High Injury Network (HIN) Scoring Methodology

The **High Injury Network (HIN)** scoring methodology was developed to identify and prioritize roadway segments and intersections with the highest rates of fatal and severe injury (KSI) crashes. This data-driven approach to the analysis incorporates crash severity, frequency, and roadway characteristics to highlight areas where focused safety improvements will yield the most significant reductions in severe crashes.

Crash Severity Weighting

To evaluate the relative severity of crashes, we employ the **Equivalent Property Damage Only (EPDO)** scoring method. This method assigns weights to different crash types based on their crash costs (insurance cost, costs of life, EMS, medical care, etc.), as provided by **KDOT**[1]. The more severe a crash, the higher its weight in the scoring calculation. This helps prioritize locations with fatal and serious injury crashes over those with minor or property-damage-only crashes.

Crash Severity Weights:

- Fatal (K): 1197.47

- Suspected Serious Injury (A): 64.05

- Suspected Minor Injury (B): 20.57

- Possible Injury (C): 11.43

- No Apparent Injury (PDO): 1.00

Formula: The crash severity score for a location is calculated as:

Crash Severity Score=(K×1197.47)+(A×64.05)+(B×20.57)+(C×11.43)+(PDO×1.00)

For each location, the sum of the weighted crash scores were used to determine hotspots.

Crash Summarization

Crashes were summarized by using a 150-foot buffer along the roadway segments and intersections to capture and summarize key crash point attributes, including the number of fatalities and injuries as they relate to the KABCO scale. These values were then entered into the formula above to get a crash severity weight by location.

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[1] KDOT crash costs (2023):
- Fatal (K): $13,999,597
- Suspected Serious Injury (A): $748,852
- Suspected Minor Injury (B): $240,505
- Possible Injury (C): $133,671

HIN Thresholds and Prioritization

To establish a High Injury Network (HIN), we calculate the crash severity score for each segment and intersection and then analyze the resulting network to establish thresholds. This ensures that the HIN captures a significant yet focused portion of the network, representing the historically most dangerous areas for intervention.

Geographic Threshold Differentiation

Given the large project area, there are several differences between areas that suggest thresholds should be localized to the geography (i.e. rural vs urban road segments).

We utilized the **Natural Jenks Method** of distribution to normalize geographies, which scales the data based on the total number of segments and intersections in each city, and places data points into five categories from low to high. This allows for an accurate representation of data clusters and natural breaks.

Garden City and Liberal were evaluated independently as large cities, while the smaller incorporated areas (e.g., Scott City, Oberlin) were grouped with rural areas into a separate category. The analysis distinguishes between urban and rural geographies to account for differing traffic patterns and road types.

For **rural segments**, a **minimum threshold of 1/2 mile** was implemented to prevent elevating small sections with low crash rates. This method ensured that locations with meaningful crash data were prioritized.

For **counties and small cities**, the methodology emphasizes systemic issues over individual crash hotspots. This approach enables broader safety strategies, targeting areas with lower crash frequencies but higher risks.

Prioritization

As mentioned, we used the **Natural Jenks Method** to distribute crash severity scores into five categories, based on the natural distribution of the data. This process helps reveal the inherent groupings in the data by minimizing variance within each category and maximizing the variance between them.

After applying the Natural Jenks Method, only the **top two categories**, corresponding to the highest crash severity scores, were used for prioritization. These categories represent the highest-risk locations in the network, scoring **4** and **5** on the five-point scale.

1. Generating a New Priority Field

A new field was created in the dataset to house the values for these top two priority levels (scores 4 and 5). This field helps identify the most critical intersections and segments across each geography. By isolating these higher-priority areas, we can focus safety interventions on the locations with the greatest potential for reducing severe crashes.

2. Application Across Geographies

This process was applied consistently across all geographies—both urban and rural. For every segment and intersection analyzed:

- **Intersections and segments** that scored in the top two categories (4 and 5) based on crash severity were flagged in the newly generated field as a "priority" location.

- The analysis was repeated for different areas (e.g., Garden City, Liberal, smaller cities, and rural areas) to ensure that the top-priority locations in each geography were highlighted for targeted intervention.

By using the top two categories from the Jenks distribution, we were able to narrow our focus to the locations with the most severe safety concerns, ensuring that limited resources are allocated to the areas with the highest risk of fatal or severe injury crashes.

