NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
SYNTHESIS OF HIGHWAY PRACTICE **94**

PHOTOLOGGING

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

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WILLIAM T. BAKER
Federal Highway Administration

Topic Panel

OLIN D. BOCKES, *U.S. Department of Agriculture*
TAPAN K. DATTA, *Wayne State University*
WILLIAM G. EBERT, *Minnesota Department of Highways*
JOE MCCULLY, *South Dakota Department of Transportation*
LAWRENCE F. SPAINE, *Transportation Research Board*
DAVID K. WITHEFORD, *Transportation Research Board*

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TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board of the National Research Council was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as: it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communications and cooperation with federal, state, and local governmental agencies, universities, and industry; its relationship to its parent organization, the National Academy of Sciences, a private, nonprofit institution, is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the Academy and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are the responsibilities of the Academy and its Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

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The members of the technical committee selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and, while they have been accepted as appropriate by the technical committee, they are not necessarily those of the Transportation Research Board, the National Research Council, the National Academy of Sciences, or the program sponsors.

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The Transportation Research Board evolved from the 54-year-old Highway Research Board. The TRB incorporates all former HRB activities and also performs additional functions under a broader scope involving all modes of transportation and the interactions of transportation with society.

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PREFACE

A vast storehouse of information exists on nearly every subject of concern to highway administrators and engineers. Much of this information has resulted from both research and the successful application of solutions to the problems faced by practitioners in their daily work. Because previously there has been no systematic means for compiling such useful information and making it available to the entire highway community, the American Association of State Highway and Transportation Officials has, through the mechanism of the National Cooperative Highway Research Program, authorized the Transportation Research Board to undertake a continuing project to search out and synthesize useful knowledge from all available sources and to prepare documented reports on current practices in the subject areas of concern.

This synthesis series reports on various practices, making specific recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems. The extent to which these reports are useful will be tempered by the user's knowledge and experience in the particular problem area.

FOREWORD

By Staff
Transportation Research Board

This synthesis report will be of special interest to transportation administrators, planners, designers, and other engineers seeking information on the use of photologging.

Administrators, engineers, and researchers are continually faced with highway problems on which much information exists, either in the form of reports or in terms of undocumented experience and practice. Unfortunately, this information often is scattered and unevaluated, and, as a consequence, in seeking solutions, full information on what has been learned about a problem frequently is not assembled. Costly research findings may go unused, valuable experience may be overlooked, and full consideration may not be given to available practices for solving or alleviating the problem. In an effort to correct this situation, a continuing NCHRP project, carried out by the Transportation Research Board as the research agency, has the objective of reporting on common highway problems and synthesizing available information. The synthesis reports from this endeavor constitute an NCHRP publication series in which various forms of relevant information are assembled into single concise documents pertaining to specific highway problems or sets of closely related problems.

Photologging is a procedure for systematically acquiring a series of photographs at even intervals along a highway. This effective new tool can be used in various ways in many parts of a highway agency. This report of the Transportation Research Board contains information on equipment and procedures for photologging, its uses, benefits, costs, and problem areas.

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, the Board analyzed available information assembled from numerous sources, including a large number of state highway and transportation departments. A topic panel of experts in the subject area was established to guide the researcher in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that now at hand.

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Information on current practice was provided by many highway and transportation agencies. Their cooperation and assistance were most helpful.

PHOTOLOGGING

SUMMARY

Photologging is a method of taking photographs of a highway and its environment and, at the same time, recording specific data about the highway. The first highway photologging was performed in the early 1960's. Since then more than 500,000 miles (800,000 km) have been photologged in the United States.

There are numerous applications of photologging. The most obvious are those that eliminate or minimize field trips. Among the more common applications are those involving highway safety (e.g., determining guardrail needs), traffic-control devices (e.g., inventory of signs and signals), and legal actions (e.g., defense against claims). Other uses include determining location and type of existing guardrails and inspecting potential detour routes.

Although the first photologs were made using 16-mm cameras, the 35-mm film size is most commonly used today. Photographs are taken every 0.01 mile (0.016 km); at the same time, data about the highway (milepoint, route number, date, etc.) are recorded on the film. A color negative film is used, permitting multiple positive copies to be made for use in various offices. The positive film can be viewed on microfilm or stop-motion projectors. The latter allow the photolog to be displayed in a way that approximates a motion picture.

The typical vehicle used for photologging is a van that has been modified to include an electric odometer, a work storage area, and a camera mount. First-generation photolog equipment permits only the collection of minimal basic highway data, which is recorded on the film. Second-generation photologging entails gathering additional information, such as bearing, degree of curvature, gradient, and roughness; these data are recorded on film and magnetic tape.

Although most photologging in the United States is performed by highway agencies using their own equipment and personnel, many cities and counties have used contract photologging, particularly where the roadway mileage does not justify the purchase of equipment. In two states photologging is also being used on railroads.

Videologging is being performed by a few agencies. The image quality obtained from video tape is inferior to that from photolog film; however, processing is not required and thus the tape can be used immediately. Also the cost of video tape is lower than the cost of film and processing. However, overall costs may not be lower.

The following are among the conclusions of this study:

- Photologging can be used by all organizational units within a state highway agency; it has significant application for traffic engineering, design, and planning personnel.
- Three factors that affect the degree of use are (a) the level of support by management, (b) the location of the film and viewing equipment in an area not identified with a specific unit, and (c) the availability of a complete, updated photolog of an entire highway system.

Among the areas in which more study or research is needed are:

- Videologging as a substitute for or a supplement to photologging.
- Integrating microprocessor-based inventory systems with photologging.
- Obtaining roadway dimensions accurately and efficiently from photolog film.
- Investigating the feasibility of using the global positioning system for locating roadway features via a receiver in the photolog vehicle.

CHAPTER ONE

INTRODUCTION

For many years highway engineers have used conventional photographic techniques to document and preserve particular highway conditions on film. In some instances, still photographs, as well as motion pictures, were taken through the windshield of a vehicle moving along a highway. Although these photographic records were used for many purposes, the systematic photographing of an entire highway system has been difficult because of the limitations of the cameras and the projectors employed to view the film.

Users of photographic equipment generally can be classified into three groups—hobbyist, commercial, and instrumentation. The hobbyist uses equipment readily available from a variety of retail stores and sold at all prices. Applications can range from family snapshots to serious bird photography using special telephoto lenses. The commercial photographer may be employed by a newspaper or a television station, may be a free-lance photojournalist, or may own a portrait studio. In most cases, equipment can be obtained from retail stores that specialize in the sale of photographic equipment.

The user of photographic instrumentation specializes in highly technical or scientific work with equipment that is not usually available from the normal sources of photographic supplies (i.e., camera shops, department stores, etc.). Applications include the photographic tracking of a missile launch and the high-speed filming of a vehicle that is being crash-tested. The sources for this specialized equipment include a number of relatively small manufacturers who produce rugged, versatile equipment adaptable to many highly specialized uses. Photologging is considered to be an application of photographic instrumentation.

However, there is not always a clear distinction between the equipment used in these three areas. For example, some scientific applications can be accomplished with hobbyist equipment; however, these exceptions usually require modification or limited use of the equipment. Agencies committed to long-term, highly technical or scientific projects that are physically demanding of the equipment almost always find that the use of instrumentation-quality equipment is cost-effective.

DEFINITIONS

Photographic Instrumentation

Photographic instrumentation is highly specialized equipment that records visual information for the purpose of detection, measurement, and interpretation. It is used to provide both qualitative and quantitative information. The record it produces is of permanent form and can be reexamined and remeasured as desired.

Photographic instrumentation is being used in transportation-related areas; for example, in time-lapse photography, vehicle detection and identification, and photologging. Of the applications of photographic instrumentation in highway engineering, none has been so extensively employed nor has affected the routine operational procedures of so many elements of highway agencies as photologging.

Photologging

Photologging is an application of photographic instrumentation whereby photographs of a highway, its environment, and specific data about the highway are obtained from a moving vehicle as it travels down the highway.

A photolog should not be confused with a motion picture of the highway: motion pictures are normally taken at rates of 18 to 24 frames per second, whereas photologs are obtained by filming at rates of about 1 frame per second when the vehicle is traveling at 35 mph (56 km/h). Photologging sometimes includes the subsequent analysis of the film.

HISTORY

Taking pictures through the windshield of moving vehicles was not unique with the development of photologging as it is known today. A U.S. patent (No. 3,151,235, entitled Method and Apparatus for Recording Road Appearance, Geometry and Surface Characteristics), obtained in 1964, describes a data-gathering vehicle that includes a camera system for taking pictures of the roadway and its environment as the vehicle proceeds down the highway. What distinguishes most of the current photologging procedures from the earlier methods is the type of equipment being employed today and the film format.

Available records indicate that the Photo/File system, a contract photolog service offered by Aero Service Corporation, probably constituted the first operational photolog (*1*). (The addresses of consultants, manufacturers, and suppliers cited in this report are given in Appendix A.) The Photo/File system equipment consisted of a 16-mm movie camera that exposed such data as milepoint, route number, and direction of travel across the bottom of each frame. Pictures were taken every 0.01 mile (0.016 km) from a camera positioned at a typical driver's eye height. In 1961 Iowa contracted with Aero Service Corporation for a limited amount of Photo/File work, and by 1969 approximately 10,000 miles (16,000 km) of primary highways in Iowa had been filmed. The Photo/File system equipment is shown in Figure 1, and the data display on the 16-mm format is shown in Figure 2.

The first photolog of an entire highway system in the United States was completed by the Oregon Department of

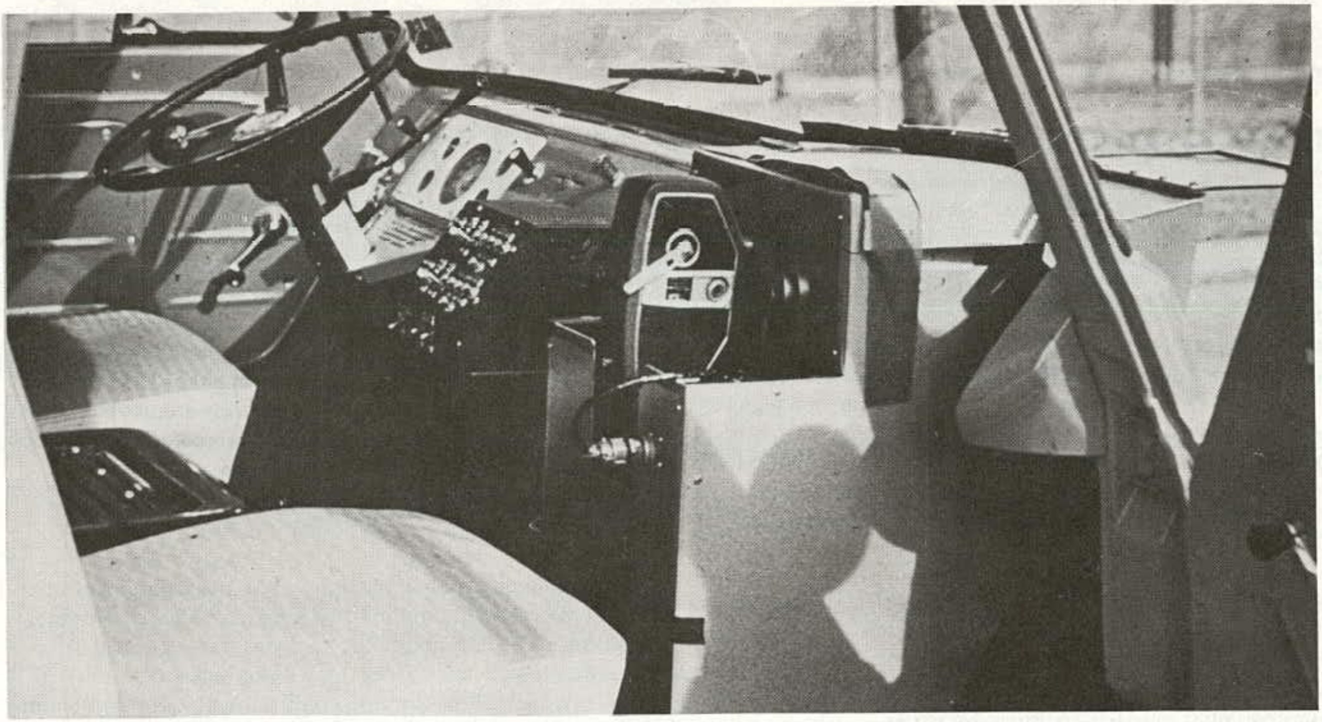


FIGURE 1 Photo/File 16-mm photologging equipment (Iowa DOT).

Highways in 1968 and was the result of extensive field testing that was begun in 1965. Because of the modifications needed to meet Oregon's requirements, the equipment and procedures were developed independently of the Photo/File system; the term "photolog" was assigned to the resultant film record. After the primary highway system was photologged and the film became available for use by the various offices in the highway department, it was evident that general use was much greater than originally anticipated.

The Oregon system was, in effect, "homemade" and therefore not available for purchase as an off-the-shelf package. In addition, the 16-mm camera was never intended for the demanding use it received as a photolog tool. This caused a maintenance problem, necessitating the purchase of a second unit so that one was always available while the other was being serviced. These limitations were somewhat of a deterrent to the increased use of photologging. Subsequently, these problems were solved by switching to instrumentation-quality equipment initially designed for scientific applications.

In early 1969, after viewing a demonstration of the Oregon system, two engineers from the Federal Highway Administration set out to determine if the equipment deficiencies could be remedied with instrumentation hardware designed for applications with strenuous demands similar to those of photologging. Contacts were made with various federal government agencies that used instrumentation-quality equipment, especially 35-mm film, in an effort to determine if the equipment could be adapted for photologging. This led to the conduct of a low-cost demonstration project by the FHWA in which a van was equipped with a 35-mm Flight Research camera and photologs were produced under actual field conditions. The results of this work were published in 1970 (*2*). Figures 3 and 4 show two of the camera positions tested in the early FHWA demonstration project.

The 1970 report (*2*) generated a great deal of interest and led to photologging being made eligible by the FHWA for federal-aid funding. Both Section 402 funds and highway planning and research (HPR) monies were designated as eligible for use in funding photologging.

During the time that the FHWA work was underway, the California Department of Transportation was also actively developing a 35-mm photolog system. This effort started in 1961 with a small Aero Service Corporation contract; however, serious interest was not generated until 1968 when the Oregon system was evaluated. The Caltrans work involved adapting an Automax 35-mm camera system for photolog use and testing the system on California highways.

In 1971 the first of two national conferences on the use of photographic instrumentation for highway transportation applications was held in Burbank, California, under the sponsorship of the Society of Photo-Optical Instrumentation Engineers (SPIE); the Institute of Transportation Engineers (ITE); the Institute of Transportation and Traffic Engineering, UCLA; and the FHWA (*3*). The second national conference, held in Washington, D.C., in 1973, was sponsored by SPIE, ITE, and FHWA (*4*). These conferences served as a forum for highway agencies in the use of some of the photographic techniques, especially photologging, for highway engineering and enabled the participants to meet industry representatives and to observe demonstrations of the equipment.

A one-day seminar on photologging was held in conjunction with ITE's annual meeting in September 1979 in Toronto, Canada. This seminar was intended primarily for city and county personnel and enabled those in attendance to

FIGURE 2 Frame from early 16-mm photolog (Iowa DOT).

FIGURE 3 FHWA photolog demonstration with camera mounted on roof of vehicle.

