CAMPO
NC Capital Area Metropolitan Planning Organization

I-40 / I-540 / NC-540 INTERCHANGE ANALYSIS

FINAL REPORT

November 2017

STV 100 Years

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1.0 INTRODUCTION

1.1 Study Purpose

During the development of the region's 2040 Metropolitan Transportation Plan (MTP), CAMPO and DCHC MPO recognized mobility issues at the I-40 / I-540 / NC 540 Interchange. The purpose of this hot spot analysis was to consider interim and future improvements for the interchange of I-40 / I-540 / NC-540 located in Wake and Durham Counties.

The results of this study are to be used as a basis for recommendations in the CTP element of the MTP, as well as identifying viable projects for ranking in SPOT 6.0. In collaboration with the project Steering Committee, the study team identified seven concepts, both at and around the interchange, which could be assessed and programmed for future improvements. Proposed improvement recommendations from this study were not to preclude the future I-40 Managed lanes project. This report includes a technical analysis of the existing conditions and several conceptual improvements developed over the course of the project.

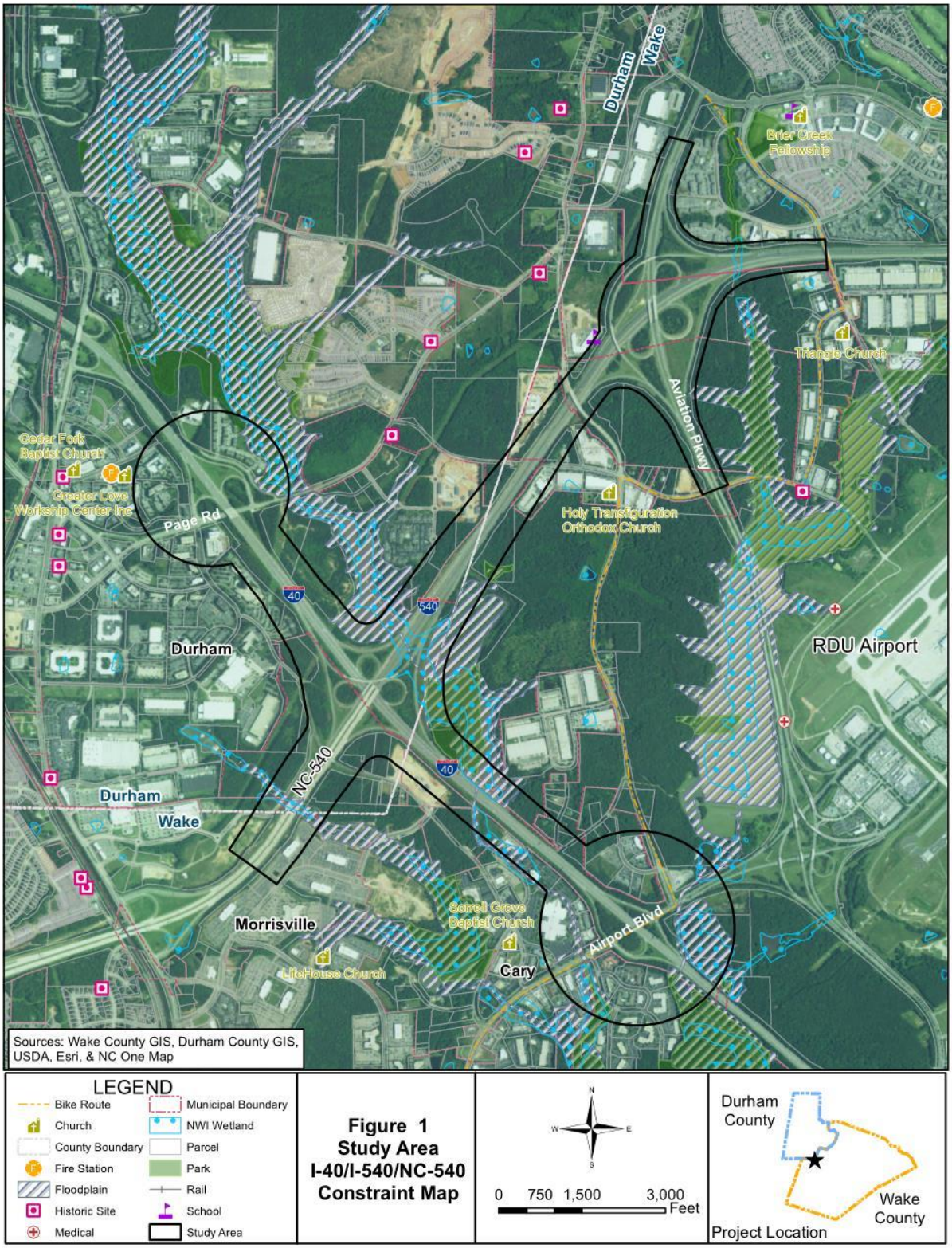
1.2 Study Area and Environmental Constraints

The original project study area was defined to be a 1,000 foot corridor centered on the I-40 and I-540 mainlines, and approximately a 200 - 500 foot buffer around the interchanges. The study area included the following interchanges:

- I-40 / Page Road
- I-40 / I-540 / NC 540
- I-40 / Airport Boulevard
- I-540 / Aviation Parkway

The study area is divided by the Wake and Durham county lines. It is surrounded by Durham, Morrisville, Cary, and Raleigh municipal boundaries. To the east of the study area is the Raleigh-Durham (RDU) Airport. **Figure 1** illustrates the study area.

According to a GIS database search, there are no historic sites within the study area. There is an NCDOT Bike Route along Airport Boulevard within the study area. There are wetlands and floodplains in the study area. The wetlands are in general to the east of I-40 between Page Road and I-540, and cross I-540 north of its interchange with I-40, culminating in the Upper Crabtree Creek Watersheds (HUC 12 ID: 030202010801). The surrounding land uses are primarily office, parks, and commercial property.


Durham
Wake
Brier Creek Fellowship
Triangle Church
Aviation Pkwy
Cedar Fork Baptist Church
Greater Love Worship Center Inc
Page Rd
Holy Transfiguration Orthodox Church
40
540
Durham
RDU Airport
NC-540
Durham
Wake
Morrisville
Borrell Grove Baptist Church
Airport Blvd
LifeHouse Church
Cary
Sources: Wake County GIS, Durham County GIS, USDA, Esri, & NC One Map
LEGEND
Bike Route
Church
County Boundary
Fire Station
Floodplain
Historic Site
Medical
Municipal Boundary
NWI Wetland
Parcel
Park
Rail
School
Study Area
Figure 1
Study Area
I-40/I-540/NC-540
Constraint Map
N
W
E
S
0 750 1,500 3,000
Feet
Durham County
Wake County
Project Location

2.0 EXISTING CONDITIONS

2.1 Existing Plans and Studies

The following relevant studies and plans in **Table 1** were reviewed:

Table 1 – Surrounding Projects

TIP No.	Project	Limits	Horizon Year
FS-1205A	I-40 Managed Lanes	Wake County Line to US 15-501	2021-2030 MTP
I-5700	Airport Blvd Interchange Improvements	ROW 2019 / Construction 2020	2021-2030 MTP
	Aviation Parkway	Airport Blvd to I-540 Interchange	Post 2040 MTP
I-3306A	I-40 Widening	I-85 to the Durham County Line	2030 MTP
I-5506	Aviation Parkway Interchange	Construct Loops in NW Quadrant	ROW 2016 / Construction 2017
I-5702A	I-40 Managed Lanes Study	US 15-501 to I-440/I-64	2030 MTP
I-5707	I-40 WB Auxiliary Lane	From NC 147 to NC 55	2030 MTP

FS-1205A is a feasibility study that was completed by NCDOT in June 2016. This study analyzed the operations of managed lanes along I-40 from I-85 in Orange County to Wade Avenue in Wake County.

I-5700 is a project on I-40 at SR 3015 (Airport Boulevard) to revise the interchange and construct an auxiliary lane on I-40 westbound from Airport Boulevard to I-540. Planning and Design are in progress. NCDOT's 2016-2025 State Transportation Improvement Plan (STIP) has funding programmed for ROW and Construction.

I-3306A will widen I-40 to six lanes and install ITS from I-85 to the Durham County line in Durham County. Planning and Design are in progress. This project is partially funded according the NCDOT's STIP.

I-5506 is an interchange improvement project at I-40 and SR 1002 (Aviation Parkway). It will also include an auxiliary lane on I-40 westbound from Aviation Parkway to Airport Boulevard. Right of Way is in progress and the project is funded for construction in NCDOT's STIP.

I-5702A would construct managed lanes along I-40 from US 15-501 to NC 147. According to NCDOT's STIP, the project is partially funded.

I-5707 constructs a west bound auxiliary lane from NC 147 on ramp to NC 55 exit. It is currently scheduled for construction in 2022 but according to NCDOT, this project could be accelerated. Planning and Design are in progress. NCDOT's STIP has funding programmed for ROW and Construction.

2.2 Existing Roadway and Traffic Conditions

I-40

I-40 within the study area is an eight lane freeway with a 65 MPH speed limit. I-40 Is functionally classified as an interstate. It is state-owned and is noted as a Strategic Highway Corridor.

The peak flow direction is westbound in the AM peak hour and eastbound in the PM peak hour. Merges, diverges, weave patterns, and lane drops cause severe congestion during both peak hours in both directions during weekdays. The close proximity of the Page Road interchange to the I-540 / NC 540 ramps also causes weaving issues in both directions.

I-540

I-540 is a six lane freeway with a 70 MPH speed limit. I-540 is state-owned and classified as an interstate.

I-540 is primarily a commuter route, therefore has a large directional split of traffic heading westbound in the AM peak hour towards I-40 and eastbound in the PM peak hour away from I-40. In the AM peak hour, westbound traffic to I-40 causes traffic congestion that propagates past the Aviation Parkway interchange.

