A COMPARATIVE ANALYSIS OF VARIOUS METHODS OF PHOTOLOGGING

by

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(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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ABSTRACT

Reported is the second of two evaluations of the potential use of photologging within the Virginia Department of Highways and Transportation. The film acquired in the first evaluation was used to establish a viewing station in a district office and the central office of the Department. Once Department personnel had gained experience with the photolog, interviews were held to determine the potential need for the data in the photolog, ascertain which divisions within the Department would be the greatest users, and select the preferred format for obtaining the data needed. The results included the establishment of activities in which the data could be used, the identification of the factors essential for the successful implementation of a photologging operation, and an estimated cost of establishing such an operation.

SUMMARY OF FINDINGS AND RECOMMENDATIONS

This study was conducted to determine if data collected and displayed through the use of photologging would be of benefit to the Department. It was anticipated that the photologging technique could contribute to the efficiency of operations by consolidating data-gathering activities and by providing needed data heretofore unavailable through routine operations.

The findings and recommendations from the study are stated in two categories. The first addresses the application of photologging data to activities within the Department; the second addresses the selection and cost of equipment.

Application of Data

Findings

1. By consolidating data-gathering trips to the field, the photolog would be valuable in reducing fuel consumption, man-hours, and the time it requires to get data from the field to the user.

2. One of the most important advantages of using the data gathered by photologging is that the user can view the information as it is seen in the field. The user is therefore able to bring all his knowledge, skills, and experience to analyzing the data. In many other methods of collecting data in the field the decision as to what data to collect and what data to omit is made by someone other than the user; therefore, the user's knowledge, skills, and experience are limited before he receives the data.

3. In order for a photologging operation to work successfully, there are several essential elements that must be incorporated into the development program. There must be —

    a. the support of top management;

    b. a training activity for those designated to obtain the data and for those who will use the data;

    c. marketing or advertising throughout the Department of the photolog facilities and their capabilities; and

d. facilities throughout the Department which will allow the photolog to be used with the idea that it belongs to everyone and is not the exclusive property of one division.

4. The photolog can provide data for use by many divisions. In order for the photolog to be cost-effective all the divisions that can effectively use it must do so.

5. The Legal Division would be able to use the photolog data to provide documentation. Litigation against highway and transportation departments because of their possible involvement in accidents by failing to maintain roadways within prevailing national and local standards are becoming common. The photolog could be used to demonstrate that roadways have been inventoried and priorities have been established for upgrading and repairing the road system. In such situations it could be asserted that the Department is meeting a reasonable standard in fulfilling its obligations.

6. The Traffic and Safety Division is involved in numerous activities which require information about the physical structure of the roadway, the signing and lighting of the roadway, and the general conditions of the surrounding environment. These activities include:

- Providing information for traffic sign inventories
- Identifying roadside obstacles
- Establishing high hazard locations
- Establishing milepost locations
- Generating data for the graphic logs
- Providing a tool for interdisciplinary investigation of accidents

The photolog could be used to provide much of this information.

7. Data generated by photologging could be used to present information to the public at informal meetings and formal hearings concerning various transportation projects. Since the information in the photolog is pictorial as well as alphanumeric it could be more easily understood by the public than much of the technical data presently used.

8. The photolog would provide a central source of information for use in answering requests and responding to complaints from the public. It would allow for the routing of these requests and complaints to a central location rather than to many divisions throughout the Department.

9. Many activities concerned with providing mass transit services require data which would help in the establishment of bus stops, preferential bus lanes, park and ride facilities, etc. The data generated by the photolog, such as those on land use and locations of intersections, could provide much of this information.

10. Sufficiency ratings are assigned to selected roadways to establish priorities for upgrading. The photolog could provide much of the data needed, with the exception of passing and stopping sight distances.

11. The Environmental Division provides an environmental assessment on all Department projects. Pictorial data provided by the photolog could facilitate this process by enabling personnel to review the project before going to the field. Also documentation of land use, wet lands, community structure, etc. could be reproduced for various reports.

Recommendations

1. The research has indicated that two of the elements — interest and application — needed for a successful photologging operation are present within the Department. Therefore, if the other elements (management support, training, and adequate facilities) can be acquired, it is recommended that a photologging operation be established within the Department.

2. Although the photolog data are meant to cover a broad range of activities, it is recommended that one specific area for application be targeted to begin the operation.

3. The Traffic and Safety Division was extremely cooperative in aiding the researcher in determining the uses of the photologging data. The research indicates that the most likely area to begin to use photolog data would be in the graphic logs section. Interviews have indicated that a large part of its work is data collection and reduction, that the section is extremely active, and that it provides needed services. Therefore, it is recommended that the

photolog be used at the start of the operation to aid in the data collection activities needed to produce the graphic logs.

4. It is recommended that before using the photolog to collect data for a specific activity, the activity should be examined to determine:

   a. why the data are being collected;

   b. the form (a formal document or merely in some retrievable form) in which the data must be available; and

   c. the extent to which the data being collected are being used.

   The results of these determinations may lead to a reduction in data collection activities by eliminating the production of written reports to record data which could easily be stored on the photolog. Also, the collection activities could be discontinued for the data found to be no longer required.

Selection and Cost of Equipment

Findings

1. There are two basic formats for displaying photolog data: a conventional format with limited numerical data and a new format which provides extensive numerical data and a computer tape capability.

   With the conventional format, the visual data are extremely important; therefore, 35mm film is the best for use with this format. With the new format, the visual data become supplementary information because of the additional capacity for numerical data. There are more options available for producing visual data in this format including, 35mm, 16mm, and videotape. To date Techwest Enterprises Ltd. of Vancouver, British Columbia, is the only manufacturer of equipment for the new format.

2. In testing eight variations of the two basic formats to evaluate how they would meet the data needs enumerated through the course of the study, it was concluded that a format with expanded numerical data display and a magnetic

tape capability would be the most advantageous. It was also concluded that the 35mm camera would give the best results in terms of information reduction and flexibility for meeting needs.

3. The average yearly investments needed to establish a photolog operation on a year-to-year basis would be approximately $106,490 for a 35mm system and $87,999 for a videotape system; the difference is 17%. The establishment of a photolog operation for a ten-year period, if the funds are dedicated at the beginning of the project and an 8% discount rate is assumed, would require an average yearly investment of approximately $49,324 for 35mm film and $40,759 for videotape.

Recommendations

1. The equipment to be used in a photologging operation should consist of the type needed to provide the expanded alphanumeric format, with a magnetic capability, shown in Figures 5 and 6 of the report.

2. The distribution of 35mm film should be primarily in the central office and district offices. Distribution to the residencies could be accomplished, if needed, by 16mm film reduced from the original 35mm negative. The 16mm film would allow the residencies to use the less expensive 16mm projectors.

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INTRODUCTION

Photologging is the sequential photographing of highways or road facilities for the purpose of developing a file or library from which an operating or administrative unit of an organization can obtain dimensional, cultural, geometrical, geographic, and structural data.

Almost without exception, large organizations with rapidly growing responsibilities become engaged in a variety of activities which require the collection of identical data. Because of the physical separation of these activities throughout the organization and the lack of a central data source, a duplication of effort in data collection results. This situation exists within the Department and the establishment of a central data source would appear to be the most obvious means of eliminating the duplication.

