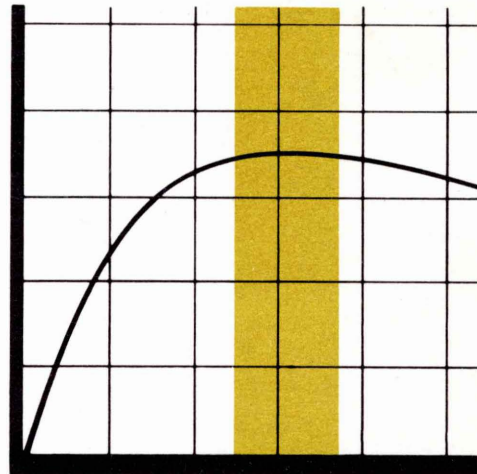
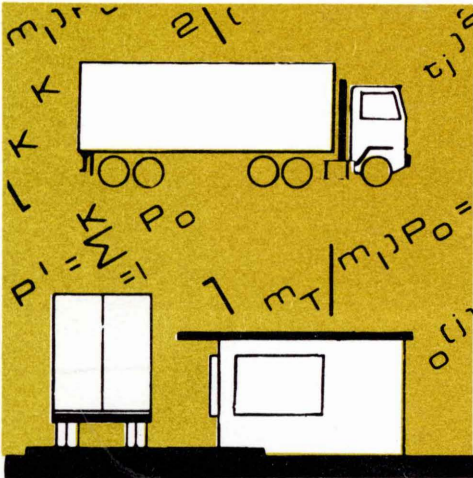


TL
230
.068
1968

OPTIMUM ENFORCEMENT LEVEL FOR TRAFFIC WEIGHT OPERATIONS

MRI REPORT

EXECUTIVE SUMMARY



IOWA HIGHWAY RESEARCH BOARD PROJECT HR-138
For the
IOWA STATE HIGHWAY COMMISSION, AMES, IOWA

Richard D. Johnson
3-4-69

OPTIMUM ENFORCEMENT LEVEL FOR
TRAFFIC WEIGHT OPERATIONS

EXECUTIVE SUMMARY

October 31, 1968

Iowa Highway Research Board
Project HR-138

Conducted by the

Midwest Research Institute
Kansas City, Missouri

for the

Iowa State Highway Commission
Ames, Iowa

PREFACE

This is the Executive Summary of the findings and recommendations to the Iowa State Highway Commission on "The Optimum Level of Enforcement of Regulations Governing the Size and Weight of Motor Vehicles Operated on Iowa Highways." This Executive Summary is a condensed nontechnical version of the final report. It provides the Commission with guidance for future decisions on the number of officers to be assigned to traffic weight operations. The full or final report contains the methodology so that forecasts of optimum levels of enforcement for future years can be easily established. Readers interested in a more detailed description of the methodology or the results should contact the Iowa State Highway Commission.

This project has utilized many specialized skills throughout Midwest Research Institute. The authors and main contributors to the development of the methodology and analysis are:

Mr. Walter Benson, Project Leader
Mr. Richard Cuthbert, cost benefit model and submodel development
Mr. Andrew St. John, road wear submodel
Mr. Marc Semanoff, data analysis
Mr. Frank Witte, computer programming


The success of the study was dependent upon the close cooperation of many ISHC personnel, especially the following:

Mr. Stephen Roberts, Research Engineer
Mr. Dennis Ehlert, Director, Traffic Weight Operations
Mr. Walter Fisher, Assistant Director, Traffic Weight Operations
Mr. Eugene Mills, Highway Planning Surveys Engineer

In addition to the above, the members of the study team are grateful to many other staff members of the Iowa State Highway Commission, Iowa Department of Public Safety, Iowa Reciprocity Board, and Midwest Research Institute for their advice and assistance in obtaining data.

Approved for:

MIDWEST RESEARCH INSTITUTE


Sheldon L. Levy, Director
Mathematics and Physics Division

October 31, 1968

TABLE OF CONTENTS

	<u>Page No.</u>
Introduction	1
Problem Statement	1
Data Acquisition	1
Analysis	2
Results--Optimum Enforcement	5
Results--Supplemental Studies	11
A. Manpower Allocation by Time of Day	11
B. Fraction of Manpower Devoted to Fixed-Site Operation versus Roving-Patrol Operation	13
C. Utilization of Fixed-Scale Sites	13
D. New Scale Construction	13
E. Procedural and Administrative Changes: Observations . . .	14
F. Use of Advanced Weighing Equipment	15

INTRODUCTION

This is a report on the enforcement of regulations governing the size and weight of vehicles operating on Iowa highways. The study was made by the Midwest Research Institute under contract with the Iowa State Highway Commission. Results of the study are intended as guides for the Commission in formulating future policies and procedures.

