Research Report
KTC-10-16/KSP3-10-1F

KENTUCKY TRANSPORTATION CENTER

EVALUATION OF THE LOCATIONS OF KENTUCKY'S TRAFFIC CRASH DATA

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KTC-10-16/KSP3-10-1F

EVALUATION OF THE LOCATIONS OF KENTUCKY'S TRAFFIC CRASH DATA

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EXECUTIVE SUMMARY

This research study evaluated the current accuracy of the location information provided in Kentucky's crash data. Since the year 2000, the Kentucky Open Portal System's (KYOPS) eCrash form has included latitude and longitude data as well as the more traditional County, Route and Milepoint data (CRMP). The Kentucky Transportation Center conducted a research report in 2004 that evaluated the effectiveness of using latitude and longitude, or GPS, as a means to locate traffic crash data.[1] This previous study found that both the CRMP and GPS location data had substantial problems resulting in the location data only being accurate about 50 percent of the time using either method. This research aimed to follow up that study since KYOPS has added a mapping system called MapIt that generates CRMP data as well as GPS data using a GIS-based interface allowing the user to click on a map using roadway names and milepoints as reference.

An evaluation of a random sample of crashes from 2009 was performed to assess the current accuracy of the crash data's location information. The location of the crash was compared to the presumed location using several report data elements such as nearest city, street address, roadway descriptions and the crash narrative. A second evaluation was performed on crash data since the MapIt system was introduced (in late 2007) through 2009. This analysis calculated the distance between the locations plotted by CRMP and by the GPS data and summarized the data by several factors.

The evaluation of the random sample of crash data revealed that the location information is accurate in a substantially higher number of records compared to the study five years ago (92 percent accuracy compared to about 50 percent). Furthermore, the evaluation of the 2007 through 2009 crash data yielded results that aided in making recommendations that will address the most egregious and frequent errors related to location data. For instance, some problems in the MapIt system were found that can greatly affect the CRMP and GPS location data. Finally a literature review based on national consensus was summarized to better describe where a crash should be located when a police report is completed.

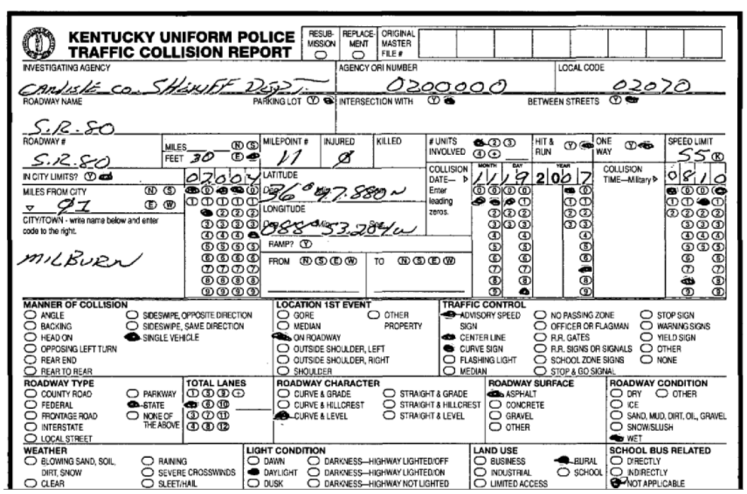
[1]Green, E. and K. Agent, "Evaluation of the Accuracy of GPS as a Method of Locating Traffic Collisions," Kentucky Transportation Center, University of Kentucky, KTC-04-08/SPR 276-04-1F, June 2004.

1.0 INTRODUCTION

An important component of a traffic crash location is the proper documentation of the crash location. This can be difficult, and somewhat subjective, if the crash occurs over a large distance or if there were multiple events. One of the most important reasons for accurate crash locations is so that a traffic engineer can properly identify where a crash occurred in an effort to avoid future crashes. Prevention can be in the form of educational campaigns, enforcement efforts or highway safety improvements. Moreover, properly locating crashes to the road it occurred (and the correct sections of road) will allow the crash data to be linked to roadway traffic volumes so that rates can be calculated. Rates allow a way for researchers to find roadway sections that may not have a large number of crashes, but rather a higher crash or fatality rate when based on the number of vehicles that travel on that roadway section.

The police agencies in Kentucky have two methods of reporting traffic crashes: using the eCrash component of Kentucky Open Portal System's (KYOPS), an electronic reporting system, or manually using paper reports. The location information for either method comes in two forms: latitude and longitude coordinates (GPS) and county, route and milepoint (CRMP). These two formats have distant advantages over one another with the ideal solution being the preservation of both formats.

The paper report contains fields for county, route and milepoint and GPS coordinates. The CRMP data is typically entered using the 'distance from' field where the distance and the direction from a reference point are entered (a milepoint from a known location). Additionally, the county and route are also entered. CRMP data is only requested for state-maintained roadway crashes. This has been the primary source of location data prior to 2000. In 2000, GPS coordinates were added to the form. On June 1st, 2002, GPS coordinates were required on all reports. The coordinates are reported in degrees, minutes and seconds. An example portion of a paper report is shown below.



KENTUCKY UNIFORM POLICE TRAFFIC COLLISION REPORT

RESUBMISSION | REPLACEMENT | ORIGINAL MASTER FILE #

INVESTIGATING AGENCY: Carlisle Co. Sheriff Dept.
AGENCY ORI NUMBER: 0200000
LOCAL CODE: 02070
ROADWAY NAME: S.R. 80
PARKING LOT (Y) (N)
INTERSECTION WITH (Y) (N)
BETWEEN STREETS (Y) (N)
ROADWAY #: S.R. 80
MILES / FEET: 30 (N) (S) (E) (W)
MILEPOINT #: 11
INJURED: Ø
KILLED
UNITS INVOLVED
HIT & RUN (Y) (N)
ONE WAY (Y) (N)
SPEED LIMIT: 55
IN CITY LIMITS? (Y) (N)
MILES FROM CITY: Ø1 (N) (S) (E) (W)
CITY/TOWN - write name below and enter code to the right.: Milburn 02004
LATITUDE: Deg 36° Min 47.880 N
LONGITUDE: Deg 088° Min 53.284 W
RAMP? (Y)
FROM (N) (S) (E) (W) TO (N) (S) (E) (W)
COLLISION DATE— Enter leading zeros.: MONTH 11 DAY 19 YEAR 2007
COLLISION TIME—Military: 0810

MANNER OF COLLISION: ANGLE; BACKING; HEAD ON; OPPOSING LEFT TURN; REAR END; REAR TO REAR; SIDESWIPE, OPPOSITE DIRECTION; SIDESWIPE, SAME DIRECTION; SINGLE VEHICLE

LOCATION 1ST EVENT: GORE; MEDIAN; ON ROADWAY; OUTSIDE SHOULDER, LEFT; OUTSIDE SHOULDER, RIGHT; SHOULDER; OTHER PROPERTY

TRAFFIC CONTROL: ADVISORY SPEED SIGN; CENTER LINE; CURVE SIGN; FLASHING LIGHT; MEDIAN; NO PASSING ZONE; OFFICER OR FLAGMAN; R.R. GATES; R.R. SIGNS OR SIGNALS; SCHOOL ZONE SIGNS; STOP & GO SIGNAL; STOP SIGN; WARNING SIGNS; YIELD SIGN; OTHER; NONE

ROADWAY TYPE: COUNTY ROAD; FEDERAL; FRONTAGE ROAD; INTERSTATE; LOCAL STREET; PARKWAY; STATE; NONE OF THE ABOVE

TOTAL LANES: 1 5 9 + 2 6 10 3 7 11 4 8 12

ROADWAY CHARACTER: CURVE & GRADE; CURVE & HILLCREST; CURVE & LEVEL; STRAIGHT & GRADE; STRAIGHT & HILLCREST; STRAIGHT & LEVEL

ROADWAY SURFACE: ASPHALT; CONCRETE; GRAVEL; OTHER

ROADWAY CONDITION: DRY; OTHER; ICE; SAND, MUD, DIRT, OIL, GRAVEL; SNOW/SLUSH; WET

WEATHER: BLOWING SAND, SOIL, DIRT, SNOW; CLEAR; RAINING; SEVERE CROSSWINDS; SLEET/HAIL

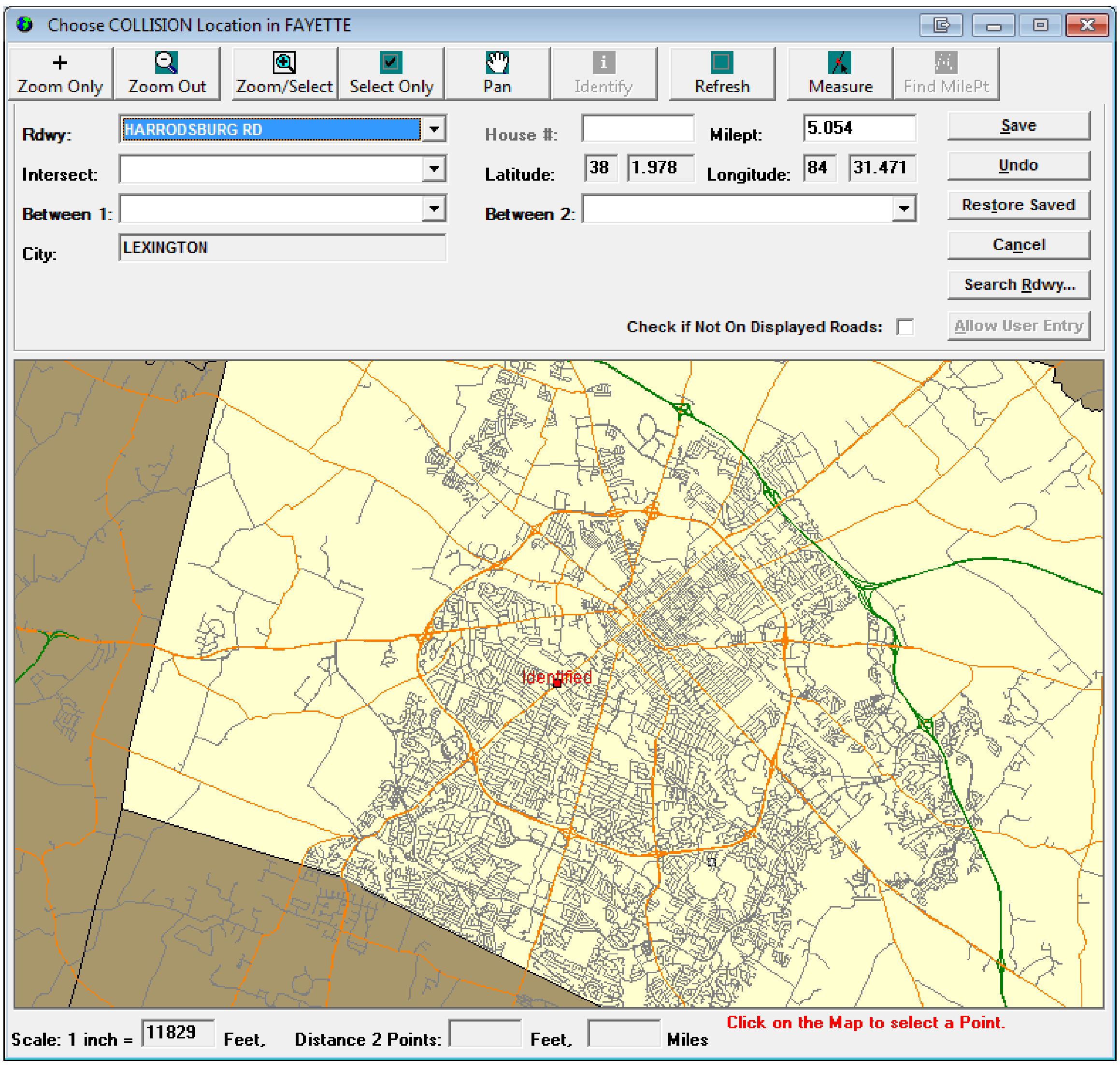
LIGHT CONDITION: DAWN; DAYLIGHT; DUSK; DARKNESS—HIGHWAY LIGHTED/OFF; DARKNESS—HIGHWAY LIGHTED/ON; DARKNESS—HIGHWAY NOT LIGHTED

LAND USE: BUSINESS; INDUSTRIAL; LIMITED ACCESS; RURAL; SCHOOL

SCHOOL BUS RELATED: DIRECTLY; INDIRECTLY; NOT APPLICABLE

The paper report shown indicates that the crash occurred 30 feet west of milepoint 11 (likely based on the presence of a mile marker). This is calculated in the database as 10.994 (11 – 30/5,280). The county is identified as Carlisle County and the route is KY-80. The CRMP data is therefore 020-KY-0080 at 11.994. The GPS data is shown in this case in degrees and decimal minutes, despite the fact that the form expects the data in degree-minutes-seconds. This can be entered erroneously into the database because of this discrepancy.

The eCrash system dramatically increases the effectiveness of the crash reporting system. Initially, the same system as in the paper report was used to locate crash data. That is, CRMP using the 'distance from' form and degree-minute-second GPS data. However, a major update to KYOPS included the implementation of a mapping system called MapIt which was added on October 1, 2007. This system allows the officer to click on a point on a map and the GPS coordinates and CRMP data would be automatically filled out. A screenshot of the MapIt system is shown below.



In this example the identified location is shown by milepoint and by degree and decimal-minutes GPS. Additionally, the proper route identifier (034-US-0068) is provided in the location form.

This research report evaluated the current accuracy of the crash data since the implementation of the MapIt system.

2.0 PROCEDURE

2.1 Random Sample of Crashes

With 126,237 reported crashes in 2009 (not including private property and parking lot crashes), a sample size of about 200 was needed to produce a 95% confidence level and a confidence interval of +/- 7 percent[2]. The number of samples needed would need to be nearly doubled to reach a confidence interval of 5 percent. Unfortunately, the process is too time-consuming to reach that level of confidence for this study.

A sample of 222 random crashes from the 2009 crash database was obtained. Only crashes with a GPS value were included in the initial dataset. Crashes occurring on local and state-maintained roadways were used. The police report for each crash was reviewed. A data field was used to verify that all reports had a GPS location that was generated by the MapIt system. Therefore, the GPS of each report was used as the "Report Location."

An attempt to determine if the report location was accurate was made for each report. A "yes" was assigned to the crash if its report location was within approximately 500 feet from the presumed location of the crash. Conversely, a "no" was given to crashes where the presumed location was outside of a 500 foot radius of the reported location. The presumed location was based on any information in the report that definitive identified its location. Report narratives, addresses or intersecting or between roads were typically used to identify the presumed location. Each crash was assigned a location type:

- Intersection – an intersecting road was given
- Between Streets – two streets were listed as reference points
- None – neither of the above

A value of "unknown" was given to reports where a definitive location could not be pinpointed. Google® Maps was the primary tool used for plotting addresses and GPS coordinates. In some cases, ArcMap® was used to plot milepoints for comparisons.

It should be noted that a distance of 500 feet is reasonable for network screening or high crash locations but it can be too small for individual crash analysis. This distance was used to account for errors in data projection or address approximations.

