where

$TT_{j,t}$ = actual trip time experienced by user j on day t;

$\gamma^{e}_{j,t}$ = a binary variable equal to -1 if $(AT_{j,t} - DAT_j) < 0$ (i.e., user j is early on day t) and 0 otherwise;

$\gamma^{\ell}_{j,t}$ = a binary variable equal to -1 if $(AT_{j,t} - DAT_j) > 0$ (i.e., user j is late on day t) and 0 otherwise, and

a,b = two parameters in the interval [0,1].

The values a = 0.5, b = 0 were used in the experiments described in the third section of this paper. Sensitivity analysis with respect to these parameters as well as an in depth discussion of the embedded behavioral assumptions can be found elsewhere (10).

Rule 2: Learning-Based Adjustment

Here $ATT_{j,t+1}$ is a function of all prior experience with the system, as follows:

$$ATT_{j,t+1} = \sum_{\ell=t_o}^{t} w_\ell \, (TT_{j,\ell})$$

where, w_ℓ, $\ell = t_o,\ldots,t$ denotes a set of non-negative weights attached to each day, starting with the initial day t_o. It is expected that users attach greater weight to more recent days than to earlier ones. Therefore, the following special form of the equation was used in the experiments:

$$ATT_{j,t+1} = [(1 - w_t)/(t - t_o)] \left(\sum_{\ell=t_o}^{t} TT_{j,\ell} \right) + w_t \, TT_{j,t}$$

where $0 < w_t \leq 1$. Thus all days before the last one are given a total weight of $(1 - w_t)$, equally allocated among all prior days; the last day is given a weight w_t. In the experiments reported in the third section of this paper, a value of 0.5 was used for w_t. The effect of the value of this parameter on system behavior does not, however, affect the general conclusions of the third section, as shown elsewhere (10).

Publication of this paper sponsored by Committee on Traffic Flow Theory and Characteristics.

Creation of Data Sets To Study Microscopic Traffic Flow in Freeway Bottleneck Sections

STEVEN A. SMITH and MARK E. ROSKIN

ABSTRACT

The methodologies employed in an FHWA research study entitled "Freeway Data Collection for Studying Vehicle Interactions" are described. The purpose of this study was to develop a series of data sets on microscopic vehicular traffic flow for selected types of freeway sections. The methodology used to develop these data sets involved digitizing vehicle positions from time-lapse aerial photographs of a series of freeway sites with various geometric configurations. Six types of freeway geometry were of interest: ramp merges, weaving sections, upgrade sections, reduced-width sections, lane drops, and horizontal curves. The aerial photography involved the use of a full-frame 35-mm motion picture camera operating in time-lapse mode mounted in a fixed-wing, short-takeoff-and-landing (STOL) aircraft. The sites were filmed at one frame per second with the aircraft flying clockwise at a slow speed around each site at altitudes ranging between 2,500 and 4,500 ft. Data were reduced to 1 hour of film (3,600 frames) of each site. Sites ranged between 1,200 and 3,200 ft in length. The data reduction method involved a microcomputer-based digitizing system. The most important components of the system were the mathematical techniques for computing vehicle position and the method of vehicle matching, which yielded complete vehicle trajectories for all vehicles passing through the sections studied. The data sets are expected to be useful both for empirical research on freeway traffic flow and for the validation of freeway simulation models. The data sets are being made available to those conducting research in these areas.

The methodologies used in an FHWA research study entitled "Freeway Data Collection for Studying Vehicle Interactions" (Contract DTFH61-82-C-00001) are described. The purpose of this study was to develop a series of data sets on microscopic vehicular traffic flow for selected types of freeway sections. The methodology used to develop these data sets involved digitizing vehicle positions from time-lapse aerial photographs of a series of freeway sites with various geometric configurations. Six types of freeway geometry were of interest:

* Ramp merges,
* Weaving sections,
* Upgrade sections,
* Reduced-width sections,
* Lane drops, and
* Horizontal curves.

There were several reasons for selecting these types of sections for analysis. These types of geometric configurations are the most frequent causes of bottlenecks or recurrent congestion points on freeways, and therefore a study of these types of sections is likely to provide the greatest benefit to overall freeway operations. In addition, these types of sections represent some of the more difficult situations for which to accurately simulate freeway traffic flow in mathematical models. Data on microscopic vehicle movements through such sections are expected to be useful in enhancing freeway simulation models as well as in direct empirical research.

