CONNECTING KENTUCKIANA

Five Counties. One Plan.

RETHINKING TRANSPORTATION

CRASH ANALYSIS

Adopted by the Transportation Policy Committee

December 17, 2015

Overview

The Kentuckiana Regional Planning and Development Agency (KIPDA), in developing the Connecting Kentuckiana Metropolitan Transportation Plan Update, undertook the process of identifying high crash locations within the region and assessing the severity of the crashes which occur at them. The analysis contains six unique components that vary by type of roadway and by mode. These are:

1. TAD-level Crash Analysis
2. High Crash Intersections
3. High Crash Roadway Segments (non-interstates)
4. High Crash Interstate Segments
5. High Crash Interchanges
6. High Crash Bicycle/Pedestrian Segments

While the individual components of the analysis varied slightly, locations were analyzed based upon the frequency of crashes which occur at a given location, the rate of crashes relative to the volume of traffic at the location, and the severity of the crashes which occurred at the location. A detailed description of each of these components is contained in this report.

The analysis of locations in components 2 through 5 (as listed above) resulted in high crash lists, and maps to accompany these lists. The lists are intended to serve as starting points for further study and as a key consideration when prioritizing the programming of funding sources. High crash lists have been developed for the portions of the states of Indiana and Kentucky which are within the KIPDA Metropolitan Planning Area (MPA), and in certain instances for each of the five counties comprising the KIPDA MPO (Clark and Floyd counties in Indiana; Bullitt, Oldham, and Jefferson counties in Kentucky).

The high crash lists (and maps) are considered to be companion resources to the Safety Review associated with the TAD Reviews completed as part of the Connecting Kentuckiana Issues Report. The TAD Reviews introduce issues related to frequency of crashes on roadways, including intersections (high frequency crash locations were identified based upon the number of crashes which occurred within 0.10 mile of each other). Several of the other components of the analysis (all but the bike/ped analysis) include analysis based upon the frequency of crashes which occur near a location, the crash rate at the location, as well as the severity of crashes at the location.

The lists of high crash locations do not necessarily indicate that one location is more dangerous than another. In some cases, the frequency of crashes that occur near a given location may be a reflection of the volume of traffic travelling through it for which there is no reasonable project-based improvement to correct it. Unfortunately, there are situations where the severity of crashes in terms of injuries and fatalities is less a matter for studied improvement and more a reality of individual driver behavior or circumstance for which little can be addressed near a given location. It is understood that reducing the number of injuries and fatalities near a given location is often a product of reducing the number of crashes as a whole.

The intent of this identification of high crash locations was to put all of the high crash locations in the KIPDA MPA on a more level playing field where a thorough review and comparison could be completed. Through an analysis which normalizes the relationship between the frequency of crashes and the volume of traffic, accounts for crash related injuries and fatalities, and focuses attention to where the greatest numbers of crashes occur, a process was developed where geo-specific safety issues are identified and relative priority assigned.

Analysis

The Analysis process focused on quantifying crash information so that one crash location can be more easily compared to another. The comparison provides a better understanding of which locations pose the greatest risk of crashes and where funding resources may be directed in order to increase safety. Research was conducted of metropolitan planning organizations, Federal Highway Administration planning resources, and other literature in order to identify the most reasonable approach for assessing the severity of crashes at locations in the KIPDA MPA. Following the review, it was determined that an approach which combined crash frequency with crash rate and severity of crashes would be an appropriate and informative means for determining which locations are of the greatest concern. It is important to point out that the combination of factors used to complete this analysis is an indicator that transportation-related safety can be measured in many different ways and that there is no single factor nor set of factors which fully reflect the concept of safety. This analysis serves as a starting point from which further examination, study, and collaboration can be conducted in order to improve transportation safety.