Enforcement of vehicle size and weight regulations is assigned to the Traffic Weight Operations Department of the Commission. (The department is frequently identified in abbreviated form as T.W.O.). Department personnel operate fixed traffic weight stations located on Primary and Interstate highways. The department also operates roving patrols equipped with portable scales.

In addition to observing the weight and size of trucks and buses, traffic weight officers inspect vehicle registrations to ascertain that the vehicles are registered for the weight that they are carrying and are properly registered for travel in Iowa. Violators of size and weight laws are subject to court imposed fines. The operator of a vehicle carrying a load in excess of that for which it is registered must purchase the registration corresponding to the load being carried when apprehended. Operation of oversize, overweight vehicles and loads requires special permits.

PROBLEM STATEMENT

The enforcement of traffic weight and size regulations involves both benefits and costs to Iowa. The problem considered in this study was the determination of the level and methods of enforcement that would yield the greatest net benefit to Iowa. Stated in another way, the solution of the problem--the objective--was to find the "optimum" level and methods of enforcement, "optimum" being defined as that which will produce the greatest difference between benefits and costs.

DATA ACQUISITION

The study began with a literature search involving several state governments, federal agencies, manufacturers of weighing equipment, etc. This search sought information on other traffic weight operation studies, scale performance and cost, research on new methods of weighing, the relative effectiveness of various enforcement strategies, and the assessment of economic forces leading to the willingness of operators to risk violations.

Subsequent to this search, probably the first such ever conducted in this country and certainly the most extensive so far, MRI gathered data from the Iowa State Highway Commission on the costs of carrying out enforcement operations in terms of manpower and equipment used, salary rates, overhead costs, and equipment purchase costs. The Commission also provided factual data concerning truck traffic, weight regulations, apprehensions, and the amounts of fines resulting from enforcement.

Personnel from MRI inspected traffic weight stations, observed the field operations of the traffic weight officers, and reviewed operational problems with the department head and his principal assistants. Records were obtained relative to assignment of crews to fixed stations and roving patrols, hours when fixed stations were operated, apprehensions per operating hour, and the variation in total truck traffic and apprehensions with respect to the hour of day or night.

ANALYSIS

The overall logic of the analysis is shown in Figure 1. The analysis is essentially a cost-benefit comparison which incorporates provisions for assessing the effects of various modes and degrees of enforcement.

The costs included in the analysis are the cost of maintaining any given number of traffic weight officers in the field and the cost of the administration needed to support and direct the field operations.

The benefits included in the analysis are identified as follows:

1. Fines for overweight vehicles,
2. Proper registration fees otherwise not paid, and
3. Prevention of uncompensated pavement wear.

In relating total benefits to any given mode and level of enforcement, two factors were found to be of paramount importance. The first of these is the probability that a violator will be apprehended. The best estimate of this factor was obtained from an analysis of historical records of apprehensions and enforcement levels in Iowa.