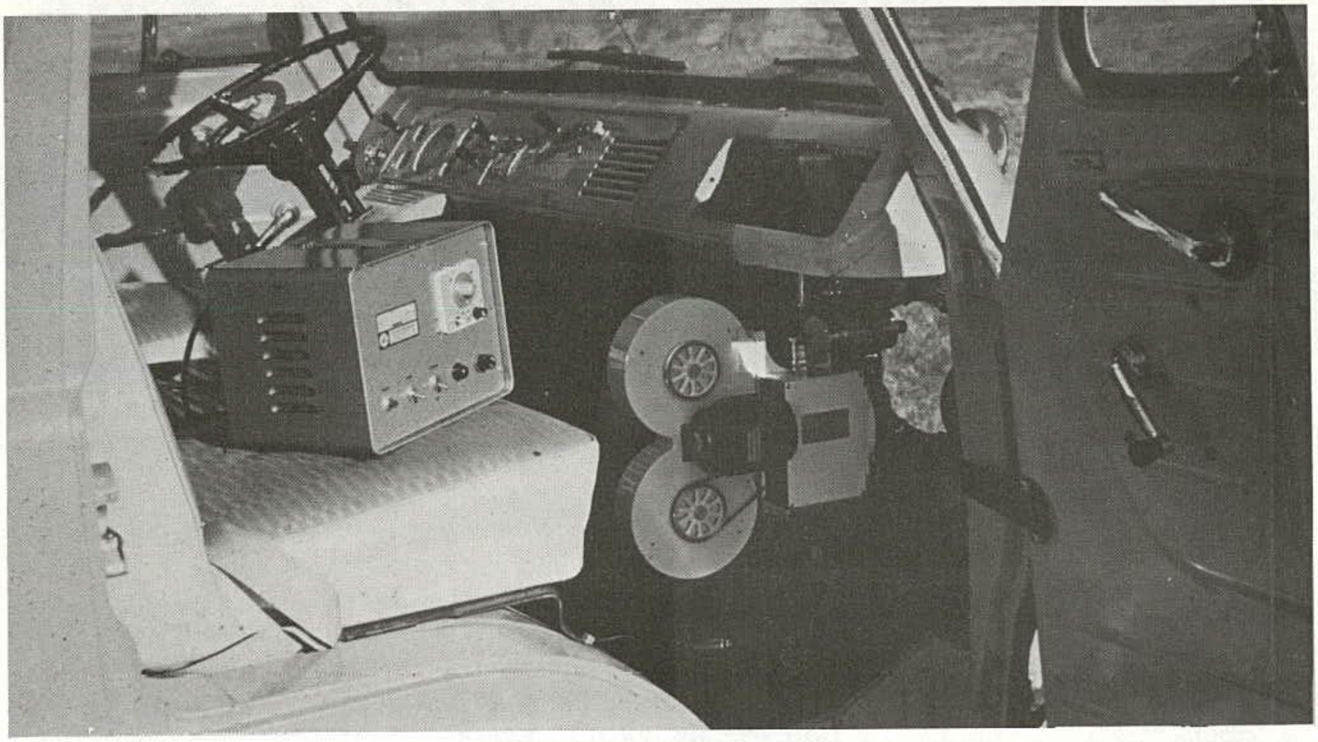


FIGURE 4 FHWA photolog demonstration with camera mounted inside vehicle.

hear technical papers, meet industry representatives, and observe equipment demonstrations. A seminar notebook, which includes copies of the technical papers, is available from ITE (*5*).

The early photologs used microfilm viewers that were readily available from a number of suppliers, such as 3M and Kodak. When 35-mm instrumentation-camera systems were adapted to photologging, a type of projector known as a stop-motion analyzer was suggested for use because the film could be shown at various speeds and by means of a presentation that facilitated reviewing a sequence of frames.

The Vanguard Instrument Corporation has provided the majority of the projectors for photologging. Typically, as the states first developed their programs, one or two Vanguard projectors would be purchased for use in the headquarters office. When it became apparent that there was a need for projectors in the district offices and it was too costly to meet this need with the conventional Vanguard projector, a unit costing about two-thirds the price of the original projector was developed primarily for photologging; this unit (Model PL-35) is the one most often purchased by users today. One other projector, manufactured by Flight Research and developed at about the same time as the Vanguard PL-35, is also available for purchase today.

In 1976 Techwest Enterprises Ltd. sold the first fully operational second-generation system to the Utah Department of Transportation; the Wyoming Highway Department soon purchased the same equipment. These systems constituted the first successful applications of second-generation photologging in the United States. Operational experience in these states has led to a number of refinements to the equipment, which are now standard features and have demonstrated the manufacturer's willingness to respond to the needs of users.

CHAPTER TWO

APPLICATIONS OF PHOTOLOGGING

A broad discussion of the wide range of the uses of photologging is presented here in order that the technique can be placed in perspective. Among the most common applications are those related to safety and planning activities, such as the review of hazardous locations, traffic control device inventories, roadside safety inventories, and planning inventories. Photologging is also being used in urban areas as a base for computerized inventory systems in which traffic control device and safety information is extracted from photolog film and used to build computer files for system management purposes. For example, the computer can access an inventory file to determine how many stop signs must be budgeted as part of the preparation of a more realistic budget.

Probably the most obvious applications of photologging are those that eliminate or minimize trips to the field. Although the review of photolog film is not always a suitable substitute for a field trip, there are many occasions when a trip can be eliminated or made more productive by first viewing the subject location on film. Several state agencies used the threat of curtailed availability of official vehicles as one of the justifications for developing a photolog system.

HIGHWAY SAFETY, TRAFFIC-CONTROL DEVICE, AND LEGAL APPLICATIONS

The following material is excerpted from a report by Stafford sponsored by the South Carolina DOT (*6*):

Highway Safety Applications

Many state highway agencies have found photolog data to be particularly useful in various highway safety studies. The fact that federal highway safety funds have been used by many states to implement photologging programs serves to indicate that the highway safety applications of photolog data are widely accepted. In general, photologging is useful in a number of areas related to the Federal Highway Safety Standards established in the National Highway Safety Act of 1966. Particular standards that can be studied by the use of photolog data include Highway Safety Program Standard 9—Identification and Surveillance of Accident Locations; Highway Safety Program Standard 12—Highway Design, Construction, and Maintenance; and Highway Safety Program Standard 13—Traffic Engineering Services.

The photolog data has been used extensively to pinpoint accident locations from accident reports and to examine the characteristics of the highway in the vicinity of accident locations in an effort to identify factors that may have contributed to the accidents and to develop accident countermeasures. The photolog data is particularly useful in studying high accident locations and identifying remedial actions that could be used to reduce the accident potential. Some states have adopted a practice of using the photolog data to review all fatal accident locations in an effort to identify conditions that may have contributed to causing the accident.

Photologs have been used for a variety of applications related to safety aspects of highway design, construction, and maintenance. The photologs provide an excellent mechanism for reviewing the characteristics of existing highways in search of specific conditions that may be of interest in a particular safety review. For instance, some states have used photologs to review the entire state highway system in an effort to locate areas where additional guardrail installation was needed. The photologs have also been used to locate roadside hazards that may need to be removed or provided with a protective guardrail. The photolog data have also been used to search for locations with sight distance restrictions caused by highway geometry, roadside development, and vegetation. The photologs have also been used to conduct a general inspection of highway conditions to identify situations that may represent potential safety problems and to develop a highway maintenance program to remedy any serious deficiencies that are located.

Traffic Control Device Applications

A considerable portion of the efforts related to Highway Safety Program Standard 13—Traffic Engineering Services—is directed toward improving traffic control devices. The complete range of traffic control devices including signs, signals, pavement markings, and traffic islands can be observed on photologs as these devices would appear to the driver moving along the highway. Photologs have been used to inventory traffic control devices, evaluate the degree to which traffic control devices comply with standards, determine the need to replace deteriorated, non-standard, or inadequate traffic control devices, determine the need for additional traffic control devices, and select the optimum location and placement for new traffic control devices.

Several cities, including Charlotte and Greensboro, North Carolina, have used photologs to develop a computerized inventory of traffic control devices throughout the city. The photolog is used as a data source and the information on the location, type, condition, and other characteristics of traffic control devices is input into a computer for storage, processing, and retrieval. The traffic control device inventory is kept current by using a work order reporting system to input all changes in traffic control devices into the data base. Computer programs are available to extract information on needs for sign replacement based on condition, the number and location of non-uniform signs, and other data summaries for use in budget preparation and management decisions. While a computerized inventory system for traffic control devices may not be feasible on a statewide basis, the photologs provide a visual inventory that is useful for many purposes.

Legal Applications

Several state highway agencies have used photolog data successfully in defending the agency against claims that result from accidents and other actions. The photolog data provide an accurate historical record of highway conditions that can be used in court to establish the system of traffic control devices, pavement conditions, or roadside environment present at the time the photolog was made. Since claims are frequently not made for a considerable period of time after a particular action occurred or a condition existed, the photolog may represent the best record of historical conditions available although the photolog is several years old. In states that have lost sovereign immunity by court or legislative action, the successful defense of the state highway agency against a few claims could go a long way toward justifying the cost of the entire photologging program. It must be noted that the photologs are also available to the plaintiff's attorney and occasionally the photolog evidence will prove useful to the complainant by supporting the claims made against the state. However, the experience of the states that have been involved in photologging for several years shows that the evidence provided by the photolog data is effective in defending the state against claims more often than it is detrimental. Another important aspect of the photolog data is that the existence of the photologging program can be used as evidence that the state highway agency has initiated a program to inventory highway conditions and to provide a data source for locating deficiencies. The photologging program can be used to show that the state highway agency is making a reasonable effort to provide a safe highway system for the public.

One situation that is particularly susceptible to the production of claims against state highway agencies is accidents in areas of highway construction. Some states that have photologging programs have adopted a policy of photologging construction areas during the early stages of construction to provide a permanent record of the construction warning signs, barricades, detours, and other conditions. While some of these features will change as construction progresses, there will be a record of the initial conditions existing within the construction area. Photologs of typical construction sites have also been used as a training tool to instruct contractors and state highway agency personnel about proper construction signing practice.

OTHER APPLICATIONS

Photolog film can be a significant aid in communicating with the public, especially when the film is used to respond in writing to public inquiries regarding signing or other physical features of the highway. It can also be a valuable aid in public hearings where viewers can be shown explicitly what changes are proposed.

Other possible uses of photologs include (*6*):

- Determining the location of speed zones and speed limits, passing zones and restricted passing zones, and sight distance restrictions.
- Determining the location and type of roadway lighting installations.
- Determining the location of median openings.
- Determining the location and type of existing guardrail and areas where additional guardrail is needed.
- Determining the location and type of curbs, sidewalks, and parking zones on urban streets.
- Planning landscaping, checking compliance with billboard and junkyard regulations, and monitoring roadside vegetation control programs.
- Selecting locations for certain maintenance activities.
- Examining abutting land use.
- Locating sections of highway with certain characteristics for research studies.
- Inspecting potential detour routes.
- Briefing utility contractors on potential safety hazards and problem areas.
- Compiling a historical record of changes over time.

CHAPTER THREE

PHOTOLOGGING EQUIPMENT

PICTURE INTERVAL

Photolog pictures are not taken on a time basis as are the photographs obtained from time-lapse photography applications. Instead photolog pictures are normally taken every 0.01 mile (0.016 km) in rural areas and 0.01 to 0.02 mile (0.016 to 0.032 km) in urban areas. A pulse from an electronic odometer actuates the camera shutter. In this way, photolog vehicles can travel at any speed and still maintain an accurate relationship between the distance traveled and the actual milepoint of a particular location on the highway. Distance actuation rates for photologs are not limited to the U.S. customary system of measurement and can be adapted to any equal distance increment scheme.

FILM FORMATS

Two film sizes, 35-mm and 16-mm, can be used for photologging, but 35-mm is by far the most common in the United States. The 35-mm film format is, in effect, a half-frame; its relationship to the full-frame format is shown in Figure 5. Film travel for a conventional 35-mm camera is in the horizontal direction and the picture size is 24 mm by 36 mm. Because the film magazines on photolog cameras move film in the vertical direction, the frame size can be reduced by one-half (24 mm by 18 mm), thereby producing twice as many pictures per unit length as full-frame photography. The resultant half-frame format is still large enough that excellent picture detail is possible, even when the images are enlarged for viewing.

CAMERAS

The camera systems used in photologging are manufactured by companies that traditionally provide high-quality photographic instrumentation in response to contract work for the U.S. government—particularly the Department of Defense. This equipment is basically modular in concept and therefore is readily adaptable to photologging applications. In addition, it is designed to withstand hard use under a variety of stringent environmental situations.

A typical photolog camera incorporates a dual-lens system. The primary lens produces that portion of the picture area that approximates what the vehicle driver observes while a secondary lens system captures such data as milepoint, route number, date, and direction. Figure 6 shows the basic components of a typical photolog camera system. Figure 7 shows four 35-mm photolog frames; in this format, the data display is across the bottom of the frame.

Lenses

Because the half-frame format is used, the focal length of the primary lens is lower than the normal focal length for 35-mm photography. For example, a 50-mm lens represents the normal focal length for full-frame 35-mm photography; i.e., with a 50-mm lens and a picture image of 24 mm by 36 mm, normal depth perception can be seen in the photograph. However, the half-frame format of 24 mm by 18 mm requires a normal lens with a focal length of about 35 mm to produce normal depth perception. Thus, if it is desirable to include more of the roadside in the picture, a lens with a focal length between 24 and 28 mm will provide moderate wide-angle coverage. These same focal-length wide-angle lenses on the full-frame format would be excessive for photologging purposes, greatly exaggerating the depth perception relationship by creating the effect that everything is far away. The same scene on the half-frame format is shown with two different focal-length lenses in Figures 8 and 9.

Film Magazines

The 400-ft (120-m) film magazine shown in Figure 6 is the most common for photolog use in the United States; however, several states do use 1,000-ft (300-m) magazines. Normally, two or more magazines are loaded in a changing bag before a day's filming. A 400-ft magazine contains sufficient film for photographing approximately 64 miles (100 km) of highway at 100 pictures per mile (60/km); i.e., one picture every 52.8 ft (16 m).

Control Unit

Another necessary component of the camera system is the control unit, which provides for operator interface and allows manual control of the camera and the data display on each picture frame (Figure 10). Operator controls, system displays, and alarms are included in the unit, which also serves as a junction box for the system's cables.

Exposure Control

Where exposure is not constant but is broken by areas of deep shade caused by trees or structures, automatic exposure control is a significant aid, relieving the operator of one additional task. Most highway agencies get excellent results with automatic exposure control; however, in heavily forested, mountainous terrain, the use of a hand-held light meter

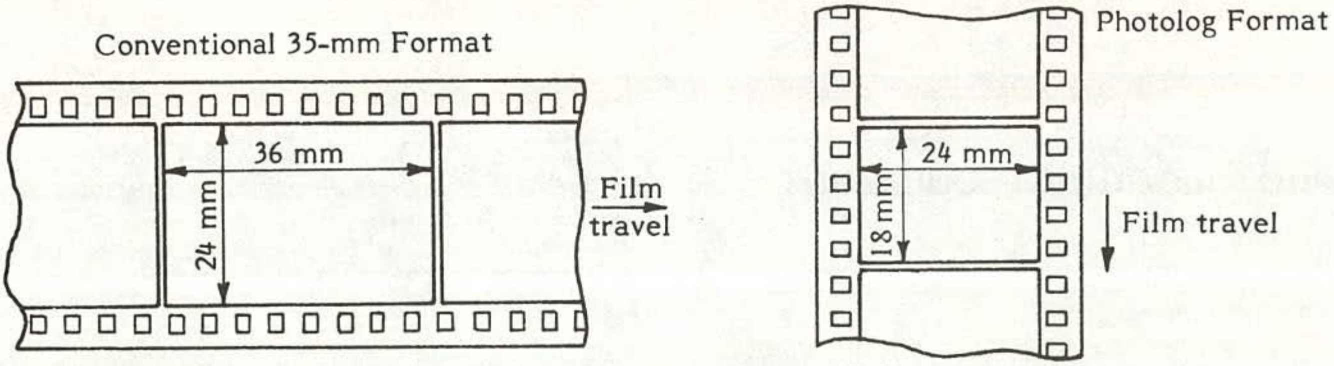


FIGURE 5 Comparison of conventional full-frame and photolog half-frame 35-mm formats.

often provides better pictures. Because hand-held light meters are relatively inexpensive, carrying one as a backup can prove to be a good investment. Figure 11 shows an automatic exposure control unit mounted on the front of a typical photolog camera.

