NATIONAL TRANSPORTATION SAFETY BOARD

Office of Highway Safety
490 L'Enfant Plaza SW, Washington, D.C. 20594

Group Chairman's Factual Report

HIGHWAY FACTORS

HWY22FH008

A. Fatal Intersection Crash

Location:	Intersection of Oklahoma State Highway 22 (SH 22) and U.S. Highway 377 (US 377) / State Highway 99 (SH 99) Tishomingo, Johnston County, Oklahoma
Date:	March 22, 2022
Time:	12:19 pm CDT
Vehicle 1:	2015 Chevrolet Spark
Vehicle 2:	1994 Peterbilt Truck Tractor in combination with a 2017 Travis semitrailer

B. HIGHWAY FACTORS GROUP

Group Chairman	David Rayburn National Transportation Safety Board Montgomery, Texas
Group Member	Ron Brown, P.E. Division Engineer Oklahoma Department of Transportation Division 3 12844 State Highway3W Ada, Oklahoma 74820
Group Member	Trooper Josh Christian Oklahoma Highway Patrol Durant, Oklahoma

C. SUMMARY

For a summary of the crash, refer to the Crash Summary Report, which can be found in the NTSB public docket for this investigation.

D. DETAILS OF THE HIGHWAY FACTORS INVESTIGATION

The Highway factors group obtained information related to the design, maintenance, and operation of the highway to determine if any of these factors contributed to or caused the crash. Information was obtained from the Oklahoma Department of Transportation (ODOT) that provides a general description of the highway location. Highway information obtained documented the geometric design of the intersecting roadways, traffic metrics (including vehicle speeds and volumes), and the crash history at the intersection. A departure sight distance was measured for traffic turning left from the minor road SH 22 onto the major road US 377. Also, angular viewing measurements were taken inside a 2017 Chevrolet Spark exemplar vehicle.

Additionally, dry pavement skid tests were performed, and ODOT provided preliminary design concepts they are considering to re-align the intersection.

1.0 GENERAL INFORMATION

The crash was located on SH 22 at its intersection with US 377, which also has the designation of SH 99. Highway design plans indicate the crash occurred near station number 59 on US 377.[1] See figures 1-3 for an overhead Google image and NTSB drone photos along with scene photo.

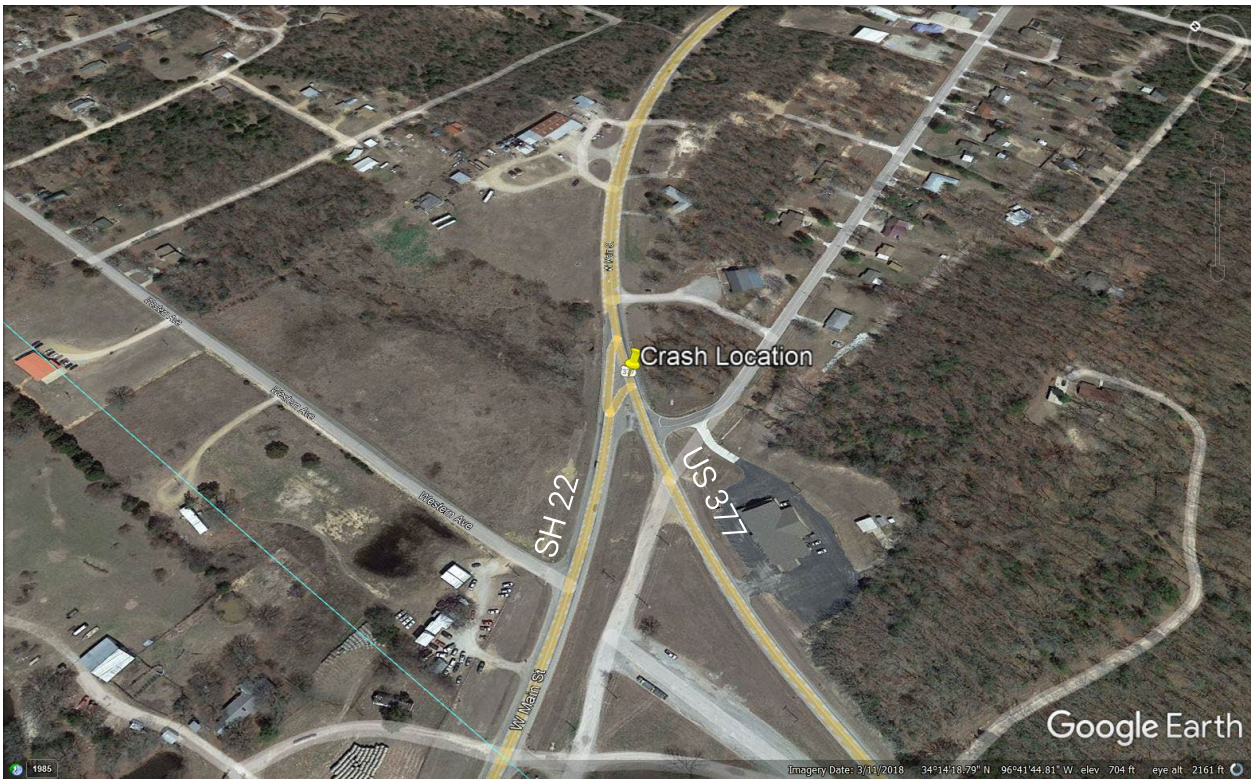

Figure 1. View looking east on SH 22 where the Chevrolet was traveling where it intersects US 377 where the Peterbilt combination was traveling south (source: Google Earth, annotated by NTSB).