NC 540

NC 540 is a southwestern extension of I-540 that leads to Western Wake County. NC 540 is a tolled facility that is state owned. It's functionally classified as a freeway. NC 540 has six lanes with a 70 MPH speed limit. Within the study area, the section between the I-40 interchange and NC 54 is non-tolled, but the portion to the south of the NC 54 interchange is a tolled facility.

SR 1973 (Page Road)

SR 1973 (Page Road) is a four lane arterial with a 45 MPH speed limit. Page Road is classified as a Major Collector and is state-owned.

Page Road connects to several large business parks within Research Triangle Park (RTP) and is heavily utilized during peak times. There are large volumes of traffic merging onto I-40 East and exiting I-40 West. These vehicles are have a short weave section on I-40 between Page Road and the I-540 ramps.

SR 3097 (Aviation Parkway)

SR 3097 (Aviation Parkway) is a four lane divided expressway with a 60 MPH speed limit. Aviation Parkway is classified as a Principal Arterial and is state-owned.

Aviation Parkway is used as an alternate route for both I-40 and I-540 and also connects to RDU Airport. The Aviation Parkway interchange with I-540 is a full system interchange. The ramps from I-40 and from Aviation Parkway on I-540 are less than a half mile apart, causing weaving issues along I-540.

2.3 Crash Analysis

Five years of crash data (May 1, 2012 to April 30, 2017) was obtained for I-40 (from 1,000 feet west of the Page Road bridge to 1,500 feet east of the Airport Boulevard bridge) and I-540/NC 540 (from Chapel Hill Road bridge to Aviation Parkway bridge) within the study area.

On I-40, there were a total of 875 crashes, including one fatal crash, 187 non-fatal injury crashes, and 687 property damage only crashes. Rear-end crashes accounted for 52% of all crashes, sideswipes (same direction) accounted for 18% of all crashes, and 33% of all crashes occurred between 5:00 PM and 7:00 PM. This is indicative of a pattern of rear-end crashes caused by traffic congestion during rush hour. The severity index for the corridor was 2.98, which is below the statewide severity index of 3.35 for an urban interstate (from three year crash rates from 2013 to 2015).

On I-540 / NC 540, there were a total of 189 crashes, including one fatal crash, 44 non-fatal injury crashes, and 144 property damage only crashes. Rear-end crashes accounted for 34% of all crashes, fixed object crashes accounted for 23% of all crashes, and sideswipes (same direction) accounted for 16% of all crashes. The highest percentage of crashes occurred between 7:00 AM and 9:00 AM. These crash times and types are indicative of a pattern of congestion related crashes, particularly along I-540 westbound in the AM peak hour where the majority of vehicles merge off of the freeway to the I-40 ramp. The severity index for the corridor was 3.49, which is above the statewide severity index of 3.35 for an urban interstate (from three year crash rates from 2013 to 2015).

2.4 Original Project Vision and Initial Stakeholder Meetings

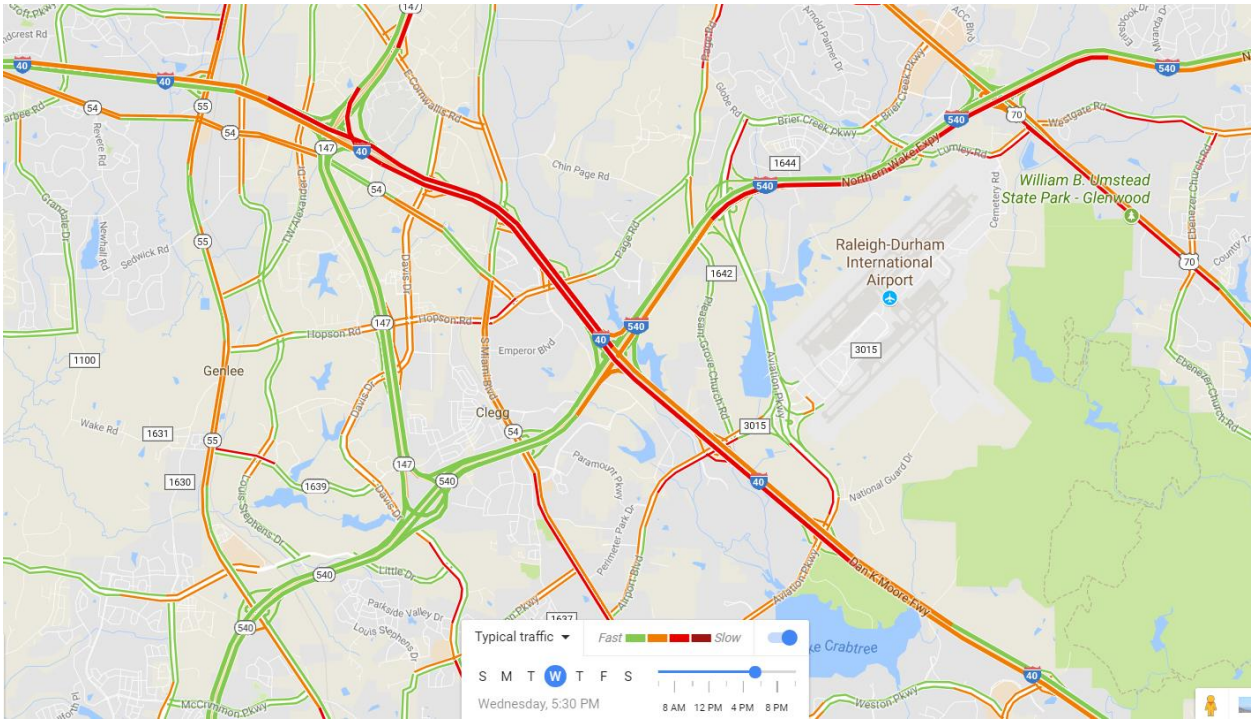
As stated above, the initial vision of this hot Spot project was to identify short and mid-term improvements that could be implemented at the I-40 / I-540 / NC 540 interchange to reduce congestion and increase capacity and safety. This process would be accomplished through both a quantitative process using TransModeler and Highway Capacity Software (HCS) for a capacity analysis study as well as a qualitative process through interviews with local stakeholders, transit officials, NCDOT, observations from field visits, and comparisons to similar interchange locations.

Stakeholder interviews were conducted with agencies identified to make up the Steering Committee for this study, which included representatives from CAMPO, DCHC MPO, NCTA, NCDOT Division 5, and Go Triangle. Meeting minutes are included in the Appendix C.

After conducting these interviews, several key points were summarized:

- The signage and pavement markings in the vicinity of the interchange could be improved. Some signs, such as those on I-40 eastbound approaching I-540, contain excess information that is difficult to comprehend in a short viewing time.
- Several areas of reoccurring congestion occur:
    - I-40 westbound through the entire study area, extending to west of NC 147. The I-5707 auxiliary lane project will help with this congestion.
    - I-40 eastbound through the study area to east of Aviation Parkway.
    - I-540 westbound approaching I-40. This congestion occurs primarily during the AM peak hour.

- Several weave areas were identified:
  - Along I-40 eastbound and westbound between NC 147 and I-540 and all interchanges (Davis Drive, Miami Boulevard, and Page Road between the system interchanges).
  - Along I-540 eastbound between the merge from I-40 and the off ramp to Aviation Parkway.
- The size of improvements and timelines for implementation vary widely such as pavement marking upgrades (short term) to rebuilding interchanges and adding collector-distributor roadways (long term).
- The BOSS system has been successful along I-40. The system may be implemented along I-540, and busses should have access to any future toll lanes or express shoulder lanes. Any transit improvements should be made in close coordination with transit agencies as well as RTA.
- On-ramp signals and/or protected-permitted phasing at signals leading to on-ramps could meter traffic onto the highway better and avoid "pulses" of traffic.
- Traffic congestion at the I-40 / I-540 / NC-540 interchange may not be due to the interchange itself; it may be due to capacity constraints and bottlenecks at points surrounding the interchange. This is evident in the traffic conditions map displayed below, which depicts average traffic conditions at 5:30 PM on a Wednesday. As can be seen in **Figure 2**, areas of severe congestion exist on I-40 in both directions, and this congestion extends well outside of the I-540 interchange influence area.



*Reference: Typical traffic conditions from Google Maps.

Figure 2 – Typical Peak Hour Congestion

2.5 Capacity Analysis

Traffic operations were analyzed for 2017 AM and PM peak hours for the study area. TransModeler micro simulation software was used in the analysis.

Capacity and operational deficiencies outside the defined study area along I-40 east and west impact traffic operations within the interchange study area; creating a constrained network along I-40. These congestion issues are associated with the I-40 mainline and not necessarily the I-40 / I-540 / NC 540 study interchange. This study did not account for the offsite congestion influences so that an unconstrained network could be analyzed. This will enable the analysis to determine where the existing geometric configuration is deficient in meeting existing traffic demands in an unconstrained network.

For the purposes of determining traffic volumes for existing conditions, the study utilized the traffic forecast for the I-40 Managed Lanes Study (STIP project FS-1205A-I-40 / I-440) dated June 2016. Peak hour volumes for the project area were calculated based on the forecasts for 2013 and 2040 No-Build conditions, and the 2013 forecasts were used to project 2017 traffic volumes along the study area network using straight line interpolation using a 1.8% and 2.6% per year growth rates for I-40 and I-540 respectively. The traffic forecast was also utilized to determine the future volumes.

Once AADT's for each road and left turn quadrants were determined, the Intersection Analysis Utility (IAU) spreadsheet developed by NCDOT was utilized to develop AM and PM peak hour volumes. An origin destination matrix was developed and assigned to a TransModeler network, which was used in the capacity analysis for existing and future conditions.

AM Peak Hour

Figure 3 depicts freeway vehicle densities and associated Levels of Service (LOS) during the AM Peak Hour for 2017.

Figure 3 - 2017 AM Peak Hour Density

The results depicted above generally match what was observed during the field visit and from examination of existing average travel times. Westbound I-40 between the Airport Boulevard On-Ramp and the Page Road On-Ramp operates at LOS E or worse during the AM peak hour in 2017. This congestion can be attributed to heavy volumes of traffic commuting to RTP, merging delays between I-540 and Page Road, a lane drop on westbound I-40 just east of I-540 on-ramp, and a lane drop on westbound I-40 between Loop Off-Ramp and On-Ramp at Page Road. Additionally, westbound I-540 has deficient capacity approaching the I-40 off-ramp.