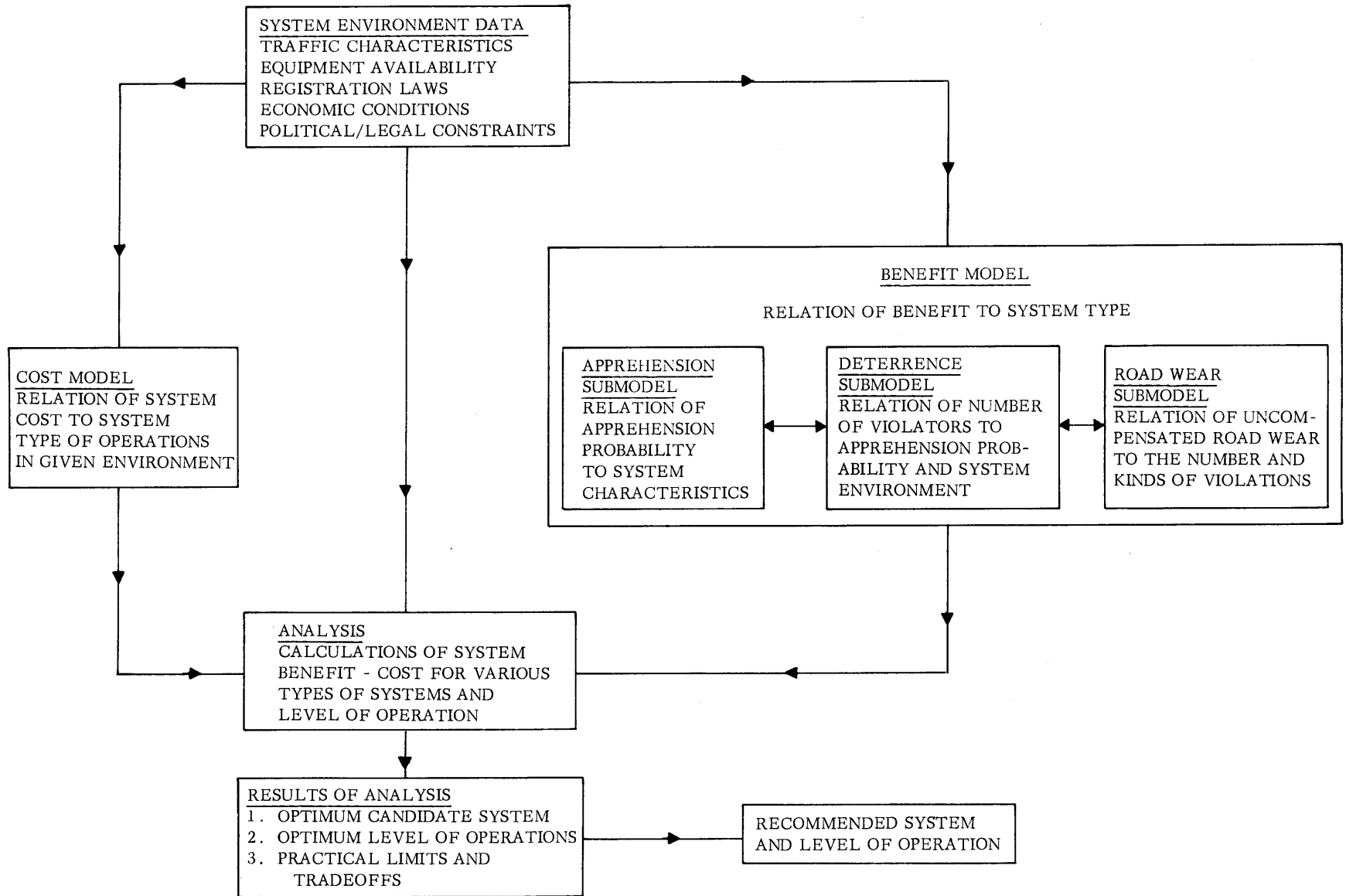


Figure 1 - Overall Logic of the Cost Effectiveness Analysis of Weight Enforcement Methods

The second factor is deterrence. It was estimated that, as of now, about 89 percent of all trucks traveling on Iowa highways comply with weight and registration regulations. In other words, the present enforcement effort produces a deterrence of 89 percent. It may be assumed that a zero enforcement effort would result in zero deterrence, meaning that regulations would be universally ignored. At the other end of the scale it appears that even a maximum enforcement effort would produce only about 98 percent deterrence, since there seems to be about 2 percent of the truck population which are in unintentional violation due to ignorance or carelessness.

The fines collected for operation of overloaded vehicles is a tangible thing which may be readily associated with enforcement. It requires no further explanation. The concept of registration fees as a benefit from enforcement is a bit more complicated. There is, of course, the additional fees obtained from apprehension of trucks operating with loads in excess of what they are registered to carry. There is also a benefit derived from the fact that enforcement, with the attendant possibility of apprehension, deters operators from deliberately registering their vehicles at less than the proper weight.

When a vehicle is improperly registered for a weight less than it is carrying, that vehicle is imposing on the highway pavement an amount of wear greater than it rightly should for the registration it carries. This uncompensated pavement wear also occurs when a vehicle is operated with a load in excess of the maximum legal load. In both instances the benefit is derived from the fact that potential violators are deterred by the enforcement efforts.

The calculation of the dollar value of uncompensated pavement wear required an extensive analysis of many factors. Estimates were made of the potential number of violators in the trucking population, the severity of these overweight violations, the number of trips per year of violators, their average mileage per trip, and lane mile costs for various kinds of pavement. These factors were all combined to determine the average cost to Iowa for each truck trip made in violation of the vehicle size or weight laws. This amount was credited to the inspection for every violator deterred. Since about 89 percent of all trucks do comply with the laws due to current traffic weight operations, this benefit to Iowa is substantial.

It is important to note that consideration of the prevailing legal, economic, and political environment affecting traffic weight operations was not part of this study. For example, despite the controversy within transportation circles concerning the fairest way to allocate highway expenses to various users, including the general public and truckers,

the study was made with the assumption that the current truck-registration structure reasonably reflects economic realities. It also assumed the equity of the fines for overweight violations. The validity of the results is not affected by accepting these assumptions.

Ultimately, since the analysis must be clear cut if the Iowa State Highway Commission is to fulfill its responsibilities in an intelligent and well-informed manner, this study concentrated on the identification and measurement of only well defined benefits associated with traffic weight operations. For this reason, safety benefits, as well as the reduction of uncompensated wear to bridges and to city streets, were not included in the analysis. In spite of their importance, there is presently almost a complete lack of data on which to base the dollar value of these benefits.