[1] Highway Attachment – ODOT Intersection Construction Plans. On page 7 of the attachment, SAP375(2) Sheet 14 indicated the station No. was 59+00. Station numbers give dimensional information on official highway plans.

Figure 2. View of an exemplar passenger car on eastbound SH 22 pulling into intersection to turn left onto northbound US 377. The crash vehicle made a similar maneuver when the crash occurred.

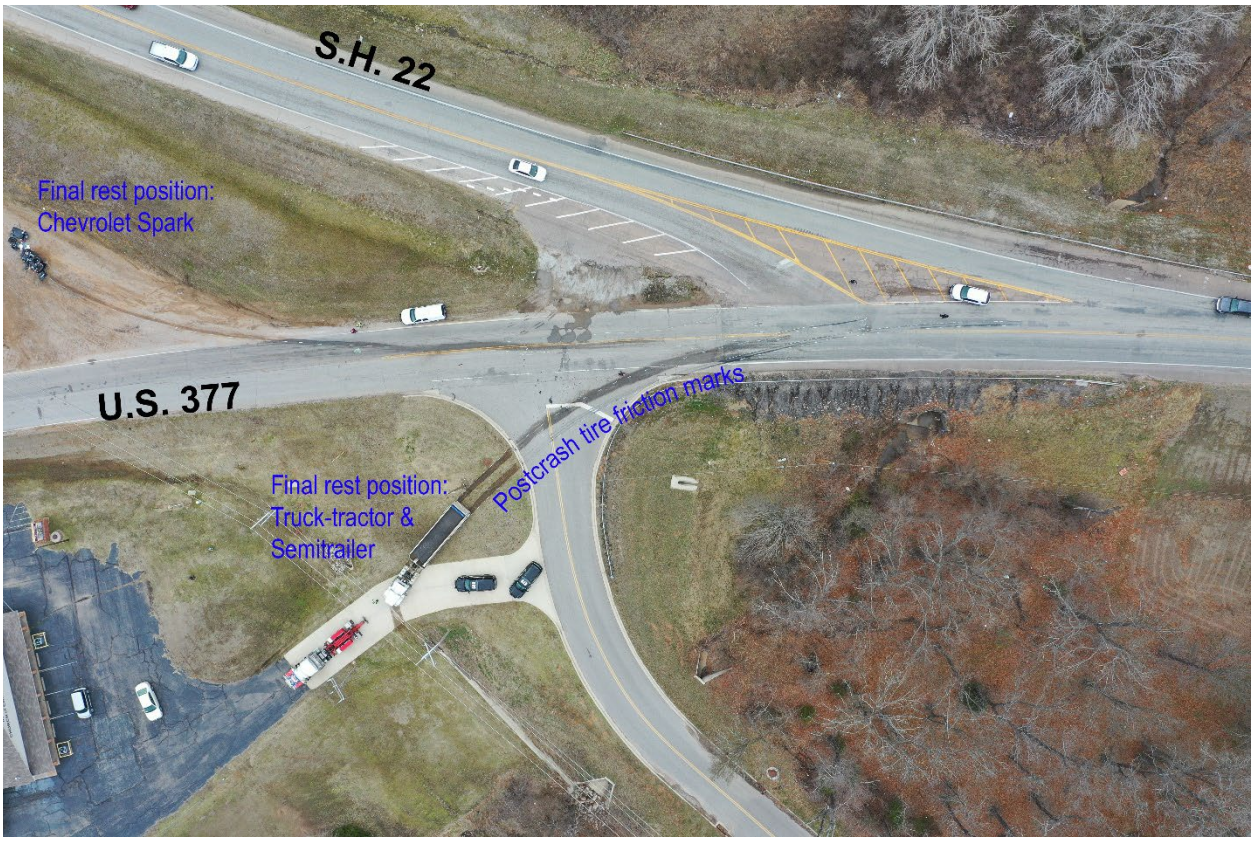

Figure 3. Aerial view of the intersection where the crash occurred. The roadway along the top of the photo is SH 22 and US 377 is shown below, going from left to right in center of the photo. The photo also shows the tire friction marks from where the collision occurred in the intersection and the final rest positions of both vehicles. (source: Oklahoma Highway Patrol, annotated by NTSB).

