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SYSTEMS ANALYSIS OF ALCOHOL COUNTERMEASURES

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16. Abstract

The purpose of the contract was to conduct a benefit/cost analysis of seven alcohol safety countermeasures in order to determine the potential for successful implementation in terms of the estimated cost/effectiveness of each countermeasure and to provide NHTSA with baseline information for allocating research monies in the area of countermeasure development. The countermeasures analyzed were:

1. Sober pill
2. Self tester
3. Evidential roadside tester
4. Non-cooperative breath tester
5. Alcohol safety interlock system
6. Continuous monitoring device
7. Operating time recorder

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ADDENDUM

This report presents the results of a study to conduct a benefit/cost analysis of seven potential alcohol/crash countermeasures. For each countermeasure, a benefit/cost model was formulated. Benefit was estimated in terms of expected accident reduction and associated monetary savings. Cost parameters specified in the models include: research and development, manufacturing, maintenance, inspection, etc. Two estimates of cost-effectiveness as defined by (Benefit/Cost ratios) are presented for each countermeasure ("average" and "Hurst" estimate). The "average" estimate is described as the lower or pessimistic estimate and the "Hurst" estimate is described as the upper or optimistic estimate. The primary difference between these estimates is that the "Hurst" estimate includes a factor that attempts to take into account the increased risk of severe injury for high BAC (> .15%) related accidents. This factor is especially critical for proper evaluation of countermeasures that would be expected to have primary impact on drivers traveling at high BAC's. Dr. Paul Hurst (a consultant to this project from the Institute for Research) estimated that for these situations, the appropriate values to be used for the average fatalities and injuries per alcohol crash were approximately twice that of the general population values that were used to determine the "average" estimates. The "Hurst" estimates reflect this approximation. However, it should be noted that the exact nature of the rational behind this approximation was not documented. Also, NHTSA examination of selected alcohol/crash data indicate (that the "Hurst" estimate is a fair approximation for fatals, but the "average" estimate is a fair approximation for injury and property damage accidents). In addition, for both the "Hurst" and "average" estimates, the values assigned to the parameters included in the Benefit/Cost models were based, in a large proportion of the situations, on assumptions. This was due primarily to the fact that real-world information was not available.

As a result of these considerations, neither the "Hurst" nor "average" estimates should be considered definitive indicators of the real-world economic potential associated with each countermeasure. Also, they should not be considered as limiting the range of Benefit/Cost ratios obtainable.

The Benefit/Cost models presented do provide a framework for systematizing the available information associated with each countermeasure and determining priority areas for future research. Clearly, much additional work is required to specify the missing parameter values before the economic potential of individual countermeasures can be specified.

EXECUTIVE SUMMARY

General Research Corporation has completed a ten-month contract (DOT-HS-4-00995) with the National Highway Traffic Safety Administration to perform a Systems Analysis of Alcohol Countermeasures. The purpose of the contract was to conduct a detailed benefit/cost analysis of seven alcohol safety countermeasures and countermeasure combinations in order to determine the potential for successful implementation in terms of the estimated cost/effectiveness of each countermeasure and to provide NHTSA with baseline information for allocating research monies in the area of countermeasure development. The countermeasures analyzed were:

1. Sober Pill
2. Self-Tester
3. Evidential Roadside Tester
4. Non-Cooperative Breath Tester
5. Alcohol Safety Interlock System
6. Continuous Monitoring Device
7. Operating Time Recorder

GENERAL APPROACH

The general approach was to calculate a set of benefit/cost ratios for each countermeasure based on the mode or scale of application, e.g., restricted and/or universal application. Sensitivity analyses were performed on the crucial assumptions and key elements of costs and benefits to test their impact on the benefit/cost ratios. Finally, the potential for successful application for each countermeasure was assessed on the basis of the benefit/cost ratios in conjunction with the aspects of the social, technological, and legal feasibility.

The benefit/cost ratio is defined as:

$$R = B/C$$

where

B is total benefits as measured by the savings in societal costs resulting from the expected reduction in crashes.

C is the total cost of developing, producing, and implementing the countermeasure.

RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

Sober Pill

The sober pill would be cost/effective (B/C range = 4.0 - 5.0) at $.25 per dose and an effective reduction in impairment of .04-.05 BAC. The critical considerations in determining the cost effectiveness of the sober pill are:

1. It must be technologically feasible.
2. It must not have undesirable side effects.
3. Use must be at least 1 out of 17,000 trips at BAC $\geq$ .05 percent.
4. Dosage cost - maximum $1.00.

It is recommended that NHTSA sponsor additional research:

1. To develop a drug that can reduce impairment by .04-.05 BAC without undesirable side effects.
2. To develop implementation procedures.

Self-Testers

Self-testers would be cost effective (B/C range = 1.0 - 2.0) if users do not drive 75 percent of the time the BAC indication is greater than or equal to .10 percent. The critical considerations in determining the cost effectiveness of the self-testers are:

1. The driver deterrence rate is unknown.
2. Use must be at least 1 out of 10,000 trips at BAC $\geq$ .10 percent.
3. Cost per use must not exceed $.80.

It is recommended that NHTSA sponsor additional research:

1. To determine the expected public usage and deterrence under different conditions.
2. To develop implementation procedures.

Evidential Roadside Tester

The evidential roadside tester would be cost/effective (B/C range = 1.0 - 2.0) if the deterrence impact is 1-2 percent of illegal BAC trips ($\geq$.10 percent). The critical considerations in determining the cost effectiveness of the evidential roadside tester are:

1. Driver deterrence is unknown.
2. Acceptance and use by law enforcement agencies is unknown.
3. A minimum of 100 units must be in service per year.
4. Incremental court costs per case must not exceed $100.
5. Incremental rehabilitation costs per case must not exceed $250.

It is recommended that NHTSA sponsor additional research:

1. To determine the deterrence potential.
2. To determine the police/court willingness to use the device.
3. To develop implementation procedures.

Non-Cooperative Breath Tester

The non-coopperative breath tester would be cost/effective (B/C range = 1.0 - 2.0) if deterrence impact is 1-2 percent of illegal BAC trips. The critical considerations in determining the cost effectiveness of the non-cooperative breath tester are:

1. The driver deterrence rate is unknown.
2. Use must comply with existing legal constraints (e.g., illegal search and seizure laws).
3. A minimum of 100 units must be in service per year.
4. Incremental court costs per case must not exceed $75.
5. Incremental rehabilitation costs per case must not exceed $200.

It is recommended that NHTSA sponsor additional research:

1. To determine the deterrence potential.
2. To develop a device that meets the specified performance and cost specifications.
3. To assess the legal constraints.
4. To develop implementation procedures.

Alcohol Safety Interlock System

The alcohol safety interlock system would be cost effective (B/C range = 1.0 - 2.0) if a device could be developed with at least a 50 percent effectiveness rate at BAC $\geq$ .10 percent, is tamperproof, and requires minimal maintenance and installation cost. The critical considerations in determining the cost effectiveness of the alcohol safety interlock systems are:

1. The effectiveness rate must be at least 50 percent.
2. The courts must be willing to impose its use (restricted use).
3. The annual maintenance cost must not exceed $10 per unit.
4. Installation and removal cost must not exceed $15 and $7.50 respectively (restricted use).
5. There must be no inspection cost.
6. If used on a restricted basis, a minimum of 1,000 units per year must be in service.

It is recommended that NHTSA sponsor additional work:

1. To develop a device that meets the stated performance and cost requirements.
2. To determine the deterrence potential.
3. To determine the court's willingness to use the device (restricted use).
4. To determine the social acceptance potential (universal use).
5. To develop implementation procedures.

Continuous Monitoring Device

The continuous monitoring device would be cost effective (B/C = 1.0 - 1.5) if DWI drivers abide by the warning 50-60 percent of the time. The critical considerations in determining the cost effectiveness of the continuous monitoring device are:

1. It must be technologically feasible.
2. The driver deterrence rate is unknown.
3. The courts must be willing to impose its use.
4. A minimum of 10,000 units must be in service per year.
5. The manufacturing price must not exceed $175 - $200 per unit.
6. Installation and removal cost must not exceed $15 and $7.50 respectively.

It is recommended that NHTSA sponsor additional research:

1. To develop a device that correlates driving impairment with BAC level.

2. To determine the deterrence potential.

3. To determine the court's willingness to use the device.

4. To develop implementation procedures.

Operating Time Recorder

The operating time reocrder would be cost effective (B/C = 1.0 - 2.0) if it were 50-60 percent effective in eliminating illegal BAC trips during restricted hours. The critical considerations in determining the cost effectiveness of the operating time recorder are:

1. The driver deterrence rate is unknown.

2. The courts must be willing to impose its use.

3. The restricted hours must encompass 50 percent of alcohol trips.

4. A minimum of 10,000 units must be in service per year.

5. The annual maintenance and calibration cost must not exceed $10 per unit.

6. The installation and removal cost per unit must not exceed $15 and $7.50 respectively.

It is recommended that NHTSA sponsor additional work:

1. To determine the deterrence potential.

2. To determine the court's willingness to use the device.

3. To develop implementation procedures.

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I. INTRODUCTION

General Research Corporation has completed a ten month contract (DOT-HS-4-00995) with the National Highway Traffic Safety Administration to perform a Systems Analysis of Alcohol Countermeasures. The purpose of the contract was to conduct a detailed benefit/cost analysis of seven alcohol safety countermeasures and countermeasure combinations in order to determine the potential for successful implementation in terms of the estimated cost/effectiveness of each countermeasure and to provide NHTSA with baseline information for allocating research monies in the area of countermeasure development. The countermeasures are listed in Tables 1 and 2 along with the mode of application for each.

This report describes in detail the methodologies developed for estimating the benefits and costs of the countermeasures, the analyses performed, and the findings, conclusions, and recommendations of the analyses. The organization of the report is as follows. Chapter II discusses the general research methodology which is applicable to all the countermeasures. Chapter III presents the analysis for each of the countermeasures and Chapter IV discusses the countermeasure combinations. Chapter V discusses the feasibility of the countermeasures with respect to the social, technological, and legal considerations which must be made. Chapter VI presents the interpretation of the research findings, and the recommendations and conclusions are presented in Chapter VII.

BACKGROUND AND DISCUSSION OF THE PROBLEM

Alcohol-related crashes have reached almost epidemic proportions throughout the United States. Of the 55,000 persons who died in 1973 in

Table 1

SINGLE COUNTERMEASURES TO BE ANALYZED

Countermeasure	Mode of Application
1. Sober pill	Universal
2. Self tester	Universal
3. Evidential roadside tester	Universal to law enforcement agencies
4. Non-cooperative breath tester	Universal to law enforcement agencies
5. Alcohol safety interlock systems	Restricted and universal
6. Operating time recorder	Restricted
7. Continuous monitoring device	Restricted

Table 2

COUNTERMEASURE COMBINATIONS

1. Sober pill and self tester
2. Evidential roadside tester and non-cooperative breath tester
3. Alcohol safety interlock and operating time clock
4. Alcohol safety interlock and continuous monitoring device
5. Operating time clock and continuous monitoring device

road accidents on the Nation's highways, approximately fifty percent of these crashes involved the use of alcohol. It has been demonstrated that there is a vast, disproportionate number of crashes that are caused by drinking drivers, and if an effective countermeasure campaign can be designed and implemented to lessen the numbers of alcohol-related crashes, it would add significantly to the achievement of the National goal of reducing the number of traffic deaths and injuries in the United States.

The problem is far from simple. It involves major psychological, physiological and sociological elements within the framework of American society. It deals with a variety of different kinds of drinkers: moderate drinkers, heavy social drinkers, problem drinkers, alcoholics, young drinkers. Even the definitions of which persons fit into any of these categories is widely disputed by experts in the field of both alcoholism and traffic safety. The inability of the medical profession to demonstrate concrete results in some type of cure for alcoholism adds greatly to the problem of reaching reasonable solutions.

Alcohol has a two-pronged effect on the human body. On the one hand, coordination and perception are impaired. On the other, judgment is affected and individuals are stimulated to drive in a more hazardous fashion. The extent of this impairment will vary greatly among the different groups of drinking drivers - the social drinkers, the heavy social drinkers, and the problem drinkers. The amount of alcohol consumed and the extent of experience in both drinking and driving (especially in the case of young drivers) is another factor to be considered in the degree and frequency of alcohol impairment.

Distinction among the three groups of drinking drivers are important to conceptionalizing the problem of enforcing drinking driving laws. The social drinkers, since they rarely reach illegal BAC levels, are generally not a problem for law enforcement. A strong public relations campaign, with the knowledge of the probability of apprehension, arrest and conviction may serve as an effective deterrent in keeping most social drinkers from driving while intoxicated. If possible, the strengthening of the community's social norms of acceptable conduct, which would exclude excessive drinking and driving, would be an important step in modifying their behavior. The social drinker who has his drinking under control can be expected to minimize these instances if the probability of being apprehended and penalized is sufficiently high.

It is the behavior of the other two groups which presents the more serious challenge. Deterrence is likely to be relatively ineffective with the problem drinker whose drinking is wholly or partially out of control. He must be apprehended, brought under the control of the court, and placed into a system that will result in his rehabilitation. While the alcohol countermeasure program is directed towards all groups of drinking drivers, it is primarily the heavy social drinkers and the problem drinkers that the main thrust of the program is focused.

One of the goals of the National Highway Traffic Safety Administration is to study and assess the alternatives for reducing the number of alcohol related crashes. A number of alcohol countermeasures have been proposed during the past few years which are designed to reduce alcohol-involved crashes. With the limited amount of funds available for research in these areas, it is reasonable and practical to project the potential costs and benefits that can be derived from the most promising of these projects.

The countermeasures analyzed in this study may be grouped into three general classes:

1. Volunteer Driver Action
   (a) Sober Pill
   (b) Self Tester
2. Traffic Law Enforcement Testers
   (a) Evidential Roadside Tester
   (b) Non-Cooperative Breath Tester
3. Regulating or Monitoring Operation of Vehicles
   (a) Alcohol Safety Interlock System
   (b) Operating Time Recorder
   (c) Continuous Monitoring Device

It is anticipated that the voluntary driver action countermeasure will be initiated primarily by the prospective drivers with relatively little compulsion from an outside source. As stated earlier, an effective public information and education program would greatly increase the probability of their use. The second category, traffic law enforcement testers, deals with obtaining evidentiary material for the prosecution of DWI offenders. In this instance, a strong effort of enforcement will complement the public information and education program by substantiating the desired public awareness of the probability of apprehension, arrest and conviction. The third category, regulating or monitoring the operation of vehicles, involves devices placed on vehicles which would be used either to prevent the vehicles from being started due to the high blood alcohol content of the driver, or his inability to pass a performance test. These countermeasures also would include the monitoring of the driver's performance, which would activate certain warning devices should the performance of the driver fall below a certain level, and the installation of a time-recorder device to register any driving during certain restricted periods of time. It is anticipated that these countermeasures will be initiated through court actions in virtually all cases. However, consideration was given to the universal application of the interlock devices on all new vehicles.

OBJECTIVES OF THE STUDY

The work performed by General Research Corporation under the contract was designed to achieve seven specific objectives. These are as follows:

1. To determine the accident reducing potential for each of the countermeasures.

2. To determine the costs of developing, implementing, and operating the countermeasures over a life cycle time period of 10 years.

3. To assess the cost/effectiveness of each countermeasure with respect to its accident reducing potential and the total system cost.

4. To perform a comparative analysis of the countermeasures to determine which ones offer the greatest potential for successful implementation.

5. To determine the economic feasibility of each of the countermeasures in terms of the benefit/cost ratios.

6. To determine what effectiveness levels would be required to make each countermeasure an economically feasible approach.

7. To determine the areas of greatest information needs that should be given priority to help reduce the uncertainties in the benefit/cost analysis.

II. RESEARCH APPROACH AND METHODOLOGY

GENERAL APPROACH

The general approach was to calculate a set of benefit/cost ratios for each countermeasure and countermeasure combination based on the mode or scale of application, e.g., restricted and/or universal application. Sensitivity analyses were performed on the crucial assumptions and key elements of costs and benefits to test their impact on the benefit/cost ratios. Finally, the potential for successful application for each countermeasure was assessed on the basis of the benefit/cost ratios in conjunction with the aspects of the social, technological, and legal feasibility.

