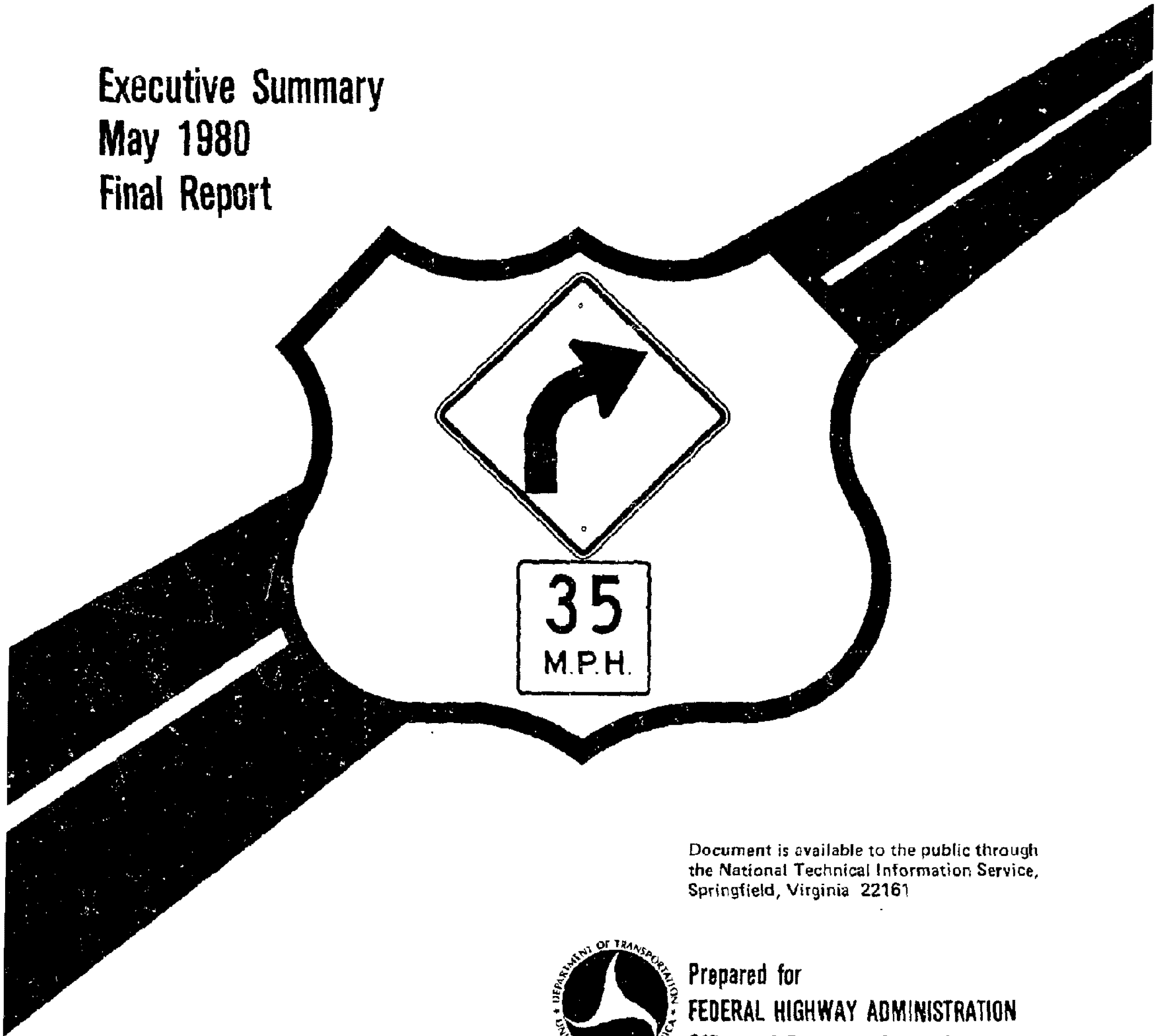
Report No. FHWA/RD-80/008 FB81-153546

AN EVALUATION OF WARNING AND REGULATORY SIGNS FOR CURVES ON RURAL ROADS

Executive Summary
May 1980
Final Report



Document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

Prepared for
FEDERAL HIGHWAY ADMINISTRATION
Offices of Research & Development
Traffic Systems Division
Washington, D.C. 20590

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161

FOREWORD

This report summarizes an experiment that was undertaken at two sites in Central Maine. The general purpose of the experiment was to evaluate several warning and regulatory signs that could be used for warning motorists on a rural two-lane road of a hazardous horizontal curve ahead. A final report, which discusses the experiment in detail, was distributed earlier to research type personnel.