The photologging technique for gathering data has the potential for providing this central data source; consequently, two studies were initiated to evaluate the efforts and costs needed to make photologging an efficiently functioning system. The first study, entitled "An Evaluation of the Feasibility of Using Photologging in the Virginia Department of Highways and Transportation", was reported in 1977.[1] It concluded that a photologging operation could be established within the Department with little difficulty. It also concluded that before any recommendations for establishing the operation could be made to the Department a number of issues would have to be studied further. The issues included identifying data needs, determining the best equipment for establishing a photologging operation that would meet these needs, and developing a cost estimate for this system.

The second study, which is reported here, addressed those issues and developed recommendations to the Department concerning the use of photologging. The report is structured into four sections as noted below.

1. A procedures section in which the study area, the equipment used, the viewing stations established, and the data gathering method (interviewing) are explained.

2. A results section in which the types of applications for the data generated by photologging are enumerated. This section also explains how the equipment best suited for collecting and displaying these data was selected.

3. A cost section in which the funds required to set up a photologging operation are estimated. Photologging methods using 35mm film and videotape are compared.

4. A summary section in which the information developed in the results and costs sections is related.

PROCEDURE

The Culpeper District was chosen as the study area for the first photologging project because it had a mix of urban and rural road types. The primary road system within the District was chosen to be filmed because roads in this system experience a greater amount of maintenance and construction activities than do roads within the secondary or interstate systems. In turn, this activity creates a potential need for the types of data produced by the photolog. With the exception of a few short road segments, the entire primary system in the Culpeper District was filmed. However, because of photographic distortion or procedural errors in filming, a log of approximately 70% of the road system was available for use in the present study.

Film for the study was acquired in two steps. First, the data base for the photolog was established using photologging equipment which utilized a conventional 35mm camera. The second step was to acquire samples of photolog film using experimental 35mm cameras, conventional 16mm cameras, and conventional videotape cameras. In addition 16mm reductions were made from the conventional 35mm film. The film sampling in the second step continued throughout the study with developments in photologging being used whenever the researcher learned of them.

The films obtained in the first study were used to develop the photolog library for the evaluation of data in the second.

Two viewing stations, one in the Central Office and the other in the Culpeper District Office, were established to identify activities throughout the Department in which the photolog data could be used. The researcher was also interested in determining which divisions would be using the photolog and to what extent.

Central Office

The Central Office station contained a film library with a wall map for identifying those road segments for which film was available (Figure 1), a card index for locating the film (Figure 2), and a photolog projector. In addition, a copy of the familiar graphic logs was available to enable the users to orient the photolog film to a given road section. Part of a page from the graphic logs is shown in Figure 3. For the first six months, a Vanguard 35mm photolog projector, model PL-35 was available for analyzing film. This was then replaced by a Flight Research, Road-O-Graph II projector/viewer for the remainder of the study.* A person from the Photogrammetry Section was available to aid users in the operation of the equipment.

An attempt was made to introduce the photolog project throughout the Department. Personnel in the Location and Design, Secondary Roads, Public Relations, Transportation Coordination, Programming and Scheduling, Environmental Quality, Maintenance, Transportation Planning, Traffic and Safety, Right-of-Way, Management Services, and Legal Divisions were contacted. Interviews were conducted with personnel involved in areas which appeared to have the most obvious potential for applying the photolog-generated data. Later in the study the photolog was used by the researcher in an attempt to duplicate some of the tasks performed by these individuals.

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*For descriptions of these viewers see Appendix A.

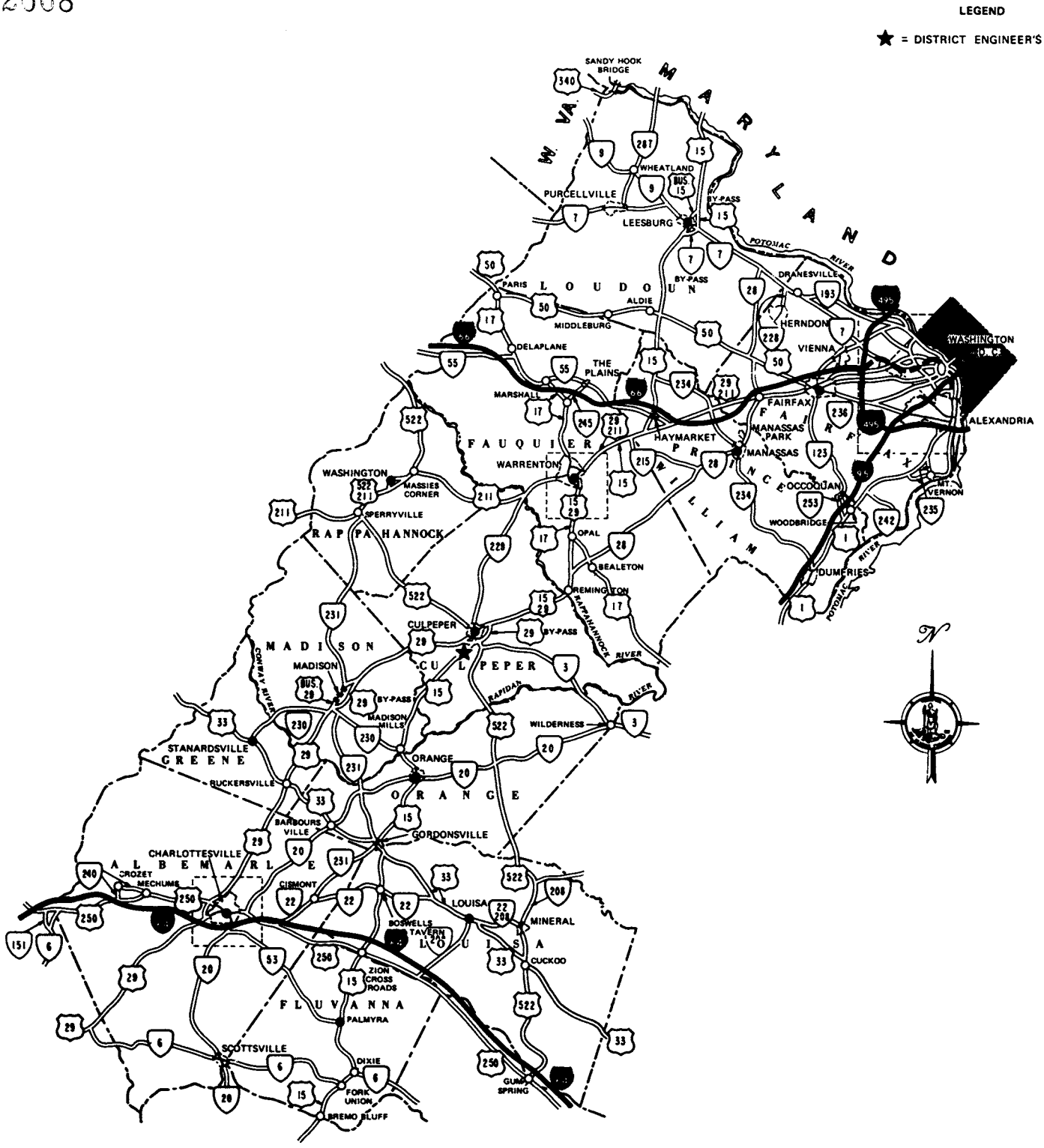


Figure 1. Map of Culpeper district road system with "lining" to show roads for which film was available.