The benefit/cost ratio is defined as:

$$R = B/C$$

where

B is total benefits as measured by the savings in societal costs resulting from the expected reduction in crashes.

C is the total cost of developing, producing, and implementing the countermeasure.

BENEFIT MEASUREMENT

Ideally it would have been desirable to experimentally derive the data for estimating the accident reducing potential for each of the countermeasures. Neither time nor cost permitted the feasibility of this approach and nonexperimental means had to be used to estimate the benefits. The approach adopted in this study was to use the empirical relationships derived by Hurst to measure the impact of estimated changes in BAC levels on crashes and fatalities.[1] The standard societal costs of crashes and

[1] Paul M. Hurst, "Epidemeological Aspects of Alcohol in Driver Crashes and Citations," Journal of Safety Research, September, 1973, p. 130, and "Estimating the Effectiveness of Blood Alcohol Limits," Behavioral Research in Highway Safety, 1970, pp. 87-99.

fatalities adopted by the US Department of Transportation were applied to the reduction projections to estimate the benefits in dollar terms, i.e., \$200,000 per fatality, \$7,200 per injury, and \$300 property damage per involvement. While it is recognized that the assignment of dollar values to fatalities and personal injuries is questionable and has been criticized by many,[2] the same values are used for all countermeasures, and therefore, the relative ranking of the countermeasures is not affected by their use. However, the issue of economic feasibility which is based on the benefit/cost ratio exceeding unity is dependent on the DOT societal costs, and therefore, the reader should interpret the findings accordingly.

Measure of Effectiveness

Thorough consideration was made with respect to which of two measures of effectiveness should be used in this study. These are:

1. Reduction in alcohol related fatalities
2. Reduction in alcohol related crashes

If fatalities are used as the criterion, the formula for calculating total benefits is:

$$B_1 = \$200{,}000\ (\Delta F)$$

where

ΔF is the expected reduction in alcohol related fatalities

\$200,000 is the average societal cost per fatality

If crash involvement is used as the criterion, the formula for calculating net benefits is

$$B_2 = \$7{,}200\ (\Delta I) + \$300\ (\Delta K) + \$200{,}000\ (\Delta F')$$

where

ΔI is the expected reduction in injuries

ΔK is the expected reduction in the number of alcohol related crashes

ΔI = (average injuries per alcohol related crash) (ΔK)

$\Delta F'$ = (average fatalities per alcohol related crash) (ΔK)

\$7,200 is the average societal cost per injury

\$300 is the average societal cost in property damage per involvement

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[2]H. C. Joksch, "A Critical Appraisal of the Applicability of Benefit/Cost Analysis to Highway Traffic Safety," Center for the Environment and Man, Inc., Hartford, Connecticut, October, 1974.

The rationale for using reduction in fatalities as the measure of effectiveness is based primarily on the fact that alcohol is related to over half of all fatalities whereas alcohol is related to only about 30 percent of the non-fatal crashes and 15 percent of all property damage crashes.[3] Since the countermeasures are directed to alcohol related crashes, the former measure had appeal in that it has a larger percentage coverage.

However, the inclusion of only fatalities in the analysis would overlook approximately 68 percent of the potential total benefits from implementing the countermeasures. Data from the US statistical Abstract for 1973 indicate that approximately 24.85 million accidents occurred in calendar year 1972. The distribution of this total is given as:

.2088 injuries per crash

.0023 fatalities per crash

Using the above figures, the DOT societal costs, and the ratios of 50 percent, 30 percent, and 15 percent for alcohol related fatalities, injuries and property damage, the total potential savings from the elimination of alcohol related crashes may be estimated. These are given in Table 3.

Table 3

POTENTIAL SAVINGS FROM ALCOHOL RELATED CRASHES

	Total number	x	Percent related to alcohol	x	DOT societal costs	=	Potential savings (billions)
Fatalities	57,000		.50		200,000		$ 5.70
Injuries	5,189,000		.30		7,200		11.21
Property	24,850,000		.15		300		1.12
			Estimated total savings (billions)				$18.03

It can be seen that any analysis which focuses only upon the savings due to a reduction in fatalities will produce a benefit/cost ratio which is greatly understated, and therefore, the approach used in this study was the reduction in total crashes.

[3] US Department of Transportation, "Chapter 2 ASAP Program Evaluation Methodology and Overall Program Impact," Evaluation of Operations 1972 Volume II Detailed Analysis, DOT HS 800874, 1972, p. 14.

In order to apply the formulae for calculating the savings in societal costs from implementing a countermeasure, it was necessary to estimate the number of personal injuries per alcohol related crash and the number of fatalities per alcohol related crash. Using the percentages in Table 3, the estimates were obtained in the following manner:

Alcohol Related Crashes = .15 x Total Crashes
3,727,500 = .15 x 24,850,000

Alcohol Related Fatalities = .50 x Total Fatalities
28,500 = .50 x 57,000

Fatalities per Alcohol Related Crash = Alcohol Related Fatalities/Alcohol Related Crashes
.00766 = 28,500/3,727,500

Alcohol Related Injuries = .3 x Total Injuries
1,556,700 = .3 x 5,189,000

Injuries per Alcohol Related Crash = Alcohol Related Injuries/Alcohol Related Crashes
.4176 = 1,556,700/3,727,500

Hurst has demonstrated that the relative probability of accident involvement for drivers with BAC >.15 is as high as 19 times that of sober drivers, and therefore, countermeasures that focus on reducing the number of drivers at elevated BAC levels will have a greater than average impact on reducing the number of alcohol related fatalities and personal injuries. Dr. Hurst estimates that the appropriate values to be used for average fatalities per alcohol related crash and average personal injuries per alcohol related crash are of the order of twice that of the average. As a means of providing a range of values for the analysis, the calculations were made for each countermeasure using the average per alcohol related crash as the lower or pessimistic estimate and the Hurst estimates per alcohol related crash as the upper or optimistic estimate. The values used were as follows:

	Fatalities per Alcohol Related Crash
Average Estimate*	.00766
Hurst Estimate	.00152

	Personal Injuries per Alcohol Related Crash
Average Estimate*	.4176
Hurst Estimate	.8352

* In order to avoid confusion, estimates using the average number of fatalities per alcohol related crash are labeled A-Estimates. Estimates using the Hurst values are called Hurst estimates.

Requirement for BAC Data

In order to apply the Hurst methodology to estimate the expected savings in crashes, it was necessary to have data on both the overall distribution of BAC levels and the distribution of BAC levels for individuals involved in crashes. Also, in order to assess the total effectiveness of the countermeasures, it was necessary to have BAC data which are representative of driving during all hours of the day for each day of the week.

Four primary sources were reviewed and assessed for data on the overall BAC distribution:[4]

1. US National Roadside Breathtesting Survey (1973)
2. Grand Rapids, Michigan, Accident and Control Data (1963)
3. Washtenaw County, Michigan, ASAP Baseline Data (1965)
4. ASAP Data Tapes, NHTSA (1973)

Three primary sources were reviewed and assessed for data on the BAC/crash distribution:

1. Grand Rapids, Michigan, Accident and Control Data (1963)
2. Nassau County, New York, ASAP DATA (1970)
3. ASAP Data Tapes, NHTSA (1973)

The assessment of the data sources revealed that the US National Roadside Breathtesting Survey provided the best representative data for determining the overall BAC distribution Nationally, and the Grand Rapids, Michigan, Accident and Control Data was the only source of data that provided the combination of both overall BAC distribution data and BAC/crash distribution data. The Hurst methodology for estimating the accident reducing potential of the countermeasures requires that consistent data on both overall BAC distributions and BAC/crash distributions in a given area be used. While it would have been desirable to have National data comparing the BAC distributions of the crash and control groups, use had to be made of the limited amount of data. As a result, an assumption had to be made that the relative probability of crash involvement is strictly a function of alcohol consumption and that differences due to geographic variations were not statistically significant. Hopefully, data will be available in the future to test the validity of the assumption.

[4] Other sources used by Hurst included Evanston, Illinois; Toronto, Canada; and Manhattan, New York.

Unfortunately, no data were available which directly gave the overall BAC distribution data for day/week, night/week, and day/weekend periods, and it was necessary to develop a methodology for estimating the distribution for these time periods. The details of the procedures used to derive these BAC distributions are presented in the subsection entitled, Generation of BAC Distributions.

COST MEASUREMENT

The cost element in the benefit/cost ratio is defined as the cost of developing, producing, and implementing the countermeasures. It is to be noted that only incremental costs were considered in the analysis. Costs which already had been incurred in the research and development of the countermeasures are sunk costs, and as such are not relevant to comparing the costs and benefits of implementing the countermeasure. In effect, only those costs which will be incurred in the future as a result of countermeasures were included.

The principle of "with and without" was used in the analysis. Under the with and without principle, only those costs and benefits which are causally related to the occurrence of the alternative are chargeable to it. This means that in addition to excluding sunk costs, all costs and benefits which would have occurred regardless of whether or not the countermeasure had been undertaken should be excluded. For example, increased court costs associated with the evidential roadside tester are measured by subtracting the total court costs without the countermeasure from the total court costs with the countermeasure.

Since many of the countermeasures are still in the early developmental stages, e.g., the sober pill, reliable cost data did not exist and it was necessary to rely upon expert opinion in order to obtain estimates. Several interviews (both personal and telephone calls) were held with prominent individuals familiar with the research and development of the countermeasures, and they were asked to supply information on costs of various activities related to the countermeasures. In all, ten elements of cost were considered:

1. Research and development
2. Manufacturing (given by selling price)

3. Installation costs
4. Maintenance costs
5. Inspection costs
6. Testing equipment
7. Cost of malfunction
8. Public information
9. Increased enforcement costs of police, courts, and corrections
10. Removal costs

The information sources used for each countermeasure are presented in Table 4.

ECONOMIC LIFE

In order to provide a basis for comparing the benefits and costs of each countermeasure, a decision had to be made regarding the time period of comparison or the economic life of each. Since there were no reliable historical data on the individual countermeasures, the estimate of economic life was an educated guess. A period of 10 years was used for the analysis. This provided a baseline, and sensitivity analysis was used to determine if the ranking of the countermeasures was sensitive to different assumptions regarding the economic life.

Since costs and benefits accrue at different rates over time, it was necessary to use discounting to take into account the time value of money. All costs and benefits were discounted to the present, and the benefit/cost ratios were stated in terms of average annual benefits and costs. The Office of Management and Budget has determined that a rate of 10 percent be used to discount cash flows for all projects involving the expenditure of Federal monies,[5] and this rate was used for the countermeasures. Year 1 was defined to be FY76 and, therefore, the analysis will carry through FY85. Thus, the model for the benefit/cost analysis is given as follows:

Time (years)	Costs	Benefits
0	C_0	B_0
1	C_1	B_1
⋮		
10	C_{10}	B_{10}

[5]Office of Management and Budget, Circular No. A-94, March 27, 1972.

Table 4

INFORMATION SOURCES FOR COUNTERMEASURES

Source	Sober Pill	Self Tester	Evidential Roadside Tester	Non-Cooperative Breath Tester	Continuous Monitor	Operating Time Clock	Interlock Systems
Dr. Ernest P. Noble University of California Irvine, Calif.	✓						
Dr. Frederick Benjamin NHTSA Washington, D.C.	✓	✓	✓	✓			
Mr. Mac Forrester Intoximeter Inc. St. Louis, Miss.		✓		✓			
Dr. Kurt Dubowski University of Oklahoma Norman, Okla.		✓					
Mr. Paul Brown Borg Warner Instruments Chicago, Ill.		✓	✓				
Dr. Leland Summers NHTSA Washington, D.C.		✓	✓		✓	✓	✓
Mr. Ken Bray Dr. Steven Huntley DOT Transportation Systems Center Cambridge, Mass.		✓	✓	✓	✓	✓	✓

Table 4 (continued)

Source	Sober Pill	Self Tester	Evidential Roadside Tester	Non-Cooperative Breath Tester	Continuous Monitor	Operating Time Clock	Interlock Systems
Mr. John Foy Lear-Siegler Inc. Oklahoma City, Okla.					✓		
Mr. H. Jex Systems Technology Inc. Hawthorne, Calif.							✓
Mr. Jack Oates Dunlap Associates Darien, Conn.							✓

The discounted present value of total costs is equal to

$$C = \sum_{i=0}^{10} \frac{C_i}{(1.1)^i}$$

where

i stands for the year

C_i is the estimated costs in year i

The discounted present value of total benefits is equal to

$$B = \sum_{i=0}^{10} \frac{B_i}{(1.1)^i}$$

where

i stands for the year

B_i is the estimated benefits in year i

Thus

$$R = \frac{B}{C} = \frac{\sum_{i=0}^{10} \frac{B_i}{(1.1)^i}}{\sum_{i=0}^{10} \frac{C_i}{(1.1)^i}}$$

It is to be noted that the trend of accidents over the next 10 years was given consideration. From 1960 to 1970, the number of vehicles on the road increased from 73,869,000 to 108,375,000, and the number of accidents increased from 11,429,000 to 22,116,000.[6] In effect, the potential for reducing accidents in 1970 was substantially greater than in 1970. If this trend were to continue, the potential for reducing accidents in 1985 would be greater than in 1975. However, in view of the energy crisis and the President's decision to reduce the rate of consumption of gasoline over the next few years, it is likely that the amount of driving will not increase nearly as rapidly over the next 10 years. A conservative approach was undertaken and it was assumed that the potential for accident reduction would be the same as 1975 in each year through 1985. Since this assumption applies equally to all countermeasures, it does not affect the relative ranking of the benefit/cost ratios.

[6]US Department of Commerce, Statistical Abstract of the United States, Bureau of Census, 1973.

HURST METHODOLOGY[7]

Dr. Paul Hurst's epidemeological model was used to estimate the accident reducing potential for each countermeasure. This model utilizes the overall BAC distributions, the BAC/crash distributions, and the application of Bayesian statistics to determine the relative likelihood of driver involvement in accidents at different BAC levels. The relative probabilities are based on the empirical evidence derived by Hurst that drivers at higher BAC levels have a greater likelihood of being involved in an accident than drivers at lower BAC levels.

Assumptions

The major assumption in applying the Hurst BAC/crash relationship is that those who currently drive at a given level BAC, e.g., .20 percent BAC, would, if driving at a lower BAC, e.g., .10 percent BAC, have the same relative crash incidence as observed among those driving at the lower BAC. Thus, if it can be demonstrated that a proposed alcohol countermeasure, e.g., the alcohol interlock, can effectively reduce the average BAC of those using the countermeasure, the empirical relationships can be used to estimate the expected reduction in accidents.

Another assumption of the Hurst model is that the relative crash probability at varying BAC levels reflects only the causal influence of the alcohol ingested. This assumption means that, all things equal, drivers at higher BAC levels have a greater likelihood (probability) of being involved in an accident than drivers at lower BAC levels.

The Model

The Hurst model for estimating the expected reduction in crashes by lowering the BAC level from B to P is given as

$$\Delta I_p = \sum_{B=P}^{B=K} I_B \left[\frac{RP(C/B) - RP(C/P)}{RP(C/B)}\right]$$

where

[7] Hurst, _op cit_.

ΔI_p = expected reduction in crashes from the application of countermeasure which reduces BAC from B to P

I_B = expected number of crashes that would occur at BAC=B without the application of the countermeasure

K = maximum value of BAC obtainable in sample

RP(C/B) = relative probability of crash given a BAC level equal to B

RP(C/P) = relative probability of crash given a BAC level equal to P

The relative probability of C given B is defined as

$$RP(C/B) = \frac{P(C/B)}{P(C/B_0)} = \frac{\frac{P(C)P(B/C)}{P(B)}}{\frac{P(C)P(B_0/C)}{P(B_0)}} = \frac{P(B_0)P(B/C)}{P(B)P(B_0/C)}$$

where

$P(B_0)$ is the absolute probability of observing a BAC level equal to .00 to .01.

$P(B)$ is the absolute probability of observing a BAC level equal to B. Both of these probabilities may be empirically derived from the overall BAC distributions given in the Grand Rapids data. See Fig. 1.

$P(B_0/C)$ is the conditional probability of observing a BAC level equal to .00 to .01 given that a crash has occurred.

