Motor Vehicle Crashes on US Highway 666 in Shiprock, New Mexico.

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On the Navajo Reservation, injuries are the leading cause of death and the second leading cause of hospitalization. Motor-vehicle-related injuries surpass all other causes of death. A 1986 study of motor-vehicle crashes in the Shiprock District revealed that 23% of all injury crashes occurred on US Highway 666, between milepost (MP) 92.7 and 93.6. The traffic volume was not considered greater than for other sections of highway in Shiprock, New Mexico (NM). US Highway 666 in Shiprock is a 4-lane, arterial highway divided by a curb- type, concrete median. The 0.9-mile section of highway between MP 92.7 and 93.6 connects two major intersections: US 666/NM 504 and US 666/US 550. Both are T-type intersections controlled by pre-timed traffic signals. This section of highway is a business/commercial corridor with some small residential areas nearby. There is also a state-operated port-of-entry (POE) weighing station for commercial truck traffic. This section of highway is interspersed with several median left-turn lanes and median crossovers for side-street intersections. The speed limit is 40 miles per hour. No physical modifications to this section of highway were made before 1986. This highway is under the maintenance jurisdiction of the NM Highway and Transportation Department.

The objectives of my study were two-fold: 1) to characterize the crashes on this section to better define their etiologies and identify risk factors (driver, vehicle, and environmental/roadway); and 2) to examine 4 geometric highway features to determine if they met design standards and/or contributed to the cause of the crashes.

Methods

Through the Records and Data Control Section, Navajo Nation Division of Public Safety, Toyei, Arizona, I reviewed police reports for motor vehicle crashes which occurred on US Highway 666, MP 92.7 to 93.6, from January 1, 1987, to December 31, 1988. I abstracted data relating to the drivers, vehicles, environment, and roadways. Most items on the police reports were mutually exclusive and had only one item checked. For example, the item “driver sobriety” had the following categories: DUI, had been drinking/ability impaired, had not been drinking, and sobriety unknown. However, multiple entries were possible under “apparent contributing factors”. Driver residence was coded as local or non-local. Local was defined as residing within a 30-mile radius of Shiprock.

I selected 4 geometric highway-design features, based on the availability of standards for comparison, and on direct observation of actual crashes, "near-miss crashes", patterns of unusual or unsafe traffic maneuvers, and patterns of traffic conflicts. I hypothesized that the existing design features may have contributed to the occurrence of some motor vehicle crashes. The four features were 1) median width; 2) the location and control of side street cross traffic, in particular the exit from the POE commercial truck weigh station; 3) left-turn lane availability and positioning; and 4) median crossover positioning in relation to business access locations. Measurements of distance were made using a standard tape measure. Estimates of traffic volume were made using vehicle counts. The standards were derived from two sources: The American Association of State Highway and Transportation Officials’ (AASHTO), “A Policy on Geometric Design of Highways and Streets,” and the Federal Highway Administration’s (FHA), “Manual on Uniform Traffic Control Devices”. I also measured the length of time it took tractor-trailers to clear the northbound lane when making a left turn from the POE exit, the length of time for any vehicle to clear the northbound lane while making a long left turn into the convenience store at MP 92.8, and the duration of the left-turn, yellow arrow phase of the traffic light at the intersection at MP 93.6.

Results and Discussion:

A. Epidemiologic Characterization: A total of 87 motor vehicle crash reports were reviewed for the 2-year period. Of this total, 25% (22) involved at least one injury. The total number of injuries was 44. There was one fatality. However, any deaths occurring after the day of the crash would not have been reflected in the police report. All crashes but one involved motor vehicles only. The exception was a motor vehicle-pedestrian collision (the one fatality). 90% (78) of the crashes involved two or more vehicles; only 10% (9) were single-vehicle. Seventeen percent (15) of the crashes involved at least one driver under the influence of alcohol.

