Development of the Sky Count Technique for Highway Traffic Analysis

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•PERSONNEL of the Port of New York Authority who are actively engaged in aerial photography for traffic survey purposes do not consider themselves experts in the field of aerial photography. Also, they are not exclusively concerned with the study of traffic movement on highways. There are other groups in the Authority that specialize in these fields and work is coordinated with them in the application of techniques to fulfilling particular information needs.

Project Sky Count's speciality is transportation operations analysis. Other fields have been entered as a result of the search for new analytical tools. The need for comprehensive measurement of transportation activities on a regional basis has provided the principal impetus for current work.

Having entered the field of aerial photographic analysis as related to all forms of transportation, it was found that the potential for improved operational analysis was so promising that a formal systems development program was established to exploit the advantages of aerial photographic data collection.

In view of the many vehicular facilities which are operated by the Port Authority, it was natural that, as a first step, applications for photographic analysis were sought in the field of highway transportation. Although this initial phase began more than a year ago, the project is still primarily occupied with highway traffic analysis.

The goal is to develop useful techniques for analyzing areas and operations of interest to the Port Authority. Accordingly, systems have been tailored to fit the operational needs and capabilities of a particular organization. To the extent that these are universal needs and capabilities, several methods suitable for widespread application have been developed.

BASIC EQUIPMENT

To implement photographic studies of highway traffic, a 12-in. focal length camera and a single-engine airplane have been used. On aerial photography missions, the aircraft operational speeds have ranged from 80 to 100 knots and flight heights above ground from 6,000 to 10,000 ft. Recently, a 6-in. focal length lens for the aerial camera was acquired, and modification of one helicopter to carry this instrument is being considered. Data reduction has been directly from 9- by 9-in. size film negatives on a specially designed light table. Scale of most of the photographs has ranged between 600 and 900 ft per in. Because data reduction is the most time-consuming element of the system, the use of computer-linked coordinate readers for the automatic computation and processing of digital information is currently being investigated.

LINCOLN TUNNEL APPROACH STUDY

The first aerial traffic study using aerial photographs was carried out over the western approaches to the Lincoln Tunnel (Figs. 1 and 2). Initially, an experimental aerial photography flight was made 6,000 ft above the ground with the camera taking ten photographs per minute. Results of this test flight indicated traffic speed, traffic

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Figure 1. Lincoln Tunnel approaches: (left) New Je
Underpass to West Portals (T = tunnel bound

Iurnpike to Union City Underpass; (right) Union City
ic, P = portals, flight height = 10,000 ft).

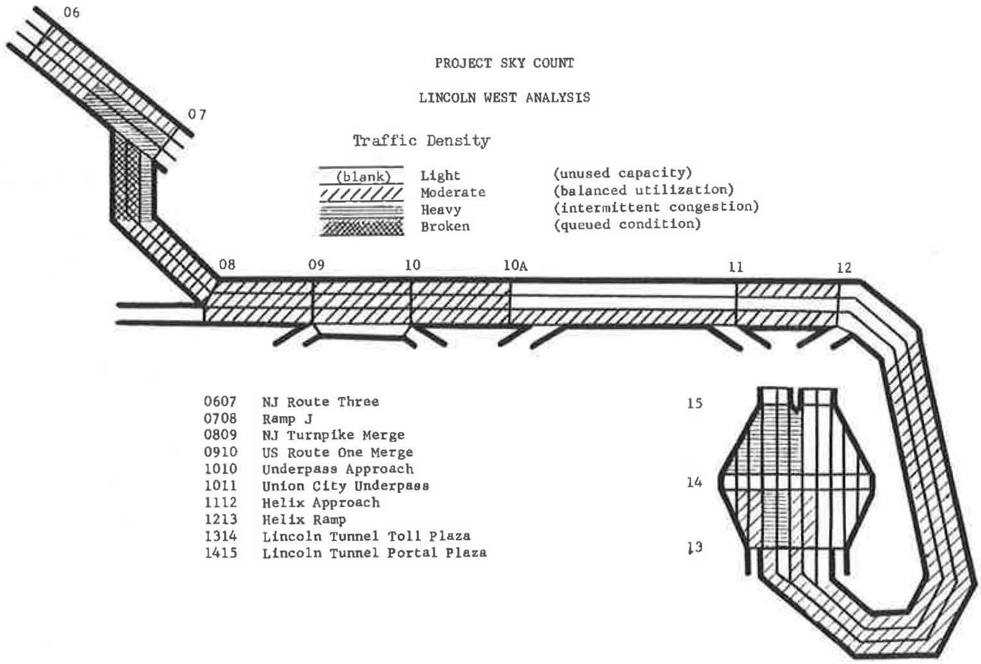


Figure 2. Average traffic conditions, 0740 to 0840, Lincoln Tunnel approaches.