Camera Mount and Bracket

Because the camera, as well as the control unit, is often removed from the vehicle at the conclusion of each workday for security and maintenance purposes, a camera mount with the ability to adjust the camera angle both in the horizontal and vertical axis is necessary. The camera mount also provides for quick removal and, together with a camera bracket, minimizes modification of the interior of the vehicle during installation of the system. Most photologging is done with the camera angled slightly to the right of the center line of travel because there is normally more interest in the roadside hardware and the traffic control devices on the right side of the traveled direction. Also, most state agencies photograph with the camera angled slightly downward in an effort to obtain coverage of pavement deficiencies (see Figure 6 for a typical camera mount and bracket).

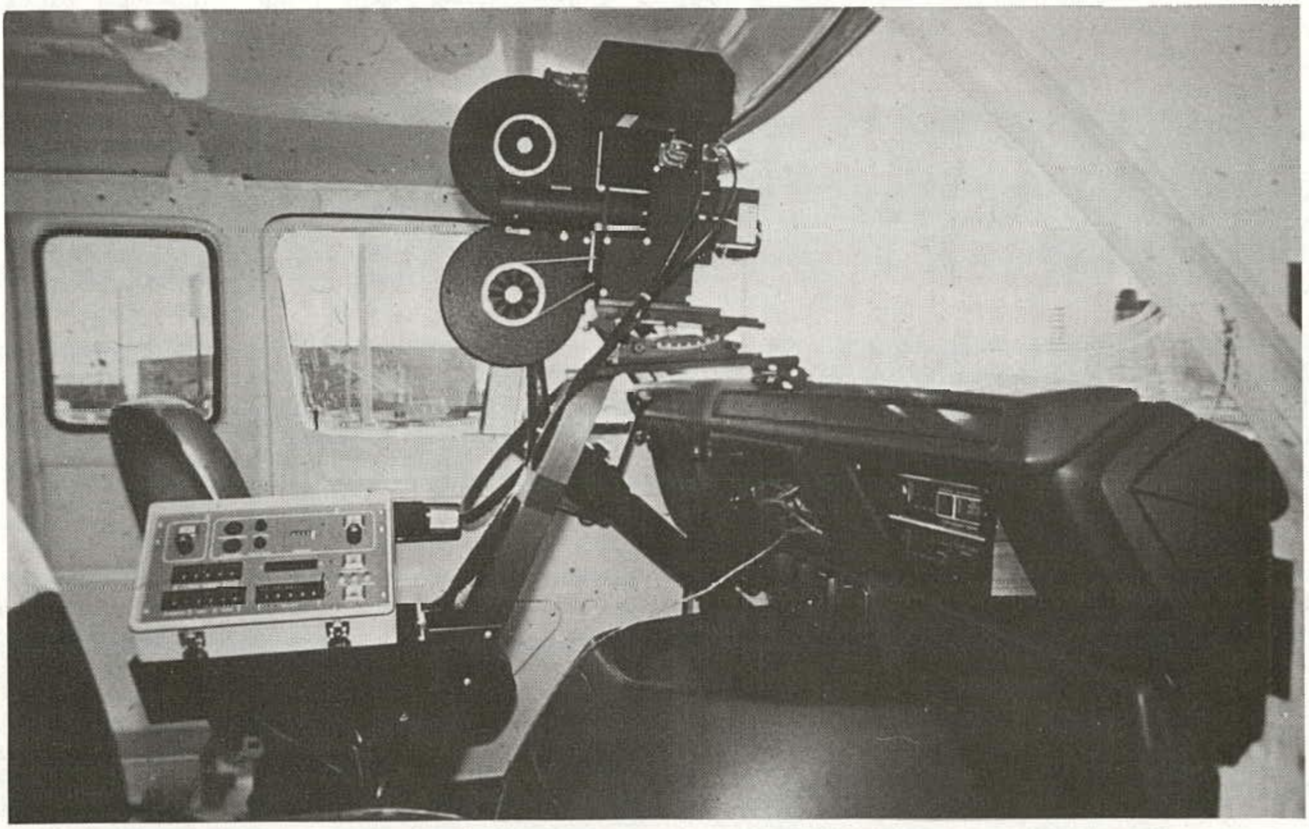
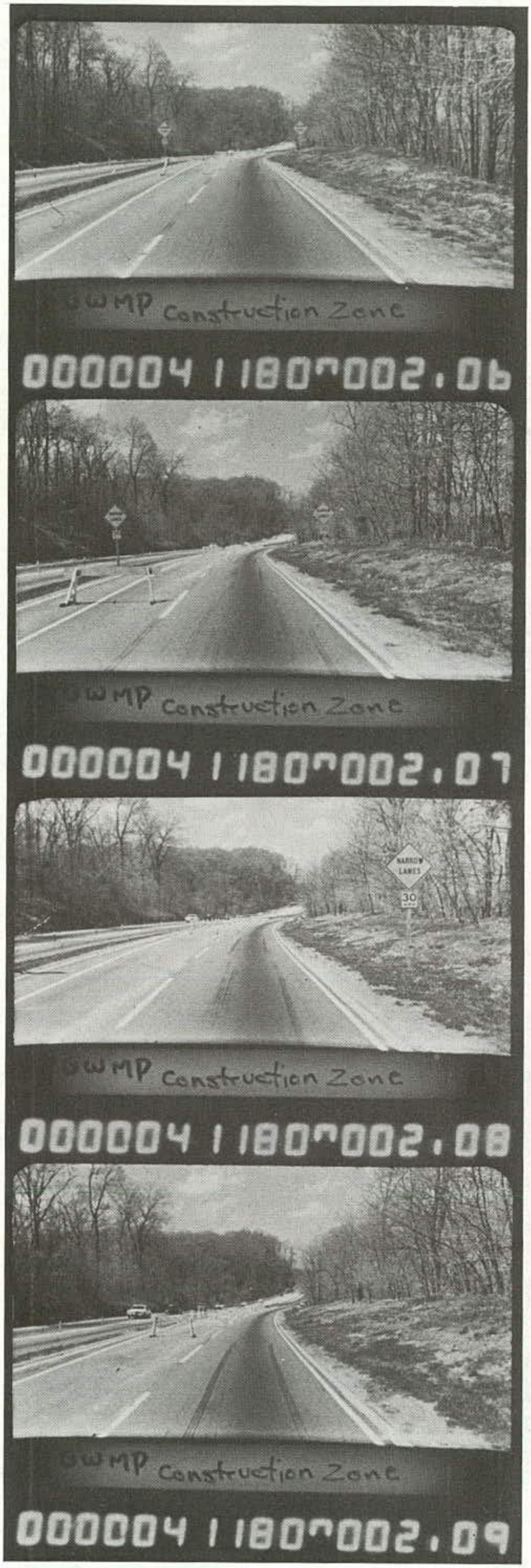


FIGURE 6 Typical photolog camera and recording equipment.



FILM TYPE AND PROCESSING

Kodak Type 5247 color negative film is the predominant type of film used for photologging. Because most agencies obtain several copies of each photolog, the color-negative original permits each copy to be of equal quality. An edited negative roll, a positive print on a reel, and a storage box with index labels are shown in Figure 12. The color negative original is stored for historical purposes or for use when newly photologged sections of highway are spliced onto the original. Where multiple copies are not required, a transparency film, such as Kodak Type 7256, can be used. Technical advice on choice of film type and problems regarding film handling can be obtained from the film manufacturer's technical representatives.

There are many film laboratories that process Type 5247 film, although Kodak is not one of them. The careful purchase of film, processing, and reproduction offers one of the best opportunities for cutting photologging costs. A review of photologging efforts indicated that film and processing costs may be in excess of 30 percent of the total per mile cost for rural photologging for most agencies. Therefore, a \$0.02 per ft (\$0.07 per m) savings in the processing of the original color negative, obtained as a result of comparison shopping, can result in a substantial savings. Because of the unpredictable and frequent increases in film costs, the prices that each highway agency is paying for film and processing are not given; however, the names and addresses of laboratories that are currently processing photolog film are provided in Appendix A.

VIEWING EQUIPMENT

Equipment used to view photolog films can be generally divided into two categories: microfilm viewers and stop-motion projectors.

Microfilm viewers are relatively inexpensive (\$800 to \$1200) but can only be used to view a photolog one frame at a time. Because these viewers are designed essentially to provide a mechanism for reading or studying printed material that has been reduced on 35-mm or 16-mm film, they do not permit the sequential viewing of a series of photographs that might approximate, for example, a motorist's view of the highway environment while driving through an intersection. Microfilm viewers can provide good-quality viewing of any particular frame and are often used by agencies; for example, in a highway district office that does not require extensive use of photologs. Some microfilm viewers can produce a black-and-white paper print of any particular frame that is sufficient for internal agency use. At least one viewer (Micro Design DC 580 from Datacorp) can produce a positive print from positive film. If an agency has a photolab, several relatively simple and inexpensive processes are available to produce color prints directly from positive film.

Stop-motion projectors, although considerably more expensive (\$6,000 to \$9,000), utilize either a shutter mechanism or a quick frame pull-down technique to present photolog

FIGURE 7 Four frames from a 35-mm photolog film.

FIGURE 8 Photolog frame taken with ''normal'' (35-mm) lens.

FIGURE 9 Photolog frame taken with wide-angle (24-mm) lens.

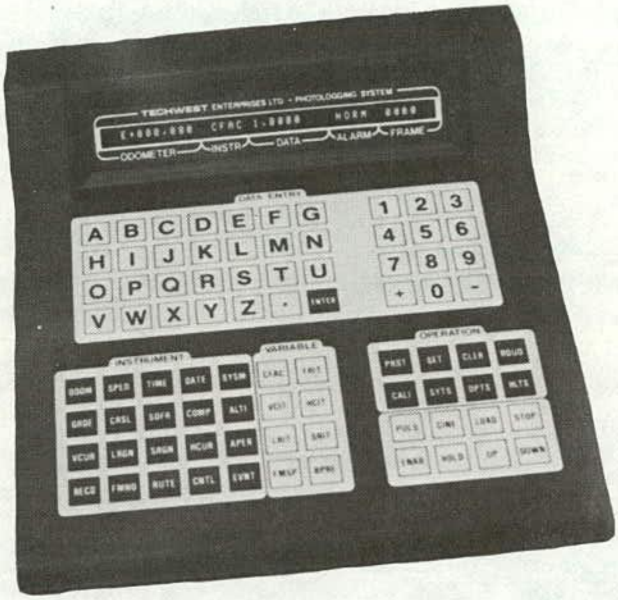


FIGURE 10 Control unit for microprocessor-based photolog system (Techwest Enterprises Ltd.).

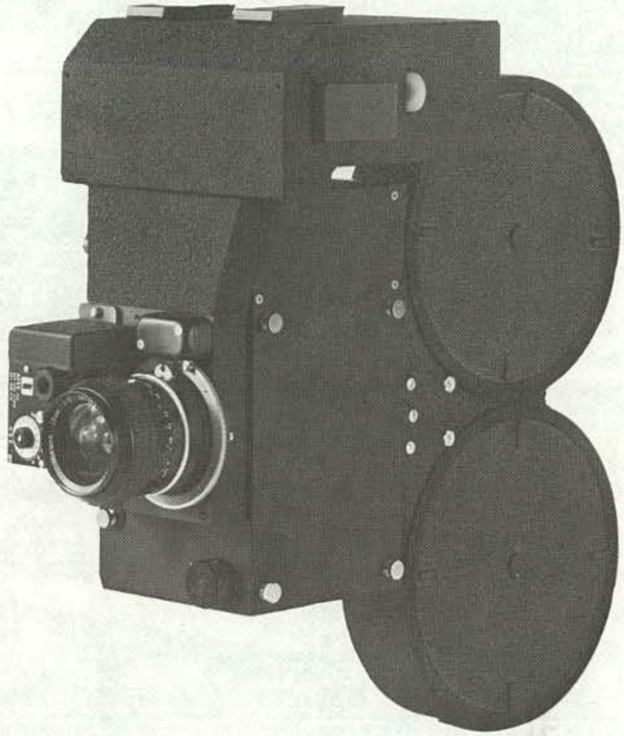


FIGURE 11 Automatic exposure control unit (Instrumentation Marketing Corp.).

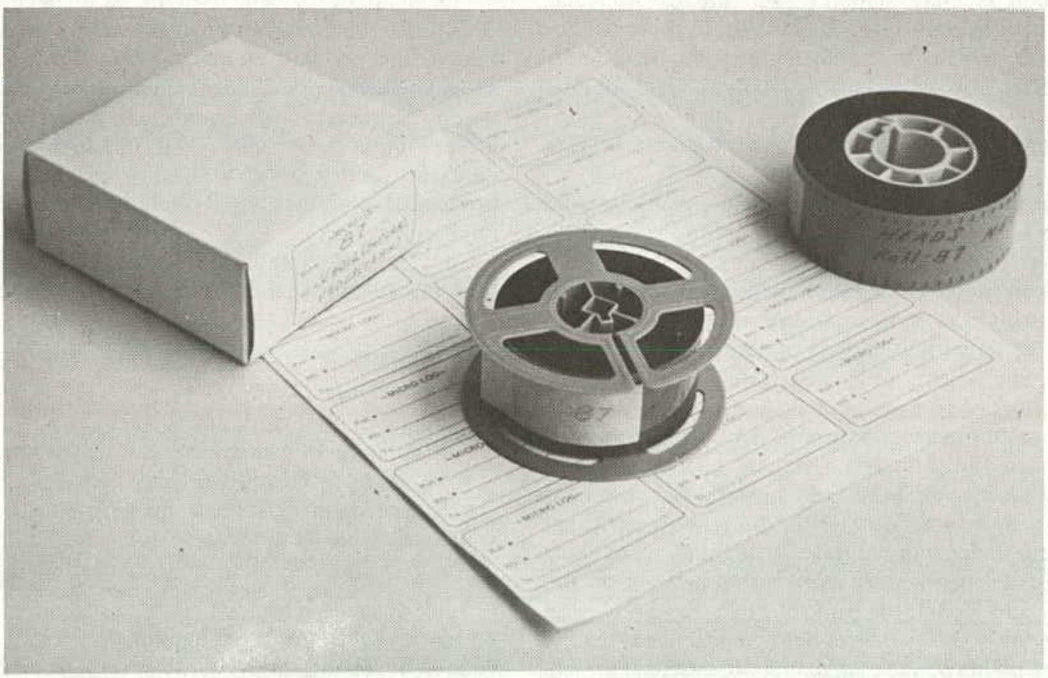


FIGURE 12 Storage box, index labels, positive print on reel, and edited negative roll.

FIGURE 13 Microfilm viewer and stop-motion analyzer.

pictures in a way that approximates a motion picture. In fact, when photologs are displayed at high projector speeds, the resultant action is quite smooth, even though vehicular speeds appear to be very high. This ability to present a sequence of pictures without the distracting frame line interruption can often provide an engineer with a "feel" for how it is to drive on a particular section of highway. Both a microfilm viewer and a stop-motion analyzer are shown in Figure 13.

