INVESTIGATION OF ASIM 29X, CANOGA, RTMS, SAS-1, SMARTSENSOR, TIRTL & OTHER SENSORS FOR AUTOMATIC VEHICLE CLASSIFICATION

RESEARCH NEED

This research will add to the national and local state-of-the-art on the ability of several non-intrusive sensors to provide simple (two-to-four category) automated vehicle classification (AVC). Past efforts on this subject, the most recent of which are the MnDOT/SRF Consulting project in Minnesota and a similar state-sponsored study in Pennsylvania used either inadequate data in terms of evaluation of classification or have reached conflicting conclusions or recommendations. (Ref. 7 and 17.)

The MnDOT/SRF Consulting project examined three sensors: RTMS, SmartSernsor and SAS-1. It specified that speed and vehicle length calibration is an iterative process and that it takes a significant time to finalize the optimal settings. Methodology for establishing optimal settings and optimal settings for typical freeway or highway cross-sections were not given. SAS-1, of which HDOT has two units available, was not tested for classification. SmartSensor has been superceded by SmartSensor HD (high definition.) Also Canoga and video-based sensors were not tested.

Two of the report's major not only for Hawaii but also for national application are: (1) All sensors were tested with offsets and heights of 20 ft. and larger, in order to satisfy manufacturer recommendations. Based on our prior experience, these sensor clearances from the first lane of travel are unrealistic for short-duration portable deployments due to the lack of right of way and clearances in urban areas. Similar limitations apply to permanent deployments in urban settings. Available infrastructure such as sign gantries and utility poles for mounting with 20/20 offset/height clearances are rarely available with the necessary clearances and heights. Our past research addressed this issue and we intend to address it again with the AVC tests. (2) The results and recommendation for the suitability of RTMS and SmartSensor to provide AVC were based on two locations on the same freeway detecting three lanes for a duration of two hours per site. There was no variety of facilities such as narrow and wide freeway cross-sections and there were no tests on rural highways and arterials. The whole classification dataset for the entire report (except for the separate TIRTL tests) was four (4) hours.

The MnDOT/SRF Consulting project concluded that the sensors mentioned above can provide three-class classification fairly reliably. On the other hand, the PennDOT report found that classification even in two classes (short and long vehicles) can be problematic with overhead sensors. TIRTL worked well in PennDOT tests but was labor-intensive and did not work well for multilane roads with a pronounced crown.

In short, the information available on the efficacy of various traffic sensors for the collection of vehicle classification data is not yet sufficient for making decisions of sensors for use in Hawaii. None of the prior efforts tested the SmartSensor HD and ASIM 29x sensors.

PROBLEM STATEMENT AND RESEARCH OBJECTIVES

The main objective of this project is to conduct cooperative research with the Hawaii State DOT (HDOT) on sensor tests and data collection for vehicle classification.

A number of questions on automated vehicle classification remain unanswered and this project will attempt to provide appropriate answers.

- **Quantitatively prove that sensors have automated classification reliable to +/-5%.**
  Compact vehicle classification in three or four major classes is allowed and recommended in the TMG. In theory, several unintrusive sensors can perform this function. However, there is only little and conflicting evidence that these sensors can provide basic AVC with a reasonable reliability such as a ±5% error in each of two to four classes.
- **Determine vehicle patterns in Oahu based on vehicle class.**
  Small vehicle and heavy vehicle traffic are likely to have distinct and different travel patterns. First this needs to be established. If heavy vehicle patterns on Oahu are distinct from cars (which is the case on most U.S. highways according to the TMG), then the truck/heavy vehicle patterns need to be established and correction or bias factors need to be developed.

Over 100 references were found on automated vehicle classification in the University of California online database of all sources, a most comprehensive resource for researchers. However, only about 20 references dating from 2000 or later (the TMG was prepared in year 2000 and published in 2001; relevant references are shown in Appendix B) and of these only two (2) have involved non-video and non-inductive loop based detection technologies, which are the main focus of tests in this project.