density, and number of vehicles could be calculated on a sampling basis from selected sequences of 3 photographs.

Following the initial photography flight, a pilot study was carried out for a 60-min period during a morning peak traffic hour. During this photography mission the aircraft was flown 10,000 ft above the ground and the time interval between each photographic exposure was shortened to 5 sec. The study area extended from the New Jersey Turnpike to the Lincoln Tunnel west portals, a distance of approximately three miles.

Aerial photography procedure consisted of a photographic flight every seven minutes for one hour. During each photographic flight, 11 or 12 aerial photographs were taken in approximately one minute. To assure the necessary accuracy for subsequent speed determinations, a time control check was made during each photographic flight to establish correction factors for the intervalometer which controlled the camera cycle.

For analytical purposes, the traffic survey zone was divided into 10 unidirectional segments, which together constituted the principal traffic route from the turnpike to the tunnel. The 10 segments were analyzed separately in the following manner:

1. Three photographs were selected from each photographic flight to compile a series of 10-sec samples uniformly distributed throughout the study period.
2. Vehicular speeds were determined from comparison of the first and third photographs of each sequence, while the mid-photograph of each three was used for counting the number of vehicles in the segment.
3. Traffic density was determined by dividing the number of vehicles in each segment by the segment length, and traffic speed was calculated by averaging the speeds of individual vehicles.
4. Total number of vehicles per unit of time on a spot basis was calculated by multiplying vehicle speed by density, and these numbers in turn were averaged to obtain the number of vehicles per hour for each segment.

Further calculations yielded average speed and concentration of traffic for selected time periods, en route travel time through the network, and the relative productivity

TABLE 1

AVERAGE TRAFFIC STATISTICS BY CLASS OF VEHICLE AND BY LANE, UNION CITY UNDERPASS (0740-0840, SEPTEMBER 27, 1961)

LANES	DATA	AUTOS	TRUCKS	BUSES	ALL VEHICLES
Right	Population	4	17	2	23
	Density (vpm)	7.6	29.9	2.7	40.2
	Speed (mph)	14.3	13.7	17.0	14.1
	Volume (vph)	109	410	46	565
	Time (min)	2:21	2:27	1:58	2:23
Center	Population	17	2	3	22
	Density	29.9	3.1	5.4	38.4
	Speed	28.0	23.9	28.1	27.7
	Volume	838	74	152	1064
	Time	1:12	1:24	1:11	1:12
Left	Population	20	0	5	25
	Density	34.8	-	8.9	43.7
	Speed	30.5	-	29.2	30.2
	Volume	1060	-	260	1320
	Time	1:06	-	1:09	1:06
All Lanes	Population	41	19	10	70
	Density	72.3	33.0	17.0	122.3
	Speed	27.8	14.7	26.9	24.1
	Volume	2007	484	458	2949
	Time	1:12	2:17	1:15	1:23

of various route segments. For critical roadway areas, this information was compiled both by class of vehicle and by lane (Table 1).