Crash Data

Crash information is recorded by state and local police agencies and collected in statewide databases annually. In Kentucky, the Kentucky State Police maintain the statewide crash database and make it available at www.crashinformationky.org. The Indiana statewide database, known as the Automated Reporting Information Exchange System (ARIES) is available to public agencies and requires a password protected account. The Indiana data can be downloaded at www.crashreports.in.gov/Public/Home.aspx In order to remain consistent with the data used in completing the TAD-level analysis for the Connecting Kentuckiana Issues Report, crash data spanning three years (2009-2011) and including the five KIPDA MPO counties was utilized. A review of the data was necessary in order to correct any obvious errors related to the assignment of the latitude and longitude of some crash locations.

Included in the crash data was information about the latitude/longitude of each crash location, if applicable, the address or cross street nearest the crash, brief information describing factors which may have contributed to the crash, and if the crash resulted in injuries or fatalities. The crash data was used to create a Geographic Information Systems (GIS) layer in order to better understand the spatial relationships between the crashes.

Crash location data in each state was fairly consistent. Each state used latitudes and longitudes from or near the site of the reported crash, as well as street address information when possible. Both states also consistently reported when a crash resulted in a fatality. The difference in the crash data from Indiana and Kentucky was in the reporting of crashes which resulted in an injury. Indiana reported significantly more injuries per crash than Kentucky. Because of the difference in the number of injuries per crash reported, and the similar travel conditions in each state, the only reasonable explanation to the reporting differences in the number of crashes resulting in injury is the manner and process used to identify and report injuries.

HIGH CRASH INTERSECTION ASSESSMENT

Overview

The High Crash Intersection Assessment was the first of the high crash lists to be developed by KIPDA staff and was used as a template for the other location-based analyses. Three factors contribute to an intersection's score and ranking:

- Crash Frequency: The number of crashes within 250 feet of the center of the intersection
- Crash Rate: The number of crashes per million vehicles entering an intersection
- Crash Severity Index: An index that assigns higher weights to crashes that result in injuries and fatalities than to crashes that result in property damage only

Crash Frequency

The crash frequency was used in two ways for the High Crash Intersection Assessment. First, it was used as a preliminary screen to determine which of the over 1,300 intersections in the region experienced a minimum number of crashes to be included in the analysis. Then, intersections that met the minimum threshold were also ranked based on the number of crashes that occurred within 250 feet from the center of each intersection.

By narrowing the analysis to intersections with the highest frequency of crashes, the probability of improving transportation user safety is increased. Over 1,300 intersections in the five-county KIPDA MPA were reviewed in order to identify the intersections with the highest frequency of crashes. The following factors were utilized when identifying which intersections to consider in the analysis. The intersection:

- Includes at least one functionally classified road
- had at least three legs
- had traffic counts available for all of the segments of roadway that comprised an intersection

Crashes which occurred on interstates, interstate ramps, or at intersections with ramps were excluded from the analysis because of their unique travel behavior. Crashes that occurred at intersections that did not meet the criteria listed above were not disregarded. They were included as part of the High Crash Roadway Segment Assessment. This includes crashes at intersections of minor streets, intersections of major roadways with parking lots or other private roadways, among others.

Using GIS, a 250-foot buffer surrounded the center of each intersection. The buffer, using a spatial join function, assigned the crashes within the buffer to the nearest intersection. By using the spatial join tool, double counting crashes when two or more intersection buffers overlapped was mitigated. The number of crashes assigned to each intersection was the basis for determining the intersections with the highest frequency of crashes.

The frequency of crashes that occurred at each intersection was completed using the criteria listed above. The top 100 intersections in Kentucky with the highest frequency of crashes and top 50 intersections in Indiana with the highest frequency of crashes underwent further analysis (incorporating Crash Rate and Severity Index). Each intersection was ranked based on the cumulative score of all three factors.

Crash Rate

The crash rate is a means for understanding the ratio of the number of crashes to the number of vehicles entering an intersection; the higher the crash-to-volume ratio, the greater concern. The crash rate was calculated using a formula which considered both the number of crashes which occurred from 2009-2011, and the Average Daily Traffic entering the intersection. The following formula was used to assess the number of crashes per million vehicles that entered the intersection:

- Crash Rate = (N/3) / (365ADT / 1,000,000)
    - N= Total number of crashes at the given location over three years
    - ADT = Average Daily Traffic entering the intersection

Severity Index

The Severity Index establishes a means for comparing the severity of crashes occurring at one intersection to another. While reducing all crashes is important, identifying where the more severe crashes occur assists with the identification of intersections of greater concern. The Severity Index introduces to the analysis a layer of information which contributes to ranking high crash intersections. The Severity Index assigns a numeric value to crashes which result in an injury or fatality and crashes with no injuries or fatalities. How to weight the severity of crashes has, for many years, been a topic of debate, study and discussion around many conference tables.