GIS Visualization

A key component of the HIN is its integration with **GIS**, allowing for spatial analysis and the mapping of crash data. The resulting HIN list should be mapped alongside other project data to help drive project recommendations.

High Risk Network (HRN) Scoring Methodology

The **High Risk Network (HRN)** scoring methodology was developed to identify and prioritize roadway segments and intersections with the highest *risk* of fatal and severe injury (KSI) crashes based on facility attributes. This data-driven approach to the analysis incorporates roadway characteristics, intersection attributes, and location context to highlight areas where focused safety improvements will yield the most significant reductions in severe crashes.

Risk Scoring

To evaluate the fatal and serious injury crash risk of locations across the study area, we scored attributes of the roadways and intersections based on their correlation to KSI crashes. The facilities were categorized into four groups:

- County Intersections
- City Intersections
- County Corridors
- City Corridors

City facilities refer to roadways or intersections located within the six participating cities: Garden City, Liberal, Holcomb, Scott City, Oberlin, and Oakley. In contrast, county facilities include roadways or intersections located outside of the six participating city boundaries. The scoring between city and county facilities were separated based on differing crash patterns depending on the context of the roadway or intersection. Although there are distinct crash patterns within individual cities or counties, many of the communities analyzed lacked a sufficient number of crashes to draw reliable conclusions about crash risk without aggregating data across multiple jurisdictions.

Representative Ratios

The risk scoring is based on the ratio of fatal and serious injury crashes to the centerline miles of roadways or the number of intersections, grouped by various roadway or intersection attributes. The scoring was aggregated for city and county facilities separately. The ratios compared the percentage of fatal and serious injuries crashes occurring in a specific attribute category to the percentage of locations that fall into that category. **Table 1** provides an example calculation of the representative ratios for county intersections.

Daily Entering Vehicles (DEV)	Number of Fatal and Serious Injury Crashes	Number of Intersections	Percentage of Fatal and Serious Injury Crashes	Percentage of Intersections	Representative Ratios
<500	13	2,405	14.8%	67.0%	0.22
500-1,999	26	804	29.5%	22.4%	1.32
2,000-4,999	19	234	21.6%	6.5%	3.31
5,000-9,999	24	130	27.3%	3.6%	7.53
>=10,000	6	18	6.8%	0.5%	13.60

A representativeness ratio of less than 1.0 indicates that a facility with that attribute (e.g., a county intersection with a DEV of <500) is at a lower risk of having a fatal or serious injury crash. A representative ratio of 1.0 indicates that the attribute does not correlate with an increased or decreased risk of fatal and serious injury crashes. Lastly, a ratio greater than 1.0 indicates an increased risk of fatal and serious injury crashes on facilities with that attribute.

Scoring Adjustments

After calculating representative ratios for each facility type and attribute, adjustments were made to finalize scoring values. Adjustments were made for the following reasons:

- To avoid overweighting any single attribute
- To balance the scoring of the same attributes between different groups, such as consistently scoring equity across all facility types and contexts
- To better align scoring with the Local Road Safety Plans, particularly for county facilities
- To account for incomplete or small data subsets leading to high variability

Intersection Risk Scoring

Table 2 and **Table 3** display the scoring used for both county and city Intersections, respectively. Overall, intersection scoring is similar between county and city intersections. The main differences between the two scoring methodologies are as follows:

- In a city context, the number of entering lanes correlated to a higher risk of KSI crashes. As a result, the number of entering lanes is a scoring criteria for city intersections, but not for county intersections.

- The intersection control type was given greater weight in cities compared to counties. In both cities and counties, signalized intersections had a higher rate of KSI crashes compared to other intersection control types. However, there were not enough signalized intersections in the counties to assign elevated scoring for signalized intersections. This is why the intersection control type is weighted higher in cities compared to counties.

- In a city context, the skew of an intersection had a stronger correlation to KSI crashes and was therefore weighted higher.

The total score for county intersections was out of 21, while the total score for city intersections was out of 33. For each intersection, a score was assigned for each attribute based on its intersection

characteristics. These scores were then summed, multiplied by 100, and divided by 21 or 33 depending on the location of the intersection. This resulted in a score out of 100 for each intersection.