Because the projectors can be operated at variable speeds, it is possible to approximate an actual driving speed on a stop-motion analyzer; therefore, an observer can make rough judgments, such as the rate at which signing information is presented to the motorist. However, the use of wide-angle lenses, along with the taking of photologs at a higher than normal eye height, precludes highly accurate judgments.

Most stop-motion projectors used for photologging have both rear-screen and wall-screen viewing capability. Wall-screen projection is normally used in darkened areas for larger groups of observers, whereas the rear-screen capability is used under normal interior lighting conditions usually by one or two observers. Also, depending on the manufacturer and model, the projector may have provision for a grid overlay or a digitizer for automatically determining coordinates of points on the rear screen. Rear-screen projection and wall projection uses of a stop-motion analyzer are shown in Figures 14 and 15.

PHOTOLOG VEHICLE

The photolog vehicle used by most agencies is a van (Figure 16). Because extensive amounts of driving and attention to the onboard equipment are required, the vehicle should be equipped with conveniences such as air conditioning, bucket seats, large engine, and power steering so that driver fatique can be minimized. In addition, a converter is necessary so that the 12 V DC power system in the van can be stepped up to the 24 V DC required for the cameras used in photologging.

Conventional photologging practice has been to include at least the following modifications to the vehicle:

- Installation of electronic odometer for accurate mileage readings (Figure 17).
- Fabrication of work/storage area.
- Installation of camera bracket, cables, and converter.
- Mounting of hazard warning lights.
- Replacement of regular tires by steel-belted radials, which are believed to increase odometer accuracy.

Some agencies have found it best not to indicate by signing or special lights that a photographic operation is underway because it can attract the curious and mischievous elements of the driving public. Other vehicle modifications are discussed in the section on second-generation photologging.

ADDITIONAL EQUIPMENT

The following equipment and supplies are needed to edit, splice, and store processed film: film splicer, film winders, optional editor/viewer, storage cabinets or wall shelves, film storage boxes, address labels, and film storage reels. Some of this equipment is shown in Figures 18 and 19.

FIRST-GENERATION VERSUS SECOND-GENERATION EQUIPMENT

The preceding discussion addresses the system of photologging most commonly in use today. The term *first generation* is appropriate to use for this type of photologging, because the more sophisticated equipment now available (referred to as *second generation*) greatly expands data-gathering and data-reduction capabilities. A careful distinction should be drawn between the two systems, because of the higher cost and level of complexity of the new equipment.

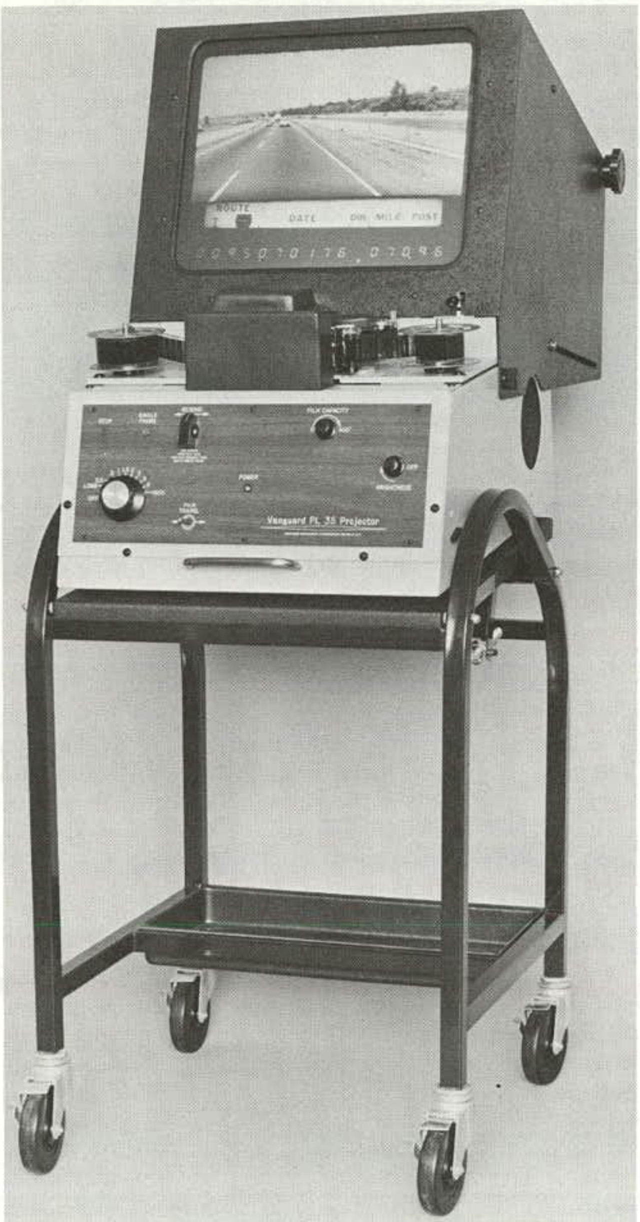


FIGURE 14 Rear projection on a stop-motion analyzer (Vanguard Instrument Corp.).

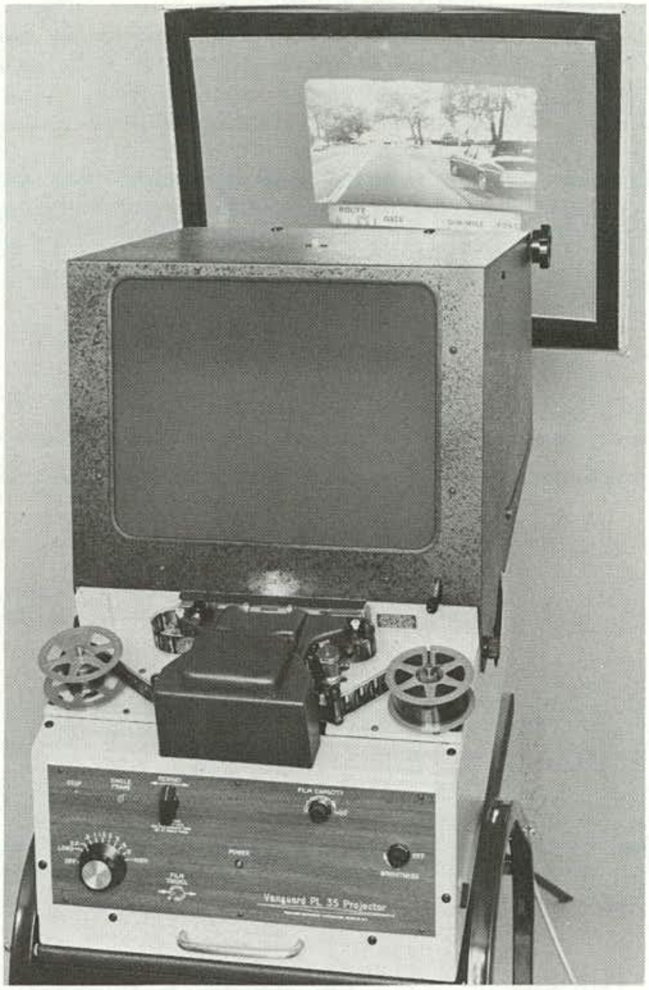


FIGURE 15 Wall projection from a stop-motion analyzer (Vanguard Instrument Corp.).

First-Generation Equipment

In first-generation photologging, the principal objective is to obtain pictures of the roadway and its environment and certain data about the highway including, as a minimum, milepoint, route number, and direction. The photolog vehicle acts as little more than a conveyance for the camera system with the exception of the milepoint information provided by the vehicle odometer. Data, other than milepoint, are preset manually before filming by using the thumbwheel switches on the control unit or by means of grease-pencil notation on the removable data slate in the camera.

First-generation photolog film is a sequential recording medium where all of the gathered data are confined to the film itself; therefore, data reduction is sequential and must be accomplished by manually searching the record for either

FIGURE 16 Photolog van used by the Maryland Department of Transportation.

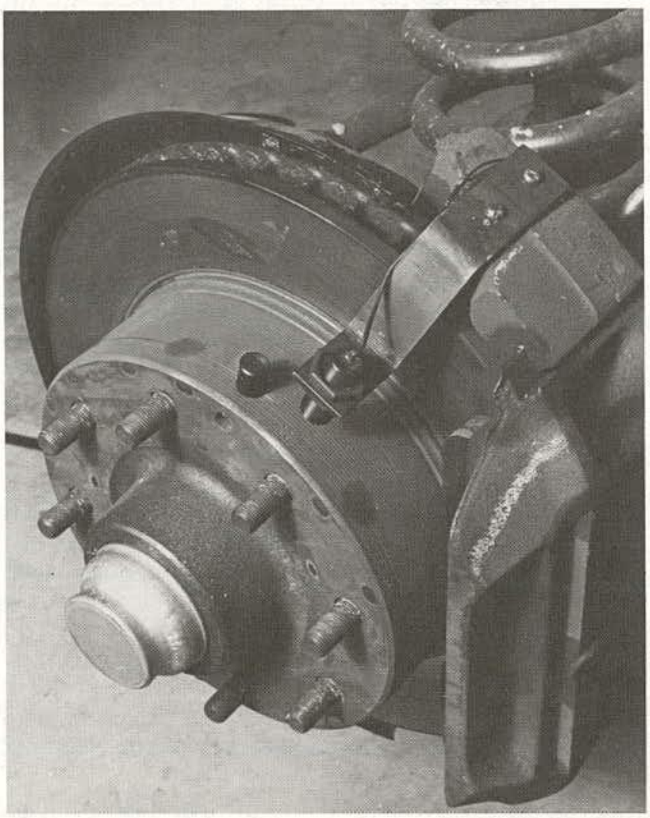


FIGURE 17 Placement of magnets for electronic odometer on photolog vehicle (Techwest Enterprises Ltd.).

known milepoint locations or for visually detectable information such as highway signs or structures. Normally, a reel of photolog film is indexed and filed by county, route number, and milepoint limits. Index maps, often with references to paper route logs or straight-line diagrams, display the file location (e.g., cabinet and drawer number) of each reel of film (see Figure 13).

Second-Generation Equipment

In addition to pictures of the roadway, its environment, and certain minimal data about the highway, second-generation photologging records data on film and magnetic tape obtained by special instrumentation in the vehicle. In short, first-generation photologging has the single function of recording pictures, whereas second-generation photologging has the two additional functions of taking measurements and recording information on magnetic tape.

Figure 20 shows a graphic representation of the data display for a typical second-generation photologging system. This information appears on each picture and is recorded on magnetic tape at the same time. Figure 21 shows a second-generation photolog frame with the data display across the top of the frame. In-vehicle second-generation equipment is shown in Figures 22–25.

The vehicles used for second-generation photologging must also be modified to some extent—most of these modifications are usually performed by the photolog equipment manufacturer after delivery of the vehicle. So that information such as bearing, degree of curvature, and gradient can

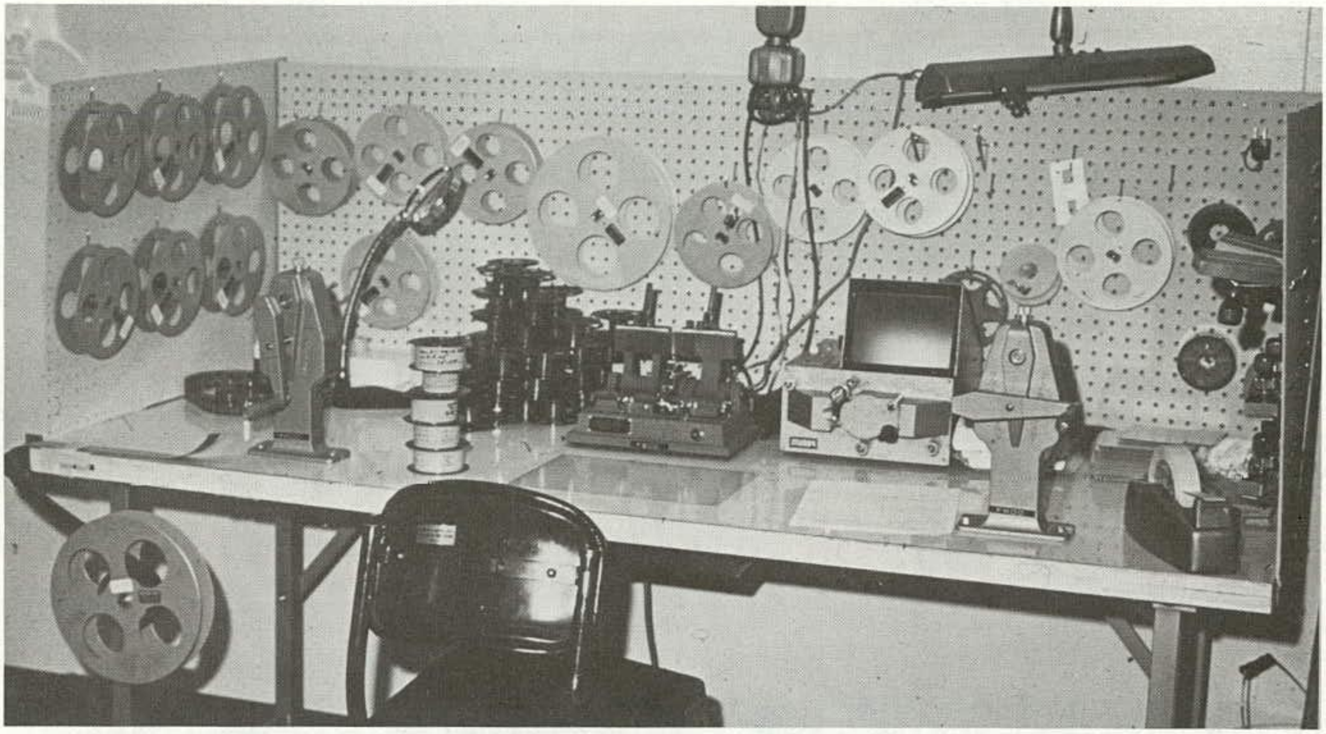


FIGURE 18 Equipment used for editing photolog film.

be obtained, both horizontal and vertical gyroscopes are included in the system. The primary source of such information as roughness and side friction factor is an instrumentation unit mounted on the axle (Figure 26). Typical second-generation installations may require at least three inverters for DC to AC conversion: one 12 V DC to 110 V AC, 60 Hz, single phase, square-wave inverter for a digital cartridge recorder or a reel-to-reel recorder; and two 12 V DC to 110 V AC, 400 Hz inverters for a vertical gyro and a gyro compass. The following features are usually specified when a second-generation system is ordered:

- Long wheelbase; e.g., 138 in. (3,400 mm) for Ford van
- Large engine; e.g., 351 cu. in. (5.8 L) V-8 for Ford van
- 100 A alternator and second battery on line to provide power for the additional electrical equipment
- Radial tires
- Heavy-duty or adjustable air shock absorbers
- Windows with dark glass (except windshield) for privacy and security
- Light-colored paint and additional insulation for temperature control
- Items for comfort and convenience of the crew, including power brakes and steering, automatic transmission, cruise control, swivel chairs (also for improved access to equipment), and high-capacity air conditioning

Before a highway agency purchases a second-generation system, three considerations should be addressed: (a) larger personnel commitment; (b) need for operator experience in electronics; and (c) cost. Because of the more sophisticated on-board electronic equipment (especially the magnetic tape recorder), an agency contemplating the purchase of second-generation photologging must be willing to commit computer systems personnel so that software edit programs and other file sorting and processing programs can be prepared. In addition, there may be a need for electronics maintenance personnel to track down problems with certain components such as circuit boards. Photologging should be accomplished as much as possible during the warm-weather months (especially in the northern states) when the days are longer, the sun is higher, and weather conditions are better; thus most of the maintenance and troubleshooting must be done by the highway agency instead of the manufacturer.

