Memorandum

HIN and Modal HIN Analysis Technical Memo

The purpose of this memorandum is to provide an overall summary of the methodology for creating high injury network (HIN) and intersection (HII) locations for the North Carolina Capital Area Metropolitan Planning Organization (CAMPO) jurisdiction. The purpose of these networks is to identify locations that have a high frequency of recent severe crashes that could be reviewed in detail for potential countermeasures, projects, and policy interventions.

Data

The project team obtained two sets of crash data from the North Carolina Department of Transportation (NCDOT):

- All crash data from the NCDOT enterprise crash database (2016-2023)
- Bicycle and pedestrian-specific crash data available via NCDOT's Open Data Portal (2013-2022)

These data sources included several characteristics such as location, roadway characteristics, and crash severity. There are several considerations for the application of both datasets:

- Crash data from NCDOT's enterprise database have limited crash location data. **Note that most, but not all crashes have a spatial location associated with them.** This limitation tends to impact less severe crashes more often.
- By contrast, the crashes in NCDOT's curated Bicycle and Pedestrian dataset are manually located, and therefore tend to have a more reliable spatial location.
- Furthermore, NCDOT reviews all potential bicycle and pedestrian crashes for accurate reporting. NCDOT:
  - removes crashes that may be labelled as bicycle or pedestrian that did not actually involve a bicyclist or a pedestrian, as well as
  - removes any crash that did not occur (or did not occur as a result of a vehicle traveling) in the public right of way (i.e., excluding parking lots or private driveways).
- Differences in crash frequency and timeliness account for the differences in the year ranges associated with each dataset (i.e., 7 years of total crashes and 10 years of bicycle and pedestrian crashes). Although all bicycle and pedestrian crashes are locatable, they are less frequent than total crashes and more observations are required for meaningful insights.

The project team also obtained NCDOT's route characteristics file and intersection inventory in a geographic information systems (GIS) format. The project team used a spatial join to link crashes with roadway segments based on a common route class (e.g., US Route or NC Route) for the all crash HIN version); this helped reduce the likelihood of erroneous joins between crashes and roadway segments. Intersection-related crashes were determined based on the 150-foot buffer standard in the NCDOT inventory.

Methodology

The scope of work for the Blueprint for Safety includes analysis of crashes occurring on the entire road network in the CAMPO region, with a purpose of understanding historic trends in the region. The following sections discuss the methodology for developing 3 high crash layers:

1. High Injury Intersections

2. High Injury Network – All crashes, regardless of crash type
3. High Injury Network – Bicycle and pedestrian crashes only

Severity Weighting

The project team used an equivalent property damage only (EPDO) approach to determine a severity weighting for crashes. This approach is consistent with a Safe System Approach by emphasizing fatal and serious injury crashes over other severities. Locations with a higher EPDO score tend to have more severe crashes than those with a lower score.

Figure 1 from [NCDOT's 2022 Standardized Crash Cost Estimates for North Carolina] provides the typical cost associated with crashes by severity.

Crash Type	Cost Per Crash 2022 Dollars
Fatal Crash	$11,983,000
A Injury Crash	$694,000
B Injury Crash	$230,000
C Injury Crash	$136,000
Property Damage Only Crash	$14,400
Average Crash	$135,000
Injury Crash (F+A+B+C)	$462,000
Non-Fatal Injury Crash (A+B+C)	$199,000
Severe Injury Crash (F+A)	$3,865,000
Moderate Injury Crash (B+C)	$168,000

Figure 1. Cost per Crash by Severity in North Carolina – Total Crashes

The EPDO methodology weights crashes based on crash costs associated with the severity of the crash, using the KABCO scale, relative to a property damage only (PDO) crash. Figure 2 provides an example of how to calculate the EPDO crash weight for a "B Injury" crash.

$$\frac{B\ Injury\ Crash\ Cost}{PDO\ Crash\ Cost} = EPDO\ Severity\ Weight$$

$$\frac{\$230{,}000}{\$14{,}400} = 16$$

Figure 2. Example EPDO Weighting of a "B Injury" Crash

Table 1 provides the weights used for all crashes in the EPDO analysis for HII/HINs.