TABLE 2: COUNTY INTERSECTION SCORING

Attribute	Total Score	Range/Value	Representative Ratio	Score
DEV	8	<500	0.22	**0**
		500-1,999	1.32	**1**
		2,000-4,999	3.31	**2**
		5,000-9,999	7.53	**5**
		>=10,000	13.60	**8**
Control Type	4	Uncontrolled	1.33	**1**
		No Data	0.46	**0**
		TWSC	1.86	**2**
		AWSC	0.00	**0**
		Signal	40.73	**4**
Skew	3	No	0.83	**0**
		Yes	2.97	**3**
Equity*	2	No	0.70	**0**
		Yes	1.57	**2**
FSI Crash History	2	No	Scoring Adjustment	**0**
		Yes		**2**
Proximity to Schools	2	No	Scoring Adjustment	**0**
		Yes		**2**

Note: "Equity" denotes if the location is in a census tract that is considered disadvantaged or in an equity area. See project documentation on equity resources and communities.

Attribute	Total Score	Range/Value	Representative Ratio	Score
DEV	8	<500	0.00	**0**
		500-1,999	0.11	**0**
		2,000-4,999	1.52	**2**
		5,000-9,999	3.79	**4**
		>=10,000	8.01	**8**
Control Type	13	Uncontrolled	0.00	**0**
		No Data	0.09	**0**
		TWSC	2.09	**2**
		AWSC	3.97	**4**
		Signal	13.45	**13**
Skew	4	No	0.82	**0**
		Yes	3.94	**4**
Equity	2	No	0.58	**0**
		Yes	1.24	**2**
FSI Crash History	2	No	Scoring Adjustment	**0**
		Yes		**2**
Proximity to Schools	2	No	0.89	**0**
		Yes	1.20	**2**
Number of Entering Lanes	2	4	0.77	**0**
		5	2.36	**2**
		6	1.16	**1**
		8	2.56	**2**

Note: "Equity" denotes if the location is in a census tract that is considered disadvantaged or in an equity area. See project documentation on equity resources and communities.

Corridor (Segment) Risk Scoring

Table 4 and **Table 5** show the scoring used for both county and city corridors (roadway segments), respectively. Overall, roadway scoring is similar between county and city intersections. The main differences between the two scoring methodologies are as follows:

- In County Scoring:
  - Crash history included roadway departure crashes.
  - For corridors, access density and the presence of edge line markings were included in the scoring.
- In City Scoring:
  - Vulnerable Road Users (VRU) crash history was included.
  - For corridors, the number of lanes and jurisdictional ownership were included in the scoring.

o Roadway width was weighted higher than in counties. As a stronger correlation between roadway width to KSI crashes was found in cities.

The maximum score county and city roadways may attain was 24. For each roadway segment, a score was assigned for each attribute based on its intersection characteristics. These scores were then summed, multiplied by 100, and divided by 24. This resulted in a score out of 100 for each segment.

TABLE 4: COUNTY CORRIDOR SCORING

Attribute	Total Score	Range/Value	Representative Ratio	Score
AADT	8	<500	0.31	0
		500-1,999	3.02	3
		2,000-4,999	8.37	5
		5,000-9,999	10.79	8
		>=10,000	8.51	8
Roadway Width	3	No Data	0.25	0
		<22	1.40	1
		22+	2.95	3
Proximity to Schools	2	No	0.98	0
		Yes	2.36	2
Equity*	2	No	0.67	0
		Yes	1.76	2
Roadway Departure Crash History	2	No	Scoring	0
		Yes	Adjustment	2
Access Density	5	No Data	0.24	0
		< 5.0	3.07	3
		5 - 9.9	2.23	3
		10 - 14.9	4.44	5
		>=15	4.80	5
Edgeline Markings	2	No Data	0.92	0
		Not Present	1.39	2
		Present	0.95	0

Note: "Equity" denotes if the location is in a census tract that is considered disadvantaged or in an equity area. See project documentation on equity resources and communities.