The nature of the electronics also requires that servicing be available in the field, either by operator expertise or highway district office technicians, so that lengthy trips back to a headquarters facility can be avoided. Some second-generation users believe that a complete second set of circuit boards should be purchased in an effort to minimize equipment downtime. Ideally, an operator should at least know how to identify and repair or replace faulty circuit boards. In addition, equipment calibration at the beginning of each day is more complex and the normal operation of the equipment requires closer monitoring than does first-generation photologging. An equipment checklist used at the beginning of each day is shown in Appendix B; the duties of the crew members are also indicated.

EQUIPMENT COSTS

The following approximate costs (1980) are typical for a standard system. The prices represent, for the most part, the costs incurred by several highway agencies in 1980 for the

FIGURE 19 Photolog film storage cabinets and viewer.

items listed below. Similar products from other suppliers may cost more or less depending on specific features and/or quantities purchased. Also, some agencies may not need, for example, microfilm viewers and projectors; therefore, simply totaling the prices of the items shown may not be indicative of the real costs of a particular agency. Second-generation systems also require additional costs for equipment maintenance and computer time and programming. [An investigation of potential applications and costs of a statewide photologging program in South Carolina included estimated equipment costs (1980) for implementing the program (Table 1) (*6*)].

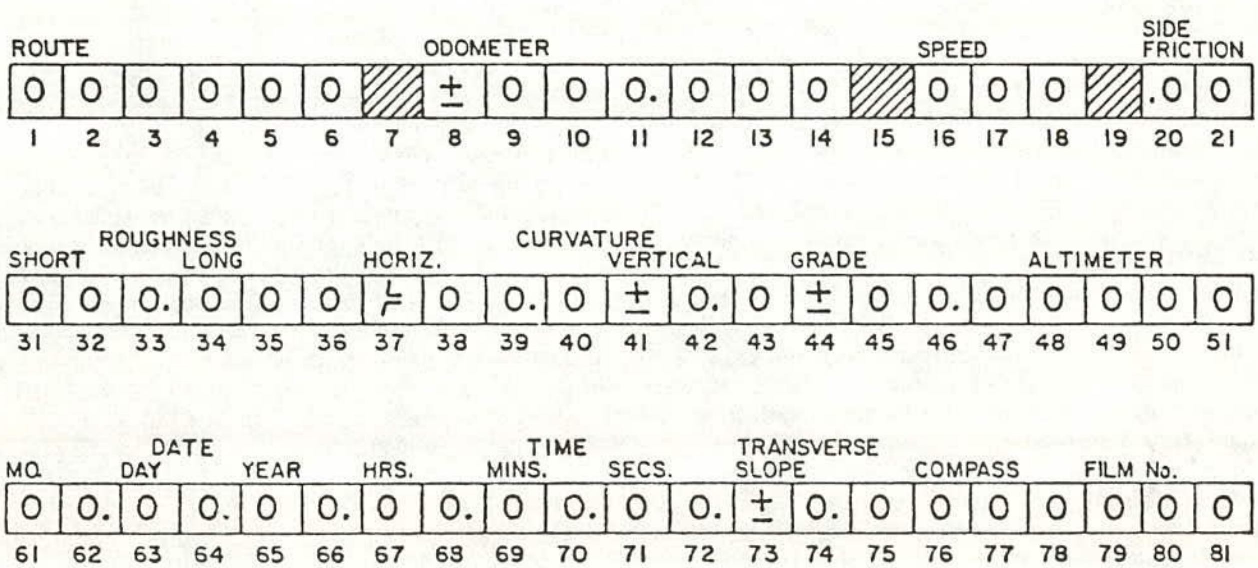


FIGURE 20 Graphic representation of second-generation photolog display (Techwest Enterprises Ltd.).

FIGURE 21 Second-generation photolog frame (Techwest Enterprises Ltd.).

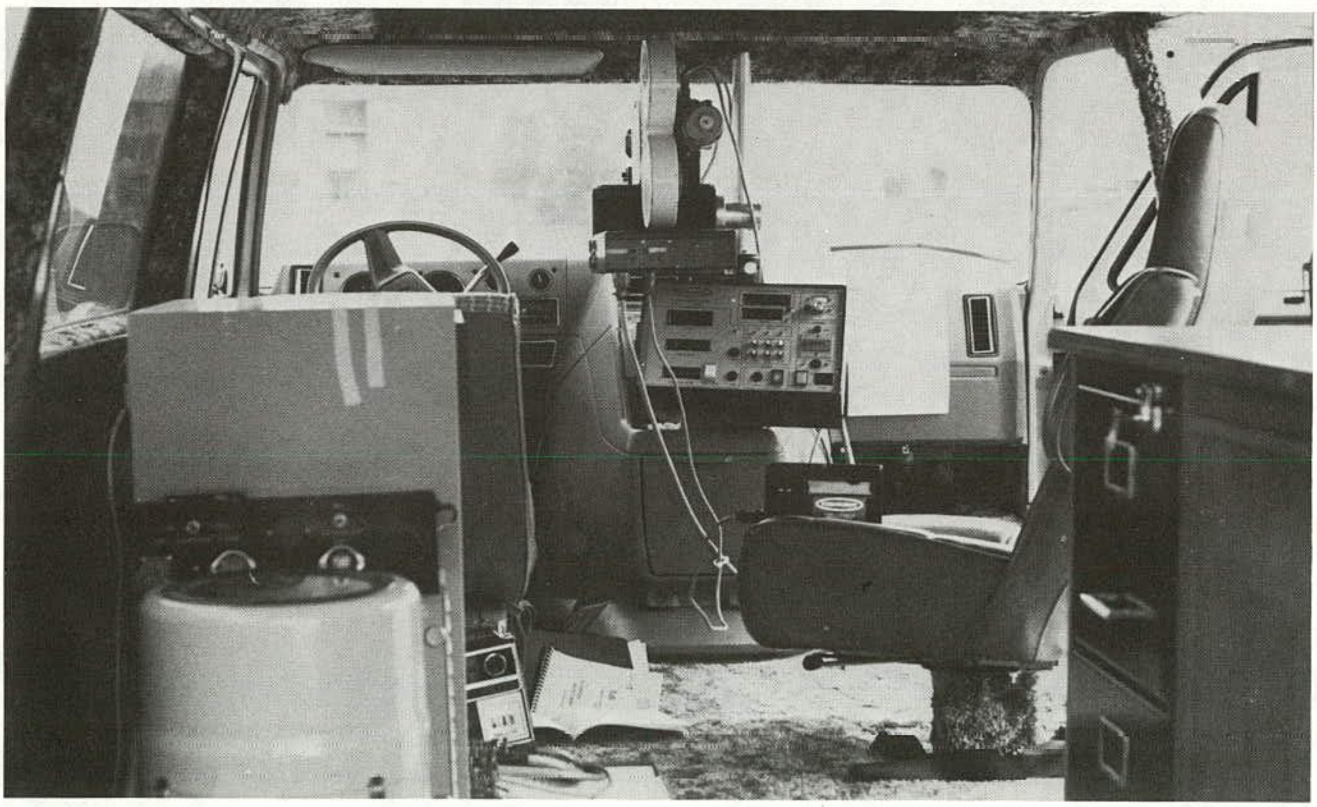


FIGURE 22 Interior of photolog van (in Maryland).

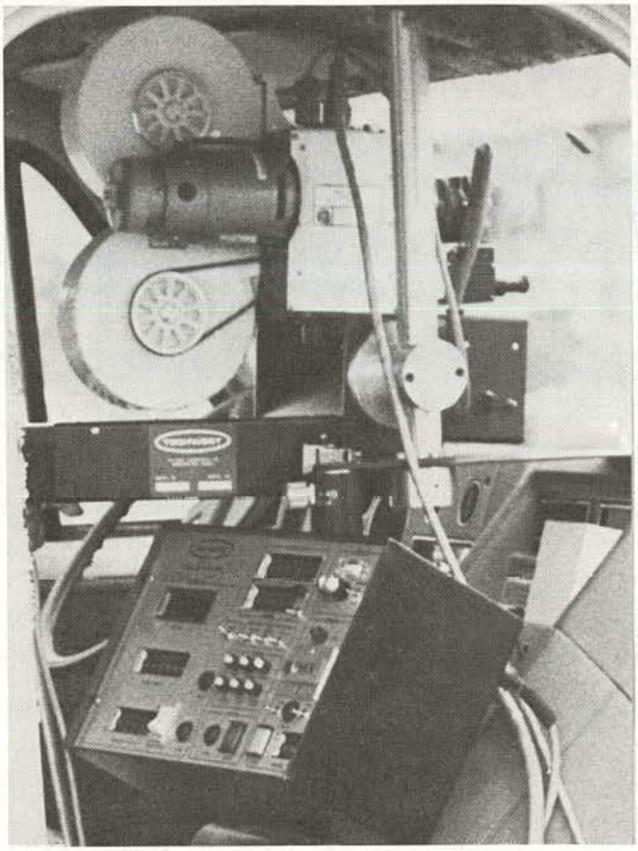


FIGURE 23 Camera and control unit (in Maryland).

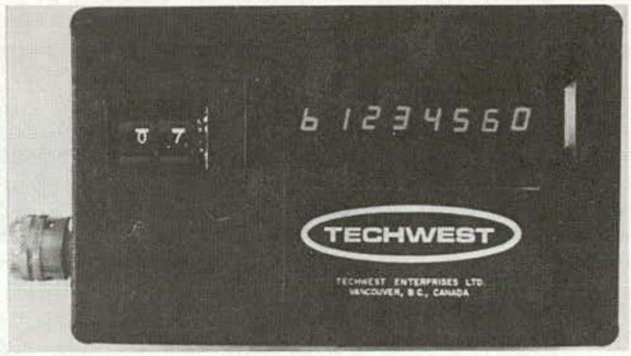


FIGURE 24 Remote display unit (Techwest Enterprises Ltd.).

First Generation

Vehicle $8,500.00

Camera system (includes 10- to 15-digit data display with removable data slate as shown in Figure 7), consisting of a 35-mm camera with variable shutter, camera mount and bracket, lens, automatic exposure control, 400-ft (120-m) film magazine, operator's control unit with external data entry, power inverter, electronic odometer, installation, and testing $24,000.00

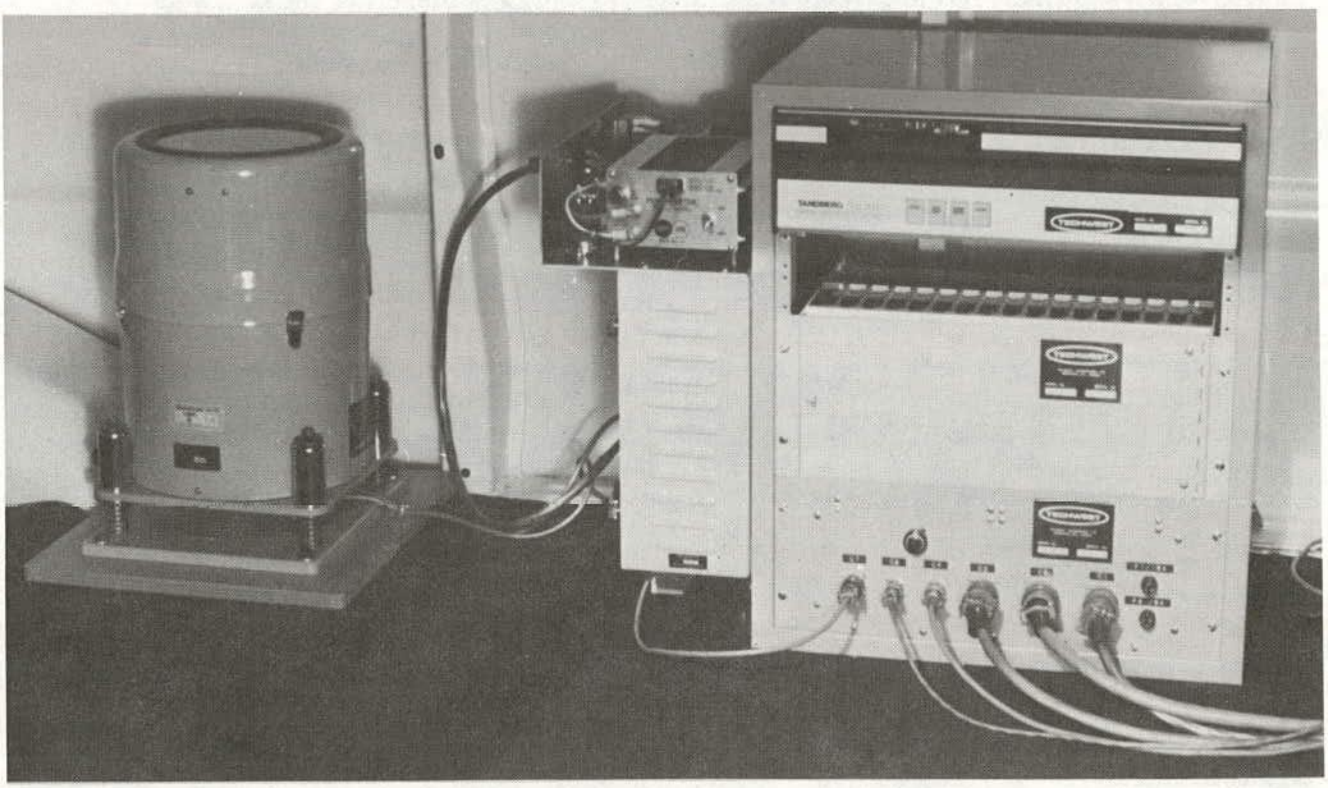


FIGURE 25 Gyroscope and magnetic tape data recorder (Techwest Enterprises Ltd.).

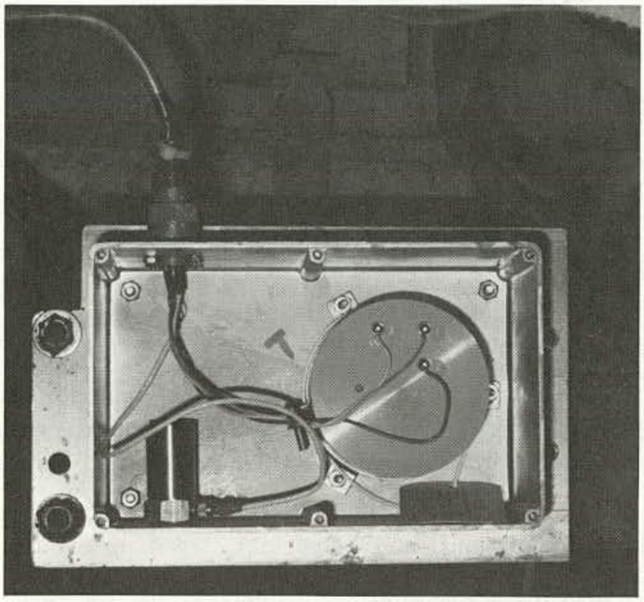


FIGURE 26 Servo box mounted on axle (Techwest Enterprises Ltd.).