PM Peak Hour

Figure 4 depicts freeway vehicle densities and associated Levels of Service (LOS) during the PM Peak Hour.

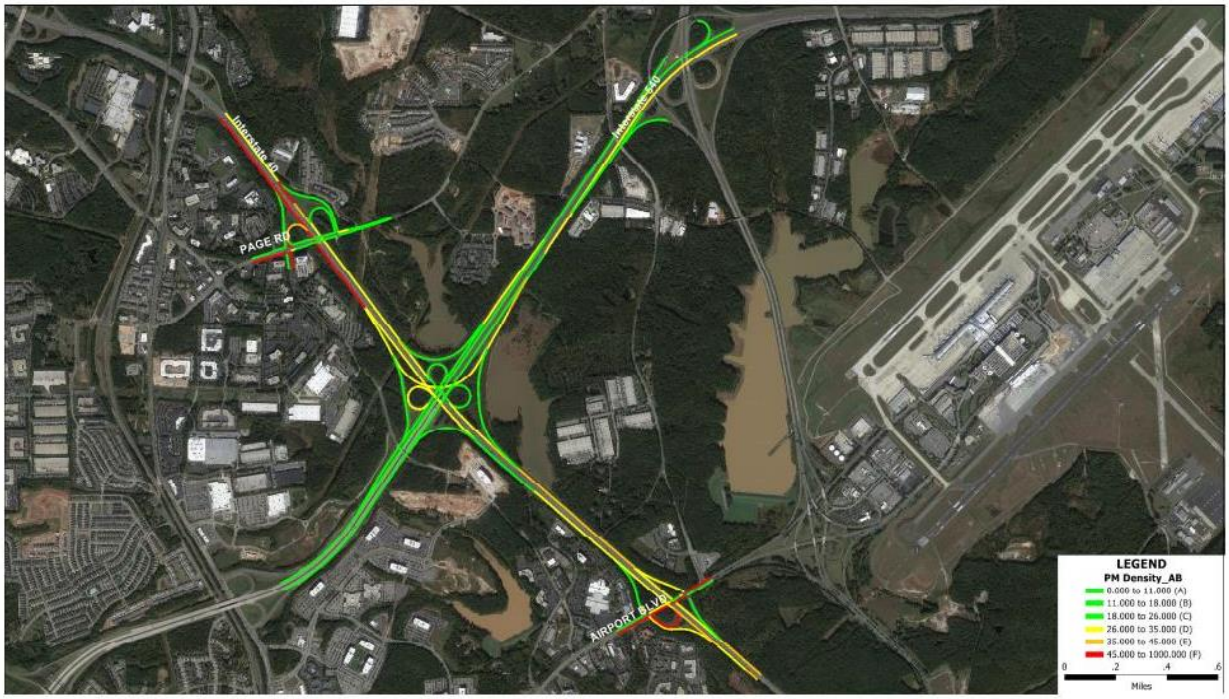


Figure 4 - 2017 PM Peak Hour Density

Westbound I-40 within the study area operates at acceptable LOS during the PM peak hour. Eastbound I-40 experiences LOS E or worse in the area of Page Road. The model suggests this issue is attributed to merging vehicles from Page Road headed eastbound on I-40. Conditions improve through the interchange study area with LOS D or better. Eastbound and westbound I-540 operate at LOS D or better.

Overall Results

The existing conditions analysis using the unconstrained traffic simulation model begins to validate the assumption that the interchange is not the primary culprit of congestion in this area. The analysis does begin to show deficiencies on westbound I-40 between I-540 and Page Road caused by merging/diverging and lane drops. In general, the overall interchange itself appears to have the capacity to carry and process the existing vehicle demand.

3.0 FUTURE CONCEPTS AND CONSIDERATIONS

3.1 Project Concepts

After project scoping, interviews with stakeholders, and the initial capacity analysis, Concepts 1-7 were developed. Diagrams of these seven Concepts are included in Appendix A.

Concept 1 – I-40 Westbound C/D Roadway

Currently on I-40 westbound through the interchange, there is a weave between two cloverleaf loops underneath the I-540 bridges. This weave is handled by a 5th lane that forms just prior to

the start of the weave and ends just past the weave, before the ramp from I-540 westbound merges. This temporary lane addition through a weave is commonly referred to as a poor man's C/D (collector-distributor). A normal C/D roadway is physically separated from the main lanes. I-540 westbound through the interchange has a C/D to separate the weave movements from the mainline lanes.

Concept 1 proposed to convert the poor man's C/D on I-40 westbound into a normal C/D by moving the added 5th lane outboard and separating it from the four main through lanes. The barrier could be a normal concrete jersey barrier, however it was determined that this would likely not be feasible due to insufficient horizontal clearance under the I-540 bridges. There is room to convert a portion of the slope protection into a retaining wall, however there is a bent for the flyover located in the slope protection, limiting the amount of extra roadway space that could be obtained by using this method. During the stakeholder interview with RTA, the idea of flexible delineators was also proposed. There was also concerns about the amount of merging area if a barrier was installed between the cloverleaf weave and the main lanes of I-40. A barrier would force all vehicles coming from the I-540 loop to merge into I-40 in a shorter window than exists today without the barrier.

Concept 2 – I-540 Eastbound Restriping

On I-540 eastbound, there are currently three lanes that are continued through the interchange. At the merge with the I-40 ramps, two lanes merge on the right. The 5th lane ends approximately 600 feet after the merge. The 4th lane then ends approximately 1000 feet later as an exit only lane to Aviation Parkway. This lane configuration places a higher priority on the I-540 through movement and forces all vehicles merging from I-40 to change multiple lanes. However, there are currently approximately 1,100 vph in the PM peak hour on I-540 eastbound through the interchange, and 3,500 vph merging onto I-540 from I-40. This creates a traffic pattern where there are 3.5 times more vehicles on two lanes (that merge in) than there are on three lanes that continue through the interchange. During the site visit, multiple drivers on the I-40 ramp were seen moving across two or three lanes of traffic in a short distance at high speeds.

Concept 2 proposed removing the 3rd (right) lane of the main I-540 eastbound lanes prior to the merge. This would allow the left lane of the I-40 ramp to become the new 3rd eastbound lane on I-540, reducing the amount of lane changes that need to currently be made by the majority of the traffic volume. The second (right) lane from the I-40 ramp would then become the exit only lane for Aviation Parkway. This would primarily involve pavement restriping (striping out lanes) and signage modifications.

Concept 3 – I-540 Westbound Restriping

Similar to I-540 eastbound in the PM peak hour, in the AM peak hour on I-540 westbound, there are 3.5 times more vehicles that exit to I-40 than continue straight through the interchange (to NC 540). With the current lane configuration, a 4th westbound lane at the merge from the southbound Aviation Parkway ramp is added, and then a 5th lane forms approximately 1,200 feet later. The 4th and 5th lanes then exit to the I-40 C/D ramp approximately 1,400 feet later. This configuration currently requires all vehicles heading to the I-40 ramp to change at least one lane to the right, and leads to many drivers opting to be in the 3rd (right) lane of I-540 westbound through the Aviation Parkway interchange. This high traffic volume in one lane, combined with forcing

vehicles to change lanes, causes congestion on I-540 westbound approaching I-40 in the AM peak hour.

Concept 3 proposed eliminating the addition of the 5th lane in the weave area and instead having the second I-40 C/D ramp lane forming from the 3rd (right most through) lane becoming an option lane. Vehicles in this lane would now be able to proceed straight through on I-540 or take the C/D ramp to I-40. This would allow vehicles in the second (middle) lane of I-540 to only have to move right one lane (to the right through/option lane) to get to the I-40 ramp. This could spread vehicles out more evenly into two lanes (especially in the vicinity of Aviation Parkway) and would lead to better lane utilization. Similar to Concept 2, Concept 3 would primarily involve pavement restriping (striping out lanes) and signage modifications.

During the second stakeholder meeting, a slight modification to this concept was also discussed. Concept 3A proposed shifting the ramp to the off-loop from I-540 westbound to I-40 eastbound away from the directional ramp to I-40 westbound (which carries a majority of the traffic volume). The ramp to the I-40 eastbound loop would diverge from the I-540 mainline approximately one half mile past the diverge for the current combined I-40 eastbound and westbound ramp.

Concept 4 – I-40 Westbound Auxiliary Lane Extension

As part of project I-5700 (Airport Boulevard interchange modification), a westbound auxiliary lane will be added to I-40 westbound from Airport Boulevard to I-540. With the current design, the auxiliary lane would end as an exit only lane to the I-540 eastbound ramp. Concept 4 proposed extending this lane past the eastbound ramp to where the 5th lane forms for the poor man's C/D along I-40 westbound. This would turn the new 5th lane into an option lane at the I-540 eastbound off-ramp and would extend it to the poor man's C/D weave lane. The 5th lane for the poor man's C/D currently forms approximately 800 feet past the I-540 eastbound ramp, so this concept would add approximately 800 feet of a new 5th lane (beyond what is being planned as part of the I-5700 project).

Concept 5 – Page Road Re-aligned Off-Loop

On I-40 westbound, there is a weave area between the on-ramp from I-540 westbound and the off-loop to Page Road. Two lanes are added to I-40 westbound from the I-540 ramp, forming a total of six lanes. The 6th lane becomes an exit only lane to Page Road, and the 5th lane merges approximately 500 feet past the Page Road off ramp. This quick narrowing from six lanes to four causes congestion during both peak hours.