AIRPORT EXODUS SURVEY

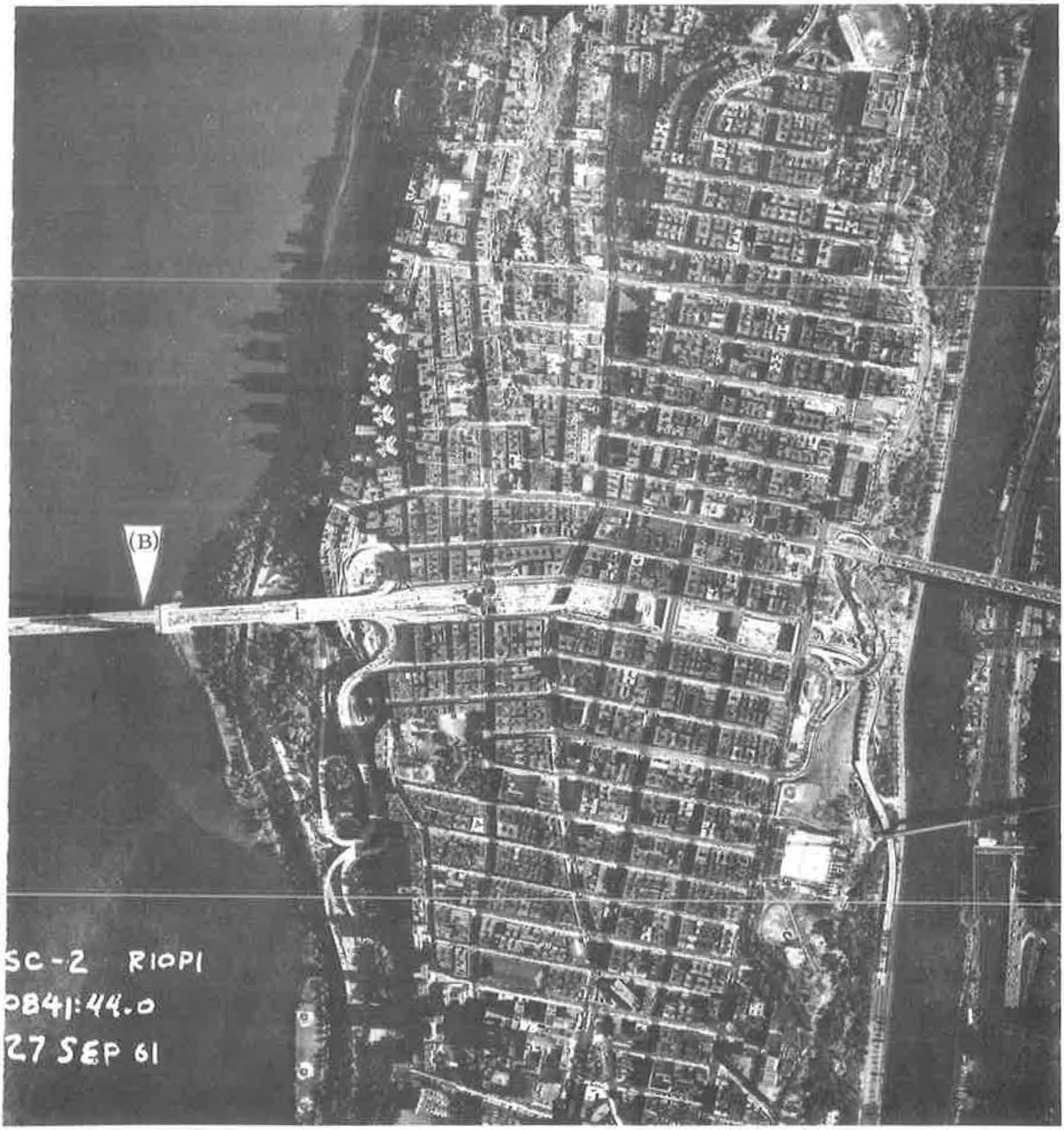
The second highway survey was carried out over the world's most active aviation facility, New York International Airport (Fig. 3). The purpose of this study was to measure the magnitude and intensity of all highway traffic leaving the airport during a 2-hr period.

Photographic flight planning for the airport survey was complicated by the scattered locations of four principal exit points and the interior highway routes leading to them from the central terminal and service areas. Furthermore, the flight height above

Figure 3. New York International
(right) Terminal City comp

·t: (left) Terminal City approach;
:light height = 8,000 ft).

Figure 4. George Washington Br
(right) eastern approach



(B): (left) western approaches;
light height = 10,000 ft).

the ground was reduced from 10,000 to 8,000 ft in order to maximize the size of vehicular images.

Traffic survey data accumulation from the photography, and data reduction and summarization were accomplished by following the basic methodology developed for the Lincoln Tunnel approach study, but several improvements and refinements were incorporated. Following the determination of speed, density, and number of vehicles per hour for each of the sample periods, a histogram of outbound traffic movement was prepared. From this graph it was possible to determine both the peak hour of traffic activity and the time at which the maximum number of vehicles occurred.