The objective of the study was to develop data sets that could be used in the study of traffic flow in these sections. No actual analysis of the data was to be performed in the study. The data sets are being made available to other researchers who will use the data to study particular aspects of traffic flow that are of interest to them. Information on how to request a copy of a data set is presented later in this paper. The following sections discuss the operational characteristics of freeway bottleneck sections and the current need for data on vehicle interactions, as developed in this study.

OVERVIEW OF METHODOLOGY

The collection of data for studying microscopic traffic flow in freeway bottleneck sections implies the need for detailed data on vehicle trajectories. This is the most difficult type of traffic data to obtain because the position of all vehicles must be known for short time increments (1 to 3 sec) and vehicles must be completely traced through the section.

There are two basic approaches to developing detailed vehicle trajectory information. The first approach involves the placement of closely spaced pairs of axle detectors on the roadway. The detectors are used to record the exact time of each axle crossing. This enables the identification of vehicles by axle characteristics and the matching of these characteristics from one detector to the next, thus tracing the vehicles through the section. Devices such as FHWA's Traffic Evaluator System (TES) have been used to develop vehicle trajectories using this method. However, the number of detectors required to track vehicles through a section in short time increments is not practical for the lengths of sections required in this study. In addition, the TES software has not been designed for vehicle matching under congested flow conditions.

The second approach to developing vehicle trajectory data involves the photographic tracing of vehicles. In this approach vehicles are tracked through the section of interest and their positions recorded at discrete points in time. This approach has been attempted in the past with varying degrees of success. One of the methods used for matching vehicles in these photographic methods has been to record the position of vehicles at short time increments (e.g., 1 sec) and to match vehicles from one frame to the next using a computer algorithm based on the position of vehicles and on known speed and lane-changing behavior. This method was used in a study by UCLA and System Development Corporation (1) to reduce vehicle trajectory data from aerial 70-mm films. Data were collected at three sites, and the data were reduced by the transformation of vehicle positions into digitized form. However, numerous problems were encountered in the vehicle matching algorithm, and an evaluation of the UCLA/SDC experience by Raudseps (2) was not terribly optimistic about this approach. This technique was also used in a study by Garner and Mountain in the United Kingdom (3), but an approximate 85 percent matching rate was reportedly all that could be achieved.

The data collection and reduction method adopted for this study involved an aerial photographic approach in conjunction with a microcomputer-based digitizing system. The key to the success of the system was the method of vehicle matching, which yielded complete vehicle trajectories for all vehicles passing through the sections studied. The matching method involved the digitizing of all vehicles within defined section limits on each successive frame of film, relying on the operators' ability to match vehicles on the basis of four key characteristics:

* Order of vehicles in the previous frame,
* Color of vehicle,
* Type of vehicle, and
* Lane vehicle was in in the previous frame.

The operator was assisted in the matching process by error checks built into the computer software. The operator matching approach (with computer assist) is superior to the computer matching approach because the operator-computer interaction allows many potential errors to be caught before entry of data into the working data files.

Some researchers have suggested that a fully automated system might be employed using the image recognition capabilities of video-recording methods. Although this method is conceptually attractive, both eliminating the need for operator matching and potentially accelerating the data reduction process, major advances need to be made in video resolution, image recognition, and matching algorithms before this technique will be feasible for the lengths of freeway sections studied here. It is possible that video methods may be developed for applications that require considerably larger-scale images.

The aerial photography involved the use of a full-frame 35-mm motion picture camera operating in the time-lapse mode mounted in a fixed-wing, short-takeoff-and-landing (STOL) aircraft. The sites were filmed at one frame per second with the aircraft flying clockwise at a slow speed around each site at altitudes ranging between 2,500 and 4,500 ft. Data were reduced to 1 hour of film of each site. Sites ranged between 1,200 and 3,200 ft in length. The sites included all six of the types of sections discussed previously. The following sections describe the filming and data reduction procedures in detail.

AERIAL PHOTOGRAPHY

Initial Experiments

Aerial photography proved to be one of the more difficult aspects of the study, given the stringent filming requirements and the budget limitations. A pilot study was conducted in which experiments were made using various combinations of film formats and aircraft until an optimum filming method was achieved. Requirements for the filming were as follows:

- The same section had to be filmed continuously at one frame per second for more than 1 hour,
- The camera angle had to be as nearly vertical as practical to maximize the accuracy of measurements, and
- The film format had to be as small as possible for reasons of economy and yet of high enough resolution for all vehicles to be distinguished.