Concept 5 proposed removing the existing Page Road off-loop and instead moving it to the Miami Boulevard off ramp. The loop would then be routed north around the Featherstone Village Apartments and would intersect Page Road approximately 800 feet northeast of where the current loop ends. For laneage on I-40 westbound, the 6th lane would end in the vicinity of the current location of the off-loop (at the I-40 bridge over Page Road). The on-ramp from Page Road would then form a 6th lane. The 6th lane would then be an exit only lane to the new combined ramp for both Miami Boulevard and Page Road, and the 5th lane would be an option lane. Finally, the 5th lane would merge just prior to the on-loop from Miami Boulevard. The new Miami Boulevard / Page Road off-ramp would then split to take one lane to each roadway. This concept would eliminate the weave between the I-540 westbound on-ramp and the Page Road off-loop and would also extend the 5th lane on I-40 by approximately 3000 feet.

Concept 6 – Braided Ramps between Davis Drive and Miami Boulevard

Currently, the three "interstate to arterial" interchanges at Page Road, Miami Boulevard, and Davis Drive are all closely spaced. This results in several short weave areas. Because all three of these interchanges are the main connections from I-40 in and out of RTP, they experience increased traffic volumes during peak commute times. The K-factors (ratio of peak hour traffic volumes to average daily traffic volumes) for these three roadways are in the range of 10-12%, meaning that 10% to 12% of the total daily traffic volume on the roadways occurs during one peak hour. Typical K-factors for urban arterial roadways range from 8% to 10%. These high volumes, combined with multiple short weave sections, create severe congestion in both directions during both peak hours.

Concept 6 proposed a much larger corridor improvement by braiding the ramps between Davis Drive and Miami Boulevard and between Miami Boulevard and Page Road. With the current configuration, there is an on-ramp from one interchange, a short weave area, and then an off-ramp for the next interchange. Braided ramps create the off-ramp first, then the on-ramp and off-ramp bridge over/under one another ("braiding" with each other), and finally the on-ramp merges. This concept eliminates the weave between the ramps on the main lanes of the highway (increasing capacity), however a bridge has to be constructed to carry one ramp over the other (increasing cost). There would also be options of connecting the ramps so that local trips to and from Davis Drive, Miami Boulevard, and Page Road could be accomplished without having to travel on the main lanes of I-40. Because of the way the ramps may be configured, a DDI (diverging diamond interchange) may be feasible at Miami Boulevard. DDIs work well when a substantial portion of the traffic volume on the arterial turns to and from the highway. This traffic pattern occurs at the Miami Boulevard interchange, with large volumes of commuters getting on and off of I-40 during the peak hours. This DDI concept is presented in Concept 6A in Appendix A.

Concept 7 – I-40 Eastbound Pavement Marking Additions

On I-40 eastbound, there is currently a weave between the on-loop from Page Road and the off-ramp to I-540. A 5th lane forms from the on-loop and then becomes an exit-only lane to the I-540 ramp. The 4th (right most through) lane is also an option lane that forms a second lane to the I-540 ramp.

Concept 7 did not propose any laneage modifications, but did propose adding pavement markings and refining overhead signage to clarify the exiting laneage. This would consist of right turn only arrows painted in the 5th lane and shared through-right arrows in the 4th lane, clarifying that it is an option lane. The new signs would also indicate that the 5th lane is an exit only lane and the 4th lane is an option lane. Mini-skip lines would also be used in place of the normal lane lines between the 4th and 5th lane to increase awareness that the 5th lane is an exit only lane.

3.2 Other Future Considerations

Signage

Signage in the area could be modified to reduce driver confusion and direct drivers to alternate routes. As an example, signage on I-40 eastbound to the split ramp to I-540 and NC 540 toll has six destinations listed. The existing signage is shown in **Figure 5**.

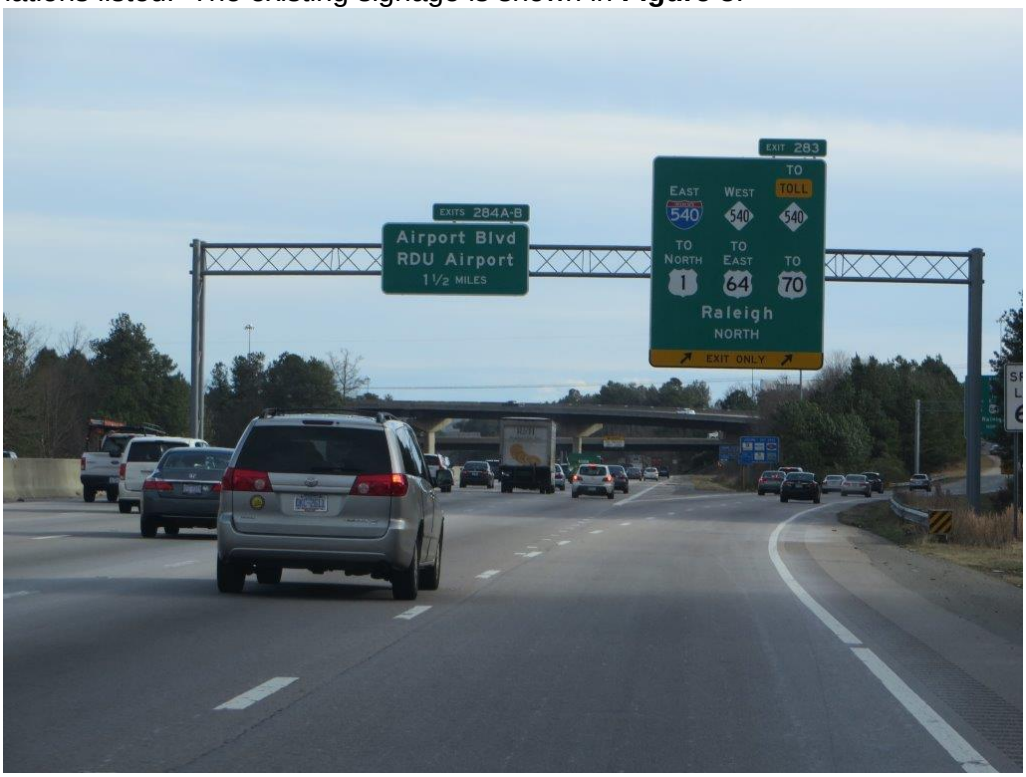


Figure 5 – Signage on I-40 Eastbound at I-540 / NC 540

For I-485 in Charlotte, several signs around the city were recently updated when the last segment of I-485 was built. The signs list three suburbs around the city (Pineville, Matthews, and Huntersville) and only contain interstate numbers/symbols. The signs also utilize the newer style of arrows pointing up/ahead (similar to traditional pavement markings), instead of down at the lane. The sign on I-85 southbound approaching I-485 is shown in **Figure 6**.

Figure 6 – Signage on I-85 Southbound at I-485

DMS Signage with Travel Times

Several DMS (dynamic message signs) are located within the study area. These signs could be used during peak times to display travel times along I-40 versus using Toll 147 and Toll 540 (to bypass the "RTP portion" of I-40 where the Davis Drive, Miami Boulevard, and Page Road interchanges are located).

As an example, there is a DMS located on I-40 eastbound between Fayetteville Road and NC 55 in Durham (west of RTP). During peak times, this sign could display "Travel time to Exit 284 Airport Boulevard; Via I-40 – XX Minutes; Via Exit 279A Toll 147 South to Toll 540 – XX Minutes." Messages like this would provide drivers with more information before they chose which route to take. It should be noted that sending more vehicles to the "toll bypass" may cause increase congestion at certain merge points.

Transit

Go Triangle currently implements a Bus on Shoulder System (BOSS) program along both directions of I-40 from U.S.15 - 501 in Durham County to Wade Avenue in Wake County. The BOSS operations allow authorized GoTriangle buses to utilize the shoulder during times of heavy congestion along I-40. Both the DRX and CRX routes travel through this interchange along I-40, which is currently 12 buses each way during peak times. The BOSS program cannot currently operate on existing I-540 due to insufficient pavement structure to support buses.

The I-40 / Airport Boulevard interchange is a key interchange for GoTriangle due to buses utilizing Slater Road to access GoTriangle's Regional Transit Center. There is the potential for buses to utilize future managed lanes, but routes would be dependent upon the access points.

On-Ramp Signals

On-ramp signals are currently being implemented at four on-ramps to westbound I-540. This project is anticipated to be operational in fall of 2017. On-ramp signals utilize a traffic signal on the ramp entering the interstate or highway to optimize traffic flows during peak travel times. The on-ramp signals reduce weaving congestion by breaking up platoons of cars, and improving safety and reduction of crashes by smoother merges. In the future, on-ramp signals could be implemented along I-40 on-ramps, which would reduce the impact of platooned vehicles on merges and weaves. Within the project study area, the on-loop from Page Road to I-40 eastbound would likely be a high priority location for further study.

Managed Lanes

Future improvements include managed lanes with value pricing in each direction along I-40 coupled with express bus and/or freeway bus rapid transit (BRT) and parallel commuter rail service. FS 1205A (2016) recommended nine access points, including one at Aviation Parkway and I-540, with a circular free flow halo interchange at I-540. Currently programmed into the MTP for 2021 - 2030, the recommendations from this feasibility study is not to preclude manage lanes.

