Radar-Platoon Technique for Efficient and Complete Speed Measurements

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A technique by which a single observer can accurately estimate speeds of all vehicles in a single lane of traffic with the use of a radar device, regardless of the volume of traffic in that lane, is described. This is accomplished by considering platoons of vehicles rather than each individual vehicle. For each platoon, the speed, platoon composition, and lead-vehicle type are recorded. The speed is measured by means of a radar unit while the platoon composition and platoon lead-vehicle type are observed visually and recorded manually. On two-lane highways, this technique can provide detailed volume counts and speed measurements for one direction of traffic flow and summarized (e.g., 5-min) vehicle counts for the opposite direction. For total two-way volumes of less than 500 vehicles/h, the single observer can provide detailed volume counts and exact speed measurements for both directions.

Although there exist many direct and indirect methods for measuring the traffic characteristics of a highway, they tend to be geared toward one specific type of measurement and do not produce, by themselves, the type of complete data that are required for a thorough analysis of highway performance. Any extra data must therefore be obtained by using other techniques and additional resources. Some of these basic data-acquisition methods are listed below and described in a previous paper (1):

1. Volume counts—visual observation, mechanical counter, and microcomputer; and
2. Speed measurements—license-plate matching, stopwatch technique, microcomputer, and radar.

There are many indicators that either individually or collectively indicate how effectively a highway accommodates various levels of traffic. The total number of vehicles and the average speed of these vehicles are two of the most commonly obtained statistics. Although speed and total volume are perhaps the most important indicators of the operating performance of a highway, other types of data are needed for a more complete analysis. It is often important to know the vehicle composition of the traffic stream, for one can seldom consider either a truck, a bus, or a motorcycle to be equivalent to a car in this regard. In addition, one is also interested in the spatial distribution of these vehicles, for again it is important to know if these vehicles are all traveling as a single group, known as a platoon, or as individual, independent units.

Similarly, one needs to know more than just the average speed of all vehicles. To know the frequency distribution of their speeds and to determine to what degree drivers are prevented from driving at their desired speeds are often of equal or even greater importance.

Obtaining this type of complete data has been expensive and time consuming. One could either employ excessive amounts of resources or settle for a smaller data set.

With this thought in mind, the radar-platoon technique was developed and tested (2). After 500 h of application in the field it has been found to be fast, accurate, and relatively inexpensive in terms of time and money. These advantages make this method for monitoring the performance of a highway most efficient and highly practical.

DESCRIPTION OF RADAR-PLATOON TECHNIQUE

The radar-platoon technique for obtaining traffic data is based on the use of a radar unit for measuring speeds and the division of the traffic flow into platoons for the purpose of assigning these speeds. Whereas various other techniques for measuring speeds require either extra calculations or several people to take a single reading, the radar unit operated by a single individual automatically produces instantaneous values of speed.

Even with the radar unit, it is not always possible to individually record the speed of every vehicle that passes by, especially at higher volumes. However, vehicles tend to form groups (platoons) at these higher volumes. Since platoons travel as one unit, the average speed of the platoon can be taken to adequately represent the speed of each member of that platoon for most practical purposes. The division of the traffic flow into platoons therefore allows a representative speed of each vehicle to be recorded.

The radar-platoon technique consists of counting the number of vehicles of each type in each platoon, recording the platoon lead-vehicle type, and recording an average speed of the given platoon from the radar unit. This can be accomplished without great difficulty by a single person, as the speeds of vehicles in a platoon are virtually identical.

All data collection for a given location is carried out by one person positioned along the road. The data-collection equipment should be sufficiently removed from the lane in which the traffic is moving (about 5 m or more, if possible) so that it does not affect traffic and preferably on the same side of the road as the principal-flow lane. Although the equipment usually consists of a vehicle that houses the radar set and operator, it is preferable to have the operator completely off the roadway, with only the radar antenna at the side of the road and camouflaged in some manner.

The use of the radar-platoon technique is described in terms of two-lane highways where it has been principally used to date. From the selected
only one speed for each platoon is part of our single person to record all of this information. If such as total volume, average speed, etc. another or falling behind, he or she need not treat definition of a platoon and makes it possible for a vehicles in the platoon. The fact that there is are counted and the type of vehicle that leads the record that is representative of the speeds of all vehicles in the platoon. The fact that there is only one speed for each platoon is part of our configuration is illustrated in Figure 1.

As discussed above, under certain terrain conditions, one may wish to collect data without having to park a vehicle on or adjacent to the roadway. In that case the power supply for the radar unit can be a portable car battery. In either case, the radar power drain is sufficiently small to allow one to collect data for at least 18 h before recharging the battery.