1.1 History of the Intersection

The "Y" intersection of SH 22 and US 377 as it exists today is the product of three major projects: South from the "Y" intersection on US 377 was realigned in 1943 and 1944.[2] North from the "Y" intersection on SH 22 was, along with the Pennington Creek bridge, realigned and reconstructed in 1953.[3] The realignment of SH 22 including the partial "Y" at US 377 (SH 99) was completed in 1965.[4] The roadways on the approach to the intersection were last separately resurfaced as follows: An armor coat (chipseal with oil) was applied on SH 22 in 2011, by District 3 maintenance and a two-inch asphalt overlay was applied on US 377 in 2012 by contract. The NO RIGHT TURN signs on SH 22 were added in 2020.

[2] Highway Attachment – ODOT Intersection Construction Plans, pages 3-5. Construction Contract SAP-825(4).
[3] Highway Attachment – ODOT Intersection Construction Plans, pages 7-10. Construction Contract SAP-375(2).
[4] Highway Attachment – ODOT Intersection Construction Plans, pages 12-13. Construction Contract FAP-89(13).

2.0 TRAFFIC METRICS

2.1 Traffic Volumes

Traffic volumes for the year 2020 indicated the Annual Average Daily Traffic (AADT) for SH 22 was 7200 vehicles per day and 3800 vehicles per day on US 377. The total truck traffic comprised of 23 percent of the volumes indicated on US 377.[5]

2.2 Speed Studies

Speed studies performed in 2019 indicated the median speed on SH 22 was 64 mph in the posted 65 mph zone, approximately 1.5 miles west from where it intersected US 377.[6] The speed limit lowered to 55 mph and then to 50 mph on the approach to the intersection. The median speed on US 377 was 47 mph on the approach to the intersection in the 50-mph speed zone.[7]

3.0 Crash History

National Highway Traffic Safety Administration (NHTSA) Fatality Analysis Reporting System (FARS) data indicate that in 2020, 29 percent of all U.S. traffic fatalities occurred at an intersection or intersection related junction. Of the 15,686 fatalities that occurred in these crashes during that period, 56% (8,819 fatalities) occurred at unsignalized intersections, such as the intersection where this crash occurred.

The Crash Records from the ODOT Collision Analysis and Safety Branch showed that 15 other crashes occurred at the large "Y" shaped SH 22/ US 377 exchange, encompassing the roadways east of Wrecker Road, between 09-01-2011 and 08-31-2021 (10-year span). Nine of the crashes involved property damage and six crashes resulted in injury. According to ODOT, its data are based on crash reports obtained from local law enforcement. Staff requested crash reports from the Tishomingo Police Department to validate the data provided by ODOT. These are summarized in Table 1 and show only a slight discrepancy in the number of injuries recorded.[8] Based on the crash reports, 9 of the 15 crashes occurred at the same intersection as the March 22, 2022, crash. Four were rear-end crashes and five involved a failure to yield for vehicles traveling east on SH 22.

These reports included a fatal crash that occurred on November 2021, which was outside the 10-year span of records provided by ODOT. According to the crash report, a vehicle traveling east on SH 22 failed to negotiate the right-hand curve that led to the stop sign at the intersection of SH 22 and US 377. Instead, the vehicle continued straight into a gore area and into the path of a southbound vehicle on US 377. The southbound driver was killed in the crash while the injuries to the eastbound driver were not list in the crash report.

[5] Highway Attachment – ODOT Traffic Volume Counts.
[6] Median speed is defined as the speed at which the speed distribution is separated into two equal parts. The number of the speed values observed higher than median value is equal to the number of observed speed values lower than median value.
[7] Highway Attachment – ODOT Speed Studies.
[8] Highway Attachment – ODOT Crash Records.

Table 1. Summary of crash reports provided by the Tishomingo Police Department. Those highlighted in yellow occurred in the same intersection as the March 22, 2022, crash.

Date	Fatalities	Injuries	Vehicle involved	At crash intersection?
10/14/2011	0	0	2	NW part of Y (turning crash)
11/4/2011	0	0	2	At intersection (rear end)
12/15/2011	0	1	2	Not at Y. on 377 east of Y (rear end)
3/6/2012	0	0	2	At intersection (rear end)
12/3/2012	0	2	2	At intersection (failure to yield to US377 traffic)
1/8/2013	0	0	2	At intersection (failure to yield to US377 traffic)
9/4/2013	0	1	2	NW part of Y (turning crash. Driver did it deliberately to "kill himself")
9/12/2013	0	1	2	At intersection (failure to yield to US377 traffic)
5/25/2017	0	0	2	Intersection of ray branum rd and US377
10/5/2018	0	2	2	At intersection (failure to yield to US377 traffic)
1/2/2019	0	0	2	At intersection (rear end)
4/26/2019	0	0	2	North part of Y (turning crash)
6/6/2019	0	1	1	North part of Y (hydroplaning crash)
1/3/2020	0	0	2	At intersection (rear end)
4/23/2020	0	0	2	At intersection (failure to yield to US377 traffic)
11/1/2021	1	0	2	At intersection (went through gore just north of intersection)
Totals	1	8	31	

