AN EVALUATION OF THE FEASIBILITY OF USING PHOTOLOGGING IN THE VIRGINIA DEPARTMENT OF HIGHWAYS AND TRANSPORTATION

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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SUMMARY OF FINDINGS AND RECOMMENDATIONS

The findings and recommendations from the study are stated in three categories. The first addresses the decision to accept or reject the use of photologging by the Virginia Department of Highways and Transportation; the second addresses the use of photologging in general; and the third concerns the operation of the photologging system.

Department's Decision

Findings

1. More than 20 states are using photologging in their daily operations. These states have found uses for the technique in almost every area of operation in which the Virginia Department of Highways and Transportation engages.

2. Because of the unavailability of an adequate viewing apparatus for the study, the potential extent of use within the Virginia Department of Highways and Transportation has not been defined.

3. In recent months new cameras and viewers have been developed which have reduced the investment needed to establish a photologging operation.

4. The first year's investment required to establish photologging in the Department's Central Office and all district offices is $102,228 for a 16mm system and $153,840 for a 35mm system. This first-year investment is the amount of money that must be written off if the program is discontinued after installation. However, if the program is fully adopted, the funds needed annually to maintain the system are estimated to be $66,728 for a 16mm system and $93,340 for a 35mm system. These estimates are based on an assumption that all equipment and services for the program will be purchased.

5. The film acquisition phase of photologging can be accomplished by a person given a short but careful training course. The overall cost of the technique can be reduced by transferring the film acquisition equipment from district to district to efficiently use personnel engaged in seasonal activities.

6. The Federal Highway Administration is presently conducting an NCHRP systhesis project aimed at defining the uses of the photologging technique in those states which have been using it extensively for the past few years. The project report will summarize the opinions of photologging technicians, researchers, and users in the field as well as those in the main office. It is hoped that this report will give a realistic appraisal of the technique.

Recommendation

Since an NCHRP synthesis study is under way which will enumerate and describe the uses of photologging by other states, and the equipment that has recently been developed is undergoing evaluation in a number of state and federal agencies, it is recommended that the Department delay any decision on establishing a system until the results of this evaluation become available, probably in June 1978.

General Uses of Photologging

The phase of photologging dealing with the acquisition and cataloguing of films is well established; however, much research is still needed in the uses of the photolog. Specifically, attention should be given to how the technique can be applied in the Department's data reduction methods, and to ways of making the photolog available to all who might benefit from it.

Findings

1. Many states are now using photologging in their daily operations. These states have cited the principal users to be divisions responsible for the legal, traffic and safety, environmental, research, maintenance, management services, public relations, location and design, and right-of-way operations of their agencies.

2. The use of a microfilm reader for analyzing the photolog films causes discomfort and consequently reduces the number of people who would use the photolog file.

Recommendation

It is recommended that adequate viewers be acquired under a current study entitled "A Comparative Analysis of Various Methods of Photologging," in order to determine the use and benefit of the existing photolog to the Department.

Operation of Photologging

Findings

1. Photologging can be accomplished within the Department with little difficulty.

2. The information requested from the photolog throughout this study has been related to the interstate, arterial, and primary road systems.

3. The estimated time needed to complete photologging of these road systems would be approximately two years, based on filming an average of 600 miles (960 km) one-way per week over about 25 weeks per year. The estimation of filming 25 weeks out of the year accounts for weather conditions, editing, and employee vacation, sick leave, etc.

4. For roads requiring frequent maintenance, construction, etc., the photolog should be updated frequently.

5. The need for updating may vary from district to district.

Recommendations

1. If a decision is made to adopt photologging as a routine data-gathering operation, the interstate, arterial, and primary systems ought to be filmed along with selected secondary roads.

2. All road systems selected for photologging should be filmed at the beginning of the program; this will take about two years. After all selected road systems have been filmed to form an information base, selective updating should begin.

3. A committee composed of representatives from those divisions and districts interested in using the photolog should set the criteria for updating each road system.

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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.

This method of obtaining data is used in at least twenty states, including all of Virginia's bordering states. Most of these states have documented that photologging has proven valuable in obtaining information for use in such highway activities as traffic engineering, safety, right-of-way acquisition, legal proceedings, maintenance, and location and design. However, since states vary significantly in a number of ways, the value of a photologging program for one will not necessarily be the same for another. In some states, for example, highway activities are highly centralized, while in others they are decentralized. A number of state governments bear the responsibility for the total road program, while others concern themselves only with the interstate system, leaving their political subdivisions the task of road maintenance within their respective jurisdictions. The degree of urbanization and the geographic size of the state will often make a difference in the uses to which the photolog can be applied.

Consequently, in July 1974 the Research Council of the Virginia Department of Highways and Transportation, in cooperation with the Federal Highway Administration, undertook a study to determine if photologging could be used advantageously in highway and transportation operations in the state of Virginia. The study was planned as a pilot project to determine (1) how the technique might be used to enhance the Department's efficiency, and (2) the cost effectiveness of instituting and running a photologging system.

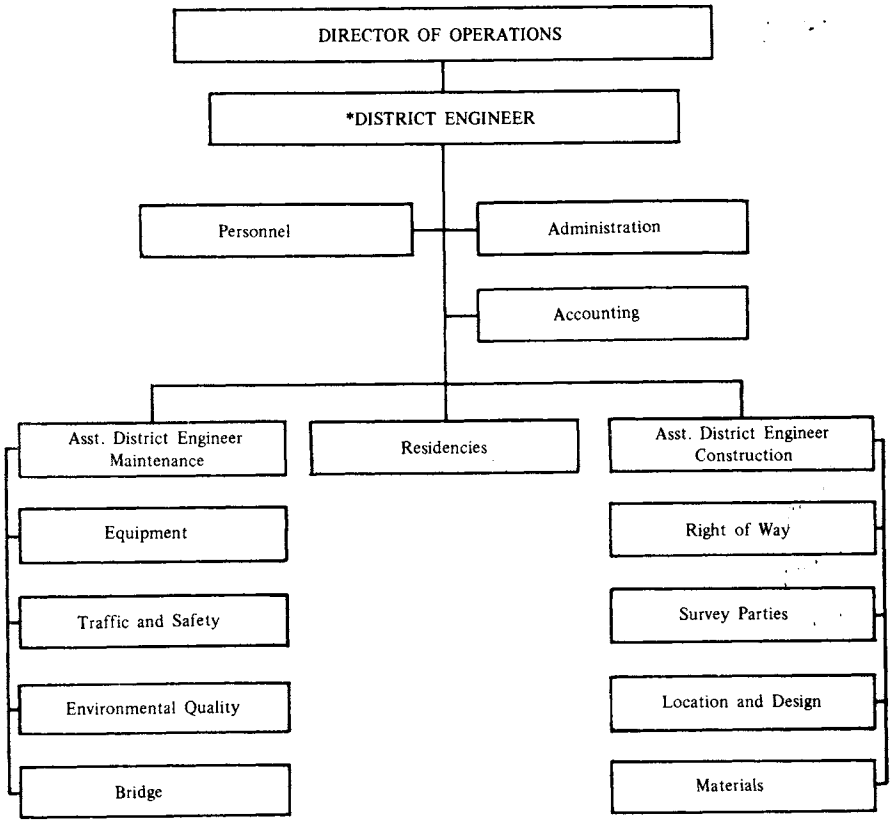
VIRGINIA'S HIGHWAY SYSTEM

The Virginia Department of Highways and Transportation is administratively centralized and operationally decentralized. The offices

of the commissioner, directors, division heads, and their staffs are located in Richmond. The operational activities are decentralized into eight construction districts,each of which is responsible for several residencies.

The Department has direct and complete responsibility for the large majority of roads and streets in Virginia, including those in the interstate and primary systems, the arterial network, and the secondary roads system. In addition, the Department has partial responsibility for the urban system comprising the urban roads which are extensions of the primary system within municipalities, secondary streets within towns under 3,500, the secondary roads in Arlington and Henrico Counties, and approximately 6,218 miles (9,948 km) of other streets within municipalities.

The eight district offices — Bristol, Salem, Lynchburg, Richmond, Suffolk, Fredericksburg, Culpeper, and Staunton — are responsible for field activities which include maintenance, road design, materials, construction, environmental quality and various accounting activities (see Figure 1).



*Eight Districts exist in the Department. Each District has four to six Residencies.

Figure 1. Organizational chart of typical district.

PURPOSE AND OBJECTIVES

One of the major services that the Research Council performs for the Virginia Department of Highways and Transportation is to be constantly on the alert for new methods that will enable the Department and thus the Commonwealth to fulfill its obligations in the most efficient manner. The photologging data-gathering technique appears to be one of these methods. The purpose of this research is to determine the extent to which photologging can be applied in the Virginia Department of Highways and Transportation.

The objective of the work reported here was to pilot test a photolog system in a specific area in Virginia. The pilot test was used to determine the potential usefulness of a statewide photologging program by comparing the cost of present operational methods with those incurred in performing the same operations with the photologging process. The evaluation included:

1. An enumeration of the applications or uses of the model photolog program which result in the greatest benefits to the Department.

2. A pricing of the program. This analysis included four optional systems for photologging.

3. Recommendations concerning alternative methods of maintaining the photolog system.

PROCEDURE

Since the project was to be a pilot study with a possibility that the photologging techniques would not be adopted, a number of questions arose which are worth mentioning here, at least for the benefit of those agencies contemplating a test research project; these were:

1. Should the filming be performed in-house, i.e. by the Research Council, or be contracted to a private firm?

2. Assuming the work was to be accomplished "in-house", should the equipment be purchased or leased?

3. What geographic area should be filmed?

4. What types of roadways should be filmed within that area?

In resolving the first of these questions, it was decided that the work would be performed in-house. In a meeting with representatives from the Federal Highway Administration, the Department and the Research Council, it was recommended that the photographic work should be performed by members of the Council's research team. By direct contact with operations, the researchers would become acquainted with the field problems and would be able to guide Department personnel in setting up a photologging system if the technique were adopted.

Next it was decided that except for the van and editing equipment, which were acquired from within the Department, all equipment would be leased. By leasing, a large capital investment in the study was avoided. This allowed the technique to be objectively studied and provided flexibility to take advantage of innovations that might develop during the course of the study without regard for funds already invested in an established system.

The Culpeper District was selected as the pilot study area because it has a mix of urban and rural road types, and because of the interest expressed by the district engineer.

Within the Culpeper District only the primary road system was to be filmed, because roads in this system experience a greater amount of maintenance and construction activity than do secondary or interstate system roads which, in turn, would create a potential need for the type of data produced by the photolog (see Figure 2).

Once these four questions were resolved the work of photologging began.

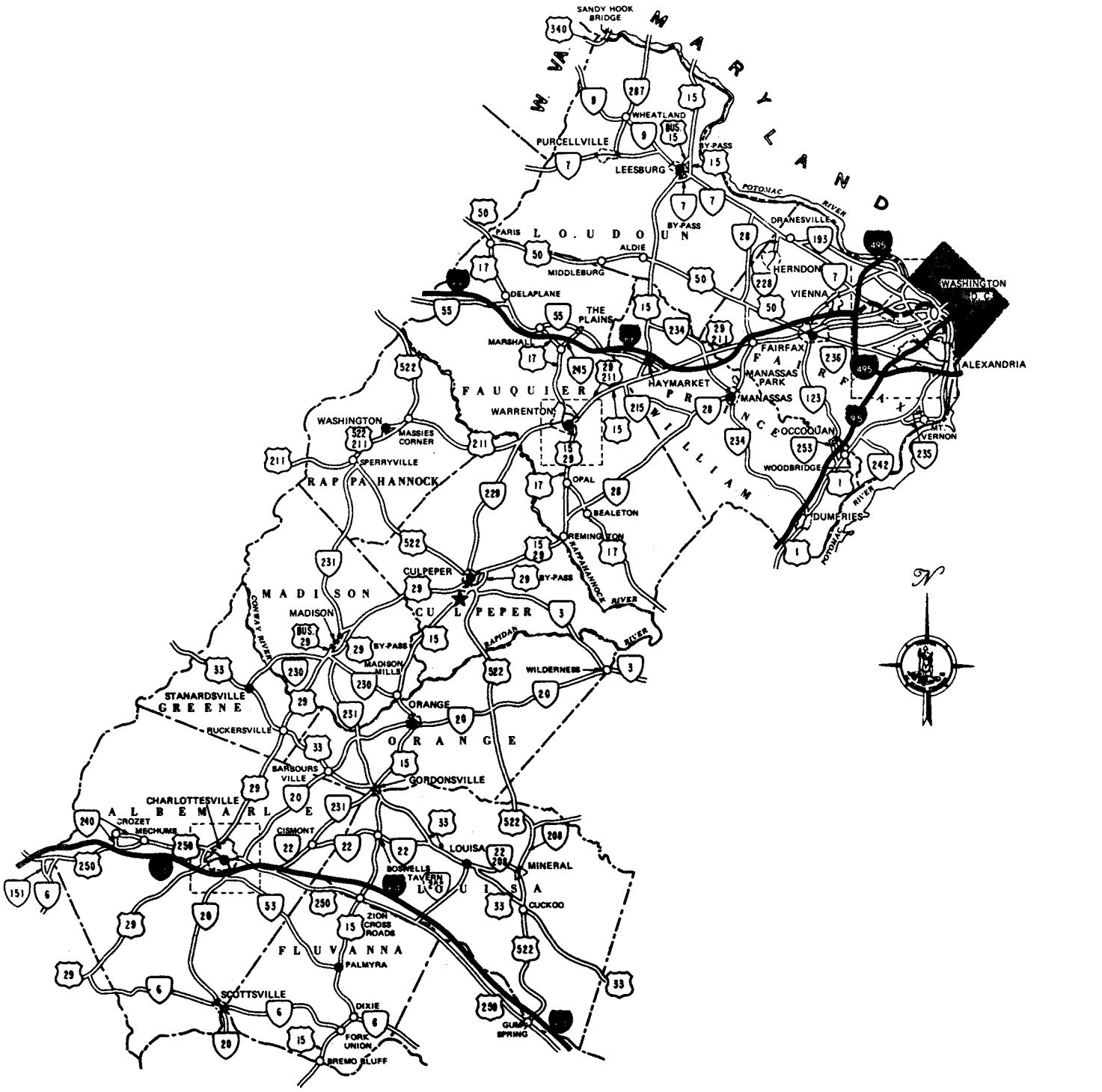


Figure 2. Map of Culpeper district road system.

EQUIPMENT

Camera

The equipment was leased from the Flight Research Co. of Richmond, Virginia, in accordance with the state of Virginia's bidding procedures. The leased equipment included a camera, control box, and needed installation accessories. The Flight Research 35mm Multidata Model 207 was the primary camera used for the project (for specifications see page 22). The camera was activated by an odometer pickoff which converted the standard exposure rate of 10 frames per second cine to one exposure every 52 ft. (15.85 m).