Experimentation with the photography was begun with a light plane circling in a tight radius and testing both 16-mm and half-frame 35-mm film formats. (Note that a half-frame 35-mm film frame is half the size of a standard 35-mm slide and a full-frame 35-mm film frame is the same size as a 35-mm slide.) A camera mount was constructed and affixed to the floor of the aircraft enabling the camera to be angled toward the ground as the aircraft was banked in a continuous circle around the freeway section being photographed. In this first experiment it was found that the aircraft (a Cessna 206) did not provide a stable enough platform and could not fly sufficiently slowly to enable the photographer to keep the camera continuously on the section. The 16-mm film format was clearly unacceptable for the length of sections studied. The 35-mm half-frame format, although considerably better, was still insufficient to obtain the resolution required.

A brief experiment was also conducted using a hovering helicopter and 35-mm half-frame format. This configuration was also found to be impractical. Although 1 hour of film could conceivably be obtained with this method, ideal conditions of wind velocity and direction would be needed at every site to avoid overheating of the helicopter engine. These highly restrictive requirements and the cost of helicopter rental eliminated this method from further consideration.

The final experiment involved the use of a Heli Porter STOL aircraft and a full-frame 35-mm film format. This configuration proved to meet all of the filming requirements and was therefore adopted for use. Enough test film was shot in the fall of 1982 to allow further development of the data reduction process. Although 70-mm film was considered in these experiments, the cost of the film and of projection equipment was substantially higher than for 35-mm film, and only 40 min of continuous 70-mm filming could be obtained with the available film magazine size.

Filming of Freeway Sections

The actual filming was undertaken in the spring of 1983 on freeway sections in both the Washington, D.C., and the Los Angeles metropolitan areas. A Helio-Courier STOL aircraft was used along with a 35-mm full-frame camera and a 1,000-ft film magazine. This magazine size enabled two sites to be filmed back-to-back in one flight, speeding up the filming process and reducing filming costs considerably. The camera was a Flight Research Model 207 equipped with a high-resolution Nikkor 35-mm focal length lens and automatic exposure control. The automatic exposure control was an important feature because camera angle with respect to the sun was continuously changing. The frame number was superimposed on the film image. The camera was angled out the rear right-side door, and the camera operator was responsible for keeping the freeway section continuously in view. Figure 1 shows the aircraft and Figure 2 shows the camera mounted in the aircraft.

Filming was done primarily in the evening peak period and sometimes in midafternoon, depending on traffic conditions. The characteristics of both the

FIGURE 1 STOL aircraft.

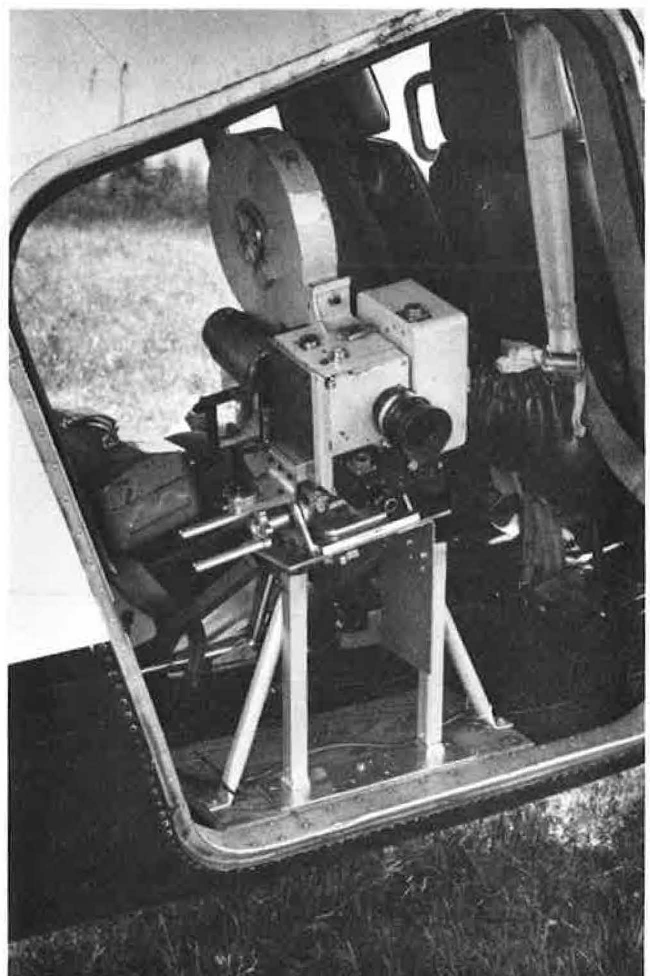

FIGURE 2 35-mm camera mounted in aircraft.