Although the basic means of analyzing methods of weight inspection was in terms of their benefits and costs, other factors were also taken into consideration. For example, the technical feasibility of various operating techniques and advanced weighing equipment was also examined. In general, an effort was made to arrive at useful recommendations concerning all important aspects of enforcement.

RESULTS--OPTIMUM ENFORCEMENT

The optimum staff level for enforcement of Iowa's laws and regulations pertaining to weight and size of trucks operating on the highways is a result of many interacting factors. The truck population, including the owners and drivers, is an adaptive one, reacting to the enforcement efforts of the state. Stated simply, if there were no enforcement effort, compliance with the law would be very low, almost zero, and conversely, if an enforcement officer were maintained at every important road junction, compliance would be very high, nearly 100 percent. For this latter case, however, the costs would be prohibitive.

Some truck drivers and owners, about 2 percent, are in violation of laws and regulations accidentally, that is, it is not their intention to violate the law, but they simply do not take the time to check.

The curves in Figure 2A show how some of these important relationships vary as the size of the enforcement staff is increased. Initially the number of violators apprehended increases rapidly as the enforcement staff is increased, but soon begins to peak and drop off as the truck population reacts to enforcement with compliance. The probability of apprehension of individual violators continues to increase as staff size increases.

Figure 2 - Factors Influencing Size of Staff

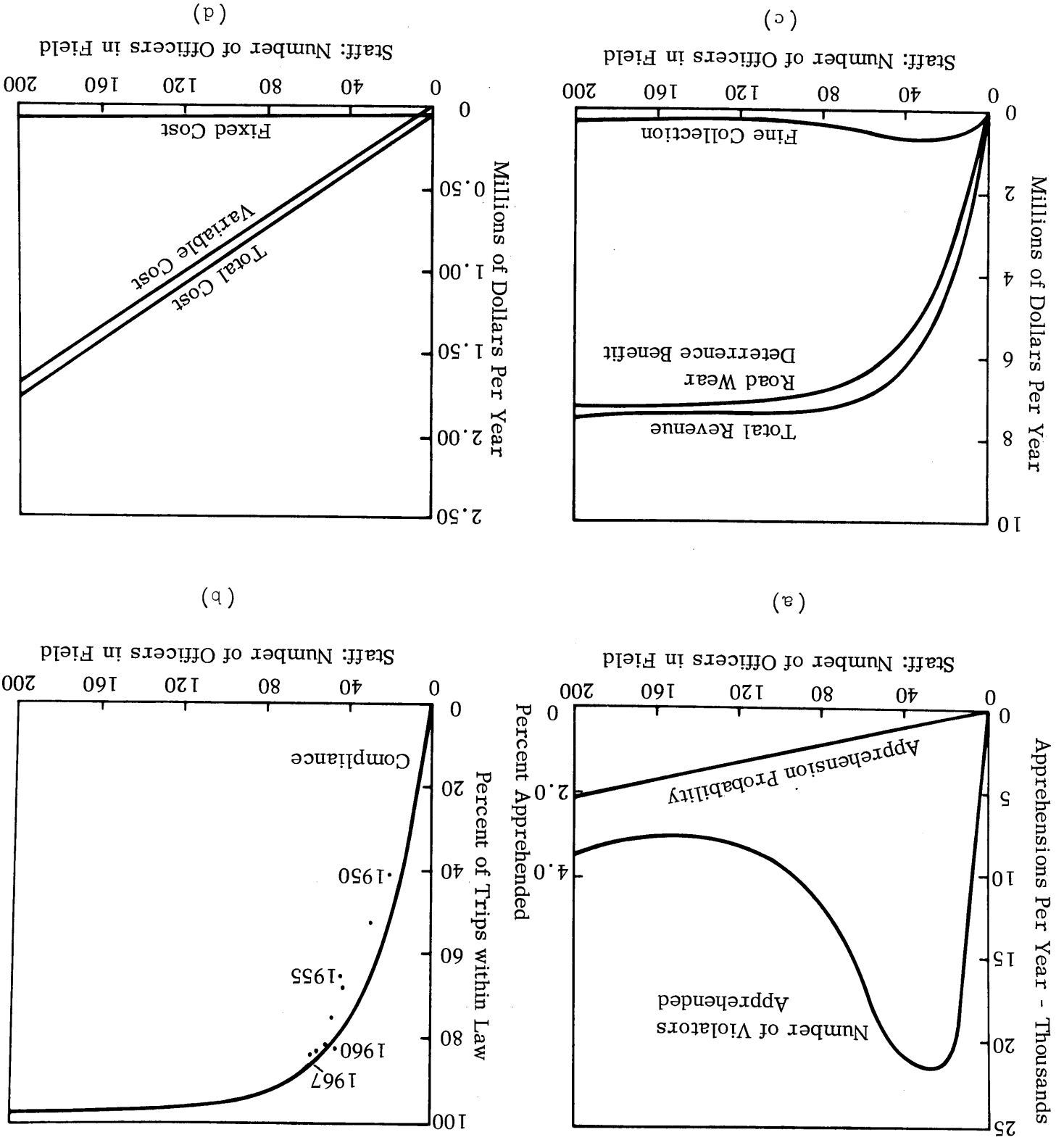


Figure 2B illustrates the increase in compliance which accompanies an increase in staff size. Compliance, which is expressed as the percentage of the total truck population complying with the law, increases rapidly at first, but begins to level out at about 95 percent. The circles appearing on or adjacent to the curve mark historical data on compliance and staff size obtained for the period 1952 through 1967.