[2] Creative Research Systems Sample Size Calculator, 2010

Each crash was given a range that defined the distance between the presumed and reported locations. For example, if the crash was determined to be approximately 300 feet from the actual location then the range would be: Min=300, Max=300. If the actual location could not be precisely pinpointed then a range of realistic values was used. This could be based on the length of the road or presence of locatable landmark (intersection, bridge, road character, etc.). For instance, it is unlikely to assume that an interstate crash is 10 miles from the reported location if there are exits every mile.
The average offset is the midpoint of Max and Min values. This value can be used to quantify the accuracy of the location. When possible, a description for why the location was incorrect was given.

2.2 Crash Database Analysis

Crash data were obtained from October 1, 2007 to December 31, 2009. This time frame was used as it was the start of KYOPS's mapping system and included data up until the last full yearly extract. This resulted in a database of 334,354 crash records.

All of the records with a valid county, route and milepoint were plotted against the state's Allrds_m shapefile using ESRI's ArcMap®. The crash fields RSEUniqueGPS (county-route) and CurrentDerivedMiepointNumber (milepoint) were used to plot along the LRS_ID field of Allrds_M. The county-route field identifies the county number and the route prefix, number, suffix as well as the route type (mainline, ramp, non-cardinal, etc.). Some of the data reported had a mis-formated RSE field. For instance, some had leading zeros in the route number and some had a dash after the county. For plotting purposes, the format required was: 001 KY-55 or 001 KY-55-20. The latter indicates that the route is an auxiliary system to KY-55 (such as a channelized right turn lane). The RSE field was modified where necessary to plot properly.

A GPS coordinate was added to all successfully plotted data. These coordinates were compared to the crash GPS data by calculating the distance between them using the following formula:

$$D = R\cos^{-1}\left(\cos\left(long_1 - long_2\right)\cos\left(lat_1\right)\cos\left(lat_2\right) + \sin\left(lat_1\right)\sin\left(lat_2\right)\right)$$

where:
D = distance in miles
R = radius of Earth (3,963.19 miles)
lat_1 = latitude from crash report
$long_1$ = longitude from crash report
lat_2 = latitude of plotted location
$long_2$ = longitude of plotted location

The difference in the longitude from the reported GPS and the longitude created from the plotted CRMP data was used to approximate the horizontal component of the distance calculated above. For such relatively small distance (as compared to the radius of the Earth), the spherical formula used above was unnecessary. The vertical distance was similarly calculated from the latitude values. Crashes that had a horizontal component that was more than 90 percent or less than 10 percent of the straight-line distance between the two coordinates were flagged as a 90/10 error (90 percent of the distance is in either the horizontal or vertical direction). The following formulas were used to calculate these values.

$$D_{horz} = Long_{CRMP} - Long_{GPS}$$
$$D_{vert} = Lat_{CRMP} - Lat_{GPS}$$
$$D = \sqrt{D_{horz}^2 + D_{vert}^2}$$
$$90/10 Error = \frac{D_{horz}^2}{D^2} \times 100$$

As an example, if the straight line distance was five miles, the horizontal distance was three miles and the vertical distance was four miles, then the horizontal percentage would be 36 percent (9/25*100).

Crashes with the horizontal component higher than 90 percent are possibly due to GPS recording errors in longitude. Likewise, crashes with a horizontal component lower than 10 percent are possibly due to GPS recording errors in latitude. A misleading instance of this error can exist in cases where roads are oriented either east-west or north-south. In these cases, either the GPS reading could have been measured down the road from the actual crash location or the milepoint may have been reported at an incorrect distance from the actual crash location. In either case, the results could be perceived as a latitudinal/longitudinal type of error. Errors in the CRMP data that could contribute to this error occur when the wrong direction is given from the reference milepoint.

3.0 RESULTS

3.1 Random Sample of Crashes

The 222 random crashes were reviewed and the results are shown in Appendix A. Of the 222 crashes, 71 percent were shown to be in the accurate position, 6 percent were not, and the remaining crashes were unable to be definitively assessed. It should not be assumed that the unknown locations are incorrect. These locations typically had a lack of reference that made them harder to pinpoint. The accuracy percentage is 92 percent when excluding those records with unknown accuracy (152 of the 167 with determinable locations). The following table shows the percentage by accuracy and type of crash location.

Was location Accurate (Percent)?	Type of Location			
	Between streets	Intersection	None	Grand Total
Yes	100.0	100.0	54.6	71.2
No	0.0	0.0	9.2	5.9
Unknown	0.0	0.0	36.2	23.0
Grand Total	**100.0**	**100.0**	**100.0**	**100.0**

In the above table percentages are shown by columns. It is clear that unknown and inaccurate data is only a factor for crashes that do not have intersecting or between streets. This is largely due to the fact that there are much fewer reference points in the MapIt system when report crashes in more rural areas.

As discussed earlier, an average offset was calculated for all crash records in this sample. This value represents an average distance the presumed location is from the reported location. When the location is known, this value represents the distance along the road that the presumed location is from the reported location. For unknown locations, this value represents the distance between the reported location and the midpoint between the minimum and maximum presumed location. This value is subjective, but is controlled by the presence of logical reference points. The following table shows the average offset in feet by location accuracy and location type.

Average of Offset (Ft)	Type of Location			
Was Location Accurate?	Between streets	Intersection	None	Grand Total
Yes	221	20	65	92
No			6,346	6,346
Unknown			2,012	2,012
Grand Total	**221**	**20**	**1,357**	**903**

Intersection crashes have the shortest offset, which is explainable as intersection crashes offer the best reference system. The second shortest offset was for accurate crashes with location type ‘none’. Between street crashes had the longest offset for accurate crashes which could be attributed to distance between the streets. These crashes have reference points but they are not nearly as definitive as a single interesting road.

The maximum offset of the crash records was over eight miles. The maximum offset for records with an unknown location was about 3.5 miles. This value, although calculated from a small sample of only 51 crashes, represents a logical maximum for crashes based on available reference points.

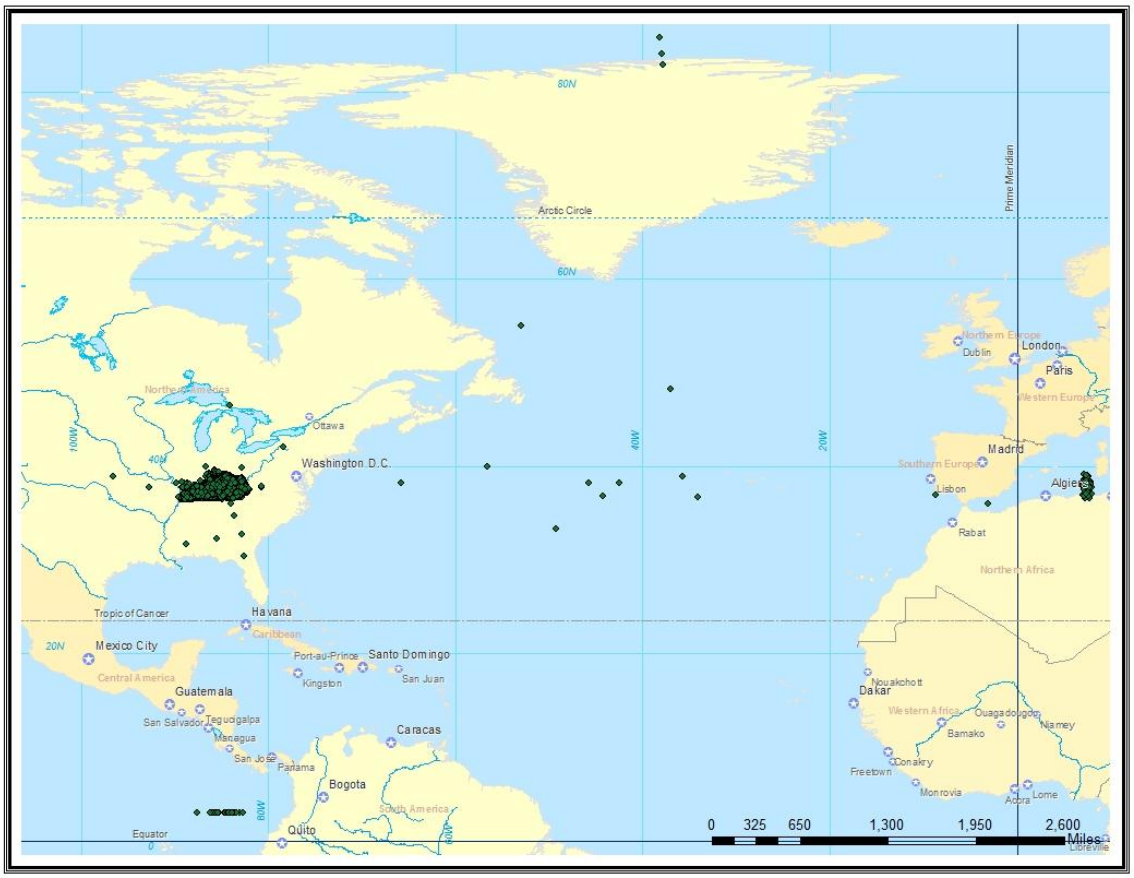
The thirteen crashes that were coded as inaccurate had two explanations:

- GPS is not consistent with address/reference (12 crashes)
- No reference point (1 crash)

The former explanation was indicated when an address or specific reference point (presumed location) was given in the narrative or otherwise on the report and that location is not within 500 feet of the GPS location (report location). In some cases this could be due to errors in the addressing system used by Google® Maps. However, this is unlikely as those types of errors would be smaller than 500 feet. The latter explanation indicated that there was not a nearby reference point for the officer to use. This implies that the officer needed to "guess" where to click on the mapping system.

3.2 Crash Database Analysis

The crash data were summarized by several factors in order to evaluate the accuracy of the data and to recommend improvements. Of the 334,354 crashes, only 186 crashes had no GPS data. The following figure shows the crash data as plotted by the reported GPS coordinates.

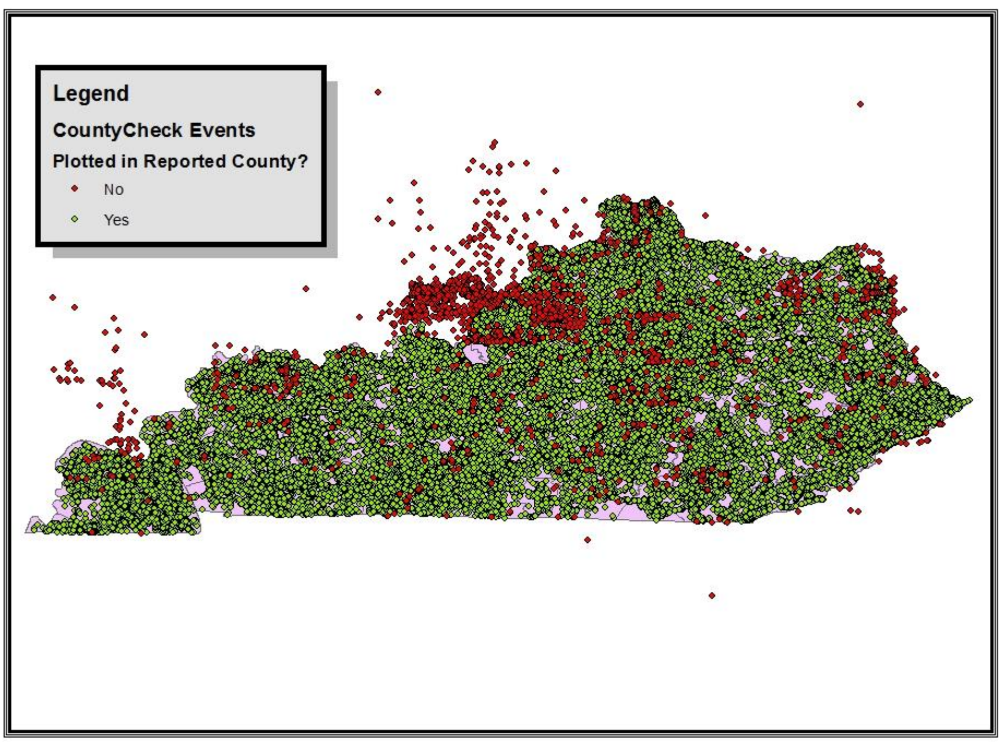


It should be noted that the above figure does not indicate what percentage of crashes that were plotted out of Kentucky. In fact, as discussed below, this is a very small percentage. However, the figure was included to show the scale of some of the GPS errors.

Of the 334,354 crashes, 261,973 (78 percent) had value for RSE (county and route) and milepoint. Of those, 258,376 (77 percent of all crashes) were able to be plotted (along local and state-maintained). For a majority of the analysis below, crashes that had a GPS and were able to be plotted were referred to as 'usable.' These represent the crashes that could have a distance calculated between the GPS and CRMP locations. There were 258,374 (77 percent of all crashes) that were usable. The following table shows the percentage of usable data by year.

	Usable (Percent)	
Year	No	Yes
2007	38.8	61.3
2008	22.9	77.2
2009	18.2	81.8
Grand Total	**22.7**	**77.3**

The "CityCountyCode" field from the crash database was used to obtain the county that each crash was reported. The reported county was compared to county that the GPS was plotted. The following figure shows all the crashes near Kentucky as red or green. Red dots represent crashes that were not plotted in their reported county. Obviously, any crashes that were plotted outside of the view frame would also be red. The red dots have been promoted to the top of the map to indicate where the mis-plotted crashes are being plotted.



The following table shows the percentage of crashes that were plotted outside of their county by year.

Year	Plotted In Reported County? (Percent) No	Yes
2007	2.7	97.3
2008	1.1	98.9
2009	0.3	99.7
Grand Total	**0.9**	**99.1**

The same is shown below summarized by reporting county. Only counties with more than one percent of the crashes plotted outside of the reported county are shown.

County	Percent Outside of Reported County
Hancock	12.79
Whitley	7.13
Fulton	6.60
Johnson	5.99
Robertson	4.35
Cumberland	3.37
Carter	3.24
Estill	2.52
Butler	2.31
Martin	2.29
Jefferson	2.13
Greenup	2.01
Lawrence	1.79
Leslie	1.48
McCracken	1.39
McCreary	1.37
Ballard	1.36
Boone	1.33
Boyd	1.27
Lewis	1.16
Lee	1.11
Nicholas	1.11
Magoffin	1.10

Only seven counties had a percentage of zero indicating that all of the crashes for that county were plotted inside of that county. Those counties are: Bracken, Graves, Hickman, Metcalfe, Owsley, Spencer and Wolfe. All percentages by reported county are shown in Appendix B in descending order.

The same analysis was repeated for the crash city code and the agency code (indicates the police agency responsible for the crash report). It should be noted that several of these cities and agencies had very small sample sizes resulting in very misleading percentages. For instance, 100 percent of all crashes in Calhoun in Daviess County were plotted outside of the county although there was only one crash reported in that city for the three-year period and that crash was located incorrectly. The following cities had the highest percentages of crashes being plotted outside of their county and at least 10 crashes plotted for that county.