Vehicle

The camera system was installed in one of the Department's vans with no extensive alterations. Although different types of vehicles have been used in photologging it is commonly recommended that the vehicle be one having no extended hood, and that it be equipped with radial tires and air conditioning. The absence of the long hood allows photographs to be taken of the road with a minimum of interruption and glare; the stability provided by the radial tires gives an accurate measurement of the mileage traversed; the air conditioning prevents film damage and minimizes driver fatigue. The van used in this study met these requirements with the exception of air conditioning; however, most filming was done in the winter and spring months and no adverse effects were observed (Figure 3).

Figure 3. Photologging van with camera unit mounted.

Film

The film used was Kodak 5247 Color Negative II, a relatively new film recommended because its emulsion enhances resolution in the photograph. In addition to this benefit, color film is a must for distinguishing details in photographs. For example, an oil spot on the road looks very much like a hole or bituminous patch when viewed in black and white, while on color film the difference is obvious.

Negative film was used to allow two prints to be made and one negative to be retained for a historical record. Although the negative film can be edited before prints are made, which can result in significant savings, excessive handling of the negative could cause irreparable damage. For this reason all editing was done on the work print.

Film Format

The primary film format used in the project is depicted in Figure 4. This is the most popular form, with the data being incorporated at the top of the film, an area that would otherwise be taken up by the sky. The data shown include the mileage location at which the photograph was taken, the direction of travel, and information which was introduced by insertion of a "data slate." Other formats investigated during the study are given later.

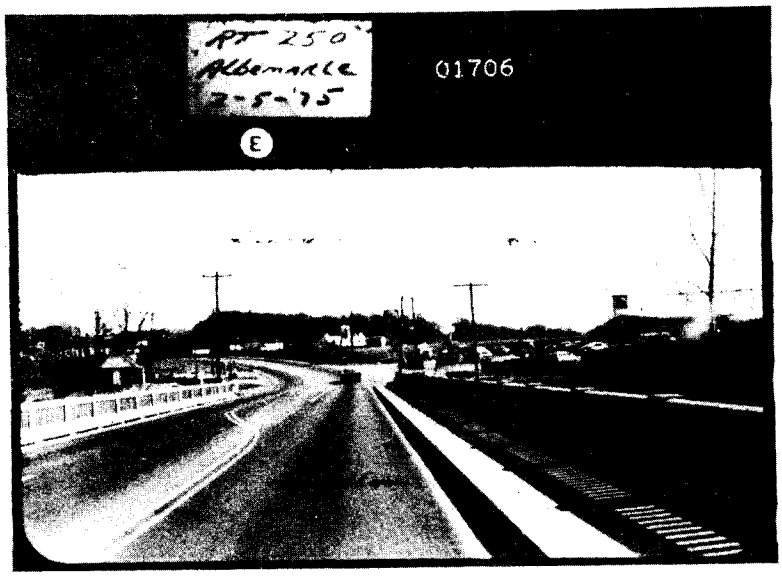


Figure 4. Typical film format produced by the 35mm Model 207 Multidata camera.

Viewer

There are a number of viewers on the market that can be used to study the 35mm photolog film. Most of them have the capabilities of forward and reverse motion, single-frame viewing, projection to a large screen, and a variable speed for controlling the number of frames projected per second. At the start of the project viewers which cost approximately $8,000 each and were recommended for reviewing the photologs were too expensive to be accommodated under the project budget. Consequently, a microfilm reader was used. However, this type of viewer lacks the capability to automatically stop each film frame and the continuous motion affects the person analyzing the film in much the same way as a rocking boat, i.e., it induces a type of motion sickness.

Because of the lack of an adequate viewer the use of the photolog film has been greatly reduced.

PLANNING

Vehicle Preparation

The vehicle was checked each morning according to a conventional set of items on a checklist, e.g., gas, oil, and operational equipment. The accuracy of the mileage recorded on the photolog film was dependent on the tire pressure of the vehicle and was controlled by an odometer pickoff. Consequently, the accuracy was checked whenever possible against a measured mile on the highway before filming began.

The camera was also checked against a checklist (Appendix I, Figure I-1) at the beginning of each filming day and after each loading. Information on factors such as direction, mileage, focus, and film footage count had to be reentered frequently, which necessitated use of the checklist at other times during filming.

Filming

It was estimated that the filming of approximately 600 miles (960 km) of roadway could be accomplished in an average week with reasonably good weather. This estimate was based on using a 400 ft. (122 m) film magazine, filming between the hours of 10 a.m. and 3 p.m. (longer hours were observed in summer) and a traveling speed of 35 mph (56 km/hr.). The hours of 10 a.m. to 3 p.m. were used to avoid filming when the sun was at its lowest and 35 mph (56 km/hr.) was an average speed which would allow traffic to pass without interrupting the field of view.

Normally the morning of the first day and the afternoon of the last day of the week were used for reviewing the work of the past week and planning the work of the week ahead.

The graphic logs (Figure 5) were used as a guide in all filming. With the aid of these logs one is able to pace the day's work and check progress while filming. Specifically the logs were used to:

- Accurately reset mileage when leaving one county and entering another (mileposts return to zero at county lines and route changes);
- check mileage agreement with logs according to various landmarks;
- check the direction of travel;
- confine filming along roads within the state's responsibility (these are indicated by a heavy black line along routes); and
- eliminate duplication by photographing a route twice (the road was filmed and catalogued according to the lowest route number when more than one route was indicated).

Routinely routes were planned for filming in a westerly direction in the afternoon to avoid poor lighting due to the angle of the sun. In theory this is logical; in practice roads change directions often enough to make this consideration one to be practiced but with the awareness that unuseable film may still result from over- or underexposure.

To avoid excessive downtime from travel to and from filming sites and from the end of one road to the beginning of another, the following basic procedures were used:

1. Those routes which were long enough to require a day or more to complete were filmed in both directions without the interruption of filming other routes along the way; these roads were the first to be filmed.
2. Shorter roads were photographed in a circular pattern when the termination point of one route was near the intersection and termination point of another route (see Figure 6, Routes 7 and 50). The purpose of photographing in this circular pattern was to gather as much information on as many roads as possible within the shortest time possible.

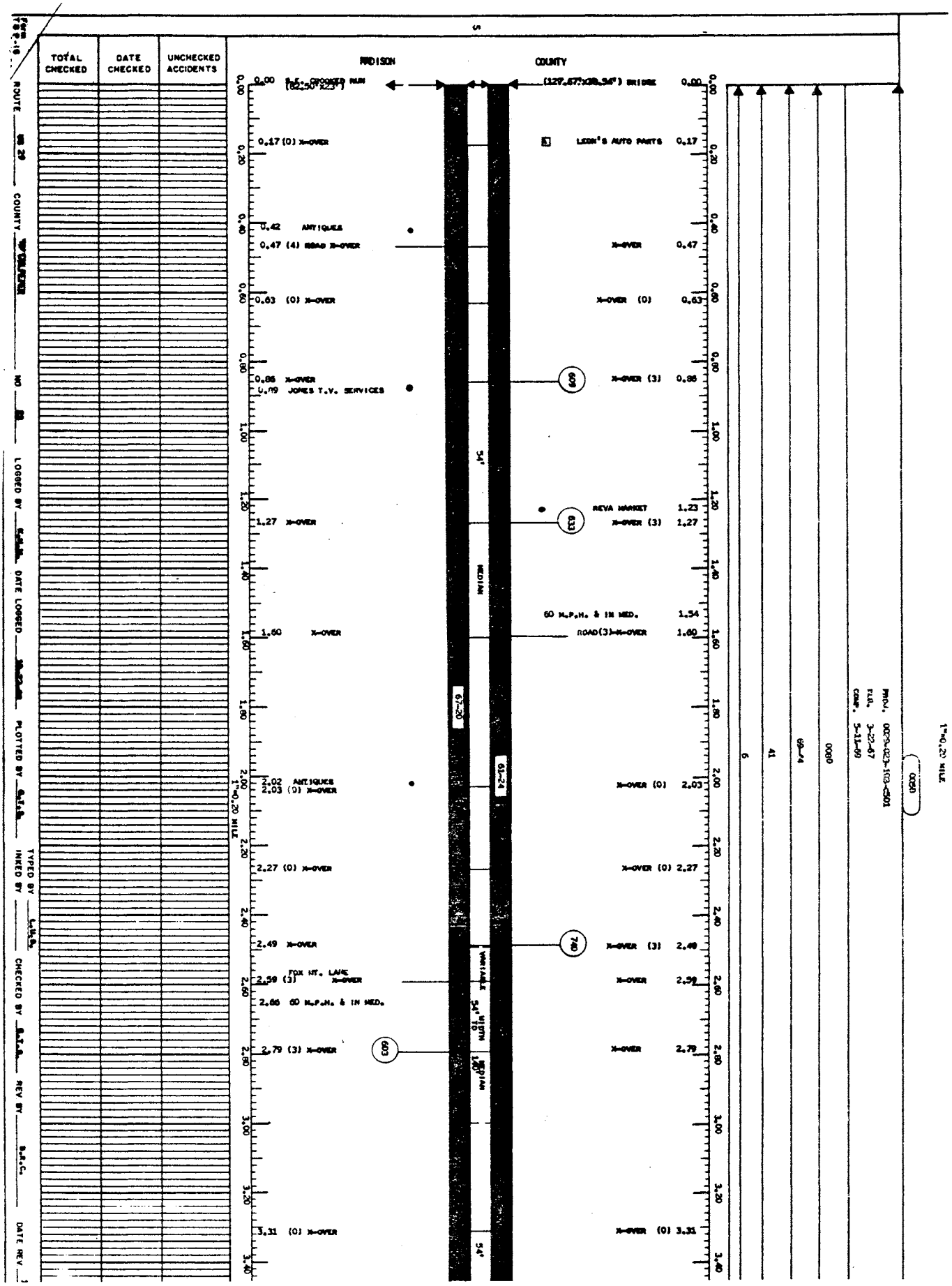


Figure 5. Typical example of graphic log on Virginia's primary system.

In Figure 6 data could be gathered on Routes 50, 7, and their connecting routes in a one-way direction in approximately the same time that information could be gathered on either Route 7 or Route 50 in both directions.

3. Other short routes which were not included in the circular pattern of filming were scheduled as fill-in routes. These were most efficiently filmed when the planned schedule for a particular day ended early and the remaining time and film enabled the photolog team to film them on the way back to the base of operations.

When the filming was ended for the day the termination point was logged using the graphic logs as a locator. The following day's filming was started a tenth of a mile behind this location, which resulted in an overlap that was used to recheck mileage, compensate against possible film damage at the end of the roll, and to aid in editing. The daily log included information on time, county, milepost, driver(s) and problems (see Appendix I, Figure I-2).

Filming progress was shown and tracked by red lining (solid line in Figure 7) all routes photographed on a map of the district. If the resulting film from any route was questionable as a result of overexposure, film damage, etc., the route was indicated by a blue line (dashed line in Figure 7) on a map overlay and scheduled for refilming. The disposition of the film was also accounted for on the film locator log form shown in Appendix I, Figure I-3.

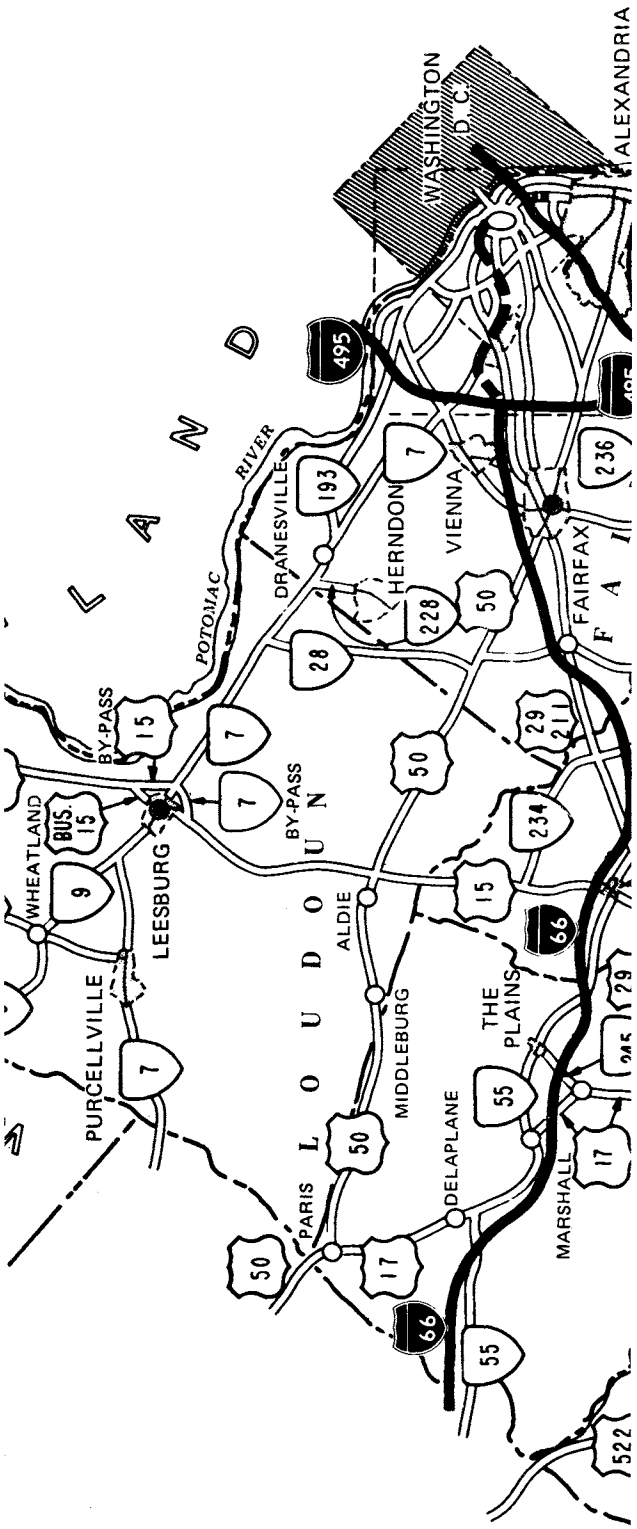


Figure 6. Circular pattern of photologging short routes.