22-E	Rt. No. & Direction
Albemarle	County
9.08 - 0.00	M.P.
Good	Quality of Print
11-15-74	Date Filmed
	Reel No.

Figure 2. Example of information contained on index card for locating film.

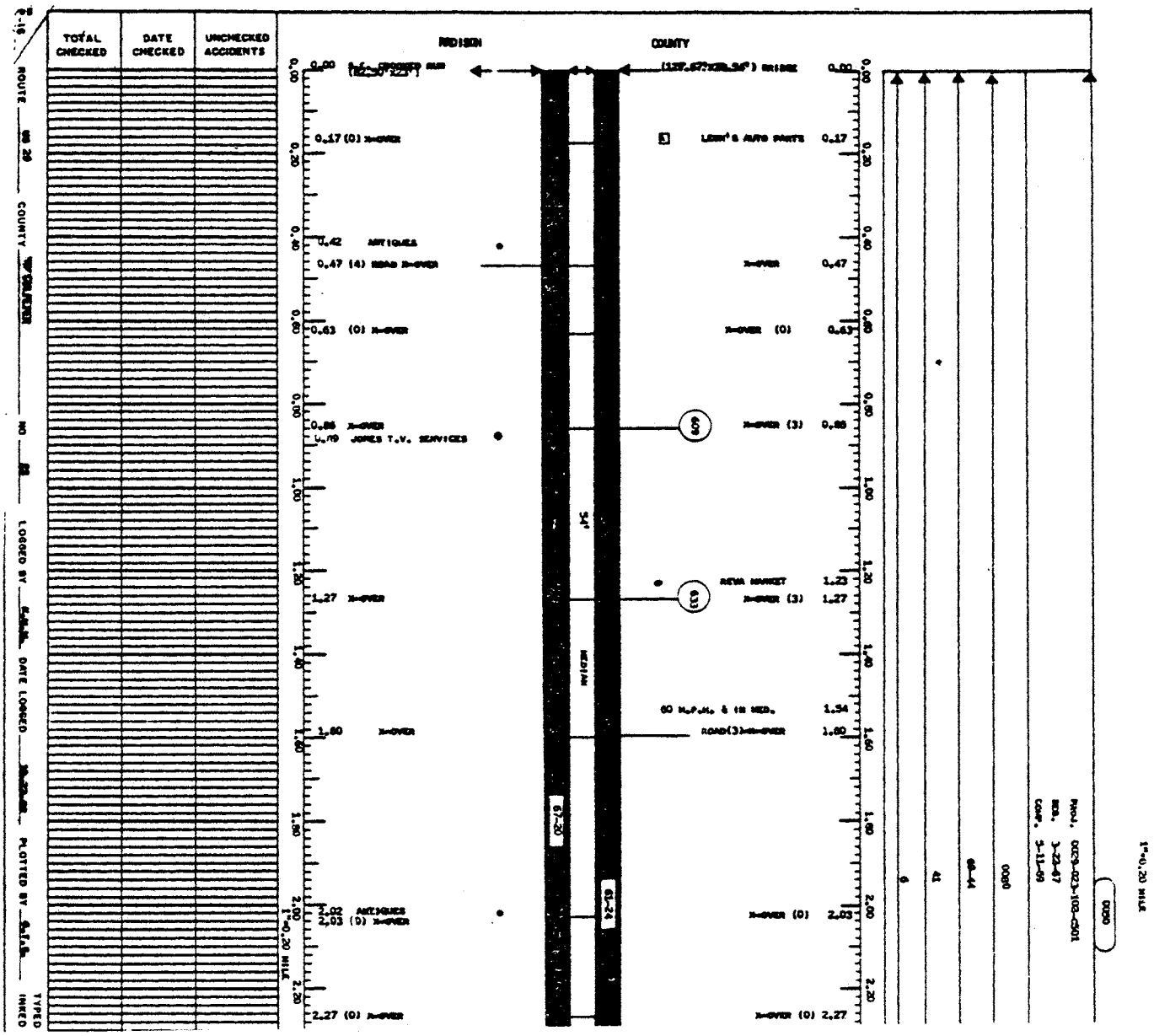


Figure 3. Example of graphic log on Virginia's primary system.

Culpeper Office

As in the Central Office, a film library, a card index for locating the film, a wall map showing the roads for which film was available, and a copy of the graphic logs were provided at the Culpeper viewing station. For the first six months a Flight Research Road-O-Graph II projector/viewer was available for analyzing the film. It was then replaced by the Vanguard 35mm photolog projector, model PL-35 from the Central Office viewing station.

One presentation was made to the District Office and another to field personnel at the district engineer's staff meeting. Descriptions of the research project being conducted, its objectives, the types of data produced through photologging, the road segments available on film, the potential use of the photologging data, and the operation of the equipment were among the information presented to both the office and field staff. The viewer was placed in a designated area for use just as it would be if photologging were adopted throughout the Department. One of the district engineer's staff members was designated to help aid the user with the equipment. In addition, the use of the photolog was monitored from forms filled in by the users.

RESULTS

Application of Photolog Data

The major objective of this study was to identify the ways in which the information developed through photologging can be used within the Department. Personnel in the Culpeper District Office and the Central Office were interviewed after they had had some experience with the use of the photolog. The interviews revealed many activities in which data could more efficiently be acquired through photologging than through field trips.

The data needs fell into two basic categories. Category 1 needs were for activities in which data are routinely collected throughout the Department. Category 2 needs were for activities in which data similar to those gathered by photologging could be used but are not presently collected on a routine basis. The uses to which the photolog data could be put in these activities are discussed in the succeeding sections.

Category I: Data Collected Routinely

Responding to Inquiries and Public Complaints

The Department's policy is to respond to inquiries and complaints from the public as quickly and as accurately as possible; however, these complaints are often addressed to many divisions (such as Maintenance, Traffic and Safety, Location and Design, Legal, Environmental, Planning and Urban), and often some type of field trip is required to verify the validity of the complaint and develop a reply. A person with general knowledge of the Department and access to information such as that generated by photologging would be able to answer many of the inquiries or complaints.

Developing Sufficiency Ratings

One of the activities within the Programming and Scheduling Division is the assigning of sufficiency ratings to selected roadways. Data required to develop these ratings include road and structure design, lane and shoulder width, stopping and passing sight distances, curve design, horizontal and vertical structure clearance, accident rate, speed limits, and the existence or lack of a median barrier. Based on interviews with personnel involved with this activity the use of Department records supplemented by data from the photolog would enable most of these data to be collected without on-site visits. However, the data needed to develop stopping and passing sight distances are gathered in the field and presently no technique has been developed which would allow the substitution of photolog data.

Inventory of Traffic Signs

Several sign inventories maintained by the Traffic and Safety Division require field trips. Some inventory operations are one-time projects while others are continuous. To evaluate the effectiveness of the photolog for gathering data for sign inventories a section of Route 50 in Arlington which had been filmed earlier was used. Along this 5-mile stretch approximately 81 signs were recorded through use of the photolog according to the types of information listed in Table 1. The collection of these types of data now requires a field trip. The details for only 1 sign were difficult to determine from the film. The sign causing difficulty was in the shadow of trees growing along the roadside and would have been a problem for drivers using this facility.