Signs that were examined in the reported research ranged from the standard curve warning arrow to a regulatory speed zone sign in conjunction with the curve warning sign. Overall, five different signing conditions were examined. Data that were collected during the experiment included automatic monitoring of vehicle speeds as drivers approached the test sites and subsequently traversed each test site horizontal curve. Vehicle classification, center and edgeline crossing, and vehicle registration information were also collected manually. Both the automatic and manual data were collected within a multi-factor experiment design. Factors controlled for included: (1) motorist familiarity with the road, (2) presence or absence of opposing traffic, (3) drivers' speed as they approached each horizontal curve test site, (4) type of vehicle being driven by drivers whose performance was being monitored, and (5) weather and ambient light conditions.

The experiment was jointly run by the Maine Department of Transportation and the University of Maine, Orono, as part of the FHWA research program at the Maine Facility.

Sufficient copies of this executive summary report are being distributed by FHWA to provide one copy to each regional office; one copy to each division office; and two copies to each State highway agency, one being for the Governor's safety representative.

Charles F. Scheffey
Director, Office of Research
Federal Highway Administration

NOTICE

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof.

The contents of this report reflect the views of its authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policy of the Department of Transportation.

This report does not constitute a standard, specification, or regulation.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/RD-80/008		PB81 153546

4. Title and Subtitle	5. Report Date
An Evaluation of Warning and Regulatory Signs for Curves on Rural Roads. Executive Summary	May 1980
	6. Performing Organization Code
	8. Performing Organization Report No.
7. Author(s) Richard W. Lyles	
9. Performing Organization Name and Address Social Science Res. Institute, Univ. of Maine - Orono, Orono, Maine 04473 Mat. & Rsch. Div., Maine DOT, Box 1208, Bangor, Maine 04402	10. Work Unit No. (TRAIS) FCP-31M2-082 11. Contract or Grant No. DOT-FH-11-9401
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Highway Administration Office of Research Washington, D.C. 20590	13. Type of Report and Period Covered Final Report June 1978 - December 1979 14. Sponsoring Agency Code T-0354

15. Supplementary Notes

Mr. Lyles designed the experiment and analyzed the data. Actual collection of the experimental data was the responsibility of Mr. J. H. Wyman of the Maine Department of Transportation.

16. Abstract

This report summarizes the results of an experiment, sponsored by the Federal Highway Administration and carried out at the Maine Facility, which examined the effectiveness of several alternative sign configurations (both warning and regulatory) for warning motorists of a hazardous horizontal curve ahead in rural two-lane situations. The principal findings were that: in spite of relatively large decreases in speed in the vicinity of the curve, no sign configuration was found to be consistently more effective than another, nor could the cause of the speed decreases that were measured necessarily be attributed to the signs, per se.

Details are given in the report FHWA/RD-80/009, "An Evaluation of Warning and Regulatory Signs for Curves on Rural Roads," authored by R. W. Lyles.

17. Key Words	18. Distribution Statement
Horizontal curves, rural two-lane roads, speed control, roadside warning signs, vehicle activated signs, regulatory speed zones.	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	7	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

TABLE OF CONTENTS

1. INTRODUCTION

One of the more common roadside warning signs seen by motorists is the curve (horizontal) warning sign - typically a black arrow, indicating the direction of the curve, on a yellow field. Placement of this sign, according to the Manual on Uniform Traffic Control Devices (MUTCD) is "...where engineering investigations of roadway, geometric, and operating conditions show the recommended speed on the curve to be in the range between 30 and 60 miles per hour and equal to or less than the speed limit established by law or by regulations for that section of highway." (FHWA, 1978). Advisory speed plates may also be used when "additional protection" is desired.

However, use of the basic warning sign often seems to be whenever the alignment changes, and the indicated advisory speeds are often quite conservative. In addition, interpretation of whether the advisory speed is enforceable, per se, varies by jurisdiction. Given the proliferation of the curve signs and potential confusion over whether the advisory speeds are enforceable, several questions arise: do motorists respond at all to curve warning signs; are reactions different if advisory speed plates are also deployed; and, are reactions to regulatory speed zones in conjunction with the curve warnings any more noticeable.

The principle objectives of the research described herein were to address the above questions in the context of rural two lane highways.

2. METHODOLOGY

The study was undertaken as part of the Federal Highway Administration's (FHWA) research program conducted by personnel at the Maine Facility. Two sites in Central Maine were used in the evaluation of several alternatives for signing horizontal curves. One site was on State Route 23 about 1.6 kilometers (1 mile) north of Dexter, and the other was on U.S. Route 202 near Albion. In both instances, motorists could not see the end of the curve or the road beyond as they entered the curve, and a speed decrease was necessary to safely traverse the curve.