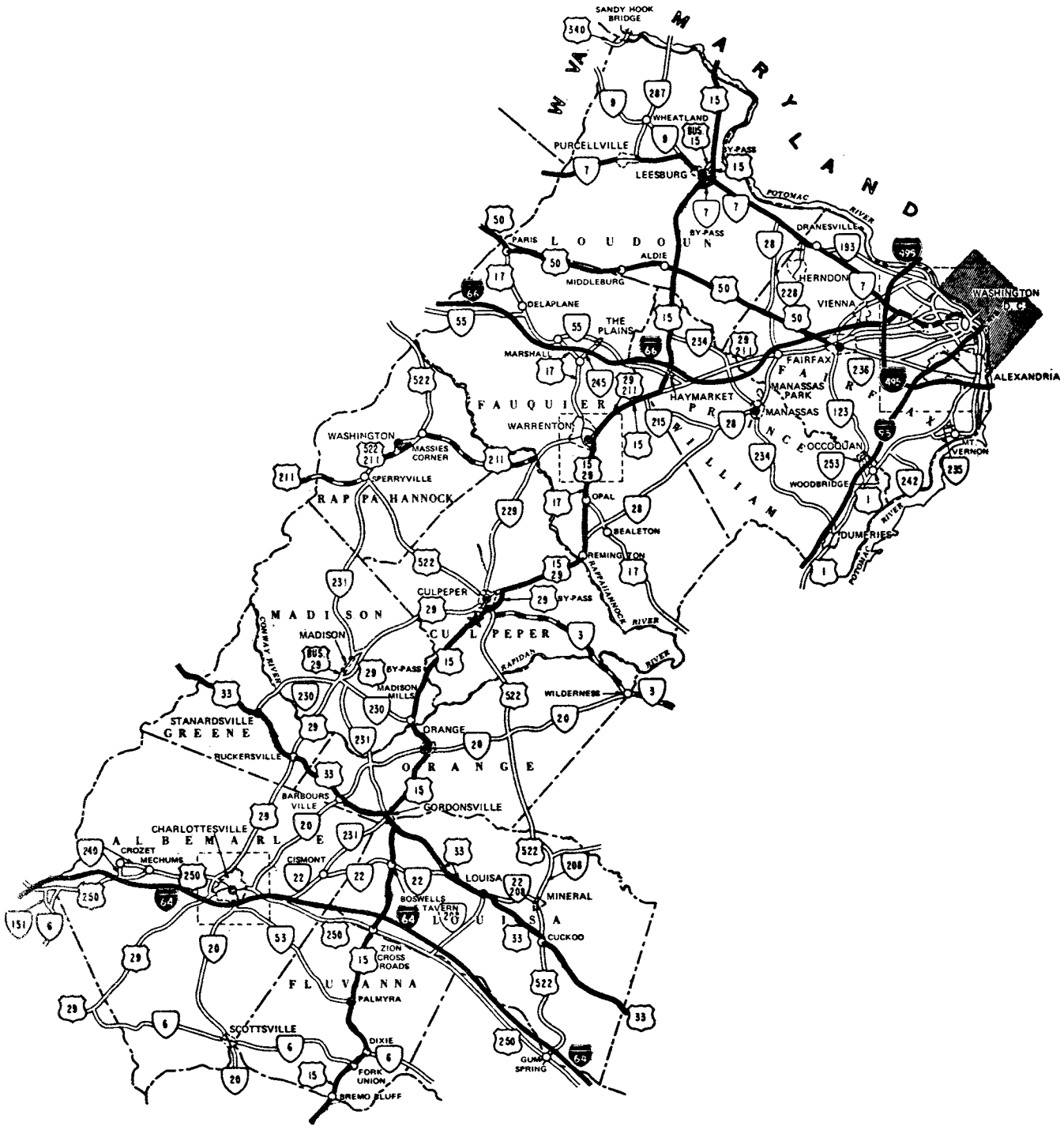


Figure 7. "Lining" to follow filming progress.

Manpower

Photologging can be tiring and for that reason two men conducted the filming most of the time. However, for research purposes the photologging was conducted at various times by only one man. The result of the work indicated that in areas of high traffic volumes a two-man crew is essential. Most roads have too much activity for one man to conduct the operation efficiently; the number of mistakes is increased and a potential safety hazard is created. Nevertheless, a number of roads were filmed easily and safely by one man. The conditions under which one man could conduct the operation are:

1. Basically rural roads with few intersections
2. Very light traffic
3. Few county boundary changes
4. Road in good repair with few mountains or tight curves.

Editing

The editing procedure was simple and equipment requirements were minimal. The two 400-ft. (122-m) negatives were sent to laboratories in Washington, D. C. for processing and printing. The processed negative was used to print two "best light" work prints. During the test project the negatives were processed and printed before editing; however, as mentioned earlier, a savings in processing could result from editing the negative before printing.

The editing equipment consisted of a light table, editing lamp, magnifying lens, various size reels, winding apparatus, and a cold splicer.

The processed prints were reviewed and each route separated into 100-foot (30.48 m) sections representing approximately 18 miles (28.97 km) of roadway. Each 100-foot (30.48 m) section was put on a reel and labeled with the following information:

- Route number and direction
- County name
- Milepost descending/ascending
- Date filmed

The reels were then catalogued and indexed in a card file. To find a film a user had only to look up the route number, which was indexed in chronological order; the county, indexed in alphabetical order; and the segment of the road, designated by milepost within the route. One set of the catalogued prints was sent to the Central Office in Richmond and the other was sent to the Culpeper District Office; the negatives were stored at the Research Council.

Viewing Stations

The viewing stations were equipped with a microfilm reader. This equipment proved satisfactory for short-term use but was unsatisfactory for any sustained use, which greatly limited the use of the photolog.

PHOTOLOGGING USES

To establish the uses of photologging a literature review and interviews with photologging users were conducted.

The studies examined in the literature review cite numerous uses of photologging falling into almost every function of the Virginia Department of Highways and Transportation. Table 1 depicts the uses of photologging in terms of the division structure used in the Department (more detailed information is given in Appendix II). The uses of the photolog in some of the divisions depicted in Table 1 are discussed under the following subheadings.

Table 1

Use of Photolog by Other States

Departments of the VDH&T	Calif.	Del.	Idaho	N.B. Canada	Wash.
Personnel	x				
Location/Design	x	x	x	x	x
Secondary Roads				x	x
Construction	x			x	x
Public Relations	x			x	
Transportation Planning	x			x	x
Programming & Scheduling	x	x		x	
Materials	x	x		x	x
Environmental	x	x	x	x	x
Maintenance	x	x		x	x
Traffic & Safety	x	x	x	x	x
Right-of-Way	x	x	x	x	x
Management Services	x			x	
Legal	x	x	x	x	x
Administration	x	x		x	
Research	x			x	x

Public Relations

The information needed to answer public questions and official letters and to report on various projects could be provided in part by the photolog. The photolog can be used to illustrate information at public meetings; for example, such as when the resident engineer must explain his budget for road improvements to a board of supervisors, the photolog can be used to illustrate his priorities.

Transportation Planning

The problems encountered in routing buses, providing right-of-way for bicycle trails, determining preferential bus lanes, and determining junctions for interfacing different modes seem to be numerous. The review of existing right-of-way could provide much of the preliminary data for establishing bus routings and bicycle paths. These data would include parking facilities, lane-change locations, passenger waiting stations, possible land acquisitions, dangerous locations, and preferential lane possibilities.

Environmental

The photolog possibly could be used by the Environmental Division in the preparation of environmental impact statements, training, controling outdoor advertising, and public participation in the planning process. Through the use of a photolog a review of the area surrounding a project could be made by personnel in the Central Office and thus allow elimination of expensive field trips. 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 has been 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 for aid in explaining the project and the evaluation resulting from the Department's review.

Training

The photolog seems to have a potential use for the training of personnel involved in writing environmental impact statements. Various projects and their respective impact statements can be viewed and studied by team leaders, various specialists within the division, field personnel, and other agencies using the photolog. This could be a training tool used to inform all personnel of omissions and possible problem areas in old statements as well as changes in the law and Departmental expectations which should be accounted for in future statements. By using the photolog, people in different locations can communicate accurately by referencing mileposts and specific road characteristics. Through the review of projects with new employees, training relating to environmental evaluation can be carried on.

Outdoor Advertising

The photolog could be useful in establishing the distances of various signs, billboards, etc., from the right-of-way. The photolog

could not be used to obtain a completely accurate inventory because the Department requires accurate measurements in excess of 660 feet from the right-of-way, which in many cases the photolog cannot accomplish. However, the review of the right-of-way could narrow down the number of signs and billboards to be measured and thus reduce costly field trips.

Public Involvement

The use of photologging in connection with the public hearing has been discussed with many Department officials, and it has been concluded that the photolog could make the explanation of a project easier. The photographs would be less confusing than blueprints and could show needs for improvements on a level that the average citizen could understand.

Maintenance

Information concerning various field operations could be gained by the Central Office through a review of the photolog. This information could aid in the development of schedules and budget allocations. The general information needed for inventories could also be gained. The photolog could not replace all field inspections because some features, e.g. guardrail and sign conditions, are subject to change within hours of the filming.

Traffic and Safety

The applications of photologging in the areas of traffic and safety seem numerous. The applications best cited are those dealing with the standards developed in the Highway Safety Act of 1963.

1963 Highway Safety Act

Section 203 — Rail-Highway Crossing

The photolog has been used to inventory all public railway-highway grade crossings. The communications for decision making would be enhanced through a photographic inventory, not only within the Department but with the FHWA and railroad companies.

Section 205 — Pavement Marking Demonstration Program

The photolog might be used to supplement the comprehensive listing of roads which qualify for the program being prepared by the Department. The list includes eight factors: county route, average daily

traffic, termini, length, pavement width, estimated cost, and type of marking. The photolog can provide five of these factors. The type of marking and cost can be decided from these data, assuming the ADT is available.

Section 209 — High Hazard Locations

The photolog could enable engineers to delineate normal intersection accident locations from high hazard locations from a common viewpoint. Not only could the photolog be viewed and discussed in a common location, but information on miles of the roadway before and after the accident location could be analyzed.

Section 210 — Elimination of Roadside Obstacles

Because of the uniqueness of each location to be analyzed, highway traffic and safety engineers, field personnel, design engineers, and other personnel could review and analyze all designated locations. Once again the photolog could provide information for the roadway before and after these locations and reduce communication time.

Additional Programs

Under this general heading falls the development of a reference system for secondary roads. It would seem that the photolog itself would provide this reference system.

It also seems possible that the photolog could cut the cost of gaining information for the graphic logs, which in themselves are a very valuable tool. Whereas the updating and maintenance of the graphic logs are funded by the Department's Traffic and Safety Division, a technique shared Department-wide could result in considerably reduced cost.

Other activities of the Department's Traffic and Safety Division for which the photolog could possibly be put to use are the substandard bridge replacement program, traffic records, wrong-way driving, and the issuance of permits for the movement of oversized trailers and houses. However, the best judge of these applications is the division itself.

Right-of-Way

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 high-rise 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.

Management Services

Within management services "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.

Legal

The legal areas in which the information provided by the photolog could be used include situations involving the personal liability of highway officials and condemnation.

Personal Liability of State Highway Officers and Employees

The complexity of the issues involved with the personal liability of Department officials goes far beyond the scope of this study. Nevertheless, there have been lawsuits against the state for negligence, and it is the finding of this study that the photolog would be helpful in defending against such cases. Specific issues which arise in these cases involve determining if there has been reasonable compliance with the 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 official was involved with a discretionary or a ministerial function. The distinction is not clear-cut, and again the subject goes beyond the scope of this study, however, the following quote 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 a neglect to exercise those powers, nor for the consequences of a lawful exercise of them, where no corruption or malice can be imputed.(1)

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.

Condemnation

When a parcel of land is taken and then goes to condemnation, the time lapse between the taking and the hearing may be a number of months, possibly years. During the time lapse the land may change significantly, which would either enhance the property beyond its value at the time of the taking or reduce the ability of the commissioners to evaluate damages. In either case the resulting judgement could be inequitable. The use of the photolog could reduce the problem of assessing damage due to elapsed time. Photographs are now taken; however, with a photolog more information concerning surrounding roadways can be obtained.

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(1) Sherman and Redfield on Negligence (3d ed.) Sec. 156 — as cited in NCHRP Research Results Digest, August 74-Sept. 75, p. 6, "Personal Liability of State Highway Department Officials & Employees."

Many of the uses of photologs in the legal area depend on the admissibility of photographs as evidence; consequently, some research has been done on this subject and is reported in Appendix III.

Summary

The possible applications mentioned in this section of the report were noted in the literature review and a number of interviews with users. The application ought to be attempted, where feasible, and the benefits calculated in actual operations. There are numerous other uses to which the photolog could be put and these should be explored. However, it is a conclusion of this study that the technique would be valuable if used only in traffic and safety, legal, right-of-way, environmental, and location and design activities.

EQUIPMENT

Cameras

During the course of the study, two 35mm camera systems were used and a 16mm camera system was studied. The following paragraphs describe these systems.

I. The Flight Research 35mm Model 207 Multidata camera shown in Figure 8 was the basic camera used throughout the project. The specifications, in part, follow.

Exposure rate:

a) 10 frames per second cine
b) Manual option
c) Modified to X frames per mile by odometer pickoff

Exposure time: 1/500 of a second standard

Lens: Honeywell Pentax 28mm f/3.5 lens with hood. Other lenses available.

Data Chamber:

a) Display on top of frame
b) Data slate for written information
c) LED display for 5-digit mileage counter and direction indicator

Automatic Exposure Control: Standard (AUTEX)

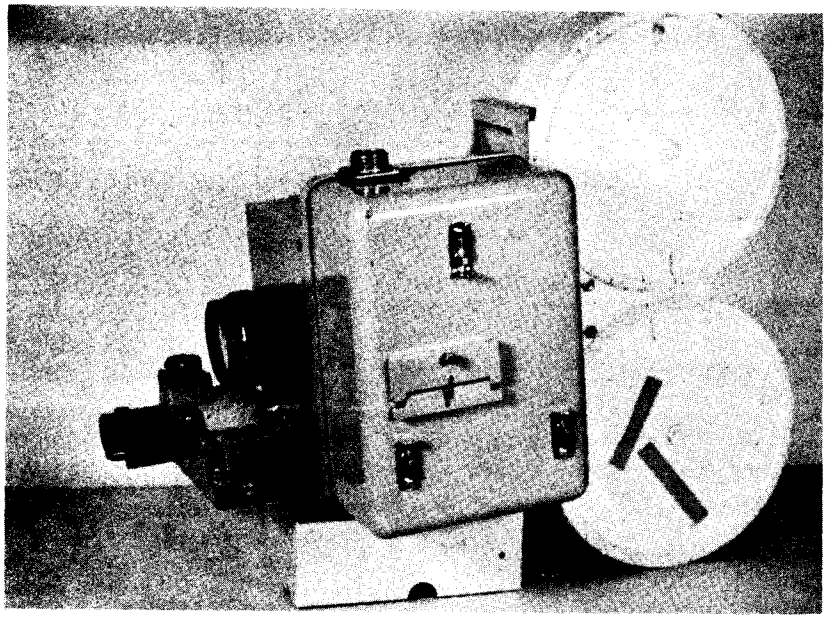

Figure 8. Flight research 35mm camera Model 207 multidata.

This camera is operated through the Road-O-Graph control box shown in Figure 9, which was mounted between the driver and the passenger seats as shown in Figure 10. The control box has the following features:

- Power switch for operating 12v converter.
- Motor switch enabling drive motor on camera to be turned off to conserve power during standby operation.
- Cine-pulse switch that delivers single-frame exposure or filming at the rate of 10 frames per second.
- Camera-odometer switch that enables the camera to be activated every time the contact closure is made (52 frames per mile)/(52 frames per 1.609 km).
- Odometer switch that enables count of pulses from odometer.
- Direction switch that enables the direction of movement (N.E.S.W.) to be printed on frame.
- Exposure indicator that lights each time a picture is taken.

