THE POTENTIAL USE OF AERIAL PHOTOGRAPHS IN TRAFFIC ANALYSIS

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SYNOPSIS

Pictorial time-motion studies have been employed for many years in industry to bring to light more efficient methods of operation. More recently, intermittent pictures taken from ground points have been used to a limited extent in analyzing traffic movements. These pictures, taken from the tops of high buildings, have included views too restricted to furnish the type of data desired and thus have pointed to the need of the unobstructed views possible from the air.

Trial flights in a helicopter for this purpose showed that the helicopter has limited possibilities as a "sky hook." It vibrates considerably, has a tendency to sway, particularly at high altitudes, and is restricted as to space.

In the fall of 1945 trial flights in a blimp were made. From the blimp pictures were taken with a 35-mm. camera at intervals of about two seconds. The blimp provided a much more stable platform, and best results were obtained when the blimp was carefully "trimmed" as to weight and when there was a head wind of about 15 mi. per hr.

The 35-mm. pictures taken from the blimp are satisfactory for recording movements within an area of at least ½ mile in either direction. Colored motion pictures taken from a blimp with a 16-mm camera, show that this film is sufficiently large for recording traffic movements from a height of about 2000 feet.

The trials with both cameras have disclosed encouraging possibilities for study of traffic over an area of several square blocks from heights up to 3000 ft.

If larger distances than about ½ mile are to be studied, it is necessary to use larger film. An aerial camera such as is employed in mapping may be used. A common aerial camera uses 9- by 9-in. film. Several pictures taken from an airplane at 7000 to 15,000 ft. over urban areas over a square mile in extent show vehicles quite clearly.

High altitude haze, shadows of buildings, trees, and the movement of the blimp are difficulties which, it is believed, are overshadowed by the complete and accurate record of all that happens within the area studied.

In view of the recognized need of a more thorough knowledge of traffic behavior than can be gained by ordinary means, it is proposed that time-motion studies of traffic be made from the vantage point of a helicopter, a blimp, or an airplane. Pictorial time-motion studies have been employed for many years in industry to bring to light more efficient methods of operation. More recently, intermittent pictures taken from ground points have been used to a limited extent in analyzing traffic movements.[1] These pictures, taken from the tops of high buildings, have included views too restricted to furnish the type of data desired and thus have pointed to the need of the unobstructed views possible from the air.

[1] B. D. Greenshields, Donald Shapiro, and Elroy L. Erickson, "Traffic Performance at Urban Street Intersections" Technical Report No. 1, Yale Bureau of Highway Traffic (1947).

The deficiencies in the information gained from data gathered by the usual field methods immediately become apparent when an attempt is made to find an answer to such a pertinent traffic question as—What is the traffic capacity of a street intersection? The familiar traffic flow chart gives the number of vehicles that cross a street intersection in a given time. It does not answer the question of how much time it takes each vehicle to make the crossing. It is this time that is of particular interest to the individual driver, whose taxes go to pay for highway improvements. He has very little interest in how many other people are using the street, but he is considerably concerned about how much time he loses in getting to work or to the shopping center. The importance of this time loss in traffic planning becomes manifest through the consideration of a problem in signal timing.

Let it be supposed that a city is contemplating the installation of a central control system that will permit a variable timing of signals to best accommodate the traffic volume as it fluctuates throughout the day. The traffic engineer should be able to give an accurate estimate of the saving in time to the motorists and to indicate to what extent congestion will be relieved. It may be that redesign of the street system and reconstruction are the only solutions to the problem and should be recognized as such.

It is known that the shortest timing that will permit all waiting vehicles to clear the intersection will cause the least delay. It is also known that the number of vehicles that will arrive at an intersection in a given time interval tends to follow the law of random distribution.[2] What is not known is how long it takes a vehicle to clear an intersection with a certain number of interfering vehicles (or pedestrians) in the intersection. This dearth of accurate information on street and intersection capacity persists because of the lack of field data.

In general, the field data used in traffic analysis should consist of a complete record of the behavior of each vehicle in terms of time, space, and motion. If any of these factors is lacking, the data are insufficient to lend complete and conclusive results.