The overall project objective is to identify a set of sensors and locations as well as bias corrections that over time will yield a reliable set of classification data for the island of Oahu. Once this is done, HDOT can expand it with permanent deployments on all islands for statewide coverage. Specific objectives are as follows:

- Develop portable or semi-portable classification stations. Some on trailers (light plants), others on luminaires or road sign/signal gantries.[1] In addition, HDOT will be providing on a part-time basis for the purposes of this project two video-based fully instrumented traffic data acquisition trailers.
- Test sensors and establish classification capability.
- Upgrade sensors so that classification can be had with no loss of routine volume and speed measurements.
- Corrections by time of day, day of the week and monthly seasonality, for locations with permanent classification stations.

Additional objectives include:

- Investigate video-based classification based on equipment already available from the past project (46518) and from expected acquisition of a trailer with camera(s) by HDOT. It is expected that either via the HDOT or via the City and County Traffic Control Center video-taping will take place as part of this project for the electronic and manual verification of the accuracy of the tested sensors.
- Test newly developed sensors in the second year, that is, the testing relatively low-cost unintrusive sensors that are currently unavailable.

[1] The installation of unintrusive sidefired or overlane sensors is de facto semi-portable. The entire system consists of the sensor, a solar panel, an antenna and a cabinet that keeps the batteries, the electric power/charging controller, the sensor data unit and the telecommunications box. All these can be attached to a properly positioned luminaire or pole-and-mast by a dozen steel brackets, and they can be removed in about one hour with a staff of two electricians and a boom-and-bucket truck.

- 3M Canoga detector cards were installed as part of the previous research project and were connected to TrafficWerks (TW) service. Use the same installations to test the ability of these cards in combination with in-pavement inductive loops to classify vehicles.
- Potentially incorporate the obtained counts into HDOT's already acquired TW Internet-based data repository and database tool. (The project will have to budget monies because the TW cost is on a "per station" basis.)

POTENTIAL IMPLEMENTATION AND BENEFIT

The benefits of the project are multifaceted. First, the ability of sensors to conduct automated vehicle classification (AVC) to provide useful data for pavement design and other purposes will be investigated. This is an essential step and it is recommend in the TMG. Past results are based on data of questionable quantity and have led to conflicting conclusions.

The project will also assess the ability of technologies that are available at HDOT (specifically loop-based Canoga stations and video-based portable trailer traffic data stations) to provide a reliable array of volume, speed and classification data.

Supplementary software technology will be developed for remote management of the data collection settings of remote field sensors.

Depending on the discovered limitations, as well as the strengths and weaknesses of the portable systems, a survey plan can be established with a mix of (1) portable, (2) semi-permanent, luminaire or mast installed sensors and (3) permanent classification stations for the coverage of volume, speed and classification data on all islands. The mix of a few permanent, some semi-fixed and some sensor-on-trailer detection stations once found sufficient for the collection of representative volume, speed and classification data should result in significant savings for HDOT.

No implementation issues are anticipated for any of these sensors since most sensors have been test-deployed as part of project 46518. However, the development of software and the tuning of communications parameters for data acquisition are expected to be challenging. Also, the sensors are likely to require significant tuning in order to provide representative vehicle classification data based on length.

APPENDIX A: 2001 TRAFFIC MANAGEMENT GUIDE

TMG on the importance of vehicle classification

- Vehicle classification data are extremely important and will become even more important as transportation agencies and legislatures grapple with increasingly older, more congested roadways that need long lasting repair and rehabilitation in order to ensure statewide economic vitality.

TMG on vehicle classification issues

- Complicating the monitoring of traffic patterns is the fact that not much data has been collected by classification and not much analytical work performed. Many of these patterns are not well understood at the State and individual roadway levels. **Further complicating matters is the fact that travel patterns for trucks are usually quite different than those for cars.** Data collection plans currently used tends to be structured around understanding the movements of cars not trucks.

- The difference between the recommended counting program for vehicle classification information and the traditional volume counting program is that the factor groups used for volume counts do not usually create accurate factors for adjusting vehicle classification data.
- Traditional volume factoring groups are oriented toward functional classification of roadway, which may or may not correlate well with truck travel patterns.
- All States currently use the 13-category classification scheme or some variation of it. …[but]… Several of the FHWA categories contain so few vehicles that it is not possible to count and accurately report them.

TMG on requirements

- A State DOT should be able to provide users with an estimate of the amount of truck traffic by type of truck by road segment.
- States should maintain and be able to report the classification algorithm used to define each vehicle category they collect.
- Several States publish "truck volume" maps and/or "freight flow" maps.
- The new pavement design guide requires considerably more traffic data than traditional pavement design procedures.
- New pavement design guide also requests knowledge about seasonal variation in truck volumes and time of day distributions in those volumes.
- Each State highway agency needs to operate a set of continuous classification counters to measure truck travel patterns and provide the factors to convert short classification counts to annual averages.