Injury Crashes: 11 of the 22 injury crashes involved multiple injuries. One crash had 5 victims. MP 93.6 accounted for 45% (10) of the injury crashes. 41% (9) were rear-end collisions. Alcohol was involved in 32% (7) of the crashes. 50% (11) of the injury crashes occurred between the hours of noon and 6 pm and 23% (5) occurred on Wednesdays. 57% (24) of drivers in injury crashes were male and 32% (7) were in the 21-25 year old age group. Driver inattention was most frequently cited as an apparent contributing factor in injury crashes.

Crash Location: Crashes were more frequent at MP 93.6 than at any other location. MP 93.6 is the site of the US 666/U.S. 550 signalized intersection. 34% (30) of all crashes, and 45% (10) of all injury crashes, occurred at this location. 14 were rear-end collisions and 12 involved vehicles making a left turn to the north in front of an oncoming vehicle. Injury crashes were next most frequent at MP 93.5, 92.7 and 93.4, each with 14% (3). Of the 10 injury crashes at MP 93.6, 4 were rear-end collisions and 4 involved left turns to the north in front of an oncoming vehicle. The 10 injury crashes at MP 93.6 accounted for 17 total injuries, which is 39% of the total number of 44 injuries. 40% (12) of the 30 total crashes at MP 93.6 involved vehicles at this intersection making a left turn to the north in front of an oncoming vehicle. MP 93.5 accounted for 21% (18) of all 87 crashes, but only 14% (3) of the injury crashes. MP 93.5 is the site of the exit from the commercial truck POE weigh station, of a median crossover, and of a business access. Five of the 18 crashes at this location involved collisions with vehicles making a left turn from the POE exit. 2 of the 5 collisions involving left turns from the POE exit were tractor-trailers. 3 of the 8 rear-end collisions at this location involved backed-up traffic from the intersection at MP 93.6.

Type of Collision: 40% (35) of all crashes, and 41% (9) of the injury crashes, involved rear-end collisions. 14 of the total rear-end collisions occurred at MP 93.6 and 9 MP 93.5.

Alcohol Involvement: Use of alcohol was a factor in 17% (15) of all crashes and in 32% (7) of the injury crashes. 4 crashes each were at MP 92.7 and 93.6 (the 2 signalized intersections). 40% (6) of the alcohol-impaired drivers were in the 26-30 year old age group and 93% (14) were male.

Time Factors: The 6-hours from noon to 6 pm accounted for 52% (45) of all crashes and 50% (11) of the injury crashes. There was not a wide variation in number of crashes by day of week. The higher incidence of crashes on Wednesday may be explained by Tribal employees' payday falling on every other Wednesday, with a possible increase in traffic in or through Shiprock. More crashes (15%) occurred in October than any other month. This is most likely due to the large attendance at the Northern Navajo Fair in Shiprock.

Lighting conditions: 76% percent (66) of all crashes and 68% (15) of injury crashes occurred during daylight hours. 14% (12) of all crashes, and 18% (4) of injury crashes, occurred in the dark with no street lights provided.

Weather Conditions: 83% (72) of all crashes and 77% (17) of injury crashes occurred during clear weather. conditions. 8% (7) of all crashes occurred in rainy weather. However, 23% (5) of the injury crashes occurred in rainy weather. Crashes in snowy weather included 9% (8) of the total crashes, but none involved injury.

Road Conditions: 82% (71) of all crashes and 73% (16) of injury crashes occurred on dry roads.

Intersection: 64% (56) of all crashes and 73% (16) of injury crashes occurred at intersections.

Driver Possession of a Driver's License: In 26% (23) of all crashes and 18% (4) of injury crashes, at least one driver did not possess a driver's license.

Age and Sex: A total of 172 drivers were involved in crashes; 104 were male, and 53 were female, and no gender was recorded for 15. In the injury crashes, there were 47 drivers involved. For male drivers in injury crashes, the leading age group was 20-25 years old, followed by 31-35. For female drivers in injury crashes, there were 3 crashes each in the 16-20, 21-25, and 26-30 age groups. The ratio of male to female drivers in all crashes was 1.9:1. For injury crashes, the ratio was 1.5:1.