- End of film indicator that lights when film runs out.
- End of film alarm that gives audible alarm when end of film is reached.
- Mile-counter, 5-digit, each digit capable of being reset individually.
- Preset button for resetting mile-counter.
- Increase-decrease switch that enables the mile indicator to show direction in a 0 to 999.99 or 999.99 to 0 progression.
- Footage indicator that shows film used.
- Autex switch that allows manual control of automatic exposure control.
- Improper light indicator that glows when there is unsatisfactory illumination.
- Improper light alarm that gives audible alarm under improper light conditions.

The film format that results was shown in Figure 4. This is the most common format used in photologging. The data are incorporated at the top, an area that would otherwise show the sky. This format results in a relatively large horizontal viewing area to accommodate filming of four-lane highways and adjacent right-of-way.

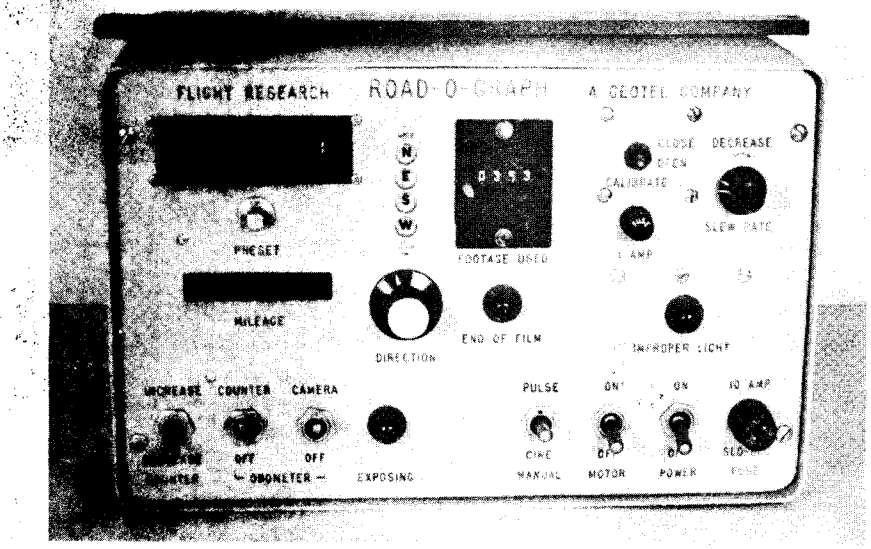

Figure 9. Road-O-Graph control box.

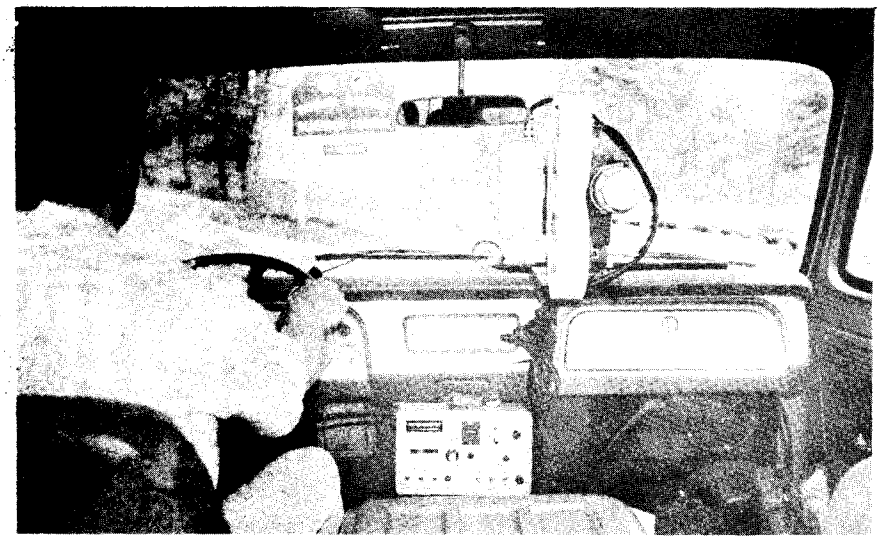

Figure 10. Control box and camera mounted in vehicle.

II. The Flight Research 35mm Camera Model 835 Road-O-Graph II. Some of the specifications for the Model 835 Road-O-Graph II camera system shown in Figures 11 and 12 follow.

Exposure rate:

a) 6 frames per second,
b) Manual
c) Modified to X frames per mile by odometer pickoff

Exposure time:

a) Customer options
b) 1/600 second standard

Lens: Honeywell Super Takumar f/1.8 55mm with lens hood. Other lenses available.

Data Chamber:

a) Display on right side of format
b) Data slate, for written information
c) LED display for 5 digit mile count and direction indicator

Automatic Exposure Control:

a) Optional

This camera is controlled through a slightly modified Road-O-Graph control box having most of the features of the control box shown previously in Figure 9.

The Flight Research Camera Model 835 Road-O-Graph II is available in two versions, full-frame and half-frame, with the only difference being the film format produced.

The film format produced by the full-frame camera is typical of the format shown in Figure 13.

This film format deviates from the conventional format which incorporates data onto the frame at the top or bottom by placing the data at the right side of the frame. This format reduces the horizontal viewing area but increases the vertical viewing area.

The half-frame camera is modified to expose half of the amount of film, resulting in a format depicted in Figure 14.

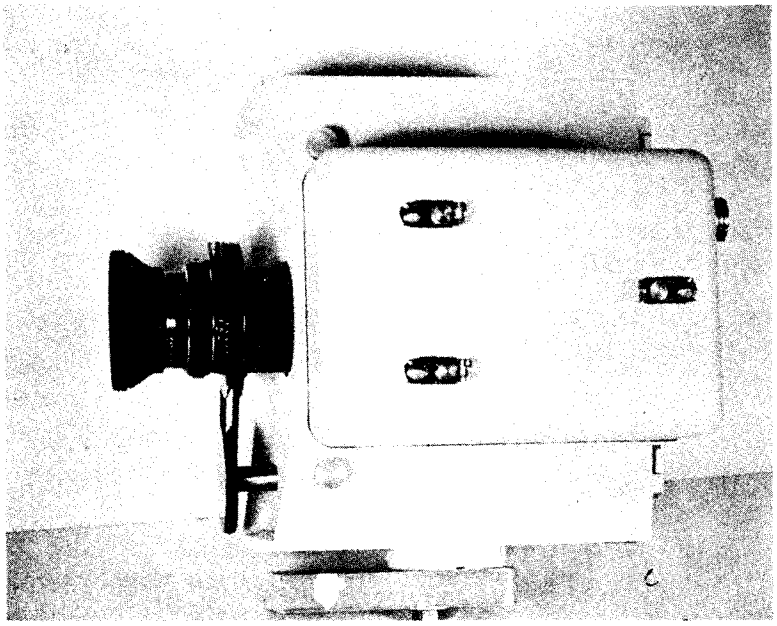

Figure 11. Flight research 35mm camera Model 835, Road-O-Graph II.

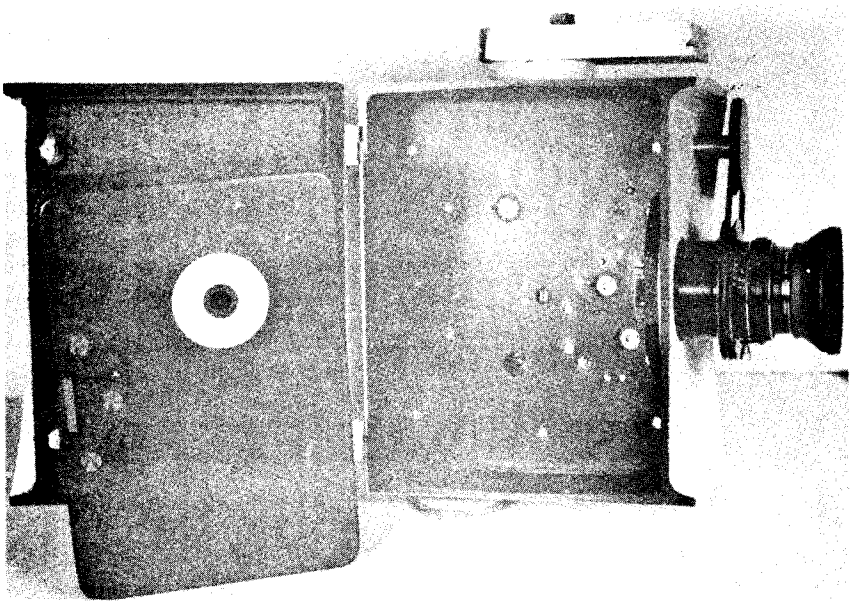

Figure 12. Flight research 35mm camera Model 835, Road-O-Graph II with film cassette.

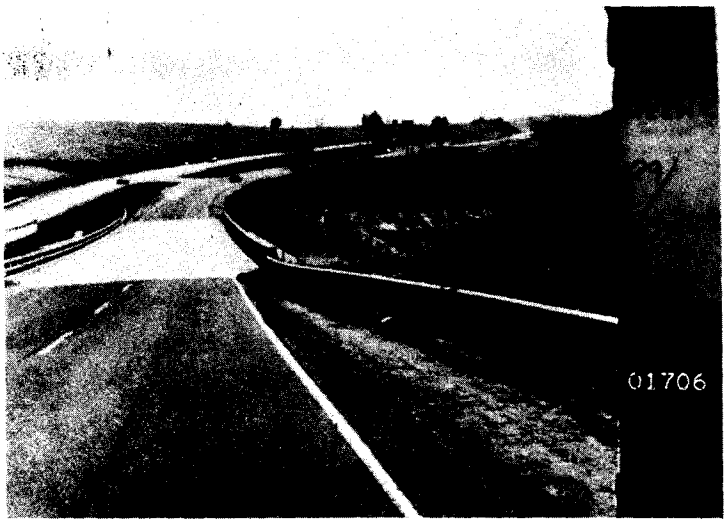

Figure 13. Format from 35mm Road-O-Graph 835 (full frame).

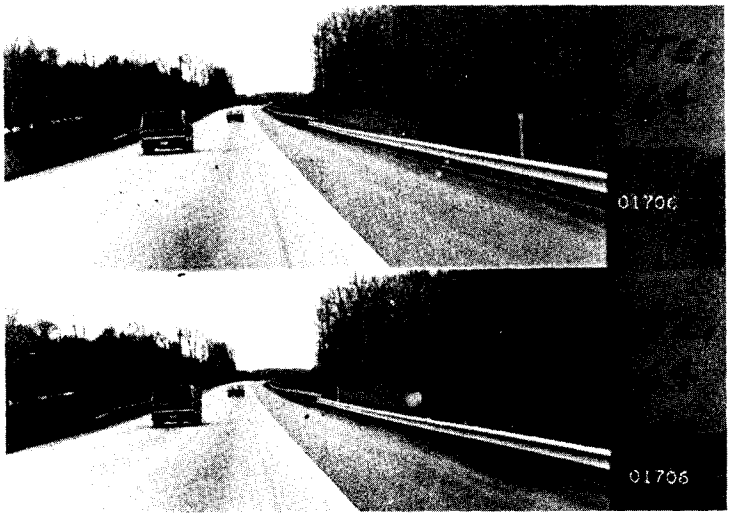

Figure 14. Format from 35mm Road-O-Graph 835 (half-frame).

III. The 16mm Photolog System

The 16mm photolog system was not tested; however, parts of that system were studied. Specifically, attention was given to the camera, viewer, film and film servicing. The results show that, under appropriate conditions, the expenses involved for equipment and services in setting up a 16mm system would be far less than those involved in setting up a 35mm system. This fact alone makes the information on the 16mm system important enough to include in this report.

The information on the 16mm system is not readily available primarily because the system is not as popular as the 35mm systems. The research has not determined that the lack of popularity is due to any inferiority of the system as compared to the 35mm systems. The research has shown that when photologging began the 16mm film did not produce the resolution needed; consequently, the development was focused on the 35mm film and equipment. However, today the 16mm film has been improved to the point where it may accommodate all the information that is needed on the photolog. Commonly the Bolex H or the Automax Cine-Pulse cameras are used in the 16mm photologging systems.

Among the specifications commonly required in the 16mm camera system are the following.[2]

Exposure rate:

a) 2 frames per second cine
b) manual
c) modified to X frames per mile by odometer pickoff or distance-measuring instrument

Exposure time:

a) customer specification
b) 1/400 second standard

Lens:

a) f/1.6, 10mm
b) others available

Data Chamber:

a) display on top of format
b) LED

Exposure Control: Automatic is standard.

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[2] The data capabilities of a 16mm camera were based on those of the TECHWEST ROUTE SCANNER system.

Operator's Control Panel

The operator's control panel provides controls and readouts for operation of the route scanner system. The control panel is mounted in an enclosure that also houses the odometer circuitry and the camera automatic aperture module. This enclosure normally is arranged for easy access by the driver-operator, if specified. The control unit is connected to the camera and instrumentation unit through flexible cables.

Controls and Displays

1. Power: Illuminated push-button switch that controls power to all parts of the system.

2. Odometer Controls and Display:

   a) Odometer Power — Illuminated push-button switch that controls power to the odometer circuits and control panel odometer display allows independent operation of the odometer.

   b) Count Mode — Illuminated two-position rocker switch up or down to control count direction.

   c) Preset — Thumbwheel switches allow presetting of odometer computer to any six-digit number up to 999.999.

   d) Load — Illuminated push-button switch to enter the preset number into the odometer computer and displays.

   e) Correction Factor — Thumbwheel switches that allow entry of a five-digit correction factor up to 4.0000 into the odometer computer, thereby making an accuracy of ±1/10% attainable.

   f) Clear — Illuminated push-button switch to clear the odometer.

   g) Test — Illuminated push-button switch to activate all segments of every digit within the two odometer displays.

   h) Distance Display — Six-digit, seven-segment, red-light-emitting diode display.

3. Camera Controls and Displays:

   a) Pulse — Illuminated push-button switch to advance one frame.

   b) Cine — Switch to advance camera at maximum rate.

   c) Load — Switch to advance camera at maximum rate and inhibit (blank) data display.

   d) Frames — Five-digit electromagnetic totalizing counter to indicate the number of film frames used.

   e) Minimum Aperture — Rotary switch to select minimum aperture of f/5.6,8/8 and 8/11 for automatic aperture module.

4. Distance Interval — Two-decade thumbwheel switch to select distance between camera frames from 1 to 99 meters (or from 1 to 99 x 10^{-3} miles if measurement is in miles).

Film Format

From inquiries it was learned that the 16mm systems have the possibility of affording three film formats similar to those depicted in Figures 15, 16, and 17. However, the only formats obtained during the course of the study were variations of the one shown in Figure 15.