KIPDA researched the weights assigned to crashes from other MPOs and state departments of transportation. While weights assigned to crashes resulting in an injury were reasonably consistent, the weights assigned to crashes resulting in at least one fatality spanned a wide range. The Mid-Ohio Regional Planning Commission (MORPC) utilizes a safety analysis tool similar to the High Crash Intersection Assessment developed by KIPDA. MORPC assigns a weight factor of 1 to crashes which result in no injuries or fatalities, 3 to crashes which resulted in an injury, and 12 to crashes which resulted in a fatality.

For the crashes that either had no injuries or fatalities or that resulted in an injury, KIPDA elected to apply the same weight factors used by MORPC. Given the variety of weights assigned to crashes resulting in a fatality, it was decided further investigation was needed. The process for determining a weight for crashes incorporated the wide range found in earlier research. KIPDA conducted the High Crash Intersection Assessment three times, each time assigning a different value to crashes resulting in a fatality. The range included a weight of 5, 12, and 30.

It was determined that the three weights that were reviewed for fatal crashes had little impact on an intersection's Severity Index or affected the High Crash Intersection Assessment rankings. This is in part due to two factors: 1) fatalities account for one-third of the formula used to determine an intersection's Severity Index (the other two-thirds are crashes which result in an injury, and crashes which do not result in an injury or a fatality); and 2) the percentage of crashes which result in a fatality is low when compared to the rest of the crashes (in the KIPDA MPA, crashes resulting in a fatality accounted for 0.26% of all crashes in the three year period of 2009 through 2011). Because the weight factor of 12 had already been established in a process similar to the KIPDA's, and the range of weight assigned to fatalities had relatively little impact on an intersection's Severity Index, it was decided to use a weight between the two extremes of the KIPDA research; or 12.

The formula used to determine an intersection's Severity Index is:

- Severity Index = (12Ftl + 3Inj + 1PDO) / N
    - Ftl = A crash resulting in at least one fatality at the given intersection
    - Inj = A crash resulting in at least one injury at the given intersection
    - PDO = A crash resulting in property damage only or did not result in any injuries or fatalities at the given intersection
    - N = The Total number of crashes (Fatal + Injury + No Injuries or Fatalities) at the given intersection

(Please Note: Each crash's severity was determined by the worst condition involved in that crash. For example, if a crash resulted in two fatalities and two injuries, it was considered in this analysis as a crash with a fatality. Crashes were not reflective of the number of fatalities or injuries that occurred, but whether or not the crash resulted in an injury or a fatality. In cases where both an injury and a fatality occurred in a single crash, than the crash was considered to have resulted in at least one fatality.)

<u>Ranking High Crash Intersections</u>

In order to facilitate a ranking of the high crash intersections each intersection was scored and ranked using the calculations for crash frequency, crash rate, and severity. Each of the three factors used in the analysis was ranked independently of the other. The independent rankings for each intersection were tallied and provided an overall score for a given intersection. An intersection with a lower combined score was ranked higher on the list. In the event that two or more intersections receive the same overall score, the crash rate score was used as a tie-breaker.

Example:

Intersection	Criteria Rankings			Intersection Score
	Crash Frequency	Crash Rate	Severity Index	
Road A @ Road B	6	3	2	11
Road X @ Road Y	9	4	5	18

Rankings by Jurisdiction

Lists and maps were developed for the KIPDA MPA for Indiana and Kentucky as well as each of the five counties in the KIPDA MPO region. The jurisdictional lists were developed for two reasons: 1) State and federal funding opportunities which may be utilized to address safety issues are available by state. 2) As indicated earlier, the process of reporting injuries within each state varied significantly. A single, regional rank which encompassed both states would have incorrectly overemphasized Indiana high crash locations due to the disparity in how injuries were reported. The lists by county assist local jurisdictions in identifying high crash locations within their county which may not have been realized when compared to the remaining high crash intersections in their respective state. Local jurisdictions may have local funding mechanisms in place which they may utilize to address high crash intersection concerns.