Table 1. EPDO Weights for the Blueprint for Safety High Injury Locations

Crash Severity	Crash Cost ($2022)	EPDO Weight
Fatal (K) or Suspected Serious Injury (A)	$3,865,000	268
Suspected Minor Injury (B)	$230,000	16
Possible Injury (C)	$136,000	9
Property Damage Only (PDO)	$14,400	1

Figure 3 provides the method to calculate the total EPDO score for a segment.

$$Total\ EPDO\ Score = Total\ \text{Fatal (K)or Suspected Serious Injury (A)}\ Crashes * 268 +$$

$$Total\ Suspected\ Minor\ Injury\ (B) * 16 +$$

$$Total\ Possible\ Injury\ (C)\ \text{Crashes}\ *\ 9\ +$$

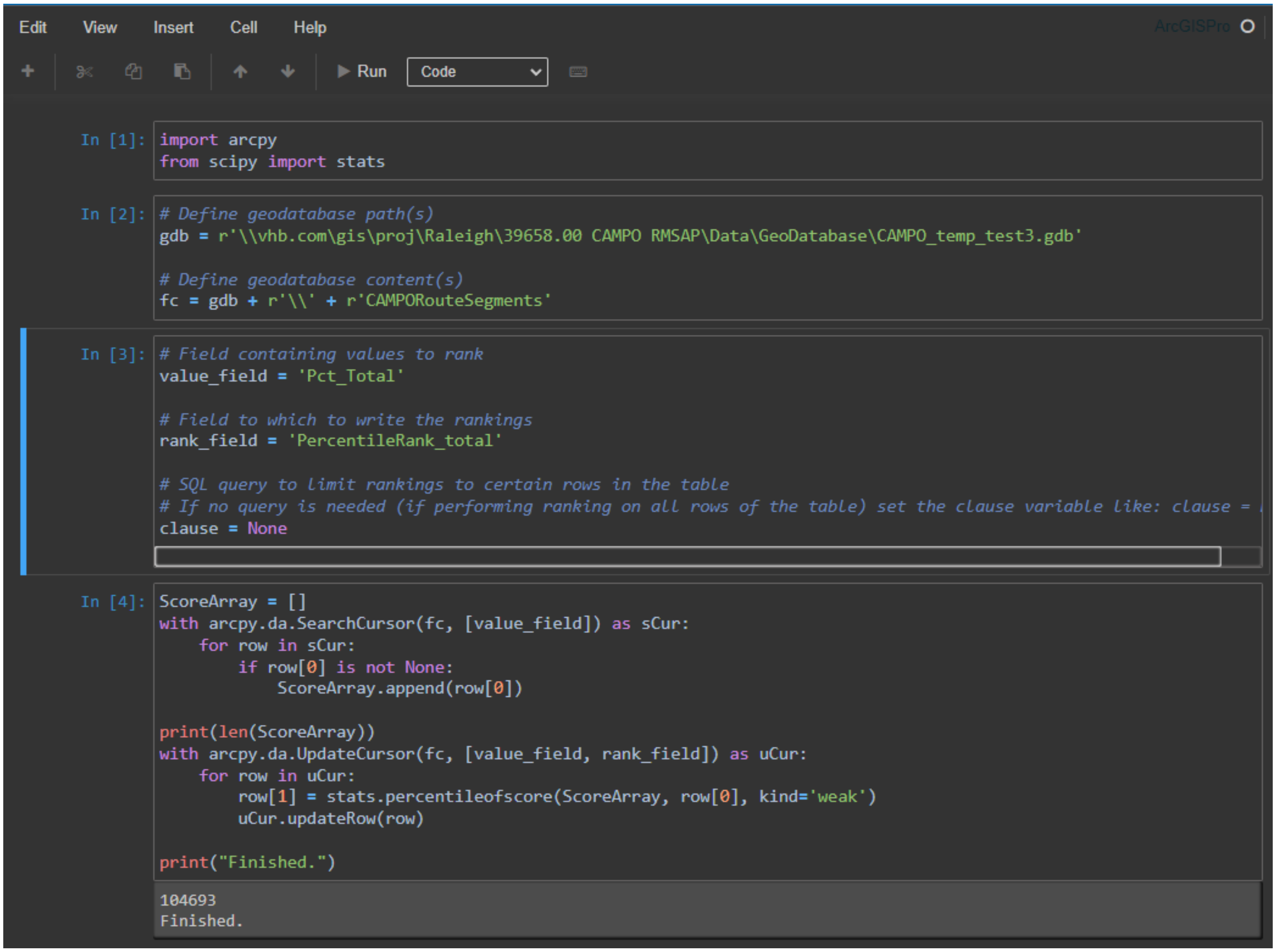
$$Total\ Property\ Damage\ Only\ (PDO)\ Crashes * 1$$

Figure 3. Example EPDO Calculation

High Injury Intersections

The following steps provide a summary for the development of the HII network.