4.0 RECOMMENDATIONS AND FUTURE CONSIDERATIONS

Many potential concepts and projects can be implemented at the interchange and surrounding network of highways to improve operations. Improvements vary in size from restriping lanes to a complete rebuild of I-40 through the study area. To list and compare concepts noted in this study, a concept summary matrix was developed. This matrix is presented in **Table 2.**

Table 2 – Concept Summary Matrix

Concept	Description	Benefits	Drawbacks	Cost	Implementation Timeframe	Notes	Recommendation
1	**I-40 Westbound C/D Roadway**	Separates weaving movement from travel lanes. BOSS system could potentially be used in the area.	Would require modification to slope protection. Bent for flyover would limit the amount the lanes could be moved to the right. Shoulders for primary lanes and C/D would likely be narrow.	Medium	Mid-Term	Likely not feasible due to flyover bent. Consider adding C/D if the interchange is ever rebuilt and the clover loops are retained. Weaving distance would be substandard.	Not recommended.
2	**I-540 Eastbound Restriping**	Improves ramp merge, which carries the majority of the traffic. Low cost improvement, could be implemented with resurfacing. No new pavement area.	Portions of pavement would have to be striped out, removed, or repurposed.	Low	Mid-Term	Could be combined as one TIP project. Could be implemented during roadway resurfacing.	Recommend as hot spot improvement.
3	**I-540 Westbound Restriping**	Improves ramp diverge, which carries the majority of the traffic. Low cost improvement, could be implemented with resurfacing. No new pavement area.	Portions of pavement would have to be striped out, removed, or repurposed.	Low	Mid-Term		Recommend as hot spot improvement.
3A	**Modified Ramp/CD**	Less traffic volume on the directional ramp to I-40 westbound.	Signage could be confusing to drivers.	Medium	Mid-Term	Could be combined with Concepts 2 and 3, or be a standalone project.	Recommend as hot spot improvement.
4	**I-40 Westbound Auxiliary Lane Extension**	Vehicles heading for the off-loop to NC 540 southbound can move out of the four main travel lanes earlier. Merging distance from Airport Boulevard on-ramp would be extended.	Would require additional pavement.	Medium	Short-Term	Could construct with I-5700 project.	Recommend adding to I-5700.
5	**Page Road Re-aligned Off-Loop**	Extends the I-40 westbound weave between I-540 ramp and Page Road off-loop. Extends 5th lane (from the I-540 ramp) approximately 0.5 miles, giving more time for drivers to merge in.	Would not meet driver expectation (off-ramp after the on-ramp). Would conflict with extension/connection of Guardian Drive and Old Page Road. Alignment is very close to Stirrup Iron Creek.	High	Long-Term	Long term project with much higher costs and impacts. Environmental concerns with stream impacts.	Provide additional capacity analysis and add to SPOT scoring.
6	**Braided Ramps between Davis Drive and Miami Boulevard**	Eliminates several weave locations on I-40. Limited ROW impacts. Several ramps exist in areas currently occupied by loops.	Large number of new bridges and structures.	High	Long-Term	Would involve substantial rebuild of the entire highway and interchanges. Could be incorporated into a future managed lanes project, which would involve a complete rebuild as well. Could be a standalone TIP project as well.	Provide additional capacity analysis and add to SPOT scoring.
6A	**Braided Ramps with Miami Boulevard DDI**	DDI at Miami Boulevard would likely increase capacity and reduce congestion at the interchange.	Going from Page Road to Davis Drive would require merging onto and off of I-40.	High	Long-Term		
7	**I-40 Eastbound Pavement Marking Additions**	Provides drivers with better lane guidance. Low cost improvement, could be implemented with resurfacing. No new pavement area.	N/A	Low	Short-Term	Markings could be added on existing pavement or implemented during roadway resurfacing.	Recommend as hot spot improvement. Improved signage should accompany this addition.
-	**Signage Modifications**	Creates simpler messages for drivers, decreasing legibility time and confusion.	Replacing overhead signs has a higher cost.	Medium	Short-Term	Coordinate with NC 540 completion, East End Connector, I-885, etc.	Design and implement signage.
-	**DMS Signage with Travel Times**	Would give more information to drivers. Could divert traffic onto under-utilized highways, reducing demand on I-40.	Potential public relations issue (advocating the toll route).	Low	Short-Term	Could be implemented any time at the discretion of NCDOT.	Conduct feasibility analysis.
-	**Transit**	More transit users reduces the amount of vehicles on the roadway.	N/A	N/A	N/A	Agencies should coordinate transit changes/improvements.	All future area improvements should coordinate with transit.
-	**On-Ramp Signals**	Improves merging and weaving issues caused by on-ramps.	Unfamiliar to drivers in this area. (New I-540 project should increase awareness.)	Low	Short-Term	Could be implemented any time at the discretion of NCDOT.	Conduct feasibility analysis.

Key observations from the summary matrix include:

- The I-40 westbound C/D (Concept 1) is likely not feasible due to the flyover bent location and downstream merging concerns. Any design would significantly reduce the amount of merge area that currently exists directly past the weave of the cloverleaf loops. If the interchange is ever rebuilt as part of a large scale project (such as managed lanes) and the weave between the cloverleaf loops is retained in the new interchange design, a separated C/D ramp should be considered.
- The laneage modifications on I-540 (Concepts 2 and 3) would likely improve traffic operations for the merges and diverges to/from the I-40 ramps. The modifications could occur during regularly scheduled highway resurfacing or as part of a standalone project.
- The westbound auxiliary lane extension on I-40 (Concept 4) could be incorporated into the I-5700 project. That project is scheduled for construction in 2019, so any additions to it would need to be added expeditiously.
- The larger projects (Concepts 5 and 6) would improve operations, but would have much larger costs and impacts, including substantial rebuilding of the freeway and most interchanges. These concepts should be added into the SPOT scoring process and be considered as standalone projects. Additionally, they should be considered as part of the managed lanes projects along I-40.
- Pavement marking improvements (including Concept 7) and signage upgrades can be implemented at any time. It is recommended that signage upgrades be coordinated and/or completed when other regional projects are completed. These include the completion of NC 540 around Raleigh, the East End Connector, and re-designation of NC 147 to I-885.
- Travel times on DMS along I-40 versus Toll 147/540 would give drivers more information and can be implemented by NCDOT at their discretion.
- On-ramp signals should be studied at interchanges in this area. Adding a ramp signal to the Page Road on-loop to I-40 eastbound should be considered a priority for future studies.
- Due to the high number of busses in this area, any improvements to shoulders and/or managed lanes projects should be closely coordinated with local transit agencies.

In summary, the concepts developed in this study vary widely in size, cost, and impact, however they all have the potential to improve traffic operations and reduce congestion on roadways in this study area. These concepts and others developed in prior feasibility studies should be considered in the future when more detailed studies, designs, and TIP projects take place.

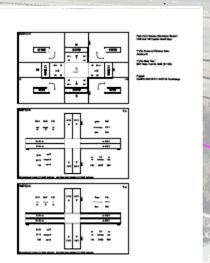
APPENDIX A

DESIGN CONCEPTS

CONCEPT I
I-40 WESTBOUND CD ROADWAY

AM DENSITY

PM DENSITY



STV Engineers, Inc.
100 Years
1500 Perimeter Park Dr., Suite 120
Morrisville, NC 27560
NC License Number F-0991

CAMPO
NC Capital Area Metropolitan Planning Organization

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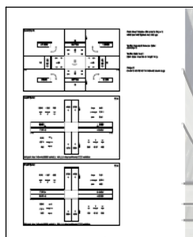
CONCEPT 2
I-540 EASTBOUND RESTRIPING



100 50 0 100 200

PROPOSED LANE MERGE/SHIFT

PROPOSED SHOULDER

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Capital Area Metropolitan Planning Organization

STV 100 Years

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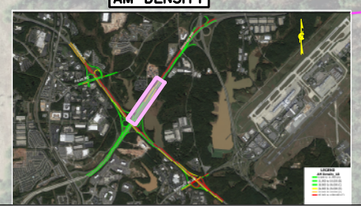
INTERSTATE 540

INTERSTATE 40

INTERSTATE 540

AM DENSITY



PM DENSITY

CONCEPT 3
I-540 WESTBOUND RESTRIPING

100 50 0 100 200

RESTRIPING

PROPOSED SHOULDER

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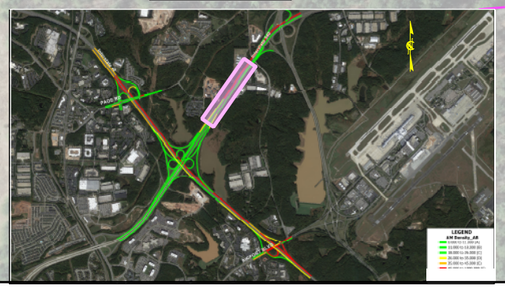
INTERSTATE 540

INTERSTATE 540

AM DENSITY



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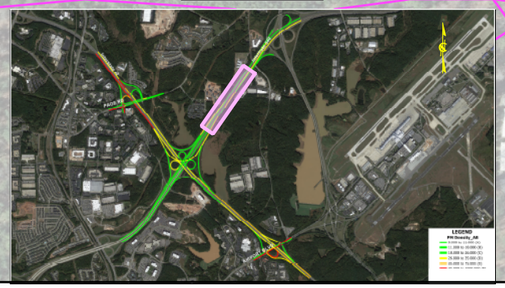

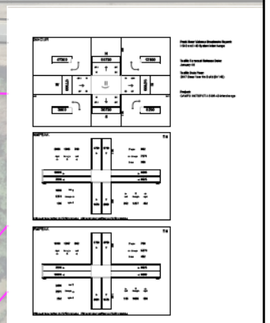

CONCEPT 3A
MODIFIED RAMP/CD

100 50 0 100 200

PROPOSED LANES

PROPOSED SHOULDER

PAVEMENT REMOVAL

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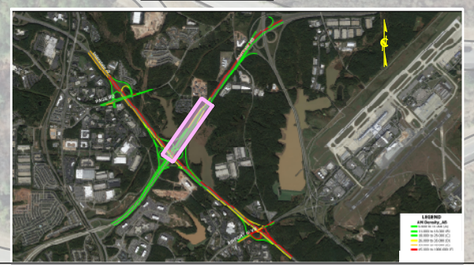
INTERSTATE 540

INTERSTATE 540

INTERSTATE 40

AM DENSITY



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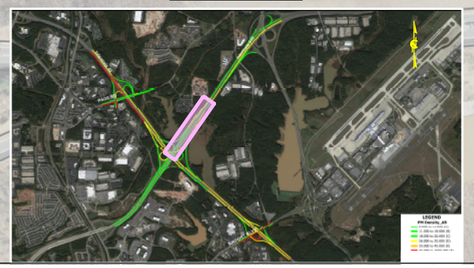