Apparent Contributing Factors: Multiple conditions were marked under "Apparent Contributing Factors" in many of the police crash reports. The 5 most frequently marked apparent contributing factors for all crashes were: too fast for conditions (65), excessive speed (60), none (54), other (not involving driver error) (23), and driver inattention (22). The 5 most frequently marked apparent contributing factors for injury crashes were driver inattention (15), none (15), under the influence of alcohol (8), failed to yield (6), and improper turn (5).

In summary, MP 93.6 is a particularly dangerous traffic location. A smaller crash cluster was identified at MP 93.5. Rear-end collisions were a considerable problem, as were collisions involving left turns in front of an oncoming vehicle. There was a high incidence of crashes between noon and 6 pm; a high weekday incidence (particularly on Wednesday); and problems with drivers speeding, drinking alcohol, and having no valid license.

B. Evaluation of Geometric Design Criteria:

Design Feature 1: Median Width: The median width was of interest because vehicles frequently stop within a median crossover and pull too far forward or fail to pull forward far enough. Thus, the front or the rear of the vehicle protrudes into a traffic lane. Although no crashes were directly observed as a result of this practice, avoidance maneuvers on the part of vehicles in the traffic lanes were often observed. The median width throughout this 0.9 section of highway is 18 feet. No specific design criterion exists for median widths. The suggested width range is 4-80 feet, depending on the land available and the cost of that land. Medians which accommodate a left-turn lane should not be less than 14 feet. The vehicle length for a passenger car is 19 feet. Median widths in excess of 22 feet are required to allow separate roadway crossings for passenger cars. A "separate roadway crossing" refers to crossing one lane of traffic with storage in a median cross-over before crossing or entering the second traffic lane. Median widths of 14 to 22 feet are not designed to allow separate roadway crossings; but only to provide left turn lanes. While the existing median width of 18 feet is sufficient for the perpendicular storage of compact and sub-compact cars, it is not sufficient for longer vehicles.

Design Feature 2: The Location and Control of Side Street Cross Traffic (in particular, the exit from the port-of-entry (POE) weigh station): Many commercial trucks exit from the POE weigh station. Four, one-hour traffic counts were conducted to estimate the weekday, daytime traffic volume exiting at this location. 33 tractor-trailers exit at this location per hour, 27% (9) of which make a left turn. A total of 80 vehicles exit at this location per hour, 33% (26) of which make a left turn. As noted above, the median is not wide enough to allow perpendicular storage of a standard size passenger vehicle, let alone a tractor-trailer. As such, tractor-trailers are required to make a single movement across the north bound traffic lanes, across the median, and into the south bound traffic lane. Potential traffic conflicts due to this type of maneuver are common. In fact, during the study period 5 crashes (2 involved tractor-trailers) were specifically attributed to left turns from this POE exit.

Left turn exits by tractor-trailers from the POE present potential traffic conflicts on a regular basis for traffic in either direction. A tractor-trailer must first cross the two northbound traffic lanes and the median before making the left turn into the southbound lane. This is not a rapid maneuver. Tractor-trailers making this left turn were timed from the moment they started forward at this exit until the rear of the trailer cleared the inside north bound traffic lane. The average time was 11 seconds. At 40 mph, this crossing time provides a potential conflict zone to northbound traffic for 645 feet upstream from that exit. During periods of heavy traffic, this is a particular problem to drivers who are several vehicles back from the POE exit. These drivers may not notice the exiting tractor-trailer, but suddenly have to contend with the braking vehicle ahead of them. An even more serious problem is occasionally seen, also during periods of heavy traffic. As several tractor-trailers queue up at this exit, the leader, through presumed impatience, will cross to the median and stop until the southbound lanes clear, and then will complete the left turn. During the median stop the north bound traffic lanes are blocked by the trailer.