Obtaining Data for Principal-Flow Direction

The study period is divided into a series of consecutive time periods (5 min is recommended), during which traffic characteristics can be considered as effectively time stationary. All data collected during this 5-min period become a single record of information.

The observer considers platoons of vehicles that are observed to be traveling together. These platoons can be easily identified as a group of vehicles that are traveling close together at a common speed, i.e., following a lead vehicle that restricts the speed of any followers.

As each such platoon moves by in the principal-flow direction, the number of vehicles of each type (i.e., cars, trucks, recreational vehicles, etc.) are counted and the type of vehicle that leads the platoon is noted. Also, a single speed can be recorded that is representative of the speeds of all vehicles in the platoon. The fact that there is only one speed for each platoon is part of our definition of a platoon and makes it possible for a single person to record all of this information. If the observer feels that one vehicle is overtaking another or falling behind, he or she need not treat them as being in the same platoon. The platoons are later aggregated during the data-processing phase to obtain any summaries required for the 5-min period, such as total volume, average speed, etc.

Figure 2 illustrates a series of three platoons traveling at speeds of 89, 81, and 56 km/h, respectively, and the recording of these platoon characteristics on a data sheet.

Data on Opposing Traffic Flow

Simultaneous to the data collection for the principal-flow direction, the opposing traffic volume is counted on a hand-held counter. For the opposing direction, no distinction is made with respect to either platoon size, platoon lead-vehicle type, or the type of vehicles in the platoon. At the end of the 5-min period, the accumulated total opposing traffic volume is recorded and a new period begins where the previous one left off.

Data Sheet

A typical data sheet, which has been used in Ontario, is illustrated in Figure 3. This sheet, which is approximately 21x36cm, has been reduced for recording the data-collection site, date, weather, and surface conditions as well as the name of the recorder. On the data sheet in Figure 3 there is room for a total of 36 platoons in each 5-min period. If this number is not exceeded for any 5-min period, data for a full hour (12 5-min periods) can be recorded on one sheet.

As stated previously, data are collected for consecutive sets of 5-min periods. On the data sheet a five-line record has been reserved for each such time period. A single vertical column of five squares represents the relevant characteristics of a single platoon, as shown in Figure 2. The number of cars, trucks, recreational vehicles, and other vehicles and platoon speed is recorded in that order.

The platoon lead vehicle is recorded by using the convention that the lead vehicle of each platoon is circled unless there is only one vehicle type, in which case the single vehicle type must be the lead vehicle by default.

Types of Information Provided by Radar-Platoon Technique

The radar-platoon technique yields a complete data
Detailed Volume Counts

The procedure yields total volume counts for each direction and a breakdown into the various types of vehicles for the principal-flow direction. A total vehicle count is usually used as a measure of road use. It is obtained by summing the number of vehicles of all four types over the given time period.

A more representative measure of road use is obtained when the heavier and longer vehicles, such as trucks or recreational vehicles, are weighted more heavily than standard passenger cars. A classification count can more accurately represent traffic conditions as larger vehicles take up more space, are more difficult to overtake, and cause greater deterioration of the road surface.

Detailed volume counts are more useful than simple aggregated totals, as they can be more fully analyzed and manipulated in the analysis stage of a study. The volume of opposing traffic is useful as it can be a critical factor that restricts the passing maneuvers of the vehicles traveling in the principal-flow direction. Passing, or the lack of it, can break up or cause platoons, respectively. Such platoon formation behind slow moving vehicles has a direct bearing on speeds and quality of service.
This circuit should be used to check the operation of the internal parts at least once every hour. Operating the radar set should always ensure that it fails either test, as such data would be invalid. During the data-collection process the persons operating the radar set should always ensure that the values of the digital readout are compatible with visual estimates. Any inconsistencies should be noted along with the data that may be affected.

### Data-Collection Technique and Recording Form

#### Weather and Surface Factors

Weather and surface conditions are important factors that influence the speeds of the drivers and the capacity of the highway. It is therefore essential that the prevailing weather and surface conditions be carefully recorded on each data sheet. Although the weather and surface conditions can be described in great detail by using several adjectives, the use of the computer restricts this vocabulary to a set of letter codes, as shown below:

1. Type of vehicle (leader to be marked by a circle)—C, car; T, truck; R, recreational; and O, other.
2. Weather—S, sunny; O, overcast; R, rain; F, freezing rain; S, snow; D, drizzle; and C, clear.
3. Surface—D, dry; W, wet; I, ice; S, snow covered; C, center bare; L, slush; and A, damp.
4. Location code—highway number, 1-9 (e.g., highway 8, northbound, location 2); direction, N, W, S, and E; and location, 1-9 (e.g., 8 W2).
5. Date—month, day, hour, and minute (e.g., July 20, 7:35 p.m. = 07201935).
6. Recorder—identified by initial of surname or other single-digit code.