Second Generation

Vehicle $9,000.00

Camera system (includes instruments for typical data display as shown in Figure 21), consisting of a 35-mm camera with variable shutter, camera mount and bracket, lens, automatic exposure control, 400-ft (120-m) film magazine, operator's control unit with external access, display unit, instrumentation unit, magnetic tape recorder, power inverters, electronic odometer, installation, and testing $66,000.00

Items Common to Both Systems

Projector (stop motion) with cart	$5,900
35-mm Camera and attachment for still photos (for use on projector)	1,650
Viewer (microfilm)	800
2 Microfilm storage cabinets with a total of 8 drawers and work table	2,200
Cold-tape film splicer	550
12 Rolls of splicing tape	133
2 2,000-ft (600-m) Negative rewinds	350
2 1,000-ft (300-m) Split reels	30
2 400-ft (120-m) Split reels	25
Film bin for editing	50
1,000 Storage boxes	80
1,000 100-ft (30-m) Plastic reels	160
100 2-in. (50-mm) Plastic cores	10
12 White cotton gloves	36
1,000 ft (300-m) Film leader	50
Changing bag	45
Editing table with light box	210

TABLE 1
ESTIMATED COSTS OF PHOTOLOGGING EQUIPMENT (1980) *(6)*

Component	Minimum Cost First Generation System	Maximum Cost Second Generation System
35mm Camera, Lens, and Control System with Automatic Exposure Control	$20,000	$65,000
Van Vehicle with Recommended Accessories	9,000	9,000
Photolog Viewers (1 in central office and 7 in district offices)	48,000	48,000
Film Editing Equipment, Film Storage Cabinets, and Miscellaneous Equipment	8,000	8,000
TOTAL EQUIPMENT COST	$85,000	$130,000

CHAPTER FOUR

PHOTOLOGGING TODAY

Information regarding photologging in the United States was obtained from the following three sources:

1. Personal knowledge and work done by the author of this synthesis,
2. Interviews with personnel in 15 states responsible for photolog programs, and
3. Survey forms sent to all known users.

SURVEY RESULTS

The survey of highway agencies and industry representatives indicates that there are 41 states, at least 5 cities, and 1 county in the United States and 3 provinces in Canada that have purchased equipment and developed their own photologging programs (Appendix C). In addition, 24 cities, 5 counties, 1 toll road, 7 Canadian highway agencies, and the U.S. Park Service have contracted for photologging work. Although this probably reflects the vast majority of all photologging efforts, there may be a few agencies not included in this report—especially if the work was done by a state for a city or county in that state.

Ten states and two Canadian provinces have taken delivery of second-generation systems. Minnesota has purchased an additional second-generation system for use on secondary roads. Nine of the states and one province had previously operated a successful first-generation system; thus the considerable additional equipment expense for the second-generation system was apparently assumed with some assurance that it would be cost-effective.

At least five other states and several counties and cities have taken initial steps toward developing a first-generation program; six additional states that now have first-generation photologging are seriously considering the purchase of second-generation systems. Second-generation photologging is also under consideration by two Canadian provinces.

Eight other countries—Tanzania, Nigeria, South Africa, New Zealand, Greece, West Germany, Argentina, and Great Britain—are known to have photolog equipment, and there have been serious inquiries from Saudi Arabia, Costa Rica, and Yugoslavia.

Several regions of the U.S. Forest Service have utilized photologs of remote-access roads, and the FHWA is under contract to the U.S. Park Service to photolog the entire park service roadway network.

The Connecticut DOT has purchased a second-generation system that is mounted in a Hy-Rail vehicle for purposes of obtaining railroad inventories. Iowa is also using a Hy-Rail vehicle and on-board computer with a 16-mm photolog camera.

Highway photologging is being done at all levels of government, as well as the private sector, and interest in the technique is on the increase. It has been estimated that in excess of 500,000 miles (800,000 km) of highway has been photologged in the United States alone.

State highway agencies are the most common users of photologs today. Within the highway agencies, the responsibility for acquiring photolog film usually lies with the planning inventory sections; however, in most cases the impetus for developing a photolog program was generated in the traffic engineering section. Arizona, California, Delaware, Idaho, Nevada, New Jersey, Oklahoma, Virginia, Washington, and Wyoming all have published reports on photologging. Most of the reports are procedural; however, several contain some evaluation information.

Following is a summary of additional specific information obtained from the survey of all agencies using photologs in the United States.

Equipment, Film, and Processing

- All but four states (Arizona, Idaho, Iowa, and Oregon) utilize the 35-mm film format.
- All contract photologging in this country is in the 35-mm format.
- The majority of states utilize either a 24-mm lens or a 28-mm lens as the primary camera lens.
- The four states with 16-mm photologging utilize 10-mm lenses.
- All but two states (Alaska and Washington) use automatic exposure control.
- Most states use 400-ft (120-m) film magazines and therefore purchase original film in 400-ft rolls.
- Three states (Idaho, Kentucky, and Louisiana) use 1000-ft (300-m) magazines; several others use combinations of 200, 400, and 1000 ft (60, 120, and 300 m) sizes.
- About three-fourths of the states that use photologs use magnetic target, electronic odometer camera actuation.
- Almost all photologs are obtained with camera shutter speeds of 1/250, 1/500, or 1/100 sec.
- At least 23 states have purchased projectors for use in all district offices.
- All states that utilize 35-mm photologging use color negative film from which prints are made for projection.
- The two states that utilize the 16-mm format use color positive film, which can be projected immediately after processing.

Procedures

- Most photologs are updated on a 3- to 5-yr cycle.
- Three-fourths of the states store their photolog prints on 100-ft (30-m) reels, and most of these states index and file the reels in commercial microfilm cabinets.

- All but a few states utilize two-person field crews.
- Forty percent of the states find it advantageous to photolog freeway ramps.
- Half of the states have some type of overlay grid with which to obtain roadway dimensions from film; however, some indicated that the grids are time-consuming to use, not very accurate, and therefore seldom used.
- About half of the states maintain logs of the uses of the photologs.
- Photolog filming is generally done from early spring to late fall; little filming—except for special projects—is done in December and January.
- Many states have initiated a preventive maintenance program during the winter months so that the equipment is ready for the start of each new filming season.

Use

Half of the states have found that photolog film or hard-copy prints made from the film have been useful in court proceedings involving tort liability cases.

Costs

A review of film processing costs indicated sufficient variations in costs to process the originals and obtain prints to suggest that each user should comparison shop for processing. Costs are changing so rapidly that it is not feasible to determine realistic averages.

COSTS AND SAVINGS

In an effort to develop an average cost per mile for photologging, the reported costs from the 12 states that submitted reasonably complete cost information were analyzed (Table 2). In these states, photologging was begun between 1970 and 1977; the one-way miles of highway that were photologged ranged from about 8,000 to 30,000 (13,000 to 48,000 km), not including deadheading. Obviously, any effort to arrive at average costs for estimating purposes is subject to great variability because costs for all elements of photologging, from equipment to manpower, have increased over the years. Further, the total number of miles photologged directly affects the calculations, as does the amount of deadheading experienced by each state. (Note that in Table 2 the total miles driven are 2.3 times the miles photologged.) Film and processing costs are included, although in the last several years this item has seen the highest percentage increase of any of the cost elements. Until the recent steep rises in film-related costs, approximately 30% of the total per-mile cost could be attributed to this item.

An operating procedure used in South Dakota saves editing time and shipping costs. Film storage reels used in the office hold 100 ft (30 m) of film, which represents 15 miles (24 km) of photologging at 100 frames per mile (62/km) and 3 ft (1 m) each of leader and tailer. The field procedure is to photolog 15 miles of highway, turn off the LED's (a switch and indicator lamp were installed for this purpose), cover the lens, pulse 6 ft (2 m) of film through the camera, uncover the lens, turn on the LED's, and continue this sequence. The resultant negative does not have to be edited; thus prints can be made before the negative is returned from the processor, which saves time and shipping costs. Prints are edited by winding to the 6 ft of black film and cutting it in the middle to make a leader and tailer for each roll; this saves editing time and eliminates many splices.

Estimated operating costs for photologging from a 1981 study are given in Table 3 (*6*). When these costs are added to the equipment costs from Table 1, the total costs, spread over a 3-yr period, are \$18.27/mile (\$11.35/km) for first-generation photologging and \$21.27/mile (\$13.22/km) for second-generation photologging.

The number of roadway miles (one-way) that can be photologged in a day depends on many factors including roadway type, traffic volume, on-street parking conditions, and length of roadway. Table 4 provides average photologging rates for various roadway types.

Information on savings was not readily available; estimates that were available were based on gross estimates of savings. The methods of determining the savings varied from state to state. Estimated savings resulting from the use of photologs in Maryland are given in Table 5.

Interviews with management officials in the 15 states visited indicated that the photolog program was perceived to be cost-effective and, although there were few efforts underway to conduct specific program evaluations, photologging was believed to be worthy of continued funding support. South Carolina and Virginia conducted evaluation studies (*6, 7*) in an effort to investigate the applicability of photologging. Both studies concluded that a statewide photolog system would be a cost-effective tool and recommended specific equipment, the organizational unit that should have responsibility for the program, and the projected costs.

TABLE 2
FIRST-GENERATION PHOTOLOGGING COSTS PER ONE-WAY MILE (AVERAGED FOR 12 STATES) (1970–1977)

Vehicle	\$0.607
Equipment	2.175
Maintenance	0.043
Personnel	2.829
Film, Processing, and Reproduction	2.668
Miscellaneous	0.124
Total	\$8.448
Total Miles Driven	480,510
Total One-Way Miles Photologged	211,139

TABLE 3
ESTIMATED ANNUAL COSTS FOR PERSONNEL, SUPPLIES, AND SERVICE (1980) (*6*)

Personnel and Expenses	
Two Technicians	$24,000
Expenses	4,000
Supplies	
Color Film (150 400-feet rolls @ $110 per roll)	16,500
Services	
Film Processing	4,000
Film Printing (two prints)	10,500
Vehicle Operating Cost 20,000 miles @ $0.20/mile	4,000
TOTAL ANNUAL COST	$63,000
Annual Cost per Mile of Highway Photologged (based on a 5,000 mile per year photologging program for a three-year period)	$12.60

USES OF PHOTOLOGGING

The uses of photologging as a tool to obtain information about the physical characteristics of the highway system have been documented. Three significant factors affect the use of photologging within a highway agency:

1. Level of support and promotion by management,
2. Access to photolog film and projectors in a neutral area, and
3. Availability of a completed, updated photolog of an entire highway system.

Basically, photologs are obtained for one or more of the following general use categories: review, confirmation, measurement, and documentation. Not all highway agencies require photologs for each of these categories. For example, a state agency, because of the large number of photologged miles of highway and the variety of users, might employ a photolog to review high-accident locations, confirm the location of utility crossings, measure physical characteristics for inventories, and document the location of roadside obstacles. On the other hand, a small city highway agency, with limited street mileage, might only be interested in a computerized inventory system that requires taking measurements from film and documenting the number and condition of traffic-control devices. Because of the short distances within a city, any site reviews or confirmation activities can be handled more quickly and efficiently by traveling to the site in question instead of viewing a photolog of the site.

In general, most photologs in state highway agencies are used primarily as a source of site review where a specific location is viewed for information about the physical characteristics of the site. This manual data-reduction practice is especially characteristic of the uses of first-generation photologs. Although second-generation photologging offers the potential for automated computer review and assembly of the data recorded on magnetic tape, it is not yet being done to any extent.

In Wyoming a computerized accident file is linked to a computerized second-generation photolog information file to review high-accident locations. This procedure can be used to program safety projects. For example, when analysis of the files indicated a high-accident section of one highway, a study of the photolog film and data showed reverse superelevation problems because of back-to-back horizontal curves, high side-friction readings, and a steep vertical grade. A re-

TABLE 4
PHOTOLOGGING RATES[a]

Roadway Type	Miles Per Day
Rural Limited Access Highways	150-170
Urban Freeways	90-110
County Roads and City Streets (Mid-Size City)	30
City Streets (Large City)	10-12
City Streets (Heavily Congested Large City)	7

[a]Courtesy of Goodell-Grivas, Inc.; Southfield, Michigan

construction project, to upgrade the roadway geometrics, was initiated.

Although it is generally true that photologging is considered to be a cost-effective tool by the majority of user states, the degree to which the tool is used varies by state. In one state, personnel make only casual use of the existing photologs and there are no plans for updating the photologs. At least two states have discontinued funding support for the photologging program because of budget cutbacks. On the other hand, it was the threat of budget cutbacks that provided the incentive for several states to implement a photolog program in the first place. Potential restrictions in the use of official vehicles for field inspections led to renewed interest in photologging. Obviously, there are many factors—existing state procedures, funding priorities, varied need for field data, and management support (to name only a few)—that influence the degree to which a tool such as photologging is used. Also, the length of time for acceptance of a new tool and when it is utilized to its maximum extent varies by state.

PHOTOLOGGING AS AN INVENTORY TOOL

Most states have not yet utilized photologs extensively for inventory purposes, as is commonly done with urban photologs (see discussion under Contract Photologging later in this chapter). This is probably due to the large personnel effort required to manually reduce the inventory data from film. Although it appears that inventorying highways on a statewide basis by means of photologs would be less expensive than doing so with field crews, there are few comparative studies to support this contention. The entire area of inventory procedures and methods, including the relative advantages and disadvantages of the various techniques, is not well documented.

In an effort to understand the use of photologging as an inventory tool, a brief discussion of the types of data and the methods available for performing inventories is helpful. Basically, the following data are obtained from most inventories: (a) locations of physical features; (b) descriptions of physical features; (c) dimensions of physical features; and (d) evaluations of physical features. Further, the majority of the inventories being done today employ one or more of the following methods: manual field crews; on-board microprocessors with keyboard entry; and photologging/videologging.

The manual inventory is the most common. Crews complete data sheets in the field for later coding and computer entry. Decisions regarding the four types of inventory data are made at the field level. This method is usually time-consuming, costly, and subject to inaccuracies, and the data are not verifiable.

On-board microprocessors, such as the Transwave Unit, are relatively new and require, again, that all four types of inventory data be gathered at the field level. Dimensions must be obtained manually and evaluations are not verifiable. The microprocessor permits the automatic compiling and manipulation of the data for review.

Photologging permits the inventory data to be recorded visually on a medium that is utilized at the office level for extracting the four types of inventory data. The visual record is verifiable and, where second-generation equipment is employed, the automatic calculation of certain data (e.g., degree of curvature) and the automatic compilation of the data generated by the vehicle are accomplished.

TABLE 5
ESTIMATED SAVINGS FROM THE USE OF PHOTOLOGGING FOR 1 YEAR IN MARYLAND

Office	Viewers	Hours Viewed	Field Trips Saved	Manhours Saved	Manhour Savings $	Travel Savings $	Vehicle Savings $	Total Savings $
Headquarters	178	167	140	2,733	32,796	2,300	3,645	38,741
Traffic	396	330	251	4,670	56,040	4,360	6,525	66,925
District 1	18	6	11	76	912	110	210	1,232
District 2	97	21	60	599	7,188	600	1,140	8,928
District 3	90	24	14	182	2,184	140	390	2,714
District 4	145	67	63	953	11,436	680	1,725	13,841
District 5	11	10	10	113	1,356	100	180	1,636
District 6	24	8	17	234	2,808	170	375	3,353
District 7	62	15	17	286	3,432	170	735	4,337
Total	1,021	648	583	9,846	118,152	8,630	14,925	141,707

As previously indicated, comparative studies on which method or combination of methods is best are lacking. There appear to be significant benefits in combining the photologging method with the microprocessor-based method, as more data can be obtained at the field level and much of the office data-reduction work would be eliminated with respect to decisions regarding descriptions and judgments being made in the field. Dimensions could be obtained by using the technique described in Chapter 5.

Techwest has developed a microprocessor-based photolog system that eliminates hard-wired components, incorporates preprogram and automatic monitoring capabilities, and extends the optical data display to 96 alpha-numeric characters.

OPERATOR QUALIFICATIONS

With the advent of second-generation photologging and the considerably more complex electronic equipment associated with it, the issue of more technically qualified operating personnel has become important. As discussed in Chapter 3, second-generation photologging requires a greater personnel commitment at the headquarters level, because a computer is used to process the information obtained from the magnetic tape recorder. Computer programs to edit and manipulate the data must be written and the newly generated photolog inventory file should be addressed, for example, by route number, direction, and milepoint termini so that it can be used with other files (e.g., accident data) having the same address.