Table 1

Traffic Sign Inventory

Data Required	Field Trip Required		Available through Photolog
	Yes	No	Yes
County	x		x
Milepost	x		x
Route	x		x
Direction	x		x
Sign mounting			
Ground (left/right)	x		x
Overhead (type)[a]	x		x
Sign Support			
Wood	x		x
Metal (type)[b]	x		x
Behind Guardrail	x		x
On Wall	x		x
On Median Barrier	x		x
On Bridges	x		x
Catwalk	x		x
No. of Poles/Posts	x		x
Sign			
MUTCD No.	x		x
Shape	x		x
Size	x		x
Color	x		x
Legend	x		x
Field	x		x
Lighted	x		x
Message	x		x
Flashers			
No. of lenses	x		x
Location	x		x

[a]Overhead mount includes differentiation between bridge, cantilever, wall, wire, or truss.

[b]Type of metal sign support includes differentiation between I/H beam, straight, tapered and breakaway.

The photolog was not used in any night activities and is not advocated for replacing night inspections. The use of the photolog at night would limit its application and run contrary to its purpose; that is, its use as a tool for gathering broad based data.

Location of Roadside Obstacles

The Traffic and Safety Division periodically conducts surveys to identify roadside obstacles such as unprotected bridge pillars, blunt-end guardrails, trees and boulders in hazardous proximity to the road, and non-breakaway signs and lighting supports. Data from the photolog were evaluated to determine the extent to which they could be used to reduce field trips in this activity. Although the photolog adequately located and identified the various obstacles, field trips would still be required to ascertain how these obstacles should be removed.

Identifying High Hazard Locations

The Traffic and Safety Division, in conjunction with the state police, designates as "high hazard locations" those sections of road systems where inordinate numbers of accidents have occurred. Photologging could be used to identify these locations with information on mileposts and landmarks. A photograph and a brief description of the roadways by investigating officers could pinpoint the location more accurately than is now the case. An additional benefit is that the user of the photolog viewer sees the roadway much the same as the driver or passenger in the vehicle would.

Producing Graphic Logs

The graphic logs are produced by the Traffic and Safety Division. The information contained in the logs includes speed limits, differentiation of city vs. state maintained roads, pavement types, road intersections, milepost locator, number of lanes, various landmarks (such as business locations), direction of travel, etc. The photolog can produce much of the information now on the graphic logs and, additionally, it can give information about such other items as signing, guardrails, geometrics, and environmental factors. Information needs for the graphic logs which could be obtained by the photolog include: highway type, lane transition, speed limits, intersection type, junkyard and dump location, route numbers, mileposts, bridge and river names, and landmarks.

Outdoor Advertising

The Environmental Quality Division is responsible for identifying the billboards and other advertising media within 660 ft. (201 m) of the highway right-of-way. Measurements for determining the exact distance of each sign from the right-of-way would not be possible with the photolog; however, the number of trips to the field to accurately measure all advertising displays could be reduced by using the photolog to identify those signs that are obviously within or beyond the legal limits.

Developing Options in Mass Transportation

Data generated by the photolog that could be used in developing mass transit options would include:

- Potential bus stop locations
- Visual display of existing bus stops
- Location of potential rights-of-way for development
- Identification of potential bus routes
- Visual record of congested areas
- Location of junctions for combining different modes such as park and ride areas

Conducting Research

Many activities carried on throughout the Research Council could be aided through the use of data. Examples of these activities are:

- Before and after surveys of road conditions (e.g., maintenance, performance of experimental materials)
- Review of accident sites
- Evaluation of pavement markings
- Location and condition of various historic landmarks

- Location of existing and potential public transit facilities
- Review of safety-related aspects of road construction and maintenance, such as use of safety barriers during construction
- Site selection for projects; e.g. driveway locations, wrong-way driving, right-turn-on-red, and possible truck escape ramp locations

Detour Location

The location and establishment of detours during major construction is a responsibility of the Location and Design Division. Data produced by the photolog could be used to aid the Division in locating and monitoring the use of these routes.

Category II: Data Not Routinely Collected

Handling Condemnation Cases

Many condemnation cases get to the courts long after the property in question has been taken. From the time of the taking to the time of settlement, the land in question may increase or decrease in value. For example, if a new road is constructed which greatly limits access to conveniences such as shopping centers or recreational facilities, then the land value may decrease. On the other hand, if the road constructed enables the adjacent landowner to sell his land for the construction of a shopping mall or highrise apartments, then obviously the land value will increase. The commissioners, those who must decide the fair value of the land in question, could be influenced by the existing land use. The photolog could give them a view of the land as it was when purchased as well as the land use pattern at that time for miles in several directions. Hopefully, this would result in an equitable settlement.

Evaluating Employee Suggestions

Within the Management Services Division "value engineering" is being carried on, and the data needed for the disposition of a number of the suggestions from Department personnel can be gained by use of the photolog. For example, if schemes are suggested for decreasing the amount of paint or materials used on roadway signs, barriers or similar objects, the photolog would enable a review

to be carried out to determine the number of items involved. Also the evaluation of field operations could be supplemented by information gained by the photolog.

Defending Against Suits Involving Personal Liability of Department Officials and Employees

The issues involving the personal liability of Department officials go far beyond the scope of this study. Nevertheless, there have been lawsuits against the state for negligence and the photolog would be helpful in defending against such cases. Specific issues which arise in these cases involve determining if there has been reasonable maintenance of a given roadway. Were the need to arise, the photolog could show that reasonable care had been taken in the maintenance of a roadway. Often cases concerning the personal liability of government officials would probably focus on deciding if the officials were involved with discretionary or ministerial functions. They would be liable for damage resulting from negligence in performing only functions of the latter type as noted in the following quote which sets forth the definition most favored by the courts.

> The liability of a public officer to an individual for his negligent acts or omissions in the discharge of an official duty depends altogether upon the nature of the duty to which the neglect is alleged. Where his duty is absolute, certain, and imperative, involving merely the execution of a set task, in other words is simply ministerial — he is liable in damages to anyone specially injured either by his omitting to perform the task, or by performing it negligently or unskillfully. On the other hand, where his powers are discretionary, to be extended or withheld according to his own judgement as to what is necessary and proper, he is not liable to any private person for neglect to exercise those powers, nor for the consequences of a lawful exercise of them, where no corruption or malice can be imputed.(2)

The use of photologging as a communications tool could lessen the probability of error in translating the directions from a supervisor to a subordinate. Consequently, the chance of directions being misunderstood with a resultant negligent act would be lessened.

Additionally the photolog could provide documentation that —

1. personnel within the Department are aware of conditions in the field;

2. priorities are established to correct dangerous or potentially dangerous conditions; and

3. those conditions which exist are reasonable due to limitations in time, funding and/or manpower.

The photolog would also be a media for enabling Department engineers and administrators to stay informed of conditions in the field.

Presenting Information at Public Hearings

The use of photologging in connection with public hearings and public meeting activities has been discussed with many Department officials, and it has been concluded that the photolog could enhance the explanation of a project. The photographs would be less confusing than blueprints and could show needs for improvements in a manner that the average citizen could understand. It should be stressed that the use of photologging data would be severely limited in connection with projects covering virgin territory. However, this limitation could be offset by combining the photologging data with data generated by aerial photography.