- **Step 1:** Clip intersection polygons and spatially locatable crashes to the CAMPO planning area using the Pairwise Clip geoprocessing tool.
- **Step 2:** Spatial join intersection polygons to crash points with the parameters Join one to many, Closest, Keep ALL, and a search radius of 25ft.
- **Step 3:** Run Summary Statistics on the spatial join layer. Sum the EPDO field by KeyIntersectionID. This provides a sum of EPDO scores by unique intersection (Figure 3).
- **Step 4:** Use the join field geoprocessing tool to tie the Sum EPDO column to the original intersection layer using fields KeyIntersectionID and KeyIntersectionID.
- **Step 5:** For any locations with a *null* value in the summed EPDO field, calculate a “0.”
- **Step 6:** Calculate the percentile rank of all locations. This produces an ordered list, between 0 and 100, where this highest intersection based on EPDO is closest to 100 and the lowest is 0 (Figure 4). For instance, to determine the top 5 percent of locations, select all rows with a value of 95 and above.
- **Step 7:** Create a non-intersection crash layer based on crashes that were not located within the 150-ft influence area of an intersection polygon.



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In [1]: import arcpy
        from scipy import stats

In [2]: # Define geodatabase path(s)
        gdb = r'\\vhb.com\gis\proj\Raleigh\39658.00 CAMPO RMSAP\Data\GeoDatabase\CAMPO_temp_test3.gdb'

        # Define geodatabase content(s)
        fc = gdb + r'\\' + r'CAMPORouteSegments'

In [3]: # Field containing values to rank
        value_field = 'Pct_Total'

        # Field to which to write the rankings
        rank_field = 'PercentileRank_total'

        # SQL query to limit rankings to certain rows in the table
        # If no query is needed (if performing ranking on all rows of the table) set the clause variable like: clause =
        clause = None

In [4]: ScoreArray = []
        with arcpy.da.SearchCursor(fc, [value_field]) as sCur:
            for row in sCur:
                if row[0] is not None:
                    ScoreArray.append(row[0])

        print(len(ScoreArray))
        with arcpy.da.UpdateCursor(fc, [value_field, rank_field]) as uCur:
            for row in uCur:
                row[1] = stats.percentileofscore(ScoreArray, row[0], kind='weak')
                uCur.updateRow(row)

        print("Finished.")

        104693
        Finished.
```

Figure 4. ArcPy Script for Calculating Percentile Rank.

High Injury Network – All Crashes

The following steps provide a summary for the development of the HIN for all crashes in the CAMPO planning area. Steps 1 through 6 generate individual segments for the HIN.

- **Step 1:** Clip road centerlines and remaining, non-intersection crashes to the CAMPO planning area using the pairwise clip geoprocessing tool.
- **Step 2:** Segment roadway centerlines to generate segments between intersections using the intersection inventory and generate a unique ID for each road segment in the study area.
- **Step 3:** Using route class as a common attribute, join roadway segments to crashes with the parameters Join one to many, Closest, Keep ALL, and a search radius of 50 ft.
- **Step 4:** Run the Merge and Summarize Script with appropriate inputs and outputs to get final route segments with sum EPDO for each segment.
- **Step 5:** For any locations with a null value in the summed EPDO field, calculate a “0”

- **Step 6:** Calculate the percentile rank of all locations. This produces an ordered list, between 0 and 100, where this highest segment based on EPDO is closest to 100 and the lowest is 0 (Figure 4). For instance, to determine the top 5 percent of locations, select all rows with a value of 95 and above.

High Injury Network – Bicycle and Pedestrian Crashes

The following steps provide a summary for the development of the HIN for all crashes in the CAMPO planning area. The primary difference between the "All Crashes" version and the "Bicycle and Pedestrian Crash" version is the segmentation of the roadway. Since bicycle and pedestrian crashes are much less frequent than other crash types, road segments are developed using dynamic segmentation; this creates longer, contiguous segments than an intersection-to-intersection approach. This process creates homogenous segments based on selected attributes. For the CAMPO analysis, the project team used RouteID, functional class, and number of lanes to create homogenous segments of similar characteristics.

- **Step 1:** Clip road centerlines and remaining, non-intersection crashes to the CAMPO planning area using the pairwise clip geoprocessing tool.
- **Step 2:** Segment roadway using RouteID, functional class, and number of lanes fields with no multi-part features and generate a unique ID for each road segment in the study area.
- **Step 3:** Exclude road segments and crashes with the "Interstate" route class (road segments) or road class (crashes).
- **Step 4:** Use Spatial Join on study area crashes and study area segments – consider using join settings of Closest with a search radius of 50 feet.
- **Step 5:** Use Summary Statistics geoprocessing tool on the crash layer to get EPDO and Frequency (i.e., total number of crashes) by SegmentID.
- **Step 6:** Use Join Field to join crash frequency and sum of EPDO back to original segments using join fields SegmentID.
- **Step 7:** Calculate the percentile rank of all locations. This produces an ordered list, between 0 and 100, where this highest segment based on EPDO is closest to 100 and the lowest is 0 (Figure 4). For instance, to determine the top 5 percent of locations, select all rows with a value of 95 and above.