Benefits to the state of Iowa in the form of collection of fines and the reduction of uncompensated road wear combine to produce a total benefit or revenue to the state. Figure 2C shows that, while the collection of fines increases rapidly at first, it falls off slowly in total dollar income even as the staff size is increased due to the fact that there are fewer violators to apprehend. The benefit from uncompensated road wear, however, continues to rise as the staff is increased, this benefit increasing approximately in proportion to compliance.

These benefits of increased compliance and greater revenue are not without an attendant cost. It is this cost that sets a practical limit on the level of enforcement. Figure 2D indicates that the cost of enforcement staff is composed of two main elements: (1) fixed costs for administration and supervision, which remains almost constant, and (2) the variable costs associated with each enforcement officer, such as salary, benefits, subsistence and travel.

The interaction of the principal factors relating to the optimum staff level is shown in Figure 3. The shaded portion delimits the area of management flexibility. The numerical values pertaining to this area are contained in Table I.

The optimum point is that size staff which produces the maximum net revenue to the state. Assuming that current enforcement policies and practices would continue, a staff of 79 enforcement officers produces maximum net revenue, and can be considered to be the optimum level of enforcement. Adding another enforcement officer from this point would add slightly less benefit than his approximate \$9,000 annual cost.

At this optimum point, a high degree of compliance--93 percent--with Iowa's truck-weight-size and registration regulations could be obtained.

At the optimum enforcement level--79 men--Iowa would derive \$6,480,000 in net benefits from traffic weight operations.