TABLE 5: CITY CORRIDOR SCORING

Attribute	Total Score	Range/Value	Representative Ratio	Score
AADT	8	<500	0.32	0
		500-1,999	0.54	1
		2,000-4,999	1.79	2
		5,000-9,999	4.33	5
		>=10,000	5.85	8
Roadway Width	4	No Data	0.46	0
		<30	3.04	3
		30-40	2.06	2
		40+	3.76	4
Proximity to Schools	2	No	Scoring Adjustment	0
		Yes		2
Equity*	2	No	0.17	0
		Yes	1.38	2
VRU Crash History	2	No	Scoring Adjustment	0
		Yes		2
Number of Lanes	4	1	0.00	0
		2	0.71	0
		3	0.00	4
		4	3.93	4
Ownership	4	City	0.75	0
		County	1.55	2
		KDOT	3.59	4

Note: "Equity" denotes if the location is in a census tract that is considered disadvantaged or in an equity area. See project documentation on equity resources and communities.

HRN Thresholds and Prioritization

To establish a High Risk Network (HRN), the overall attribute risk score for each intersection and roadway segment was calculated. The resulting network was then analyzed to establish thresholds. This ensures that the HRN captures a significant yet focused portion of the network, representing areas of highest need for intervention.

Geographic Threshold Differentiation

Given the large project area, there are several differences between areas that suggest thresholds should be localized to smaller sub-geographies, similar to what was done for the HIN.

To align with the HIN methodology, we utilized the Natural Jenks Method of distribution to normalize geographies, which scales the data based on the total number of segments and intersections in each city and county, and places them into 5 categories from low to high. This allows for an accurate representation of data clusters and natural breaks.

Differing from the HIN methodology, each jurisdiction was evaluated independently to show a reasonable number of facilities within the High Risk Network for each jurisdiction. This methodology ensured that an actionable HRN was created for each jurisdiction.

Prioritization

As mentioned, the **Natural Jenks Method** was used to distribute crash severity scores into five categories, based on the natural distribution of the data. This process helped reveal the inherent groupings in the data by minimizing variance within each category and maximizing the variance between them.

After applying the Jenks Natural Breaks, only the **top two categories**, corresponding to the highest crash severity scores, were used for prioritization. These categories represent the highest-risk locations in the network, scoring **4** and **5** on the five-point scale.

1. Generating a New Priority Field

A new field was created in the dataset to house the values for these top two priority levels (scores 4 and 5). This field helps identify the most critical intersections and segments across each geography. By isolating these higher-priority areas, safety interventions are focused on the locations with the greatest potential for reducing severe crashes.

2. Application Across Geographies

This process was applied consistently across all geographies—both city and county. For every segment and intersection analyzed:

- **Intersections and segments** that scored in the top two categories (4 and 5) based on risk attributes were flagged in the newly generated field.

- The analysis was repeated for each individual jurisdiction that is a part of the US-83 safety coalition to ensure that the highest priority locations in each geography were highlighted for targeted intervention.

By using the top two categories from the Jenks distribution, the focus was narrowed to the locations with the most severe safety concerns, ensuring that limited resources are allocated to the areas with the highest risk of fatal or severe injury crashes.

GIS Visualization

A key component of the HRN is its integration with **GIS**, allowing for spatial analysis and the mapping of crash data. The resulting HRN list should be mapped alongside other project data to help determine project recommendations.

Final Priority Network HIN/HRN Overlay/ Engagement Results

After the HIN and HRN were created, the Priority Network was created by integrating findings from two key safety analyses—the High Injury Network (HIN) and the High-Risk Network (HRN)—along with community feedback. It categorizes road segments and intersections into various priority levels based on data from the HIN and HRN analyses. These findings are further cross-referenced with locations highlighted by the community during public engagement. The priority levels are defined as follows:

- **Priority Level 1** includes corridors and intersections that scored level 5 on both the HIN <u>and</u> HRN <u>and</u> identified by the community
- **Priority Level 2** includes corridors and intersections identified as level 5 on either the HIN* <u>or</u> the HRN <u>and</u> identified by the community
- **Priority Level 3** includes corridors and intersections identified as level 4 on both the HIN* <u>and</u> HRN <u>and</u> identified by the community
- **Priority Level 4** includes corridors and intersections identified as level 4 or higher on the HIN* <u>or</u> the HRN

*Network segments only exist where there is HIN and HRN alignment

The result is a network of roadway segments and intersections that show severe crash history, risk, and acknowledgment from the public as a known issue. An example of scoring results for Garden City, KS can be seen below.