Based on the data it had on the intersection, the ODOT Collision Analysis and Safety Branch provided the NTSB with the hazard ranking of this intersection in comparison to the top 200 (or 25 depending on the given year) rural intersections in ODOT Division 3.[9] In 2014, its ranking was 131, in 2015 it was 59, and in 2016 it was 74. In other words, out of all the rural intersections in Division 3, the Tishomingo intersection's worst hazard ranking was 59 in the year 2015. For all the other years, it did not make the top 200 most hazardous intersections (Table 2). According to ODOT, the "Ranking Method" column in Table 2 is based on the performance measures laid out in the Highway Safety Manual (2010 AASHTO) and reflects the opinions of different ODOT highway safety engineers regarding the best performance measure to use for each year's ranking. According to ODOT, the hazard ranking is used as a consideration for which intersections to target for possible action on improvements. Actions could vary from further study, new signage, striping, signalization, clearance of view obstructions, and geometric changes depending upon the location and conditions. There is no specific threshold for action, but those intersections at the top of the list would be given first consideration for improvements. The rankings are not the only method by which intersections may be targeted for improvement, as each division may also request action based on recent crashes or local appeal.

[9] According to ODOT, data for each year are based on historical data from the past 5 years.

Table 2. The ranking of the Tishomingo Y intersection compared to other rural intersections in ODOT Division 3. In nine of those years, the intersection was not in the top 200 and in three of those years (2014-2016) it ranked from 59-131.
Source: Oklahoma DOT

Tishomingo Intersection Rankings ODOT Collision Digests				
Report Year	**Ranking method**	**Category**	**SH 22 & SH 99 Ranking**	
2021	Expected Collisions	Top 25 Division 3*	Not Present	*Top 200 reviewed and Y intersection is not present
2020	Expected Collisions	Top 25 Division 3*	Not Present	*Top 200 reviewed and Y intersection is not present
2019	Excess Crashes	Top 25 Division 3*	Not Present	*Top 200 reviewed and Y intersection is not present
2018	Expected Collisions	Top 200 Division 3	Not Present	
2017	Cumulative Percentile	Top 200 Division 3	Not Present	
2016	Cumulative Percentile	Top 200 Division 3	#74	
2015	Adjusted Mainline Injury Rate	Top 200 Division 3	#59	
2014	Adjusted Mainline Injury Rate	Top 200 Division 3	#131	
2013	Adjusted Mainline Severity Rate	Top 200 Division 3	Not Present	
2012	Mainline Severity Rate	Top 200 Division 3	Not Present	
2011	Severity Index	Top 200 Division 3	Not Present	
2010	Severity Index	Top 25 Statewide Rural Highways	Not Present	

4.0 Geometric Alignment

SH 22 intersects US 377 at an approximate 65-degree angle. An approximate 120-foot-long curve that has a radius of approximately 239 feet precedes the intersection. The approach on US 377 is on a 2.4-degree or 2,148.59-foot radius, left-hand curve that begins at Station No:55 + 64.22. The crash occurred at Station No: 59. US 377 slopes downward approximately 1 percent at this location. US 377 has two 12-footwide lanes; one in each direction with 5-foot-wide paved shoulders. The southbound and northbound lanes are delineated by a double yellow pavement stripe. SH 22 also has two 12-footwide lanes; one eastbound and one westbound, which are also delineated by a double yellow pavement stripe. SH 22 has 8-foot-wide paved shoulders. On the eastbound SH 22 approach to the intersection at US 377 a 48-inch-wide STOP AHEAD sign is posted approximately 750 feet from the intersection, and a 48-inch-wide STOP sign is posted at the intersection. The STOP sign is posted approximately 41 feet from the roadway edge and the center is mounted approximately 7 feet above the pavement. The stop line had a faded appearance. It was set back from the US 377 pavement edge approximately 14 feet on the right and 36 feet on the left.[10] The variation is due to the intersection angle and curved approach of US 377. On the immediate approach to the intersection a channelizing pavement

[10] Oklahoma Statute 47 §11-403 states: *"every driver of a vehicle approaching a stop intersection indicated by a stop sign shall stop as required by 47 §11-703 and after having stopped shall yield the right-of-way to any vehicle which has entered the intersection from another highway or which is approaching so closely on said highway as to constitute an immediate hazard.*

marking is arranged with diagonal hash marks in the gore to separate the eastbound and westbound lanes of SH 22. See figures 4 and 5.

Figure 4. View of STOP AHEAD advance warning sign.

Figure 5. View of STOP sign on eastbound SH 22 at US 377.