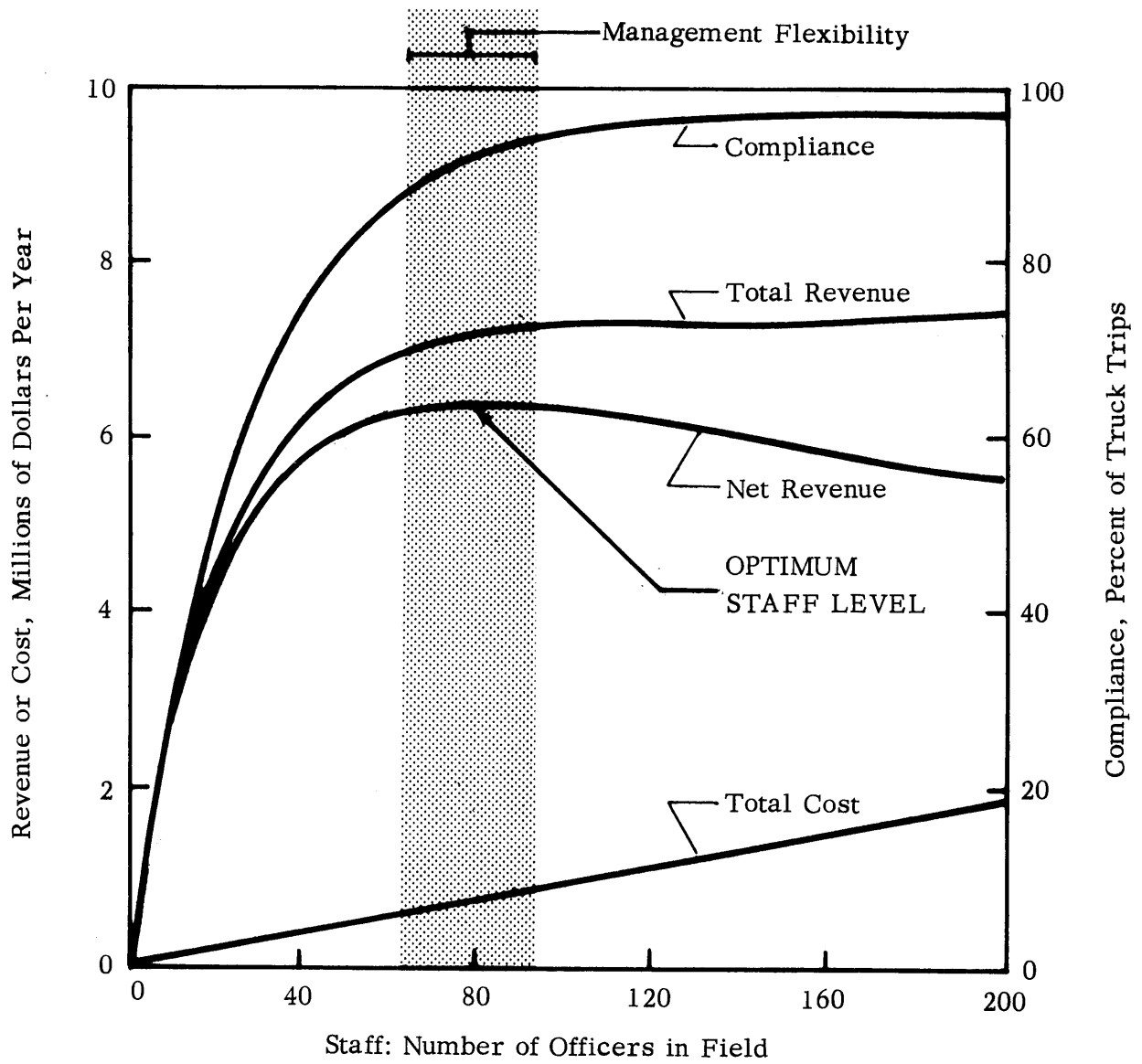


Figure 3 - Optimum Staff Level

TABLE I

NUMERICAL VALUES FOR AREA OF MANAGEMENT FLEXIBILITY

<u>Item No.</u>	<u>Item</u>	<u>Item-Value</u>		
		<u>Optimum</u>		
1	Size of enforcement staff - field officers only	64	79	95
2	Expected number of truck trips in Iowa 1968	20,000,000	20,000,000	20,000,000
3	Expected compliance with regulations - percent	89	93	95
4	Expected number of truck trips made in compliance (Item 2 x Item 3) ^{1/}	17,800,000	18,600,000	19,000,000
5	Estimated value for increased compliance per trip, dollars	0.37	0.37	0.37
6	Estimated value from increased compliance (Item 4 x Item 5), dollars ^{1/}	6,590,000	6,870,000	7,041,000
7	Expected cash income from apprehended violators, dollars	469,000	376,000	306,000
8	Total benefits (Item 6 + Item 7), dollars	7,060,000	7,250,000	7,350,000
9	Estimated total cost of traffic weight operations, dollars	629,000	763,000	919,000
10	Net benefits (Item 8 - Item 9), dollars	6,430,000	6,480,000	6,430,000

^{1/} Actual calculations used values to 4 significant figures.

It is significant to note that the net revenue curve is very flat in the vicinity of the optimum staff level. From the viewpoint of management, this situation affords considerable latitude in staff manning levels without significant risk. For example, if current operating funds are the critical factor, then a staff level of 64 enforcement officers could be considered. This is the same as the 1967 average enforcement staff and would provide a net benefit to Iowa of \$6,430,000, a reduction of less than 1 percent from the optimum net benefit. Eighty-nine percent of the trucks operating on Iowa's highways are caused to comply with truck-weight-size and registration regulations at this staff level.

If increased compliance with the law is paramount, an increase of staff level to 95 field enforcement officers would reduce net revenue to the same level attainable at the 64-man level, but compliance would be increased to 95 percent. The operating budget would be higher at this staff level, but the increased compliance would mean an increase in the benefits from deterred violations.

According to ISHC figures, truck traffic in Iowa is forecast to increase annually by 3 percent during the next few years. However, the probability of violators being apprehended is a matter of manpower and geography, as well as of increased efficiency per T.W.O. official, not a function of the number of trucks. The recommended or optimum staff level will not grow in direct proportion to increases in truck traffic; the new trucks will still use the same road network. Results of the analysis, briefly summarized, are as follows:

<u>Year</u>	<u>Truck Traffic Millions of Trips per Year</u>	<u>Optimum Staff</u>
1968	20.0	79
1973	23.2	83
1978	27.0	86
1983	31.0	89
1988	36.0	92

Cost of living increases in staff salary have not been considered since these same factors would also influence the principal source of benefits--road replacement costs. Also, the forecasts pertaining to optimum staff level of enforcement officers are based on past and present performance and policies of enforcement. If these same policies are continued, the optimum staff levels will prevail.

RESULTS--SUPPLEMENTAL STUDIES

During the course of this study, MRI also investigated possible areas for more economical or efficient utilization of enforcement personnel. The operating level of 64 field enforcement officers for 1967 is very close to the optimum for current operating methods. These methods very obviously have been improved by ISHC personnel over the years and no doubt will continue to become more efficient in the future. Some of the areas which we believe the Commission should focus upon as a continuation of their efficiency improvement program are discussed in the following paragraphs.

