

# Safety Analysis of Scenarios for US 74 in Cleveland County

Performed for R-4045 for the US 74 corridor, with a focus on alternatives for the junction with Lattimore/N.Academy/SR 1168.

2/21/22

*This memo was updated from the January 2022 memo in order to add a traditional signalized scenario to the predictive analysis and to add an analysis based on Safe Systems at Intersections methodology.*

## Overview

This safety analysis compares the following scenarios:

- **No Build:** The major intersection (Lattimore/Academy/SR 1168) remains a minor road stop-controlled intersection with flashers. No changes to other access points on US 74.
- **Build 1 – Full movement signalized intersection:** Add a traffic signal to the existing intersection with Lattimore/Academy/SR 1168. Close other access points on US 74 from US 74BUS and Main/SR 1167.
- **Build 2 – Reduced Conflict Intersection:** Convert the major intersection (Lattimore/Academy/SR 1168) to a Reduced Conflict Intersection. Close other access points on US 74 from US 74BUS and Main/SR 1167.
- **Build 3 – Interchange:** Convert the major intersection (Lattimore/Academy/SR 1168) to an interchange. Close other access points on US 74 from US 74BUS and Main/SR 1167.

This analysis was conducted with two approaches: 1) predictive crash analysis and 2) Safe Systems at Intersections analysis.

1. The predictive crash analysis focuses on the effect of each design option on *frontal impact crashes* at the junction points. Segment crashes on the US 74 segment are not considered in this analysis (prior predictive analysis in May 2021 showed crashes on the segment to be roughly equal between design alternatives).
2. The Safe Systems at Intersections (SSI) analysis focuses on the potential for *fatalities and serious injuries* for the intersections in each scenario.



## Scenario Descriptions

### No Build (existing)



#### Description:

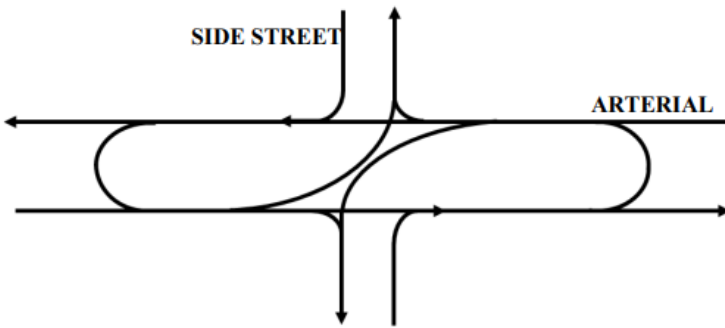
- SR 1168/Lattimore/Academy intersection
  - o Minor road stop controlled intersection with flashing beacons on all approaches
  - o Left turn lanes on both major road approaches; none on minor approaches
  - o No exclusive right turn lanes
- BUS 74 / Ellenboro intersection
  - o Rural multilane stop controlled 3-leg intersection with no left turns allowed from US 74 EB and a severely skewed geometry.
- SR 1167 / Main
  - o Minor road stop controlled intersection (3-leg)
  - o Left turn lanes on both major road approaches; none on minor approaches
  - o One exclusive right turn lane on major approach

### Build 1 – Signalized Intersection

#### Description:

- SR 1168/Lattimore/Academy intersection
  - o Full movement traditional signalized intersection.
- Closure of:
  - o Ellenboro intersection
  - o Cornerstone Baptist Church driveway
  - o Duncan Drive intersection

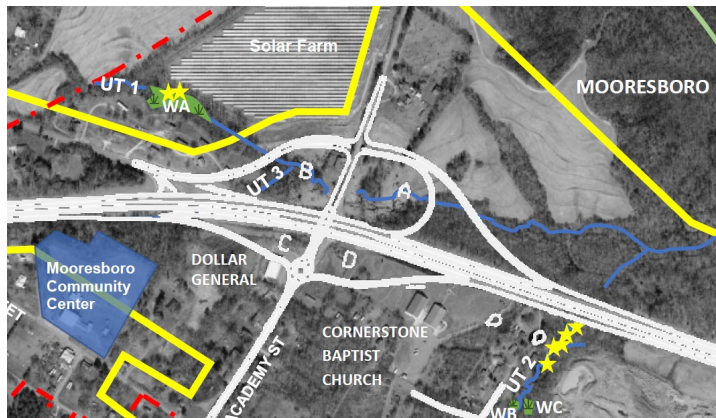
## Build 2 – Reduced Conflict Intersection