5.0 Departure Sight Distance at Intersection

A sight triangle was measured at the intersection with a test vehicle placed 10 feet before the stop sign with the driver viewing angle approximately 18 feet rearward of the stop sign on SH 22. [11] A 7.5 second gap-acceptance time was used to measure the viewing distance at the 50-mph speed limit on US 377, which was 550 feet or rounded up to a 555-foot design distance.[12] At this distance there were no sight obstructions that limited the driver's view from the 555-foot mark on US 377 back to the test vehicle driver's eye position. See figure 6 for a view of a stopped Peterbilt combination unit viewed from the test vehicle.

[11] A distance for viewing 18 feet back from the stop sign was chosen because, according to witness statements, another vehicle was slowing or stopped in front of the Chevrolet Spark.
[12] See Table 9-7 page 9-46, Design Intersection Sight Distance, "A Policy on Geometric Design of Highways and Streets. American Association of State and Highway Transportation Officials, AASHTO

Figure 6. View of Peterbilt combination unit 555 feet from the intersection.

6.0 Scene Information and Skid Testing

There were pre-impact tire friction marks followed by pavement gouges where the impact occurred. Locked wheel skid testing was conducted, and the test vehicle skidded 111.4 feet at a speed of 48.3 mph, resulting in a drag factor was 0.719 longitudinal Gs as measured by a VC3000 accelerometer supplied by the Oklahoma Highway Patrol.

7.0 ODOT Design Concepts for Intersection Re-alignment

After the fatal crash that occurred November 2021, ODOT began developing design concepts for realigning the intersection of SH 22 and US 377. One concept shared with the NTSB was a re-alignment of the intersection using a modern roundabout design (figure 7). ODOT has not made any decisions on realignment at this time but, according to the Division 3 engineer, ODOT has reserved 2 million dollars for a future project. Other conceptual designs are shown in figures 8-11.

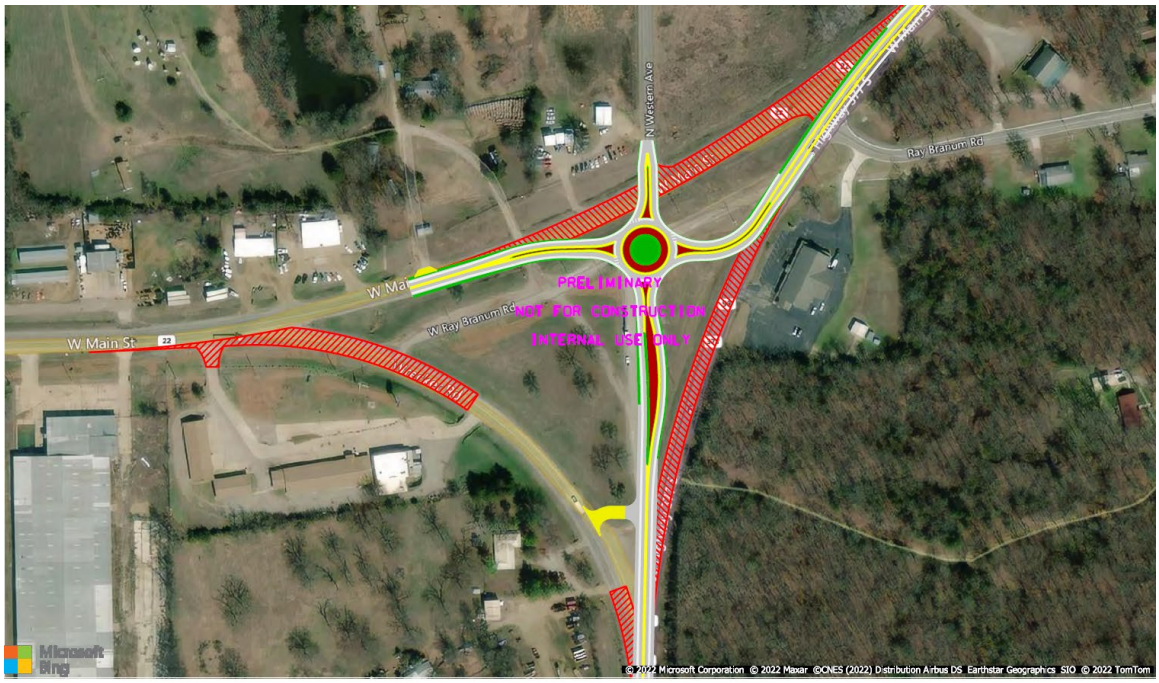

Figure 7. View of roundabout concept drawing being considered to re-align the intersection of SH 22 and US 377.