City	County	Percent Outside of Reported County	Sample
Volga	Johnson	28.57	14
Carter	Carter	25.93	81
Hickman	Fulton	22.73	110
Hode	Martin	18.18	11
Staffordsville	Johnson	17.69	130
Thealka	Johnson	17.65	17
Lewisport	Hancock	15.94	69
Tutor key	Johnson	15.38	13
Upton	Hardin	15.22	46
Sitka	Johnson	15.00	60

There were too many cities to include the entire list in this report. The following agencies had the highest percentages of crashes being plotted outside of their county and at least 10 crashes.

Agency	Agency City	Agency County	Percent Outside of Reported County	Sample
Breathitt County Sheriff Dept.	Jackson	Breathitt	62.50	16
Hickman Police Department	Hickman	Fulton	60.00	45
Lewisport Police Department	Lewisport	Hancock	45.45	22
Johnson County Sheriff Dept.	Paintsville	Johnson	17.86	644
Hancock County Sheriff Dept.	Hawesville	Hancock	14.35	216
Burkesville Police Department	Burkesville	Cumberland	13.79	29
Whitley County Sheriff Dept.	Williamsburg	Whitley	10.59	746
Jefferson County Sheriff Dept.	Louisville	Jefferson	9.38	32
Ferguson Police Department	Ferguson	Pulaski	9.09	11
Ky State Police, Post 14	Ashland	N/A	7.48	1176
Corbin Police Department	Corbin	Whitley	7.16	1551
Bloomfield Police Department	Bloomfield	Nelson	6.67	15
Catlettsburg Police Department	Catlettsburg	Boyd	6.11	229
Estill County Sheriff Dept.	Irvine	Estill	5.61	428
Worthington Police Department	Worthington	Greenup	5.56	18

Similarly, there were too many agencies to include all of them in this report.

Every year there are fewer paper reports submitted. This trend is in favor of the newer and easier to use eCrash system through KYOPS. The following table shows this trend over the crash study period.

	Percent			
	Year			
Submission Type	2007	2008	2009	Grand Total
Electronic	82.9	88.7	97.3	91.8
Paper	17.0	11.3	2.8	8.2
Grand Total	**100.0**	**100.0**	**100.0**	**100.0**

Only 2.8 percent (4,067 of 148,010) of all submitted reports were paper in 2009. This is the lowest percentage of paper reports year-to-date. Paper reports were fairly evenly distributed by agency type (KSP, Sheriff, etc.) and by roadway type (local or state routes). The counties with the lowest percentages of electronic reports are shown below.

County	Percent of Electronic Reports	Sample
Hancock	11.1	34
Nicholas	52.8	190
Johnson	60.7	942
Jefferson	67.3	43,210
Whitley	71.0	1,793
Owsley	73.5	86
Gallatin	79.6	483
Estill	80.5	574
Warren	80.9	8,168

It should be noted that Hancock County also had the highest percentage of crashes being plotted outside of their county. This is likely due to their low electronic crash reporting. It should also be noted that Jefferson County has a very high percentage of paper reports being submitted (32.7 percent) and it has a very high number of paper reports. However, Jefferson County has seen a reduction in the percentage of paper (from 4,067 of 143,943 or 2.8 percent in 2009 down from 12.7 percent in 2008). A list of all counties, percentage of electronic reports and total reported crashes is shown in Appendix C.

The following is a list of cities that had an electronic submission rate of 75 percent or lower and had at least 10 crashes submitted.

City	County	Percent of Electronic Reports	Sample
Plantation	Jefferson	1.04	96
Villa hills	Kenton	5.22	115
Thealka	Johnson	5.88	17
Sitka	Johnson	6.67	60
Volga	Johnson	7.14	14
Tutor key	Johnson	7.69	13
Meally	Johnson	8.00	25
Hawesville	Hancock	8.97	234
Boons camp	Johnson	16.67	12
Lewisport	Hancock	17.39	69
Thelma	Johnson	18.18	11
Williamsport	Johnson	19.05	21
Staffordsville	Johnson	19.23	130
Riceville	Johnson	20.00	10
Van lear	Johnson	20.45	44
Wittensville	Johnson	20.59	34
West van lear	Johnson	20.83	24
Hagerhill	Johnson	22.77	101
Flatgap	Johnson	23.91	46
Lowmansville	Johnson	25.00	16
East point	Johnson	26.09	23
Oil springs	Johnson	29.41	34
Worthington	Greenup	41.18	17
Neon	Letcher	46.00	50
Carlisle	Nicholas	50.15	341
Powderly	Muhlenberg	50.39	127
Williamsburg	Whitley	55.95	1092
Bellevue	Campbell	56.50	600
Millersburg	Bourbon	56.92	65
Hickman	Fulton	60.91	110
Reidland	McCracken	62.00	100
Louisville	Jefferson	62.57	55,541
Elkhorn city	Pike	62.90	124
Pineville	Bell	62.93	410
Hyden	Leslie	63.39	112
Lone oak	McCracken	66.43	277
Napoleon	Gallatin	67.86	28
Northfield	Jefferson	67.89	109
Cloverport	Breckinridge	70.00	60
West paducah	McCracken	70.83	24
Booneville	Owsley	70.87	103
Whitesburg	Letcher	72.10	448
Clementsville	Casey	72.41	29
Cunningham	Carlisle	75.00	60
Dunnville	Casey	75.00	24
Jacktown	Casey	75.00	12

Several of these cities are in Johnson County and a large proportion of the crashes are in Louisville. The same analysis was performed on agencies. Again, a complete list of percentages by city and agency were excluded due to their vast size. The following table shows agencies that reported at least 10 crashes and had an electronic submission rate of 75 percent or below.

Agency	Agency City	Agency County	Percent of Electronic Reports	Sample
Hindman Police Department	Hindman	Knott	0.00	12
Lone Oak Police Department	Paducah	McCracken	0.00	12
Augusta Police Department	Augusta	Bracken	0.00	15
Breathitt County Sheriff Dept.	Jackson	Breathitt	0.00	16
Caneyille Police Department	Caneyville	Grayson	0.00	17
Millersburg Police Department	Millersburg	Bourbon	0.00	21
Booneville Police Department	Bonneville	Owsley	0.00	21
Lewisport Police Department	Lewisport	Hancock	0.00	22
Burkesville Police Department	Burkesville	Cumberland	0.00	29
Fleming-Neon Police Department	Neon	Letcher	0.00	31
Hawesville Police Department	Hawesville	Hancock	0.00	36
Northfield Police Department	Northfield	Jefferson	0.00	41
Hyden City Police	Hyden	Leslie	0.00	41
Hickman Police Department	Hickman	Fulton	0.00	45
Elkhorn City Police Department	Elkhorn city	Pike	0.00	46
Powderly Police Department	Powderly	Muhlenberg	0.00	62
Carlisle Police Department	Carlisle	Nicholas	0.00	170
Hancock County Sheriff Dept.	Hawesville	Hancock	0.00	216
Whitley County Sheriff Dept.	Williamsburg	Whitley	0.00	746
Villa Hills Police Department	Villa hills	Kenton	0.85	117
Johnson County Sheriff Dept.	Paintsville	Johnson	1.86	644
Cloverport Police Department	Cloverport	Breckinridge	18.18	22
Simpsonville Police Department	Simpsonville	Shelby	18.37	98
Pineville Police Department	Pineville	Bell	18.42	190
Jefferson County Sheriff Dept.	Louisville	Jefferson	18.75	32
Worthington Police Department	Worthington	Greenup	33.33	18
Silver Grove Police Department	Silver grove	Campbell	38.10	21
Irvine Police Department	Irvine	Estill	41.53	118
Bellevue Police Department	Bellevue	Campbell	56.26	599
Whitesburg Police Department	Whitesburg	Letcher	56.45	287
Gallatin County Sheriff Dept.	Warsaw	Gallatin	62.11	322
Louisville Metro Police Dept	Louisville	Jefferson	62.75	56,189
Division Of Law Enforcement	Lexington	Fayette	63.16	114
Barbourville Police Department	Barbourville	Knox	63.45	249
Nortonville Police Department	Nortonville	Hopkins	70.83	24
Bowling Green Police	Bowling green	Warren	72.58	6,930
Casey County Sheriff Dept.	Liberty	Casey	73.99	396

The crash database contains a field called UserEnteredRdwysInd that served a dual-purpose in this analysis. This field is populated with a “Y” if the user chooses to modify the location data provided by the MapIt system. By default the field is “N” indicating that the user did not modify the MapIt location data. However, if a system was used that did not have the MapIt system, then the field was blank. The following table shows the percentage of each type of report by year as well as for electronic and paper submission types.

Submission Type	Percent Year 2007	2008	2009	Grand Total
Electronic	**82.9**	**88.7**	**97.3**	**91.8**
No MapIt	44.3	14.0	0.0	11.5
Used MapIt	35.6	70.7	90.3	75.1
Used MapIt But Changed	3.0	4.0	6.9	5.2
Paper	**17.1**	**11.3**	**2.7**	**8.2**
No MapIt	17.1	11.3	2.7	8.2
Grand Total	**100.0**	**100.0**	**100.0**	**100.0**

Less than three percent of all crashes did not use MapIt in 2009 compared to over 25 percent in 2008.

The remainder of this analysis involved looking at the difference between the plotted GPS location versus the plotted CRMP location. Both the GPS and CRMP locations had to be useable. All records with a usable location data were flagged and referred to as "usable." Crashes with no GPS were not usable. Very few crashes had no GPS. There were 186 crashes in the timeframe with no GPS. Crashes with no RSE, MP or crashes that had an invalid RSE or MP were not usable. That is to say, any crash that did not plot on the state's allrods_m shapefile was not usable. The following table shows the percentage of each plot type by year.

All Records (Percent) Plot Type	Year 2007	2008	2009	Grand Total
OKAY	61.3	77.2	81.8	77.3
No RSE	6.1	2.4	1.7	2.6
Did Not Plot	1.2	1.3	0.8	1.1
No RSE and MP	25.7	8.0	4.4	8.5
No MP	5.8	11.2	11.3	10.6
Grand Total	**100.0**	**100.0**	**100.0**	**100.0**

A large majority (over 80 percent) of all paper reports didn't have CRMP data; however, a large portion of these could be local roads that do not require this data for paper submissions. The following table shows the same data as above for only electronic submissions.

Electronic Plot Type	Percent Year 2007	2008	2009	Grand Total
OKAY	70.0	84.9	83.6	82.6
No RSE	7.0	2.5	1.7	2.6
Did Not Plot	0.7	1.1	0.8	0.9
No RSE and MP	22.2	3.1	2.8	5.1
No MP	0.1	8.4	11.1	8.8
Grand Total	**100.0**	**100.0**	**100.0**	**100.0**

Some of these percentages may include crashes that had no GPS. Only crashes with GPS and a plot type of 'okay' were considered usable. The following table shows the number and percentage of crashes by agency and whether it is usable.

	Usable				Total	
	Yes		No			
Reporting Agency	Count	Percentage	Count	Percentage	Count	Percentage
KSP	35,208	92.6	2,811	7.4	38,019	100.0
Local	169,352	72.2	65,322	27.8	234,674	100.0
Sheriff	53,814	87.3	7,847	12.7	61,661	100.0
Grand Total	**258,374**	**77.3**	**75,980**	**22.7**	**334,354**	**100.0**

Kentucky State Police had the highest percentage of usable crashes, followed closely by County Sheriff. Local police had the lowest percentage of usable crashes (72.7 percent), however, they handled the majority of crashes (70 percent).

When "distance" is referred to in the remainder of this report, the distance is between CRMP and GPS locations. The "distance" was calculated for all usable crashes. The following table shows the average "distance" (in feet and miles) for all usable crashes by year and a count of the crashes.

Row Labels	Average "Distance" (Feet)	Average "Distance" (Miles)	Crash Count
2007	16,185	3.1	24,874
2008	40,713	7.7	112,434
2009	1,793	0.3	121,066
Grand Total	**20,115**	**3.8**	**258,374**

It should be noted that calculating an average distance is largely affected by outliers. Furthermore, the "distance" should not be viewed as a measure of crash location accuracy but rather a discrepancy of the locations which might be an indicator of an inaccurately located crash.

The crash database was sorted by "distance" and several of the most egregious errors were examined. There were two types of electronic reporting errors that yielded large "distance" between the CRMP and GPS locations.

One error resulted in the longitude being off by -96 degrees. Adding this value to these crashes re-plotted the crash very close to the CRMP location. For example, the crash with a master file number of 70651040 had a reported longitude of 7.759983063 but a longitude based on the CRMP of -88.2399139 (7.76 - 96 = -88.24). Interestingly, the erroneous GPS value is reported as 7.759983063 on the printable crash report and in the online database, however, the raw database (used in this analysis) shows a value of "07.759983-01" whereas a typical value would be "-86.43655862." There was a similar error for latitude. It should be noted that this only occurred for electronic reports. It was also only observed in 252 crashes, most of which were in 2008. The error was not observed since January of 2009. It is assumed to have been fixed.

The second error was harder to quantify its frequency as the "distance" was not nearly as egregious as the former error however it was more prevalent. It was noticed in about 700 crashes that the GPS coordinates were modified by the 'distance from' field. Prior to the existence of the MapIt system, the user could enter a reference milepoint (typically from a milepoint log book or reference marker) and modify this location with a distance and direction. For instance, if an officer knew he or she was a half of a mile south (based on the cardinal direction of the roadway) from a logged intersection at MP 1.750 then they could enter 0.5 miles South into the 'distance from' form and the new milepoint would be 1.250. It seems that officers can still use the 'distance from' form even if they use the MapIt system. For instance, it was noticed that the GPS spatially offset from the CRMP location for several crashes that had values in the 'distance from' fields – curiously, even if the value in this field was zero. It is assumed that this is by design so that the user can offset their location by a distance if they know the GPS of a reference location. Unfortunately, the user can only offset due north, south, east or west, which is a very unlikely alignment. It is likely that this affected more than 700 crashes, however the error is presumed to be much smaller. This error is currently repeatable on a KYOPS installation with the latest version as of this writing.

There were also several errors noticed related to the paper reporting system. Several of these errors were related to the officer entering the data wrong or the data being keyed into the system incorrectly. There were 731 crashes with a GPS minute value 60 or greater (which is not a valid value). There were also over 400 crashes with noticeably bad GPS. Furthermore, there were several crashes that had no minutes or seconds or suspicious values such as 30 minutes. Although these represent a small number of crashes, they are a much higher proportion when only paper reports (about 27,000) are considered.