However, utilizing computer systems personnel does not address the problem of whether the more sophisticated onboard electronics (e.g., gyroscope) requires a more technically qualified field crew to calibrate and operate the system. Also, if in the future microprocessors with keyboard coding are added to the system, the issue may be even more acute because one of the operators would be required to be involved in the physical inventory acquisition process.

Two of the first states to address this problem were Maryland and Wyoming. Personnel in both states believe that, because of the additional calibration, maintenance, and servicing required for second-generation photologging, their needs are best served by utilizing field personnel with an electronics background.

CONTRACT PHOTOLOGGING

By far the majority of photologging in this country has been accomplished by highway agencies that have purchased equipment and performed the work with their own personnel. Two firms, Goodell-Grivas, Inc., and Techwest Enterprises, Ltd., actively offer contract photologging.

Most contract photologging is performed in urban areas or at the county level where the roadway mileage does not justify the purchase of the equipment. Further, most urban photologging is done for one primary reason—as a base for a traffic-control device inventory. The photolog itself is the information base from which the traffic-control device inventory file is developed (*8*). After the data are extracted from the film, the photolog is retained by the local agency for other uses. However, in smaller urban areas the demand for the use of photologs as a general reference is minimal because it is neither difficult nor time-consuming to actually travel to a particular location for an on-site review.

The largest contract photologging effort to date was begun in 1978 in the Borough of Manhattan, New York. The contractor, Goodell-Grivas, Inc., photologged the 510 miles (820 km) of city streets as part of an inventory of existing signs for a computerized sign inventory system that updates a manual card system dating back to the early 1950's.

RAILROAD PHOTOLOGGING

Just as there are well-defined needs for highway-related inventory data, there are also similar requirements for inventory data regarding the physical features within the rights-of-way of railroads. In 1980 the Connecticut DOT purchased a second-generation photolog system, along with a dual-purpose Hy-Rail vehicle (Figure 27) for potential use on both highways and railroad tracks. Tests were run and a technique developed for producing photologs of the more than 1000 track miles (1600 km) of railroad currently in service in Connecticut.

The photolog equipment incorporates a data display that is similar to those systems now in use in highway photologging and includes data recording on film and magnetic tape. Specific data requirements, including condition of track and roadbed, signing, signalization, cumulative mileage, adjacent environment, and terminal facilities, were determined by the Connecticut DOT. After completion of the filming, the railroad photolog will be available for use by affected railroad operators and others interested in railroad inventory data. Computer programs will also be developed for automatically editing and processing the magnetic tapes. The feasibility of utilizing the Hy-Rail vehicle for highway photologging will be investigated as well.

Iowa is utilizing a Hy-Rail vehicle and on-board computer with a track geometry system that measures degree of curvature, roughness, cross-slope, and rail gauge. The system includes a 16-mm photolog camera, which records railroad identification, time of day, and milepoint; however, the track geometry data are not recorded on film. Photologging is secondary to the track geometry recording function of this system. The rail photologging system in Iowa is separate from that of highway photologging.

VIDEOLOGGING

Partly because of the large increases in the cost of film and processing and because of improvements in video technology, there is considerable interest in the potential of videologging (Figures 28 and 29) as an alternative to photologging. Some of the advantages of utilizing video tape as a recording medium are:

- Video tape does not require processing; finished product is immediate, permitting real-time monitoring.

FIGURE 27 Photolog van for use on railroad tracks as well as on highways.

• Voice recording can be added to the video tape either in the field or at a later date.
• Video tape can be reused.

It should be remembered that video recording, unlike film recording, does not produce individual still photographs and the videotape is in constant motion while in the record mode. Some of the disadvantages of videologging are:

• The image quality of typical video systems is inferior to that of 35-mm photography.
• Video-tape equipment, including a high-quality color camera, can be more expensive than second-generation photologging equipment.
• Video playback for large groups of viewers usually requires that several TV monitors be utilized.
• Stop-motion playback on most video equipment is not as convenient and precise as with stop-motion film analyzers.

A study conducted in 1978 (*9*) provided a quantitative comparison of data collection by manual means, photologging, and videologging as a tool for computerized inventory systems. The study was designed as a controlled experiment, utilizing 22 miles (35 km) of both high- and low-volume suburban arterial roadways. Table 6 gives the man-hour requirements and costs for each inventory technique. The personnel costs were based on a $6.00 per hour salary plus 100% for overhead and fringe benefits. The comparison costs did not include such items as vehicle operations, equipment use (depreciation), system maintenance, subsistence in the field, and viewing-equipment costs. Photologging proved to be the least expensive alternative, because, for the most part, only one person was needed for the data collection activity.

It has been suggested that there may be applications for both videologging and photologging within a single agency, especially if the two techniques are not designed to compete with one another. For example, a low-cost video camera and recording deck adapted to record the same data display that is utilized for photologging could be employed to obtain a quick videolog of the traffic control in a construction zone. The need for a less-than-first-quality image and the probable short-term usefulness of the product would suggest that videologging might, at times, be a cost-effective substitute for photologging.

Continued increases in the cost of film and processing together with technological improvements in color video cameras may make videologging an attractive alternative to

FIGURE 28 Videologging camera and equipment (Travel Technology Corp.).

photologging. At least one company, Travel Technology Corp., believes that there is a market today for products based on videologging; the company plans to provide a complete range of contract videologging services. In addition, the company is developing an integrated microcomputer video system that will permit a wide range of highway features to be inventoried in an automated manner, either during the survey or subsequently in the office. The system will provide random access to inventory data, printing or plotting of selected inventory features, an index of the video-tape library, and automatic search of selected road segments. Another firm is said to have available programs that allow measurements to be taken from the screen. Two other consultants, Goodell-Grivas, Inc., and Novak, Dempsey & Associates, have the capability to provide videologging services, although the only work done to date has been a limited amount of black-and-white video work recorded on 0.5-in. (12-mm) video tape.

The Washington DOT has recently purchased a videologging unit from Security Records Systems. Although the image quality is not as good as that of 35-mm photologging, Washington DOT personnel believe that the potentially large savings in operating costs (estimated to be 80 percent) will offset the possible loss of some users. The Washington unit uses 0.75-in. (19-mm) color video tape, a gyro dampener for camera stabilization, and a microcomputer. District offices will use 0.5-in. (12-mm) playback machines to display the video image, which shows route number, milepoint, direction, date, and time.

Techwest Enterprises is planning to offer a videolog camera module that can be used in place of a second-generation photolog camera and still retain the data display on tape.

Ultimately, the selection of photologging versus videologging depends on the intended use and the total costs incurred in implementing and managing the program.

NEW DEVELOPMENTS

Early in 1982 Techwest Enterprises Ltd. announced the development of two new microprocessor-based photologging systems. Each features full alpha-numeric display with a data entry capability via a keyboard. The systems may be fitted to 16- or 35-mm optical or video cameras. The design of the two systems is such that at a later date it will be possible to expand an existing system A to a more sophisticated system B. This will entail certain minor modifications, such as modifying the camera image area to accommodate additional lines of data.

System A is offered as a fixed package with camera, mount, display head, control panel with slave readout,

FIGURE 29 Videolog display (Travel Technology Corp.).

odometer, manual date, route identification, and direction of travel. The display format has 26 alpha-numeric characters, 12 of which are isolated for route identification, enabling street names, or route numbers, to be keyed in for identification.

System B is offered as a flexible package with the following basic components: camera, mount, display head, control panel with slave readout, instrumentation unit, odometer, route identification, control, automatic date and time, and event marker. An additional selection of various instruments is available to suit specific requirements. System B may also be retrofitted to most existing photolog cameras. Figure 10 shows the prototype System B control panel with slave display.

TABLE 6
MAN-HOUR REQUIREMENTS FOR VARIOUS INVENTORY TECHNIQUES (*9*)[a]

	Man-Hours to Collect and Extract Data			Cost Per Mile		
Technique	Data Collection	Data Extraction	Total	Raw Stock & Processing	Personnel	Total
Manual	2 @ 16 hrs.[b] = 32.0	5.4	37.4	$ 0	$ 20.40	$ 20.40
Photolog @ 1/200 mile	1 @ 5 hrs. = 5.0	13.4	18.4	6.60	10.04	16.64
Videolog	2 @ 6 hrs. = 12.0	14.75	26.75	4.42	14.59	19.01

[a]Sign and Obstacle Inventory (Roadside Inventory was not performed with the video system and not included in the comparison of man-hours).

[b]Sign and Obstacle Inventories accounted for approximately 80% of the time of field crew.

CHAPTER FIVE

PROBLEM AREAS

EQUIPMENT

As with any other electromechanical device, there are always problems associated with maintenance and operation of photologging equipment. Because the basic components of the photolog system as it is known today (i.e., camera, control unit, projector, etc.) were in use in other areas before being adapted to photologging, the equipment was well tested before the early work conducted by California and the FHWA. For this reason, those highway agencies that purchased conventional systems experienced only minor equipment problems, and it was not long before it became common practice to send the equipment (especially cameras) back to the manufacturer in the off-filming season for preventive maintenance.

However, two states, New York and Kansas, which pioneered in developing the more advanced equipment now known as second generation, had serious equipment problems. These problems were eventually resolved, and today the available equipment is very reliable with the exception of the vertical gyro. Several states are experiencing problems with the vertical gyro caused, apparently, by design modifications by the gyro manufacturer. Second-generation users have been notified by Techwest Enterprises Ltd. (the equipment supplier) that attempts are being made to rectify the problems. Ultimately, the solution may be that a better quality gyro is required to meet the rigorous demands of photologging.

Because the market for photologging equipment is relatively small, the manufacturers serving this market are small. One of the ways that the industry is coping with the problems associated with the "small market-small industry" situation is to offer training in the routine maintenance and operation of the equipment. Two manufacturers, Techwest Enterprises Ltd., and Vanguard Instrument Corp., have been particularly sensitive to the needs of highway agencies and have been willing to refine their products in response to operational experience.

Techwest, the sole manufacturer of second-generation equipment, is active in product development; work has recently been completed on microprocessor-based systems and is underway on videologging.

COMMUNICATIONS

The consistent application of any technology depends, to some extent, on communication with others who are also applying that technology. The exchange of ideas and the solving of mutual problems are usually the first fruits of communication. With the exception of three national meetings between 1971 and 1979 on the subject of photologging and related photo-optical techniques, there has not been established a formal mechanism for regular communication between photolog operators and managers. Several activities have been considered, including newsletters and the formation of a photolog technical organization; however, because there is such a wide range of users in this country alone, these efforts would probably be best coordinated by an independent group such as the Institute of Transportation Engineers or AASHTO.

COMPUTERIZED INVENTORIES

Although the development of computerized inventories has not been a problem, particularly for the states, there has been little effort to utilize photologs for this purpose. However, the advent of second-generation photologging offers the potential for developing limited computerized inventories automatically from the magnetic tape units onboard the photolog vehicle. Two applications are particularly noteworthy. Both involve the capability to record and utilize locational information suitable for mapping and for computer-based geographic information systems.

One technique involves recording azimuth, slope gradient, and acceleration information from sensors incorporated in the photologging van. By starting and ending on known control points, the path of the vehicle and the elevation at any point (hence the roadway geometry) can be accurately computed. A commercial firm, SPAN International, Inc., currently provides contract services of this type, but no attempt has been made to combine this tracking technique with a photologging system as part of a computerized inventory.

A second technique involves the use of satellite technology for tracking the photologging vehicle. Current systems such as Loran or Doppler are slow and inaccurate, but a new system known as the Global Positioning System (GPS) is under development. The GPS is expected to have the capability to determine the user's location within about 100 ft (30 m) in a minute or so, and more accurately if more time is spent at each site.

FILM COSTS

The rapidly rising cost of film, processing, and reproduction is a problem that has become acute within the last few years. Film costs will probably affect how often a photolog is updated. The increased costs most certainly contributed to the decisions to discontinue funding the photolog programs in two states and the switch to videologging in another. Increasing film costs together with advancements in video technology suggest that videologging might one day be competitive with photologging in terms of cost.

DIMENSIONS FROM PHOTOLOGS

Most highway agencies developed grids with the expectations of obtaining accurate roadway dimensions. About 23 states have some form of overlay grid for obtaining dimensions; however, the grids are seldom used in many of these states. Superimposing grids on photolog frames confines the user to obtaining dimensions only from the roadway plane and does not permit dimensions to be taken beyond the roadway edge. Pryor and Miller (*10*) presented a reliable method of obtaining roadway dimensions, although it is limited to measuring linear objects in a plane parallel to the film plane of the camera.

An FHWA-funded research project with the Ohio DOT, "Research in Analytical Photogrammetry in Application to Transportation Surveys," is underway to develop and demonstrate the measurement potential of standard photolog imagery in application to the needs of state departments of transportation. Methods of analytical photogrammetric reduction will be developed to facilitate use of pairs of photolog pictures. Sequential pairs of imagery will be observed and measured, and dimensional information regarding roadway details extracted. The procedures and, to a limited extent, the hardware for the demonstration of this concept will be developed under the current 2-year project.

An alternate approach to obtaining dimensions from photologs would involve redesign of the optical system in the photolog camera to produce stereoscopic pairs of photographs on each photo frame. Dual-objective lenses could be employed, and a beam splitter introduced into the optical path to record stereoscopic images on the film at each exposure point. A corresponding optical train of the viewing system would permit 3-dimensional examination of the series of photolog images. In projection systems, either polarized light on an aluminized screen or alternating light similar to the "flicker systems" used on Kelsh plotters could be used. In either case, the fixed geometry of the photologging camera would produce images that do not require any "interior orientation" between scenes. Stereoscopic viewing could proceed as fast as desired; after the system was calibrated, the user could make accurate measurements using a floating mark in the stereoscopic model.

Theoretically, it would be possible to rigidly mount two photologging cameras instead of one in the van, and to trigger both shutters simultaneously. In practice it is difficult to exactly synchronize two camera shutters. If both cameras do not expose at the same instant, the constant geometric relationships between the two cameras would not be maintained and routine stereoscopic viewing and measuring would not be feasible.

The problem of developing a stereoscopic photologging system relates directly to the small market for photologging equipment and the film-cost problems cited earlier. Recording two images with one camera would require significantly more film for both original exposures and reproductions than is used for current systems. Dual cameras would, of course, double film and reproduction use. On the equipment side, it is difficult for any manufacturer to justify the investment in optical redesign and retooling for only a few cameras and viewing systems. On the other hand, if the system were developed, other applications such as recording pavement surface condition for stereoscopic measurement or speed and motion studies would be feasible. Hand-held, still cameras incorporating the same optical system would have application to accident investigation, recording highway backslope failures, and other uses where measurements are desired but aerial photogrammetric methods are too slow and expensive.

CHAPTER SIX

CONCLUSIONS AND RESEARCH NEEDS

CONCLUSIONS

Although there have been few formal evaluations made of the photologging technique, evidence of its cost effectiveness as a convenient, efficient source of information about the physical plant appears to be substantive. The fact that most states continue to fund a photologging program and, in at least 10 cases, have committed substantially increased funds for second-generation systems is an indication that highway managers are convinced of its utility. The interviews with highway officials, as well as the information provided on the survey forms, indicated that photologging has generally enjoyed wide acceptance among highway personnel in many disciplines and at most organizational levels. In addition, there is little doubt that the use of the photologging technique is on the increase in the United States and abroad.

General

- At least 41 states, 29 cities, 6 counties, the U.S. Park Service, and the U.S. Forest Service have used photologs. At least 10 states utilize second-generation systems.
- It has been estimated that in excess of 500,000 miles (800,000 km) of highway have been photologged in the United States.
- There is a definite need for the establishment of a forum or means by which photolog operators and users can exchange ideas and address problems.