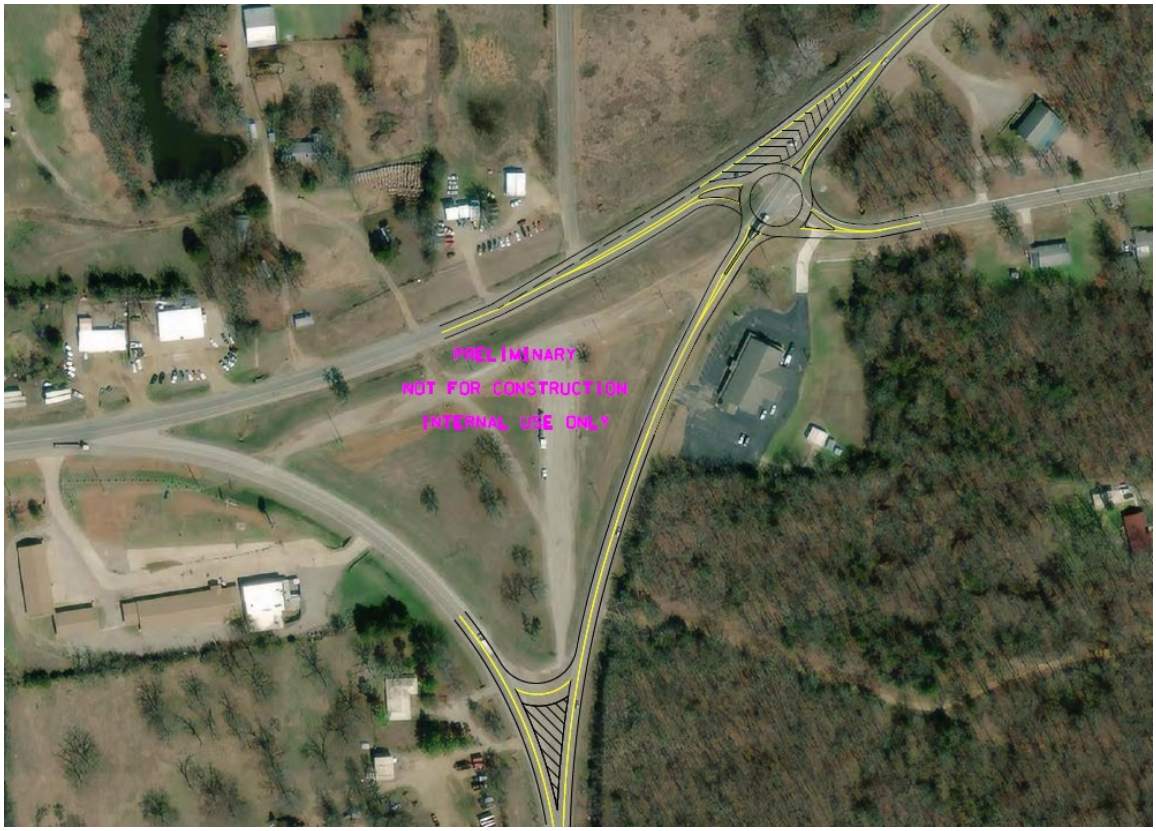

Figure 8. View of additional roundabout design being considered.