### Description:

- SR 1168/Lattimore/Academy intersection
  - o Reduced conflict intersection that allows left-turns from US 74 onto the minor road but prevents left turns or through movements from the minor road. Adds two U-turn locations east and west of the main intersection.
- Closure of:
  - o Ellenboro intersection (realigned into north ramp intersection)
  - o Cornerstone Baptist Church driveway
  - o Duncan Drive intersection

## Build 3 - Interchange



### Description:

- Four-lane rural freeway
- Direct ramps with roundabout at south ramp intersection
- Partial cloverleaf with four-leg roundabout at north ramp intersection
- Closure of:
  - o Ellenboro intersection (realigned into north ramp intersection)
  - o Cornerstone Baptist Church driveway
  - o Duncan Drive intersection

## Traffic Volumes from Traffic Forecast

### 2020 Base Year - No Build

US 74 at Lattimore/Academy

- North & South legs = 800 & 1000; average of 900
- West & East legs = 22100 & 21300; average of 21,500

US 74 at Ellenboro

- North leg = 2,600
- West & East legs = 19700 and 22100; average of 21,000

US 74 at SR 1167/Main

- South leg = 500
- West & East legs = average of 21,000

### 2045 Future Year – No Build, Build 1, Build 2

US 74 at Lattimore/Academy

- North & South legs = 1000 & 1400; average of 1,200
- West & East legs = 32100 & 30900; average of 31,500

US 74 at Ellenboro (*No Build scenario only*)

- North leg = 3,500
- West & East legs = 29000 and 32100; average of 31,000

US 74 at SR 1167/Main (*No Build scenario only*)

- South leg = 600
- West & East legs = average of 31,000

### 2045 Future Year – Build 3 – Interchange

Ramps

- On ramp, US 74 WB = 900
- Off ramp, US 74 WB = 1900
- On ramp, US 74 EB = 1500
- Off ramp, US 74 EB = 400

US 74 at Lattimore/Academy interchange, north ramp intersection

- North & South legs = 1000 & 3100; average of 2,000
- West & East legs = 3500 & 2800; average of 3,200

US 74 at Lattimore/Academy interchange, south ramp intersection

- North & South legs = 2000 & 1400; average of 1,700
- West & East legs = 400 & 1500; average of 900

## Predictive Analysis Results

*Note: This predictive analysis focuses only on frontal impact crashes at the main junction of US 74 with Lattimore/Academy/SR 1168. For predictive results on other portions of the facility, such as segment crashes, see the predictive analysis memo from May 2021. All predictions are for the future year scenario (2045).*

### No Build scenario

*Intersection of US 74 and SR 1168 / Lattimore / Academy* – this was modeled as a rural, multilane, 4-leg, minor road stop controlled intersection. To account for the flashing beacons, the prediction was adjusted with a CMF of 0.88 (source: Hummer and Murphy 2006, CMF for total crashes for overhead beacons at stop controlled intersections).

Prediction was adjusted with the 6-yr average calibration factors from 2010-2015. The calibration factor for a rural multilane 4-leg stop controlled intersection is 1.44.

Predicted crashes for US 74 at SR 1168/Lattimore/Academy: 5.0 total crashes per year

To calculate the number of frontal impact crashes per year, an assumed crash proportion was applied. The table below provides the most recent crash proportion numbers for rural multilane intersections (source: Saleem et al, “Updated and Regional Calibration Factors for Highway Safety Manual Crash Prediction Models”, NCDOT Research Project No. 2020-27, June 2021). The proportion of angle crashes is 0.508.

Crash proportions from 2021 report (rural multilane intersections):

Collision Type	Four-Leg Intersections with Minor-Road Stop Control			
	Total	Fatal and Injury (KABC)	Fatal and Injury (KAB only)	PDO
Head-on	0.008	0.016	--	0.000
Sideswipe	0.050	0.016	--	0.086
Rear-end	0.025	0.000	--	0.052
Angle	0.508	0.710	--	0.293
Single	0.142	0.048	--	0.241
Other	0.267	0.210	--	0.328
<b>Total (should sum to 1)</b>	1.000	1.000	--	1.000

Using these crash proportion, the intersection is predicted to have  $5.00 \times 0.508 = 2.54$  frontal impact crashes per year in the no-build scenario.

## Build 1 – Signalized Intersection

Intersection of US 74 and SR 1168 / Lattimore / Academy –modeled as a rural, multilane, 4-leg, signalized intersection.

Prediction was adjusted with the 6-yr average calibration factors for rural multilane intersections from 2010-2015. The calibration factor for a 4-leg signalized intersection is 0.41.