The information that can be incorporated into the 16mm format includes the mileage, direction, time, date, route, speedometer, compass (magnetic and gyro), roughness meter, grade indicator, transverse slope or crown angle, and magnetic data recorder unit based on TEC WEST unit. Table 2 summarizes the specifications for all the cameras.

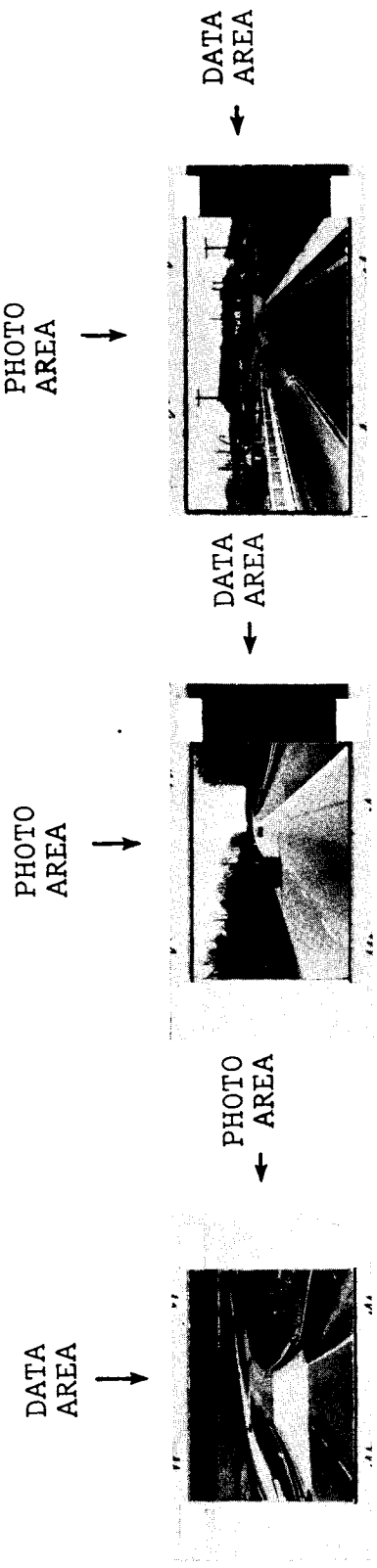

Figure 15. Typical photo from Figure 16. Format for 16mm with data at top.

Figure 17. Format for 16mm with data at side. Perforation on one side only.

Table 2

Summary of Camera Specifications

Camera	Exposure Rate			Exposure Time		Data Display	Lens		Automatic Exposure Control
	Standard	Manual	Modifiable	Standard	Others Available		Standard	Others Available	
1. Flight Research Model 207 Multidata	10/sec.	yes	yes	1/500	yes	a) top of frame b) LED c) Data slate	Honeywell Pentax 28mm f/3.5	Yes	Standard
2. Flight Research Model 835 Road-O-Graph II (full-frame)	6/sec.	yes	yes	1/600	yes	a) rt. side of frame b) LED c) Data slate	Honeywell Super Takumar f/1.8, 55mm	Yes	Optional
3. Flight Research Model 835 Road-O-Graph II (1/2-frame)	6/sec.	yes	yes	1/600	yes	a) rt. side of frame b) LED c) Data slate	Honeywell Super Takumar f/1.8, 55mm	Yes	Optional
4. Typical 16mm	2/sec.	yes	yes	1/400	yes	a) LED b) Data slate	f/1.6, 10mm	Yes	Standard

NOTE: a. The number of LED figures vary from one camera system to another.

b. Other 35mm camera systems, such as those marketed by Instrument Marketing Corp and TEC WEST, have similar capabilities.

Viewers

The viewer is a very important part of the photologging system. If the viewer is not easy to operate and comfortable to work with, the use of the photolog will be greatly inhibited.

When this study was originated only one viewer, which was designed for use in 35mm photo analysis, was available. This viewer was not available for lease and was too expensive to be purchased within the funding limits of the project; consequently, a microfilm reader was used throughout the study. This reader did not prove to be conducive to sustained viewing because according to all users it induced a sensation similar to motion sickness.

Because a suitable viewer is an intrinsic component of the photolog system,viewing alternatives were examined.

Vanguard Motion Analyzer

The Vanguard motion analyzer was one of the original apparatus used for viewing photologging films. This viewer maintained its popularity mainly because of its excellent performance and because no suitable substitute was available until recently. As depicted in Figures 18 and 19, the analyzer consists of three parts, the S-13 projection case, the model M-35 CF projector, and the S-1 projection stand.

The specifications for the Model-35 CF/S1 projection head include:

- Variable speed from one frame per second to maximum of 24 frames per second
- Instant stop-start at any film speed setting
- Single frame advance, forward and reverse
- Miniaturized remote control unit on 12-foot cable for all modes of projection (3.66m)
- Film capacity 35mm x 360m (1200 ft.)
- Standard 3-inch focal length projection lens.
- Projected image approximately .914m (3 ft.) wide at 3.05m (10 ft.)
- Precision flickerless projection.

The specifications for the Model-35CF/S13 projection case include:

- Viewing screen 32.07 cm (12-5/8 in.) x 37.15 cm (14-5/8 in.)
- Transparent scale, chart clips, and overlay sheets
- Rear projected image on 33 cm (13 in.) x 38 cm (15 in.) viewing screen
- Projection heads (16mm or 35mm)
- Interchangeable use of any of the projection heads

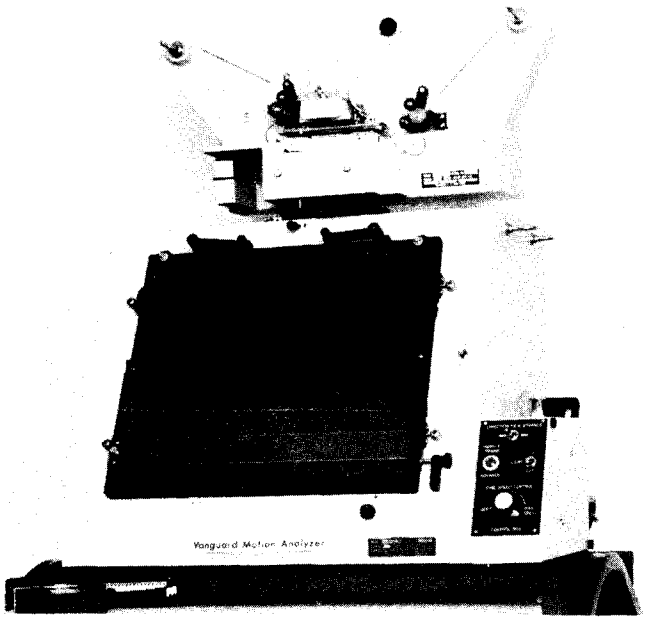

Figure 18. Projection head model-35CF and projection stand model S-1.

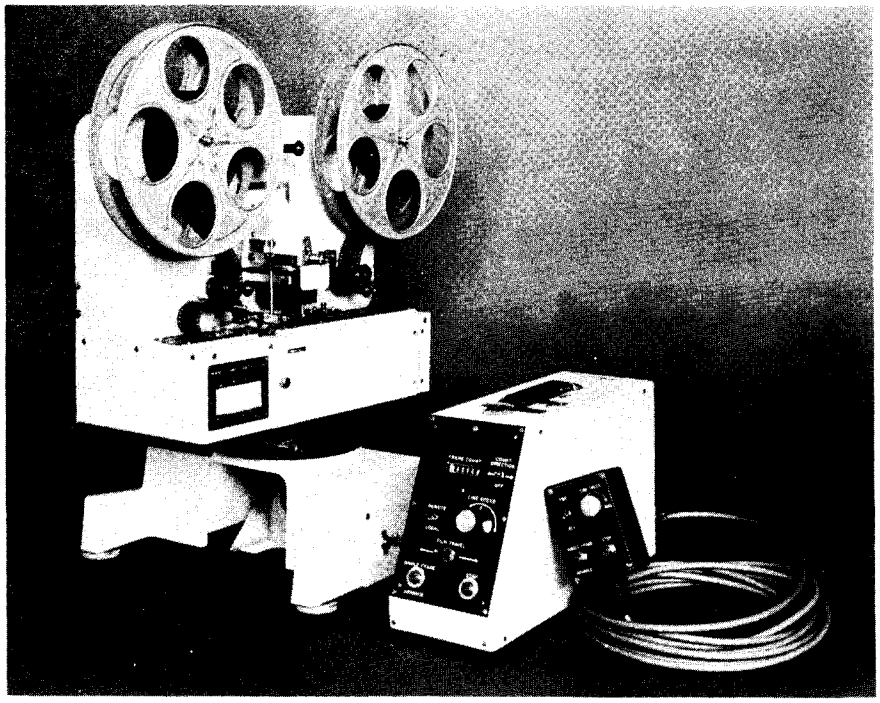

Figure 19. 35mm analysis projector model M-35 CF with S-13 projection case.

NAC Analyzer

NAC analyzers mcdels 160B, 350B, 700B have only recently been marketed in the U. S. and therefore were not used by the researcher on this project. Similar to the Vanguard, they have two components; the MC-0B projection case and the PH-350B (PH-160B or PH-700B) projection head. These are shown in one unit in Figure 20.

The projector has the following specifications:

- Large diameter film drive sprockets that provide completely secure transport of film.
- Extra large mounting base collars for the projection head that assure accurate alignment and thus eliminate displacement errors.
- Lamp housing and PC electronics that are easily and quickly accessible.
- A motorized joystick drive for X-Y cross hairs.
- X-Y coordinates that are roughly positioned manually.
- Large viewing screen that provides x23 magnification for 16mm film and x10 for 35mm.
- Film Specifications: Monochrome and color, with perforations on either one or both sides. Shrinkage of film must be less than 0.2% after development.
- Film Capacity: 16mm: 240m (800 ft.)
  35mm: 120m (400 ft.)
  70mm: 300m (1,000 ft.)
- Aperture size (standard): 16mm: 8.2mm x 14.2mm (0.333 in. x 0.559 in.)
  35mm: 20mm x 31.7mm (0.787 in. x 1.248 in.)
  70mm: 58mm x 58mm (2.283 in. x 2.283 in.)
- Film running modes:
  a) Auto-stop: Automatic sequential film advance at preselected frame intervals of 1-10 frames.
  b) Continuous: 16mm and 35mm variable from 1 to 2 frames per second; 70 mm variable from 1 to 5 frames per second.

c) Film feeding direction: Forward and reverse for both continuous and auto-stop modes.

d) Flicker-free projection at any speed of continuous film feeding mode.

- Screen: Rear projection (can be viewed in daylight)
- Magnifications: 16mm, x23; 35mm, x10
- Measuring Range: 300mm (12 in.) for both X and Y axes.

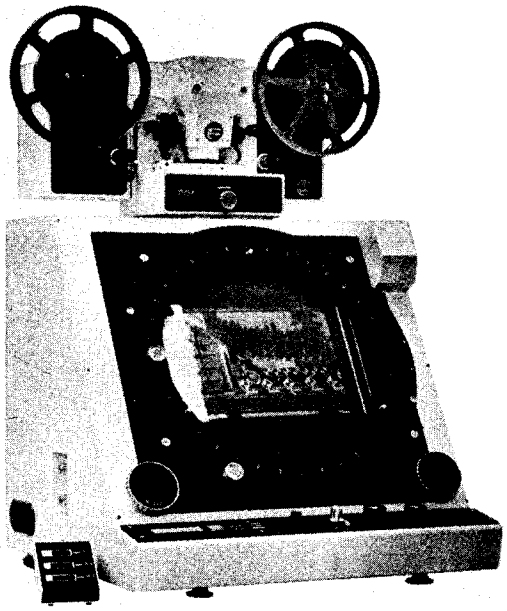

Figure 20. NAC Model 350B analyzer.

The specifications for these viewers include:

- Up to 800 feet (244 m) film capacity.
- Optional angle measuring screen easily attached to case with no special tools.
- Minimum readout scale of 0.05mm (0.002 in.)
- Cross hair (X and Y) driving modes:
    a) motorized drive by joystick for rough positioning
    b) manual drive for fine positioning.
- LED electronic counter for frame, X and Y axes, 5 digits, zero reset. Readout displayed in remote control box.
- Image rotated 360° by rotating projection head.
- Quick rewind mode.
- 100V, 300 W halogen lamp, blower-cooled light source. Adjustable to minimize operator fatigue and compensate for over- or underexposed film.
- 115V 60Hz, 220-240V 50Hz input voltage (to be specified).
- Approximately 650VA power consumption

NAC Projector

The NAC Model DF-35 analysis projector also was recently put on the U. S. market and was not tested in the study. This projector is shown in Figure 21 with an optional polaroid adapter.

Features and specifications for this projector include:

- Continuously variable speed from 0 to 32 frames per second.
- Stop motion, single frame and reverse actions.
- Sharp image of full frame area in ambient illumination.

- Large screen front projection.
- Polaroid photos can be taken while viewing image on rear screen.
- Remote control box containing projection speed/direction knob, illuminated digital frame counter with push-button zero reset, and push-button for single frame advance/ reverse or instantaneous stop at any speed from 1 to 16 frames per second.
- 35mm film size
- 120m (400 ft.) film capacity
- 24.4mm x 19mm aperture size
- 75mm f 1.9 (standard) projection lens
- 500-watt halogen lamp light source
- LED, 5 digits, zero reset frame counter
- 100V (50/60Hz), 115V(60Hz), 220V or 240V, (to be specified when ordering); 700VA power supply
- Dimensions: 540mm, 530mm, 290mm (20-1/4" W, 21" L, 11-1/2" H)
- Weight: 33 kg (73 lbs.)
- Viewing screen: 270mm x 220mm, acrylic daylight (Approximately 11 in. x 9 in.)
- x11 magnification.
- Polaroid adapter (optional) Model DF-PA405
- Polaroid film holder #405
- Polaroid Land film B/W-#105, Color - #108
- Dimensions: 200W. 250L, 400 mmH (7-7/8 in. W, 9-7/8 in. L, 15-3/4 in H)
- Weight: 4.8 kg (10.5 lbs.)

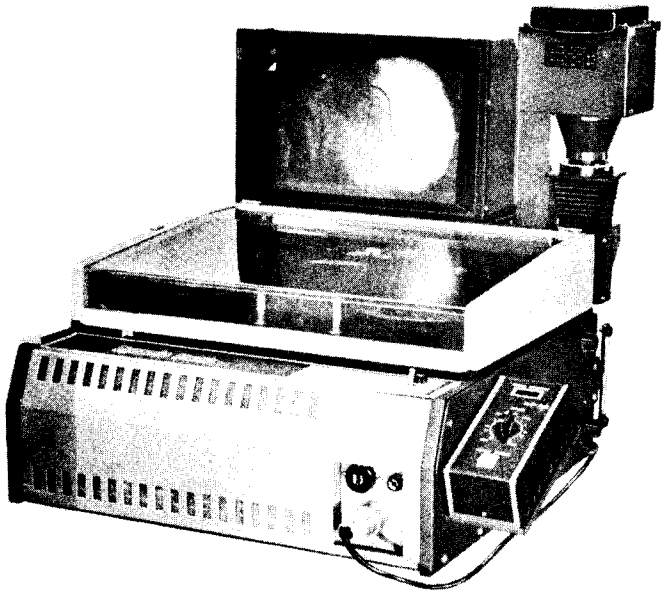

Figure 21. NAC Model DF-35 analysis projector and optional polaroid camera adapter.