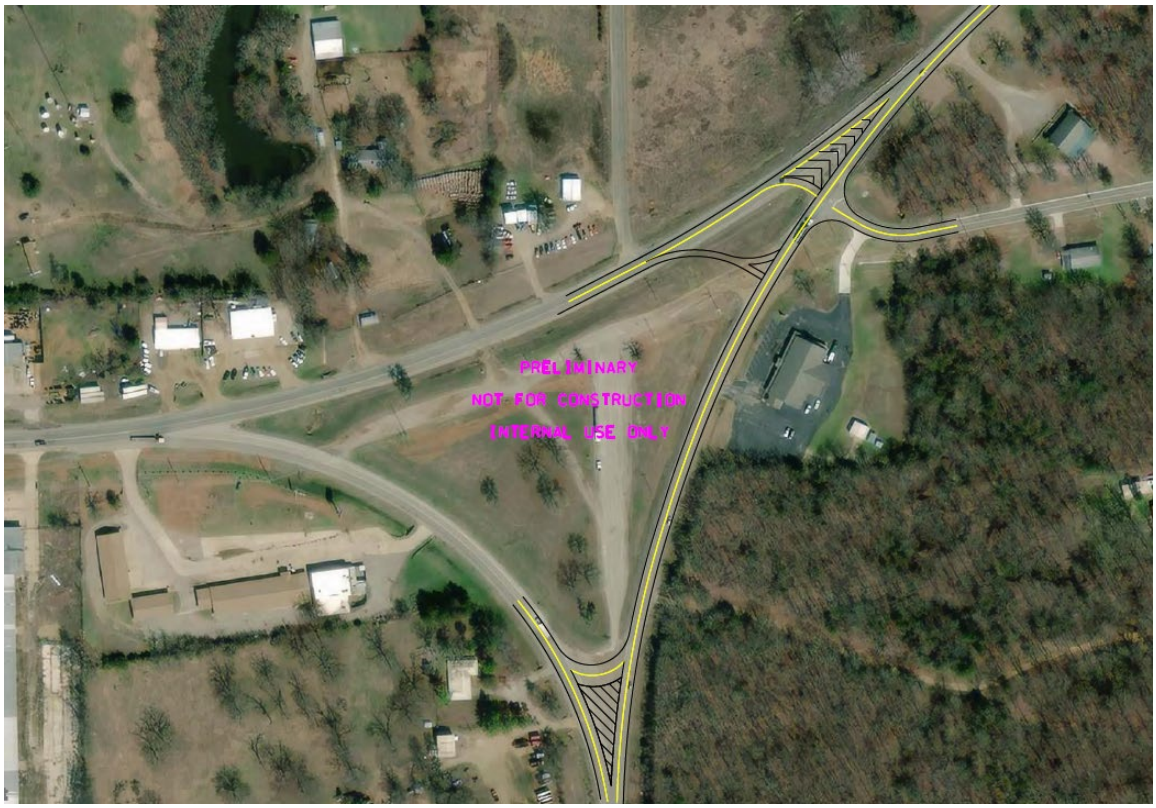

Figure 9. Concept drawing with intersection aligned closer to 90 degrees.

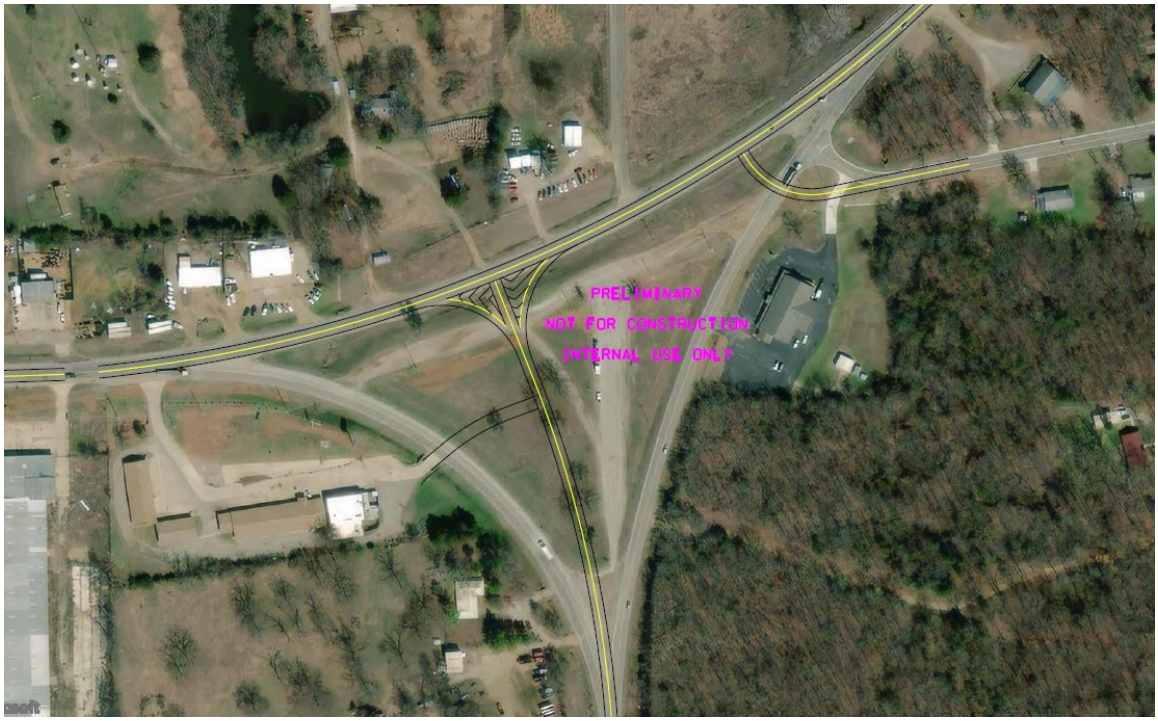

Figure 10. Concept drawing with US 377 routed through the triangle area to intersect SH 22 near 90 degrees.