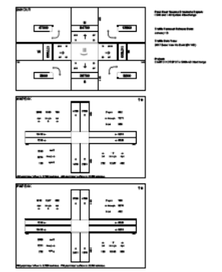

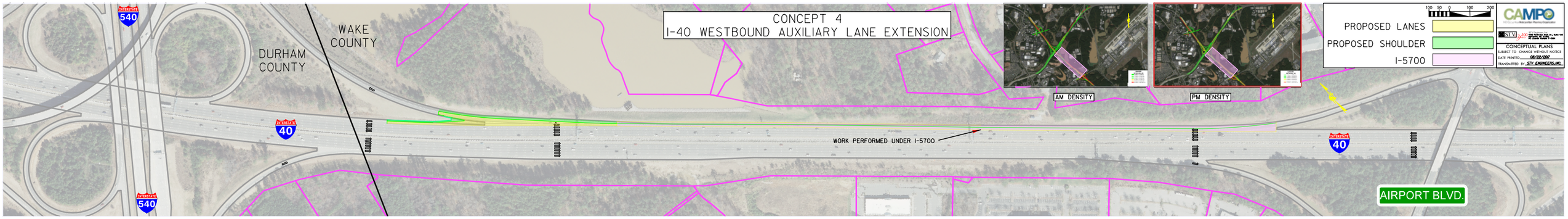
CONCEPT 4
I-40 WESTBOUND AUXILIARY LANE EXTENSION
WAKE COUNTY
DURHAM COUNTY
AM DENSITY
PM DENSITY
PROPOSED LANES
PROPOSED SHOULDER
I-5700
CONCEPTUAL PLANS
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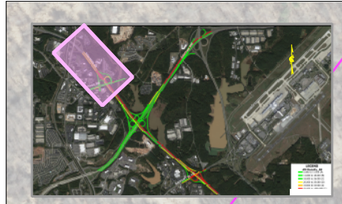
WORK PERFORMED UNDER I-5700
AIRPORT BLVD.
540
40

CONCEPT 5
PAGE ROAD RE-ALIGNED OFF-LOOP



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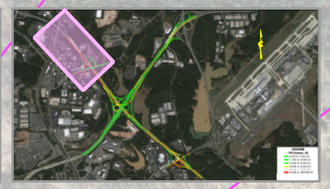

PM DENSITY

100 50 0 100 200

PROPOSED LANES

PAVEMENT REMOVAL

MONOLITHIC ISLAND

CAMPO
NC Capital Area Metropolitan Planning Organization

STV 100 Years
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PAGE RD.

S. MIAMI BLVD.

INTERSTATE 40

INTERSTATE 40

CONCEPT 6
BRAIDED RAMPS BETWEEN DAVIS DR AND MIAMI BLVD

200 100 0 200 400

- PROPOSED LANES
- WORK BY OTHERS
- PAVEMENT REMOVAL
- WALL
- PROPOSED BRIDGE

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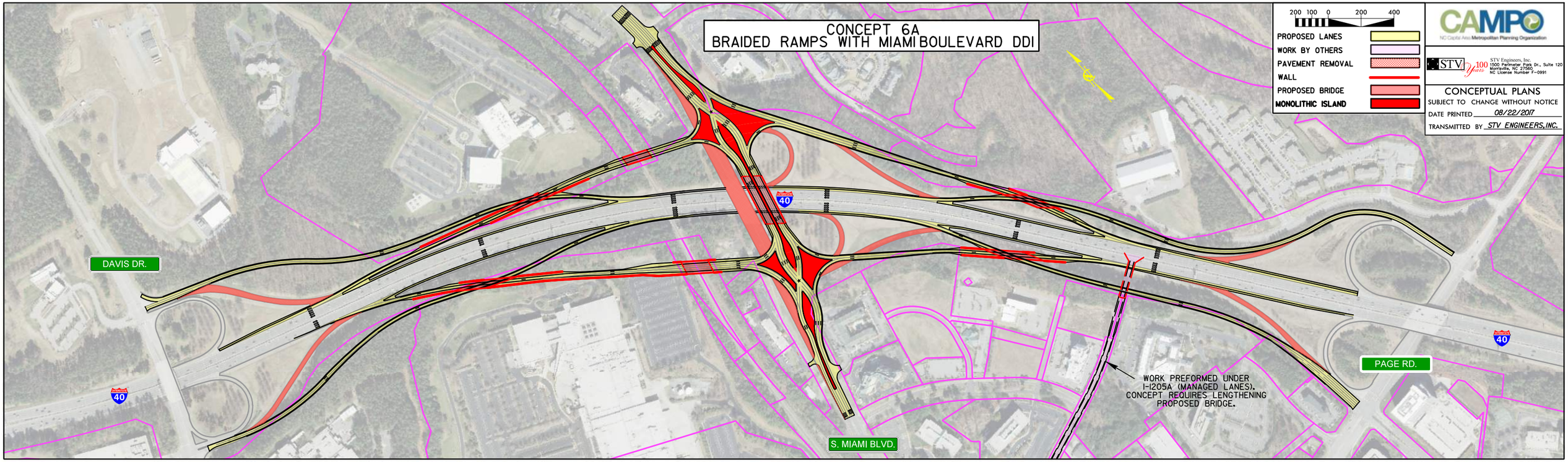
DAVIS DR.

S. MIAMI BLVD.

PAGE RD.

WORK PREFORMED UNDER
I-1205A (MANAGED LANES).
CONCEPT REQUIRES LENGTHENING
PROPOSED BRIDGE.

CONCEPT 6A
BRAIDED RAMPS WITH MIAMI BOULEVARD DDI



200 100 0 200 400

- PROPOSED LANES
- WORK BY OTHERS
- PAVEMENT REMOVAL
- WALL
- PROPOSED BRIDGE
- MONOLITHIC ISLAND

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CONCEPT 7
I-40 EASTBOUND PAVEMENT MARKING ADDITIONS

DURHAM COUNTY

INTERSTATE 40

INTERSTATE 40

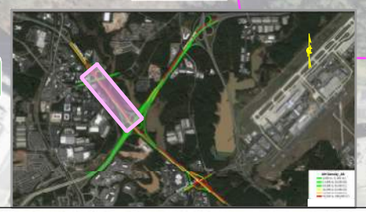
TO WAKE COUNTY →

NEW SIGN

INTERSTATE 540

PAGE ROAD

AM DENSITY



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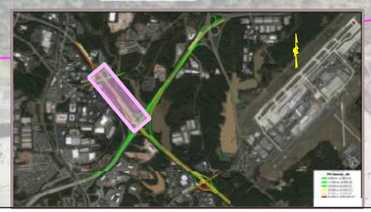

100 50 0 100 200

RESTRIPING

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NC Capital Area Metropolitan Planning Organization

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APPENDIX B

STAKEHOLDER MEETING MINUTES

I-40/I-540/NC 540 CAMPO Feasibility Study
Raleigh, NC
June 8, 2017

Attendees

Justin Carroll	STV	Justin.Carroll@stvinc.com
John Johnson	STV	John.Johnson@stvinv.com
Andy Lelewski (Partial)	NC Turnpike	andy.lelewski@ncdot.gov
David Keilson	NCDOT Div. 5	dpkeilson@ncdot.gov
Alex Rickard	CAMPO	Alex.Rickard@campo-nc.us
Doumit Ishak	NCDOT Congestion Mgmt.	dishak@ncdot.gov
Patrick Livingston	STV	Patrick.Livingston@stvinc.com
Kenneth Withrow	CAMPO	Kenneth.Withrow@campo-nc.us
Shelby Powell	CAMPO	Shelby.Powell@campo-nc.us
Felix Nwoko	DCHC	felix.nwoko@durhamnc.gov
Joe Milazzo	RTA	joe@letsgetmoving.org
Chris Lukasina (Partial)	CAMPO	Chris.Lukasina@campo-nc.us
Richard Hancock	NCDOT Div. 5	rwhancock@ncdot.gov

Meeting Minutes

- Justin Carroll debriefed previous stakeholder interviews and gave an overview of existing conditions
- Justin Carroll showed AM and PM peak hour maps.
- Joe Milazzo mentioned Page Rd ramp onto I-40 signals with protected vs protected permitted.
    - Over protection is slowing signal down but may not be feasible to remove because of small gaps during peak hour.
- There is a backup on the Page Rd ramp from I-40 Eastbound with a short length of ramp and lack of ramp width
    - In order to get left turns down to double left, some lane repurposing may be feasible
- Chris Lukasina thinks lane use is bad between I-540 westbound and Page Rd
    - Existing Configuration is not intuitive to drivers and should be looked at moving forward
- Justin Carroll started the conversation of concepts and asked the group to think of other concepts during the meeting
- John Johnson talked on "poor man" collector-distributor and existing conditions
    - Concept 1 with CD separation and other alternative loop alignments was shown and discussed
- Concepts for loop realignment are likely not feasible
    - John Johnson showed multiple costly options
- John Johnson showed Airport Rd Auxiliary Lane Project and how to include this with the 540 Interchange Hot Spot concepts
- John Johnson showed I-485/Johnson Rd example for an Auxiliary lane ending into loop with directional ramp exiting from auxiliary lane
- Alex Rickard mentioned another Auxiliary Lane is planned between Airport Blvd and Aviation Pkwy
- Chris Lukasina brought up combo of Page Rd exit loop and Miami exit ramp to prevent merging/weaving issues. This would combine the two interchanges and eliminate some movements.