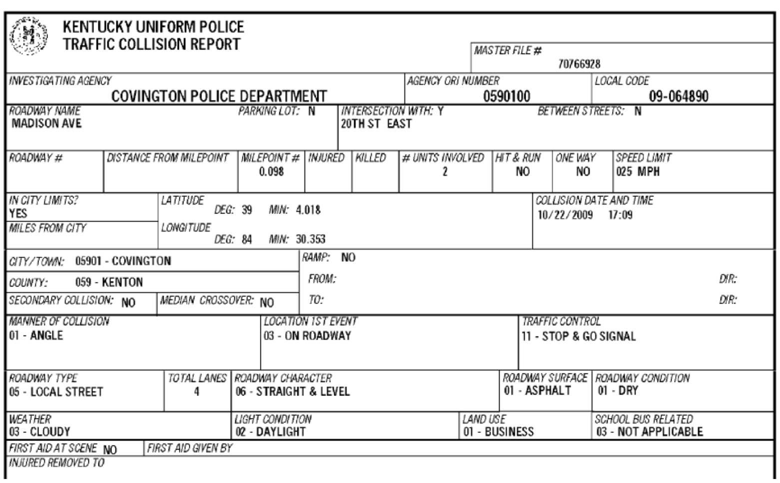
As shown earlier, the average "distance" of all usable crashes was 3.8 miles. The effect of some preventable errors can be shown despite the fact that this average "distance" is largely affected by the outliers. For instance, if all crashes that were plotted outside of their reported county are removed, this “distance” reduces from 3.8 to 0.2 miles. This implies that if a county check was performed before accepting a crash that the most egregious errors could be eliminated. It should be noted that most of the worst errors occurred prior to 2009. That is to say, the average “distance” in 2009 would reduce from 0.3 miles to 0.1 miles by requiring this check.

Another unexpected error was seen in crashes indicating that the officer used the MapIt system and did not edit its location. It would be expected that the “distance” between the CRMP and the GPS locations would be ostensibly zero. It would be expected to observe rounding and map projection errors that would yield some distance between the two locations. Unexpectedly, however, there were 5,267 (4.4%) usable crashes in 2009 that used an unedited MapIt location, yet had a “distance” of 500 feet or more. There were six crashes with a “distance” over 4,000 miles; however this can be explained by the latitude/longitude errors discussed above. There were 12 crashes with a “distance” of over 20 miles. The average “distance” of this dataset was 6.6 miles (1.3 miles excluding the six with latitude/longitude errors). The 50th and 85th percentiles were 0.2 miles and 1.8 miles respectively. Several of these crashes were reviewed to determine the reason for these errors. For 127 of the crashes the error seemed to be related to ‘distance from’ error discussed above.

The following are two case studies for typical errors found causing the discrepancy in the locations.

<u>Crash report# 70766928 – Covington Police Department, 10/22/2009</u>

The crash was reported as being on Madison Ave intersecting 20th St. East in Kenton County in Covington. There was no Route number on the police report; however, the database has a route of ‘059 KY-0017’ reported. The report indicated a milepoint of 0.098. It was coded as within city limits. The narrative verifies the location by indicating that unit 1 was travelling northbound on Madison Ave, striking Unit 2 who was travelling westbound on 20th street. The following is a screen shot of the pertinent information from the police report.



KENTUCKY UNIFORM POLICE
TRAFFIC COLLISION REPORT

MASTER FILE # 70766928		
INVESTIGATING AGENCY: COVINGTON POLICE DEPARTMENT	AGENCY ORI NUMBER: 0590100	LOCAL CODE: 09-064890
ROADWAY NAME: MADISON AVE; PARKING LOT: N	INTERSECTION WITH: Y 20TH ST EAST	BETWEEN STREETS: N

ROADWAY #	DISTANCE FROM MILEPOINT	MILEPOINT #	INJURED	KILLED	# UNITS INVOLVED	HIT & RUN	ONE WAY	SPEED LIMIT
		0.098			2	NO	NO	025 MPH

IN CITY LIMITS? YES	LATITUDE DEG: 39 MIN: 4.018	COLLISION DATE AND TIME 10/22/2009 17:09
MILES FROM CITY	LONGITUDE DEG: 84 MIN: 30.353	
CITY/TOWN: 05901 - COVINGTON	RAMP: NO	
COUNTY: 059 - KENTON	FROM:	DIR:
SECONDARY COLLISION: NO; MEDIAN CROSSOVER: NO	TO:	DIR:
MANNER OF COLLISION 01 - ANGLE	LOCATION 1ST EVENT 03 - ON ROADWAY	TRAFFIC CONTROL 11 - STOP & GO SIGNAL

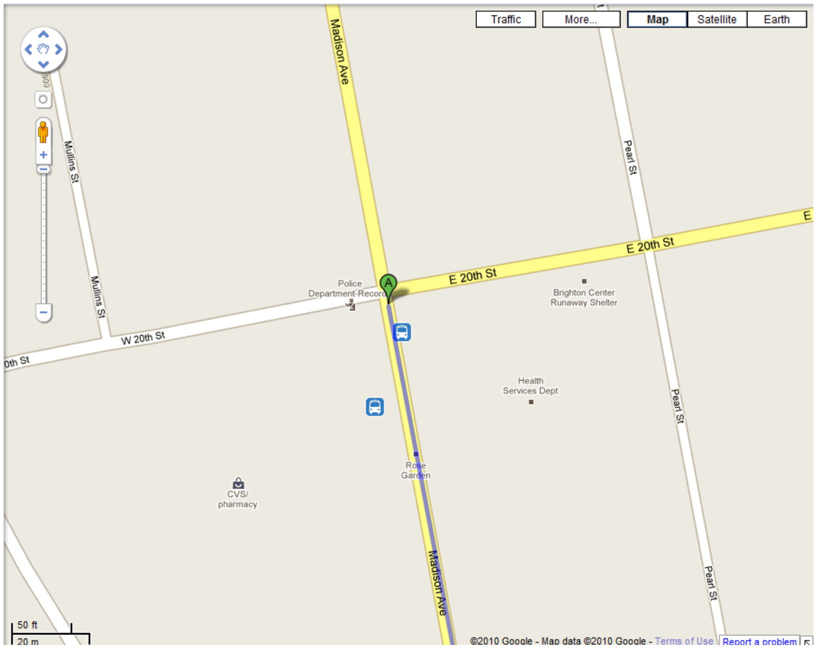
ROADWAY TYPE	TOTAL LANES	ROADWAY CHARACTER	ROADWAY SURFACE	ROADWAY CONDITION
05 - LOCAL STREET	4	06 - STRAIGHT & LEVEL	01 - ASPHALT	01 - DRY

WEATHER	LIGHT CONDITION	LAND USE	SCHOOL BUS RELATED
03 - CLOUDY	02 - DAYLIGHT	01 - BUSINESS	03 - NOT APPLICABLE

FIRST AID AT SCENE NO | FIRST AID GIVEN BY

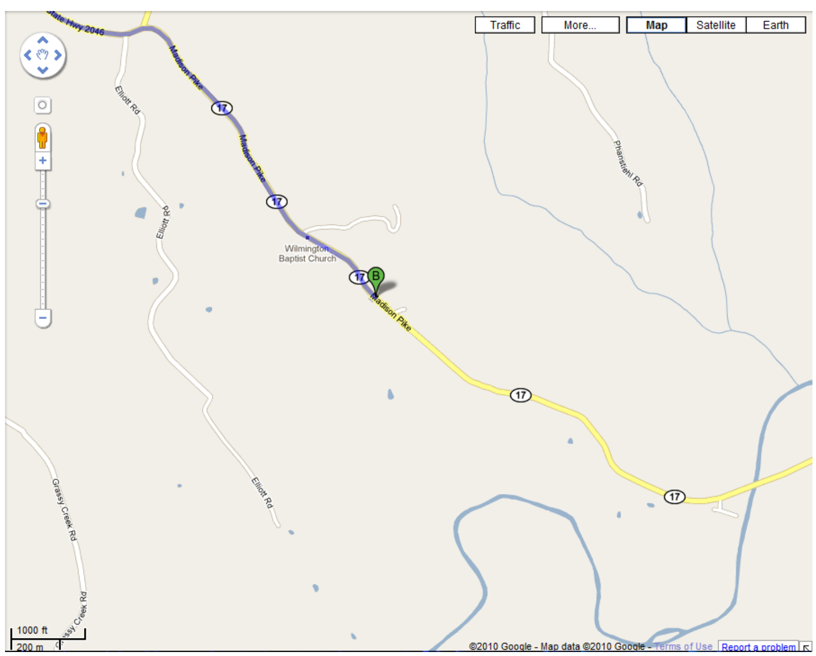
INJURED REMOVED TO

The GPS location was 39 degrees 4.018 minutes and -84 degrees 30.353 minutes. This location plotted precisely where the report indicated as seen below.



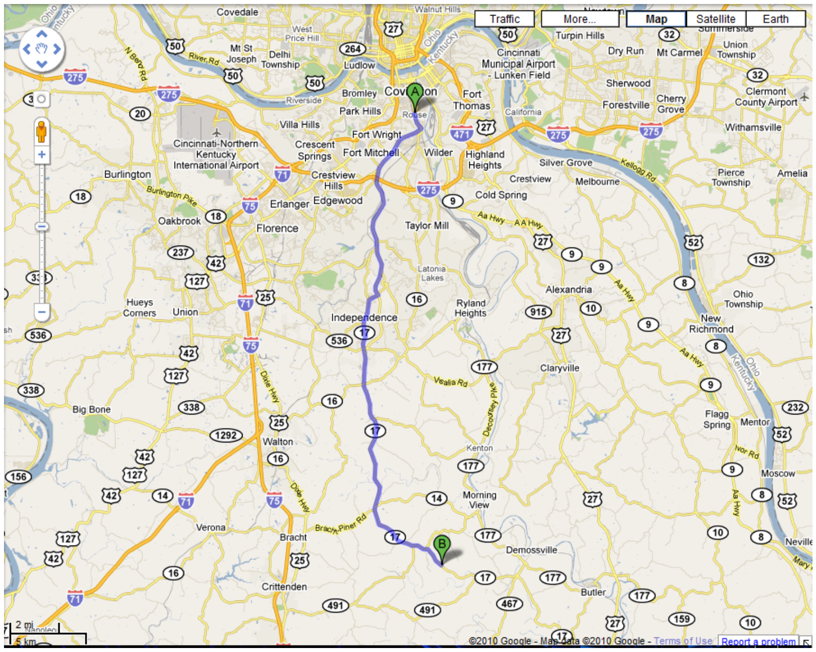
Properly located crash# 70766928

The location of the crash plotted by the databases CRMP information: 059 KY-0017 at 0.098 is shown below.



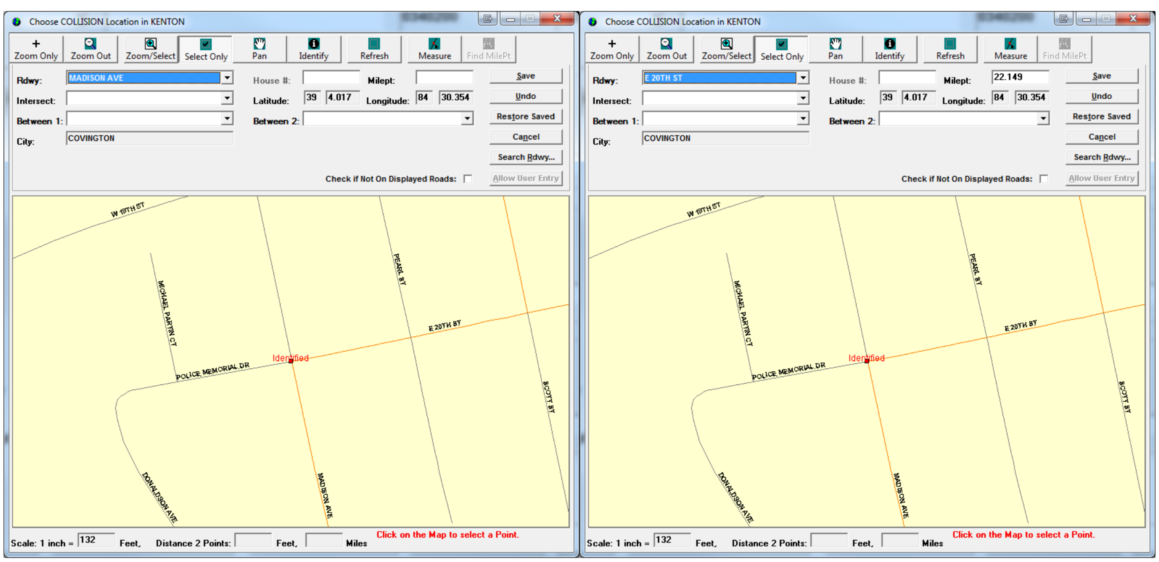
Improperly located crash# 70766928

The following shows the relationship of the two, where A is the GPS location and B is the CRMP location.

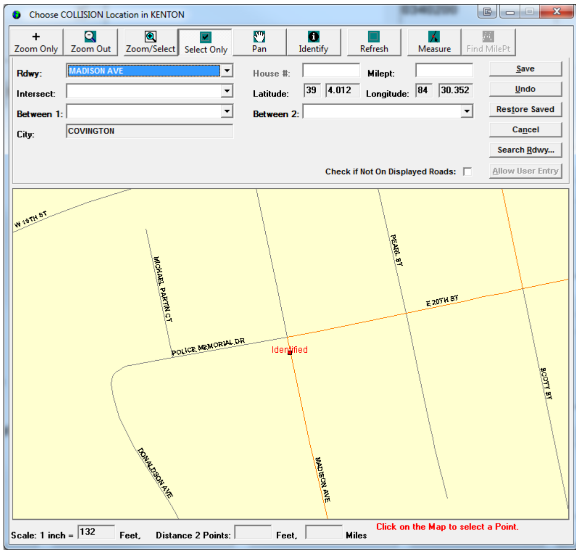


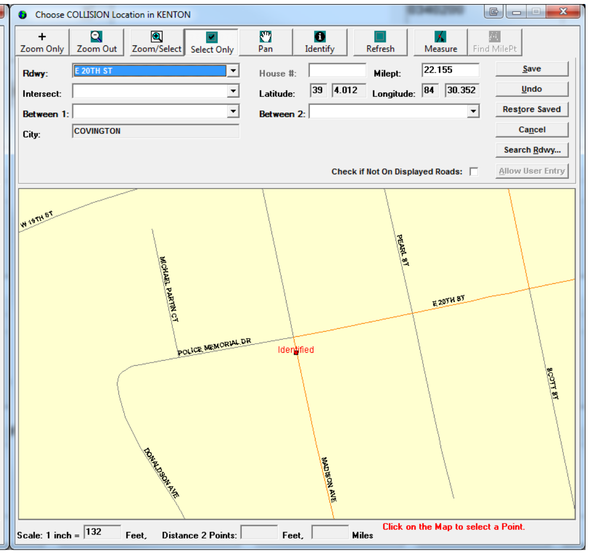
Crash# 70766928 plotted by GPS (A) and CRMP (B)

This discrepancy was attempted to be recreated using the latest version of the KYOPS eCrash system. The MapIt system presents the user with a populated list of choices when the user clicks on an intersection. In this case, the user is shown Police Memorial Drive, Madison Ave and E 20th Street. The following screen shots show that when an officer uses Madison Ave (which is the obvious choice for this crash) there is no milepoint given, however, if they choose E 20th Street they are given milepoint 22.149.