site itself and the traffic conditions on the site were critical. Some of the site requirements included the following:

- Traffic levels of service should be in the C to E range, depending on the type of site. For most sites an effort was made to include the transition period from uncongested flow to congested flow.
- There must be no condition downstream of the site that influences congestion within the site. In other words, there can be no backup from a downstream location into the site area.
- There should be few or no bridge structures passing over the site, and those that are present should not be so wide as to obscure vehicles from view in the films.
- For best film resolution, the site should generally be no longer than 3,000 ft. The average site was approximately 1,800 ft long.
- The peak traffic time to be filmed must occur when light conditions are favorable for filming. Image quality significantly deteriorates with low sun angles.
- Suitable locations must exist for establishing and placing control points.
- The site should not be so incident prone that obtaining satisfactory film footage of incident-free traffic flow is unlikely.

No sites were filmed in the morning peak period because of low sun angles that existed at the times the filming would have had to be begun. Other than this, the traffic flow requirement was the most difficult criterion to satisfy in the site selection process.

A total of 18 sites was filmed, 8 in Washington and 10 in Los Angeles. The following numbers of sites were obtained:

- Weaving sections (7 sites, not all under the preferred traffic conditions);
- Ramp merges (3 sites);
- Reduced-width sections (2 sites);
- Upgrades (2 sites);
- Horizontal curves (2 sites); and
- Lane drops (2 sites, not all under the preferred traffic conditions).

Before filming, a set of targets, which would be visible in the film, was set out on the right shoulders of each direction of travel on the freeway sections to filmed. The targets consisted of 3- to 4-ft squares of dayglow orange plastic material with nylon mesh and were nailed to the pavement the day of or the day before filming. Typically four pairs of targets were laid out on each section to be filmed. The relative position of the targets was established by a ground survey. These positions served as control points and were used to establish a known ground coordinate system for the data reduction process.

DATA REDUCTION

Digitizing

The data reduction system consisted of a digitizing tablet and processor, a microcomputer and terminal, a voice synthesizer, and a 35-mm full-frame filmstrip projector. The system components are shown in Figure 3. A SAGE IV microcomputer with 512K bytes of memory and an 18-megabyte hard disk was used, and UCSD Pascal was employed as the programming language. The microcomputer was operated under a multiuser configuration, enabling two digitizing systems to be operated simultaneously.

The digitizing process is controlled by the operator primarily through the digitizer keypad. The keypad can be used to generate and transmit to the computer the X and Y coordinates of any point on the active area of the digitizing surface and to transmit numerical codes entered by the operator. Computer algorithms are used to transform digitized positions on the film to meaningful information on vehicle positions. The voice synthesizer is used to prompt the operator with audible feedback from the computer.

The key components of the data reduction process are the algorithms used to compute vehicle position and the method of tracking vehicles through the section. A two-stage process is used to compute vehicle position. First, a photogrammetric technique is used to translate the X-Y coordinates digitized from the projected film image (which is in a perspective view) into the coordinate system of the ground established with the control points (plan view). The specific technique used is termed "projective transformation" and involves the use of eight simultaneous equations to compute the coefficients of equa-

