Methodologies for Estimating Motorcycle VMT

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ABSTRACT

Increasing rates of motorcyclist fatalities and registrations but decreasing reported vehicle-miles traveled (VMT) resulted in suspicions that motorcycle monitoring programs need improvement. Better detection of motorcycles is needed along with guidance on locations to capture representative counts of motorcycles. This research used field-testing to investigate the following technologies:

- inductive loops/piezoelectric sensors (full lane width),
- magnetometers by Sensys Networks,
- multi-technology system by Migma Systems, Inc.,
- tracking video system by TrafficVision, and
- infrared classifier (Transportable Infrared Traffic Logger, TIRTL).

In addition to the technology, states need to consider the data sampling methodology. The research team hoped to find one or more states whose data collection methodology could provide an example to guide other states but did not find any. The alternate approach investigated by this research project was the use of motorcycle crashes to determine if a correlation exists between crash locations and motorcycle counts. Analysis of crashes in four states indicated that motorcycle crash locations are reasonably good predictors of where to count motorcycles.

INTRODUCTION

Motorcyclist fatalities declined in 2009 for the first time in 11 years. Data from the National Highway Traffic Safety Administration's (NHTSA) Fatality Analysis Reporting System (FARS) show that motorcyclist deaths decreased by 16 percent, from a record high of 5,312 in 2008 to 4,452 in 2009 (*1*). Some states attributed these declines to fewer beginning motorcyclists; expanded motorcycle safety efforts; and fewer miles traveled due to bad weather and the economic downturn (*2*). However, the decline did not continue, and the 2010 and 2011 data both indicate increases in fatalities to 4,518 in 2010 and 4,612 in 2011 (*3*).

Meanwhile, according to the Federal Highway Administration (FHWA), the primary indicator of motorcycle travel, vehicle-miles traveled (VMT), had not grown nearly as much during that period, increasing by 38 percent from 10.5 million miles in 2000 to 14.5 million miles in 2008 (*4*). Accurate and reliable motorcycle travel data are necessary to examine highway safety trends over the course of several years, and for the nation as a whole. Most commercially available traffic monitoring systems have difficulty detecting and classifying motorcycles accurately because motorcycles have unique features, such as their small size and narrow width, low metal mass, and single wheel track.

Better detection of motorcycles is only part of the solution. The other part has to do with the spatial distribution of vehicle classification sites to accurately represent the distribution of vehicles by class, especially motorcycles. State traffic monitoring programs need to know the locations and times most appropriate for counting motorcycles to get a representative count of motorcycles. States need to consider weekend rural counts to improve their estimated motorcycle average annual daily traffic (AADT) and VMT.

DATA COLLECTION PROTOCOLS

The research team searched for one or more states whose data collection protocols could serve as an adequate example for others to follow but did not find one. The alternate methodology was to investigate crash data to determine whether motorcycle crash locations are distributed geographically in a pattern that reflects the geographic distribution of traffic volume. Generally, there is agreement in the transportation safety field that traffic volume is directly related to crash frequency. In modeling crashes at specific locations or for specific roadway types, traffic volume is typically the single most significant predictive value. For example, Golob and Recker found that traffic flow characteristics accounted for 77 percent of the variance in crash location and type (*5*). This model was limited to urban freeways in California and thus had a constrained list of location types, perhaps accounting for the high level of correlation.

TTI was unable to identify any published studies making the link between motorcycle traffic volume and crashes. However, the existing modeling results for crashes in general, along with logical reasoning based on past modeling results, led researchers to suspect that motorcycle crash locations, like all other motor vehicle crashes, are strongly linked to traffic volume. There are two alternative ways to look at this as a hypothesis. First, the volume of motorcycle traffic, considered in isolation from all other traffic count data, should be positively associated with crash locations—motorcycle crashes happen where the motorcycles travel. Second, the volume of overall traffic (counting all vehicles, including motorcycles), should be positively associated with motorcycle crash locations because of the already established relationship between overall volume and crashes.

Researchers approached this analysis based on an initial mapping of crash and traffic volume data for four states that recorded precise locations of crashes—Michigan, Montana, Texas, and Wisconsin. The goal of this analysis was to determine to what extent a state might be able to rely on the spatial distribution of motorcycle crashes when attempting to determine where best to count motorcycle traffic.

FIELD DATA COLLECTION AND ANALYSIS

The field data analysis initially used two ways of calculating accuracy of each detection system. The first is called “simple detection accuracy” and compares total correct detections of motorcycles by each test system to total correct detections. The second method of calculating accuracy was the "overall detection accuracy." It combined correct detections and correct rejections in the numerator divided by the total of all responses in the denominator. While appropriate for many applications of signal detection, the overall detection accuracy resulted in accuracy values so close to unity in almost all cases that it did not facilitate comparisons and was not deemed appropriate for further use.

Table 1 shows where testing occurred for each of the five selected detector technologies and the products selected to represent each technology. Products within each technology group other than those tested could yield different results. Much of the testing occurred at TTI's freeway testbed in College Station with additional data collected at two motorcycle rallies—one in New Ulm, Texas, in May 2012, and the other in Daytona Beach, Florida, in October 2012.

Table 1. Test locations and products used for this research.