Jurisdiction	**High Crash Intersections Analyzed**	**High Crash Intersections Ranked**
Indiana	50	20
Kentucky	100	40
Clark, Co. IN	10	5
Floyd Co. IN	10	5
Bullitt Co. KY	10	5
Jefferson Co. KY	10	5
Oldham Co. KY	10	5

HIGH CRASH ROADWAY SEGMENT ASSESSMENT

Overview

The High Crash Roadway Segment Assessment was the second of the high crash lists developed by KIPDA staff. The methodology used in developing the High Crash Roadway Segment Assessment mirrored that of the High Crash Intersection Assessment, with several minor differences that are covered below. Crashes that occurred at any of the more than 1,300 intersections that were included in the High Crash Intersection Assessment were not included in this analysis, to avoid the possibility of double counting a crash. High crash roadway segments were ranked based on three factors:

- Crashes per Mile: the number of crashes that occurred within 150 feet of the centerline of a roadway per mile of length
- Crash Rate: the number of crashes within 150 feet of the centerline of a segment per million vehicle miles traveled (VMT) on that segment
- Crash Severity Index: An index that assigns higher weights to crashes that result in injuries and fatalities than to crashes that result in property damage only

Crashes per Mile

Crashes per mile was used as one of the three criteria on which segments would be ranked. This choice was made due to the fact that the length of the segments between intersections in the KIPDA Region vary widely, from as small as a city block in downtown Louisville to several miles long in the more rural portions of the region.

Crash Frequency, that is the number of crashes that occurred along a segment, was calculated and used as the first of two initial screenings of segments that reduced the number of segments that would ultimately be ranked. It was imperative to screen the segments since there were over 2,400 segments in the region, which was thought to be far too many to effectively rank. The first screening reduced the 2,400 segments to the top 10 percent of these segments, in terms of crash frequency. This resulted in 191 segments in Kentucky and 55 segments in Indiana proceeding from the crash frequency screening. Subsequently, a second screening reduced the 191 segments in Kentucky to the Top 100 segments, based on crashes per mile. These 100 segments in Kentucky, as well as all 55 segments that came out of the first screening in Indiana were the ones that were ultimately ranked.

Screening the segments in the manner mentioned above added two primary benefits. By eliminating the segments with very few crashes, segments that were very short in length, yet had a high number of crashes per mile were eliminated, allowing the analysis to focus on those segments where larger number of crashes occurred. By further screening the segments (in Kentucky only) based on crashes per mile, segments that met the minimum crash frequency threshold simply because they were very long segments, were also eliminated.

Crash Rate

The crash rate is used to compare the number of crashes that occurred along a segment to a normalized volume of traffic. In this analysis, the unit used was the number of crashes per million vehicle miles traveled, or VMT. To calculate VMT on a segment, the length of the segment was multiplied by the average daily traffic, with the product being the amount of Daily VMT. The following formula was used to assess the number of crashes per million VMT on a segment:

- Crash Rate = (N/3) / (365*Daily VMT/1,000,000)
  - N = Total number of crashes along a segment over three years
  - Daily VMT = Length of Segment (in miles) * Average Daily Traffic

Severity Index

The Severity Index establishes a means for comparing the severity of crashes occurring along one segment to another. The index used in the High Crash Roadway Segment Assessment is identical to the index used in the High Crash Intersection Assessment, and described earlier in this document. The same weights were used for crashes that resulted in an injury or fatality. Similar to the High Crash Intersection Assessment, the discrepancy between the two state crash databases in the classification of what constitutes an injury crash necessitates that two lists, one for each state, are created for the High Crash Roadway Segment Assessment.