Another problem involving tractor-trailers at this exit also affects northbound traffic. A tractor-trailer making a right turn from the POE exit, and desiring to make a left turn at the US 666/US 550 intersection, must make an almost immediate movement across 2 traffic lanes into the left-turn lane. The distance between the end of the right turn exit lane and the start of the left turn lane is only 26 feet. Again, this is not a rapid maneuver. Tractor-trailers must either wait for a clear path, or proceed under less than optimal traffic conditions and let the traffic beware.

Tractor-trailers exiting the POE exit also affect the southbound traffic. As noted, it takes the average tractor-trailer 11 seconds to clear the northbound lane. It takes another several seconds for that same tractor-trailer to become fully merged into a southbound traffic lane, and even longer for the vehicle to attain the running speed of the through-traffic. Potential traffic conflicts are relatively frequent with this type of maneuver, particularly during heavy traffic.

In determining appropriate standards against which to compare this existing design feature, three applicable standards were found. The Federal Highway Administration Manual of Uniform Traffic Control Devices (MUTCD) was referenced for warrants on the signalization of intersections. According to MUTCD Warrant 1, a minimum hourly traffic volume (MHTV) on the highway would be 420, with a side-street MHTV of 105. With an average daytime hourly traffic volume of 80 at the POE exit, these warrant requirements are not met. MUTCD Warrant 2, Interruption of Continuous Traffic, is for conditions where traffic volume on the major street is so heavy that the minor intersecting street experiences excessive delays or hazards in entering or crossing the main street. These warrant requirements were MHTVs of 630 for the major street and 52 for the minor street. It is believed that the average hourly traffic volume on US 666 would exceed 630 vehicles.

The AASHTO Policy on Geometric Design of Highways and Streets has a section on required sight distance (RSD). RSD was analyzed in terms of a left-turn movement into a crossroad with a narrow median where both lane clearances are made in a single maneuver. The RSD refers to the sight distance required to complete the left turn maneuver and accelerate to the average running speed of the major road without being overtaken by approaching vehicles in the same direction. The RSD for passenger vehicles is approximately 650 feet. The RSD for tractor-trailers making the same maneuver would be substantially longer, due to their much slower acceleration rates. This POE exit intersection is less than 550 feet west of the US 666/US 550 intersection. The north leg of the main intersection is visible for some distance to the north of that intersection, but the traffic signal phase must also be evaluated to determine if approaching traffic will affect the left-turn maneuver from the POE exit. The east leg of the US 666/US 550 intersection is not readily visible beyond that intersection due to a curve and vision interference by traffic signals. Insufficient sight distance for left-turn maneuvers from the POE exit, particularly for tractor trailers, justifies modification of this intersection.

Design Feature 3: Left Turn Lane Availability and Positioning: There is no left-turn lane for southbound traffic at MP 93.5. Vehicles turning left at this location typically turn partially into the median crossover for storage, leaving the rear-end of the vehicle partially in the through-lane. Some vehicles just stop in the through-lane until they make the left turn. Either variation provides potential traffic conflicts, particularly for rear-end crashes.

There is an off-set left-turn lane for southbound traffic near MP 92.8. The extent of the off-set (from the end of the center median to the nearest side of the business access) is 134 feet. Drivers using this left-turn lane for access into the convenience store have to make a long diagonal movement across the northbound lanes. On average, it took 6.9 seconds to clear the outside northbound traffic lane. At 40 mph, there is a potential conflict zone of 405 feet upstream from the access point in the northbound lane. This zone extends around a curve and more than half-way to the intersection at MP 92.7. In the 2-year study period, 2 crashes were attributed to these long left turns.

At the long left turn near MP 92.8, the median itself is a significant problem. The median left-turn lane for southbound traffic is channeling traffic into an unsafe maneuver.

Design Feature 4: Median Cross-Over Positioning: Vehicles were observed making U-turns to gain access to businesses or side streets. This 0.9 mile section of highway is interspersed with 5 median crossover points, 3 for side-street intersections and 2 for business access. Three of these median cross-overs were between MP 92.7 and 93.0. This same 0.3 mile section contains 9 business access locations and 1 side street intersection. Of concern was whether the existing number of median crossovers were too few, correct, or too many. However, I was unable to find any standards addressing median cross-overs.