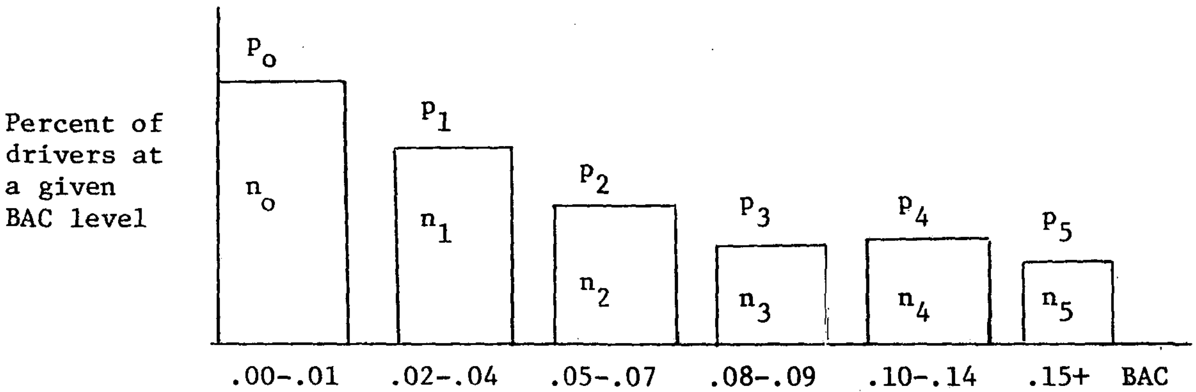
$P(B/C)$ is the conditional probability of observing a BAC level equal to B given that a crash has occurred. Both of these conditional probabilities may be empirically derived from the BAC/crash distributions given in the Grand Rapids data. See Fig. 2.

In applying the Hurst model to the individual countermeasures, the relative probabilities were derived from the Grand Rapids data, and are presented in Table 5.

Table 5

RELATIVE PROBABILITIES

BAC	Relative Probabilities
.00-.01	R_1 = 1.0
.02-.04	R_2 = 1.0
.05-.07	R_3 = 1.36
.08-.09	R_4 = 1.933
.10-.14	R_5 = 5.74
.15+	R_6 =18.97

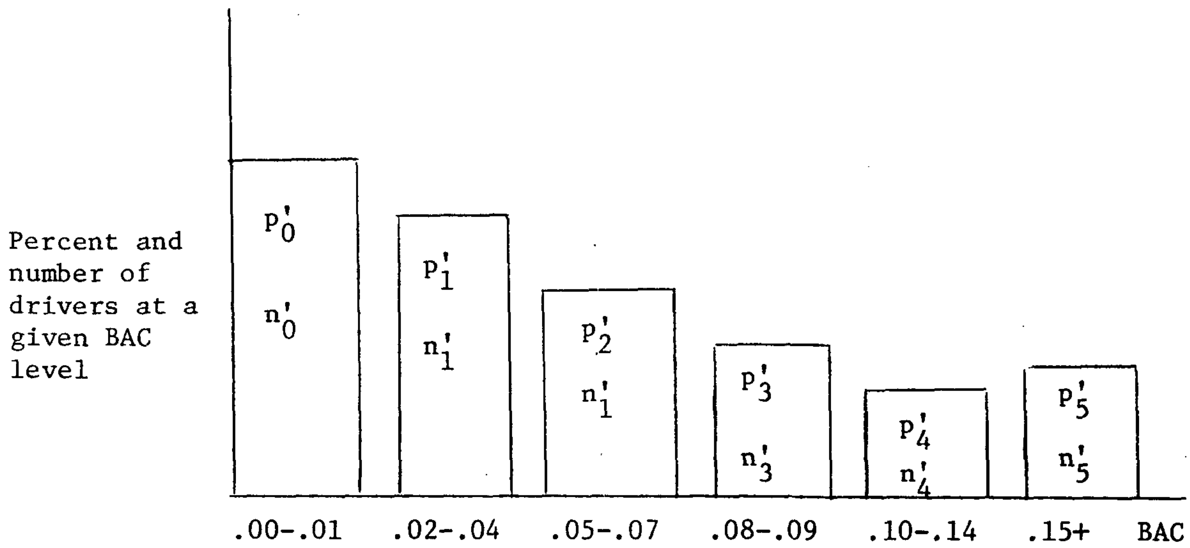


where p_i = proportion of driving population sampled who have BAC levels corresponding to i, i = 0, 1, ..., 5

n_i = number of drivers in sample at a given BAC level, i = o, 1, ..., 5

Fig. 1—Overall Distribution of BAC Drivers*

*The intervals selected correspond to the data in the HSRI National Roadside Survey.



where p'_i = proportion of accident involved drivers in sample at a given BAC level; i = 0, 1, ..., 8

n'_i = number of accident involved drivers in sample at a given BAC level, i = 0, 1, ..., 8

Fig. 2—Distribution of BAC/Crash Drivers*

*The intervals selected correspond to the data in the HSRI National Roadside Survey.

The meaning of relative probability may be illustrated as follows. For example, a relative probability of 5.74 for BAC = .10-.14 means that a driver at this BAC under similar traffic conditions and time of day would be 5.74 times more likely to be involved in an accident than a driver at BAC = .00-.01. A driver at BAC = .08-.09 would be only 1.933 times more likely to be involved in an accident than a driver at BAC = .00-.01. Thus, if a driver could be shifted from BAC = .10-.14 to BAC = .08-.09, his risk of being involved in an accident is .66 percent of what it was at the higher BAC level.

$$\frac{5.74 - 1.933}{5.74} = .66$$

The remaining tasks were to estimate the impact of the countermeasure's use on the BAC levels of those using it, and also to estimate the number of crashes ($\hat{I}_B$) that potentially would be affected by the application of the countermeasure.

For example, the application of the alcohol safety interlock, if 100 percent effective, would have the impact of preventing any driver with such a device from driving with a BAC greater than .09 if the limit is set at .1. The Hurst formula would be used to calculate the expected reduction in accidents from reducing the BAC level from .10-.14 and .15+ to .09.

Since only a limited number of drivers would have the device, it is necessary to adjust I_B to reflect the crashes that are potentially affected ($\hat{I}_B$). This adjustment was made in the following manner.

$$\hat{I}_B = \left[\frac{P_B(912.5)X}{T_B}\right] I_B \qquad T_B = P_B T$$

where

P_B = the proportion of drivers at BAC = B. See Fig. 1.

912.5 = average number of trips per year per person[8] (912.5 = 2.5 x 365).

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[8] It has been estimated by Oates and McCoy that the average number of trips per day per licensed driver is 2.5. See J. F. Oates and R. T. McCoy, Methodologies for Estimating the Effectiveness of Alcohol Safety Interlock Systems, DOT-TSC-251-3, 1973.

X = the number of drivers who have the device.

T_B = total number of trips per year at BAC = B.

T = total number of trips per year.

I_B = number of crashes occurring per year at BAC = B. See Fig. 2.

Thus, for each countermeasure, it was necessary to calculate an adjusted $I_B(\hat{I}_B)$ which reflects the number of trips per year which are potentially affected by the application of the countermeasures. It is important to note that the concept of the "trip" provides the weighing factor rather than mileage exposure. While an argument may be made for using mileage as the weighing factor, many of the countermeasure devices focus on preventing a trip from occurring and costs are in many instances directly proportional to trips rather than mileage. As a pragmatic approach, the trip provided the best weighing measure. Furthermore, it is likely that the total number of trips in the aggregate for all licensed drivers would be closely correlated with mileage, and if this is true, then weighing factors based on trips would be identical to those based on mileage.

The Grand Rapids crash distributions were used to estimate the total number of crashes at each BAC level $(\hat{I}_B)$. This distribution is presented in Table 6.

Table 6

BAC/CRASH DISTRIBUTION

BAC	Crash Probability	Crashes (I_B)
.00-.01	.8654	C_1 = 21,505,190
.02-.04	.0364	C_2 = 904,540
.05-.07	.0221	C_3 = 549,185
.08-.09	.8130	C_4 = 323,050
.10-.14	.0310	C_5 = 770,350
.15+	.0318	C_6 = 790,230

Generation of BAC Distributions

As noted previously, existing BAC data were available only for night/weekend periods and it was necessary to make estimates for these BAC distributions for day/week, day/weekend, and night/week. The existing data from the National Roadside Survey were used as the baseline and supplementary data from the Grand Rapids Study, Mr. Richard Zylman, and the Delaware ASAP summary reports were used to estimate the overall BAC distributions. The exact procedures that were followed are described in App A. The estimated BAC distribution by time of day and day of week is given in Table 7. It is to be noted that the total BAC distribution is not a simple average of the time of day/day of week distributions, but rather a weighted average where the weights are the percentage of trips associated with each.

Table 7

BAC DISTRIBUTION BY TIME OF DAY/DAY OF WEEK

BAC	Night/ Weekend	Night/Week	Day/Weekend	Day/Week	Total
.00-.01	.773	.809	.901	.941	B_1 = .878
.02-.04	.092	.077	.040	.024	B_2 = .049
.05-.07	.061	.051	.027	.016	B_3 = .032
.08-.09	.024	.020	.010	.006	B_4 = .013
.10-.14	.036	.031	.016	.009	B_5 = .020
.15+	.014	.012	.006	.004	B_6 = .008

Summary of Research Approach and Methodology

The primary steps for implementing the benefit/cost methodologies may be summarized as follows:

1. Estimate fatalities per alcohol related crash.

2. Estimate injuries per alcohol related crash.

3. Estimate relative crash probabilities for Hurst Model using the Grand Rapids data for overall BAC and BAC/crash distributions.

4. Estimate aggregate BAC distributions from National Roadside Survey and other sources.

5. Use Grand Rapids data to estimate the distribution of crashes by BAC.

6. Use the aggregate BAC distribution to estimate the total number of trips per year at each BAC.

7. Estimate the number of trips at each BAC per year potentially affected by the application of each countermeasure.

8. Use Hurst formula to estimate the potential annual crash savings for each countermeasure.

9. Convert crash savings into annual savings in societal costs using the DOT societal cost estimates and the estimates for fatalities and injuries per alcohol related crash.

10. Estimate average annual cost of developing, implementing and operating each countermeasure.

11. Calculate benefit/cost ratio by dividing average annual savings in societal by the average annual costs for each countermeasure.

12. Perform sensitivity analyses in key elements of costs and benefits.

13. Rank countermeasures by benefit/cost ratio.

14. Interpret findings.

III. ANALYSIS OF COUNTERMEASURES

This chapter presents the models, analyses, and findings for each of the alcohol countermeasures and countermeasure combinations. Each countermeasure is discussed in a separate subsection and the subsections are organized in the following manner:

1. Description and Performance Characteristics
2. Benefit/Cost Model
3. Summary of Findings - Baseline Case and Sensitivity Analysis

The non-technical reader not concerned with the formulae and who is interested primarily in the results of the analyses may skip the benefit/cost model section without losing the continuity of the report.

Before presenting the discussion of the individual countermeasures, it is important to note that certain parameters were the same for all benefit/cost models, and therefore, changes in the values for these parameters do not affect the relative rank ordering of the benefit/cost ratios. These parameters and the values used in the models are given in Table 8.

Also, a number of assumptions were made which applied to all the countermeasures. These assumptions are as follows:

1. It was assumed that the sample of overall BAC distributions (Table 7) is representative of the distribution of annual trips made by the average driver.

2. It was assumed that the relative probabilities (Table 5) were applicable to all geographic regions of the Nation.

Table 8

PARAMETERS INCLUDED IN ALL MODELS

Parameter	Value
1. Number of Licensed Drivers	114,397,000
2. Average Trips per Year per Driver	912.5
3. Total Number of Crashes	24,850,000
4. BAC/Crash Distribution	See Table 6
5. BAC Distribution by Time of Day/Day of Week	See Table 7
6. Relative Probability by BAC	See Table 5
7. Fatalities per Alcohol Related Crash	A-Estimate = .00766 Hurst = .0152
8. Injuries per Alcohol Related Crash	A-Estimate = .4176 Hurst = .8752
9. DOT Societal Cost per Fatality	$200,000
10. DOT Societal Cost per Personal Injury	$ 7,200
11. DOT Societal Cost per Property Damage Crash	$ 300

3. It was assumed that the application of the countermeasures would not significantly affect the total number of trips per year.

4. It was assumed that the number of alcohol related crashes at each BAC level is proportional to the number of trips made at that level. Thus, in applying the Hurst relative probability model if 50 percent of the trips at a BAC level are affected by the countermeasure, then potentially 50 percent of the accidents may be eliminated at that BAC level.

5. It was assumed that the total number of trips per year would remain constant over the 10 year period. This assumption does not affect the relative ranking of the countermeasurs, and furthermore, may not be unrealistic in view of the recent energy crisis where driving actually declined from 1973 to 1974.

6. It was assumed that the A-Estimate for fatalities and injuries per alcohol related crash represented a lower bound and the Hurst estimates represent an upper bound.

SOBER PILL

DESCRIPTION AND PERFORMANCE CHARACTERISTICS

The concept of the "sober pill" is to allow a person, who believes he has had too much alcohol to drink, to take a pill which contains ingredients that can reduce the effects of the alcohol on his driving behavior.

There are primarily two concepts which have been used to describe a pill that will limit the impairing effects of alcohol on the central nervous system: blood alcohol metabolization and a blocking agent to the brain. In regard to the first concept, which would metabolize the blood alcohol concentration throughout the body beyond the norm of .015 percent per hour, there has been insufficient evidence to date to indicate any probability of success. An experiment conducted in England, which was reported by Merry and Marks,[9] showed that eleven volunteers ingested a fructose-alcohol mixture on one occasion and a placebo-alcohol mixture on another. Mean blood alcohol levels were lower after the ingestion of the fructose-alcohol mixture, but there was no significant effect on test performance. It appears that a large amount of fructose would be required before any appreciable increase in metabolism can be affected.

The second concept is the use of a drug or combination of drugs that selectively can block the effects of alcohol on the brain and central nervous system. A number of different drugs which included L-dopa, Stedeze, Ephedrine, Aminophylline, Aminophylline-Ephedrine Combination, Nikethamide, Peprodrol, and Ammonium Chloride have been tested recently by Dr. Ernest Noble of the University of California, Irvine as possible agents for a sober pill.[10] While Dr. Noble's findings are encouraging, a successful sobering pill agent has not been developed and further research will be required.

Figure 3 presents a causal chain diagram illustrating how the sober pill would operate to reduce accidents. With the limited experimental results available, it is not possible to make a reliable estimate of the expected performance of the sober pill, but it is anticipated that it

[9] Merry, J., Marks, V., "Effect on Performance of Reducing Blood Alcohol with Oral Fructose," Lancet, West Park Hospital, Epsom, Surrey, England, December 1967.

[10] Noble, Ernest P., Testing for a Sobering Pill, prepared under DOT Contract DOT-HS-3-744 for the National Highway Traffic Safety Administration, October 31, 1974.

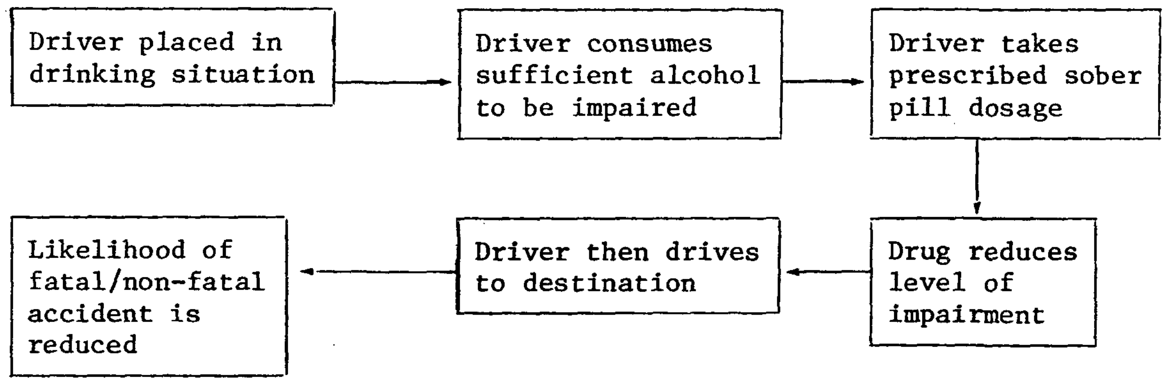

Fig. 3—Causal Chain for Sober Pill

could improve a driver's performance by as much as .1 percent BAC. Thus, if a driver is at .14 percent BAC, a dose of the drug would bring his effective BAC down to .04 percent. Different assumptions regarding the potential effectiveness of a sober pill were included in the analysis.