Vanguard Projector

The Vanguard Model PL-35 photolog projector is a recent development in photologging and was examined and briefly used by the researcher during this study. The analyzer, shown in Figure 22, 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 with 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: 63mm focal length, mounted with image inverting prism.

- Image Size: See Projection Capability.

- Projection Screen: See Projection Capability.

- Elevation Mechanism: The Model PL-35 35mm 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 and Weight: Normal — 500 mm W x 613 mm H x 900 mm D (20" W x 24-1/2" H x 36" D)

  In Carrying Position

  500 mm W x 600 mm H x 500 mm D (20" W x 24" H x 20" D)

  Weight: 17 lbs. (7.7 kg)

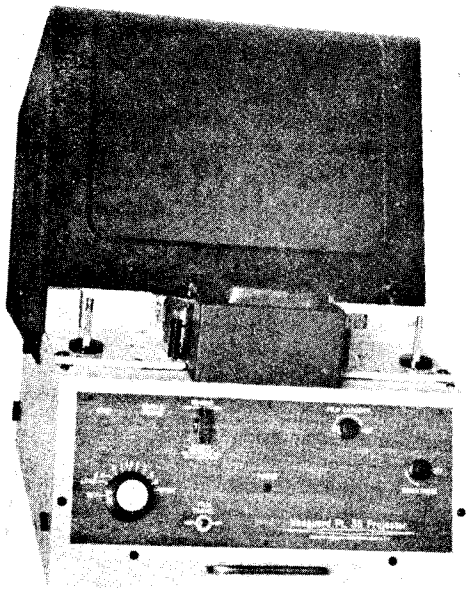

Figure 22. Vanguard 35mm photolog projector, Model PL-35.

Flight Research Road-O-Graph II Projector/Viewer

The Flight Research Road-O-Graph II projector/viewer was used briefly during the course of the research (Figure 23).

- 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.

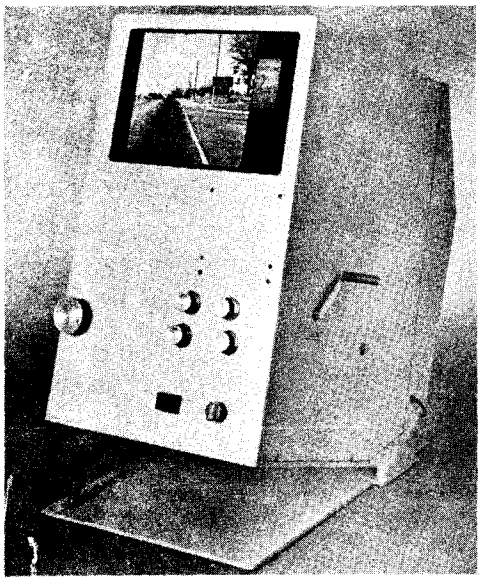

Figure 23. Road-O-Graph II projector/viewer.

L & W International's Model 224-A Data Analyzer

The L & W International's photo-optical data analyzer model 224-A was used extensively for reviewing 16mm film prints as well as 16mm reductions of selected 35mm film during the study. It is similar to the one shown in Figure 24, modified by adding 1-2-4-6-8-12 frames per second automatic framing control. The specifications for this analyzer include:

- Flickerless at pulse rates of 1-2-4-6-8-12 frames per second.
- Variable cine rates from 16 to 24 frames per second.
- Stop without loss of light.
- Frame by frame push-button control.
- Forward-reverse travel.
- Instant stop-start action.
- 400-foot (122 m) film capacity.
- Hand-size control box offering option of at-machine projection or remote control.
- Frame counter.

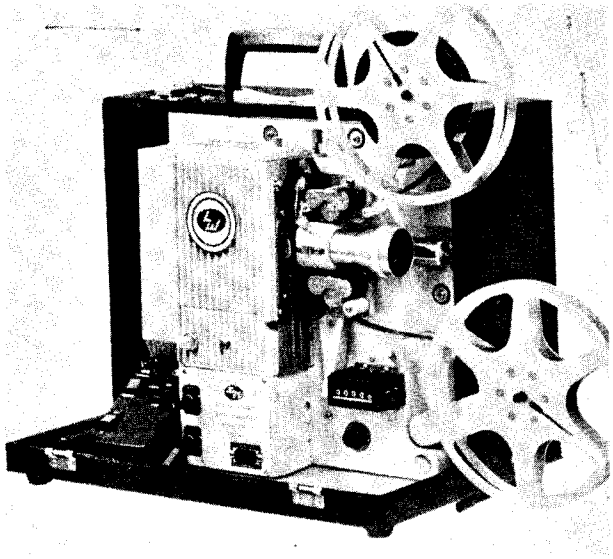

Figure 24. L-W International's 16mm Model 224-A special projector.

Summary

The projector/analyzer specifications discussed above are summarized in Table 3. These viewers offer photolog viewing in 16mm and 35mm formats at a price from approximately $1,300 to $9,000.

The researcher has had experience with four of the units and found that all would be acceptable in a photologging operation. Therefore, the main factors to be considered would be cost and film size.

Table 3

Summary of Viewer Specifications

	Film Size, mm			Stop Motion Analysis		Price				Projection Capabilities	
	16	35	16/35	Variable Speed	Frame Selection	$1,000	$3,000	$5,000	$10,000	Direct	Reflected
Vanguard Model M-35CF/S-1 Analyzer	x	x		x	x			x			x
NAC Models 160B, 350B, and 700B Analyzers		x		x	x			x		x	
NAC Model DF-35 Projector	x	x		x	x			x		x	
Vanguard Model PL-35 Projector		x		x	x		x			x	
Flight Research Road-O-Graph II Projector/Viewer		x		x			x			x	
L & W Model 224-A Analyzer	x			x	x	x				x	

SYSTEM COSTS

This section of the report presents pricing schemes for the four basic photologging systems. Since "cost" is defined as "the outlay or expenditure (as of effort or sacrifice) made to achieve an objective," then 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 may be a negative dollar figure, i.e., photologging may result in a net savings. Consequently, the tables included in this section should be considered as input only.

Systems Considered

The four photologging systems for which costs were considered are: (1) the typical system incorporating the camera and equipment used by most states involved in 35mm photologging; (2) the 1/2 frame system which utilizes a newly developed camera that produces a film format of the same width as the typical system but approximately 1/2 the height; (3) a system that utilizes the typical 35mm camera whose output would be distributed to the district offices in 16mm prints; and (4) a typical 16mm system.

Assumptions

Throughout the calculations the following assumptions were used.

1. All personnel, equipment, and services were calculated as if they were obtained specifically for the project, even if they were actually transferred from within the Department for the project. See Appendix IV on costs.

2. The life of all equipment was taken as six years, which could mean a one time replacement every six years or a yearly maintenance equaling replacement cost every six years.

3. The increase in price of any equipment was considered to be offset by discounts resulting from the bid procedure and amount purchased.

4. Photologging was assumed to be done statewide on a one-way mile basis accomplishing 12,000 miles (19,312 km) each year.

5. The program would require several people throughout the year, some full-time and some part-time; however, the pricing scheme assumes that total personal services would equal three full-time employees with a salary of $15,000 each, including an additive factor.

Cost Items

Costs were calculated for each of the systems under two options; one assuming that a viewing station would be placed in the Central Office only, and the other assuming that stations would be placed in the Central Office and in the eight District Offices.

The costs of the systems are broken down into equipment, film and film services, personnel, and maintenance (vehicle, camera, and projector). In general, the pricing categories were based on the information given under the following subheads.

Equipment

1. Camera price includes all accessories and installation.
2. Vehicle price includes air conditioning and radial tires.
3. Viewers are those in the mid-price range.
4. Editing equipment is based on an average price for minimal equipment.

Film Purchase & Service

1. Film purchase is based on the amount of film needed to accomplish photologging of 12,000 miles (19,312 km) of road per year.
2. Processing is based on developing all film.
3. Printing is based on the need for one print in calculations for distribution to Central Office only and two prints in calculations for distribution to Central Office and District Offices.

Personnel

1. Salary is based on three full-time employees and includes additive payments for various overhead items and benefits.
2. Expenses are those incurred by employee for meals and lodging during photologging.

Maintenance

1. Vehicle maintenance includes the cost of gas, oil, and general servicing and repairs.

2. Camera and projector maintenance includes preventive maintenance as well as repairs. This cost is an estimated average and depends on manufacturer warranty.

Table 4 shows the estimated increase in investment for establishing viewing stations in each district over that needed to establish a station in the Central Office only.

From the table it can be seen that —

1. the most expensive system is the typical 35mm, the least expensive is the typical 16mm;

2. the range of investment for the first year is from $153,840 ($12.82 a mile/$7.97 per km) to $102,228 ($8.52 a mile/$5.29 per km.); and

3. the increase in investment in the first year for a system for the Central Office and the districts is an average of 39% as compared to the investment for a system for the Central Office only, and for the following years the average increase is about 10%.

The additional funds needed in the first year for the Central Office and the districts (Col. 2 vs. Col. 3) result from the purchase of additional viewers and one additional work print. For the second year the viewer purchase price is dropped but the price of the second work print continues. Consequently, the percentage after the first year is due totally to the purchase of the second work print.

In Table 5 the investment needed to establish a photologging system in the Central Office and the District Offices is estimated. From observation of the table three factors stand out:

1. The capital outlay for equipment is made in the first year. Maintenance costs are included to account for continued operation.

2. The cost of personnel is constant.

3. The estimated cost for maintenance is constant.

Table 4

Comparison of Investments for Developing Photologging Systems

Col. 1 Camera System	Col. 2 Central Office	Col. 3 Central Office and District Offices	Col. 4 Percent Increase Col. 2 - Col. 3
Typical 35mm			
First Year	$110,390/ 9.20 mi. /(5.72 km)	$153,840/12.82 (7.97)	39%
Following Year	81,890/ 6.82 mi. /(4.24 km)	93,340/ 7.78 (4.83)	14%
35mm, 1/2 frame			
First Year	86,370 /7.20/(4.47)	124,220/10.36 (6.43)	44%
Following Year	66,370 /5.53/(3.44)	72,220/ 6.02 (3.74)	9%
Typical 35mm (16mm distribution)			
First Year		128,740/10.73 (6.67)	
Following Year		87,740/ 7.32 (4.54)	
Typical 16mm			
First Year	85,578/ 7.14/(4.43)	102,228/ 8.52 (5.29)	20%
Following Year	62,078/ 5.18/(3.22)	66,728/ 5.56 (3.46)	8%

NOTE: All figures are in dollars, figures after / represent dollars per mile.
Figures in parentheses represent dollars per km.

Table 5

Costs of Various Components for Photolog System
in Central Office and District Offices

First Year Investment	Equipment	Film & Services	Personnel	Maintenance	Total
35mm Typical	$60,500	$42,240	$50,000	$1,100	$153,840
35mm 1/2 frame	52,000	21,120	50,000	1,100	124,220
35mm (16mm dist)	41,000	36,640	50,000	1,100	128,740
16mm Typical	35,500	15,628	50,000	1,100	102,228
Following Years' Maintenance					
35mm Typical		42,240	50,000	1,100	93,340
35mm (1/2 frame)		21,120	50,000	1,100	72,220
35mm (16 distribution)		36,640	50,000	1,100	87,740
16mm Typical		15,628	50,000	1,100	66,728

The conclusions which can be drawn from the information found in this study and the available pricing data are as follows:

1. If it is determined that photologging should be used in Virginia, then the increased investment to expand its use to the districts should be made. The increased chances for use would help the technique pay for itself.

2. The utilization of existing manpower could greatly decrease the investment needed to implement a photologging system. Consequently, it is concluded that if the photologging van were moved from district to district during slow work seasons the photologging system investment could be held to a minimum.

EVALUATION OF SYSTEMS

Camera Systems

The camera and viewing systems described in the previous sections were evaluated based on their potential use in the state of Virginia. It should be stressed that this evaluation was not meant to be exhaustive, but was tailored to the kinds of priorities that probably would be established in the Virginia Department of Highways and Transportation.

In the evaluation, four camera systems were considered.

1. The typical 35mm photologging camera system marketed by Instrument Marketing Corporation, Techwest Enterprises Ltd., or Flight Research Co.

2. The 35mm camera recently developed by Flight Research used in full-frame format.

3. The 35mm camera recently developed by Flight Research used in 1/2 frame format.

4. A typical 16mm camera system marketed by Techwest, Instrument Marketing Corporation, or Flight Research Co.

The criteria used in this evaluation included but were not restricted to cost, information output capability, field experience, simplicity of operation, and film format produced. Each criterion was given a rating on a scale of poor-fair-good-excellent-not acceptable-unknown. The criteria are discussed below.

Cost

The costs of the camera systems installed run from about $6,000 to in excess of $23,000. Since Virginia is in the very beginning stages of photologging the evaluation was limited to basic camera systems. The typical 35mm and 16mm camera systems are in approximately the same price range and both are rated "good." The new systems developed by Flight Research are estimated to cost approximately half the price of the typical 35mm camera system; therefore, these systems were given an "excellent" rating.

Information Output Capability

All of the camera systems evaluated have the capability to incorporate data in the film output. Some have a greater capability than others, but they all meet the needs of the basic operation in Virginia. Therefore their rating in this category is "excellent."

Field Experience

Field experience refers to the testing of the equipment under the demands of the photologging operation. Many of the cameras have performed excellently in different activities, however, their performance records in those activities should not be transferred to photologging, which is one of the most demanding activities in which a camera can be used.

The ratings used in this study do not reflect a lack of quality in performance but a lack of experience with the camera in photologging. As experience is gained the ratings in this category may change.

The ratings were based on:

poor — New camera with no claims by manufacturer in the area of photologging.

fair — The only claims were by manufacturer.

good — Satisfactory claims from manufacturer and some users.

excellent — Satisfactory claims from manufacturer, users, and satisfactory first-hand experience.

The typical 35mm camera was given an "excellent" rating because it has been used with excellent results by other states and it gave trouble-free service throughout this project. The camera systems

recently developed by Flight Research were rated "fair" because, although they present a possible outstanding innovation in photologging, they have seen relatively little field use and their rating is based mainly on the manufacturer's claims. The typical 16mm system was given a "good" rating on the basis of the claims of the manufacturer and agencies that have used it.