Predicted crashes for US 74 at SR 1168/Lattimore/Academy: 6.0 total crashes per year

To calculate the number of frontal impact crashes per year, an assumed crash proportion was applied. The table below provides the most recent crash proportion numbers for rural multilane intersections (source: Saleem et al, “Updated and Regional Calibration Factors for Highway Safety Manual Crash Prediction Models”, NCDOT Research Project No. 2020-27, June 2021). The proportion of angle crashes is 0.214.

Crash proportions from 2021 report (rural multilane intersections):

Collision Type	Four-Leg Signalized Intersections			
	Total	Fatal and Injury (KABC)	Fatal and Injury (KAB only)	PDO
Head-on	0.014	0.027	--	0.008
Sideswipe	0.103	0.021	--	0.142
Rear-end	0.395	0.314	--	0.435
Angle	0.214	0.367	--	0.140
Single	0.054	0.043	--	0.060
Other	0.220	0.229	--	0.215
<b>Total (should sum to 1)</b>	<b>1.000</b>	<b>1.000</b>	<b>--</b>	<b>1.000</b>

Using these crash proportion, the intersection is predicted to have  $6.0 \times 0.214 = 1.28$  frontal impact crashes per year in the no-build scenario.

## Build 2 – Reduced Conflict Intersection

The prediction for frontal impact crashes for the RCI scenario is based on applying a CMF to the predicted crashes for the no-build scenario, since no safety performance function is available to model an RCI intersection.

The NCDOT CRF table shows a CMF of 0.37 for frontal impact crashes for converting minor road stop control to RCI (CRF 2.3.1). This means the predicted amount of frontal impact crashes for the RCI option is  $2.54 \times 0.37 = 0.94$  frontal impact crashes per year.



### Build 3 – Interchange

The analysis modeled the two ramp terminal intersections in iSatE, both as signalized intersections. For scenarios involving roundabouts at these terminals, the predictions were adjusted using CMF 2.1.3 from the NCDOT list (it is not currently possible to model roundabout ramp terminals in iSatE).

For ramp terminal intersections, the prediction was adjusted with the 6-yr average calibration factor from 2010-2015 for “Rural 2U 4SG – Total” for a value of 0.77.

Predicted crashes at ramp terminals (as roundabouts):

- North ramp: 1.1 total crashes per year
- South ramp: 0.27 total crashes per year

So, the interchange terminals are predicted to have a combined (sum of both intersections) total of 1.37 crashes per year.

To determine how many of these crashes would be frontal impact crashes, we cannot use crash proportions specifically for ramp terminals (unavailable), but we can use the proportions for rural 2-lane intersections as the closest approximation (see table below) (*source: Saleem et al, “Updated and Regional Calibration Factors for Highway Safety Manual Crash Prediction Models”, NCDOT Research Project No. 2020-27, June 2021*). The proportion of angle crashes is 0.1609.

**Table 10-6: Distribution by Collision Type and Manner of Collision at Rural Two-Lane, Two-Way Intersections**

Collision Type	Percentage of Total Crashes by Collision Type								
	Three-Leg Stop-Controlled Intersections			Four-Leg Stop-Controlled Intersections			Four-Leg Signalized Intersections		
	Fatal and Injury	Property Damage Only	Total	Fatal and Injury	Property Damage Only	Total	Fatal and Injury	Property Damage Only	Total
<b>SINGLE-VEHICLE CRASHES</b>									
Collision with animal	1.60	7.20	5.30	0.00	5.74	3.11	0.19	1.97	1.44
Collision with bicycle	1.20	0.00	0.41	0.39	0.00	0.18	0.00	0.08	0.06
Collision with pedestrian	0.00	0.00	0.00	0.77	0.00	0.35	1.13	0.08	0.39
Overturned	2.40	0.82	1.36	0.97	0.82	0.89	0.38	0.08	0.17
Ran off road	26.80	18.31	21.20	5.42	11.48	8.70	4.52	6.53	5.94
Other single-vehicle crash	0.40	0.41	0.41	0.58	0.00	0.27	0.19	0.00	0.06
<b>Total single-vehicle crashes</b>	<b>32.40</b>	<b>26.75</b>	<b>28.67</b>	<b>8.12</b>	<b>18.03</b>	<b>13.49</b>	<b>6.40</b>	<b>8.73</b>	<b>8.05</b>
<b>MULTIPLE-VEHICLE CRASHES</b>									
Angle collision	2.80	5.56	4.62	61.90	37.54	48.71	25.61	12.12	<b>16.09</b>
Head-on collision	2.80	0.41	1.22	1.35	0.33	0.80	0.94	0.47	0.61
Rear-end collision	26.80	37.45	33.83	12.19	16.23	14.37	32.02	41.54	38.73
Sideswipe collision	4.40	5.14	4.89	0.97	2.79	1.95	2.64	8.10	6.49
Other multiple-vehicle	30.80	24.69	26.77	15.47	25.08	20.67	32.39	29.03	30.02
<b>Total multiple-vehicle crashes</b>	<b>67.60</b>	<b>73.25</b>	<b>71.33</b>	<b>91.88</b>	<b>81.97</b>	<b>86.51</b>	<b>93.60</b>	<b>91.27</b>	<b>91.95</b>
<b>Total Crashes (should sum to 100)</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