The limited number of time-motion studies of traffic made to date show not only that we have the mathematical tools for analyzing traffic provided we can get accurate and complete field data, but they also disclose that the average number of vehicles passing through an intersection or over a highway in a given time may be all the field information needed to give a fairly complete picture of what is happening on the roadway, once the correlation between average flow and other phases of traffic behavior is established. Thus correlation becomes of value, however, only when it is accurately known.

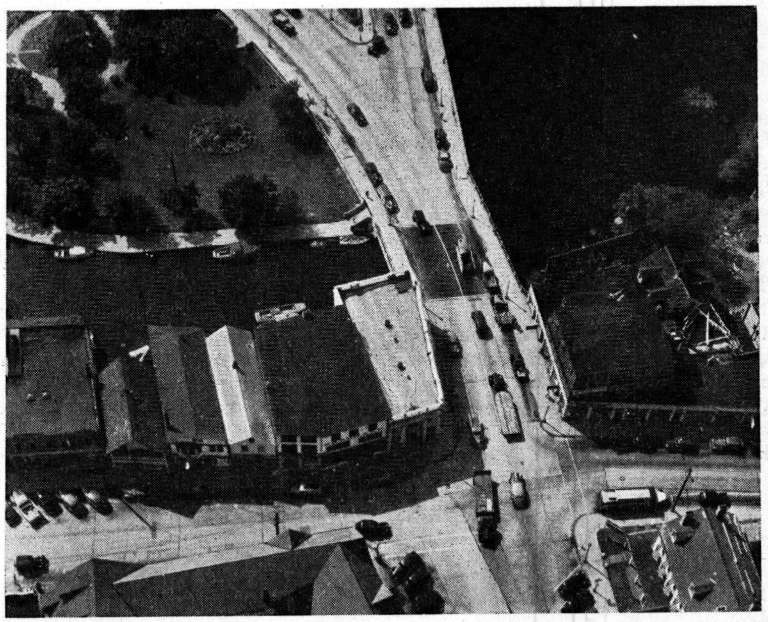

Figure 1. Portion of Picture Taken on 35-mm Film over Trenton, N. J., at an Elevation of Approximately 1,000 ft.—Enlarged Approximately three Times

The intermittent pictures employed in making time motion studies of traffic are neither moving pictures nor still pictures but something in between. Moving pictures are taken at the rate of about 32 per second, so that when projected they appear to be continuous. A still picture implies one picture of an object or a scene. Most of the intermittent pictures

[2] Op. cit.

employed up to the present have been taken at the rate of 88 per minute. This interval has been found convenient because the distance in feet that a vehicle moves during this interval equals its speed in miles per hour. This interval has also been found to give sufficiently detailed information. In general, the larger the area covered in each picture, the greater may be the interval between pictures. With aerial pictures covering a square mile or more in area, an interval of 5 seconds should be sufficiently small.

The desirability of aerial pictures, as already indicated, is made clear by the limitations of those taken from such vantage points as are available on the ground. Only rarely is it possible to secure a view that includes all of the area, not only desired but necessary to give the complete pattern of the traffic movement being studied. No such limitations of view are imposed on pictures taken from the air, for they may include several blocks or several square miles of area.

Figure 2. One Frame of Picture Taken on 35-mm Film over Trenton, N. J., at an Elevation of Approximately 3,000 ft.—Enlarged Approximately two times

There are other limitations, however, that restrict the use of aerial pictures, and these must be weighed carefully. Neither the helicopter, the airplane, nor the blimp furnishes that ideal stationary sky hook for taking pictures.

The first trials of aerial pictures were made while I was working with the Bureau of Highway Traffic at Yale in 1945. The first trial was with a helicopter furnished by the U. S. Coast Guard at Floyd Bennet Field, L. I.

The small amount of space in the two-place helicopter made it difficult to find room to mount the 16-mm. camera and the timer mechanism for regulating the interval between pictures. The best arrangement that could be worked out was to mount the camera in the space between and below the two seats. This space is about 8 inches wide and did not leave much freedom of movement for the camera. Rubber shock absorbers were used to deaden the vibration. Space for mounting the timer was found by removing the door to the right of the passenger seat and fastening a bracket to the door frame. The timer used had to be wound every 7 or 8 minutes and having it at the right hand of the operator made this convenient.