- John Johnson mentioned closing Davis Drive and Page Rd altogether, but this would likely not be an option with the political climate.
- Joe Milazzo thinks Mall of America dynamic signage is a good example for directing traffic away from some ramps/loops but believe it to be impossible to completely close ramps during peak times
- The Split Diamond interchange in Charlotte may be a good example for a concept to combine Davis, Miami, and Page interchanges
- Justin Carroll showed Concept 2
    - Group agrees it makes sense, but suggests to use 3 lanes instead of 2 since it is already near capacity
- Justin Carroll showed Concept 3
    - David Keilson mentioned closing a lane on I-540 to repurpose and add more lanes to ramp.
- Congestion management to send plans of updating signage that is already in the works.
    - Not sure if they are working on including pavement markings on their plans or not, but they will update with any proposed plans
- Signing for future projects should be included and evaluated when making any changes to the signs.
- Alex Rickard will meet week of 6/12/17 with STV to discuss path forward and debrief meeting on 6/8/17.
- STV will provide plots and PowerPoints to add to the SharePoint site
- STV will provide concepts
    - Chris's Combination Ramp/Loop at I-40 WB & Page/Miami
    - Split Diamond Interchange including Davis, Miami, and Page Interchanges.
    - Flyover to replace loop with insufficient acceleration from I-540 Inner to I-40 WB.
    - Traffic Divergence through dynamic signage during peak hours (closing interchanges)

I-40/I-540/NC 540 CAMPO Feasibility Study
Raleigh, NC
July 24, 2017

Attendees

Justin Carroll	STV	Justin.Carroll@stvinc.com
David Keilson	NCDOT Div. 5	dpkeilson@ncdot.gov
Alex Rickard	CAMPO	Alex.Rickard@campo-nc.us
Doumit Ishak	NCDOT Congestion Mgmt.	dishak@ncdot.gov
Patrick Livingston	STV	Patrick.Livingston@stvinc.com
Kenneth Withrow	CAMPO	Kenneth.Withrow@campo-nc.us
Shelby Powell	CAMPO	Shelby.Powell@campo-nc.us
Felix Nwoko	DCHC	felix.nwoko@durhamnc.gov
Joe Milazzo	RTA	joe@letsgetmoving.org
Chris Lukasina (Partial)	CAMPO	Chris.Lukasina@campo-nc.us

Meeting Minutes

- Justin Carroll debriefed previous stakeholder meeting #1 and gave an overview of progress made toward the additional concepts.
- Justin Carroll discussed scope change and what it meant for the deliverables.
- Justin Carroll reiterated how the preliminary capacity analysis and stakeholders believe the I-40/I-540/NC540 interchange is not necessarily the congestion issue; rather it is upstream/downstream interchange spacing coupled with weaving/merging issues.
- Justin Carroll began going through previously presented yet modified (based off of stakeholder feedback) concepts 1-4.
    - Concept 1- I-40 WB CD
        - Consensus was to ultimately not recommend this concept due to not meeting required weave distance.
    - Concept 2- I-540 EB Repurpose/restriping
        - A discussion occurred with determining weaving issues (LOS) in this section with Aviation Pkwy.
        - Ultimately the stakeholder group agrees this should be implemented as a short-midterm solution.
    - Concept 3- I-540 WB Repurpose/restriping
        - The stakeholder group agrees this should be implemented as a short-midterm solution.
        - David Keilson suggested we provide a concept sketch of removing I-40 EB traffic to a separate dedicated off ramp from I-540.
- Patrick Livingston introduced the newly created concepts
    - Concept 4- I-40 WB Auxiliary Lane Extension
        - This project was described as an addition to the I-5700 project.
        - The stakeholder group agreed this should be implemented.
    - Concept 5- Loop to Page

- Patrick described why the loop appeared to be larger than first envisioned by the stakeholder group.
    - Design speed, required merge distance, gore to gore separation, etc.
- The stakeholder group did not completely dismiss this concept, however they recognize the challenges of implementing due to ROW and environmental concerns with Stirrup Iron Creek.

o Concept 6- Braided Ramps
- This concept drew the most interest from the stakeholder group. The majority of the discussion centered on this concept and its benefits.
- Discussion occurred on why Page/Miami/Davis had direct ramps to I-40 rather than creating more of a "split-diamond" concept where only access to I-40 EB and WB would occur from Page and Davis. Keep local trips from accessing I-40 and keep them on the service road.
- Miami Blvd interchange type was discussed. The stakeholders wanted to see a DDI concept for this interchange.
- Alex Rickard suggested that Transmodeler analysis would occur in-house on these concepts and asked STV to upload files into SharePoint for easy access.
- Doumit Ishak suggested Dr. Joe Hummer be afforded the opportunity to review and improve upon this concept.
- Joe Milazzo suggested a phasing study be conducted to see which improvements have the biggest impact on travel time from point to point.
- David Keilson noted that the extension of the I-540 WB to I-40 WB ramp should be extended and incorporated into concept 6. All stakeholders agreed this should occur.

o Concept 7- I-40 EB Pavement Marking and Signage Additions
- All stakeholders agree this improvement should occur
- STV was directed to call Renee Roach for with NCDOT signage to inquire about ongoing plans for this area for signage upgrades.
- The stakeholders looked at the current RDU directional signage on both 40 and 540 to see if there were opportunities to direct users more consistently. We also discussed the possibilities of incorporating DMS for this as well.

o DMS Signage
- Joe Milazzo referenced the "Mall of America" example with their dynamic signage.
- The stakeholders are in favor of such a concept, however all agreed this should be handled with a further study.

- The meeting was adjourned and Alex Rickard scheduled a meeting to debrief for the following week.

APPENDIX C

STAKEHOLDER INTERVIEW MEETING MINUTES

I-40/I-540/NC 540 Interchange Study
Wake & Durham Counties
DCHCMPO
May 16, 2017
11:00 am – 12:00 noon

Attendees

Felix Nwoko	City of Durham, Transportation	felix.nwoko@durham.nc.gov
Anne Lenart-Redmond	STV Planning	anne.redmond@stvinc.com
Justin Carroll (via phone)	STV Traffic	justin.carroll@stvinc.com
Rob Dubnicka (via phone)	STV Traffic	robert.dubnicka@stvinc.com

Meeting Minutes

The purpose of this CAMPO hot spot feasibility analysis is to take a look at the operations of the I-40/I-540/NC 540 interchange to determine whether interim improvements could be made which could be programmed into SPOT for implementation. Go Triangle was identified to participate in the study's Steering Committee (along with DCHC MPO, NCTA, RTA and NCDOT). This interview is the first step in contacting each of the stakeholders to provide insight into the operations of the interchange, as well as gathering existing conditions data.

Items discussed:

- The study area will include I-40 between Page Road and Airport Boulevard interchanges, and I-540/NC 540 between the I-40 and Aviation Parkway Interchange. Study will assess a 2017 baseline, and a 2035 future year and assess 3 concepts. The study team will be using version 6.0 of the regional model.
- There is a weaving issue on page road on I-40 EB. The study team could repurpose laneage.
- Simplify or improve operations through signage.
- Do not preclude the future I-40 Managed Lanes. DCHCMPO favors allowing buses to access toll lanes.
- DCHCMPO does not have crash data or safety related statistics for this study area.
- This feasibility study will hold two stakeholder meetings, on June 8 and 16. Both meetings will be held at CAMPO. The first stakeholder meeting will be to present on existing conditions, traffic and preliminary findings. The second meeting will be to present study recommendations.

I-40/I-540/NC 540 Interchange Study
Wake & Durham Counties
NC Turnpike Authority
May 17, 2017
11:00 am – 12:00 noon

Attendees

Andrew Lelewski	NCTA	andy.lelewski@ncdot.gov
Anne Redmond (via phone)	STV Planning	anne.redmond@stvinc.com
Justin Carroll (via phone)	STV Traffic	justin.carroll@stvinc.com
Rob Dubnicka (via phone)	STV Traffic	robert.dubnicka@stvinc.com

Meeting Minutes

The purpose of this CAMPO hot spot feasibility analysis is to take a look at the operations of the I-40/I-540/NC 540 interchange to determine whether interim improvements could be made which could be programmed into SPOT for implementation. Go Triangle was identified to participate in the study's Steering Committee (along with DCHC MPO, NCTA, RTA and NCDOT). This interview is the first step in contacting each of the stakeholders to provide insight into the operations of the interchange, as well as gathering existing conditions data.

Items discussed:

- Andy recommends that Roger Rochelle participate in the Stakeholder Meetings.
- A Level 1 traffic & revenue study has been conducted for the FS 1005-A Managed Lanes project.
- NC 540 Toll ends at the NC 54 interchange. The segment of NC 540 between I-40 and NC 54 is managed by NCDOT Division 5.
- There is major movement from the north on I-540 and west on I-40. It has been found that people are using the Triangle Expressway to bypass traffic on the interchange.
- Some drivers traveling to RTP will use NC 147 rather than traveling through the I-40/I-540 Interchange.
- Capacity on the interchange itself seems adequate, delays seem to be caused by adjacent segment congestion.
- Signage on I-40 EB to the split ramp to I-540 and NC 540 toll has 6 destinations listed. Could be simplified.
- Maintenance bridge work will be conducted by NCDOT this summer on the flyover from I-40 EB to I-540 NB. The Triangle Expressway (NC-147) will be used as a detour.
- The NC 147 interchange with Davis Drive / Hopson Road has ample capacity. Possibility of signage / outreach to direct people destined to RTP to utilize NC 147 could improve operations.
- This feasibility study will hold two stakeholder meetings, on June 8 and 16. Both meetings will be held at CAMPO. The first stakeholder meeting will be to present on existing conditions, traffic and preliminary findings. The second meeting will be to present study recommendations.

I-40/I-540/NC 540 Interchange Study
Wake & Durham Counties
NCDOT Division 5
May 19, 2017
1:00 pm – 2:00 pm

Attendees

Richard Hancock	NCDOT Division 5	rwhancock@ncdot.gov
David Keilson	NCDOT Division 5	dpkeilson@ncdot.gov
John Sandor	NCDOT Division 5	jesandor@ncdot.gov
Anne Lenart-Redmond	STV Planning	anne.redmond@stvinc.com
Patrick Livingston	STV Roadway	Patrick.Livingston@stvinc.com
Justin Carroll (via phone)	STV Traffic	justin.carroll@stvinc.com
Rob Dubnicka (via phone)	STV Traffic	robert.dubnicka@stvinc.com

Meeting Minutes

The purpose of this CAMPO hot spot feasibility analysis is to take a look at the operations of the I-40/I-540/NC 540 interchange to determine whether interim improvements could be made which could be programmed into SPOT for implementation. Go Triangle was identified to participate in the study's Steering Committee (along with DCHC MPO, NCTA, RTA and NCDOT). This interview is the first step in contacting each of the stakeholders to provide insight into the operations of the interchange, as well as gathering existing conditions data.