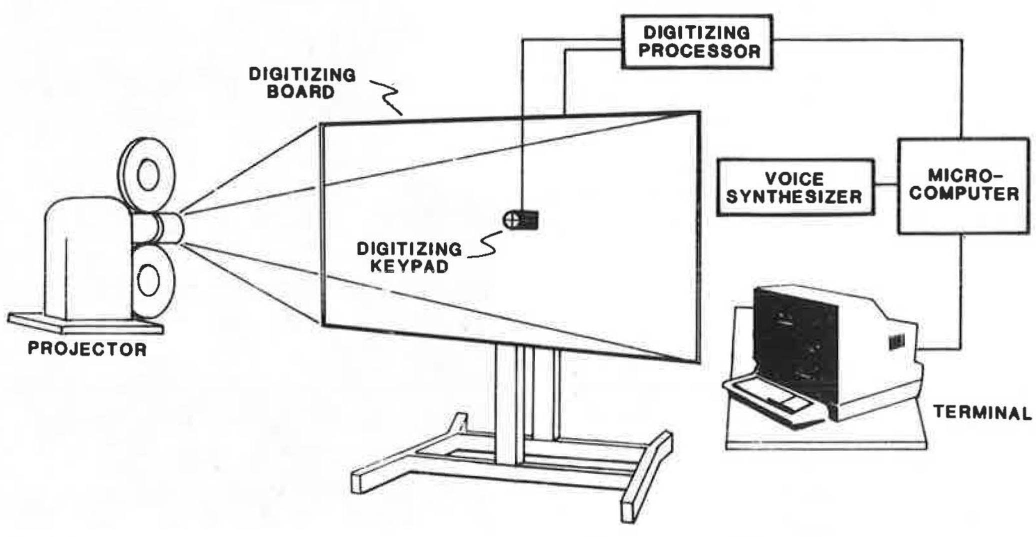

FIGURE 3 Schematic of digitizing system components.

tions that are, in turn, used to compute the X and Y coordinates of the ground plane for any digitized point on the film. This technique has been well described in previous publications (3,4) and the details need not be repeated here.

Figure 4 shows the relationship between the plane of the film and the plane of the ground and how the digitized position of a vehicle would be translated from one plane to another. The primary rule governing the establishment of the control points is that they lie in the same plane and that that plane follow the vertical alignment of the highway as closely as possible. All vehicles or points digitized will thus take on the coordinates of that plane. If changes in vertical alignment occur within a section, separate planes, with separate sets of control points, are needed to adequately carry out the transformation to ground coordinates. Any points digitized that are not in that plane will introduce a parallax error if the point is not viewed directly from above. This was particularly important for this study because all highway sections were photographed at an oblique angle.

Other rules governing the use of control points included the need to maintain all of the internal angles of the quadrilateral reasonably close to right angles and to make all sides of the quadrilateral of sufficient length. It was found that the width of the highway did not generally provide sufficient lateral distance between control points to enable stability to be achieved in the film-to-ground coordinate transformation. Therefore, a new set of control points was often established on one side of the highway using points outside the highway right-of-way that were also visible on the film (e.g., corners of rooftops) and were roughly within the plane of the highway. Other rules were also applied to minimize transformation errors.

The second coordinate transformation process involved translating the coordinate system of the ground into the coordinate system of the highway. The highway coordinate system was established to follow the horizontal alignment of the highway. The longitudinal axis was parallel to the highway centerline, coinciding with the right edge of the main line, and the lateral axis was always perpendicular to the longitudinal axis. The longitudinal coordinates began with zero at the upstream end of the section and ended at the downstream end of the section. The lateral coordinates were measured from the baseline at the right edge of the main line. The positive direction was defined as being to the left and the negative direction was to the right, so that the positions of any vehicles on an off-ramp or on-ramp took on a negative value.

The mathematics used to translate ground coordinates to highway coordinates were based on standard trigonometric equations used in highway design. More details on the mathematics are available in the final report (5). Subsections were defined by highway sections with homogeneous geometry. A number of the sections were either entirely tangent or entirely curved throughout, whereas others required up to three subsections.

The digitizing process is shown in simplified form in Figure 5. The figure shows the basic iterations involved but does not show the error checking and correction features, the initial creation of the geometric profile, and other more detailed aspects of the process. The digitizing of each frame of film begins with entering the next frame to be digitized. The four control points are then digitized and, following a computer calibration, a fifth point with known position is used to check the calibration.

Following a successful calibration, the computer recalls the most downstream vehicle digitized in the previous frame and, through the voice synthesizer, prompts the operator with several items of information: (a) the color of the vehicle, (b) the vehicle type, and (c) the number of the lane in which the