A coordinated field check of outbound traffic in number of vehicles per hour on Van Wyck Expressway was provided by members of the traffic engineering staff. Comparison of Sky Count and field count statistics for this route revealed a variation of one-half of 1 percent for the 2-hr study period.

GEORGE WASHINGTON BRIDGE ANALYSIS

Having established the Sky Count technique as an effective method for traffic surveys by use of large-scale aerial photographs, the project was asked to employ the system to study a small but extremely important section of 8-lane highway, the center span of the George Washington Bridge (Fig. 4).

The requested study period was three hours; from 4:00 to 7:00 PM on a Friday in July. Speed, density, and vehicles per hour statistics were required for each of the eight bridge lanes in 10-min increments (Fig. 5).

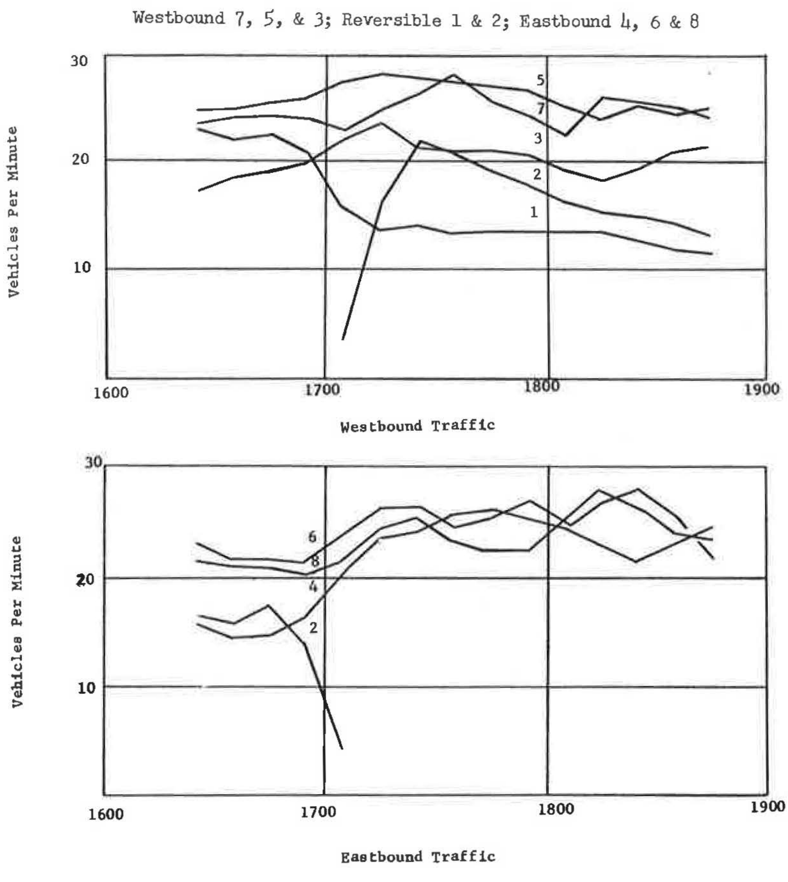


Figure 5. Traffic lane performance, George Washington Bridge.

On this aerial photography mission the aircraft was flown at a height of 6,000 ft, a lower height than had been planned but necessary because of a prevailing cloud ceiling (Fig. 4 is from a different mission). The photography flights were made at 8-min intervals with the camera operating on an optimum cycle for taking 12 photographs per minute. This aerial photography cycle has become standard for Sky Count traffic surveys to assure compatibility with standardized data reduction procedures, which have been designed to yield speed information based on a 10-sec sample of 3 photographs. A time check of the camera intervalometer was made during every third photographic flight.

As with the previous aerial surveys, correlation was obtained with independent traffic determinations of the number of vehicles per hour. A variance of less than 1 percent was found between total Sky Count of traffic in vehicles per hour and bridge toll transactions for the 3-hr study period.