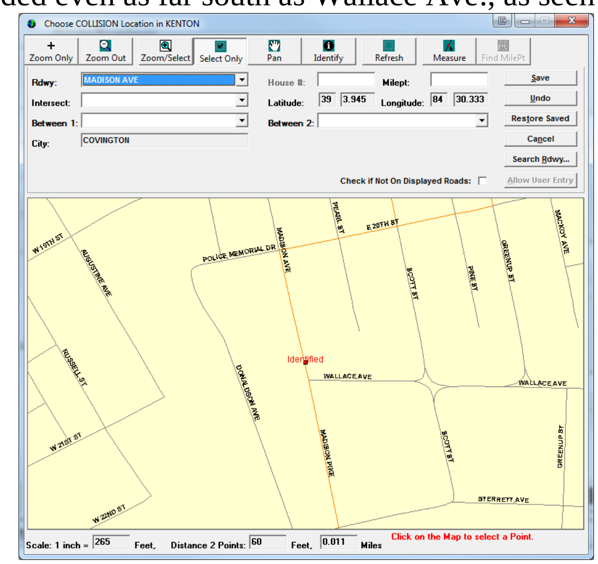


An explanation for this situation is that the MapIt system uses a buffer distance to search for intersecting roads when a user chooses a point. There is an obvious precedence given to state roads (the orange routes) over the local roads (grey roads). The system seems to have assigned the milepoint for the local road Madison Ave as 0.098 which is 500 feet north of this intersection between 19th and Shaler Street. Choosing a point 60 feet south of the intersection yields the same results as seen below.





A milepoint is not coded even as far south as Wallace Ave., as seen below.



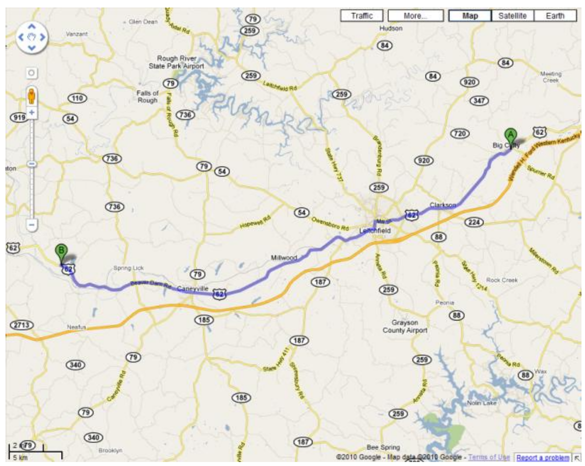
A milepoint is populated when Madison Pike is chosen, however. This implies that perhaps this section of roadway, labeled Madison Ave, is not coded as being on the state maintained system even though it is an orange route and it is connected to E 20th and Madison Pike, both coded as KY-17.

In this case the roadway number field was not populated which means in some forms of analysis this will not be treated as a state-maintained road crash. However, it is clear that this crash should have been plotted on the state-maintained system. State-maintained crashes are able to be matched to roadway volumes and have rates calculated that allow the State to determine where to direct safety, operation and maintenance improvements.

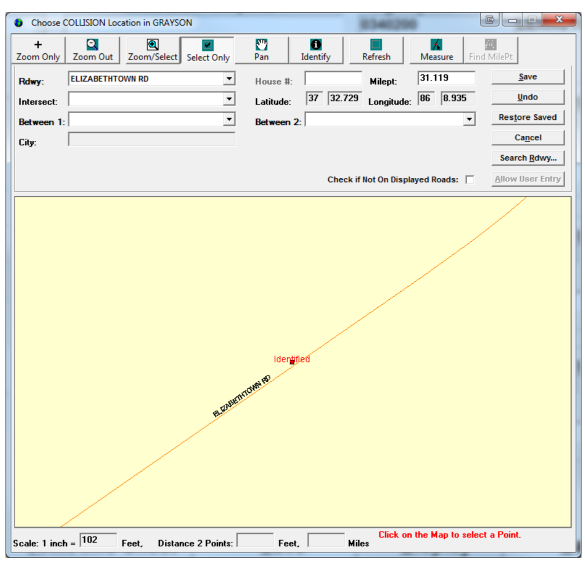
Furthermore, when this crash is plotted using the newer county and route field (RSE) it would be erroneously assigned to a location on the other side of the county.

<u>Crash report# 70702614– Grayson County Sheriff, 5/11/2009</u>

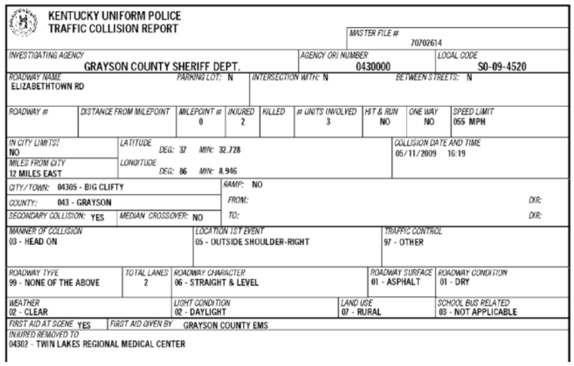
This case was similar in that the GPS location (A) was assumed to be correct based on the fact that Big Clifty was referenced as the city. The GPS location was very close to Big Clifty, whereas the CRMP location was closer to Spring Lick or Caneyville. The report did list the crash as being 12 miles east of Big Clifty; however, since 12 miles east of the city would be outside of Grayson County, it is more likely the officer meant 12 miles east of Leitchfield (cities are listed in a dropdown box and the two are adjacent to one another). The following shows the plotted location of GPS (A) and CRMP (B).



Unlike the previous example, the error was unable to be repeated by clicking on the precise GPS coordinate as reported in the crash report. As shown below, a milepoint of 31.119 was retrieved when clicking on the reported location.



This location also correctly reported the route as US-0062. The printable report (shown below) did not list any state route; however the database reported US-0062 correctly, but an incorrect milepoint (zero).


KENTUCKY UNIFORM POLICE
TRAFFIC COLLISION REPORT

MASTER FILE # 70702614

INVESTIGATING AGENCY: GRAYSON COUNTY SHERIFF DEPT. | AGENCY ORI NUMBER: 0430000 | LOCAL CODE: S0-09-4520

ROADWAY NAME: ELIZABETHTOWN RD | PARKING LOT: N | INTERSECTION WITH: N | BETWEEN STREETS: N

ROADWAY #	DISTANCE FROM MILEPOINT	MILEPOINT #	INJURED	KILLED	# UNITS INVOLVED	HIT & RUN	ONE WAY	SPEED LIMIT
		0	2		3	NO	NO	055 MPH

IN CITY LIMITS? NO
MILES FROM CITY: 12 MILES EAST
LATITUDE DEG: 37 MIN: 32.728
LONGITUDE DEG: 86 MIN: 8.946
COLLISION DATE AND TIME: 05/11/2009 16:19

CITY/TOWN: 04305 - BIG CLIFTY
COUNTY: 043 - GRAYSON
SECONDARY COLLISION: YES | MEDIAN CROSSOVER: NO
RAMP: NO
FROM: DIR:
TO: DIR:

MANNER OF COLLISION: 03 - HEAD ON | LOCATION 1ST EVENT: 05 - OUTSIDE SHOULDER-RIGHT | TRAFFIC CONTROL: 97 - OTHER

ROADWAY TYPE: 99 - NONE OF THE ABOVE | TOTAL LANES: 2 | ROADWAY CHARACTER: 06 - STRAIGHT & LEVEL | ROADWAY SURFACE: 01 - ASPHALT | ROADWAY CONDITION: 01 - DRY

WEATHER: 02 - CLEAR | LIGHT CONDITION: 02 - DAYLIGHT | LAND USE: 07 - RURAL | SCHOOL BUS RELATED: 03 - NOT APPLICABLE

FIRST AID AT SCENE: YES | FIRST AID GIVEN BY: GRAYSON COUNTY EMS
INJURED REMOVED TO: 04302 - TWIN LAKES REGIONAL MEDICAL CENTER

This example illustrates an error that was noticed in several of the over 5,000 crash records where the GPS did not match the CRMP location even though MapIt was used and unchanged. The fact that the error was unrepeatable may have been due to the fact that it has been resolved since these crashes were submitted (this issue was observed in crashes even on December 31, 2009). It is possible that the reporting officer achieved this result through a different means. Either way, it is an issue worthy of review by KYOPS programmers.

Appendix D-1 shows the Master File Number and "distance" for the worst 200 crashes, excluding the six crashes with latitude/longitude errors.

A summary was performed on all of the crashes that had an unmodified MapIt location in 2009 by county-route combinations. The number of each county-route (for example KY-36 in Bath County) was counted in the unmodified MapIt location database and this number was compared to that county-route's occurrence in all 2009 crashes. A percentage was calculated based on these two counts. The unmodified MapIt location database represents only 4.4 percent of all 2009 crashes. Therefore, any county-route combination with a percentage higher than 4.4 percent is overrepresented. Appendix D-2 shows the county-routes with the highest percentages of all 2009 crashes (only county-routes with more than 20 crashes are shown). Several county-routes had very high percentages implying that there may be something wrong with these routes in the MapIt database.

The same analysis was performed by the reporting agency. Appendix D-3 shows the agencies with the highest percentages of all 2009 crashes (only county-routes with more than 20 crashes are shown). Again, these percentages can be compared to 4.4 percent. Agencies with higher percentages may indicate that training issues may prevent some of these errors. Appendix D-4 shows the same summary by reporting county.

Although most of the location errors have been addressed and mitigated in KYOPS, the following analysis only looks at paper reports or electronic reports with modified MapIt locations. The "distance" between the GPS and CRMP should be zero for all unmodified MapIt locations (the previous analysis investigated those that were not); therefore these were removed from the analysis so that the averages were not driven down by the frequency of such crashes. The following table shows the average "distance" and crash count by year for all usable crashes with modified MapIt locations or using paper reports.

Year	Average "distance" (Miles)	Count
2007	2.2	11,565
2008	5.9	11,405
2009	1.2	4,709
Grand Total	**3.5**	**27,679**

The data from 2009 has the lowest proportion of modified locations and paper crashes (3.9 percent of all 2009 usable crashes) and the lowest average "distance". The remaining tables summarize usable crashes (modified MapIt location and paper reports) from 2009 in order to minimize the influence of the worst errors (mostly seen prior to 2009).

As seen in the previous section, a check for crashes being plotted outside of their reported county would reduce the average "distance". The average "distance" of 1.2 miles is reduced to 0.8 miles when only looking at crashes plotted within their county. The remainder of the error is likely related to milepoint errors as seen in KTC's previous study where errors were caused by poor milepoint references, inaccurate estimations of distance or incorrect 'direction from' values.[3] These types of errors are typically seen on paper reports but the proper county would still be reported.

The following table shows the average "distance" and crash count by submission type (all electronic reports had a modified location).

Submission Type	Average "Distance" (Miles)	Count
Electronic (modified location)	0.1	3,929
Paper	6.4	780
Grand Total	**1.2**	**4,709**

Paper reports produce the largest "distance" yet make up a very small percentage of submission type.

The following table shows the average "distance" in miles for all usable data in 2009 by several crash type indicators of location.

[3]Green, E. and K. Agent, "Evaluation of the Accuracy of GPS as a Method of Locating Traffic Collisions," Kentucky Transportation Center, University of Kentucky, KTC-04-08/SPR 276-04-1F, June 2004.

Average “Distance” (Miles)		
Location Indicator	**Yes**	**No**
Intersection	0.50	1.31
Parking Lot	0.20	1.17
Between Streets	0.53	1.27
Ramp	0.10	2.40

As seen in previous research and, as one might expect, the average “distance” is improved when one of the above indicators is a ‘Yes.’ Such indicators offer a better reference system than, for example, a rural two-lane road. More reference points allow the reporting officer to be able to locate a crash properly. Moreover, the above indicators are more prevalent in urban areas where the crash location is easier to pinpoint. In the above table, almost all of the ramp crashes were electronic reports (only 10 of 2,502 ramp crashes were paper). The MapIt system introduced a better ramp classification system by adding indicators to the RSE field. Even though these MapIt locations were modified, ramps are typically small in length; therefore there is little room for error. This explains ramp crashes low average “distance”.

The following table shows the average “distance” for all usable crashes in 2009 by functional classification.

Average “Distance” and Sample by Function Class for all Usable Paper and Edited Electronic Crashes in 2009		
Functional Classification	**Average “Distance” (Miles)**	**Sample Size**
Rural Interstate	1.1	92
Rural Principal Arterial (non-interstate)	3.4	198
Rural Minor Arterial	1.7	149
Rural Major Collector	3.8	325
Rural Minor Collector	3.2	127
Rural Local	60.8	40
Urban Interstate	0.1	1,005
Urban Principal Arterial (Freeway & Expressways)	0.0	211
Urban Principal Arterial (other)	0.2	452
Urban Minor Arterial	0.2	224
Urban Collector	0.3	67
Urban Local	0.1	17
Unknown	0.1	1,802
Grand Total	**1.2**	**4,709**

As expected, rural locations tend to have a higher average “distance” (5.5 miles) compared to urban (0.1 miles). The highest “distance” also has one of the lowest sample sizes. Rural locations have fewer reference points making it more difficult for an officer to pinpoint their location on a map.

The location data is better for fatal crashes as compared to all crashes in the 2009 data. Compared to an average "distance" of 0.34 miles for all crashes there was an average "distance" of 0.31 miles for injury crashes and 0.07 miles for fatal crashes. More care is usually given to the reporting of serious crashes especially those resulting in a fatality.

The 50th and 85th percentile "distances" were also summarized in an effort to reduce the impact of outliers on the results. The following table shows the 50th and 85th percentiles for several subsets of the crash data. All years of crash data were used (October 1st 2007 to December 31st 2009).

	"Distance" (Miles)		"Distance" (Feet)	
Subset	**50th**	**85th**	**50th**	**85th**
All	0.0031	5,788	16	30,561,059
All Usable	0.0023	0.0369	12	195
All Usable - Intersections	0.0028	0.0440	15	232
All Usable - Between	0.0025	0.0443	13	234
All Usable - eCrash	0.0022	0.0323	12	170
All Usable - Paper	0.2774	3.2183	1,465	16,993
All Usable - Intersections - Paper	0.2668	4.4773	1,409	23,640
All Usable - Intersections - eCrash	0.0012	0.0136	6	72
All Usable - Sheriff	0.0049	0.0886	26	468
All Usable - Local	0.0016	0.0209	9	110
All Usable - KSP	0.0050	0.0754	26	398
All Usable - Intersections - Sheriff	0.0020	0.0974	11	514
All Usable - Intersections - Local	0.0012	0.0144	7	76
All Usable - Intersections - KSP	0.0011	0.0362	6	191
All Usable - In County	0.0023	0.0356	12	188

The first subset shows all of the data (even data with explainable errors or no CRMP or GPS data). Unfortunately, the prevalence of very small "distance" values confounds this type of analysis. In addition, large "distances" (typically seen on paper reports) also confound the results. Some of the trends seen in the previous report were not seen because of these two factors.