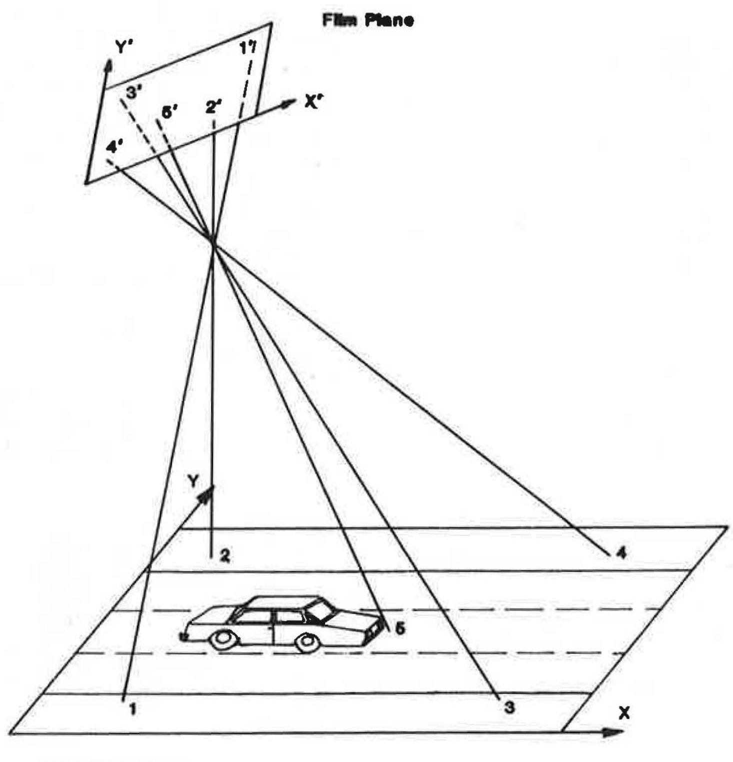

FIGURE 4 Relationship of points in roadway plane to points in film plane.

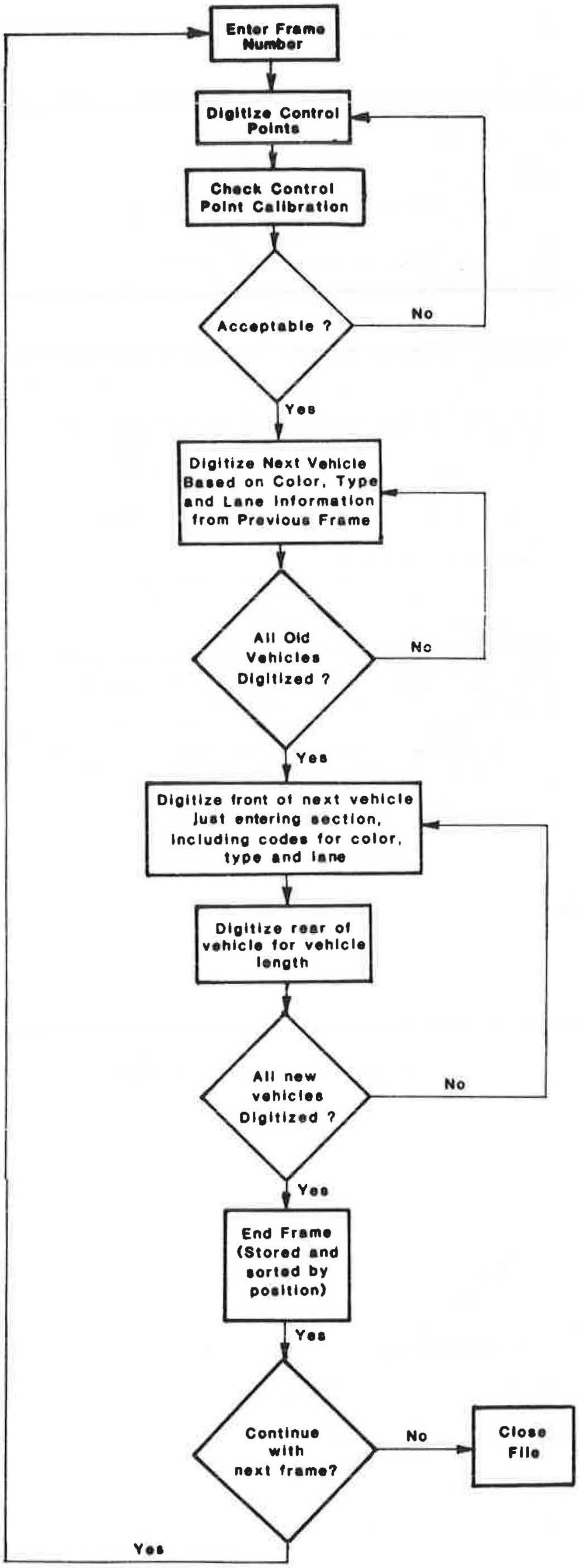

FIGURE 5 Overview of digitizing process.