Preparing Environmental Impact Statements

The photolog possibly could be used by the Environmental Quality Division in the preparation of environmental impact statements. Through the use of the photolog a review of the area to be affected by a project could be made by personnel in the Central Office and thus the necessity for some field trips could be eliminated. This review, made in advance of the need for an impact statement, could provide information regarding historical sites, schools, recreation areas, etc. Once the impact study was started recall of the information could be aided by the photolog. Since prints can be made from the photolog, these could be incorporated into the impact statement to aid in explaining the project and the evaluation resulting from the Department's review.

Training

The photolog has a potential use for the training of personnel involved in writing reports for which photographic documentation

would be needed. Various projects can be viewed and studied by team leaders, various specialists, and field personnel. This viewing could be used to inform personnel of omissions and possible problem areas in their reports and of Departmental expectations. Through the review of projects with new employees, training relating to environmental evaluations and other aspects of highway planning can be carried on.

Other Activities

Other Department activities for which the photolog could possibly be put to use are those relating to the substandard bridge replacement program, traffic records, wrong-way driving, and the issuance of permits for the movement of oversized loads.

SELECTION AND COST OF PHOTOLOG SYSTEM

Comparison of Photolog Components

Selection

In order to develop a photologging operation which would most efficiently meet the needs of the Department, an attempt was made to determine what equipment was needed to provide the data required for the applications enumerated in the previous section. Factors considered in this determination were the cost of the equipment, the features of the equipment which would encourage its use (e.g., simplicity), and its flexibility for meeting future needs.

It is important that the reader understand the relationships between the vehicle instrumentation, the camera used, and the format desired for data display. The instrumentation (which may include compasses, altimeters, clocks, etc.) determines the amount and types of data that can be collected. The camera determines the format in which the data will be displayed, in other words, the size, resolution and organization of the data. The format is the final product and determines the usefulness of the data to the user.

Therefore, the most important decision to be made when attempting to establish a photolog system is the selection of the best format for displaying the information collected. Although there are several variations of data display formats, there are only two basic types as shown in Figures 4, 5, and 6. The format in Figure 4 incorporates alphanumeric data in a picture taken

with a 35mm photologging camera. Because of the limited amount of alphanumeric data included, the information contained in the picture is extremely important; 35mm film produces the best resolution and is, therefore, essential for use in this format.

The format shown in Figures 5 and 6 has an expanded numerical data display, and efficient data reduction depends less on the information contained in the picture; in other words, the picture becomes a supplementary rather than a primary source of information. The importance of less dependence on the information available through the picture is that the photographic resolution sufficient to efficiently produce the needed information can be obtained with cameras less sophisticated and less expensive than the 35mm. Therefore, a wider variety of camera systems are available for establishing photologging operations.

It was concluded that only the type format depicted in Figures 5 and 6 should be considered. The format shown in Figure 4 is of the first generation and there is a strong possibility of it being phased out. The format selected is of the second generation, and its expanded numerical information base combined with a data tape capability could provide excellent data display for present needs and is flexible enough to satisfy future needs. Further, it was concluded that only the 35mm photographic camera system or the videotape camera system (1/2 or 3/4 inch) should be employed with the expanded numerical data format. The study indicated that the 16mm and super 8mm cameras produced photographic information that would greatly inhibit the use of the photolog without significantly reducing the cost of establishing and maintaining the system. Both the 16 and the super 8mm required continuous purchase of film and the availability of reproducing and printing facilities and services. In other words, all of the disadvantages of the 35mm are inherent in the 16 and super 8mm cameras but they provide few of the advantages.

On the other hand, it was decided that the videotape has enough advantages to warrant consideration as a possible substitute for the 35mm camera, and a cost comparison was made between the 35mm camera and the videotape camera as used to produce the expanded data format shown in Figures 5 and 6.

Cost

In the cost comparison of the two cameras "cost" was defined as "the outlay for expenditures (as of effort or sacrifice) made to achieve an objective". Under this definition it is possible that when the outlay for implementing photologging is compared to the outlay for achieving the same objective under the current method or methods the result could be a negative dollar figure; i.e., photologging could result in a net savings.

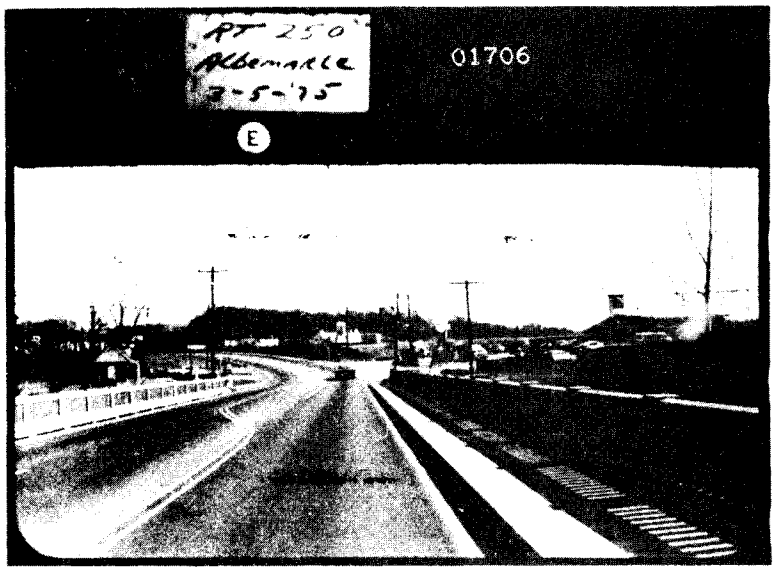
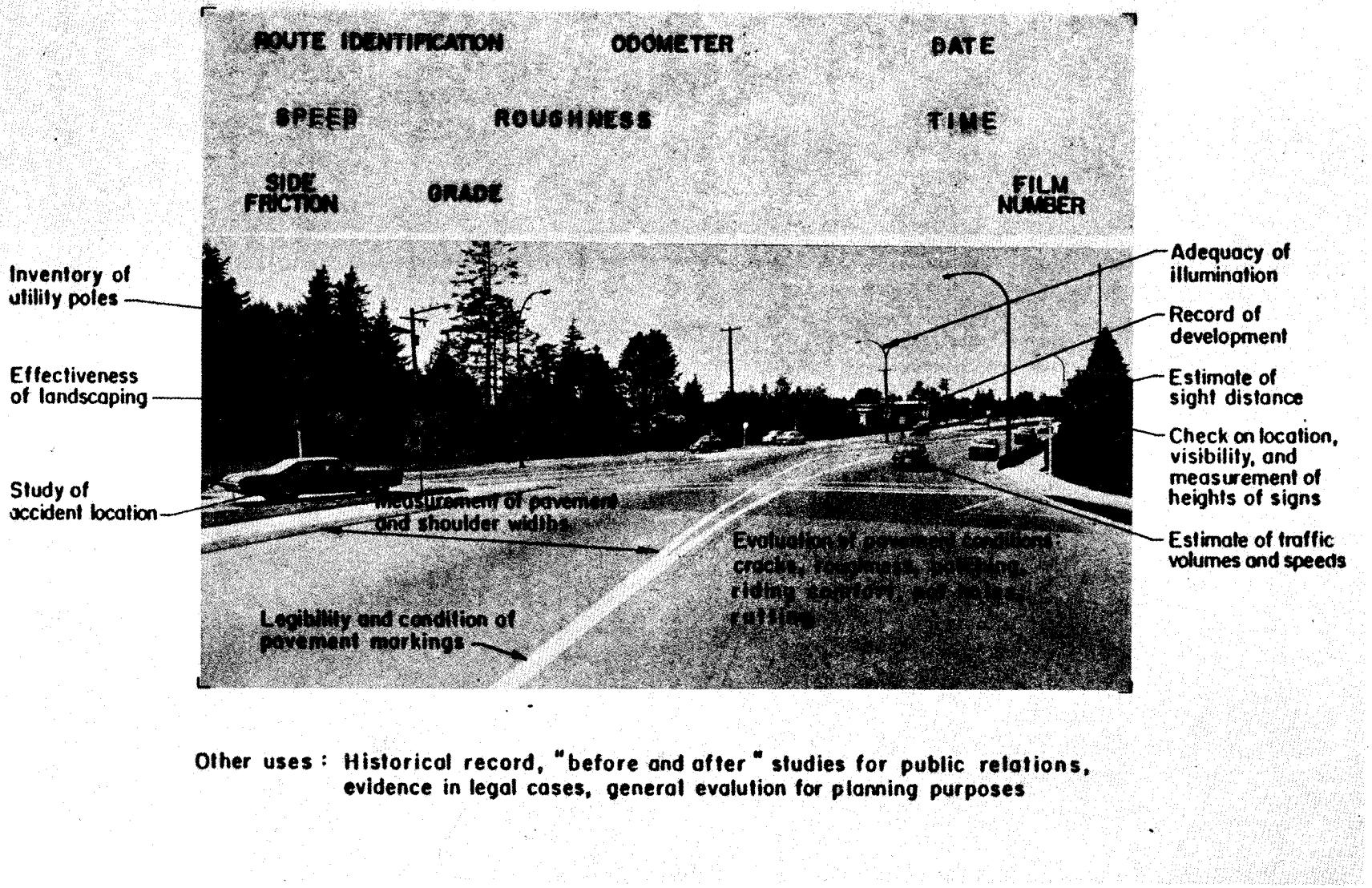