At each site, the road in the vicinity of the curve was instrumented (from approximately 550 m (1800 ft.) in advance of the point of curvature to a point near the end of the curve) so that vehicles could be tracked as they approached and then traversed the curve (in one direction). The instrumentation consisted of using coaxial sensors on the road at 61 m (200 ft.) intervals to provide time intercepts of each vehicle as it traversed the site. These sensors were connected to a recording system housed in a van which was out of sight and off the main road. The data, recorded on a nine track magnetic tape, were later processed at the Facility to yield several variables for each vehicle (e.g., speed over the initial interval, speed at the point of curvature).

Each vehicle that traversed a site during a data collection period were tracked unbeknownst to the driver (non-lead vehicles in a platoon were, however, discarded). Data collection occurred from about 8:00 A.M. to midnight on selected dates. In addition to the automatic data (from the sensors), several manual data were also collected (and made part of the vehicle record on tape). They included: an indication of whether the vehicle was registered in Maine or not; an indication of whether the vehicle was an auto or recreational vehicle (trucks were excluded); and an indication of how many times the vehicle crossed the edge of pavement and center line. (The last indications had to be discarded because of software problems.) The Maine/non-Maine classification was made in order to discern the potential effect of repeat drivers being included in the data.

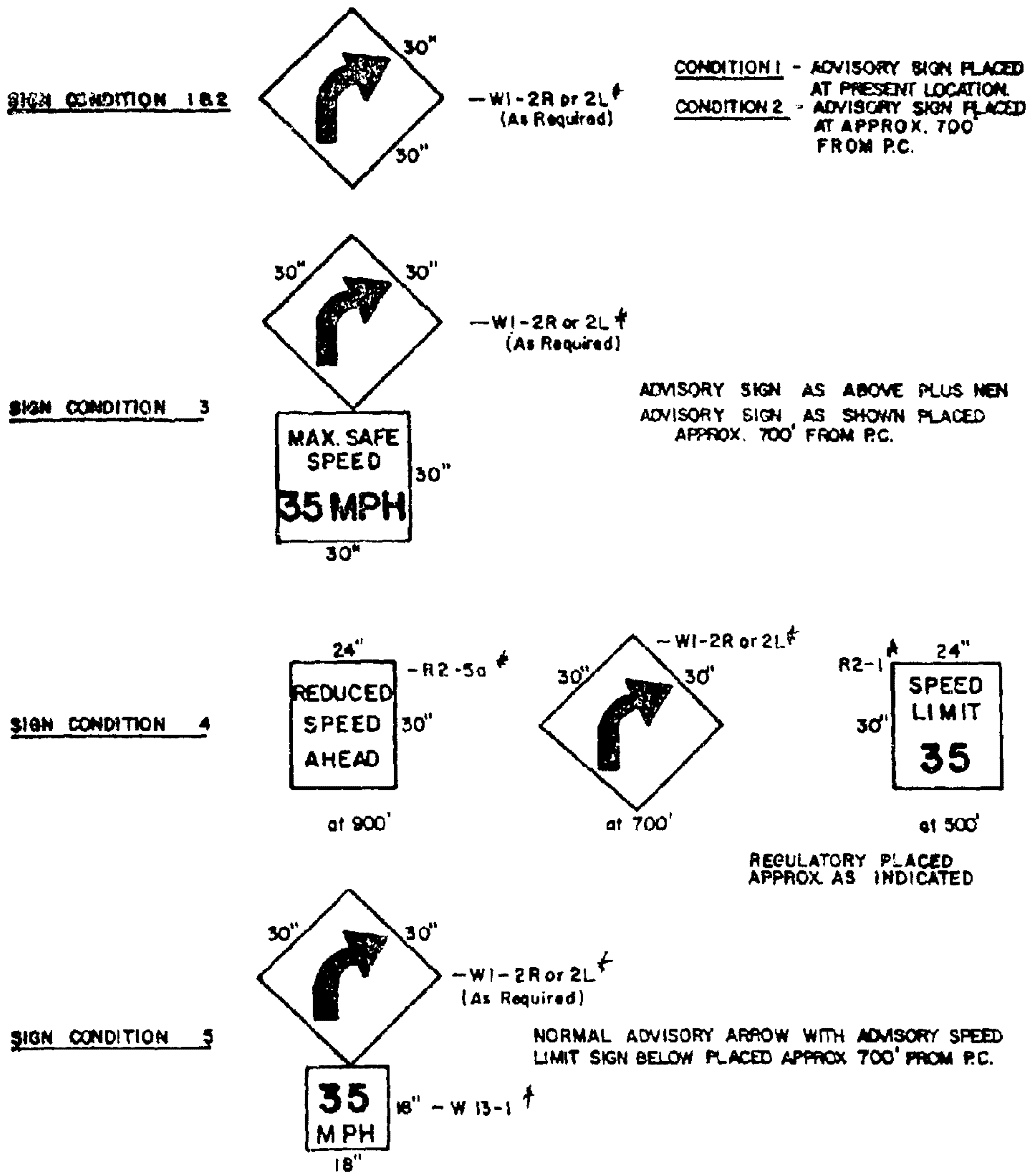
In general then, the experiment procedure was to: deploy a given sign alternative in advance of the curve and collect data as vehicles traversed the site; move the data collection equipment to another site (the same equipment was used for another experiment - hence, data were collected at four sites in a sequential fashion); change the signs to the next alternative; and continue to cycle through the sites in the same manner until all sign alternatives had been "tested".