Simplicity of Operation

One of the most attractive facets of the photologging technique is the ease with which an operator can be trained to efficiently use the photographic equipment. This ease of training implies that an operator can be selected from within an agency's work force. It also implies that the equipment can be moved from area to area so as to utilize personnel engaged in seasonal activities during their slack periods. Simplicity of operation therefore is a major consideration. Both the typical 35mm and typical 16mm systems were given a "good" rating because they were found to be easily loaded and operated. The new Flight Research cameras were rated "excellent" because of their cassette loading feature, which eliminates possible operating problems caused by faulty film loading and possible light leaks caused by faulty magazine loading.

Film Format

The film formats produced by the cameras are different as was shown in a previous section of the report. In interviews with potential users of photologging in the Department and with people familiar with the technique in various agencies, the format produced by the typical 35mm system was preferred and therefore it was given a rating of "excellent." The other 35mm formats were given a rating of "unknown" because insufficient work has been done with them to enable a judgement to be made. Little information relating to the use of the 16mm format was obtained because few agencies have used it, or it was in the experimental stage. This format was also rated "unknown." The above findings about the camera systems are summarized in Table 6.

Table 6

Summary of Ratings for Camera Systems

Camera System	Cost	Information Capacity	Field Experience	Simplicity of Operation	Film Format
Typical 35mm	Good	Excellent	Excellent	Good	Excellent
Flight Research (full-frame)	Excellent	Excellent	Fair	Excellent	Unknown
Flight Research (1/2-frame)	Excellent	Excellent	Fair	Excellent	Unknown
Typical 16mm	Good	Excellent	Good	Good	Unknown

Viewers

The method of rating for the viewers was similar to that for the camera systems; that is, the categories rated were cost, information output capabilities, field experience, and simplicity of operation. Again, the ratings were based on the needs of the Department and were not meant as a general evaluation.

Cost

The Vanguard Model M-35 CF/S-1, the NAC Models 350B, and the NAC Model DF-35 are priced beyond the range considered acceptable for the type of photologging system considered in this study. All these models are sophisticated beyond the needs of the Department and the prices reflect this sophistication. These viewers were rated "unacceptable."

The Vanguard Model PL-35 and the Flight Research Road-O-Graph II are in a price range that seems reasonable for photologging purposes, and these were rated "good." The L & W 16mm Model 224-A was rated "excellent", because it has the lowest price of any of the available photologging viewers and has the needed capabilities.

Information Output Capabilities

All the viewers studied had excellent capabilities for presenting the information needed in analyzing photolog films. These capabilities included the ability to frame the film as it is being shown. All have stop motion analysis features, and all have the capability of projecting the photolog image on a wall screen. The viewers were all rated "excellent."

Field Experience

The Vanguard Model M-35 CF/S-1 and the L & W 16mm Model 224-A were both rated "excellent." They have a number of years of excellent performance documented by other agencies coupled with trouble-free use during the present study.

The NAC Models 350-B and Model DF-35 were rated "fair" along with the Vanguard PL-35 and the Flight Research Road-O-Graph II. This rating reflects the claims made by the manufacturer or distributor and the limited use in the field.

Simplicity of Operation

All the viewers were rated "good", except the NAC model DF-35, which was rated "unknown." All the viewers rated "good" have an easily accessible loading mechanism and controls which are clearly marked. The NAC model DF-35 has only been studied in the literature and therefore was rated unknown. The above ratings are summarized in Table 7.

Table 7

Summary of Ratings for Viewers

Viewers	Cost	Information Capabilities	Field Experience	Simplicity of Operation
Vanguard Model M-35 CF/S-1	Not Acceptable	Excellent	Excellent	Good
NAC Model 350B	Not Acceptable	Excellent	Fair	Good
NAC Model DF-35	Not Acceptable	Excellent	Fair	Unknown
Vanguard Model PL-35	Good	Excellent	Fair	Good
Flight Research Road-O-Graph II	Good	Excellent	Fair	Good
L & W Model 224-A	Excellent	Excellent	Excellent	Good

Summary of Equipment Evaluation

It should be stressed again that the rating system used was based on the potential use of the photolog in the Virginia Department of Highways and Transportation and was not intended to give an indication of the overall quality of the system.

Tables 6 and 7 show that the ratings favor the typical 35mm camera. It should be noted that the categories of "fair" and "unknown" are based on experience. The cameras rated in these categories either lacked field use and documentation or the film formats they produce had not been used enough to permit an evaluation. In either case it is possible that favorable experience could convert these ratings to "excellent," which would result in a more favorable rating for the two recently developed Flight Research cameras.

The ratings also favor the Vanguard Model PL-35 and the Flight Research Road-O-Graph II viewers. Although the L & W viewer had a better rating than the others, it is not compatible with a 35mm camera system and for that reason cannot be recommended. Either of the other two would be suitable. Therefore, while the ratings can change, the typical 35mm camera system is recommended for use at this time. However, if experience proves the Flight Research camera to perform as well, then considerable savings can be realized by using it to establish a system.

Appendix I

Figure I-1 Check List

1. Film properly loaded.
2. Cover on film magazine.
3. ASA set up properly.
4. Lens set properly and locked.
5. Take-up belt on film magazine.
6. Lens cover removed.
7. Punch footage indicator *(New roll only).
8. Preset odometer L.E.D.
9. Set direction indicator.
10. Punch preset button, calibrate up and back.
11. Data slate in place.
12. Power Switch on.
    Motor Switch on.
13. Windshield clean.

Figure I-2
Photo Log Field Sheet
Va. Dept. of Hwys. & Transportation

Date	Weather	Crew	County	State Route #	Direction	Neg. Film Roll #	Begin MP	End MP	Approx. Film Used	Field Remarks

Editing Information

Route				Reel No.		
No. & Direction	Date Filmed	County	Mp	Neg. Roll	Quality of Print	Remarks

Figure I-4

Location of Film
Being Processed

Roll No.	Route No.	No. Ft.	Date Sent	Date Returned

Appendix II

Photologging Uses in Other States

Idaho

The Idaho photolog experience is reported in The Idaho Photolog System, 1972. The system is used in conjunction with aerial photographs of the state highway system to provide needed roadway information in compliance with the Federal Highway Safety Standards promulgated in the National Highway Safety Act of 1966 as described below.

Standard 309— Identification and Surveillance of Accident Locations

The photolog provides a visual record of highway facilities that enables Department personnel to identify problem locations. It also provides data necessary for analyzing the comparative hazards of particular locations, the contiguous land use, the roadway features and surface conditions, and maintenance deficiencies.

Standard 313— Traffic Control Devices

The photolog supplements the computerized inventory of traffic control devices. It is used specifically to correlate traffic control devices to:

1. Sight distance restrictions,
2. railroad crossings,
3. structures,
4. sharp curves,
5. character of roadway,
6. roadside development,
7. approach roads, and
8. inherent hazards in the control device.

Standard 310— Traffic Records

The photolog is used to fulfill partial responsibility in this area by providing highway characteristics from Standard 309 and traffic control devices from Standard 313.

Standard 312— Highway Design, Construction and Maintenance

The photolog provides information in this area to:

1. Study highway accident locations,
2. inventory roadway geometrics and traffic control devices,
3. determine driver sight distance,
4. evaluate highway sufficiency ratings,
5. review highway encroachments,
6. evaluate pavement and roadside design,
7. correlate skid resistance measurements with roadway features, and
8. provide historical records.

Standard 308— Alcohol in Relation to Highway Safety

The photolog provides data for relating highway accident data and citation information relative to the Alcohol Safety Action Program to the investigation of specific occurrences.

The Idaho study suggested that possible other uses were in the areas of billboard inventory, speed zoning studies, landscaping studies, court actions, project design, road mileage inventory, right-of-way encroachments, and access permits.

California

In the study titled The California Photologging System, July 1972, the following areas of application for the photolog techniques are cited.

1. Gathering data for intersection evaluation, such as signals, lighting, channelization, medians, islands, curbs, stop signs, and pavement markers.

2. Providing data for legal cases.

3. Reviewing fatal accident scenes.

4. Managing manpower. The districts are able to communicate with each other while viewing identical photography. This results in "farming out" of the workload from district to district.

5. Obtaining additional information when projects are along existing alignment.

6. Answering miscellaneous correspondence relating to roadway conditions and signing.

7. Reviewing sites quickly before issuing encroachment permits. The photolog is used to aid superintendents in reviewing road conditions with their foremen.

8. Familiarizing management personnel with specific locations brought to their attention by district reports, private citizens, and the legislature.

9. Checking compliance with the nation's Highway Beautification Act.

10. Determining pavement wear rates by type and location.

California's principal users are administration, 1%; claims, 2%; design, 10%; operations, 5%; planning, 12%; right-of-way, 2%; and traffic, 68%. Added to these users are nonstate groups such as city traffic engineers, county road supervisors, outdoor advertisers, private traffic researchers, and claims adjusters for insurance companies.

Delaware

A January 1974 report, Photologging in Delaware, enumerates 10 areas of use for the photolog system.

1. Accident Investigation. The photolog is used to determine what characteristics of the roadway may have contributed to given accidents.

2. Inventories. A method of measuring right-of-way, pavement width and shoulder width has been developed with accuracy to within ± 0.5 foot. However, curves either horizontal or vertical have caused problems and methods are being developed to solve those problems.

3. Project Design. When project is constructed along an existing alignment, information can be obtained from the photolog.

4. Legal. Precise pictorial data will be available for a claims action or any court case. Conclusive evidence is provided by the photolog system.

5. Administration. Questions from citizens, legislators, official correspondence, etc. are answered with aide of information gained from the photolog.

6. Maintenance. Existing road and roadside conditions as determined by viewing the photolog file can be used as a guide in scheduling manpower and equipment allotments.

7. Materials and Research Lab. Over a period of years, studies of apparent pavement wear can be made.

8. Right-of-Way. Quick estimates can be made of the additional right-of-way required for a road improvement project.

9. Development Review. The impact of proposed entrances onto public highway can be quickly assessed.

10. Junkyard and Billboard Control. An analysis of the compliability with junkyard and billboard regulations can be made.

Washington

A 1973 report entitled Photologging System lists 20 possible uses of photologging.

1. Accident location identification.
2. Evaluation of high accident rate locations.
3. Maintenance considerations and general inspection.
4. Sign locations and effectiveness.
5. Sight restrictions at intersections.
6. Evaluation of existing routes for construction program reviews.
7. Traffic analysis, for indication of traffic generators and access points.
8. Establishing origin and destination interview locations.
9. Before-and-after construction highway condition.
10. Tort claim cases.
11. Geometrics.
12. Confirming county road and city street names.
13. Traffic signals.
14. Relocation of historical monuments.
15. Railroad protection.
16. Landscaping.
17. Cartography.
18. Billboard control.
19. Evaluation of right-of-way for bicycle route consideration.
20. Evaluation of roadside spraying program.

Society of Photo-optical Instrumentation Engineers

The Proceedings, Volume 37, resulting from the April 11-12, 1973, meeting of the Society is a very useful source of information on photologging. At this meeting, the Province of New Brunswick's Department of Highways listed its uses under seven categories: all branches, traffic, maintenance, construction, planning, public relations, and district offices. Under "all branches", uses were listed as:

(a) Viewing of general condition of pavement, shoulders, striping, guardrails.

(b) Compiling a historical record of changes over a period of time.

(c) Compiling a record of the highway system to facilitate or expedite management decisions in such fields as public relations, legal actions, accident cause evaluation.

(d) Assessing driver-reaction to road conditions remote from headquarters.

(e) Studying road geometrics by use of a mathematical grid overlay.

Under traffic the uses were:

(a) Inventorying location and condition of traffic control devices, e.g., signs, signals, posted speeds, channelization and parking areas.

(b) Viewing of reported accident sites for adequate signing, posted highway speeds vs. road banking on curves, etc.

(c) Detecting possible confusion from multiple signs at intersections.

(d) Assessing adequacy of sign and road lighting.

The uses under maintenance were:

(a) Study of roadside development, i.e., suburban ribbon development, road access, brush control, etc.

(b) Study of pavement deterioration, particularly if selected spots are photologged several times over a suitable period.

(c) Study effectiveness of various landscape designs.

(d) In special areas, monitor effectiveness of snowplowing, i.e., plowing speed versus efficiency.

The uses under construction were:

(a) Estimating costs of repair or reconstruction in deteriorated areas. Assessing cost of construction of minor improvements such as tourist lookouts and truck pull-offs and rest areas.

(b) Estimating damage due to natural causes.

(c) Recording construction in progress on streets in new housing subdivisions. Summer and fall conditions kept on record to determine the point in time when bonds may be released to contractors.

The uses in the planning area were listed as:

(a) Determination of most economical method for improved route using existing road.

(b) Estimation of improvement costs.

(c) Location and costing of up-hill passing lanes.

In public relations four areas were cited as follows:

(a) Illustrate highway problems and dangerous practices.

(b) Show "before and after" conditions in presentations on highway development.

(c) Provide justification for suggested highway changes.

(d) Provide internal information to answer inquiries or complaints from the public.

The uses in the district offices were not specifically listed but in general stated as judgment in building applications, entrance investigations, and clarification of instructions between headquarters and districts.

U. S. Forest Service

The U. S. Forest Service reported on its experience in the Southern National Forest. The uses were listed as road system inventories, sign inventories, visibility and location studies, inventories for transportation system modeling, inventory of road conditions, landscape management and design, map coordination, road design training aids, aid in conducting public hearings, answering official and public inquiries, and location and design of information signing.

Appendix III

Admissibility of Photologs as Evidence

INTRODUCTION

A survey of the state Code and case law uncovered neither statutory nor common law rules precisely on point. However, by analogy to general rules on legal photography in Virginia and around the country, the conclusion may easily be drawn that photographs are evidence equally as admissible as plats or surveys to illustrate and clarify testimony. Photologs should pass the fundamental tests of authenticity and relevancy even more easily than ordinary photographs. Once the photologging procedure is established, and the courts are informed as to its import and effectiveness, duly authorized photologs should be deemed competent and, in some cases, conclusive evidence in courts throughout Virginia.

VIRGINIA CODE PROVISIONS ON PHOTOGRAPHIC EVIDENCE

The only codified provisions for the use of photostats from the Virginia Department of Highways as evidence pertain to the admissibility of copies of driving records. Recognizing that the Department and the Division of Motor Vehicles keep their records "...by electronic media or by photographic processes ...", the General Assembly has ruled that a copy of such a record, attested by the bureau's officer-in-chief, is always admissible in place of the original evidence. Va. Code. Ann. Secs. 46.1-34, 46.1-413, and 8-266.

Only two sections in the Virginia Code specifically mention the issue of admitting photographs as evidence. One concerns pictures of abused children, the other snapshots of stolen merchandise. The very existence of these provisions does not necessarily call for similar legislative sanction of photologs as competent evidence, however. The section on child abuse in essence addressed the problem of taking photographs on X-rays without the permission of a parent or guardian. Va. Code Ann. Sec. 63.1-248.13.

The shoplifted goods section is more concerned with complications in breaking the chain of custody than in submitting photos into evidence. Va. Code Ann. Sec. 19.2-270.1.