BENEFIT/COST MODEL

Assumptions

1. A sober pill would be available for sale to the public by 1 July 1976.

2. A single dosage of the pill would have the impact of reducing the average driver's effective BAC by the following values: .10, .08, .06, .05, .04, and .02.

3. The utilization rate was assumed to be equal to the following values: .0001, .001, .01, .05. The utilization rate may be interpreted as follows: a rate of .0001 means that the pill would be used in one out of every 10,000 trips at BAC = .05 or greater.

4. It was assumed that the price per dosage could have the following values: \$.05, \$.10, \$.50, \$.75, \$1.00.

Model Equations

The benefit/cost model for the sober pill is given as follows:

$$B/C_i = \frac{\text{Average Annual Savings in Societal Costs (SCC)}_i}{\text{Average Annual Total Cost (TC)}} \qquad i = 1,2$$

where

$i = 1$ is the savings in societal costs where the values for average fatalities and injuries per alcohol related crash are used.

$i = 2$ is the savings in societal costs where the Hurst values for fatalities and injuries per alcohol related crash are used.

$$SSC_1 = CR\left[F_1\ (200{,}000) + P_1\ (7{,}200) + (300)\right]$$
$$SSC_2 = CR\left[F_2\ (200{,}000) + P_2\ (7{,}200) + (300)\right]$$

where

CR is the average annual crash savings

F_1 is the A-Estimate of fatalities per alcohol related crash (.00766)

P_1 is the A-Estimate of personal injuries per alcohol related crash (.4176)

F_2 is the Hurst estimate of fatalities per alcohol related crash (.00152)

P_2 is the Hurst estimate of personal injuries per alcohol related crash (.8352)

$$CR = (A)(C_3)\left[\left[\frac{R_3 - R_{b3}}{R_3}\right] + C_4\left[\frac{R_4 - R_{b4}}{R_4}\right] + C_5\left[\frac{R_5 - R_{b5}}{R_5}\right] + C_6\left[\frac{R_6 - R_{b6}}{R_6}\right]\right]$$

where

A is the utilization rate

C_3, C_4, C_5, C_6 are annual crashes at BAC = .05+ (see Table 6)

R_3, R_4, R_5, R_6 are the relative crash probabilities (see Table 5)

R_{b3}, R_{b4}, R_{b5}, R_{b6} are relative crash probabilities given in Table 9

Since different effective reductions in BAC levels were assumed, e.g., .10, .08, etc., a range of different relative probabilities had to be considered. For example, if the effective reduction in BAC were assumed to be .05, then an original BAC = .10-.14 would have an effective level of BAC = .05-.09 and the relative probability would be 1.524 (see Table 9). A number of relative probability values had to be considered for the sober pill that did not have to be included for the other countermeasures, and therefore, a separate table was constructed for these values.

TC (Average Annual Total Cost) = Research and Development Cost (RD)
+ Public Information Cost (PI)
+ FDA Approval Cost (FDA)
+ Dosage Cost (DC)

Table 9

RELATIVE PROBABILITIES APPLICABLE TO THE SOBER PILL

BAC	Relative Probability	BAC	Relative Probability
.02-.06	1.032	.07-.11	2.589
.03-.07	1.113	.07-.17	3.837
.04-.05	1.133	.08-.12	3.143
.04-.06	1.20	.08-.18	4.714
.04-.08	1.324	.09-.19	5.866
.05-.06	1.303	.09-.13	4.073
.05-.09	1.524	.10-.20	7.879
.05-.15	2.478	.11-.21	9.149
.06-.07	1.465	.12-.22	9.736
.06-.10	2.004	.13-.23	14.73
.06-.16	3.045	.14-.24	16.93
.07-.08	1.70		

$RD = .16275\ RD_T$

$PI = PI_A$

$FDA = .16275\ FDA_T$

$DC = UDC(Z_3 + Z_4 + Z_5 + Z_6)A$

where

.16275 is the amortization factor for determining the average annual cost over 10 years discounted at 10 percent

RD_T is total research and development cost

PI_A is annual public information cost

FDA_T is total FDA approval cost

UDC is unit dosage cost

Z_3, Z_4, Z_5, and Z_6 are total trips annually at BAC - .05-.07, .08-.09, .10-.14 and .15+ respectively. See Table A-1 in App A

A is the utilization rate

SUMMARY OF FINDINGS - BASELINE CASE AND SENSITIVITY ANALYSES

Table 10 summarizes the findings for the baseline case and the sensitivity analyses for the sober pill. The table (and all subsequent tables for other countermeasures) may be interpreted as follows. The input data specific to the sober pill (the general data which apply to all countermeasures were given in Table 8) are given first. Next, the annual savings are presented in terms of savings in crashes, savings in fatalities and personal injuries using the A-Estimates per alcohol related crash. Savings are in fatalities and personal injuries using the Hurst estimates for alcohol related crashes are given, and then the savings in societal costs using both the A-Estimates and Hurst estimates are given. The third grouping presents the annual cost estimates for each cost element in the total cost equation. Finally, the benefit/cost ratios are given for the A-Estimates and Hurst estimates, and the crash/cost ratio is given which is converted into estimated crash savings per million dollars of cost.

The first column presents the baseline case. It is important to note that the baseline case represents the initial estimates for the input data, and they do not necessarily reflect the most probable input values (this is time for all the countermeasures), and should not be interpreted as such. A substantial amount of speculation was involved in obtaining many of the estimates for the countermeasures, and the primary advantage of

Table 10

SOBER PILL

	Baseline case	1	2	3	4	5	6	7	8	9	10	11	12	13	Most favorable 14	Least favorable 15
Input Data																
Utilization rate	.01	.001	.05	.0001												.0001
Unit dosage cost	.25				.05	.10	.50	.75	1.00						.05	1.00
Research and development cost	500,000															
Public information cost	250,000															
FDA cost	100,000															
Effective reduction in BAC	.1									.08	.06	.05	.04	.02		
Annual Savings																
Savings in crashes	16,244.9	1,624.5	81,244.5	162.4						15,635	14,398	13,291	11,897	7,487.5		162.4
Savings in fatalities (average)	124.4	12.44	622	1.24						119.7	110.3	101.8	91.1	57.3		1.24
Savings in fatalities (Hurst	246.9	24.69	1,234.5	2.47						237.6	218.8	202.0	180.8	113.8		2.47
Savings in personal injuries (average)	6,783.9	678.4	33,919.5	67.84						6,525.2	6,012.6	5,550.3	4,968.2	3,126.8		67.84
Savings in personal injuries (Hurst)	13,567.7	1,356.8	67,838.5	135.7						13,058.3	12,625.2	11,100.6	9,936.3	6,253.5		135.7
Savings in societal costs (average)	78,597,539	7,859,754	392,987,695	785,975						75,646,665	69,661,701	64,305,714	57,561,137	36,226,697		785,975
Savings in societal costs (Hurst)	151,940,900	15,194,000	759,704,500	1,519,409						146,235,417	134,666,577	124,312,646	111,274,362	70,031,671		1,519,409
Annual Costs																
Research and development (.004)	81,375															
Public information (.013)	250,000															
FDA cost	16,275															
Dosage cost (.982)	19,271,716	1,927,172	96,358,580	192,717	3,854,343	7,708,686	38,543,430	57,815,145	77,086,860						3,854,343	770,868
Total annual cost	19,619,366	2,274,822	96,706,230	540,367	4,201,993	8,056,336	38,891,082	58,162,795	77,434,510	19,619,366	19,619,366	19,619,366	19,619,366	19,619,366	4,201,993	1,118,518
B/C (average)	4.01	3.46	4.06	1.45	18.70	9.76	2.02	1.35	1.02	3.86	3.55	3.27	2.93	1.85	18.70	.70
B/C (Hurst)	7.74	6.68	7.86	2.81	36.16	18.86	3.91	2.61	1.96	7.45	6.86	6.34	5.67	3.57	36.16	1.36
Crash/cost	.000828	.000714	.000840	.000300	.003866	.002016	.000418	.000279	.000210	.000797	.000734	.000677	.000606	.000382	.003866	.000145
	828/Mil	714/Mil	840/Mil	300/Mil	3866/Mil	2016/Mil	418/Mil	279/Mil	210/Mil	797/Mil	734/Mil	677/Mil	606/Mil	382/Mil	3866/Mil	145/Mil

presenting the results in this manner is that it is possible to determine what the costs and benefits would be under an array of different assumptions.

Also, it is to be noted that the numbers in parentheses to the left of the baseline cost data give the percentage that each cost element contributes to total system cost. In this manner, it is possible to determine which cost elements are significant and which elements would have a significant impact on the benefit/cost ratio if their values were to change or were erroneously estimated.

The sensitivity analyses are given by reading across the table from left to right. The objective is to see how changes in different input values affect the baseline case. In slots where numbers do not appear in the table, they are the same as the baseline case, thereby providing an easy visual method of determining which elements are affected by changing the value of an input variable.

The last two columns in the table give the most favorable case and the least favorable case. The most favorable case is based on the most optimistic assumptions with respect to the input variables and the least favorable case is based on the worst case for the input variables.

Figures 4, 5 and 6 present the relationships between utilization rate and the B/C rates, effective reduction in BAC and B/C rates, and dosage cost and B/C ratio respectively.

The findings may be summarized as follows:

1. All cases had favorable B/C ratios, except when combinations of unfavorable results were present.

2. The Hurst estimates produced B/C ratios almost twice as large as the A-Estimates.

3. Low utilization rates, e.g., below 1 out of 17,000 trips may cause the sober pill to be uneconomical as the fixed costs become large relative to the variable usage cost.

4. The effective reduction in BAC can be as low as .02 and the sober pill will remain an economically feasible concept, e.g., $B/C \geq 1$.

5. The unit dosage cost can be as large as \$1.00-\$2.00 for economic feasibility.

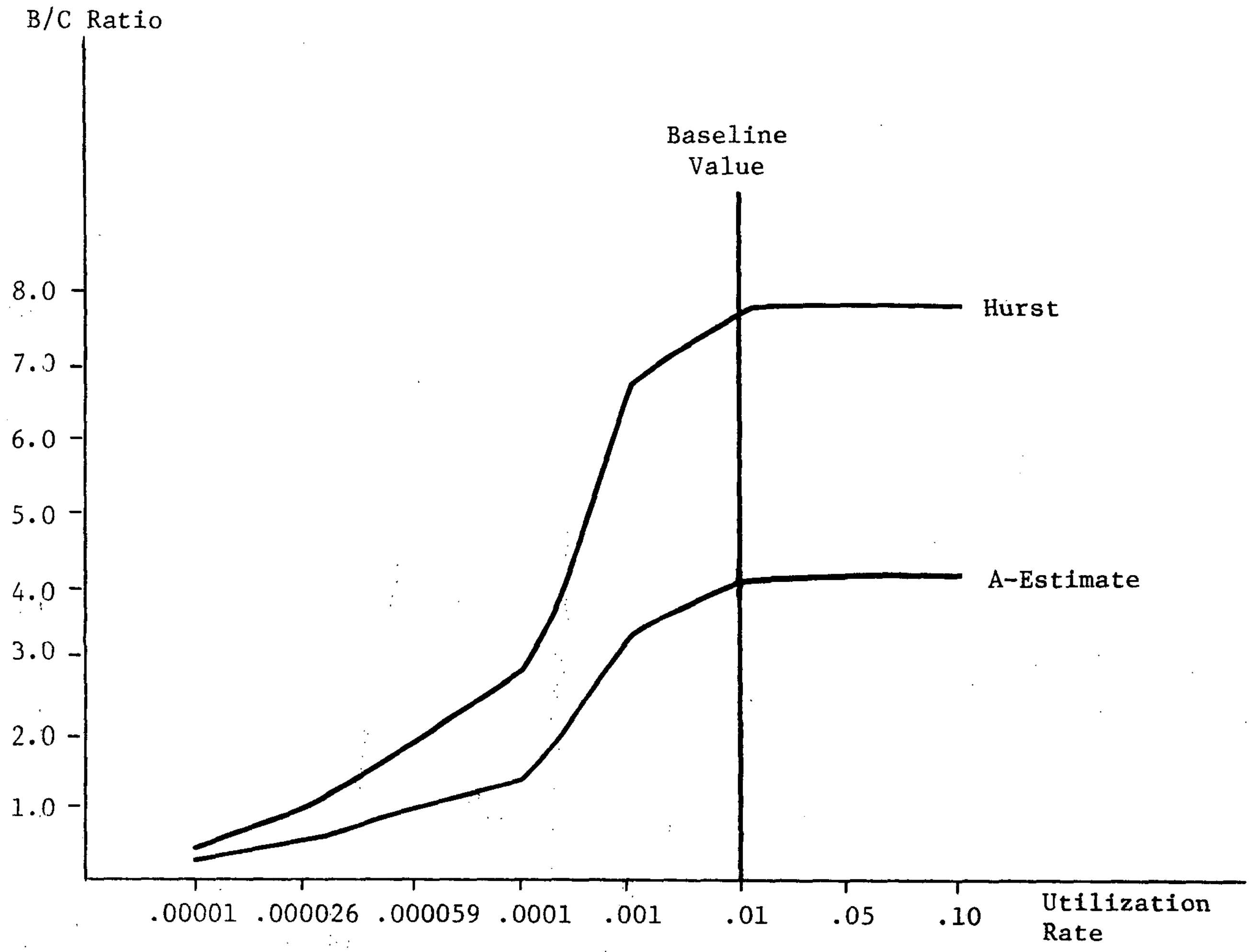

Fig. 4—Relationship Between Utilization Rate and B/C Ratio For the Sober Pill

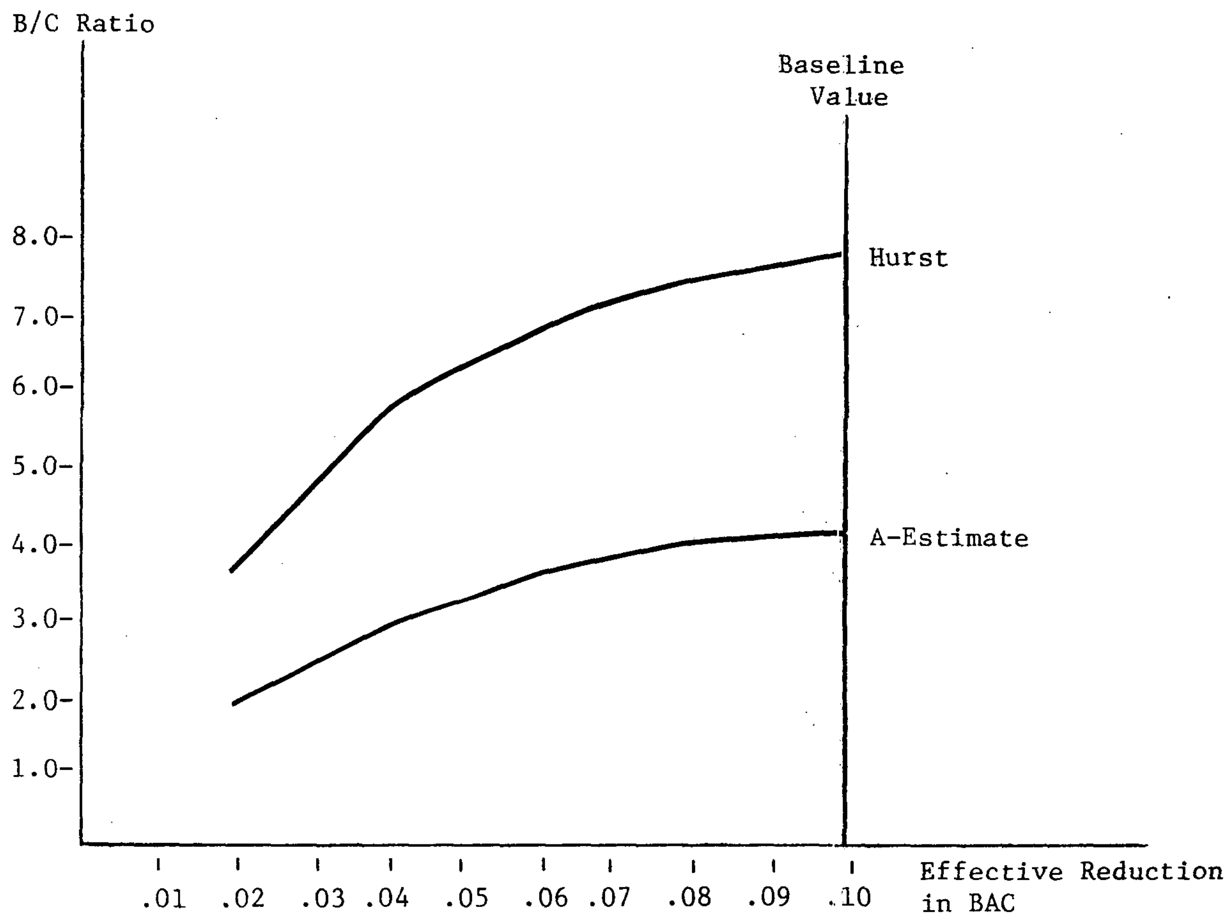

Fig. 5—Relationship Between Effective Reduction in BAC and B/C Ratio For the Sober Pill