The five different sign alternatives (conditions) that were tested are shown in Figure 1. The alternatives cover three standard deployments as well as an experimental advisory plate, and the standard curve warning arrow at a position somewhat closer (existing placement) to the point of curvature (152 m (500 ft.)) than the MUTCD suggests. The order in which the sign conditions were deployed at each site was randomized. The alternatives were tested under a variety of conditions - i.e., day/night, good weather/bad weather (limited data), effect of driver familiarity with site (i.e., Maine/non-Maine), type of vehicle (auto/recreational vehicle), two sites, and whether opposing traffic was present.

3. FINDINGS

The major finding of the research was that no sign condition was consistently found to be more effective than any other relative to decreasing the potential hazard at horizontal curves in rural two-lane situations.

In order to better appreciate the overall finding it was instructive to review them with reference to a scenario for a "good" driver traversing a horizontal curve when an effective sign was present. Such an ideal scenario had the following elements: the driver entered



* SEE THE MANUAL ON UNIFORM TRAFFIC CONTROL DEVISES FOR STANDARDS
CONVERSION: 1 FT. = .3048 M

FIGURE 1. SIGN CONDITIONS FOR HORIZONTAL CURVE EXPERIMENT

the instrumented area traveling at about the speed limit; he/she saw the sign(s) ahead and became alert for the possible need for corrective (defensive) action to be taken ahead; as the sign became legible, the driver read it and began to take the corrective action (i.e., slowed down for the curve); the driver, having slowed down, entered the curve at, or close to, the appropriate (e.g., posted) speed; and, finally, having seen the road ahead and realizing that the hazard had been safely negotiated, accelerated slightly as the curve was left behind.

The random drivers that were studied in the experiment behaved somewhat differently than indicated by the idealized scenario. While motorists at Site 1 slowed considerably initially and prior to the signs, their counterparts at Site 2 actually increased their speed slightly in several instances. In addition, signs that were effective (relative to these initial variables) at Site 1 were not effective at Site 2.

Subsequent speed changes at Site 1 were operationally quite small (most averages were less than 2.4 km/h (1.5 mph)), while at Site 2 slight increases were still being recorded in many instances. Although Site 2 data did show a decrease in speed from the last sign position to that at the curve, a consistent trend in sign effectiveness was still not apparent (e.g., signs that were effective during the day were not at night).

In addition, in every case at Site 2 the average speed leaving the instrumented area was lower than the average speed at the curve. This, and the fact that the minimum speed (on the instrumented section) had occurred beyond the point of curvature, proved conclusively that drivers were still slowing down as they entered the curve - counter to the "good" driver scenario.

In general then, it was seen that the drivers' behavior differed substantially from what was desireable and, furthermore, that no consistent trend in effectiveness was apparent. The basic result was that no sign, or group of signs, can be concluded to be more effective than others.

In spite of the lack of clear evidence of one sign being superior to another, there were reasonable speed changes in most instances. There was the question, however, as to whether the presence of any sign was responsible for the speed change or whether the motorist slowed down merely because of his/her own ability to see (or not, as the case may be) and react to the physical conditions present ahead.

Based on the data that were available and the results of the analyses, it is impossible to say that the signs had no effect as advance warnings of the condition ahead. It is possible, and appropriate, however, to say that no sign(s) was (were) found to be indisputably superior to the others.