Figure 4. Conventional film format incorporating alphanumerical data with 35mm photograph.

Figure 5. Typical data format produced by TECWEST Enterprises, Ltd. equipment.



Other uses : Historical record, "before and after" studies for public relations, evidence in legal cases, general evalution for planning purposes

Figure 6. Format with interpretation of coding shown in Figure 5 .

Assumptions

In the calculations for the cost comparison the following assumptions were made.

1. The equipment life and the program were to be in operation over a 10-year period.
2. The funding for this 10-year program would be set aside in the first year.
3. The discount rate for the 10-year period would be 8%.
4. The program could be discontinued within the first 2 years at which time the salvage value of the equipment would be approximately 50% of its original value.
5. All personnel, equipment, and services were to be obtained specifically for the project, even if they were to actually be transferred from within the Department for the project.
6. The increase in price on any equipment would be offset by discounts resulting from the bid procedure.
7. Data would be acquired statewide on a one-way mile basis for 12,000 miles (19,312 km) of roadway each year.
8. The program would require the services of several people throughout the year, some full-time and some part-time; however, the pricing scheme would assume that total personal services would equal 3 full-time employees with a salary of $15,000 each, including the additive factor.
9. The cost of overhead (e.g., space) would not be included.
10. The costs of training and marketing needed in the first 2 years of the project would not be included.

Cost Items

The costs of the systems were broken down into equipment, film/tape purchase and services, personnel, and maintenance (vehicle, camera, and projector).

The costs for equipment covered the following items.

1. Camera price included all accessories and installation.

2. Vehicle price included air conditioning and radial tires.

3. Viewers were in the mid-price range.

4. Editing equipment was based on an average price for minimal equipment.

Costs for film, videotape and related services were developed under the following assumptions.

1. Film/tape purchase was based on the amount of film or tape needed to accomplish photologging 12,000 miles (19,312 km) of road per year.

2. Processing was based on developing all film.

3. Printing was based on the need for two prints, one for distribution to Central Office and the other to the appropriate District Office.

The costs for personnel included salaries for 3 full-time employees, with additive payments for various overhead items and benefits; and the expenses incurred by employees for meals and lodging during photologging operations.

Maintenance costs covered those to be incurred for maintaining the vehicle used in photologging including the cost of gas, oil, and general servicing repairs and those for repairs and preventive maintenance on the camera and projector. The cost for maintenance of the camera and projector was estimated and would depend on warranties.

Table 2 shows the amount of funding needed to establish a photolog system with viewing stations in each of the eight district offices, the Research Council and the Central Office. (See Appendix B for specific cost information.) It is estimated that at least 5 viewers would be needed in the Central Office; therefore the equipment cost would include the purchase of 14 viewers.

Table 2

Ten-Year Cost Comparison Between the 35mm and the Videotape Camera

	35mm System	Video System
Equipment	$ 119,500	$ 68,995
Purchase film & services	422,400	300,000
Personnel	500,000	500,000
Maintenance	23,000	11,000
Total	$1,064,900	$879,995
Average yearly cost	$ 106,490	$ 87,999
Cost per mile	$ 8.87	$ 7.33

The figures in Table 2 are not discounted, which means that based on today's values this is the amount of money that would be needed to fund a photologging project under annual allocation. However, if all the funds were set aside at the beginning of the 10-year photologging program, the present value costs would resemble those in Table 3.

Table 3

Present Value Costs Between the 35mm and the Videotape Cameras at an 8% Discount Rate

	35 mm System	Video System
Equipment	$ 55,350	$ 31,957
Film purchase & services	195,646	138,953
Personnel	231,589	231,589
Maintenance	10,653	5,095
Total	$493,238	$407,594
Average yearly cost	$ 49,324	$ 40,759
Cost per mile	$ 4.11	$ 3.40

The figures in Table 3 were developed on the supposition that once implemented the program would be successfully operated for a 10-year period. The figures in Table 4 represent the cost to the Department if the project were to be dropped within the first 2 years. The assumption is that about 50% of the equipment cost could be salvaged.

Table 4

Salvage Value of the Program (at 8%)
Within Two Years of Its Inception

	35mm	Video
Equipment	$102,137	$ 59,122
Film purchase & services	72,391	51,414
Personnel	85,690	85,690
Maintenance	3,942	1,885
Total	$264,160	$198,111
Salvage value of equipment	$ 51,068	$ 29,561
Risk investment for first two years	$213,092	$168,550

In the foregoing tables it can be seen that the cost of using the 35mm camera is higher than that for using the videotape camera. However, cost alone should not be the deciding factor in the selection of the camera.

In the following paragraphs the advantages and disadvantages of the 35mm and the videotape cameras are compared. The selection of the best camera is extremely important because it will determine the usefulness of the data produced. Moreover, the selection will determine whether videotape (which needs no processing, can be seen immediately after taping, and is reusable) or 35mm film (which needs developing, printing, and the purchase of new film through the life of the program) will be used. The use of tape or film will influence the cost of the project.