The longest trial flight was made by Donald Schapiro, Assistant on the project, during which a height of 6,000 feet was reached. At greater heights the swaying and vibration of the helicopter increase. The helicopter hovers best at a low height, where the backwash of air from the ground acts as a stabilizer.

The drawbacks of the helicopter do not necessarily mean that it cannot be used to make time-motion studies of traffic. It is cheaper to operate than the blimp, it can remain in the air for three hours or more, and it can hover fairly closely over one location. The camera used would necessarily be restricted in size to the 16-mm. movie camera. The timer would need to be operated electrically so that it would not need to be wound. The helicopter should fly at about 1000 ft. for best results.

The next trial was with a blimp, furnished by U. S. Naval Air Station at Lakehurst. The pictures taken from the helicopter had shown the 16-mm. size to be too small for the area we wanted to cover, which was about 1 square mile. Since we wished to make a continuous three hour observation, the logical camera to be used was a 35-mm., which can be loaded with 400 ft. of film. We chose a professional model, Bell and Howell camera.

In order to obtain constant speed it was decided to use a motor driven by 110-v. D.C. supplied by special portable dry cells. The picture interval selected was about 2 seconds.

The camera was mounted on a tripod head fixed to a board which was arranged in the forward machine gun blister of the blimp, so that the camera could be pointed downward and directed at the will of the operator using the viewfinder mounted on the side of the camera. Figure 1 shows part of one frame of pictures taken of Trenton, N. J., in October, 1945, at an elevation of about 1000 ft. Some

of the pictures were taken with a counter which operated off a micro-switch on the drive shaft. Each time the drive shaft revolved to operate the camera, the switch actuated the counter through a 3 volt dry cell. Thus each picture or frame was numbered. For an example see Figure 2 showing one frame of pictures taken over Trenton.

Figure 3. Portion of 9-by 9-in. Aerial Photograph Taken at Philadelphia in March, 1946—Original Scale of 1:16,000—Total Area Covered by Original Approximately 5 Square Miles

Colored 16-mm. motion pictures were taken by Mr. O. K. Norman, of the Public Roads Administration through the cooperation of the Naval L. T. A. Station at Lakehurst, N. J., and the Photographic Section of the Department of Agriculture, in September 1947, from a blimp. These pictures show that this size film is sufficiently large for recording traffic movements from a height of about 2,000 ft.

In brief, it may be said the trial flights have disclosed very encouraging possibilities for the study of traffic over an area several square blocks in extent by the use of either the 16-mm. or 35-mm. camera from heights up to 3000 ft. The 35-mm. film gives better definition for the larger areas, but the 16-mm. color film gives good contrast which helps in following individual vehicles. The color film is much slower and therefore requires better lighting conditions. The 16-mm. film is, of course, cheaper, but the cost of the film is a small fraction of the total cost of analysis.

The extent to which pictures may be enlarged by projection for study is limited; and, if distances greater than about ½ mile are to be studied, it is necessary to use larger film. The use of an aerial camera such as is employed in mapping, naturally comes to mind. A common size aerial camera film is 9 in. square. No pictures for the study of traffic movements have been made with this type of camera, but several other pictures taken from planes flying blimp, makes it possible to include more area in each picture. But the fact that the speed of the plane is over 100 mph. makes it difficult even by circling to keep one area in view. The handicap of the ceiling for the blimp, which may be practically put at 5000 to 6000 ft., can be partly overcome by using a short focal length lens. A 9- by 9-in. film with a 4½-in. focal length lens would furnish a picture of an area of nearly 4 sq. mi. at an altitude of 5000

Figure 4. Portion of 9-by 9-in. Aerial Photograph of the Center of the City of Lansing, Michigan, Taken in 1947—Original Scale of Photograph 1:24000—Total Area Included in the 9-by 9-, Approximately 11½ Square Miles

at altitudes of 7000 to 15,000 feet over urban districts and including areas of over a square mile in extent show vehicles quite clearly. These pictures have been made available through the cooperation of the U. S. Coast and Geodetic Survey. Figures 3, 4, and 5 show the relative detail obtained from different elevations. The airplane furnishes a steadier base for mounting the camera than the blimp, and the 20,000-ft. altitude at which it may fly, compared to the 9000-ft. ceiling for the ft. On the whole, the blimp seems more practicable than the airplane.