The formula used to determine a segment's Severity Index is:

- Severity Index = (12Ftl + 3Inj + 1PDO) / N
  - Ftl = A crash resulting in at least one fatality along the given segment
  - Inj = A crash resulting in at least one injury along the given segment
  - PDO = A crash resulting in property damage only or did not result in any injuries or fatalities along the given segment
  - N = The Total number of crashes (Fatal + Injury + No Injuries or Fatalities) along the given segment

Ranking High Crash Segments

Similar to the ranking of intersections in the High Crash Intersection Assessment, segments were ranked based on the three independent criteria described above: Crashes per Mile, Crash Rate, and Severity Index. Due to the differences in the injury crash classification, segments were ranked separately for each state. The segment that had the worst condition (i.e. highest number of crashes per mile, most crashes per million VMT, highest severity index) was ranked number 1, the second worst was ranked number 2, and so on. The sum of the three individual rankings is assigned as the segment's overall score, called the Total Criteria Score. The high crash segment lists are based on the rankings of the Total Criteria Score, with the segment with the lowest Total Criteria Score being ranked number 1. In the event two or more segments have the same Total Criteria Score, the crash rate was used as the tie-breaker.

Rankings by Jurisdiction

Lists and maps were developed for the KIPDA MPA for Indiana and Kentucky as well as each of the five counties in the KIPDA MPO region. The jurisdictional lists were developed for two reasons: 1) State and federal funding opportunities which may be utilized to address safety issues are available by state. 2) As indicated earlier, the process of reporting injuries within each state varied significantly. A single, regional rank which encompassed both states would have incorrectly overemphasized Indiana high crash locations due to the disparity in how injuries were reported. The lists by county assist local jurisdictions in identifying high crash locations within their county which may not have been realized when compared to the remaining high crash segmentss in their respective state. Local jurisdictions may have local funding mechanisms in place which they may utilize to address high crash segment concerns.

Jurisdiction	High Crash Segments Analyzed	High Crash Segments Ranked
Indiana	55	20
Kentucky	100	40
Clark, Co. IN	10	5
Floyd Co. IN	10	5
Bullitt Co. KY	17	5
Jefferson Co. KY	10	5
Oldham Co. KY	5	5

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HIGH CRASH INTERCHANGE ASSESSMENT

Overview

Early on in the assessment of crashes in the region, it became apparent that the procedures used to analyze crashes on the interstates, on the ramps, and at intersections within interchanges in the region would need to be treated separately from the crashes and locations along non-interstate roadway segments and at intersections other than those at interchanges. At interchanges, the variety of intersection designs make it impossible in many cases to limit crashes that are attributable to an intersection or a point where merging occurs to a 250 foot radius, which was defined as the limit of an intersection.

The High Crash Interchange Assessment mirrors the High Crash Intersection Assessment, with an expanded area that was defined as the interchange's limits that goes well beyond the 250 foot radius used in the prior analysis. The limits of an interchange were defined for the purpose of this analysis to include crashes that occurred within the following areas:

- Within the interchange (within the interchange meaning the area between the exit and entrance ramps in all directions)
- A 150 foot buffer along all ramps and roadways within the interchange
- An additional 350 foot buffer extending along the interstate segment (for a total of 500 feet) to account for merging, diverging, and weaving sections.

The same three factors used in the High Crash Intersection Assessment were used in the High Crash Interchange Assessment to contribute to an interchange's score and ranking:

- Crash Frequency: The number of crashes that occurred at the interchange
- Crash Rate: The number of crashes per million vehicles entering an interchange
- Crash Severity Index: An index that assigns higher weights to crashes that result in injuries and fatalities than to crashes that result in property damage only

Several interchanges were removed from the analysis due to there being an ongoing construction project at the interchange. These include:

- Kennedy Interchange (I-64, I-65, I-71 Interchange)
- I-65 Southbound at Brook & Jefferson Streets
- I-65 Northbound at Muhammad Ali Boulevard and Liberty Street
- I-64 Westbound at 3rd Street
- I-64 Eastbound at 2nd Street
- KY 841 (Gene Snyder Freeway) at US 42
- I-65 at Court Avenue
- I-65 at 10th Street
- I-65 at Stansifer Avenue
- I-65 at Browns Station Way