Aside from cost two other capabilities were compared: that of information reduction and adaptation capabilities. Information

reduction is the quality of the data displayed, which determines the ways in which it can be analyzed and used, such as the preciseness of measurements.

35mm film

- The 35mm film has better resolution than videotape.
- During review 35mm can be stopped without significant loss of clarity and the information can be reduced through accurate measurements.
- 35mm film can be displayed by projection to a large audience, e.g., that of a public meeting. The film can be shown running continuously, one frame at a time, or stopped.
- 35mm can be used to produce clear prints with excellent resolution for use in reports.

Videotape

- Videotape can be presented to a group on a monitor screen only.
- When video is stopped for analysis of a given section of tape, it becomes very distorted.
- Video has a voice capability for collecting and reducing data.
- Video cannot be reproduced for use in a report except by photographing an image on a video monitor.

Adaptation capabilities are those features of the equipment which would facilitate its use, such as simplicity of operation.

35mm

- Must be threaded through several gears and cogs in both the filming and projection operations.

- Processing and printing of the film are needed and although a skilled operator is not likely to make a mistake, the results of filming are not known for several days after filming.

- 35mm must be edited by a skilled technician; however, this skill can be developed with a minimum of training.

Videotape

- Videotape equipment uses mostly cassette tapes which are very easy for both the viewer and the operator to use.

- With videotape the filming in the field can be monitored during operations.

- Video must be edited by skilled technicians.

After the capabilities and limitations of both the 35mm and the videotape cameras were weighed, it was concluded that the 35mm would be the best choice in a photologging operation. Although the videotape camera is less expensive and has better adaptation capabilities, the 35mm camera allows for greater use of the data produced. Another important advantage afforded by the 35mm camera is that it has been proven in the use of photologging while the videotape camera would be experimental.

SUMMARY

During the operation of the photolog stations in both the Culpeper District Office and the Central Office a number of observations were made which at first glance appear to be contradictory. For example, although a great deal of interest was shown in the photolog technique and numerous applications were identified for the data developed, the actual use of the equipment was minimal. In the following paragraphs the findings are stated and are followed by explanations as to how the researcher interprets the findings relative to the future use of photologging.

Most people interviewed showed an interest in the photolog. The interest expressed in photologging by those interviewed throughout the Department was an indication that photologging is a dynamic enough technique to arouse interest, which would aid in publicizing the operation should it be established. This interest was extremely valuable in bringing many concerns, both pro and con, about photologging to the attention of the researcher.

Many potential applications for the photologging data were identified. This finding is the strongest indication that a photolog operation would be successful. The Department is in a position to start photologging with many more applications than did other states which now have successful photologging operations. During the study many conversations were held with people involved with the successful use of photologging throughout the U. S. and Canada. These people indicated that once the photolog had been introduced and used in a few data gathering applications, new areas were rapidly developed. No state indicated that the photolog had been immediately accepted.

The photolog was not widely used. The minimal use of the photolog was the biggest concern throughout the project. The obvious implication is that the photolog, if established, would not be used. However, the information gained from interviews seems to indicate that no other result could have been expected.

The basic reasons for this underutilization are given below.

1. Most divisions and district personnel were working at full capacity; consequently, they were unwilling to give up proven methods of accomplishing their task for one that was experimental.

2. No training was available for potential users. Therefore, it was not clear how the photologging data could be substituted for the information they were presently using.

3. There was some reluctance on the part of middle management personnel to fully support an activity which was threatening in a number of ways.

   Since the photologging would have to be used by many divisions throughout the Department, it was not clear who would be responsible for funding and maintaining the operation. Many were

reluctant to have the operation financed from their budget and did not think they could handle the additional work load.

- If photologging were to maximize efficiency, it would obviously mean that the manpower requirements would be reduced; those in charge of a section felt a responsibility toward their employees and felt that the use of photologging was a potential threat.

It should be noted here that photologging would actually act to transfer the skills of many employees from one type of task to another rather than eliminate positions. Further, those tasks that would eventually be eliminated would have to be phased out because the implementation of photologging would have to run concurrently with some present tasks until the completion of filming.

4. The question was raised about how the photologging data would meet present Department requirements for specific tasks. Fears in this regard are legitimate, especially in instances where federal requirements involve the collection and tabulation of data. In these cases it is possible that the data need not be documented in print but merely be stored in a retrievable form. Photolog data would then suffice.

The influence the support of top management would have on the success of the photolog operation was noted at both viewing station locations. In the Central Office, where personnel did not know how top management felt about the project, interest was high, but it was mixed with expressions of skepticism and uncertainty. In contrast, in the Culpeper District Office, where the district engineer openly encouraged support of the project, interest was also high but expressions of skepticism and uncertainty were minimal. However, as previously mentioned use of the photolog was low.

The support of top management was deemed essential because it would allow for changes in methods for performing given tasks and would give personnel the confidence to work with, develop, and improve the photologging operation.

The development of a training program for users of photologging is essential. The program should be capable of satisfying the needs of two distinct groups of users. One group would be made up of those people actually involved in establishing the photolog system; the other would be comprised of those using the data collected. In

the first instance several strategies are available. For example, some states photolog their entire road system the first year and update the entire system each subsequent year. The strategy suggested here would be to select the road system or systems for which the photolog data would be most useful. The selected system(s) would then be photologged in their entirety in the first year or two. The film would be updated according to priorities based upon activities planned for those road segments.

Although many states operate their photologging activities out of a central location, it appears to be more economical to assign the filming equipment on a district basis and use the seasonal activities and work load of the districts to define the most opportune time for filming. This approach could combine the advantages of the mobility and simplicity of the equipment with off-peak work loads of personnel.

To establish this system some personnel would have to be trained as operators, film editors, and film cataloguers. Additionally, this training would have to be updated because of equipment changes and personnel turnover.

To gain maximum use of the system, a training program should be geared to enable users to interpret data produced through photologging and apply the data in their jobs. In most cases, this training would involve knowledge of cataloguing, data reading, equipment (viewer) operation, and skills peculiar to specific jobs.

The equipment must be readily accessible in two senses. In one sense, it must be accessible by not being so complex that it inhibits use. Therefore, simplicity of operation ought to be a standard for selecting equipment (i.e. the use of cassette film or tape versus reel-to-reel tape or film).

In a second sense the film/tape containing the data should be advertised throughout the Department so that potential users will be aware that the equipment is available. Also the film/tape library should be made available to all who want to use it. Basically, this means that the viewers should be close to the library for those who want to use it on an infrequent basis. For those who would use it on a constant basis, the viewers should be close to their work areas and the tapes/films should be available through messenger mail or in duplicate sets. If a user chooses to use a tape/film he should not feel he is imposing on another person's work area; therefore, the equipment should not be in an area expressly under the jurisdiction of a division.

REFERENCES

1. McGeehan, Daniel D., An Evaluation of the Feasibility of Using Photologging in the Virginia Department of Highways and Transportation, Charlottesville, Virginia, Virginia Highway and Transportation Research Council, March 1977.

2. Hughes and Cantor, Photographs in Civil Litigation, Bobbs-Merrill, 1973, p. xvii.

APPENDIX A

SPECIFICATIONS FOR PHOTOLOG PROJECTORS

The features and specifications for the Vanguard and Flight Research viewing equipment are described in the succeeding listings.