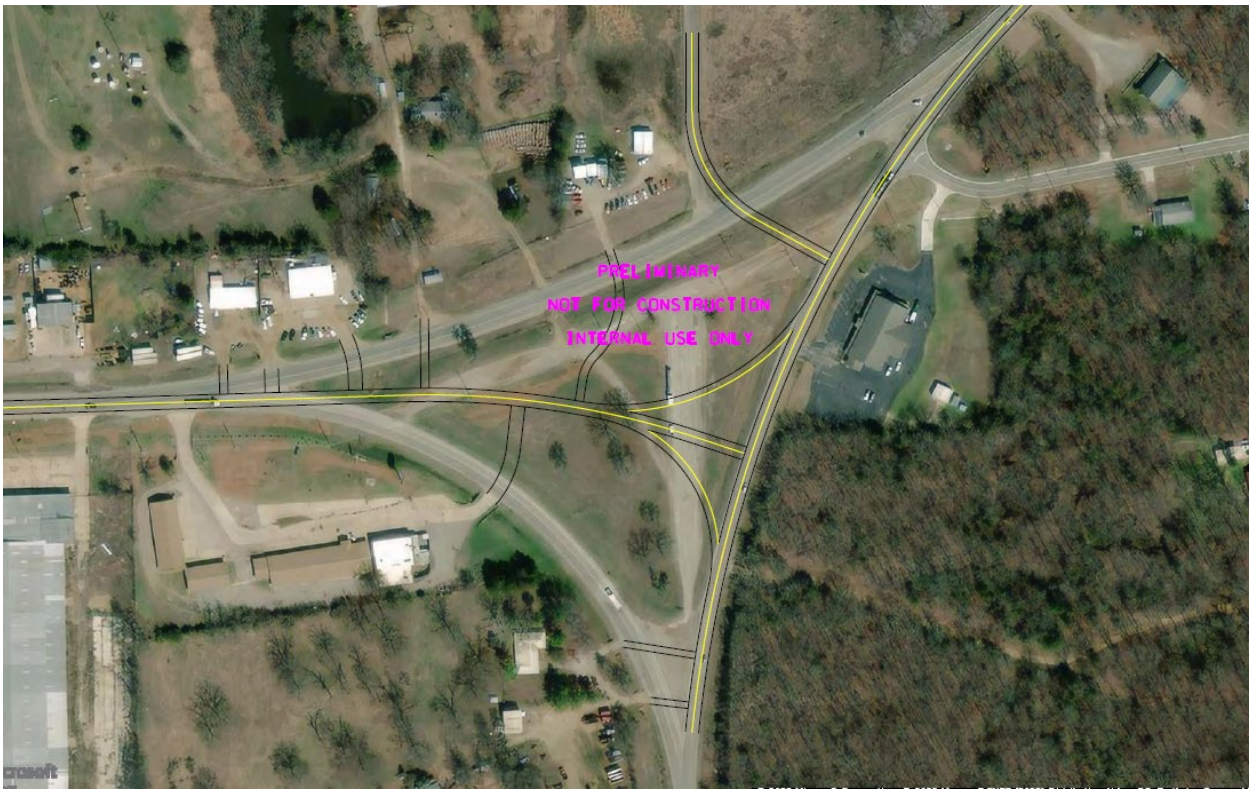

Figure 11. View of concept drawing with eastbound SH 22 re-aligned through the dirt triangle area to intersect US 377 near a 90-degree angle.

8.0 Interim ODOT Intersection Improvements

ODOT schedules construction for design improvements on an 8-year cycle. ODOT indicated they were going to place this improvement project to re-align the intersection into this schedule and try to accomplish the improvement as soon as funding was available. The project initiation report for the re-alignment of the intersection was submitted on October 18, 2022.[13] By mid-May ODOT had incorporated several interim changes at the intersection to improve the traffic control. The following maintenance changes were made:

1. The pavement striping on all approaches to the intersection was refreshed.
2. The stop bar on eastbound SH22 at US 377 was re-striped.
3. Flags were added to the STOP AHEAD sign and STOP sign.
4. Flashing beacons were added to the STOP SIGN.
5. Two sets of transverse rumble strips were added to eastbound SH 22 on the approach to the STOP SIGN.
6. New NO LEFT TURN signs were added for northbound US 377.

[13] Highway Attachment – ODOT Project Initiation Report.

7. New NO RIGHT TURN signs were added to eastbound SH 22.

See figures 12-17 for views of the improvements.

Figure 12. View of transverse rumble strips preceding the STOP AHEAD advance warning sign on eastbound SH 22. (source: ODOT)

Figure 13. View of the STOP AHEAD advance warning sign equipped with flags on eastbound SH 22. (source: ODOT)

Figure 14. Close-up view of transverse rumble strips on eastbound SH 22 on the approach to the STOP sign. (source: ODOT)

Figure 15. View of new NO RIGHT TURN sign with STOP sign in the background on eastbound SH 22. (source: Oklahoma DOT)

Figure 16. View of STOP sign equipped with flags and flashing beacon at the intersection of SH 22 and US 377. (source: Oklahoma DOT)

Figure 17. View of re-striped STOP bar on eastbound SH 22. (source: Oklahoma DOT)

E. LIST OF ATTACHMENTS

1. Highway Attachment ODOT Intersection Construction Plans
2. Highway Attachment ODOT Traffic Volume Counts
3. Highway Attachment ODOT Speed Studies
4. Highway Attachment ODOT Crash Records
5. Highway Attachment ODOT Project Initiation Report
6. Highway Photographs (19)

Submitted by:

David S. Rayburn
Highway Group Chairman