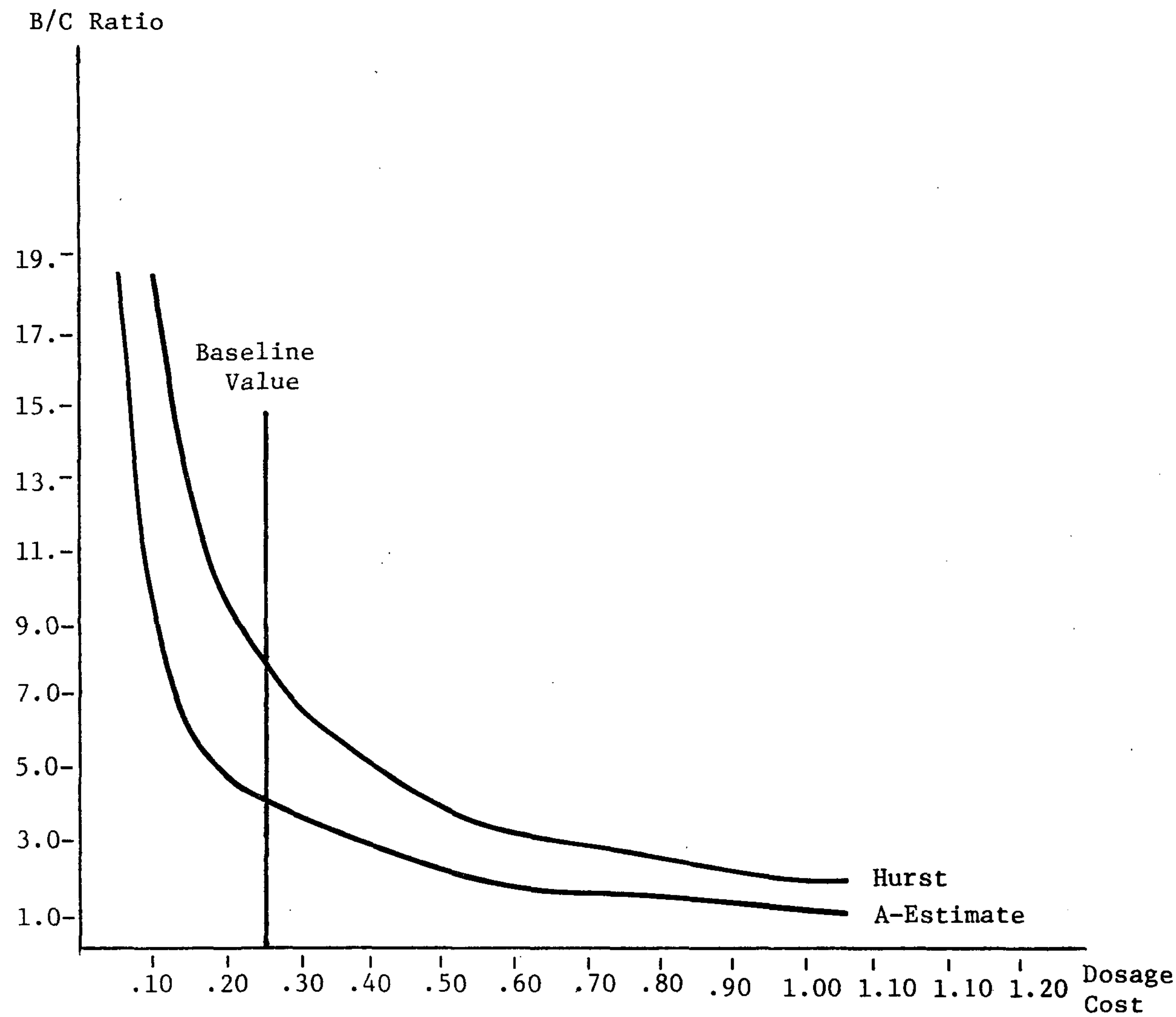

Fig. 6—Relationship Between Dosage Cost and B/C Ratio For the Sober Pill

6. At utilization rates of .0001 and above, the unit dosage cost is the only significant cost element.

7. A tremendous range of values are possible for the B/C ratio, e.g., .32 to 36.16, depending upon the assumptions made.

8. Research and Development, public information cost and FDA costs were not significant at utilization rates above .00059.

SELF-TESTER

DESCRIPTION AND PERFORMANCE CHARACTERISTICS

The self-tester, like the sober pill, is a voluntary device. Its effectiveness is based on the premise that individuals will be able to test themselves to determine their BAC levels and to either stop drinking when their observed BAC level reaches a specific maximum (e.g., .08 percent BAC), or to refrain from driving should the BAC reading exceed the safe level (.10 percent BAC or higher). Figure 7 presents a causal chain diagram illustrating how the self-tester would operate to reduce accidents.

There are a number of different types of self-testers. The original devices were called "balloon" testers. These testers were used by law enforcement agencies (especially in England) as pre-arrest breath testing devices. The object of the test was for the driver to breathe into a measurement instrument which would determine the amount of alcohol in the body. The disposable chemical reagent screening devices are all similar in design and operation. Each is comprised of a small glass tube containing either a column or multiple bands of an alcohol sensitive reagent (a chromote salt and a mineral acid) with an inert silicon support, and a breath volume measurement device (either a rubber balloon, plastic bag or air pump).[11]

A second type of device has been developed recently which is mechanical, portable and relatively accurate. This device is designed for widespread use by law enforcement officers. A number of tests are presently underway to determine its feasibility in the field. These reusable "electro-mechanical" type screening breath testers are a recent development in the

[11] Moulden, J. V. and Voas, R. B., Breath Measurement Instrumentation in the U.S., National Highway Traffic Safety Administration, US Department of Transportation, Washington, D.C., 1974, unpublished.

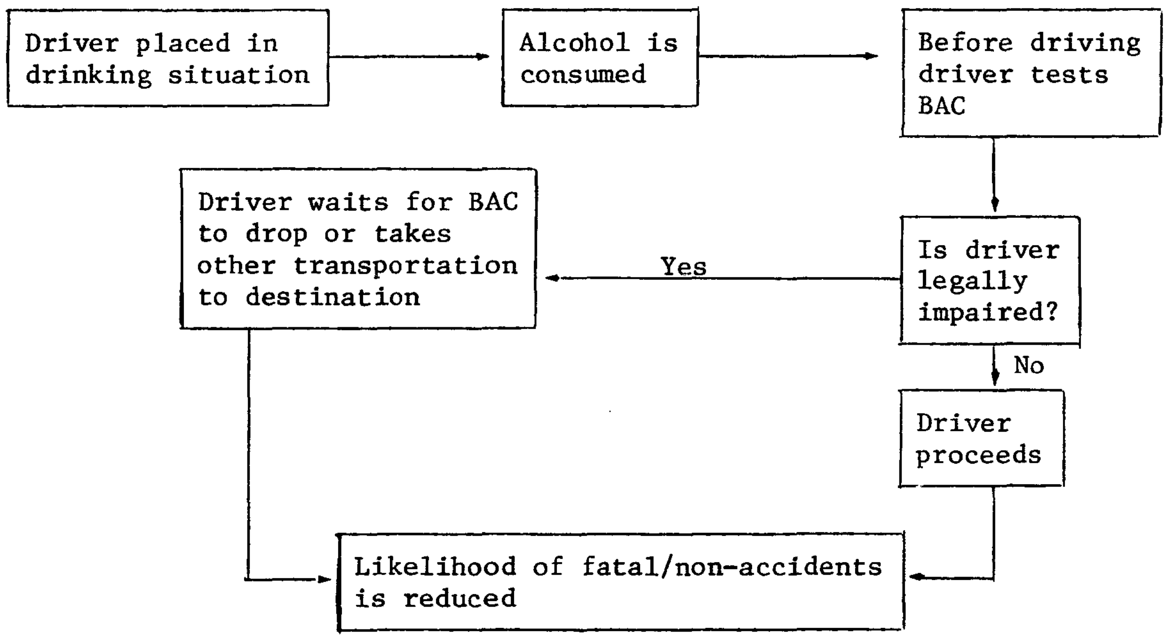

Fig. 7—Causal Chain for Self Tester

field of forensic alcohol measurement instrumentation. Developed since 1970, they are small, reusable, electronic breath analyzers, generally the size of transistor radios, which employ a variety of alcohol sensor designs. They can be classified according to the four basic alcohol sensor types employed: Chemoelectric or fuel cells, catalytic burner, infrared, and semiconductor sensor types.[12]

Another concept of the self-tester is a screening device to be used by the general public, which would be placed in convenient locations and possibly would be coin-operated. There are a number of devices that are being considered for commercial use by breath-testing equipment manufacturers. The device will probably use one of the alcohol sensor units mentioned previously. It is doubtful that any chemical analysis will be used.

The performance of the balloon-type devices has been strongly challenged as a result of the potentially large number of false positive and false negative readings. A study in 1970 by Prouty and O'Neill demonstrated that inexpensive disposable devices for breath-testing of blood alcohol concentration produced high numbers of erroneous results.[13] The authors conclude:

> "The need for a breath screening test for alcohol has been recognized for some time. However, devices producing excessive error, if widely used, will impede progress toward the development of effective countermeasures against the problem of the abusive use of alcohol as a source of road losses." (See also the report by Roberts and Fletcher.[14])

As a result of this study, the use of the "balloon" type tests for pre-arrest breath test purposes has not been widely utilized by police authorities. Experiments currently are being conducted to produce a more reliable tester using this concept which would be acceptable by the law enforcement officers.

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[12] Ibid.

[13] Prouty, R.L. and O'Neill, B., An Evaluation of Some Qualitative Breath Screening Tests for Alcohol, North Dakota State University and Insurance Institute for Highway Safety, 1970.

[14] Roberts, D.L. and Fletcher, D.C., "A Comparative Study of Blood Alcohol Testing Devices," Rocky Mountain Medical Journal, March, 1969.

In order to evaluate the operational effectiveness of the electro-mechanical screening devices, the National Highway Traffic Safety Administration has initiated a series of field tests in several states with the prerequisite pre-arrest screening legislation. The test in Hinnepin County, Minnesota has resulted in an estensive study in the use of these devices.[15] The results indicated that these pre-arrest screening devices are accepted by the police and that the models tested functioned accurately and dependably (another discussion of these type devices is found in a recent report by Harger[16]). The evidence from the field tests program that screening breath testing is a viable and effective concept and that those breath screening devices tested are both accurate and reliable.

Three types of self-testers were analyzed in this study:

1. Balloon Type Tester
2. Alcosensor Device
3. TSC Type Device

The Balloon type testers and the Alcosensor devices would be purchased individually whereas the TSC type device would be purchased by drinking establishments to be used by its patrons.

BENEFIT/COST MODELS

Assumptions

Balloon Tester:

1. The Balloon Testers would be available for sale to the public by 1 July 1976.

2. The percentage of licensed drivers who purchase and use Balloon Testers would be 1 percent.

3. The effectiveness rate was assumed to have the following values: .75, .85, and 1.00. The effectiveness rate refers to the percent of individuals who abide by the results when they test to be above the legal limit of .10.

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[15] Rosen, S.D., et al, Evaluation of Portable Breath Test Devices for Screening Suspected Drunken Drivers by Police in Hennepin County, Minnesota, Hennepin County Alcohol Safety Action Project, Minneapolis, Minnesota, June, 1974.

[16] Harger, R.H., Recently Published Analytical Methods for Determining Alcohol in Body Materials - Alcohol Countermeasure Literature Review, National Safety Council, Chicago, Illinois, October, 1974.

4. It was assumed that individuals who purchase Balloon Testers would use them at BAC = .05 or greater.

5. It was assumed that the unit price of the Balloon Tester could have the following values: $.10, .25, .50, .75, and 1.00.

6. It was assumed that research and development cost would be $100,000 and public information cost would be $85,000 per year.

Alcosensor Device:

1. The Alcosensor Device would be available for sale to the public by 1 July 1976.

2. The percentage of licensed drivers who purchase the Alcosensor device would be 1 percent.

3. The effectiveness rate was assumed to have the following values: .75, .85 and 1.00.

4. The utilization rate was assumed to have the following values: .40, .60, .80, and 1.0. The utilization rate refers to the percentage of trips at illegal BAC levels covered by the device. Also, it is assumed that individuals would test themselves at BAC = .05 and above.

5. It was assumed that the unit manufacturer's price could have the following values: $.25, .50, 1.00, and 2.00.

6. It was assumed that the Alcosensor device would be used an average of 1.5 times per trip.

7. It was assumed that research and development costs would be $100,000 and public information costs would be $85,000 per year.

TSC Device:

1. The TSC device would be available for sale to drinking establishments by 1 July 1976.

2. It was assumed that the effectiveness rate could have the following values: .25, .5 and .75.

3. It was assumed that the percent of people who use the device who would normally reach a BAC - .10-.14 is equal to the following values: .25, .5 and .75.

4. It was assumed that the percent of people who use the device who would normally reach a BAC = .15+ is equal to the following values: .10, .20 and .30.

5. It was assumed that the average number of times each device is used per year could have the following values: 1,000, 5,000, and 12,480.

6. It was assumed that the number of units sold to drinking establishments could have the following values: 500, 5,000, 10,000 and 50,000.

7. It was assumed that the average use per driver per trip could have the following values: 2,3, and 4.

8. It was assumed that the annual maintenance and calibration cost could have the following values: $75 and $150.

9. It was assumed that the unit operating cost could have the following values: .07, .10, and .25.

10. It was assumed that the research and development cost would be $100,000 and public information costs would be $85,000 per year.

Model Equations

The benefit/cost model for the Balloon Type tester is given as follows:

$$B/C_i = \frac{\text{Average Annual Savings in Societal Costs (SSC)}_i}{\text{Average Annual Total Cost (TC)}} \quad i = 1,2$$

where

$$SSC_1 = CR \left[F_1 \ (200{,}000) + P_1 \ (7{,}200) + (300)\right]$$
$$SSC_2 = CR \left[F_2 \ (200{,}000) + P_2 \ (7{,}200) + (300)\right]$$

and SSC_1, SSC_2, F_1, F_2, P_1 and P_2 are the same as previously defined.

$$CR = A \ (PR) \left[C_5 \left[\frac{R_5 - R_4}{R_5}\right] + C_6 \left[\frac{R_6 - R_4}{R_6}\right]\right]$$

where

CR is average annual crash savings

A is the effectiveness rate

PR is the percent of drivers who purchase and use balloon testers

C_5 and C_6 are annual crashes (see Table 6)

R_4, R_5, and R_6 are relative probabilities (see Table 5)

TC (Average Annual Total Cost) = Research and Development Cost (RD)
+ Manufacturing Costs (MN)
+ Public Information Costs (PI)

$$RD = .16275 \ RD_T$$
$$MN = (K)(L)(ATD)(PR)(B_3 + B_4 + B_5 + B_6)$$
$$PI = PI_A$$

where

.16275 is the amortization factor for determining the average annual cost over 10 years discounted at 10 percent.