Design Feature 5 - US 666/US 550 Intersection: Most crashes at this intersection were rear-end collisions and collisions involving left turns to the north in front of oncoming traffic. One observed problem involved vehicles making a left turn to the north at this intersection. The vehicles are allowed to make a provided-left-turn on a green arrow simultaneous to the regular green light for forward east-bound traffic. The green arrow is followed by a yellow arrow, which ends leaving only the regular green light. After the yellow arrow ends, the opposing west-bound traffic receive the green light for forward movement. A permitted-left-turn to the north is allowed on the east-bound green light phase, although there is no sign indicating the need to yield to oncoming traffic. Confusion concerning who has the right-of-way is inevitable. All 12 collisions involving a left turn in front of oncoming traffic occurred during the permitted-left-turn phase, none during the provided-left-turn phase. A second observed problem involved the yellow-arrow phase (YAP) for north-bound, left-turn traffic. The YAP was timed at 2.9 seconds. Assuming a 15 mph speed in the left-turn lane, the Traffic Engineering Handbook requires a 5.4 second YAP for a safe stopping distance. The yellow-light phase for east-bound traffic was also insufficient. This phase was timed at 3.6 seconds, while the Handbook formula calculated a need for a 7-second phase.

Recommendations: The following recommendations are intended to present viable intervention options and encourage further dialogue. Successful interventions will require the cooperation of several groups, including: the Shiprock Chapter, the Navajo Tribe, The Navajo Department of Public Safety (NDPS), IHS, the NM Highway and Transportation Department (NMHTD), and the NM Office of the Federal Highway Administration.

1. The NMHTD should conduct an engineering study at the US 666-US 550 intersection (MP 93.6) to identify additional traffic flow and traffic safety problems. NMHTD traffic crash data should *not* be used in any such study because the data system has a serious problem with underreporting of crashes.
2. The NMHTD should conduct an engineering study at the US 666 Port-of-Entry exit intersection at MP 93.5 to evaluate the traffic flow patterns and identify the highway traffic volume.
3. The traffic signal at the US 666/US 550 intersection should be modified: a) eliminate permitted (as opposed to provided) left turns for north bound traffic; b) lengthen the left-turn phase for northbound traffic during peak volume periods; c) increase the northbound, left-turn, yellow-arrow phase to 5.4 seconds; d) increase the eastbound yellow-light phase to 7 seconds; and e) consider double left-turn lanes for northbound traffic (for provided turns only).
4. The Port-of-Entry exit at MP 93.5 should be rerouted to exit at the signalized intersection at MP 93.6. This would change this intersection from a 3- to a 4-leg intersection, eliminating many of the traffic problems at MP 93.5.
5. Along with item 4, the Port-of-Entry exit at MP 93.5 should be blocked off.
6. The NMHTD should evaluate the function of the median from MP 92.7 to 93.0. Does the median enhance traffic safety by effective channelization or does it create problems by limiting left turns and access to business entrances? The adequacy of the existing number and locations of median crossovers along this 0.3 mile section, particularly given the insufficient width of the median for perpendicular vehicle storage, should be analyzed.
7. If no changes are deemed necessary to the median at MP 92.8, then changes should be made to the long, off-set left turn for southbound traffic to access into the convenience store. This may involve relocating the entrance access to this store so that the business access is perpendicular to this intersection.
8. The NDPS should consider increased enforcement efforts during the peak crash times (noon to 6 pm), as well as increased enforcement of speeding and DUI laws.
9. The NDPS and/or the Tribal Court system should consider a study of driving-without-licenses.
10. The IHS Office of Environmental Health and Engineering should follow-up on the injuries sustained in the motor vehicle crashes, specifically to determine the severity of injuries by crash type and location and to estimate the overall costs of these injuries.