Relative to the overall reactions of motorists to the situation, it should be noted that the result was always in less than desired behavior in the curve - motorists all entered the curve faster than desired and continued to slow as they traversed at least the first section. The important point being that they all attained their minimum speed at approximately the same point, regardless of which sign had been deployed.

Thus, although there was considerable evidence that the physical characteristics of the sites as well as the motorists' perceptions of the hazard ahead (apart from what the sign conveyed) had some impact on their reactions, it cannot be stated that these factors were the only, or even the major, things affecting motorists' behavior. It is impossible, however, in the context of the experiment that was undertaken, to allocate the decreases in speed, between the signs and the reactions to physical characteristics. Note that this is not to imply that no warning device should be deployed in such situations.

The reasons for the above result are not immediately clear. It may well be, however, that the proliferation of curve warning signs with and without advisory speed plates has lessened the average motorist's respect for the message they convey. An implied result is that when a really serious curve exists, advisory speed plates and/or regulatory signs may be ineffective remedies.

In light of the above, additional research on the most effective device in more serious curve situations may be indicated, possibly including investigation of motorists' stated perceptions (via a survey) of the seriousness of situations when they are confronted with various signs. Other areas of inquiry might include a more definitive review of the criteria used by state and local traffic engineers for deploying curve warning signs of various types. The results of such research could be revised standards/guidelines for sign deployment.

FEDERALLY COORDINATED PROGRAM (FCP) OF HIGHWAY RESEARCH AND DEVELOPMENT

The Offices of Research and Development (R&D) of the Federal Highway Administration (FHWA) are responsible for a broad program of staff and contract research and development and a Federal-aid program, conducted by or through the State highway transportation agencies, that includes the Highway Planning and Research (HP&R) program and the National Cooperative Highway Research Program (NCHRP) managed by the Transportation Research Board. The FCP is a carefully selected group of projects that uses research and development resources to obtain timely solutions to urgent national highway engineering problems.*

The diagonal double stripe on the cover of this report represents a highway and is color-coded to identify the FCP category that the report falls under. A red stripe is used for category 1, dark blue for category 2, light blue for category 3, brown for category 4, gray for category 5, green for categories 6 and 7, and an orange stripe identifies category 0.

FCP Category Descriptions

1. Improved Highway Design and Operation for Safety

Safety R&D addresses problems associated with the responsibilities of the FHWA under the Highway Safety Act and includes investigation of appropriate design standards, roadside hardware, signing, and physical and scientific data for the formulation of improved safety regulations.

2. Reduction of Traffic Congestion, and Improved Operational Efficiency

Traffic R&D is concerned with increasing the operational efficiency of existing highways by advancing technology, by improving designs for existing as well as new facilities, and by balancing the demand-capacity relationship through traffic management techniques such as bus and carpool preferential treatment, motorist information, and rerouting of traffic.

3. Environmental Considerations in Highway Design, Location, Construction, and Operation

Environmental R&D is directed toward identifying and evaluating highway elements that affect the quality of the human environment. The goals are reduction of adverse highway and traffic impacts, and protection and enhancement of the environment.

4. Improved Materials Utilization and Durability

Materials R&D is concerned with expanding the knowledge and technology of materials properties, using available natural materials, improving structural foundation materials, recycling highway materials, converting industrial wastes into useful highway products, developing extender or substitute materials for those in short supply, and developing more rapid and reliable testing procedures. The goals are lower highway construction costs and extended maintenance-free operation.

5. Improved Design to Reduce Costs, Extend Life Expectancy, and Insure Structural Safety

Structural R&D is concerned with furthering the latest technological advances in structural and hydraulic designs, fabrication processes, and construction techniques to provide safe, efficient highways at reasonable costs.

6. Improved Technology for Highway Construction

This category is concerned with the research, development, and implementation of highway construction technology to increase productivity, reduce energy consumption, conserve dwindling resources, and reduce costs while improving the quality and methods of construction.

7. Improved Technology for Highway Maintenance

This category addresses problems in preserving the Nation's highways and includes activities in physical maintenance, traffic services, management, and equipment. The goal is to maximize operational efficiency and safety to the traveling public while conserving resources.

0. Other New Studies

This category, not included in the seven-volume official statement of the FCP, is concerned with HP&R and NCHRP studies not specifically related to FCP projects. These studies involve R&D support of other FHWA program office research.

* The complete seven-volume official statement of the FCP is available from the National Technical Information Service, Springfield, Va. 22161. Single copies of the introductory volume are available without charge from Program Analysis (HRD-3), Offices of Research and Development, Federal Highway Administration, Washington, D.C. 20590.