RD_T is total research and development cost

K is the unit price of the balloon tester

L is the number of licensed drivers

ATD is the average number of trips per driver per year

PR is the percent of drivers who purchase testers

A is the utilization rate

B_3, B_4, B_5 and B_6 are the percent of trips at BAC = .05-.07, .08-.09, .10-.14, and .15+ respectively (see Table 7)

PI_A is the annual public information cost

The benefit/cost model for the alcosensor device is given as follows:

$$B/C_i = \frac{\text{Average Annual Savings in Societal Costs (SSC)}_i}{\text{Average Annual Total Cost (TC)}} \qquad i = 1,2$$

where

$$SSC_1 = CR \left[F_1 \ (200{,}000) + P_1 \ (7{,}200) + (300)\right]$$
$$SSC_2 = CR \left[F_2 \ (200{,}000) + P_2 \ (7{,}200) + (300)\right]$$

and

SSC_1, SSC_2, F_1, F_2, P_1, and P_2 are the same as previously defined.

$$CR = (A_1)(A_2)(PR) \left[C_5 \left(\frac{R_5 - R_4}{R_5}\right) + C_6 \left(\frac{R_6 - R_4}{R_6}\right)\right]$$

where

CR is average annual crash savings

A_1 is the effectiveness rate

A_2 is the utilization rate

PR is the percent of drivers who purchase the alcosensor device

C_5 and C_6 are annual crashes (see Table 6)

R_4, R_5 and R_6 are relative probabilities (see Table 5)

TC(Average Annual Total Cost) = Research and Development Cost (RD)
+ Manufacturing Cost (MN)
+ Maintenance Cost (MT)
+ Calibration Cost (CC)
+ Public Information (PI)

$$RD = .16275\ RD_T$$

$$MN = .16275\ (K)(L)(PR)$$

$$MT = (KT)(L)(PR)$$

$$CC = \frac{(L)(ATD)(PR)(A_2)\ (AVT)(C)(B_3 + B_4 + B_5 + B_6)}{50}$$

$$PI = PI_A$$

where

.16275 is the amortization factor for determining the average annual cost over 10 years discounted at 10 percent

RD_T is the total research and development cost

K is the unit purchase price of the alcosensor

L is the number of licensed drivers

PR is the percent of drivers who purchase testers

KT is the annual maintenance cost per device

ATD is the average number of trips per driver per year

AVT is the average number of times the device is used per trip

B_3, B_4, B_5 and B_6 are the percent of trips at BAC = .05-.07, .08-.09 .10-.14, and .15+ respectively (see Table 7)

C is the operating cost per 50 times used

PI_A is the annual public information cost

The benefit/cost model for the TSC device is given as follows:

$$B/C_i = \frac{\text{Average Annual Savings in Societal Costs (SSC)}_i}{\text{Average Annual Total Cost (TC)}} \qquad i = 1,2$$

where

$$SSC_1 = CR \left[F_1\ (200,000) + P_1\ (7,200) + (300)\right]$$

$$SSC_2 = CR \left[F_2\ (200,000) + P_2\ (7,200) + (300)\right]$$

and SSC_1, SSC_2, F_1, F_2, P_1 and P_2 are the same as previously defined.

$$CR = \left[\frac{(P_1)(NTS)(PNT)(A)}{(B_5)(L)(ATD)(AU)}\right] C_5 \left[\frac{R_5 - R_4}{R_5}\right] + \left[\frac{(P_2)(NTS)(PNT)(A)}{(B_6)(L)(ATD)(AU)}\right] C_6 \left[\frac{R_6 - R_4}{R_6}\right]$$

where

P_1 is the percent of individuals taking the test who would normally reach a BAC = .10-.14

P_2 is the percent of individuals taking the test who would normally reach a BAC = .15+

NTS is the number of units installed

PNT is the average number of times each device is used per year

A is the effectiveness rate

B_5 and B_6 are the percent of trips annually at BAC = .10-.14 and .15+ respectively

L is the number of licensed drivers

ATD is the average number of trips per driver per year

AU is the average number of times each driver uses the device per trip

C_5, C_6, R_4, R_5 and R_6 are the same as defined previously.

TC(Average Annual Total Cost) = Research and Development Cost (RD)
+ Manufacturing Cost (MN)
+ Maintenance and Calibration Cost (MT)
+ Public Information Cost (PI)
+ Operating Cost (OL)

$RD = .16275\ RD_T$

$MN = .16275\ (K)(NTS)$

$MT = (C)(NTS)$

$PI = PI_A$

$OC = (NTS)(PNT)(UC)$

where

.16275 is the amortization factor for determining the annual cost over 10 years discounted at 10 percent

RD_T is total research and development cost

K is the unit price of the TSC device

C is the annual maintenance and calibration ocst per year per device

PI_A is the annual public information cost

UC is the unit operating cost

NTS and PNT are the same as defined above.

SUMMARY OF FINDINGS - BASELINE CASE AND SENSITIVITY ANALYSES

Tables 11, 12, and 13 summarize the findings for the baseline cases and the sensitivity analyses for the Balloon Tester, Alcosensor, and TSC devices respectively. Figures 8 and 9 present relationships between key variables and B/C ratios for the Balloon Tester. Figures 10, 11, 12 and 13 present relationships for the Alcosensor device, and Figs. 14, 15, 16, 17 and 18 present relationships for the TSC devices.

The findings of the self-testers may be summarized as follows:

Balloon Tester:

1. The range of values for the benefit/cost ratio was .58 - 15.28.

2. The Hurst estimates produced B/C ratios about twice as large as the A-Estimates.

3. The B/C ratio was not significantly affected by the utilization rate or the purchase rate, except at very low levels, e.g., below .05.

4. The B/C ratio was significantly affected by changes in the effectiveness ratio. An effectiveness rate of .65 was necessary to produce economic feasibility using the Hurst estimates. Using the A-Estimates, economic feasibility was not possible.

5. The B/C ratio was sensitive to changes in the unit operating cost. Amounts less than .70 produced favorable results.

6. Economic feasibility was possible in all cases using the Hurst estimates.

7. Research and development cost and public information costs were not significant at utilization rates above .05.

Alcosensor Device:

1. The range of values for the benefit/cost ratios was .19 - 5.10.

2. The Hurst estimates produced B/C ratios about twice as large as the A-Estimates.

3. The B/C ratio was sensitive to changes in the utilization rate. A utilization rate of .85 was required to bring the Hurst B/C equal to unity and 100 percent utilization brought the A-Estimate B/C ratio to only .58.

4. The B/C ratio was sensitive to changes in the effectiveness rate. However, it was not possible to achieve economic feasibility with either the Hurst estimate or the A-Estimate with a 100 percent effectiveness rate.

Table 11

SELF TESTER - BALLOON TESTER

	Baseline case	1	2	3	4	5	6	Most favorable 7	Least favorable 8
<u>Input Data</u>									
Effectiveness rate	.75	.85	1.00					1.00	.75
Purchase rate	.01								
Unit price of balloon tester	1.00			.10	.25	.50	.75	.10	1.00
Research and development cost	100,000								
Public information cost	85,000								
<u>Annual Savings</u>									
Savings in crashes	9,154.5	10,375.1	12,206					12,206	
Savings in fatalities (average)	69.6	78.9	92.8					92.8	
Savings in fatalities (Hurst)	139.2	158.8	185.6					185.6	
Savings in personal injury (average)	3,823.5	4,333.3	5098					5098	
Savings in personal injury (Hurst)	8,011.5	9,079.7	10,682					10,682	
Savings in societal costs (average)	44,197,950	50,091,010	58,930,600					58,930,600	
Savings in societal costs (Hurst)	88,274,475	100,044,405	117,699,300					117,699,300	
<u>Annual Cost</u>									
Research and development (.002)	16,275								
Manufacturing cost (.99)	76,027,000			7,602,700	19,006,750	38,013,500	57,020,250	7,602,700	76,027,000
Public information (.008)	85,000								
Total annual cost	76,128,275	76,128,275	76,128,275	7,703,975	19,108,025	38,114,775	57,121,525	7,703,975	76,128,275
B/C (average)	.58	.66	.77	5.73	2.31	1.16	.77	7.64	.58
B/C (Hurst)	1.16	1.31	1.55	11.45	4.61	2.32	1.54	15.28	1.16
Crash/cost	.000120	.000136	.000160	.001188	.000478	.000240	.000160	.001584	.000120
	120/Mil	136/Mil	160/Mil	1188/Mil	478/Mil	240/Mil	160/Mil	1584/Mil	120/Mil

Table 12

SELF TESTER - ALCOSENSOR

	Baseline case	1	2	3	4	5	6	7	8	9	10	Most favorable 11	Least favorable 12
Input Data													
Effectiveness rate	.75	.85	1.00									1.0	.75
Utilization rate	.60			.40	.80	1.0						1.0	.40
Purchase rate	.01												
Unit manufacturing price	100						25	50	200			25	200
Research and development cost	100,000												
Public information cost	85,000												
Maintenance cost	45									10	25	10	45
Calibration cost	3.00												
Average times used per trip	1.5												
Annual Savings													
Savings in crashes	5492.7	6225.06	7323.6	3661.8	7323.6	9154.5						12,206	3661.8
Savings in fatalities (average)	41.76	47.33	55.68	27.84	55.68	69.6						92.8	27.84
Savings in fatalities (Hurst)	83.52	94.66	111.36	55.68	111.36	139.2						185.6	55.68
Savings in personal injuries (average)	2294.1	2599.98	3058.80	1529.4	3058.80	3823.5						5098	1529.4
Savings in personal injuries (Hurst)	4806.9	5447.8	6409.20	3204.6	6409.20	8011.5						10,682	3204.6
Savings in societal costs (average)	26,518,770	30,054,605	35,358,360	17,679,180	35,358,360	44,197,950						58,930,600	17,679,180
Savings in societal costs (Hurst)	52,964,685	60,026,643	70,619,580	35,309,790	70,619,580	88,274,475						117,699,300	35,309,979
Annual Cost													
Research and development	16,275												
Manufacturing (.25)	18,618,111						4,654,528	9,309,056	37,236,222			4,654,528	37,236,222
Maintenance (.69)	51,478,650									11,439,700	28,599,250	11,439,700	51,478,650
Calibration (.06)	4,114,946	4,114,946	4,114,946	2,743,297	5,486,594	6,858,242						6,858,243	2,743,297
Public information (.001)	85,000												
Total annual cost	74,312,982	74,312,982	74,312,982	72,941,333	75,684,630	77,056,278	60,349,399	65,003,926	92,931,093	34,274,032	51,433,582	23,053,746	91,559,444
B/C (average	.36	.40	.48	.24	.47	.57	.44	.41	.29	.77	.52	2.56	.19
B/C (Hurst)	.71	.81	.95	.48	.93	1.14	.88	.81	.57	1.54	1.04	5.10	.39
Crash/cost	.000079	.000084	.000098	.000050	.000097	.000119	.000091	.000084	.000059	.000160	.000107	.000529	.000040
	79/Mil	84/Mil	98/Mil	50/Mil	97/Mil	110/Mil	91/Mil	84/Mil	59/Mil	160/Mil	107/Mil	529/Mil	40/Mil

Table 13

SELF-TESTER - TSC DEVICE

	Baseline case	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Most favorable 15	Least favorable 16
Input Data																	
Number of units in use per year	50,000	500	5,000	10,000												5,000	500
Effectiveness rate	.75				.25	.50										.75	.25
Percent who normally reach BAC=.10-.14	.50						.25	.75								.75	.25
Percent who normally reach BAC=.15+	.20						.10	.30								.30	.10
Average number of times device used/year	12,480								1,000	5,000						12,480	1,000
Average use per driver per visit	2										3	4				2	4
Research and development	100,000																
Unit manufacturing price	400																
Maintenance and calibration per unit	75												150			75	150
Public information cost	85,000																
Unit operation cost	.07													.10	.25	.07	.25
Annual Savings																	
Savings in crashes	70,995	709.95	7,099.5	14,199	23,665	47,330	35,498	99,791	5,688.7	28,443.5	47,330	35,497.5				10,649	4.66
Savings in fatalities (average)	543.8	5.44	54.4	108.8	181.27	362.5	271.9	764.4	43.6	217.9	362.5	271.9				81.60	.0357
Savings in fatalities (Hurst)	1,079.1	10.8	107.9	215.8	359.7	719.4	539.6	1,516.8	86.5	432.3	719.4	539.6				161.85	.071
Savings in personal injuries (average)	29,647.5	296.5	2,964.8	5,919.5	9,882.5	19,765	14,823.8	41,672.8	2,375.6	11,878.0	19,765.1	14,823.8				4,447.2	1.95
Savings in personal injuries (Hurst)	59,295	592.9	5,929.5	11,859	19,765	39,530	29,647.5	83,345.5	4,751.2	23,756.0	39,530.3	29,647.7				8,894.3	3.89
Savings in societal costs (average)	343,520,500	3,435,205	34,352,050	68,704,100	114,506,833	229,013,666	171,760,250	482,854,774	27,525,681	137,628,405	229,015,179	171,761,384				51,528,427	22,557
Savings in societal costs (Hurst)	664,042,500	6,640,425	66,404,250	132,808,500	221,134,700	442,269,400	332,021,250	933,382,698	53,208,534	266,042,668	442,697,924	332,023,443				99,607,056	43,604.7
Annual Costs																	
Research and development (.0003)	16,275																
Manufacturing (.06)	3,255,000	32,550	325,500	651,000												325,500	32,550
Maintenance and calibration (.07)	3,750,000	37,500	375,000	750,000									7,500,000			375,000	75,000
Operating cost (.86)	43,680,000	436,800	4,368,000	8,736,000					3,500,000	17,500,000				62,400,000	156,000,000	4,368,000	125,000
Public information (.002)	85,000																
Total average cost	50,786,275	608,125	5,169,775	10,238,275	50,786,275	50,786,275	50,786,275	50,786,275	10,606,275	24,606,275	50,786,275	50,768,275	54,536,275	69,506,275	163,106,275	5,169,775	333,825
B/C (average)	6.76	5.65	6.64	6.71	2.25	4.51	3.38	9.51	2.60	5.59	4.51	3.38	6.30	4.94	2.11	9.97	.07
B/C (Hurst)	13.08	10.92	12.84	12.97	4.36	8.71	6.54	18.39	5.01	10.81	8.72	6.53	12.18	9.55	4.07	19.27	.13
Crash/cost	.001398	.001167	.001373	.001387	.000466	.000932	.000699	.001965	.000536	.001156	.000932	.000699	.001302	.001021	.000435	.002060	.000014
	1398/Mil	1167/Mil	1373/Mil	1387/Mil	466/Mil	932/Mil	699/Mil	1965/Mil	536/Mil	1156/Mil	932/Mil	699/Mil	1302/Mil	1021/Mil	435/Mil	2060/Mil	14/Mil

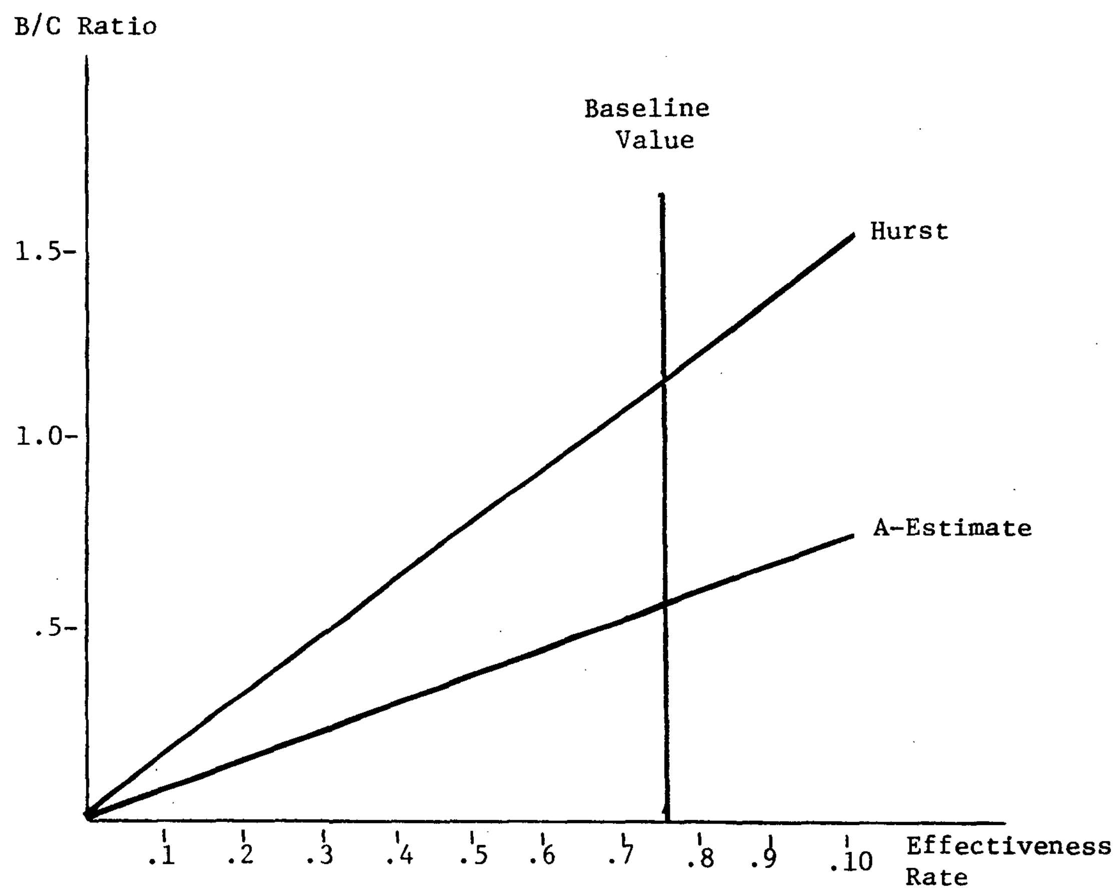

Fig. 8—Relationship Between Effectiveness Rates and Benefit/Cost Ratio - Balloon Tester