This analysis uses the signalized intersection proportions, under the assumption that the crash proportions of a roundabout would be more similar to signals than stop control. If anything, this is conservative, since a roundabout would produce fewer angle crashes than a signalized intersection, due to the lower speeds and lack of conflict points. Using the proportion from the table, the combined amount of frontal impact crashes at the two ramp terminals would be  $1.37 * 0.1609 = 0.22$  **frontal impact crashes per year**.

## Summary of Crash Predictive Analysis

The comparison of predicted totals from the no-build and build scenarios is shown below.

Scenario	Predicted Frontal Impact Crashes per Year
Future Year 2045 – No Build	2.54
Future Year 2045 – Build 1 – Signalized	1.28
Future Year 2045 – Build 2 – RCI	0.94
Future Year 2045 – Build 3 – Interchange	0.22

The interchange scenario is predicted to have the fewest frontal impact crashes. Additionally, an interchange is the only option that does not present the potential for high speed frontal impact crashes.

## Safe Systems at Intersections (SSI) Analysis

The Safe Systems approach has been championed by FHWA in recent years as an approach that focuses on preventing fatalities and serious injuries to all road users. The concepts of minimizing or preventing crashes between users having large differences in direction, speed, and mass are central to a Safe System approach.

The SSI method incorporates concepts of **conflict point** identification and classification, **exposure**, kinetic **energy transfer**, conflict point **severity**, and intersection **movement complexity**. Application of the SSI method results in scores that characterize the extent to which an intersection alternative in a given context aligns with the principles of kinetic energy management and a Safe System.

More information on the SSI approach is available at <https://safety.fhwa.dot.gov/intersection/ssi/>

## Data Inputs

### No Build, Build 1 (Signal), Build 2 (RCI)

- Major AADT: 31,500
- Minor AADT: 1,200
- Major number of thru lanes (one direction): 2
- Minor number of thru lanes (one direction): 1
- Major posted speed limit: 55 mph
- Minor posted speed limit: 45 mph (*NOTE: The speed limit on Lattimore/Academy is 55 mph north of the interchange and 35 mph south of the interchange. The SSI calculator is configured to accept a single posted speed limit per road, so the average (45 mph) was used for the minor road for the at-grade build scenarios.*)



*NOTE: Build 2 (RCI) was assumed to be a signalized RCI for the purposes of the SSI analysis.*

Build 3 (Interchange), north ramp intersection:

- Major AADT: 2,000
- Minor AADT: 3,200 (*Note: Minor AADT is larger than major due to the fact that the ramps have more volume than the Lattimore cross road, but it is more reasonable to deem the full road as the major road of the intersection rather than ramps.*)
- Major number of thru lanes (one direction): 1
- Minor number of thru lanes (one direction): 1
- Major posted speed limit: 55 mph (*NOTE: This is a conservative estimate; it is likely the 35 mph zone south of the interchange that currently ends at US 74 would be extended through the interchange after build out.*)
- Minor posted speed limit: 35 mph

Build 3 (Interchange), south ramp intersection:

- Major AADT: 1,700
- Minor AADT: 900
- Major number of thru lanes (one direction): 1
- Minor number of thru lanes (one direction): 1
- Major posted speed limit: 35 mph
- Minor posted speed limit: 35 mph

### Summary of SSI Analysis Results

Using the inputs above and a spreadsheet tool, SSI scores were calculated for the no-build and build scenarios. Results are shown below. The higher the score, the safer the intersection design, with respect to its potential to prevent fatalities and serious injuries. A score of 1.00 is the highest score possible.

<b>Scenario</b>	<b>SSI Score</b>
Future Year 2045 – No Build	0.63
Future Year 2045 – Build 1 – Signalized	0.69
Future Year 2045 – Build 2 – RCI	0.79
Future Year 2045 – Build 3 – Interchange	1.00

The interchange scenario is shown to have the highest (safest) SSI score.