Technology	Product Selected	TTI Testbed	Texas Rally	Florida Rally
Infrared (IR) classifier	Transportable Infrared Traffic Logger (TIRTL)	NO	YES	YES
Loop/piezo	IRD TRS Rack II classifier, MSI[a] "BL" piezo sensor	YES	NO	NO
Magnetometer	Sensys Networks	YES	NO	NO
Multi-technology	Migma Systems, Inc.	YES	YES	NO
Tracking video	TrafficVision	YES	YES	NO

[a] MSI: Measurement Specialties, Inc.; BL: brass linguini.

Table 2 presents the findings of the field studies in terms of simple detection accuracy, initial cost, portability, and ease of setup. These findings cover both motorcycles and other vehicles for technologies designed to detect all vehicles. These accuracy values represent optimum conditions, so the technologies would not always perform this well. The multiple technology system is designed specifically to detect only motorcycles. The full lane width piezo and loop system appeared to exhibit problems for motorcycle and other light vehicles, so results could improve as problems are resolved. Magnetometer accuracy values assume that motorcycles pass very close to the sensors.

Table 2. Overall technology comparison.

Technology	MC Accuracy	Non MC Accuracy	Initial Cost		Portability	Skill Level for Setup [a]
			Two-lane	Four-lane		
Infrared classifier	95%	98%	$26,850	$26,850	Fixed/Portable [b]	Expert
Loop/piezo	45%	95%	$33,000 [c]	$61,000 [c]	Fixed	Field Tech.
Magnetometer	80%	95%	$10,204	$15,964	Fixed [d]	Field Tech.
Multi-technology	50%	N/A	$6,000	$12,000	Fixed [d]	Field Tech.
Tracking video	75%	90%	$15,000	$15,000	Fixed [d]	Field Tech.

[a] Setup skill level—expert required versus field technician (with proper training).
[b] TIRTL is available as either portable or fixed but only portable was tested in this research.
[c] Estimated by TxDOT: $61,000 total for four-lane site and $33,000 total for two-lane site.
[d] Some components could be portable, or detector could be portable with modification.

For non-motorcycle detection, results from four detectors are in the acceptable range. The only technologies in the group that are likely to be affected significantly by inclement weather such as rain and fog are the tracking video system and the multi-technology system, although the research team did not encounter these conditions. In northern climates with potential for snow/ice accumulation, the infrared classifier's performance would likely be affected as long as the accumulation remains.

The cost and portability of each system should be considered together since a highly portable system can serve several sites instead of only one. A good example is the infrared classifier with an initial cost for four lanes that is almost twice the cost of magnetometers, the multi-technology detector, or the tracking video. The discrepancy is even greater for two-lane sites, but its portability is high. The multi-technology system is the least expensive and is portable, but its accuracy is not sufficient for it to be a viable contender at this time. The video system could become portable by using a trailer-mounted camera and power supply. It could also use fixed cameras that are used for other purposes as long as their pan/tilt/zoom capability is available during the data collection period. Certain components of the magnetometers would be portable, but the sensor nodes in the pavement would be fixed.

RECOMMENDATIONS

Data Collection Protocols

Evidence indicates that the spatial distribution of motorcycle crashes is associated with the spatial distribution of traffic to the point that a state could be confident in using crash location as an indicator of where it should invest first in improved motorcycle count setups. The authors believe this is a viable method of checking existing classification count locations and determining the need for additional sites for detecting motorcycles, but this belief should be verified with data from additional states.

The spatial distribution of motorcycle crashes is associated with the spatial distribution of traffic (and vice versa) to the point that a state could be confident in using crash location as an indicator of where (geographically) it should invest first in improved motorcycle count setups. The logical extension is that the methodology works equally well for weekends and weekdays. That is, the locations of weekend motorcycle crashes can be used to determine where to conduct weekend counts just as the location of weekday crashes can be used to determine where to conduct weekday counts.

Technology Selection

Recommendations pertaining to the five detectors address each one individually rather than to rank them against each other. The reason direct comparison would not be appropriate is:

- This research did not test them all simultaneously under the same conditions.
- Different technologies have their own inherent strengths and weaknesses.
- Environmental conditions affect some technologies more than others.

Infrared Classifier. The setup of the portable system appears to require an expert and site selection is critical to a proper setup, but its accuracy for all vehicle types and being able to classify all of the FHWA Scheme F classes are strong positive attributes. The portable IR classifier can provide lower cost per lane compared to other alternatives.

Inductive Loops/Piezos. Many states are already using loops and piezos but the low detection rate for motorcycles plus their other negative factors should encourage states to replace these legacy systems with non-intrusive detectors that are more accurate. At the very least, states will need to replace existing 6-ft piezos with full lane width piezos for detection of motorcycles.

Magnetometers. The data collected in this research indicates that covering the full lane width in a way to avoid gaps in coverage will require at least two (and perhaps three) magnetometers at each station in a 2-2 or 3-3 configuration separated by at least 12 ft longitudinally. Magnetometers appear to overestimate the length of motorcycles, so future research needs to verify length estimates. This research did not investigate detector sensitivity settings and their impact on Class 1 detections or length estimates.

Multi-Technology Sensor. This sensor is already undergoing improvement through Small Business Innovation Research funding and will be evaluated again with rigorous field testing following modifications. Changes that are known to be underway include an improved user interface and the ability to detect non-motorcycles. The user community should wait until these new features are incorporated and full testing shows it to be a reliable sensor.

Tracking Video. The tracking video system has the potential to be even better than this research indicated with the planned improvements that are already underway by the manufacturer. Future testing needs to include a variety of environmental conditions using both infrared and traditional cameras.

REFERENCES

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