane road with residential and business access issues, and was ultimately dismissed for further analysis.

## Continuous Flow Intersection (CFI)

The basic principle of the CFI is to remove the left turns from the main intersection, reducing the number of conflict points and allowing signal phasing for the main signal to be simplified. By shifting the left turns upstream of the main intersection and allowing turning traffic to travel on the left side of opposing traffic, the left turns can now travel with its paired through movement. If done for all approaches at an intersection (i.e., a 4-leg CFI), the main signal will be reduced to a two-phase signal, increasing the efficiency of the intersection. Since displacing the left turns requires an additional signal prior to the main signal, (which also requires only two phases) signal timing must be coordinated to avoid any queueing issues. **Figure 8** show an example of a CFI that displaces two left turning movements (i.e., a 2-leg CFI).



**FIGURE 8: Example of a CFI in Loveland, CO.**



Both a 2-leg and 4-leg CFI were evaluated at Military Cutoff Road and Eastwood Road. For the 2-leg CFI, both pairs of left turns – north-south and east- west – were explored. Due to ROW impacts, the preference to favor traffic operations on Eastwood Road, and access considerations, it was determined that it would not be feasible to displace the left turns on Military Cutoff Road. Therefore, the preferred CFI design was the east-west displaced left turns on Eastwood Road. The geometric layout for this alternative is shown in **Figure 9**.



**FIGURE 9: Geometric Layout of CFI along Eastwood Road.**

While this alternative addressed many of the project considerations, it was determined that it did not facilitate intuitive navigation for people who do not drive the corridor regularly. It also created complications with pedestrian and bicycle traffic along the CCT. For these reasons, the CFI was not chosen for further analysis.



## NW Quadrant Road

The quadrant road option along Commonwealth Drive performed very well operationally, and the NCDOT liked the general idea of the quadrant road, but they wanted to make sure that all options were entertained. Therefore, an option that created a new road behind the residential development in the NW quadrant of the intersection was investigated. The NW quadrant road alternative adds a new road traveling from the west side of Eastwood Road to the north side of Military Cutoff Road, serving the eastbound and westbound left turns on Eastwood Road. This option resulted in the least amount of impact to adjacent ROW and existing access. **Figure 10** shows the geometric layout of this option. Due to the minimal ROW and access impacts, as well as the low cost, the NW quadrant road option was chosen for the short list of preferred alternatives.



**FIGURE 10: Geometric Layout of NW Quadrant Road.**

**NEXT STEPS**

Following subsequent feedback and correspondence with local municipalities, two alternatives were identified for further development and analysis:

- A single-point urban interchange (SPUI) allowing an overpass for the east-west approaches and
- An at-grade northwest quadrant that proposes adding a new “bypass” connection northwest of the intersection

These two preferred alternatives will be presented to the public for their input and the NCDOT will use this feedback to select a single alternative to move forward with final design.