Other interchanges were merged with another interchange(s) due to their proximity to one another and/or due to the way the ramps interact with one another. These include:

- I-65 at Lewis & Clark Parkway and Veterans Parkway
- I-64 at Story Avenue and Mellwood Avenue
- I-264 at Crittenden Drive, Louisville International Airport, I-65, and Preston Highway

Crash Frequency

The crash frequency was calculated as the sum of all crashes that occurred within the limits of the interchange as is described in the previous section. Interchanges were ranked based on the number of crashes that occurred at each interchange.

Crash Rate

The crash rate is a means for understanding the ratio of the number of crashes to the number of vehicles entering an interchange; the higher the crash-to-volume ratio, the greater concern. The crash rate was calculated using a formula which considered both the number of crashes which occurred from 2009-2011, and the Average Daily Traffic entering the interchange. The following formula was used to assess the number of crashes per million vehicles that entered the interchange:

- Crash Rate = (N/3) / (365ADT / 1,000,000)
    - N= Total number of crashes at the given location over three years
    - ADT = Average Daily Traffic entering the interchange

Severity Index

The Severity Index establishes a means for comparing the severity of crashes occurring at one interchange to another. The index used in the High Crash Interchange Assessment is identical to the indices used in the assessments described earlier in this document. The same weights were used for crashes that resulted in an injury or fatality. Similar to the other assessments, the discrepancy between the two state crash databases in the classification of what constitutes an injury crash necessitates that two lists, one for each state, are created for the High Crash Interchange Assessment.

The formula used to determine an interchange's Severity Index is:

- Severity Index = (12Ftl + 3Inj + 1PDO) / N
    - Ftl = A crash resulting in at least one fatality at an interchange
    - Inj = A crash resulting in at least one injury at an interchange
    - PDO = A crash resulting in property damage only or did not result in any injuries or fatalities at an interchange

- N = The Total number of crashes (Fatal + Injury + No Injuries or Fatalities) at the interchange

<u>Ranking High Crash Interchanges</u>

In order to facilitate a ranking of the high crash interchanges, each interchange was scored and ranked using the calculations for crash frequency, crash rate, and severity. Each of the three factors used in the analysis was ranked independently of the other. The independent rankings for each interchange were tallied and provided an overall score for a given interchange. An interchange with a lower combined score was ranked higher on the list. In the event that two or more interchanges receive the same overall score, the crash rate score was used as a tie-breaker.

Example:

Intersection	Criteria Rankings			Intersection Score
	Crash Frequency	Crash Rate	Severity Index	
Interstate A @ Road B	10	18	9	37
Interstate X @ Road Y	7	17	16	40

HIGH CRASH INTERSTATE SEGMENT ASSESSMENT

Overview

Early on in the assessment of crashes in the region, it became apparent that the procedures used to analyze crashes on the interstates, on the ramps, and at intersections within interchanges in the region would need to be treated separately from the crashes and the high crash locations along non-interstate roadway segments and intersections other than those at interchanges. Segments along interstates differ greatly differ from non-interstate segments for many reasons. Among the most important are the lack of access points on interstates compared to other roadways which have at-grade intersections with other streets and driveways. These access points create numerous conflict points that are not present along interstates.

The High Crash Interstate Segment Assessment mirrors the High Crash Roadway Segment Assessment, with a few differences described below. Interstate segments are defined as the portions of interstates and freeways in the region that are located between the approximately 90 interchanges within the KIPDA Region. A buffer of 150 feet from the centerline of each direction of travel was applied. In Kentucky, the GIS crash data was provided in enough detail to differentiate between directions of travel on interstates. In Indiana, crashes were inconsistently geo-located in such a way that made it impossible to easily determine in which direction of travel many of the interstate crashes occurred. Therefore, the Kentucky analysis is bi-directional, while the Indiana analysis includes crashes (and traffic volumes) in both directions of travel.