Items discussed:

- Frequent reoccurring congestion in auxiliary lanes from airport on I-40 to I-540. Lane drops WB on I-40 near Miami and merging from Page to Miami has caused issues. SB I-540 to WB I-40 has heavy congestion.
- Upgrading I-40 with auxiliary lanes will occur within 5-8 years (I-5707) I-5707 constructs a west bound auxillary lane from NC 147 on ramp to NC 55 exit. It is currently scheduled for construction in 2022 but could be accelerated.
- Interchange spacing between Page Road and Miami Boulevard is an issue. One solution would be to combine these interchanges with a service road, but would be expensive.
- Loops are working well and do not appear to have a lot of traffic volumes on those loops. Has not been on the safety list. There have been numerous gore accidents at I-540/NC 540
- Signage to divert traffic on I-40 to tolled NC 540 south to NC 147 to avoid congestion at peak times through the interchange could have public relations issues/concerns.
- Permissive phasing was considered by NCDOT at Page Road interchange, but found very few options or gaps were available to make turns.
- Signage is cluttered and a recommendation of arrows to better designate pavements markings. Would likely be funded from safety but operational improvements would be difficult to measure.
- There is a weaving issue at the I-40/I-540 flyover which could be addressed by extending an auxiliary lane at I-540 through Aviation Parkway and dropping a lane on the mainline (repurposing it).
- Hold fifth lane from WB I-40 at Page Road to Miami Boulevard
- NCDOT believes model will underestimate the growth.
- The BOSS program has been a success.
- There are ramp metering projects on I-540, and could be considered for I- 40.

- This feasibility study will hold two stakeholder meetings, on June 8 and 16. Both meetings will be held at CAMPO. The first stakeholder meeting will be to present on existing conditions, traffic and preliminary findings. The second meeting will be to present study recommendations.

I-40/I-540/NC 540 Interchange Study
Wake & Durham Counties
Go Triangle
May 15, 2017
11:00 – 12 noon

Attendees

Darcy Downs	Go-Triangle Transportation Planner	ddowns@gotriangle.org
Anne Lenart-Redmond	STV Planning	anne.redmond@stvinc.com
Justin Carroll (via phone)	STV Traffic	justin.carroll@stvinc.com
Rob Dubnicka (via phone)	STV Traffic	robert.dubnicka@stvinc.com

Meeting Minutes

The purpose of this CAMPO hot spot feasibility analysis is to take a look at the operations of the I-40/I-540/NC 540 interchange to determine whether interim improvements could be made which could be programmed into SPOT for implementation. Go Triangle was identified to participate in the study's Steering Committee (along with DCHC MPO, NCTA, RTA and NCDOT). This interview is the first step in contacting each of the stakeholders to provide insight into the operations of the interchange, as well as gathering existing conditions data.

Items discussed:

- Go Triangle currently implements a bus on shoulders program (BOSS), with routes traveling on I-40 between Raleigh and Chapel Hill, the DRX and CRX (~12 busses each way during peak times). The program allows bus operators to run on the shoulders when speeds along I-40 are reduced to 35 mph or less.
- Implementation of the Wake County Transit plan would mean more buses coming into the interchange from North Raleigh. The timeline and implementation of service expansion is currently being determined with Go Cary.
- The autonomous vehicle pilot study should not be a factor in this study.
- The BOSS program operates at the discretion of the bus operator, although the routes travel through the interchange along I-40, it's unlikely that operators use the shoulders through the interchange due to the merging and weaving of existing traffic flow. Creating a C-D through the interchange would eliminate the need for the busses to contend with the cloverleaf weave; instead they could use the mainline shoulder that would be in between the main lanes and the C-D ramp. This could be a distance of up to a half mile, which would have the potential save 2-3 minutes of time for the bus during severe congestion."
- Visibility could be an issue, and any improvements to improve the line of sight from the shoulder would benefit BOSS.
- The BOSS program cannot operate on existing I-540 due to insufficient pavement structure to support busses. It would be cost prohibitive upgrade the existing shoulders. Go Triangle would like to reserve the right to implement BOSS on future improvements of I-540.
- Go Triangle has plans to move the RTC to Park Center, although the timeline is 10 years out. Bus operators currently access the RTC at the Airport Boulevard/I-40 interchange. Go Triangle's bus maintenance facility is located on Nelson Road. Bus operators can travel down NC 54 to enter the back way into the RTC rather than using Emporer to Slater.
- Weaving is an issue in the vicinity of the Page Road interchange due to its close spacing with Airport Blvd.
- The I-40/Airport Boulevard interchange is a key interchange for Go Triangle due to buses utilizing Slater Road to access the RTC. A bus only connection to Slater Road was discussed (which would benefit EB I-40 bus traffic more), but due to the future move of the RTC to Park Central, with all DSC and CRX routes

operating out of RTC – it may not make sense to make a capital improvement like this for its current location.

- Go Triangle operates RTP shuttles which service RTP businesses exclusively. Numbers are small.
- Buses could utilize future managed lanes, but depends upon the entry/exit points. Tractor trailers are currently excluded from using managed lanes.
- This feasibility study will hold two stakeholder meetings, on June 8 and 16. Both meetings will be held at CAMPO. The first stakeholder meeting will be to present on existing conditions, traffic and preliminary findings. The second meeting will be to present study recommendations.

Post Meeting feedback from Go Triangle on BOSS operations:

- Due to RTC's location in the shadow of the interchange, only Routes CRX and DRX actually travel through it along I-40 – all the other routes on I-40 exit either at Page Rd or Airport Blvd. Both a CRX and a DRX cross the interchange every 30-35 minutes in each direction during rush hour (6:00 AM – 9:30 AM, 3:30 PM – 7:00 PM). There is a total of 25 trips in each direction per day.
- Route 201 travels through it along NC 540/I-540. There are only 4 trips per direction per day, spaced roughly a half hour apart – westbound only in the morning, eastbound only in the afternoon.
- If there was access from westbound 1-40 to Slater Rd and vice versa as part of the interchange, it would a substantial save time on Routes 100, 105,and 300.

I-40/I-540/NC 540 Interchange Study
Wake & Durham Counties
Regional Transportation Alliance
May 18, 2017
11:00 am – 12:00 noon

Attendees

Joe Milazzo	RTA, Executive Director	joe@letsgetmoving.org
Anne Redmond (via phone)	STV Planning	anne.redmond@stvinc.com
Justin Carroll (via phone)	STV Traffic	justin.carroll@stvinc.com
Rob Dubnicka (via phone)	STV Traffic	robert.dubnicka@stvinc.com

Meeting Minutes

The purpose of this CAMPO hot spot feasibility analysis is to take a look at the operations of the I-40/I-540/NC 540 system interchange to determine whether interim improvements could be identified within or in the vicinity of the interchange which could be programmed into SPOT for implementation. Go Triangle was identified to participate in the study's Steering Committee (along with DCHC MPO, NCTA, RTA and NCDOT). This interview is the first step in contacting each of the stakeholders to provide insight into the operations of the interchange, as well as gathering existing conditions data. RTA represents the voice of the regional business community on transportation issues.

Items discussed:

- RTA has established the "Fast Mobility Fund" concept to accelerate small mobility projects and has lobbied for its implementation. $24 Million has been allocated in the approved Senate budget, the House has not yet approved its budget.
- Implement simplification of signage. Some of the Signage is too busy on I-40 and presents too much information to process during drive by.
- Removal of "Triangle Expressway" on guide signs and only sign the turnpike as "Toll 540" and "Toll 147."
- NC 147/540 interchange is a "T" interchange; Toll 147 may be renumbered Toll 885 when the "East End Connector" / "Triangle Connector" project is open.
- Weaving is an issue, especially on EB I-40.
- Advance signage on I-40 EB that the Airport Parkway off-ramp is an "exit only" ramp could be beneficial.
- Distance on I-540 North merge from I-40 to Aviation Parkway seems short. Do we need all three through lanes on I-540 to the merge point in that vicinity—could some be repurposed?
- Suggested widening for NC 540. Currently short and tight on I-540 south at the I-40 interchange.
- Additional laneage on I-540 via collector-distributor ramp to EB I-40?
- Could possibly add a 5th lane on I-40 (encroaching on the slope protection) and form a proper CD road—maybe "quad white strip with flex post" (similar to I-495 express lanes in Northern Virginia – hyperlink here) instead of a jersey barrier. Shy distance is less.
- Variable message signing -to give driver time and navigation options (e.g., I-40 EB vs Toll 147 SB to I-540 NB)
- Additional capacity could be reached by Express Shoulder Lanes (on left/median/inside shoulder) on I-540 or I-40 like I-70 west of Denver. Buses could also use those express shoulder lanes; BOSS (bus on shoulder system) operation could be retained for the right/outside shoulder for buses making shorter trips along the freeway.
- Reversible lanes in center of I-540 would be costly, Express Shoulder Lanes (shoulder managed lanes) would be more implementable.

- Evaluate all service interchanges in vicinity of I-40/540 system interchange for feasibility of on-ramp closures during rush hour to redirect traffic and improve freeway operations and safety.
- Examine potential for Page Road signal phasing- protected/permitted on adjacent y-lines to reduce impact on I-40 main line from queue of left turning vehicles entering the freeway all-at-once. Kelly Becker conducted or coordinated prior study for NCDOT.
- Possible options along NC 54 eastbound at 540: currently two fully-protected long left turn lanes, could evaluate for dual left flashing yellow operation to reduce impact on 540 mainline.
- Examine the potential of part-time on-ramp signals?
- This feasibility study will hold two stakeholder meetings, on June 8th and 16th. Both meetings will be held at CAMPO. The first stakeholder meeting will be to present on existing conditions, traffic and preliminary findings. The second meeting will be to present study recommendations.
- STV to provide RTA a feasibility project description and timeline for their newsletter.