#### Cycle Length Selection

A counting cycle of 5 min is recommended because either a longer or a shorter cycle would lead to increased difficulties. In addition, 5 min is a convenient time span for calculations and physical checks.

The radar-platoon technique is based on the fact that speeds can be accurately assigned to each platoon that passes the observation site during the timing cycle. During a 5-min cycle, an average of approximately 20 platoons will go by. This means that if the last platoon in each 5-min cycle runs over into the next time period, at the most 5 percent of all the platoons will need to be broken up between the adjacent two time periods. However, this percentage doubles if the time period is cut in half and becomes 25 percent when the cycle length is 1 min.

The above argument favors long counting cycles. However, as cycle length increases, the data become more aggregated and special conditions that prevail for only a short time become hidden in the remainder of the data with which they are averaged.

For those two reasons a time length of 5 min was chosen as being short enough to show any short-term fluctuations and yet long enough to keep the number of split-up platoons to an acceptable level.

#### Platoon Measurement

A platoon is a physical group of vehicles whose actions are interdependent. The speed of a platoon is dictated by the lead vehicle. The speeds of the following vehicles might fluctuate slightly but their average corresponds approximately to that of the leader. This average speed is assumed to be
The radar-platoon technique has both technical and economic advantages over existing state-of-the-art techniques. These advantages are briefly described below.

Technical Advantages

The radar-platoon technique creates an unbiased data set since the speed of each vehicle is represented. This is a significant improvement over most other techniques that only consider a sample of the vehicles.

The vehicle counts and the speed measurements are accurate at each vehicle is counted manually and the speeds are measured by using calibrated radar sets. No difference could be detected between measurements of independent observers. The recognition of platoon formations is a type of surrogate measure of service levels that could not be obtained from any of the previous techniques.

The simplicity of the technique eliminates the need for skilled operators, which in turn eliminates lengthy training requirements. Even unstable platoons can be handled with this method. The setup is highly mobile and, as a result, several different locations can be sampled without duplication of capital costs or difficult setups.

The thoroughness of the radar-platoon technique is illustrated by the sample output of summary data in Figure 5. The summary for each 5-min period is printed on a single line and consists of six basic sections. The first block describes the weather and surface conditions at the given date and time. Next, the total number of platoons and their breakdown according to sub-category type are given. The third block has the total vehicle counts for each vehicle type and then for each direction. The fourth block gives the passenger car unit equivalents for each direction. The final two blocks of numbers represent the speed distribution for each 5-min period. This distribution is described by its average, low, and high speeds and then the percentile speeds from the 10th to the 90th.

Economic Advantages

The initial capital cost of the radar-platoon technique is small if no radar set needs to be purchased. The counter used for counting the opposing volume is inexpensive and the remainder of the equipment is available in the form of standard office supplies.

The variable cost of operating a monitoring station is also kept to a minimum because only one person is required to operate each such station. Each station also produces an additional count for opposing traffic. The data-collection technique yields a maximum return of data during low volumes when two-directional data are obtained.

Conclusions

The radar-platoon technique for collecting traffic data is fast, relatively inexpensive, requires a minimum of manpower, and provides a 100 percent sample of speeds. The distinction between different vehicle types allows for the evaluation of the effect of different vehicle type distributions on the behavior of traffic. The use of platoons as a measure of highway performance recognizes that individual vehicles may be affected by the other users of the highway. The composing of the opposing traffic volume as well as the principal traffic flow provides a means of evaluating the impact of different directional traffic splits. The effect of slow moving vehicles can be determined through the analysis of the platoon lead-vehicle types.

The spot values of vehicle speed and traffic volume provide a direct means of establishing the relation between speed and volume for a set of specific highway conditions. The ability of mea-
The evaluation of signalized intersection performance has long been an issue of concern, a concern that has intensified in recent years with the changing emphasis in urban transportation planning. Tightening budgetary constraints have led to reduced capital expenditure on transportation and have been partly responsible for the present emphasis on transportation system management. Moreover, there has been an increasing need to acquire more knowledge of demand so that the management of it is both publicly acceptable and consistent with an efficient allocation of resources, both privately and socially. To this end, energy conservation, environmental consequences, and equity (in terms of resource allocation, e.g., time savings) have become important concerns. The measurement of intersection performance, for example, should no longer be concerned solely with the motorist but with societal goals as a whole and with the equitable allocation of resources to individual members of society.

Determination of the level of performance of a signalized intersection has application in traffic engineering planning and design, in the study of the effects of physical and operational improvements.