The crashes with 90/10 errors where 90 percent of the "distance" between CRMP and GPS is in either the horizontal or vertical direction were summarized. Similarly, the crashes with 95/5 errors were summarized. Again, data from 2009 were used in order to minimize errors. There were no major differences between all crashes and intersections crashes.

3.3 Locating a Traffic Crash

As discussed previously, it can be difficult and subjective to properly locate crashes. According to the American National Standards, the definition of a crash location is the location on a roadway to be documented as where the first harmful event of the crash occurred.[4] A harmful event is characterized as the first injury or damage-producing event. There are several types of crashes that require specific attention. Such crash types are discussed below. Recommendations to handling these crash types are also given in the subsequent section.

Intersection Crashes

Intersections crashes can be easy to define when the crash is clearly intersection related (an angle crash as a result of a red light running). However, intersection crashes would also include crashes occurring as a result of a sight distance issue related to the environment around an intersection or a rear-end collision as a result of stopped traffic at an intersection.

The location alone does not fully provide all of the crash location data particularly at intersections. According to results from research at the Northwestern University's Center for Public Safety, the road in which the most harmful event occurred should be listed as the primary road.[5] When the crash involves two or more vehicles travelling on different roads then the road with the higher importance should be used. The research study defines the follow categories of roads in order of importance.

1. Interstate Highway
2. Other U.S. route numbered highway
3. Other state route numbered highway
4. County road
5. City street
6. All others

If the two intersecting roads are of equal importance, the collision should then be located on the traffic way "with the lowest route, number, or street name nearest the beginning of the alphabet"[6].

Ramp or Interchange Crashes

Ramp crashes have previously been difficult to properly locate. With the addition of the MapIt system in KYOPS, ramp identifiers (provided by the transportation cabinet) are available for all roads.

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[4] (ANS) American National Standard: ANSI D16.1-2007 Manual of Classification of Motor Vehicle Traffic Accidents. 7th Edition.
[5] Traffic Collision Investigation (TCI). Kenneth S. Baker. Copyright 2001, Northwestern University Center for Public Safety
[6] Ibid.

Crashes Over Large Distances

For crashes that cover a large distance or involve several vehicles, the location of the first harmful event should be used as the crash location and not the final resting place of any of the vehicles.

4.0 CONCLUSIONS

This evaluation has determined that the accuracy of traffic crash location data is substantially better than the previous study completed in 2004. A random sample of crashes indicated that 92 percent of all crashes were accurate compared to around 50 percent in the previous study. Most of this improvement can be attributed to the implementation of the MapIt system in eCrash. The crashes that were determined to be incorrectly located were largely due to a lack of reference points. The MapIt system requires the user to click a location on a map which requires the user to know their current location. Since there isn't a GPS receiver integrated with the system, the user must use intersecting roadways, roadway geometry and mile-markers to help pinpoint their location.

Several components could be added to the MapIt system to help provide more reference points, particularly for rural or interstate locations where reference points are not as frequent. The following is a list of additions that could be implemented.

<u>Aerial Photos</u>

Integrating the MapIt system with aerial photos would largely increase the number of reference points to more accurately locate a crash. Buildings, driveways and many other features could be used as reference points. Aerial photos are admittedly very large but several techniques can be employed to minimize the space needed. For example, aerials can only be shown when needed and could be tied to the Kentucky Transportation Cabinet's mapping systems or one of many free mapping services. Furthermore, some agencies could download only the aerials they need.

<u>GPS Receivers</u>

The previous study evaluated the use handheld GPS receivers for locating crashes. Unfortunately, human error contributed largely to the use of these devices. GPS receivers are cheaper and a lot more user friendly today. The data show that the mapping system is much more effective in locating crashes. However, the ideal solution would be to integrate the two systems: GIS of MapIt and GPS of receivers. A cheap USB receiver that requires no user interface could be integrated into eCrash to provide an indication of the user's current location. The "distance" between the MapIt location can be compared to an integrated GPS and flagged if it is above a certain level. The GPS data from the already-purchased GPS units could be used to verify the MapIt bases GPS coordinates, but is not ideal due to the propensity for user error.

Reference Logs

The transportation cabinet provides a route log inventory of the roadways in Kentucky that is spatially-enabled. This inventory could be added as a layer to the MapIt system that would indicate many features that can be used as reference points such as: bridges, culverts, mile markers, etc. Mile marker information is already provided in the MapIt system but it requires the user to continually click points along a road until a mile point ending in a zero is found; which can be tedious.

Training

Training could be provided to encourage users to use other tools available to help pinpoint their location. Other mapping sources such as Google® Maps could be used. The importance of a proper location should be emphasized, particularly its role in highway safety. Preference should always be given to state routes over local roads so that the data can be tied to inventory data and be used to calculate crash rates. Additionally, the measure tool in the MapIt system can be used to help gauge distances.

Other Recommendations

Several of the major issues found have been addressed or minimized by the use of the eCrash system. Agencies still using paper reports should be encouraged to move to eCrash or addition training should be provided to minimize some of these errors. The following agencies, cities and counties should be contacted.

- Hancock, Nicholas, Johnson, Jefferson and Whitely Counties all had nearly 30 percent or more of their reports submitted as paper
- The following cities had paper submission rates over 90 percent:
    - Plantation
    - Villa Hills
    - Thealka
    - Sitka
    - Volga
    - Tutor Key
    - Meally
    - Hawesville
- Several agencies had very high paper submission rates. Louisville Metro Police Department had the highest submission rate when considering the number of crashes filed by agency (37 percent paper with 56,189 reports in the study period).

Most of the plotting issues have been minimized, however, the following counties, cities and agencies had the highest percentages of crashes plotted outside of their counties.

- Hancock, Whitely and Fulton Counties had over five percent of their crashes plotted outside of their county

- The cities of Volga, Carter and Hickman had over 20 percent of their crashes plotted outside of their county
- The following agencies had over 10 percent of their crashes plotted outside of their county:
    - Breathitt County Sheriff Dept.
    - Hickman Police Department
    - Lewisport Police Department
    - Johnson County Sheriff Dept.
    - Hancock County Sheriff Dept.
    - Burkesville Police Department
    - Whitley County Sheriff Dept.

Attention should be given to the glitch linked to the 'distance from' field. Several cases seem to imply that there is an issue with the 'distance from' field. This should be investigated by KYOPS programmers.

As discussed earlier, in 2009 there were 392 crashes plotted outside of their reported county and 5,267 crashes using MapIt (unmodified) that had "distances" over 500 feet when compared to the CRMP data. Both of these should be software edits that prevent or flag the location data as potentially being incorrect. A more advanced county check could be used to ensure that the crash is within the county boundary instead of checking if it is within a box surrounding the county. Furthermore the "distance" between the CRMP data and the GPS location should always be checked and flagged if above 500 feet.

Ramp crash data is substantially better than previous years due to the implementation of the MapIt system. It should be noted that ramps take advantage to the RT_UNIQUE's suffix information. The following table explains the information provided by the three-digit suffix appended to the RT_UNIQUE field.

Suffix Type	RT
Mainline	-000
One-way couplet non-cardinal	-001… -009
Non-cardinal side of highway	-010…-090
Ramp*	-111…-949

*First digit is which interchange in the county, Second digit is the quadrant, and Third digit is the ramp

When querying crash data, the proper RT_UNIQUE suffix (e.g. "-000") should be used to avoid returning undesired results. For instance, a query of Roadway ID = I 0064 between milepoints 0.0 and 5.0 would also return any ramp crash on I-64 throughout the entire state since ramp crashes have very low milepoints. This can be avoided by filtering all ramp crashes by the RT_UNIQUE field.

Attention should be given to how traffic crashes should be properly located. National consensus defines the crash site as the location of the first harmful event. Training should underscore this definition. The Model Minimum Uniform Crash Criteria (MMUCC) has diagrams that could be included in training or in KYOPS to better exemplify this standard.

Training and possible KYOPS edits should include the importance of roadway selection priority at intersections. That is, choosing a state-maintained road over a local road when available. The following priority table could be used (the highest priority listed first):

1. Interstates*
2. Parkways*
3. US routes*
4. KY routes*
5. All other roads

*The lower number should be used if both roads are the same priority

Between streets should always be selected when a crash occurs in midblock to assist in crash locating.

5.0 REFERENCES

1) Green, E. and K. Agent, "Evaluation of the Accuracy of GPS as a Method of Locating Traffic Collisions," Kentucky Transportation Center, University of Kentucky, KTC-04-08/SPR 276-04-1F, June 2004.
2) Creative Research Systems, Sample Size Calculator, http://www.surveysystem.com/sscalc.htm#one, accessed August 2010
3) American National Standard: ANSI D16.1-2007 Manual of Classification of Motor Vehicle Traffic Accidents. 7th Edition.
4) TCI: Traffic Collision Investigation. Kenneth S. Baker. Copyright 2001, Northwestern University Center for Public Safety

Appendix A. List of Randomly Analyzed Crash Reports and Their Assessment

Appendix A. List of Randomly Analyzed Crash Reports and Their Assessment

ID	MFN	Type	Accurate	Offset	Units	If Not Accurate Why?
1	70719993	Between streets	Yes	150	ft	N/A
2	70716674	None	No	5280	miles	cop had no reference point
3	70676586	None	Yes	100	ft	N/A
4	70704333	Between streets	Yes	25	ft	N/A
5	70737484	Between streets	Yes	250	ft	N/A
6	70757967	None	Yes	40	ft	
7	70692396	None	Yes	0	miles	N/A
8	70759826	None	Unknown	2640	miles	description vague
9	70737923	Between streets	Yes	0	miles	N/A
11	70770540	None	Yes	0	miles	N/A
12	70675470	Between streets	Yes	150	ft	N/A
13	70750357	None	Yes	400	ft	N/A
14	70689876	None	Yes	25	ft	N/A
15	70772834	None	Yes	300	ft	N/A
16	70689053	None	Yes	75	ft	N/A
17	70701392	None	Unknown	1320	miles	description vague
18	70723671	None	Unknown	5280	miles	description vague
19	70750960	None	Unknown	660	miles	description vague
20	70681076	None	Unknown	1320	miles	description vague
21	70739888	None	Unknown	1320	miles	description vague
22	70767791	Intersection	Yes	0	miles	N/A
23	70663474	None	Unknown	1320	miles	description vague
24	70780327	Intersection	Yes	400	ft	N/A
25	70699347	None	Unknown	500	ft	description vague
26	70774974	Intersection	Yes	200	ft	N/A
27	70792149	Intersection	Yes	0	miles	N/A
28	70797919	None	Yes	0	miles	N/A
29	70740846	None	Unknown	2640	miles	description vague
30	70786770	Between streets	Yes	25	ft	N/A
31	70723915	None	Unknown	1320	miles	description vague
32	70770454	None	Yes	150	ft	N/A
33	70726917	None	Yes	0	miles	N/A
34	70783980	None	Yes	50	ft	N/A
35	70746937	Between streets	Yes	50	ft	N/A
36	70790470	Between streets	Yes	0	miles	N/A
37	70794874	None	Unknown	2640	miles	description vague
38	70658955	None	Yes	0	miles	N/A
39	70677242	Between streets	Yes	125	ft	N/A
40	70709476	Between streets	Yes	250	ft	N/A
41	70727605	None	Yes	0	miles	N/A
42	70757619	None	Unknown	528	miles	description vague
43	70728935	None	Unknown	2640	miles	description vague
44	70729250	Intersection	Yes	0	miles	N/A
45	70732670	Between streets	Yes	2112	miles	description vague
46	70733680	None	Yes	50	ft	N/A
47	70774980	None	Yes	0	miles	N/A
48	70747235	None	Unknown	1320	miles	description vague
49	70754132	Between streets	Yes	0.1	ft	description vague
50	70795020	None	Yes	200	ft	N/A
51	70694633	None	Yes	250	ft	N/A
52	70726105	Intersection	Yes	0	miles	N/A
53	70753551	None	Yes	0	miles	N/A
54	70676551	None	Unknown	2640	miles	description vague
55	70678436	Intersection	Yes	0	miles	N/A
56	70695107	None	No	1056	miles	GPS is not consistent with address
57	70716884	None	Yes	0	miles	N/A
58	70709865	Between streets	Yes	50	ft	N/A
59	70794771	Intersection	Yes	0	miles	N/A
60	70767314	None	Unknown	2640	miles	description vague
61	70791409	Intersection	Yes	0	miles	N/A

Appendix A. List of Randomly Analyzed Crash Reports and Their Assessment

ID	MFN	Type	Accurate	Offset	Units	If Not Accurate Why?
62	70703951	None	No	6600	miles	GPS is not consistent with address
63	70758733	None	Unknown	2640	miles	description vague
64	70791828	Between streets	Yes	25	ft	N/A
65	70799060	None	Unknown	500	ft	description vague
66	70740208	None	Unknown	0.25	ft	description vague
67	70720805	None	No	5280	miles	GPS is not consistent with address
68	70729104	None	Yes	0	miles	N/A
69	70759219	Intersection	Yes	25	ft	N/A
70	70654251	None	Yes	125	ft	N/A
71	70687226	None	Yes	500ft	ft	N/A
72	70706149	None	Unknown	1320	miles	description vague
73	70693764	None	Yes	25	ft	N/A
74	70708786	Between streets	Yes	125	ft	N/A
75	70662641	Intersection	Yes	25	ft	N/A
76	70739980	Intersection	Yes	0	miles	N/A
77	70778941	None	Yes	0	miles	N/A
78	70702936	None	Yes	0	ft	N/A
79	70737696	None	No	4000	ft	GPS 4000+ft off address
80	70728139	None	Unknown	0.25	ft	description vague
81	70751223	Between streets	Yes	125	ft	N/A
82	70680917	None	Unknown	2640	miles	description vague
83	70767176	None	Yes	0	miles	N/A
84	70728058	Intersection	Yes	0	miles	N/A
85	70779567	Between streets	Yes	0	miles	N/A
86	70685190	None	Yes	100	ft	N/A
87	70674938	None	Unknown	2640	miles	description vague
88	70739656	None	Unknown	1320	miles	GPS is not consistent with address
90	70699617	None	Unknown	1320	miles	description vague
91	70700473	None	Yes	0	miles	N/A
92	70659987	None	Unknown	1320	miles	description vague
93	70717951	None	Unknown	1320	miles	description vague
94	70673409	None	Unknown	2640	miles	description vague
95	70771794	None	Yes	0	miles	N/A
96	70738898	None	Yes	250	ft	N/A
97	70774177	None	Unknown	1320	miles	description vague
98	70713230	None	Yes	50	ft	N/A
99	70658346	None	Yes	0	miles	N/A
100	70665510	Intersection	Yes	0	miles	N/A
101	70677369	None	Yes	125	ft	N/A
102	70724269	Intersection	Yes	25	ft	N/A
103	70673469	Between streets	Yes	1320	miles	N/A
104	70718492	Intersection	Yes	0	ft	N/A
105	70750042	None	No	1056	miles	GPS is not consistent with address
106	70767459	None	Yes	0	ft	N/A
107	70686603	None	Unknown	500	ft	description vague
108	70791606	None	Unknown	500	ft	description vague
109	70661195	Between streets	Yes	50	ft	N/A
110	70786532	Intersection	Yes	0	ft	N/A
111	70747129	None	Yes	100	ft	N/A
112	70784424	Intersection	Yes	0	ft	N/A
113	70692918	None	Yes	0	ft	N/A
114	70694800	None	Yes	125	ft	N/A
115	70785006	None	Unknown	1320	miles	description vague
116	70777946	Intersection	Yes	0	miles	N/A
117	70697147	Between streets	Yes	250	ft	N/A
118	70745336	Intersection	Yes	0	ft	N/A
119	70785826	None	Unknown	275	ft	description vague
120	70750923	Between streets	Yes	200	ft	N/A
121	70748829	Intersection	Yes	0	ft	N/A
122	70772795	Intersection	Yes	0	ft	N/A