Vanguard Projector

The Vanguard Model PL-35 photolog projector used by the researcher during this study is a recent development in photologging.

The analyzer has the following features and specifications.

- Projection Speed: 0.5, 1.0, 2.0, 3.0, 5.0, 8 and approximately 25 frames per second. The film can be stopped at any speed by depressing a push-button switch. Also there is a single frame advance capability.

- Film Direction: Forward and reverse; direction can be changed at any speed.

- Film Capacity: 35mm x 400 ft. (35mm x 122 m) maximum ANSIPH 22.93, PH22.34, PH22.139, PH22.36 perforated both edges. Film reel shafts have a square driving shank with a keeper suitable for plastic or metal reels. When cores are used, an adapter is required. Adapter reels are not supplied with the projector. The amount of torque provided at the reel shafts may be adjusted by a voltage control on the front panel.

- Film Path: The direction of film reel rotation should be set up at the factory. This requirement is necessary because of the different standards of winding film on reels and the need for projecting a picture which has no "mirror image" reversal. A sample reel of film should be furnished for this purpose.

- Film Loading: One knob opens the film gate and all film keepers to provide fast and simple loading.

- Film Rewind: Forward and reverse through the film gate.

- Illumination System: 300 watt focus lamp: The lamp housing and projection aperture are air-cooled. A light intensity control is provided. 500-watt tungsten halogen lamp optional.

- Power: 115 ± 5 VAC 60-HZ 550-watts.

- Projection Lens: 63 mm focal length, mounted with image-inverting prism.

- Image Size: 14" W (356 mm) x 11.2" H (279 mm)

- Projection Screen: 3.5' W (1.37 m) x 4.4' H (1.71 m)

- Elevation Mechanism: The Model PL-35 photolog projector has an elevation mechanism that provides an adjustment of picture height for wall projection. It can also be used for changing the angle of the viewing screen.

- Size: Normal — 20" W (500 mm) x 24-1/2" H (613 mm) x 36" D (900 mm)

  In Carrying Position — 20" W (500 mm) x 24" H (600 mm) x 20" D (500 mm)

- Weight: 17 lb. (7.7 kg)

Flight Research Road-O-Graph II Projector/Viewer

The Flight Research Road-O-Graph II projector/viewer was used during the course of the research. It has the following features and specifications.

- Viewing Screen Image: 7-1/4" (18.4 cm) high and 10-1/2" (26.7 cm) wide

- Projection Image: 4' (1.2 m) high, 5'6" (1.7 m) wide at 14 ft. (4.3 m) from screen

- Picture Brightness Control: Allows operator to adjust picture to any comfortable brightness.

- Conversion From Mode: Accomplished instantly within console by simple control adjustment; film is not touched in operation.

- Flickerless viewing provided by shutter that blanks film image during advancing and reversing motions.

- Film reels up to 400' (122 m) capacity accommodated. Fast forward and reverse mode allows 400' (122 m) reel to be rewound in approximately 5 minutes.

- Manual and motorized versions available.

APPENDIX B

COST DATA FOR 35mm AND VIDEOTAPE PHOTOLOG SYSTEMS

Table B-1

10-Year Cost Comparison of 35mm and Videotape Systems

1st Year

35mm System		Videotape	
Equipment	$119,500	Equipment	$ 68,995
Film & Services	42,240	Tape & Services	30,000
Personnel	50,000	Personnel	50,000
Maintenance	2,300	Maintenance	1,100
Total	$214,040	Total	$150,695

Second Year (3rd year's costs will be the same)

Equipment	$ -0-	Equipment	$ -0-
Film & Services	42,240	Tape & Services	30,000
Personnel	50,000	Personnel	50,000
Maintenance	23,000	Maintenance	1,100
Total	$ 94,540	Total	$ 81,100

4th through 10th Years

Equipment	$ -0-	Equipment	$ -0-
Film & SErvices	42,240	Film & Services	30,000
Personnel	50,000	Personnel	50,000
Maintenance	2,300	Maintenance	1,100
Total	$ 94,540	Total	$ 61,000

Table B-2

Detailed Cost Comparison by Year

1st Year

35mm System			Video System		
Equipment			Equipment		
Camera	$55,000		Camera	$40,000	
Vehicle	7,000		Vehicle	7,000	
Viewers (14)	56,000		Viewers (14)	21,995	
Editing Equipment	1,500	$119,500	Editing Equipment	-0-	$68,995
Film & Services			Tape & Services		
Film Purchase	14,080		Tape Purchase	15,000	
Processing	5,760		Processing	-0-	
Printing	22,400	42,240	Printing (duplication)	15,000	30,000
Personnel			Personnel		
Salary	45,000		Salary	45,000	
Expenses	5,000	50,000	Expenses	5,000	50,000
Maintenance			Maintenance		
Vehicle	700		Vehicle	700	
Camera & Projector	1,600	2,300	Camera	400	1,100
Total		$214,040	Total		$150,095
Per mile/km cost		$17.84/1124	Per mile/km		$12.50/7.88

Table B-2 (cont.)

2nd and 3rd Years

35mm System			Video System		
Equipment			Equipment		
Camera	$ -0-		Camera	$ -0-	
Vehicle	-0-		Vehicle	-0-	
Viewer	-0-		Viewers (14)	-0-	
Editing Equipment	-0-	$ -0-	Editing Equipment	-0-	$ -0-
Film & Services			Tape & Services		
Film Purchase	14,080		Tape Purchase	15,000	
Processing	5,760		Processing	-0-	
Printing	22,400	$42,240	Printing (duplication)	15,000	$30,000
Personnel			Personnel		
Salary	45,000		Salary	45,000	
Expenses	5,000	$50,000	Expenses	5,000	$50,000
Maintenance			Maintenance		
Vehicle	700		Vehicle	700	
Camera & Projector	1,600	$ 2,300	Camera	400	$ 1,100
Total		$94,540	Total		$81,100
Cost per mile/km		$7.88/4.96	Cost per mile/km		$6.76/4.26

Table B-2 (cont.)

4th through 10th Years

35mm System			Video System		
Equipment			Equipment		
Camera	$ -0-		Camera	$ -0-	
Vehicle	-0-		Vehicle	-0-	
Viewers (14)	-0-		Viewers (14)	-0-	
Editing Equipment	-0-	$ -0-	Editing Equipment	-0-	$ -0-
Film & Service			Tape & Service		
Film Purchase	14,080		Tape Purchase	-0-	
Processing	5,760		Processing	-0-	
Printing	22,400	42,240	Printing (Duplication)	-0-	-0-
Personnel			Personnel		
Salary	45,000		Salary	45,000	
Expenses	5,000	50,000	Expenses	5,000	50,000
Maintenance			Maintenance		
Vehicle	700		Vehicle	700	
Camera/Projector	1,600	2,300	Camera	400	1,100
Total		$94,540	Total		$61,000
Cost per mile/km		$7.88/4.96	Cost per mile/km		$5.08/3.20

Table B-3

Cost Comparison of Two Systems Over 10-Year Period

35mm		Video	
Total cost	$1,064,900	Total cost	$739,295
Average yearly cost	106,490	Average yearly cost	72,930
Cost per mile/km	8.87/5.59	Cost per mile/km	6.16/3.88