TMG on sensor issues

- The three types of sensors most frequently used for collecting truck volume information (visual, axle, and presence sensors) each provide a different mechanism for classifying vehicles. Within each of these three broad categories is an array of sensors with different capabilities.
- Each type of sensor works well under some conditions and poorly in others. The result is an array of options for classifying vehicles, and an even wider array of ways in which the resulting vehicle counts are stored and reported from the field.
- Many States use other classification schemes in places where **axle sensors do not work effectively (e.g., congested urban conditions)** or where non-intrusive sensors are needed.
- Many States use a variety of equipment for different conditions and therefore are confronted with the task of dealing with different vehicle classification schemes at different points in the network.
- Existing counter technologies have significant difficulty classifying vehicles in conditions where vehicles do not operate at constant speed, where vehicles follow very closely, or where stop and go traffic occurs. This is particularly true for equipment that relies on inductance loops and axle detectors.
- **Agencies must take special care in selecting both the technologies they use and the locations where they place the equipment to ensure that the data collected are valid. Research efforts to investigate new technologies should continue.**
- For each of the technology solutions (axle, length, or vision) there are generally a number of different sensor technologies. Each sensor has its own advantages and disadvantages regarding cost, reliability, accuracy, life span, ease of set up, and type of information provided.
- Each of the basic classification and sensing technologies has strengths and weaknesses that allow some classification techniques to work better than others under specific environmental and traffic conditions. No technology has proven to be the best under all conditions.
- The ideal vehicle classifier would be able to measure a wide variety of vehicle characteristics to differentiate trucks on the basis of several different factors and to meet the needs of different users. Unfortunately, such a sensor does not currently exist at an affordable price. Consequently, agencies must select the technologies that provide the data they most need to provide the

classification information they require, at the locations where those data are needed, at prices they can afford.

- Research and development of **new sensors using infrared, microwave, and radar technologies is in progress. Several traffic monitoring systems using these technologies are on the market and are capable of providing vehicle volumes by at least length classification. Highway agencies are encouraged to investigate these devices** to determine where and when these new technologies can provide more cost-effective solutions to the accurate collection of classification data.

TMG on classification methodology

- A fairly large number of short duration classification counts should be performed to monitor and capture truck movements taking place on individual roads. … However, without adjustment, short duration classification counts yield biased estimates. … Sources of variation: time of day, day of week, time of year, direction, geography.
- The permanent classifiers should be used to compute adjustment factors that can be applied to short duration classification count data to convert a daily count into an estimate of annual average daily volume for that roadway.
- **For many analyses, simple vehicle classification schemes (passenger vehicles, single unit trucks, combination trucks) are more than sufficient.**
- Fine tuning the classification algorithm is needed because the visual basis of the FHWA 13 categories does not translate to an exact set of axle spacings. For example, classes 2 and 3 (passenger car and other two-axle, four-tire, single-unit vehicles) are easily identified visually. However these classes are often inter-mixed by axle-sensor-based classification counters. This is because larger cars often have wheelbases equal to or longer than those of small trucks. These types of problems exist in a variety of vehicle classes.
- Difficult choices are made to fine-tune the classification algorithms. This usually means ensuring that the algorithms correctly classify "important" truck categories and only have problems classifying types of trucks that are rare and of less importance to the highway community.
- The aggregation of the FHWA 13 classes into three or four classes is specifically recommended for the seasonal factoring of truck volumes.
- **It is recommended that adjustment factors to remove the temporal bias be computed only for three or four "generalized" vehicle classes. … The four traditional categories often used are: passenger vehicle (cars and light pick-ups), single unit trucks, single combination trucks (tractor-trailer), multi-trailer trucks.**
- Where practical, a State highway agency should collect data in the 13 FHWA vehicle classes but perform the majority of its data reporting with a more aggregated classification system, such as the four categories described above.
- Vehicle classification counts of longer than 48 hours are useful, particularly when those counts extend over the weekend, since they provide better day-of-week volume information. However, in many locations it is difficult to keep portable axle sensors in place for periods that significantly exceed 48 hours.