Appendix A. List of Randomly Analyzed Crash Reports and Their Assessment

ID	MFN	Type	Accurate	Offset	Units	If Not Accurate Why?
123	70780950	None	Yes	125	ft	N/A
124	70799078	None	Yes	0	ft	N/A
125	70710066	Intersection	Yes	0	ft	N/A
126	70764244	Between streets	Yes	0	ft	N/A
127	70750147	None	Yes	0	ft	N/A
128	70793699	None	Unknown	1320	miles	N/A
129	70661552	Between streets	Yes	0	ft	N/A
130	70802328	None	Unknown	2640	miles	N/A
131	70666966	None	Yes	50	ft	N/A
132	70754666	Intersection	Yes	0	ft	N/A
133	70752736	None	Yes	0	ft	N/A
134	70742879	None	Yes	25	ft	N/A
135	70757079	None	Unknown	528	miles	description vague
136	70728694	Intersection	Yes	0	ft	N/A
137	70752643	Intersection	Yes	100	ft	N/A
138	70696416	Intersection	Yes	0	ft	N/A
139	70777100	None	Yes	50	ft	N/A
140	70780978	None	Unknown	1320	miles	description vague
141	70808458	None	Yes	0	ft	N/A
142	70715062	None	Unknown	275	ft	description vague
143	70788238	None	Yes	0	ft	N/A
144	70701080	Between streets	Yes	0	ft	N/A
145	70776361	Between streets	Yes	125	ft	N/A
146	70723836	None	Yes	0	ft	GPS is not consistent with address
147	70667147	Intersection	Yes	0	ft	N/A
148	70719014	None	Yes	0	ft	N/A
149	70772590	Intersection	Yes	25	ft	N/A
150	70786684	Intersection	Yes	0	ft	N/A
151	70756591	Between streets	Yes	100	ft	N/A
152	70781378	None	Yes	25	ft	N/A
153	70661578	Between streets	Yes	0	ft	N/A
154	70717059	None	No	1056	miles	GPS is not consistent with address
155	70713195	Intersection	Yes	0	ft	N/A
156	70751096	Between streets	Yes	0	ft	N/A
157	70781928	None	Yes	0	ft	N/A
158	70707609	Intersection	Yes	0	ft	N/A
159	70654305	Between streets	Yes	50	ft	N/A
160	70704438	None	No	1584	miles	GPS is not consistent with address
161	70808223	None	Yes	500	ft	N/A
162	70702349	Intersection	Yes	0	ft	N/A
163	70670692	Intersection	Yes	0	ft	N/A
164	70776315	None	Unknown	2640	miles	description vague
165	70773203	None	No	2640	miles	GPS is not consistent with address
166	70730354	Between streets	Yes	125	ft	N/A
167	70729279	None	No	2900	ft	GPS is not consistent with address
168	70771572	None	Yes	25	ft	N/A
169	70798117	Between streets	Yes	100	ft	N/A
170	70736261	None	Unknown	5280	miles	description vague
171	70771602	None	Yes	25	ft	N/A
172	70736964	None	No	625	ft	GPS is not consistent with address
173	70651637	None	Yes	0	miles	GPS is not consistent with address
174	70704576	None	Yes	0	ft	N/A
175	70706155	None	Yes	0	ft	N/A
176	70798063	None	Yes	0	ft	N/A
177	70692015	None	Unknown	18480	miles	description vague
178	70698383	None	Yes	0	ft	N/A
179	70655711	Intersection	Yes	0	ft	N/A
180	70691265	Between streets	Yes	528	miles	description vague
181	70719218	None	Unknown	1320	miles	description vague
182	70767090	None	Yes	100	ft	N/A

Appendix A. List of Randomly Analyzed Crash Reports and Their Assessment

ID	MFN	Type	Accurate	Offset	Units	If Not Accurate Why?
183	70800738	None	Yes	50	ft	N/A
184	70706304	None	Yes	0	ft	N/A
185	70721977	Between streets	Yes	125	ft	N/A
186	70768554	None	Yes	0	ft	N/A
187	70711860	None	Yes	0	ft	N/A
188	70747401	None	Unknown	2640	miles	description vague
189	70748846	None	Unknown	2640	miles	description vague
190	70801910	None	Yes	125	ft	N/A
191	70661862	Between streets	Yes	250	ft	N/A
192	70735163	None	Unknown	1320	miles	description vague
193	70740005	None	No	46200	miles	GPS is not consistent with address
194	70681267	None	Yes	250	ft	N/A
195	70802685	None	Unknown	1320	miles	Road could not be found
197	70710063	None	Yes	100	ft	N/A
198	70684266	None	Unknown	2640	miles	description vague
199	70741360	None	Unknown	1320	miles	description vague
200	70677234	Between streets	Yes	125	ft	N/A
201	70789746	None	No	4224	miles	GPS is not consistent with address
202	70786623	None	Yes	0	ft	N/A
203	70667972	None	Unknown	1320	miles	description vague
204	70727258	Intersection	Yes	0	ft	N/A
205	70720314	None	Yes	50	ft	N/A
206	70685443	Intersection	Yes	0	ft	N/A
207	70744840	Between streets	Yes	250	ft	N/A
208	70730228	Intersection	Yes	50	ft	N/A
209	70698623	None	Yes	25	ft	N/A
210	70670511	None	Yes	250	ft	N/A
211	70678530	Intersection	Yes	0	ft	N/A
212	70718488	Between streets	Yes	100	ft	N/A
213	70736937	None	Yes	250	ft	N/A
214	70745978	Intersection	Yes	0	ft	N/A
215	70756488	None	Yes	50	ft	N/A
216	70748949	None	Yes	0	ft	N/A
217	70658852	None	Unknown	1980	miles	description vague
218	70711106	Between streets	Yes	1320	miles	description vague
219	70691361	Between streets	Yes	125	ft	N/A
220	70778460	Intersection	Yes	0	ft	N/A
221	70763217	None	Unknown	1320	miles	description vague
222	70705249	Intersection	Yes	0.1	miles	description vague
223	70767883	None	Yes	0	ft	N/A
224	70683255	None	Yes	50	ft	N/A
225	70714659	None	Yes	250	ft	N/A

Appendix B. Percentage of Crashes Plotted Outside of Their Reported County in Descending Order by Reported County

Appendix B. Percentage of Crashes Plotted Outside of Their Reported County in Descending Order by Reported County

County	Percent
Hancock	12.79%
Whitley	7.13%
Fulton	6.60%
Johnson	5.99%
Robertson	4.35%
Cumberland	3.37%
Carter	3.24%
Estill	2.52%
Butler	2.31%
Martin	2.29%
Jefferson	2.13%
Greenup	2.01%
Lawrence	1.79%
Leslie	1.48%
McCracken	1.39%
McCreary	1.37%
Ballard	1.36%
Boone	1.33%
Boyd	1.27%
Lewis	1.16%
Lee	1.11%
Nicholas	1.11%
Magoffin	1.10%
Gallatin	0.99%
Edmonson	0.96%
Henderson	0.95%
Knott	0.92%
Webster	0.87%
Russell	0.86%
Lincoln	0.84%
Powell	0.79%
Elliott	0.78%
Carlisle	0.74%
Anderson	0.74%
Kenton	0.73%
Casey	0.72%
Shelby	0.72%
Pulaski	0.71%
Knox	0.66%
Monroe	0.62%
Union	0.61%
Bell	0.60%
Oldham	0.60%

County	Percent
Trimble	0.60%
Adair	0.59%
Letcher	0.58%
Laurel	0.56%
Carroll	0.56%
Breathitt	0.56%
Clinton	0.54%
Scott	0.52%
Hart	0.51%
Madison	0.46%
Menifee	0.45%
Harlan	0.44%
Nelson	0.44%
Jessamine	0.43%
Clark	0.43%
McLean	0.43%
Wayne	0.43%
Bourbon	0.41%
Morgan	0.40%
Floyd	0.39%
Ohio	0.38%
Livingston	0.36%
Grant	0.35%
Simpson	0.34%
Woodford	0.33%
Perry	0.33%
Pendleton	0.33%
Boyle	0.32%
Garrard	0.32%
Daviess	0.31%
Lyon	0.30%
Pike	0.30%
Washington	0.30%
Fleming	0.27%
Meade	0.26%
Hardin	0.24%
Breckinridge	0.24%
Logan	0.24%
Allen	0.24%
Green	0.24%
Campbell	0.23%
Fayette	0.23%
Caldwell	0.22%

County	Percent
Bath	0.22%
Henry	0.22%
Mercer	0.21%
Mason	0.20%
Crittenden	0.20%
Owen	0.20%
Jackson	0.18%
Todd	0.18%
Grayson	0.18%
Clay	0.17%
Bullitt	0.17%
Montgomery	0.16%
Rockcastle	0.16%
Larue	0.15%
Franklin	0.12%
Rowan	0.12%
Trigg	0.12%
Warren	0.11%
Taylor	0.10%
Marshall	0.09%
Hopkins	0.09%
Muhlenberg	0.09%
Marion	0.08%
Harrison	0.07%
Barren	0.05%
Calloway	0.03%
Christian	0.02%
Bracken	0.00%
Graves	0.00%
Hickman	0.00%
Metcalfe	0.00%
Owsley	0.00%
Spencer	0.00%
Wolfe	0.00%

Appendix C. Percentage and Number of Electronic Crash Reports by County (November 2007 to December 2009)

Appendix C. Percentage and Number of Electronic Crash Reports by County (November 2007 to December 2009)

County	Percent	Sample	County	Percent	Sample	County	Percent	Sample
Adair	100.0%	841	Greenup	99.3%	2,123	Muhlenberg	96.7%	2,267
Allen	100.0%	1,247	Hancock	11.1%	34	Nelson	100.0%	3,168
Anderson	99.9%	1,221	Hardin	100.0%	6,965	Nicholas	52.8%	190
Ballard	99.8%	512	Harlan	99.4%	1,575	Ohio	99.7%	1,586
Barren	100.0%	3,671	Harrison	100.0%	1,458	Oldham	100.0%	2,174
Bath	100.0%	459	Hart	99.9%	1,172	Owen	100.0%	508
Bell	92.2%	1,833	Henderson	100.0%	4,635	Owsley	73.5%	86
Boone	100.0%	11,038	Henry	100.0%	921	Pendleton	99.1%	913
Bourbon	97.4%	1,432	Hickman	100.0%	67	Perry	100.0%	2,736
Boyd	99.2%	4,938	Hopkins	99.8%	4,411	Pike	99.1%	5,236
Boyle	100.0%	2,470	Jackson	99.6%	539	Powell	99.2%	752
Bracken	95.3%	326	Jefferson	67.3%	43,210	Pulaski	99.9%	5,081
Breathitt	98.9%	712	Jessamine	100.0%	3,950	Robertson	100.0%	23
Breckinridge	97.8%	806	Johnson	60.7%	942	Rockcastle	100.0%	1,247
Bullitt	100.0%	4,180	Kenton	99.1%	12,554	Rowan	100.0%	2,444
Butler	100.0%	519	Knott	96.7%	943	Russell	100.0%	1,051
Caldwell	100.0%	900	Knox	94.5%	1,573	Scott	98.5%	3,576
Calloway	100.0%	3,095	Larue	100.0%	680	Shelby	97.5%	3,116
Campbell	96.3%	7,197	Laurel	100.0%	4,430	Simpson	100.0%	1,476
Carlisle	85.9%	231	Lawrence	100.0%	781	Spencer	100.0%	592
Carroll	100.0%	897	Lee	98.9%	267	Taylor	100.0%	2,022
Carter	99.5%	1,473	Leslie	87.6%	296	Todd	99.8%	555
Casey	87.8%	730	Letcher	88.6%	1,218	Trigg	100.0%	823
Christian	100.0%	4,826	Lewis	100.0%	516	Trimble	100.0%	502
Clark	100.0%	3,041	Lincoln	100.0%	1,192	Union	100.0%	982
Clay	99.9%	1,184	Livingston	99.8%	549	Warren	80.9%	8,168
Clinton	100.0%	369	Logan	99.9%	1,653	Washington	100.0%	671
Crittenden	100.0%	508	Lyon	100.0%	658	Wayne	95.5%	897
Cumberland	83.1%	148	McCracken	91.9%	5,421	Webster	93.6%	538
Daviess	100.0%	9,310	McCreary	99.4%	654	Whitley	71.0%	1,793
Edmonson	100.0%	521	McLean	100.0%	469	Wolfe	99.6%	529
Elliott	100.0%	257	Madison	100.0%	7,671	Woodford	100.0%	2,092
Estill	80.5%	574	Magoffin	98.6%	630			
Fayette	99.5%	33,543	Marion	100.0%	1,306			
Fleming	100.0%	729	Marshall	100.0%	2,202			
Floyd	100.0%	2,851	Martin	100.0%	567			
Franklin	100.0%	4,863	Mason	100.0%	2,011			
Fulton	88.8%	363	Meade	98.9%	1,127			
Gallatin	79.6%	483	Menifee	100.0%	220			
Garrard	100.0%	950	Mercer	100.0%	1,419			
Grant	100.0%	2,313	Metcalfe	100.0%	563			
Graves	99.7%	2,237	Monroe	100.0%	485			
Grayson	99.0%	1,673	Montgomery	100.0%	2,452			
Green	100.0%	422	Morgan	100.0%	755			

Appendix D. 200 Crash Records with Largest Distance Between CRMP and GPS Locations Using Unedited MapIt (Excluding those with Altered GPS Data)

Appendix D. 200 Crash Records with Largest Distance Between CRMP and GPS Locations Using Unedited MapIt (Excluding those with Altered GPS Data)