Aerial cameras can be operated automatically and will take 200 pictures on one roll of film. Pictures of such a large area as would require the aerial camera would obviously be used to analyze over-all movements and hence could be taken at intervals of 5 seconds or more. One roll of film would thus record traffic movements for over 15 minutes. It would be necessary to have two cameras op-

erating alternately to give a continuous record of more than 15 minutes. These pictures covering a square mile or more in area would provide data for a time-origin-destination survey. They should provide an accurate measure of the increase in traffic friction as traffic data from which a more exact knowledge of street and highway capacity may be gained and should disclose those conflicting motions of traffic that result in accidents.

In proposing aerial pictures, it must be kept in mind that at high altitudes haze makes

Figure 5. Portion of 9-by 9-in. Aerial Photograph of Washington, D. C., Taken in 1946—Scale of Original Photograph 1:7000—Area Covered by the 9-by 9-in. Photograph was Approximately 1 square mile.

pressure builds up at intersections and thus disclose the location of bottlenecks and whether they were caused by street plan or by faulty timing of signals.

The more detailed information furnished by the 16- or 35-mm. pictures taken at shorter intervals and of smaller areas should yield clear pictures difficult to get; that in the morning and evening when traffic is heavy shadows of buildings obscure streets; that trees interfere particularly in the summer; and that at all times the movement of the blimp adds to the other difficulties. It is believed, however, that these difficulties can largely be over-

come. The pictures should be worth what they cost in time, effort, and money, for they would furnish a complete and accurate record of all that happens within the area studied. It is felt that several hours of such observations will reveal more than days of less complete data. From this standpoint it could well be that aerial photographs will prove comparatively cheap.

Past experience leads to the conclusion that analyzing the data will be even more difficult than obtaining them. The data will be complete and therefore entirely non-selective. The investigator must select those phases of traffic that are significant and then prove them so. There is the compensatory factor that if a wrong selection is made, complete data are at hand from which to make a new selection for a new start. Past experience, while making one aware of the difficulties to be expected, has revealed that traffic performs in definite patterns and that these patterns may be analyzed by established statistical methods. It is our opinion that only through basic research may we reduce traffic engineering to a more exact science comparable to that of civil or mechanical engineering. In view of the fact that research pays a bigger return in the long run than almost any form of human endeavor, we feel justified in proposing the expense and difficulty of aerial photographs to supplement the more common field surveys of traffic movements and to further traffic research.

SIMPLIFIED METHODS FOR TRAVEL STUDIES IN SMALLER CITIES

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SYNOPSIS

Techniques have been developed in recent years for comprehensive surveys in larger cities. Less costly and time-consuming studies are needed to obtain less extensive information in smaller cities. There were 1,843 cities between 5,000 and 50,000 population in 1940.

A new procedure has been developed which utilizes an external origin and destination study and a modified parking survey in combination. Such studies are appropriate in cities where mass transportation is not an important factor and where all but a minor portion of the places of business and recreation are concentrated in the downtown area.

Information is obtained for external trips crossing a cordon at or near the city limits, and for internal trips that end in parking in the central business district.

The analysis procedures for this type of survey were developed in the Alexandria, Louisiana study where acceptable information was obtained by the new technique.

It is possible to make statistical checks to determine the accuracy of the new procedure. These checks have proven satisfactory.

Another method of conducting origin and destination surveys in smaller cities with characteristics favorable for such procedures, involves street-side interviews similar to those made at external stations. In a study of this kind, origin and destination information for vehicles crossing a cordon around the downtown area was obtained recently in Hagerstown, Maryland, a city of approximately 35,000 population.

Time to conduct the field work for these types of surveys ranges from 10 days to six weeks. If properly organized, the whole job can be completed in from one to four months depending on the size of the city and the ability of the organization handling the work.

Urban surveys are necessary to plan properly highways in cities to serve through and local traffic to the best advantage. Travel has increased more than sixfold since 1920 and something must be done to relieve congestion particularly in the cities.