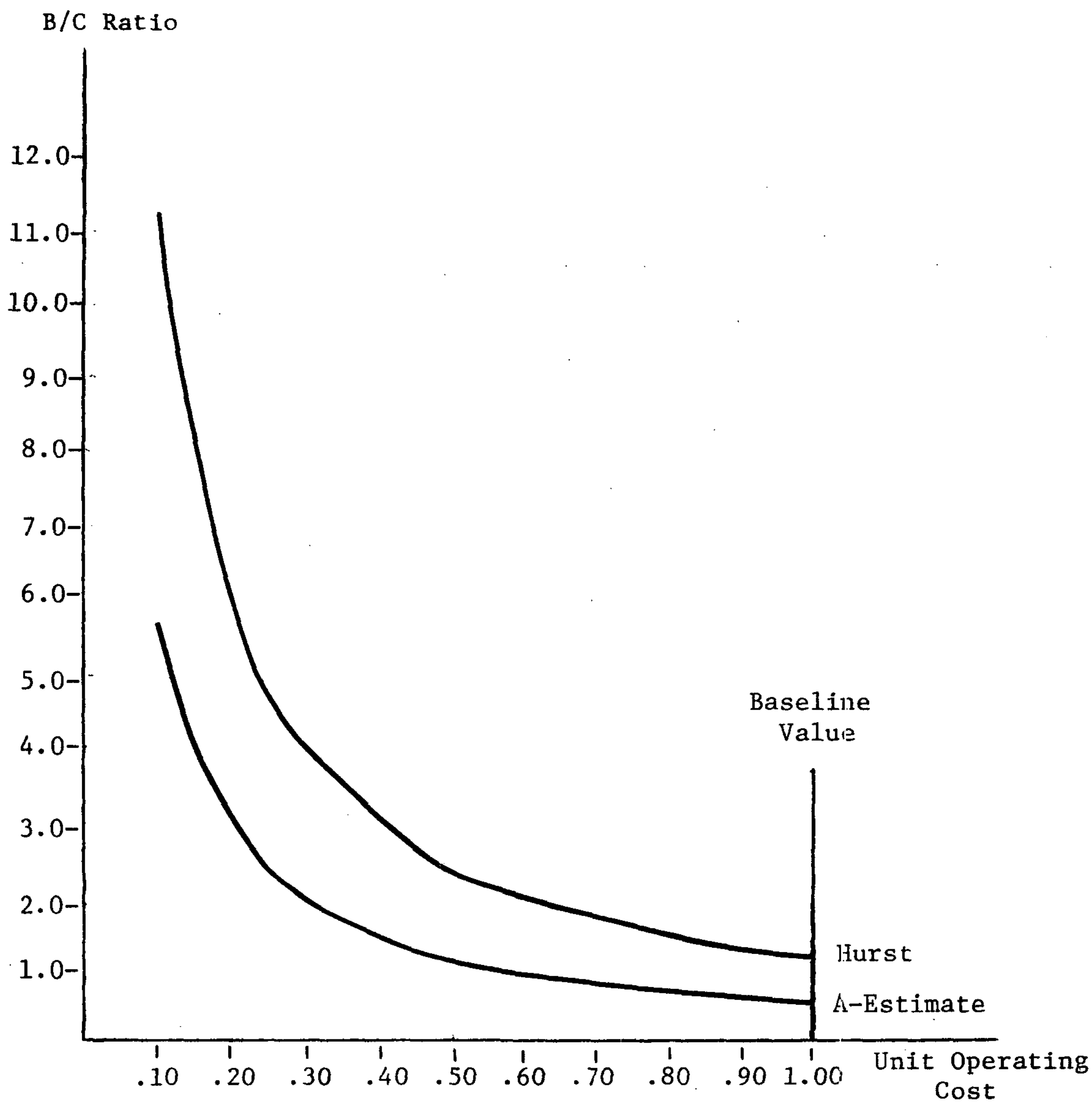

Fig. 9—Relationship Between Unit Operating Cost and the Benefit/Cost Ratio - Balloon Tester

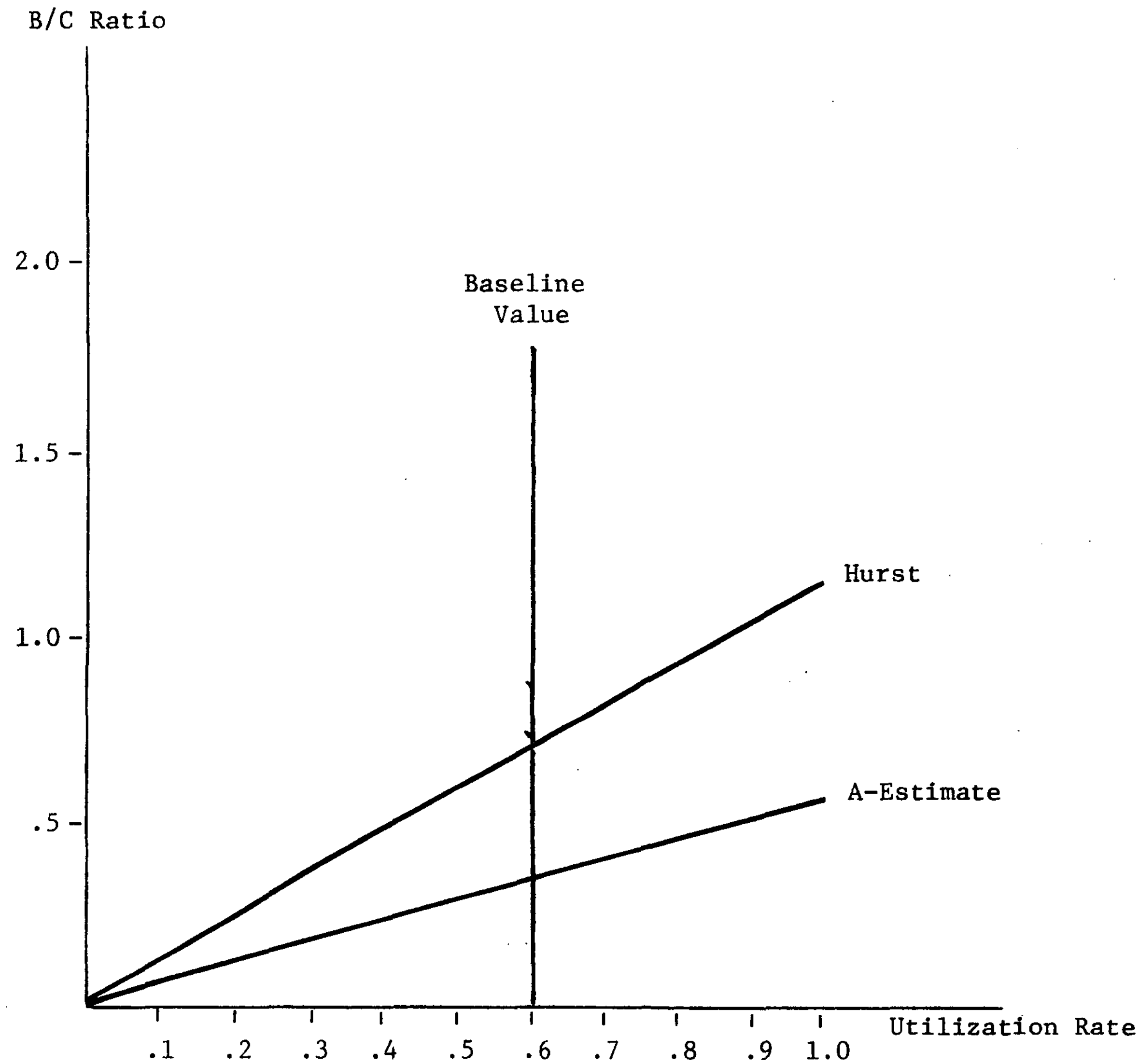

Fig. 10—Relationship Between Utilization Rate and B/C Ratios - Alcosensor Device

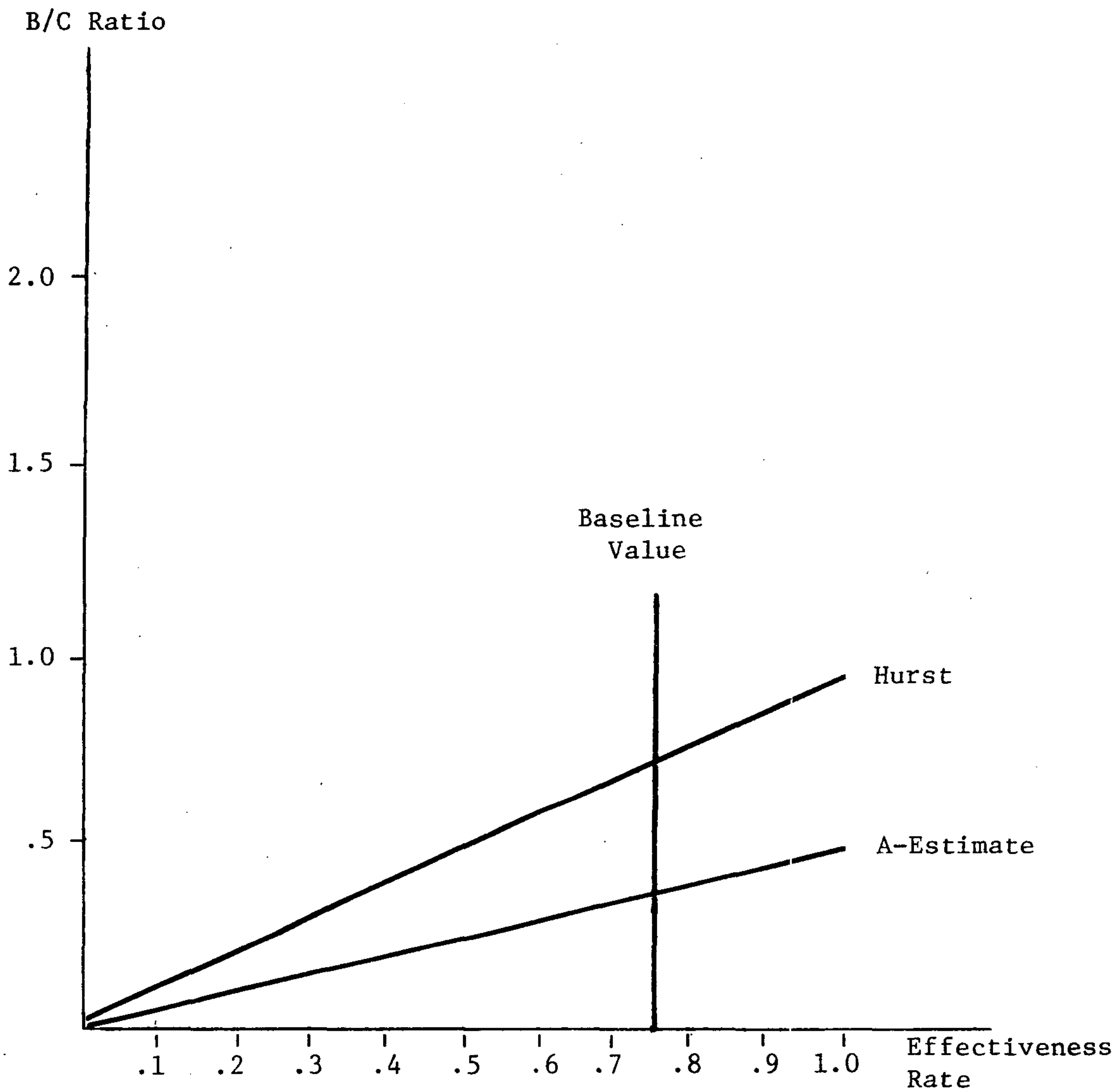

Fig. 11—Relationship Between Effectiveness Rate and B/C Ratios - Alcosensor Device