Several segments were eliminated from the analysis due to their proximity to an ongoing construction project, their proximity to an interchange that was excluded from the High Crash Interchange Assessment, and/or due to the distance between interchanges being very short. After making these adjustments, a total of 140 interstate segments in Kentucky, and 17 segments in Indiana were analyzed. To focus on the segments where the most crashes occurred in Kentucky, only the Top 70 interstate segments based on the number of crashes per segment were ranked on the three criteria described below.

The High Crash Interstate Segment Assessment utilizes the same three factors used in the High Crash Roadway Segment Analysis. These are:

- Crashes per Mile: the number of crashes that occurred within 150 feet of the centerline of an interstate segment per mile of length
- Crash Rate: the number of crashes within 150 feet of the centerline of an interstate segment per million vehicle miles traveled (VMT) on that segment
- Crash Severity Index: An index that assigns higher weights to crashes that result in injuries and fatalities than to crashes that result in property damage only

Crashes per Mile

Crashes per mile was used in the High Crash Interstate Segment Assessment as one of the three criteria on which interstate segments would be ranked. The choice to use crashes per mile in place of crash frequency, or crashes per segment, was due to the fact that the length of the interstate segments between interchanges varies widely, typically shorter near the urban core of the region and longer in the more rural portions of the region. Using the simple crash frequency would have skewed the results by favoring those longer segments.

Crash Rate

The crash rate is used to compare the number of crashes that occurred along an interstate segment to a normalized volume of traffic. In this analysis, the unit used was the number of crashes per million vehicle miles traveled, or VMT. To calculate VMT on a segment, the length of the segment was multiplied by the average daily traffic, with the product being the amount of Daily VMT. In Kentucky, one-half of the bi-directional traffic count was assumed as the ADT in each direction of travel. In Indiana, the ADT was used as it was reported. The following formula was used to assess the number of crashes per million VMT on a segment:

- Crash Rate = (N/3) / (365*Daily VMT/1,000,000)
    - N = Total number of crashes along a segment over three years
    - Daily VMT = Length of Segment (in miles) * Average Daily Traffic

Severity Index

The Severity Index establishes a means for comparing the severity of crashes occurring along one segment to another. The index used in the High Crash Interstate Segment Assessment is identical to the indices used in the other High Crash Assessments, and described earlier in this document. The same weights were used for crashes that resulted in an injury or fatality.

The formula used to determine an interstate segment's Severity Index is:

- Severity Index = (12Ftl + 3Inj + 1PDO) / N
    - Ftl = A crash resulting in at least one fatality along the given segment
    - Inj = A crash resulting in at least one injury along the given segment
    - PDO = A crash resulting in property damage only or did not result in any injuries or fatalities along the given segment
    - N = The Total number of crashes (Fatal + Injury + No Injuries or Fatalities) along the given segment

Ranking High Crash Segments

Similar to the ranking of locations in the other High Crash Assessments, interstate segments were ranked based on the three independent criteria described above: Crashes per Mile, Crash Rate, and Severity Index. Due to the lack of consistency of the GIS data in Indiana, interstate segments were ranked separately for each state. The segment that had the worst condition (i.e. highest number of crashes per mile, most crashes per million VMT, highest severity index) was ranked number 1, the second worst was ranked number 2, and so on. The sum of the three individual rankings is assigned as the segment's overall score, called the Total Criteria Score. The high crash interstate segment lists are based on the rankings of the Total Criteria Score, with the segment with the lowest Total Criteria Score being ranked number 1. In the event two or more interstate segments have the same Total Criteria Score, the crash rate was used as the tiebreaker.

HIGH CRASH BIKE & PEDESTRIAN SEGMENT ASSESSMENT

Overview

The crashes that were analyzed in the previous sections of this report included crashes that involved all vehicles, both motorized and non-motorized. Through additional scrutiny and analysis of the crash data from the two states, crashes involving bicyclists and pedestrians can be extracted from the data for additional review. In an effort to identify any problem locations where crashes involving bicyclists and pedestrians were consistently occurring, a separate assessment was performed for these types of crashes.