Uses

- Photologging can be used by all organizational units within a state highway agency and has significant application for traffic engineering, design, and highway planning personnel. Its use in the courts is on the increase.
- Three important factors affect the degree of use within a state highway agency: (a) level of support and promotion by management; (b) location of photolog film and projectors in an area not identified with a specific unit or division (e.g., in the library); and (c) availability of a complete, updated photolog of an entire highway system.
- Most state highway agencies have not yet utilized photologs extensively for performing inventories as is commonly done in urban photologging.
- Although many states have developed an overlay grid to obtain dimensions from photologs, they are seldom used because of accuracy limitations and complexity.
- Approximately half of the states that utilize photologging have purchased projectors for use in all district offices.
- Many states regularly utilize photographs from photolog film in court proceedings involving tort liability cases.

Costs

- Data from 12 states that utilize first-generation photologging systems suggest that an average cost per one-way mile would be about $8.50 ($5.30/km); however, in estimating costs for current systems, this figure should probably be doubled.
- Although there is evidence in two states that the photolog program was the victim of cost-cutting efforts, a number of states have implemented photologging as a potential cost-saving tool.
- Comparison shopping for film and processing prices can result in substantial savings.

Second-Generation Equipment

- Second-generation systems require a larger agency commitment to funding and personnel (e.g., computer systems personnel).
- Additional training and an electronics background may be required for operators of second-generation equipment.
- Although second-generation photologging offers the potential for automated computer review and data assembly, it is not yet being done to any extent.

Procedures

- The entire area of inventory procedures and methods, including the relative advantages and disadvantages of the various techniques, is not well documented.
- Most photologs are updated on a 3- to 5-yr cycle.
- Photologging rates can be as high as 170 miles (270 km) per day for rural limited-access highways and as low as 7 miles (11 km) per day for heavily congested large-city streets.
- One of the ways in which photolog equipment manufacturers are coping with the problems associated with the "small market-small industry" situation is to offer training in the routine maintenance and operation of the equipment.

Contract Photologging

Most contract photologging is done in urban areas or at the county level where the roadway mileage does not justify the purchase of photologging equipment.

Cities

Photologging as a routine operational tool is not as useful in cities. Almost all urban work is done as a base information source for the development of a computerized traffic-control device inventory.

Videologging

Because of the recent large increases in the costs of film and processing and because of advances in video technology, there is renewed interest in the potential use of videologging. Comparisons, however, between the costs of data collection by videologging and photologging show that, for the present, photologging is less expensive.

RESEARCH NEEDS

The following subject areas, most of which have been previously addressed in this synthesis, require formal study or research:

- Videologging as a substitute for or a supplement to photologging.
- Photologging of railroads.
- Integrating microprocessor-based inventory systems with photologging.
- Photologging under nighttime conditions.
- Developing corollary uses of the photolog technique, such as obtaining vertical photographs of the pavement surface for pavement-life studies.
- Developing secondary support instrumentation, such as a device that would provide data on sign reflectivity, as input to a second-generation system.
- Obtaining roadway dimensions accurately and efficiently from projected photolog film.
- Investigating the feasibility of using the global positioning system (GPS) for locating roadway features via a receiver in the photolog vehicle.

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APPENDIX A

ADDRESSES OF CONSULTANTS, MANUFACTURERS, SUPPLIERS, AND LABORATORIES

CONSULTANTS, MANUFACTURERS, AND SUPPLIERS

Aero Service Corporation
4219 Van Kirk Street
Philadelphia, Pennsylvania 19135

Datacorp
6301 Ivy Lane
Greenbelt, Maryland 20770

Flight Research
P. O. Box 1-F
Richmond, Virginia 23201

Goodell-Grivas, Inc.
17320 West Eight Mile Road
Southfield, Michigan 48075

Instrumentation Marketing Corporation
820 South Mariposa Street
Burbank, California 91506

Newmade Products Corporation
Box 568
Scarsdale, New York 10583

Northwest Computer (Video Electronics)
P. O. Box 599
San Pablo, California 94806

Novak, Dempsey & Associates
Palatine, Illinois 60078

Security Records Systems, Inc.
4224 6th Avenue, S.E.
Lacey, Washington 98503

SPAN International, Inc.
Reston International Center, Suite 227
11800 Sunrise Valley Drive
Reston, Virginia 22091

Techwest Enterprises Ltd.
3650 Wesbrook Mall
Vancouver, British Columbia
Canada V6S 2L2

Transwave Corporation
Cedar Valley
RD 1, Box 489
Vanderbilt, Pennsylvania 15486

Travel Technology Corporation
Cockeysville, Maryland 21030

Vanguard Instrument Corporation
1860 Walt Whitman Road
Melville, New York 11746

LABORATORIES FOR PHOTOLOG FILM PROCESSING

Alexander Film Services
Colorado Springs, Colorado 80901

Allied Film Laboratories
7375 Woodward Ave.
Detroit, Michigan 48202

Alpha Cine Laboratory
1001 Lenora
Seattle, Washington 98121

Astro Color Laboratories
61 E. Erie
Chicago, Illinois 60611

Capital Film Laboratories, Inc.
1998 N.E. 150th St.
North Miami, Florida 33181

DuArt Film Laboratories, Inc.
245 W. 55th St.
New York, New York 10019

Galaxy Film Laboratories
Minneapolis, Minnesota 55401

Maritz Laboratories, Inc.
3000 France Ave. S.
Minneapolis, Minnesota 55416

Maritz Labs
1313 East Kemper Rd.
Cincinnati, Ohio 45246

Monaco Labs
234 9th St.
San Francisco, California 94103

Movielab, Inc.
619 W. 54th St.
New York, New York 10019

Photo Tech (formerly Cine Chrome)
Palo Alto, California 94303

Producer's Color Service, Inc.
2921 E. Grand Blvd.
Detroit, Michigan 48202

PSI Film Lab, Inc.
3011 Diamond Pk.
Dallas, Texas 75247

Technicolor, Inc.
321 W. 44th St.
New York, New York 10036

Teknifilm, Inc.
909 N.W. 19th St.
Portland, Oregon 97209

TVC Labs
311 W. 43rd St.
New York, New York 10036

Western Cine
312 S. Pearl
Denver, Colorado 80209

Wometco Film Lab
65 N.W. 3rd St.
Miami, Florida 33128

APPENDIX B

DAILY EQUIPMENT CHECKLIST (MARYLAND)

MARYLAND"S SECOND GENERATION
PHOTOLOG CHECK LIST

NOTE: All instructions should be followed in this order only.

I. MASTER GYROCOMPASS START-UP

1) Remove compass cover.
2) Plug extension cord into 110-120 V.-A.C. outlet.
3) Set power select switch to "AC".
4) Switch on "Master Compass".
5) When green "Run" light comes on, level gyro and return to previous days heading.
6) Allow gyro to erect for 15-20 minutes.

II. CAMERA MAINTENANCE & FILM LOADING/UNLOADING

1) While gyro is erecting, film magazines should be reloaded by one crew member.
2) The other crew member should thoroughly clean the Data Transfer Mirror with canned air only. The Data Transfer Mirror must never be wiped with a dry lens tissue. The Mirror may be cleaned with lens cleaning fluid applied to a lens tissue if circumstances require. This should only be done when the mirror cannot be cleaned otherwise.
3) Camera may then be loaded as per instructions on camera cover. (Before loading reset frame counter to zero.)

III. SYSTEM START-UP

1) Check Master Compass Heading again - level and adjust as necessary.
2) Start van, switch on powerverter and move power select switch to "DC".
3) Unplug and stow extension cord.
4) Switch on system power (Red button on control panel).
5) Allow vertical gyro (Controls reading for grade & cross-slope). to erect for 10 minutes, meanwhile;
6) Move display test switch to on (up) position with hold switch engaged (Up position).
7) Open display box and check for correct pulsing of LED's.
8) Switch on rear of display box should then be set to "Test" position (LED's constantly illuminated).
9) Switch on "All 8's" test switch at control box and check LED segments in display box and display module for full illumination. Switch off when check is complete.
10) Check day/date display; if correction is necessary, see manual.
11) Check route/control display by dialing in route information.
12) Close display box, insuring that there are no light leaks at joining surfaces.

Important 13) Switch on rear of control box should be returned to "pulse" position.

14) Once vertical gyro has erected (10 min. approx.). Check side friction, grade & cross-slope reading against known values logged on calibration sheet.
15) Set altitude to known value w/heater fan on low setting or whatever setting is to be used in photologging (if vent is open and fan is not used, cabin will pressurize unevenly as vehicle speed changes causing irregular altitude readings).
16) Switch off "Display"test toggle
- System start-up and precheck is now complete (ready for filming).

IV. FILMING

1) Once film has been loaded properly power up camera power button.
2) Advance film 20-25 frames using "Load" toggle switch.
3) Calibrate automatic aperture control using toggle on right front of camera. Have the other crew member observe the movement of the lens aperture ring to insure travel through the full range of f-stops. Several attempts may be necessary and this step cannot be performed in a darkened area. Camera must be recalibrated whenever camera power is switched on since the automatic exposure control has no memory function.
4) Enter and/or check route and control information for route to be filmed.
5) Set count mode rocker switch to correct mode-ascending (green) or descending (red).

Important 6) Once again, insure that LED switch on rear of display box is set to "pulse" position.

7) Dial in correct beginning milepoint using mileage preset thumb wheels, or if zero miles-point, use "clear" button to reset odometer to zero.
8) If route information is to be taped on the Tandberg Recorder in the direction being filmed, tape should now be powered up following procedure outlined in Techwest Manual entitled "Operation Procedure for Tandberg SCDR 3000 Recorder". These instructions should be followed exactly as they insure accurate data transfer storage.
9) Press "reset" button; this resets all data modules to zero (this is especially important to roughness and degree of curvature readings).
10) Using "load" toggle, advance film approximately 5 frames before and after every route/direction.
11) When approaching beginning point for the route to be filmed, take several approach shots.
12) To start filming, release "hold" switch and simultaneously pulse camera using "pulse" button.
13) Once under way, scan controls to insure that no errors have been made. If taping, listen for audible "beep" every 21 frames to ensure tape is advancing. Equipment operator should constantly scan performance of each and every data module to ensure correct operation.
14) When filming of route is complete, flip up hold switch and take several exit shots.
15) Using "load" toggle, advance film 5 frames. Power down tape as per manual instructions if next route is not to be taped.
16) Ready for next route/directions.

APPENDIX C

STATUS OF PHOTOLOGGING

Agency	Date Started First Generation	Date Started Second Generation	Film Format	Principal Contact
Alabama	1976	--	35 mm	State Planning, Alabama Highway Dept.
Alaska	1977	--	35 mm	Traffic & Safety Engr., Dept. of Transportation & Public Facilities
Arizona	1970	--	16 mm	H.O.D.S. Manager, Hwys. Div., Arizona DOT
California	1970	--	35 mm	Supervisor of Photography, California DOT
Colorado	1976	--	35 mm	Inventory Unit, Colorado Dept. of Highways
Connecticut	1973	1979[a]	35 mm	Eng. Data, Bureau of Hwys., Connecticut DOT or Director, Office of Res., Connecticut DOT (Railroad Photologging)
Delaware	1973	--	35 mm	Planning Survey, Delaware DOT
Florida	1977	--	35 mm	Research and Studies Engineer, Florida DOT
Georgia	1974	--	35 mm	Planning Data Services Section, Georgia DOT
Hawaii	1973	--	35 mm	Land Transp. Facilities Div., Planning Survey Section, Hawaii DOT
Idaho	1973	1981	16 mm	Traffic Section, Idaho DOT
Illinois	1973	--	35 mm	Bureau of Planning, Illinois DOT
Indiana	1975	--	35 mm	Technical Services, Indiana State Highway Commission
Iowa	1962	1979	16 mm	Office of Transp. Inventory, Planning & Research Div., Iowa DOT
Kansas	1975	1979	35 mm	Photogrammetry Section, Eng. Services Dept., Kansas DOT
Kentucky	1972	--	35 mm	Div. of Photogrammetry, Kentucky DOT
Louisiana	1972	--	35 mm	Planning Division, Louisiana Dept. of Transportation and Development
Maryland	1973	1979	35 mm	Bureau of Hwy. Statistics, Maryland DOT
Mass.	1973	--	35 mm	Bureau of Traffic Operations, Massachusetts Dept. of Public Works
Michigan	1973	--	35 mm	Traffic & Safety Div., Michigan Dept. of Hwys. & Transportation
Minnesota	1973	1979	35 mm	Photolog Project Supervisor, Minnesota DOT
Miss.	1975	--	35 mm	Transportation Planning, Mississippi State Hwy. Dept.
Montana	1970	--	35 mm	Photographic Unit, Montana Dept. of Highways
Nebraska	1975	--	35 mm	Highway Inventory Supervisor, Nebraska Dept. of Roads
Nevada	1974	--	35 mm	Planning Survey Division, Nevada DOT
N. J.	1975	--	35 mm	Bureau of Data Resources, New Jersey DOT
N. M.	1975	1981	35 mm	Planning Research Supervisor, New Mexico State Hwy. Dept.
N. Y.	1975	--	35 mm	Transp. Inventory Unit, New York State DOT
N. C.	1971	--	35 mm	Traffic Engineering, North Carolina DOT
Ohio	1975	1979	35 mm	Bureau of Transp. Technical Services, Ohio DOT
Oklahoma	1975	--	35 mm	Traffic Engineering, Oklahoma DOT
Oregon	1966	--	16 mm	Highway Division, Traffic Section, Oregon DOT
S. D.	1972	--	35 mm	Photogrammetry & Surveys, South Dakota DOT
Tennessee	1973	--	35 mm	Planning Survey Division, Tennessee DOT
Texas	1977	--	35 mm	Texas Office of Traffic Safety, Austin
Utah	--	1977	35 mm	Transportation Planning, Utah DOT

Agency	Date Started: First Generation	Date Started: Second Generation	Film Format	Principal Contact
Vermont	1976	—	35 mm	Planning Division, Vermont Agency of Transportation
Virginia	1975[b]	—	35 mm	Virginia Hwy. & Transp. Research Council, Charlottesville
Washington	1970	—	35 mm Video	Transportation Data & Traffic, Safety Section, Washington DOT
West Va.	1972	—	35 mm	Advance Planning Division, West Virginia Dept. of Highways
Wisconsin	1974	—	35 mm	Engineering Services, Wisconsin DOT
Wyoming	1973	1978	35 mm	Highway Safety Branch, Wyoming State Highway Dept.
Prince Georges County, Md.	1978	—	35 mm	Div. of Traffic Engineering, P.G. County Dept. of Public Works & Transp.
Corpus Christi, Texas	1975	—	35 mm	Traffic & Transp. Dept., Corpus Christi, Texas
San Antonio, Texas	1973	—	35 mm	Traffic & Transp. Dept., San Antonio, Texas
San Diego, Calif.	1973	—	35 mm	Department of Public Works, San Diego County
Seattle, Wash.	1973	—	35 mm	Engineering Dept., Traffic and Transportation Dir., Seattle
Tacoma, Wash.	1977	—	35 mm	City Traffic Engineer, Tacoma
British Columbia	1965	—	16 mm	Planning Branch, British Columbia Ministry of Highways
New Brunswick	1968	—	16 mm	Planning Dept., New Brunswick Dept. of Transportation
Ontario	—	1981	16 mm	Municipality of Metropolitan Toronto
Quebec	1973	1980	16 mm	Quebec Ministry of Transport
United Republic of Tanzania	1972	—	16 mm	Ministry of Works
Oyo State of Nigeria	1973	—	16 mm	Ministry of Works and Housing
New Zealand	1974	1980	16 mm	Ministry of Works and Development
Democritus Univ. Thrace, Greece	—	1979	-	School of Engineering

[a]For use on railroads

[b]Pilot project

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RESEARCH SUPERVISOR

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