vehicle was positioned in the previous frame. On the basis of this information, the operator finds the vehicle matching that description, beginning the search at the downstream end of the section. The cross hairs of the digitizer's cursor pad are placed over the center of the front bumper of the vehicle, and the key corresponding to the current lane number of that vehicle is depressed. The depression of the key on the cursor pad transmits the X-Y coordinates of that point on the projected film image and the lane number to the computer. A vehicle may have changed lanes since the last frame, so the lane number may have changed since the previous frame. The computer then performs the film-to-ground and ground-to-highway coordinate transformations and a series of checks to screen out possible errors made by the operator (particularly digitizing the wrong vehicle). Provided the computer finds no errors in the operator's digitizing of that vehicle, a new record is created in the vehicle file. The new record includes the frame number, a unique identification for that vehicle, the vehicle's lateral and longitudinal position, and other data such as the vehicle's color, type, and length. The computer then prompts the operator with the next upstream vehicle, which the operator then locates in the current frame, just as was done with the first vehicle. The digitizing proceeds in the upstream direction until all of the vehicles that appeared in the previous frame are digitized in the current frame. Vehicles that are entering the section for the first time are then digitized. The vehicle color and type are entered along with the lane number, using the digitizer's cursor pad. Vehicle length is also obtained by digitizing the rear of the vehicle the first time it enters the section.

The accuracy of the longitudinal and lateral position is dependent on a multitude of factors. The most important control on errors is the placement of the control points and the accuracy of the ground measurements taken. Ideal control point configurations are not always possible. As the points being digitized become farther from either of the control point pairs, the higher the error is likely to be. Points digitized close to a control point will be subject primarily to errors by the operator in placing the cross hairs of the cursor over the true position of the vehicle. These errors are typically 2 ft or less. Errors arising from control point calibration are typically greater in the longitudinal dimension than in the lateral dimension because the distance from a control point is likely to be greater in the longitudinal than in the lateral dimension. The overall positional error is estimated to be within ±5 ft in the longitudinal direction and ±3 ft in the lateral direction.

The prompting of the operator by the computer is done primarily through a general purpose speech synthesizer. The color, type, and lane number of the next vehicle to digitize are given audibly, enabling the operator to continually keep his or her eyes on the projected film image instead of having to look back and forth between a CRT screen and the digitizing surface. When an error or special situation is encountered, a message is sent to the operator through the speech synthesizer to look at the CRT screen where additional information is displayed. The speech synthesizer not only saves substantial amounts of time in the digitizing process but also reduces both operator fatigue and the probability of error.

The digitizing rate varied with the quality of the film. Sections with asphalt pavement tended to be more difficult to digitize because of the greater difficulty in seeing dark-colored vehicles on the dark pavement. Better contrast was achieved on concrete pavements, especially those that had been heavily traveled and had both dark and light tones. Digitizing vehicles that had been previously digitized could be accomplished at a rate of approximately 5 sec per vehicle. New vehicles just entering the section could normally be digitized in 20 sec, including color, type, and length information. Entering the control points at the beginning of each frame could be done in approximately 30 sec. Thus the time to digitize one frame would depend primarily on the number of vehicles within each frame, which, in turn, is dependent on the section length, number of lanes, and traffic density. The time to digitize one frame of film would ordinarily be between 4 and 12 min, depending on these factors and assuming minimal need for error correction. Error correction is handled through an error correction menu on the CRT screen, which gives the operator the options of modifying an entry, restarting the frame at any point, or deleting an entry, among others. The number of errors and the time to correct an error are dependent on a number of factors, primarily image quality and operator proficiency.

Format of Data Files

Figure 6 shows the format of the data file created as a result of the digitizing process. The section shown is from an upgrade section with five 11-ft lanes, filmed in Los Angeles. The distance of each vehicle from the beginning of the section is shown in field 6, and the lateral position is shown in field 7. If vehicles are traveling in the center of the lane, the value in field 7 should be approximately equal to 11 times the lane number minus 5 or 6 ft (half a lane). Speeds are shown in field 5. Records with a zero speed represent vehicles that had only been digitized once at this point in the file and therefore could not have developed a speed history. As indicated, the file is organized by frame number with vehicles ordered sequentially from the downstream to the upstream end.