No crash was included in more than one of the assessments discussed previously in this report. In other words, all crashes were assigned to one of the following: an intersection, a roadway (non-interstate) segment, an interchange, or an interstate segment. Pedestrian and bicycle crashes were potentially double counted, meaning that a bike/ped crash was analyzed as part of the intersection or roadway segment analysis, and this Bike/Ped Segment Assessment. A buffer of 250 feet at each intersection was not utilized in this analysis. A crash was assigned to the nearest segment, no matter how close it was to an intersection.

Number of Crashes

In the 5-county KIPDA Region, there are approximately 40,000 crashes that are reported on public roadways each year. Of these 40,000 crashes, only about 500 crashes (1.25%) involve pedestrians each year. An additional 200 (0.5%) crashes involve bicyclists. These numbers represent the number of crashes that are reported. It is possible, if not very likely, that a number of crashes that involve pedestrians and bicyclists go unreported when they do not result in injury and/or significant property damage.

Despite the relative few number of crashes involving pedestrians and bicyclists, these crashes tend to result in a disproportionate number of injuries and fatalities than crashes between motorized vehicles. Speaking specifically about pedestrian crashes, while they constitute only about 1% of all crashes, they are about 6% of the crashes that result in an injury, and 18% of the crashes that result in fatalities. This is a key reason why a separate analysis was performed for this subset of crashes.

Pedestrian and bicycle crashes also disproportionately occur in the more urban areas of the region. This is reflected in that over 85% of pedestrian crashes in the region that occurred between 2005 and 2014 occurred in Jefferson County, despite under 70% of the region's population residing in Jefferson County. This is further illustrated by using Oldham County as an example: Over the 10-year analysis period, the maximum number of crashes involving pedestrians in a year in Oldham County was 10. When these types of crashes are occurring this infrequently, it makes identifying problem locations very difficult.

To assist in identifying high crash locations specific to pedestrian and bicycle crashes, the study period was expanded from 3 years to 10 years. The study period for this specific assessment was 2005 through 2014.

Ranking High Crash Segments

The same group of roadway segments was analyzed in the High Crash Bike/Pedestrian Assessment as in the High Crash Roadway Segment Assessment. Segments were expanded to the center of each intersection. However, the ranking of high crash Bike/Ped segments was different than the methods used in the other assessments. An approach where segments were ranked on three unique criteria was not used in this analysis. There are two key reasons for this:

1) *There is no way to calculate an accurate bike/ped crash rat*e: In the other assessments, traffic counts were critical components to calculating the crash rate of a segment or an intersection. If there were no traffic counts available, the crash rate could not be calculated, and therefore that segment or intersection could not be analyzed. There are no widespread, reliable sources of bicycle and pedestrian counts that are available and it does not make sense to use the traffic count of motorized vehicles in the crash rate for bike/ped crashes, so crash rates were not a part of this particular analysis.

2) *There is enough uncertainty in the injury data that a severity index should not be used:* Over 85% of the reported bike/ped crashes resulted in an injury and/or a fatality. While this does not necessarily preclude the calculation of a severity index specifically for the bike/ped crash analysis, it does bring into question the number of crashes involving a pedestrian or bicyclist that has gone unreported. For bike/ped crashes that did not result in an injury, a fatality, nor caused significant property damage, it is thought that these crashes are likely going unreported. For this reason, a severity index was not used in this analysis. Further, with relatively few crashes being assessed in this analysis, 1 fatality can significantly increase the severity index should it be calculated as it was in the other analyses, potentially significantly skewing the results.

Without a crash rate or severity index to use in this analysis, a simpler approach was utilized in this assessment that focused on the frequency of crashes. All segments were assessed for the following four measures:

- the number of pedestrian crashes
- the number of pedestrian crashes per mile
- the number of bicycle crashes
- the number of bicycle crashes per mile

The 20 segments that had the greatest number of each of these measures were identified as high crash bike/ped segments. Four maps and lists, one for each of these measures, were created that show the high crash bike/ped segments in the region.

Since the injury data was not utilized in this analysis, only one list for the entire region was created.