POPULATION SAMPLING TECHNIQUE

The system which has been described for obtaining speed, density, and number of vehicles per hour from sequentially taken aerial photographs is necessarily complex and time consuming. Not every traffic survey requires such thorough analysis, however, and to meet the need for relatively quick and simple traffic counts, a streamlined technique for certain applications is being developed. This method is based on a raw sampling of traffic by the number of vehicles in small segments of each street or highway.

One study using this new technique has been conducted: a reversing lane analysis at New York International Airport. The purpose of this survey was to provide peak hour traffic counts for 23 reversing lanes located in the median areas of the airport highway system.

Because sequentially obtained photographic coverage of the airport was available from a previous Sky Count study, it was not necessary to conduct original photographic flight operations for this traffic survey. Using the film negatives on hand, the number of vehicles utilizing various reversing lanes was determined as a function of the sample duration. After summarizing the counts and durations of all samples, hourly estimates for each segment were established by projection.

The average size of traffic survey sample obtained was 7 percent of all traffic, but some samples ran as high as 9 percent. If specialized photographic flight procedures are employed, it appears that sample sizes of up to 20 percent may be obtained. In view of the simplicity and effectiveness of this technique, it is planned to develop the concept further as a supplement to the regular system.

HIGHWAY RESEARCH APPLICATIONS

Another area of interest to the Port Authority is highway traffic research. In cooperation with members of the research staff, the use of sequentially taken aerial photography as a measurement tool for the study of basic traffic phenomena is being investigated.

The first use of the system in this connection was made by Dr. Renfrey Potts of the University of Adelaide, Australia. Dr. Potts asked for permission to use some of the film negatives of the sequentially taken aerial photography for a study of platoon acceleration. The film negatives of the airport exodus survey were provided with the understanding that he would reciprocate by making the results of his research available. Dr. Potts has recently completed a preliminary study of platoon acceleration along a section of a 4-lane highway. In this study the trajectories and interactions of more than 40 vehicles have been analyzed in considerable detail.

REGIONAL TRAFFIC ANALYSIS

Perhaps the most interesting and potentially significant work that has been carried out by Project Sky Count lies in the field of regional transportation analysis.

In addition to conducting a land economics survey of the Hudson River Valley, the project has participated in a study to determine potential traffic diversion from the Tappan Zee Bridge to the George Washington Bridge. A diversionary influence is presently being created by the completion of the George Washington Bridge lower level, the Alexander Hamilton Bridge, and the Cross-Bronx Expressway.

To analyze quantitatively this influence, it was necessary to examine the present utilization of all routes serving the two bridges on both sides of the Hudson River. The study zone extended from Throgs Neck to Rye on the east and from Paterson to Suffern on the west, an area of more than 600 sq mi.

After considering a number of methods for measuring traffic movements throughout this large area, it was decided to dispense with the aerial camera in favor of visual data collection. The principal factor influencing this decision was speed. By flying a carefully planned route, it was possible to pass within visual range of each segment in the study area at 40-min intervals.

A visual judgment of traffic activity was made while passing over each segment. The evaluation was based on a traffic rating scale of 5 increments ranging from virtually no traffic to solid congestion. In this manner it was possible to rate more than 100 highway route segments throughout the area of study every 40 min.

During a 4-hr survey, six ratings were obtained for each segment. Average traffic conditions were computed from the individual ratings and these were used to calculate speed, density, and vehicles per hour based on average performance curves developed from previous photographic traffic surveys. Three of these visual rating surveys were conducted during periods of peak traffic. Flight height above the ground was limited to 3,000 ft by local visibility conditions.

The principal advantage of this method relative to aerial photographic techniques is the wide and rapid coverage which it provides. Another important advantage lies in the adaptability of this technique to night operations.

CONCLUSION

The work undertaken to date has touched on many important aspects of highway planning, design, and research. It is felt that aerial traffic analysis, however, has yet to be exploited enough to ascertain all of its potentialities. An extensive study of traffic interaction in midtown Manhattan and studies of traffic signal effectiveness and shock wave transmission are planned.

Few fields of study can derive as much benefit from the application of aerial photographic techniques as the field of highway traffic analysis. A large variety of effective study techniques may be developed using sequentially taken aerial photography as the basic data collection medium. Potential uses for these techniques are virtually unlimited.

ACKNOWLEDGMENTS

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