MFN	DIST_MI	MFN	DIST_MI	MFN	DIST_MI	MFN	DIST_MI
70702614	27.2	70730429	15.9	70727995	12.1	70735457	10.7
70668339	25.7	70730430	15.9	70681812	12.1	70707066	10.7
70282282	24.8	70783650	15.6	70757042	12.1	70778390	10.6
70671018	24.0	70771374	15.5	70732326	12.0	70691803	10.6
70747394	23.5	70794931	15.5	70711414	12.0	70757587	10.5
70778959	23.3	70727416	15.5	70738659	12.0	70789714	10.4
70656923	21.8	70729474	15.5	70662320	12.0	70667768	10.4
70778506	21.2	70731202	15.4	70768725	12.0	70756898	10.4
70749322	20.4	70665004	15.3	70792192	11.9	70703520	10.4
70712957	20.2	70727194	15.2	70798017	11.8	70685673	10.4
70756593	20.2	70760822	15.1	70683287	11.7	70688504	10.4
70686626	20.2	70701552	15.0	70778978	11.6	70697075	10.3
70753392	20.0	70740194	14.8	70753742	11.6	70734615	10.2
70719582	19.7	70711552	14.6	70787216	11.6	70668688	10.2
70747403	19.7	70766634	14.6	70764337	11.6	70669889	10.0
70679469	19.6	70654995	14.6	70693969	11.6	70720901	10.0
70784013	19.5	70788973	14.5	70791699	11.6	70693574	9.9
70764366	19.1	70656988	14.5	70659017	11.6	70667138	9.9
70754723	19.1	70758224	14.3	70790017	11.6	70735046	9.8
70740673	18.8	70729820	14.2	70763854	11.6	70697885	9.8
70766928	18.6	70730509	14.0	70756833	11.5	70722388	9.7
70731348	18.6	70679014	13.7	70721252	11.5	70677661	9.7
70736223	18.6	70731799	13.7	70742850	11.4	70688063	9.7
70722915	18.6	70781744	13.6	70688565	11.4	70738950	9.7
70654363	18.6	70742925	13.6	70725173	11.3	70743821	9.6
70772749	18.5	70756913	13.6	70737784	11.3	70768867	9.6
70700508	18.5	70675313	13.5	70767630	11.3	70731448	9.5
70688914	18.5	70741365	13.5	70677020	11.3	70672580	9.5
70705932	18.3	70778296	13.4	70729247	11.3	70750842	9.5
70711973	18.0	70662271	13.2	70771284	11.2	70715965	9.4
70695220	17.9	70693319	13.2	70804261	11.2	70779467	9.4
70791535	17.9	70725105	13.0	70710458	11.2	70754795	9.4
70717654	17.8	70664175	12.8	70798164	11.2	70755057	9.4
70745126	17.8	70675112	12.8	70722721	11.1	70719769	9.4
70740931	17.7	70736261	12.7	70765228	11.1	70703407	9.4
70697970	17.4	70736805	12.7	70743635	11.1	70703659	9.4
70782885	17.2	70795883	12.7	70656482	11.1	70657702	9.4
70699975	17.0	70745549	12.5	70699240	11.0	70783518	9.4
70764553	17.0	70678629	12.5	70783123	11.0	70783590	9.4
70732055	16.9	70735315	12.5	70671787	11.0	70765557	9.3
70686391	16.7	70681360	12.4	70745935	10.9	70781197	9.3
70770629	16.5	70667024	12.4	70751853	10.9	70773995	9.3
70777803	16.4	70759665	12.3	70725286	10.9	70771917	9.3
70709611	16.4	70694091	12.3	70799077	10.8	70679398	9.3
70739837	16.4	70727233	12.2	70759639	10.8	70729334	9.3
70679564	16.2	70707959	12.2	70786122	10.8	70743468	9.3
70696066	16.2	70778351	12.2	70711058	10.7	70710393	9.3
70669437	16.1	70703378	12.2	70687895	10.7	70749532	9.3
70763978	16.1	70668249	12.2	70747799	10.7	70710394	9.3
70688978	15.9	70670755	12.2	70675444	10.7	70658741	9.3

Appendix E-3. The Counties with 20 or More Crashes and an Unmodified MapIt Location in 2009 Ordered by Descending Percentage of All 2009 Crashes

Agency Name	Number of Crashes in 2009 with Unmodified MapIt Location	Number of Crashes in 2009	Percent
Adair	100	841	11.9
Bath	45	459	9.8
Lewis	46	516	8.9
Owen	43	508	8.5
Wolfe	36	531	6.8
Powell	48	758	6.3
Rockcastle	71	1247	5.7
Grant	131	2314	5.7
Lee	14	270	5.2
Breathitt	37	720	5.1
Harlan	80	1584	5.1
Pendleton	44	921	4.8
Carter	70	1481	4.7
Pike	244	5282	4.6
Martin	26	567	4.6
Muhlenberg	107	2344	4.6
Leslie	15	338	4.4
Gallatin	26	607	4.3
Magoffin	27	639	4.2
Clay	50	1185	4.2
Logan	67	1655	4.0
Hardin	269	6965	3.9
Nelson	112	3168	3.5
Letcher	46	1374	3.3
Green	14	422	3.3
Fleming	24	729	3.3
Grayson	55	1690	3.3
Jackson	17	541	3.1
Carroll	28	897	3.1
Elliott	8	257	3.1
Kenton	394	12674	3.1
Butler	16	519	3.1
Trimble	15	502	3.0
Knott	29	975	3.0
Scott	106	3629	2.9
Morgan	22	755	2.9
Ohio	46	1590	2.9
Casey	24	831	2.9
Allen	36	1247	2.9
Webster	16	575	2.8
Warren	280	10100	2.8
Lincoln	32	1192	2.7

Appendix E-3. The Counties with 20 or More Crashes and an Unmodified MapIt Location in 2009 Ordered by Descending Percentage of All 2009 Crashes

Agency Name	Number of Crashes in 2009 with Unmodified MapIt Location	Number of Crashes in 2009	Percent
Rowan	64	2445	2.6
Simpson	38	1476	2.6
Graves	57	2243	2.5
Anderson	30	1222	2.5
Mercer	34	1419	2.4
Washington	16	671	2.4
Spencer	14	592	2.4
Bracken	8	342	2.3
Trigg	19	823	2.3
Henry	21	921	2.3
Monroe	11	485	2.3
Cumberland	4	178	2.2
Lawrence	17	781	2.2
Knox	36	1664	2.2
Hart	25	1173	2.1
McCreary	13	658	2.0
Crittenden	10	508	2.0
Metcalfe	11	563	2.0
Edmonson	10	521	1.9
Floyd	54	2852	1.9
Mason	38	2011	1.9
Meade	21	1140	1.8
Menifee	4	220	1.8
Bell	35	1988	1.8
Livingston	9	550	1.6
Estill	11	713	1.5
Whitley	38	2526	1.5
Perry	41	2736	1.5
Pulaski	75	5086	1.5
Caldwell	13	900	1.4
Woodford	30	2092	1.4
Russell	15	1051	1.4
Nicholas	5	360	1.4
Laurel	61	4430	1.4
Bullitt	57	4180	1.4
Bourbon	20	1470	1.4
Franklin	66	4863	1.4
Clinton	5	369	1.4
Oldham	29	2174	1.3
Clark	40	3041	1.3
Boyd	63	4979	1.3
Barren	43	3671	1.2

Appendix E-3. The Counties with 20 or More Crashes and an Unmodified MapIt Location in 2009 Ordered by Descending Percentage of All 2009 Crashes

Agency Name	Number of Crashes in 2009 with Unmodified MapIt Location	Number of Crashes in 2009	Percent
Harrison	17	1458	1.2
Daviess	107	9310	1.1
Jessamine	45	3950	1.1
Madison	84	7671	1.1
Breckinridge	9	824	1.1
Todd	6	556	1.1
Wayne	10	939	1.1
Shelby	34	3196	1.1
Greenup	22	2139	1.0
Marion	13	1306	1.0
Fulton	4	409	1.0
Hopkins	43	4419	1.0
Union	9	982	0.9
Lyon	6	658	0.9
Henderson	42	4635	0.9
Larue	6	680	0.9
Marshall	19	2202	0.9
Montgomery	21	2452	0.9
Boone	88	11038	0.8
Ballard	4	513	0.8
Campbell	53	7475	0.7
Taylor	14	2022	0.7
Calloway	21	3095	0.7
Christian	31	4826	0.6
McLean	3	469	0.6
Garrard	6	950	0.6
Boyle	14	2471	0.6
McCracken	26	5897	0.4
Jefferson	255	64215	0.4
Carlisle	1	269	0.4
Fayette	123	33711	0.4
Hancock	1	305	0.3
Johnson	3	1552	0.2

Appendix E. Unmodified MapIt Location in 2009 Ordered by Descending Percentage of All 2009 Crashes

Appendix E-1. The County-Routes with 20 or More Crashes and an Unmodified MapIt Location in 2009 Ordered by Descending Percentage of All 2009 Crashes

County-Route	Number of Crashes in 2009 with Unmodified MapIt Location	Number of Crashes in 2009	Percent
Bath @ KY-36	23	25	92.0
Kenton @ KY-1072	139	152	91.4
Hardin @ KY-3005	107	119	89.9
Lewis @ KY-8	39	47	83.0
Pulaski @ KY-914	24	29	82.8
Warren @ KY-185	44	59	74.6
Nelson @ BG-9002-10	36	49	73.5
Adair @ KY-80	26	36	72.2
Powell @ KY-9000	27	43	62.8
Graves @ KY-121	35	58	60.3
Adair @ KY-55	41	73	56.2
Kenton @ CS-2103	57	105	54.3
Kenton @ KY-2045	21	39	53.8
Pike @ US-119-10	35	67	52.2
Rockcastle @ I-75-10	32	66	48.5
Warren @ US-68	85	179	47.5
Pike @ US-119	64	139	46.0
Carter @ I-64	26	57	45.6
Muhlenberg @ KY-70	25	55	45.5
Scott @ I-75-10	46	103	44.7
Carter @ I-64-10	27	61	44.3
Logan @ US-431	43	105	41.0
Harlan @ US-421	47	118	39.8
Muhlenberg @ US-431	64	174	36.8
Rockcastle @ I-75	21	58	36.2
Grant @ I-75-10	40	149	26.8
Kenton @ KY-1303	34	138	24.6
Hardin @ I-65-10	21	87	24.1
Pike @ KY-194	33	148	22.3
Grant @ I-75	24	109	22.0
Hardin @ I-65	25	126	19.8
Rowan @ KY-32	29	281	10.3
Kenton @ KY-17	31	378	8.2
Warren @ US-231	41	657	6.2

Appendix E-2. The Agencies with 20 or More Crashes and an Unmodified MapIt Location in 2009 Ordered by Descending Percentage of All 2009 Crashes

Agency Name	Number of Crashes in 2009 with Unmodified MapIt Location	Number of Crashes in 2009	Percent
COLUMBIA POLICE DEPARTMENT	47	79	59.5
CENTRAL CITY POLICE DEPARTMENT	55	165	33.3
LEWIS COUNTY SHERIFF DEPT.	33	112	29.5
FT. WRIGHT POLICE DEPARTMENT	138	546	25.3
HARLAN POLICE DEPARTMENT	34	150	22.7
ADAIR COUNTY SHERIFF DEPT.	28	133	21.1
CARTER COUNTY SHERIFF DEPT.	29	155	18.7
LOGAN COUNTY SHERIFF DEPT.	53	287	18.5
WARREN COUNTY SHERIFF DEPT.	118	687	17.2
GRANT COUNTY SHERIFF DEPT.	53	316	16.8
INDEPENDENCE POLICE DEPARTMENT	55	330	16.7
PENDLETON CTY SHERIFF DEPT.	33	204	16.2
NELSON COUNTY SHERIFF DEPT.	78	524	14.9
KY STATE POLICE, POST 08	160	1142	14.0
MARTIN COUNTY SHERIFF DEPT.	24	173	13.9
KY STATE POLICE, POST 15	57	427	13.3
KY STATE POLICE, POST 06	81	625	13.0
KY STATE POLICE, POST 09	281	2179	12.9
ELIZABETHTOWN POLICE DEPT.	147	1164	12.6
KY STATE POLICE, POST 04	154	1255	12.3
KY STATE POLICE, POST 14	55	452	12.2
SCOTT COUNTY SHERIFF DEPT.	77	666	11.6
KY STATE POLICE, POST 11	110	963	11.4
KY STATE POLICE, POST 05	94	840	11.2
MERCER COUNTY SHERIFF DEPT.	22	203	10.8
KY STATE POLICE, POST 03	110	1048	10.5
MUHLENBERG CO SHERIFF DEPT	21	204	10.3
EDGEWOOD POLICE DEPARTMENT	22	223	9.9
MASON COUNTY SHERIFF	23	237	9.7
ALLEN COUNTY SHERIFF DEPT.	29	300	9.7
KY STATE POLICE, CVE	90	978	9.2
CAMPBELL COUNTY POLICE DEPT.	26	284	9.2
KY STATE POLICE, POST 10	53	580	9.1
OHIO COUNTY SHERIFF DEPT.	27	296	9.1
KY STATE POLICE, POST 13	109	1197	9.1
JESSAMINE COUNTY SHERIFF DEPT.	39	446	8.7
KY STATE POLICE, POST 12	55	667	8.2
GRAVES COUNTY SHERIFF DEPT.	24	292	8.2
FRANKLIN COUNTY SHERIFF DEPT.	23	287	8.0
GRAYSON COUNTY SHERIFF DEPT.	22	285	7.7
PULASKI COUNTY SHERIFF DEPT.	65	856	7.6
COVINGTON POLICE DEPARTMENT	102	1359	7.5
KY STATE POLICE, POST 16	40	558	7.2
KENTON COUNTY POLICE DEPT.	24	336	7.1

Appendix E-2. The Agencies with 20 or More Crashes and an Unmodified MapIt Location in 2009 Ordered by Descending Percentage of All 2009 Crashes

Agency Name	Number of Crashes in 2009 with Unmodified MapIt Location	Number of Crashes in 2009	Percent
DAVIESS COUNTY SHERIFF DEPT.	56	787	7.1
CLARK COUNTY SHERIFF DEPT.	30	426	7.0
LINCOLN COUNTY SHERIFF DEPT.	24	352	6.8
BULLITT COUNTY SHERIFF DEPT.	37	548	6.8
MOREHEAD POLICE DEPARTMENT	25	378	6.6
KY STATE POLICE, POST 07	67	1040	6.4
HENDERSON COUNTY SHERIFF DEPT.	21	337	6.2
BARREN COUNTY SHERIFF DEPT.	28	466	6.0
LAUREL COUNTY SHERIFF DEPT.	35	598	5.9
KY STATE POLICE, POST 02	72	1241	5.8
ERLANGER POLICE DEPARTMENT	44	846	5.2
CORBIN POLICE DEPARTMENT	27	561	4.8
OLDHAM COUNTY POLICE DEPT.	28	646	4.3
BOYD COUNTY SHERIFF DEPARTMENT	28	647	4.3
VERSAILLES POLICE DEPARTMENT	30	721	4.2
KY STATE POLICE, POST 01	35	842	4.2
SHELBY COUNTY SHERIFF DEPT.	25	631	4.0
BOWLING GREEN POLICE	88	2240	3.9
ASHLAND POLICE DEPARTMENT	30	921	3.3
FRANKFORT POLICE DEPARTMENT	26	941	2.8
BOONE COUNTY SHERIFF DEPT.	59	2347	2.5
OWENSBORO POLICE DEPARTMENT	35	2224	1.6
LOUISVILLE METRO POLICE DEPT	219	21413	1.0
LEXINGTON POLICE DEPARTMENT	114	11414	1.0

For more information or a complete publication list, contact us at:

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