A. Manpower Allocation by Time of Day

MRI investigated the possibility that more manpower should be allocated to night operations in order to apprehend violators who are trying to avoid the law by driving at night. A computer program accumulated traffic and apprehensions or violations from all scale sites, and grouped them by the time period in which they occurred. The program also calculated the "fraction violating" for each time period by dividing the number of apprehensions or violations by the traffic counted (see Figure 4). The results show, as might be expected, that truck traffic is heaviest during the middle of the day, and drops off sharply at night; and also, that this night traffic contains a higher percent of violations. Another result of the analysis was to show that there is no significant reduction in traffic volume or the fraction of vehicles in violation shortly after a scale is opened. The latter finding contradicts the commonly held belief that truckers warn each other that a scale has just opened; they may do so, but there is no significant effect on traffic characteristics. Truckers knowingly in violation avoid routes with fixed sites whenever possible; and adjust their time of travel to avoid the operating hours of fixed scale sites.

An increased use of night-operating schedules--as well as more frequent changes in scale scheduling--would seem desirable, to improve the apprehension rate. Computer assistance could overcome administrative problems associated with frequent schedule changes and intermittent shifts in manpower.

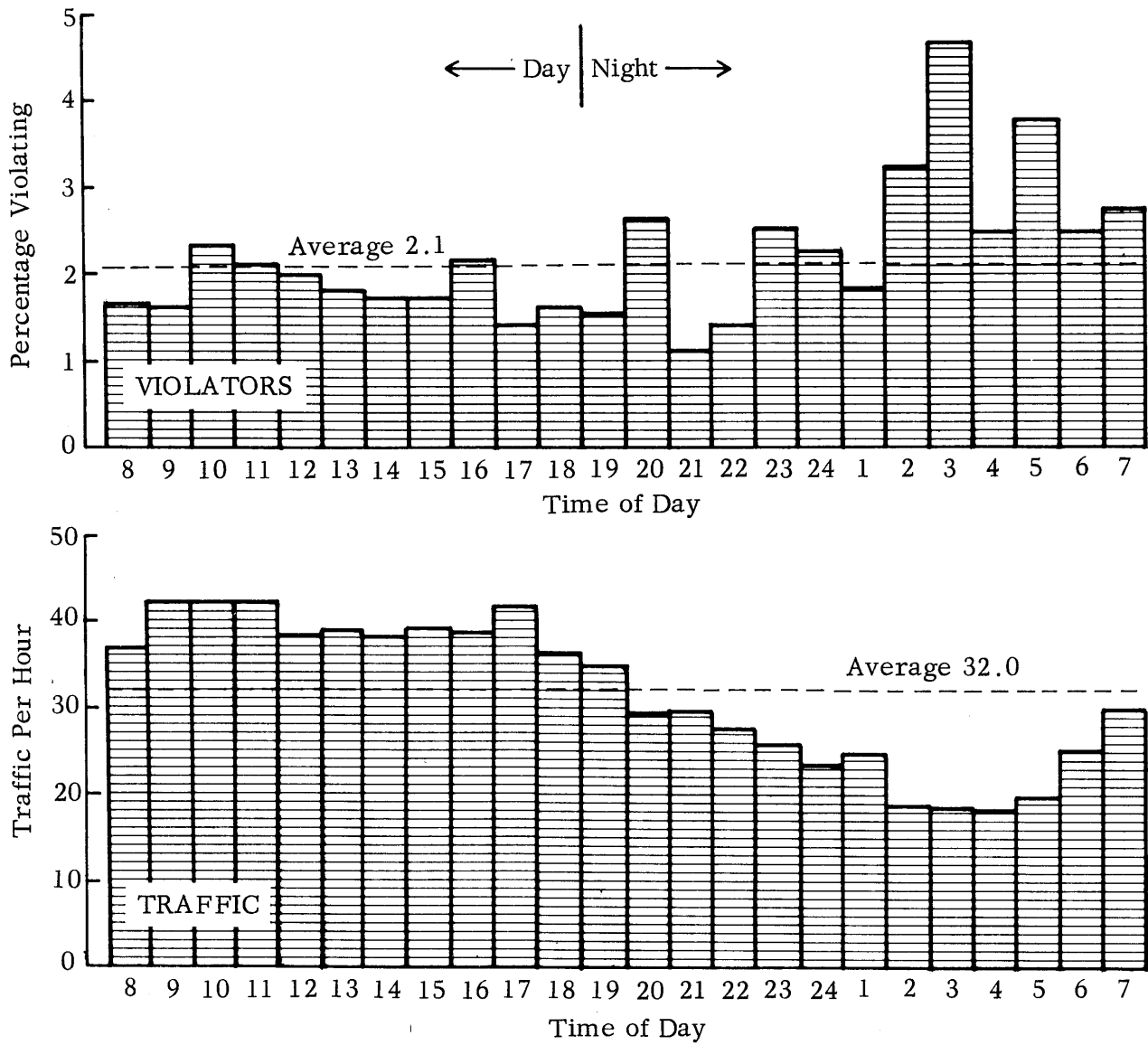


Figure 4 - Traffic Characteristics With Respect To
The Time of Day

B. Fraction of Manpower Devoted to Fixed-Site Operation versus Roving-Patrol Operation

The present strategy for allocating manpower is 75 percent to fixed-site operations, 25 percent to roving patrol. The average fine obtained from roving patrol apprehension is 61 percent higher than the average fines paid by violators apprehended at fixed scale sites. An operational experiment, designed to determine the effect of increasing the fraction of manpower devoted to roving patrol did not produce definitive results because of short-term scheduling problems and "learning effects" during the experimentation. There is little doubt, however, that greater use of roving patrols can improve compliance and increase revenues.

C. Utilization of Fixed-Scale Sites

Fixed scales cost approximately \$15 per hour to operate. MRI analyzed the operation of fixed scale sites and ranked each traffic-weight station by the total revenue earned per operating hour. The total revenue consisted of the fines collected from summonses, and an implicit value for uncompensated pavement wear. There was, and is, considerable variation between stations. Nine stations collect from \$15 to \$20 per operating hour; six stations collect approximately \$10-\$13 per operating hour; and 15 stations in the lowest group receive less than \$10 per operating hour. These differences are due to local differences in traffic volume, fraction of traffic in violation, and the average fine per summons.

As a general conclusion, manpower should be allocated to each traffic-weight station in direct proportion to the demonstrated earning ability of the station. The continued operation of certain stations is questionable unless the cost of an operating hour can be reduced, or the stations can be justified as protecting unusually vulnerable roads. A computer program would be valuable for keeping fully up to date with changes in traffic volume, degree of compliance, and the average fine collected per summons.

D. New Scale Construction

The question of construction of new scale sites is clearly related to the cost of such construction, the expected life of the scale, the expected traffic on the road, the size of the enforcement staff available and the method of financing the construction.