In each film there are approximately 3,600 frames to be digitized (1 hr at one frame per second). The number of vehicles within the section may range between 25 and 130, depending on the section and traffic characteristics, but will typically be in the 50 to 60 vehicle range. Thus, the average size of a data set may be nearly 200,000 records, but certain data sets may be half that size and others may be twice that size.

The data files are assembled in stages, beginning with the individual microcomputer files. The microcomputer files are limited in size so that final editing can be accomplished on the microcomputer itself. One microcomputer file might consist of between 5 and 30 frames of data. These files are concatenated in the process of being telecommunicated to a mainframe computer.

The validity of the data is dependent primarily on the validity of the calibration of each frame using the control points. Because eight pairs of control points were generally available at each site, it was possible to use several of the points other than the four used in the calibration itself to check the calibration. Although no ground-based data were collected at the same time as the film data, careful calibration of the film frames ensures that the data adequately represent traffic flow within the general tolerances indicated earlier. Because the vehicle positions are not perfectly precise, there will be some degree of jerkiness associated with vehicle movements, especially if

FIELD NUMBERS

1	2	3	4	5	6	7	8	9
53	125	1	14	59	234	50	3	5
53	121	1	17	46	199	7	7	1
53	126	1	15	48	146	6	6	1
53	127	1	18	46	106	19	6	2
53	128	4	19	0	28	8	1	1
54	82	1	12	48	1248	6	3	1
54	86	1	13	47	1240	25	6	3
54	92	1	18	57	1234	36	4	4
54	93	1	16	52	1165	48	2	5
54	94	1	14	52	1150	30	2	3
54	95	4	13	55	1111	49	9	5
54	91	1	17	46	1074	26	7	3
54	90	1	12	46	1055	4	1	1
54	97	1	16	55	1035	38	8	4
54	96	1	20	48	964	27	2	3
54	98	1	14	52	946	15	3	2
54	99	1	15	52	941	48	2	5
54	101	4	19	52	900	16	9	2
54	105	1	15	61	870	36	8	4
54	100	1	20	52	847	16	2	2
54	103	1	12	52	846	5	7	1
54	104	1	19	55	843	50	2	5
54	102	1	18	48	790	26	2	3
54	106	1	19	55	782	49	7	5
54	108	4	22	52	683	26	4	3
54	111	1	13	59	677	49	2	5
54	107	1	19	47	667	16	2	2
54	110	1	19	50	609	24	4	3
54	115	1	16	59	589	39	2	4
54	109	1	13	44	587	16	2	2
54	113	1	15	50	540	28	3	3
54	114	4	16	52	509	5	9	1
54	112	1	15	46	492	16	3	2
54	116	1	17	50	444	5	4	1
54	118	1	12	55	431	48	7	5
54	119	1	16	48	347	4	1	1
54	124	1	16	55	335	36	2	4
54	125	1	14	58	319	49	3	5
54	120	1	11	48	316	27	7	3

KEY TO FIELD NUMBERS

1 – FRAME NUMBER

2 – VEHICLE ID

3 – VEHICLE TYPE CODE

4 – VEHICLE LENGTH (FEET)

5 – SPEED (MPH)

6 – DISTANCE FROM BEGINNING OF SECTION TO FRONT OF VEHICLE

7 – DISTANCE FROM RIGHT EDGELINE TO MIDDLE FRONT OF VEHICLE

8 – VEHICLE COLOR CODE

9 – LANE NUMBER (RIGHT LANE = LANE 1)

FIGURE 6 Sample record format of digitized data file.

viewed in the unsmoothed 1-sec increments. The vehicle movements could be smoothed, if desired, to eliminate some of the jerkiness of movement. Studying movements over time increments longer than 1 sec will proportionately reduce this effect as well.

Availability of Data Sets

Each data set is available on 9-track magnetic tape from the FHWA Office of Research, HSR-20, Turner-Fairbank Highway Research Center, 6300 Georgetown Pike, McLean, Virginia 22101. Fourteen data sets were reduced in the study, including six weaving sites, three ramp merges, two grades, one curve, one lane drop, and one reduced-width section. In addition to the vehicle data file, each magnetic tape contains a file of geometric data for the section, coded in accordance with the conventions used in the INTRAS freeway simulation model. More information on the data sets is available elsewhere (5).

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