A new California law on eminent domain proceedings, reputedly among the most progressive in the nation, authorizes the photographing of the property to be acquired upon extrajudicial request, without a showing of "good cause", which is normally required. Yet the California code nowhere mentions the admission of the developed prints into evidence. Since the Department is concerned with the mechanics not of taking pictures, but of getting its photologs accepted by the court, the common law, not the Virginia Code, will hold the answer to the admissibility question.

Common Law Issues Relating to Admissibility of Photologs as Evidence

Champions of legal photography in general praise its effectiveness in clarifying testimony and in illuminating history. Some have called the use of photographs in the courtroom "...the most significant contribution to the fact-finding process since emergence of the testimonial witness",(1)* for photographs may solve many problems of conflicting testimony.

> By thus reducing the warping effect of time and human memory, we avoid confusions and uncertainties that arise "from the want of coincidence between accounts of the same occurrences by different eyewitnesses; arising sometimes from imperfect memory, and sometimes from undue partiality for one side or the other". (Thucydides, c.460-400 B.C....)(2)

In negligence actions turning upon some highway defect, for example, a dated photolog identified as an accurate depiction of the scene of the wreck might be determinative proof that the road was in fact in reasonable repair at the time of the accident. In eminent domain hearings, a certified photolog would be indispensable in figuring just compensation, especially in actions tried after the property has been taken. To have its photologs certified as evidence, the Department must convince the court that the pictures are authentic and relevant to the case. The admission is within the trial judge's discretion. Of course thereafter "the question of what weight should be given to a photograph...is a question for jury, to be determined by the tests used in weighting other evidence".(3) As far as passing the authenticity and relevancy hurdles alone is concerned, there would seem to be no reason why official photographs would not be certified as easily as any map, survey, or diagram. The superior illustrative, and in consequence, persuasive powers of a photograph over a plat need no lengthy explanation.

I. The Authenticity Test

"Parties offering photographs must show by extrinsic evidence that such pictures are true and accurate representations of the

*numbers in parenthesis indicate references.

property that they purport to portray".(4) There is no requirement in Virginia that the photographer be sworn in as a witness. "All that is necessary is that the photograph be identified". Lawson v. Darter, 157 Va. 284, 288, 160 S.E. 74 (1931), citing Spencer v. Looney, 116 Va. 767, 82 S.E. 745 (1914). (In each of these cases, non-current photographs were admitted into evidence.) Verification may be established by any competent witness, ranging from persons familiar with the depicted scene to registered professional engineers.(5) State troopers have verified photographs in cases of record in this state. Venable v. Stockner, 200 Va.900, 108 S.E. 2d 380 (1959). Given, too, that duly attesting copies of driving records are routinely admitted as evidence, (see supra, p. III-1) official photologs should meet with no certification problems, particularly after the effectiveness of this pictorial cataloguing system become more widely known.

If the photologs are submitted in moving picture sequence, they will in all likelihood be admitted as easily as still shots. Courts in some states seem to require more authentication for a movie than for a photo, however. In the absence of precedents in Virginia, it might be advisable to include facts about the circumstances under which the log was taken and developed and projection instructions, as well as the normal testimonial sponsorship by a person who was present at the time of taking the film, or by the bureau chief who can identify the film as an accurate depiction.(6)

II. The Relevancy Test

Authenticity having been established, a fundamental and more difficult requirement remains to be satisfied. To establish a photolog's relevancy, the moving party must show the picture's connection to the facts and circumstances which were obtained at the time of the accident. In general, photographs are deemed to have a material bearing upon the issues of the case only if they assist the jury in understanding the case or aid a witness in explaining his testimonv.(7) "The determination of the relevance and materiality of a photograph is left to the sound discretion of the trial judge". Am. Jur., Evidence, Sec. 729, cited in Wright v. Kelly, 203 Va. 135, 141, 122 S.E. 2d 670 (1962).

Photos taken after or before a wreck, in the case of a negligence action, or after or before the valuation date, in eminent domain proceedings, are admissible only so long as the scene is the same as, or very similar to, the road condition at the relevant time.(8) Any discrepancies between the picture and the site on the day of either the accident or the valuation should be pointed out in an accompanying statement.(9) For example, in

one Virginia case arising from the collision of a car and a tractor-trailer, photographs of the road taken three months after the accident were held to have been properly admitted, because the state trooper who had investigated the accident testified that despite the picture's lack of timeliness, the highway looked identical, and the skid marks shown on it were "of the same type" as those made by the trailer's broken wheel. Venable v. Stockner, 200 Va. 900, 108 S.E. 2d 380(1959). Another, still more dramatic divergence was between the site of a summer wreck and a winter scene in the evidential photograph. This summer-winter anachronism was the basis of appeal in Saunders v. Bullock, 208 Va. 551, 159 S.E.2d 820 (1968). There again the trial judge's ruling was upheld due to a state trooper's accompanying testimony as to the width of the road shoulders at the place of the accident, the snow-free state of the road at the time, and the lack of any distortion of the actual situation due to the snow in the photograph itself. Finally, there is an eminent domain case of record in Maryland in which

> photographs taken of the property nine months before the date of condemnation were held to be relevant to the issue of the case and so admissible even though improvements had been made on the property between the dates of photographing and valuation. Such pictures became relevant through the accompanying testimony of witnesses and other evidence that indicated what improvements had been made on the property since the date of photographing and what condition the property was in at the time of valuation. Hance v. State Roads Comm'n, 221 Md. 164, 156 A. 2d 644 (1959)

There are several recorded instances in Virginia of photographs being rejected either because the scene was not accurately portrayed, or because the shot seemed calculated to arouse the sympathies or prejudices of the jury. See Virginia Ry. Co. v. Hillsman, 162 Va. 359, 173 S.E. 503 (1934); Sprinkle v. Davis, 111 F. 2d 925 (Va., 1940); and Major v.Hoppe, 209 Va. 193, 163 S.E. 2d 164 (1968). In Hillsman, supra, a photo showing the accident scene three months after a wreck was excluded because road conditions had materially changed. In Sprinkle, supra, a movie was introduced to show how far away the defendant's approaching car should have been visible to the injured plaintiff. The judge excluded the evidence because the winter foliage in the movie enhanced highway visibility, thereby distorting the material fact which was purportedly shown. In Hoppe, supra, an aerial

photograph failed the relevancy test since it neither accurately nor instructively depicted the road at issue. A Virginia case involving a prejudicial photo was Wright v. Kelly, 203 Va. 135, 122 S.E. 2d 670 (1972). There a snapshot of a handsome child taken five months before his fatal accident seemed designed to arouse the jury's sympathy, and hence was held to have been improperly admitted. The Wright court approved the American Jurisprudence rule relative to the introduction of photographs into evidence, which in part reads: " 'A photograph which is entirely irrelevant and immaterial to any issue in the cause (sic), and which is of such a character as to divert the minds of the jury to improper and irrelevant considerations should be excluded from the evidence.' " 20 Am. Jur., Evidence, Sec. 729, cited in Wright, supra, 203 Va. at 141.

Attorneys attempting to introduce photologs into evidence should have little trouble avoiding this "diversionary-irrelevant photograph" pitfall. The pertinency of the photolog will be patent. If, as was mentioned earlier, the photo is accompained by a statement of any discrepancies between the picture and the road condition on the relevant date, admission into evidence is nearly assured.

The final conceivable objection which might thwart admission of a photolog is that the jury might have seen the site in question, thereby obviating the need for photographic evidence. A prior viewing by the jury was the reason given for the rejection of photos in Hill v. Lee, 209 Va. 569, 166 S.E. 2d 274 (1969). Again, though, this is a matter discretionary with the trial judge. The weight of precedent in Virginia would seem to allow a jury both to visit the scene and to deliberate later over photographs thereof. Lambert v. Jenkins, 112 Va. 376, 71 S.E. 718 (1911); McGowan v. Jenkins, 144 Va. 358, 132 S.E. 316 (1926). In still other cases a photo alone has been held to be sufficient, or, as the court remarked, to make it "...unnecessary for other proof, though there was other proof....In Martin v. Commonwealth, 184 Va. 1009, 1022, 37 S.E. 2d 43, we said: '...An authentic photograph shows no more than would be disclosed by a view of the object itself.' " Newberry v. Commonwealth, 191 Va. 445, 455, 61 S.E. 2d 318 (1950).

In conclusion, it is worthwhile to note the evidential value of a photograph as compared to other visual aids. Plats and surveys, for example, are usually entered not independently, but as illustrative of other testimony.(11) Photos are not considered proof positive of a highway's perfect condition, or of a property's value, but their evidentiary independence gives them special strength, and their faithful accuracy, special weight, during a jury's deliberations. Newberry, supra, 191 Va. at 455. For the defense of a negligence action, or during the course of condemnation hearings, photographs often prove invaluable. It would be difficult for the

Department to find more persuasive evidence, either of its observance of reasonable maintenance standards or of any conditions affecting the value of the property in question. And once the efficacy of this cataloguing system is established, there should be no problems in seeing a photolog admitted into evidence in almost every case.

REFERENCES

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

2. Thucydides, The History of the Peloponnesian War, Book I, Sec. 22, cited in Hughes and Cantor, Ibid.

3. Marshall, et al., The Law of Evidence in Virginia and West Virginia, C. P. Nash, ed., The Michie Company, Charlottesville, Va., Sec. 29, p. 55.

4. Massey, Rules of Compensability and Valuation Evidence for Highway Land Acquisition, Highway Research Board, Program Report 104, 1970, p. 59.

5. Ibid.

6. Hughes and Cantor, Photographs, supra, p. 180.

7. Massey, Rules, supra, p. 59.

8. Hughes and Cantor, Photographs, supra, p. 183.

9. Massey, Rules, supra, p. 61.

10. Ibid., p. 60.

11. Ibid., p. 61.

Appendix IV

System Costs

Table IV-1

Typical 35mm System
Central Office Only

	First Year Investment		Operating Costs for following years	
Equipment				
Camera	$16,000		-0-	
Vehicle	7,000		-0-	
Viewer	4,000		-0-	
Edit. Equip.	1,500	$28,500	-0-	
Film & Service				
Film Purchase	14,080		$14,080	
Processing	5,760		5,760	
Printing	11,200	31,040	11,200	$31,040
Personnel				
Salary	45,000		45,000	
Expenses	5,000	50,000	5,000	50,000
Maintenance				
Vehicle	600		600	
Camera & Viewer	250	850	250	850
Total		$110,390		$81,890
Cost/Mile		$9.20		$6.82
Cost/Km		$5.72		$4.24

Table IV-2

Typical 35mm System
Central Office and District Offices

	First Year Investment		Operating Costs for Following Years	
Equipment				
Camera	$16,000		-0-	
Vehicle	7,000		-0-	
Viewer	36,000		-0-	
Edit. Equip.	1,500	$60,500	-0-	
Film & Service				
Film Purchase	14,080		$14,080	
Processing	5,760		5,760	
Printing	22,400	42,240	22,400	$42,240
Personnel				
Salary	45,000		45,000	
Expenses	5,000	50,000	5,000	50,000
Maintenance				
Vehicle	600		600	
Camera & Proj.	500	1,100	500	1,100
Total		$153,840		$93,340
Cost/Mile		$12.82		$7.78
Cost/Km		$ 7.97		$ 4.83

Table IV-3

Modified 1/2 Frame 35mm System
Central Office Only

	First Year Investment		Operating Cost for Following Years	
Equipment				
Camera	$ 7,500		-0-	
Vehicle	7,000		-0-	
Viewer	4,000		-0-	
Edit. Equip.	1,500	$20,000	-0-	
Film & Service				
Film Purchase	7,040		$ 7,040	
Processing	2,880		2,880	
Printing	5,600	15,520	5,600	$15,520
Personnel				
Salary	45,000		45,000	
Expenses	5,000	50,000	5,000	50,000
Maintenance				
Vehicle	600		600	
Camera & Proj.	250	850	250	850
Total		$86,370		$66,370
Cost/Mile		$7.20		$5.53
Cost/Km		$4.47		$3.44

Table IV-4

Modified 1/2 Frame 35mm System
Central Office and District Offices

	First Year Investment		Operating Cost for Following Years	
Equipment				
Camera	$ 7,500		-0-	
Vehicle	7,000		-0-	
Viewer	36,000		-0-	
Edit. Equip.	1,500	$52,000	-0-	
Film & Service				
Film Purchase	7,040		$ 7,040	
Processing	2,880		2,880	
Printing	11,200	21,120	11,200	$21,120
Personnel				
Salary	45,000		45,000	
Expenses	5,000	50,000	5,000	50,000
Maintenance				
Vehicle	600		600	
Camera & Proj.	500	1,100	500	1,100
Total		$124,220		$72,220
Cost/Mile		$10.36		$6.02
Cost/Km		$ 6.43		$3.74

Table IV-5

Typical 35mm System with 16mm Distribution
Central Office and District Offices

	First Year Investment		Operating Cost for Following Years	
Equipment				
Camera	$16,000		-0-	
Vehicle	7,000		-0-	
Viewer	16,000		-0-	
Edit. Equip.	2,000	$41,000	-0-	
Film & Service				
Film Purchase	14,080		$14,080	
Processing	5,760		5,760	
Printing	16,800	36,640	16,800	$36,640
Personnel				
Salary	45,000		45,000	
Expenses	5,000	50,000	5,000	50,000
Maintenance				
Vehicle	600		600	
Camera & Proj.	500	1,100	500	1,100
Total		$128,740		$87,740
Cost/Mile		$10.73		$7.32
Cost/Km		$6.73		$4.54

Table IV-6

Typical 16mm System
Central Office Only

	First Year Investment		Operating Cost for Following Years	
Equipment				
Camera	$14,000		-0-	
Vehicle	7,000		-0-	
Viewer	1,500		-0-	
Edit. Equip.	1,000	$23,500	-0-	
Film & Service				
Film Purchase	4,068		$ 4,068	
Processing	2,760		2,760	
Printing	4,400	11,228	4,400	$11,228
Personnel				
Salary	45,000		45,000	
Expenses	5,000	50,000	5,000	50,000
Maintenance				
Vehicle	600		600	
Camera & Proj.	250	850	250	850
Total		$85,578		$62,078
Cost/Mile		$7.14		$5.18
Cost/Km		$4.43		$3.22

Table IV-7

Typical 16mm System
Central Office and District Offices

	First Year Investment		Operating Cost for Following Years	
Equipment				
Camera	$14,000		-0-	
Vehicle	7,000		-0-	
Viewer	13,500		-0-	
Edit. Equip.	1,000	$35,500	-0-	
Film & Service				
Film Purchase	4,068		4,068	
Processing	2,760		2,760	
Printing	8,800	15,628	8,800	$15,628
Personnel				
Salary	45,000		45,000	
Expenses	5,000	50,000	5,000	50,000
Maintenance				
Vehicle	600		600	
Camera & Proj.	500	1,100	500	1,100
Total		$102,228		$66,728
Cost/Mile		$8.52		$5.56
Cost/Km		$5.29		$3.46