Traffic forecasts for interstate and primary roads for the next 20 years can be estimated as averaging 77 and 33 trucks per hour respectively. Assuming a 20 year scale life, and that manpower would be available to operate the new scale sites, a rule of thumb can be expressed in terms of the cost of construction. If the cost to Iowa of a pair of interstate scales is less than \$300,000, the scales can be expected to be profitable. For primary roads, the critical figure is \$80,000, based on the average expected traffic.

Each proposed scale site should be examined in detail, however, before construction is authorized. The methodology for the analysis is detailed in the full report.

E. Procedural and Administrative Changes: Observations

1. With present T.W.O. enforcement practices approximately 30 percent of all cases are issued delayed appearances. Investigation by the Director of T.W.O. indicates that no more cases are lost in court with delayed appearance than with immediate appearance with present practices. The current Iowa practice of more immediate prosecution does not seem necessary. The size of the weighing crew might well be reduced, which would free the same staff size to man and operate more scale sites.

2. The Assistant Director of T.W.O. is charged with the responsibility to review when and where violations are occurring. We believe that computerized aids--in the form of operational schedules and work assignments--would provide significant opportunities for more frequent changes of schedules, and prevent violator avoidance.

3. Despite the fact that the average fine from violators apprehended by roving patrol is significantly higher than the average fine from violators apprehended at fixed scale sites, the apprehension rate for all roving patrol is lower than that for fixed scale sites. In addition, this apprehension rate varies widely from team to team, as much as by a factor of 20. The implication is that some teams are assigned better sites from which to conduct their operations than others, such as one which complements the active operation of a fixed scale site and successfully apprehends violators attempting to avoid the fixed scale. While there may be differences in the traffic density in the areas of operations of some of these roving patrol teams, we believe that significant gains can be made in the roving patrol effectiveness by increased training.

4. A central file of owner names associated with vehicle license numbers would help to identify repeat offenders.

F. Use of Advanced Weighing Equipment

A literature search and field trips to two experimental installations were used to investigate advanced weighing equipment. Research programs on improved weighing methods are currently going on in six states and at least an equal number of foreign nations. Equipment has been developed that will weigh trucks at full highway speeds of 60-70 mph. Such equipment research, particularly when refined, will permit the carrying-out of traffic surveys at a great number of locations without construction of expensive ramps, parking facilities, etc., and will permit sorting out of possible violators from the general truck population without stopping all vehicles and creating waiting lines. Also, the development of scales with remote read-out that require less manpower to operate is particularly promising.

Dynamic weighing is not yet as accurate as it must be for wide adoption, though below speeds of 15 mph it is as accurate as conventional methods. Moreover, it involves the use of electronics, with attendant maintenance and reliability problems.

For the near term, conventional static weighing methods should be continued, but Iowa should consider limited experiments with selected developmental techniques.

STATE LIBRARY OF IOWA



3 1723 02104 4367