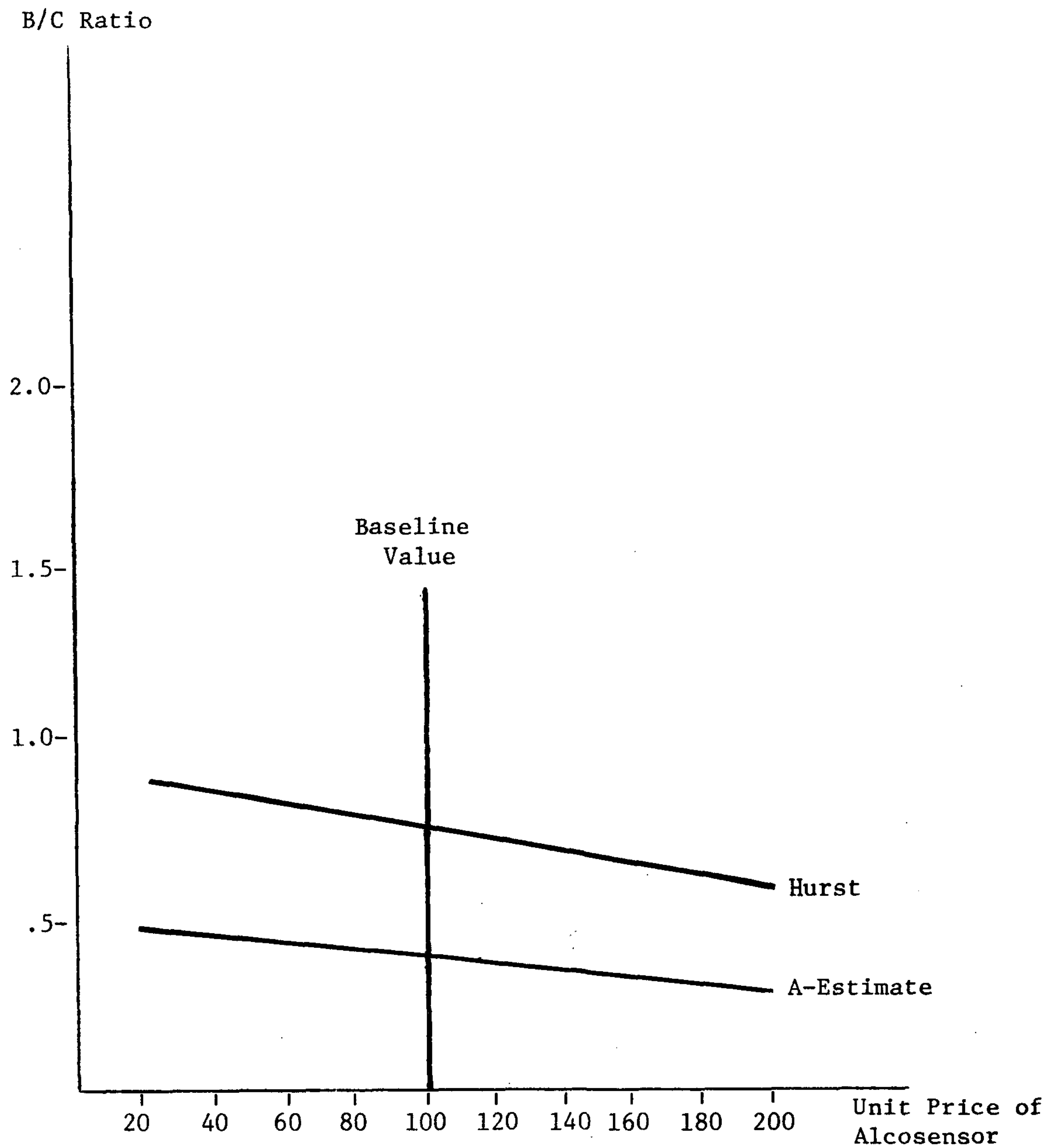

Fig. 12—Relationship Between Unit Price and B/C Ratio - Alcosensor Device

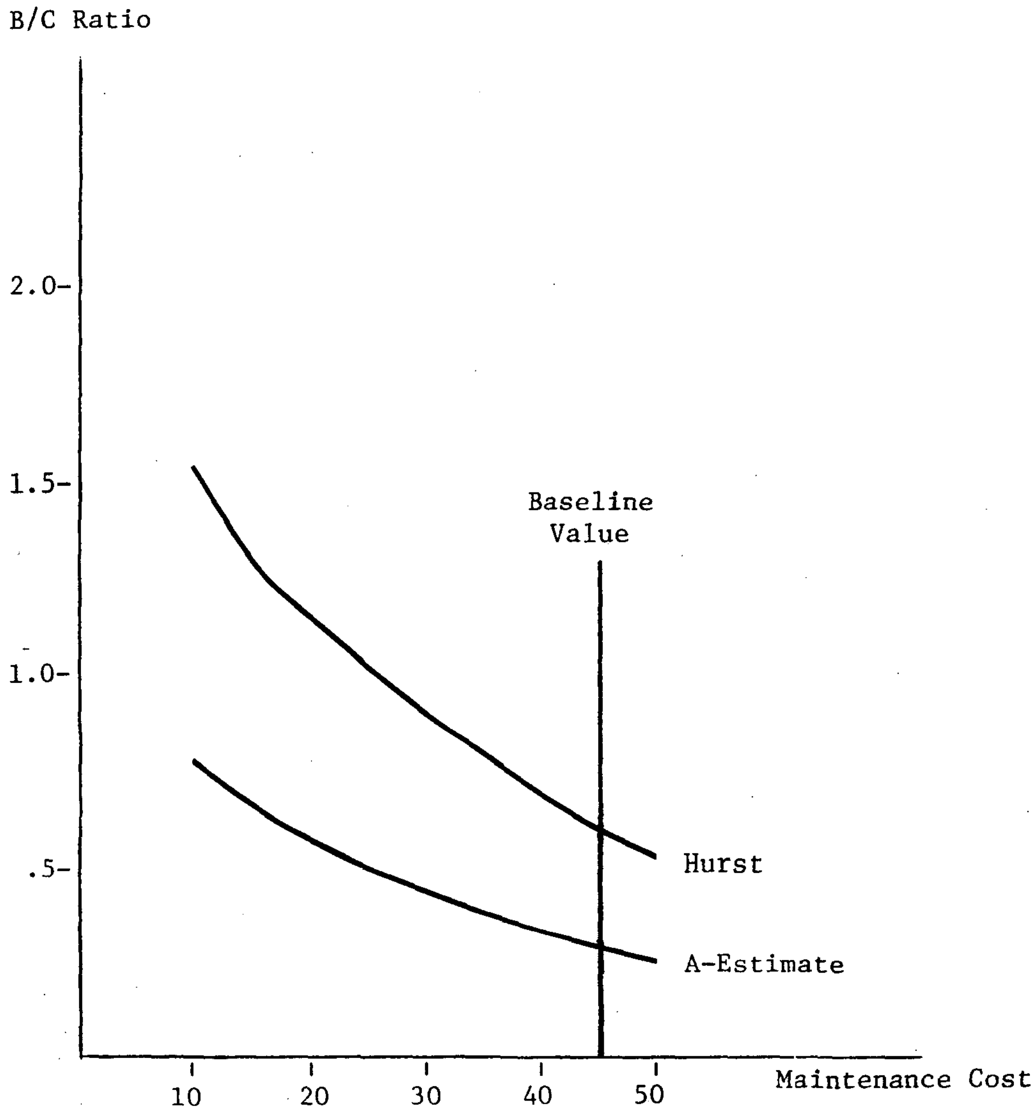

Fig. 13—Relationship Between Annual Maintenance Cost per Unit and B/C Ratio - Alcosensor

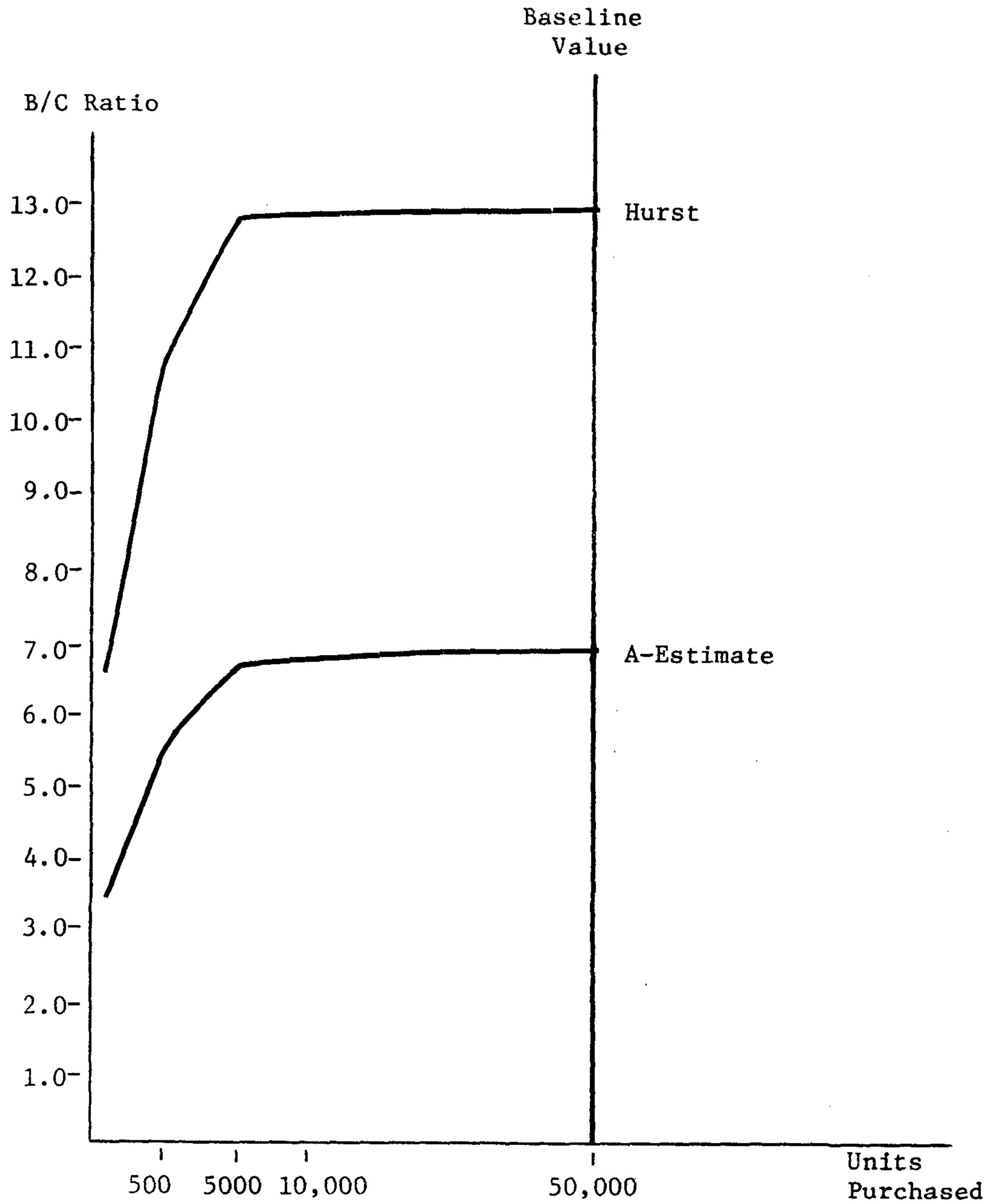

Fig. 14 —Relationship Between Number of Units Placed in Drinking Establishments and the Benefit/Cost Ratio - TSC Device

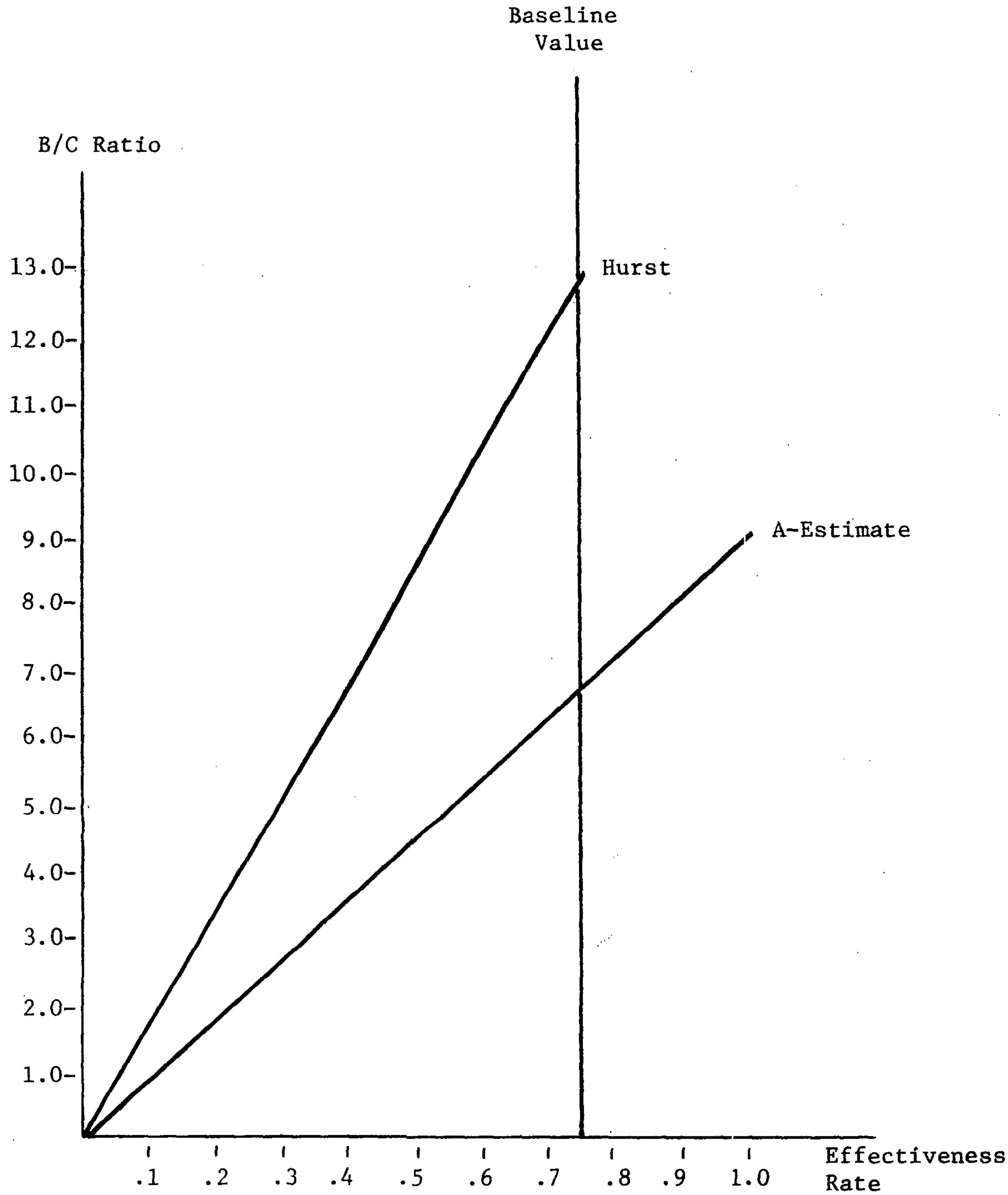

Fig. 15—Relationship Between Effectiveness Rate and Benefit/Cost Ratio - TSC Device

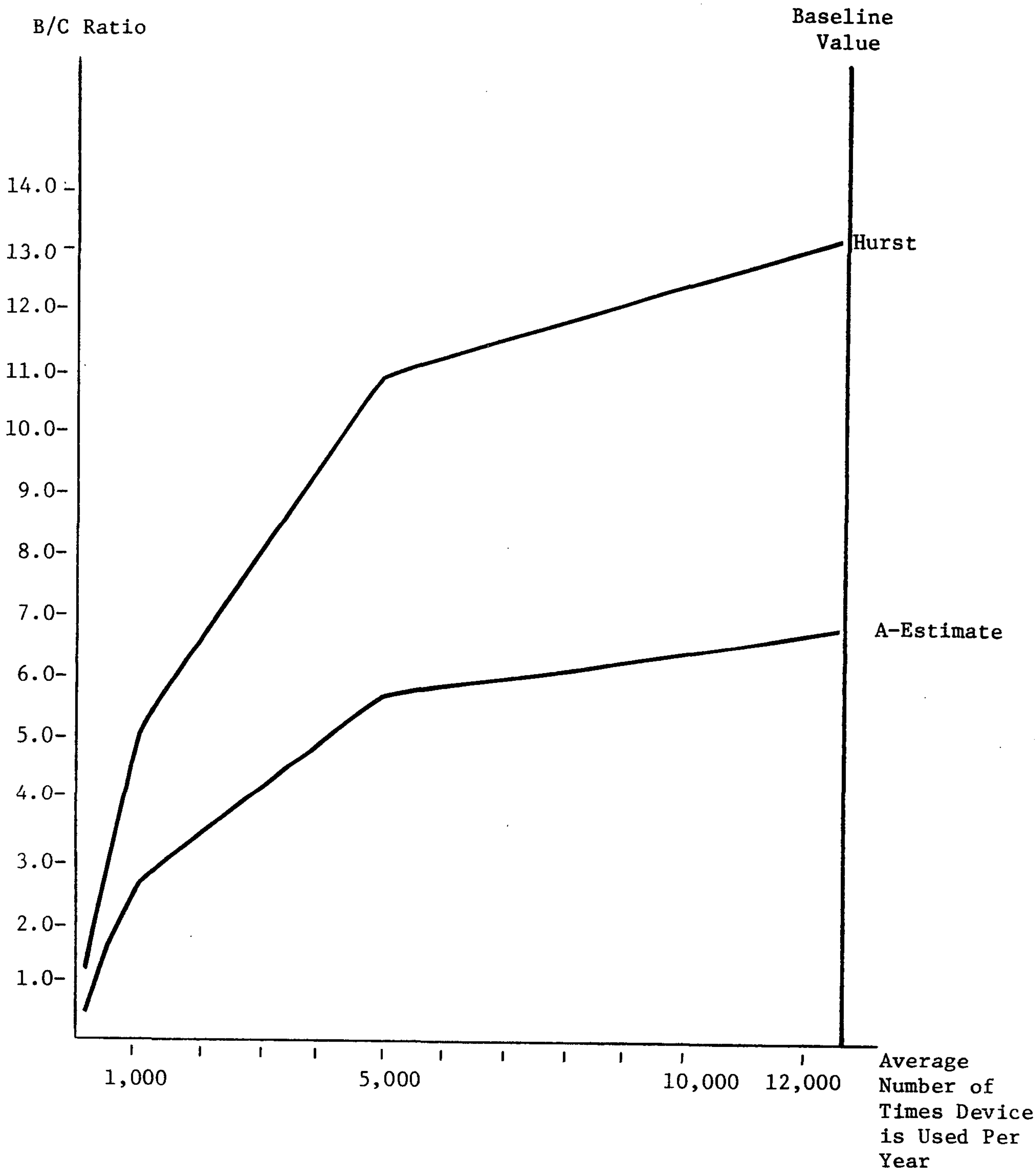

Fig. 16—Relationship Between Average Number of Times Device is Used per Year and B/C Ratios - TSC Device

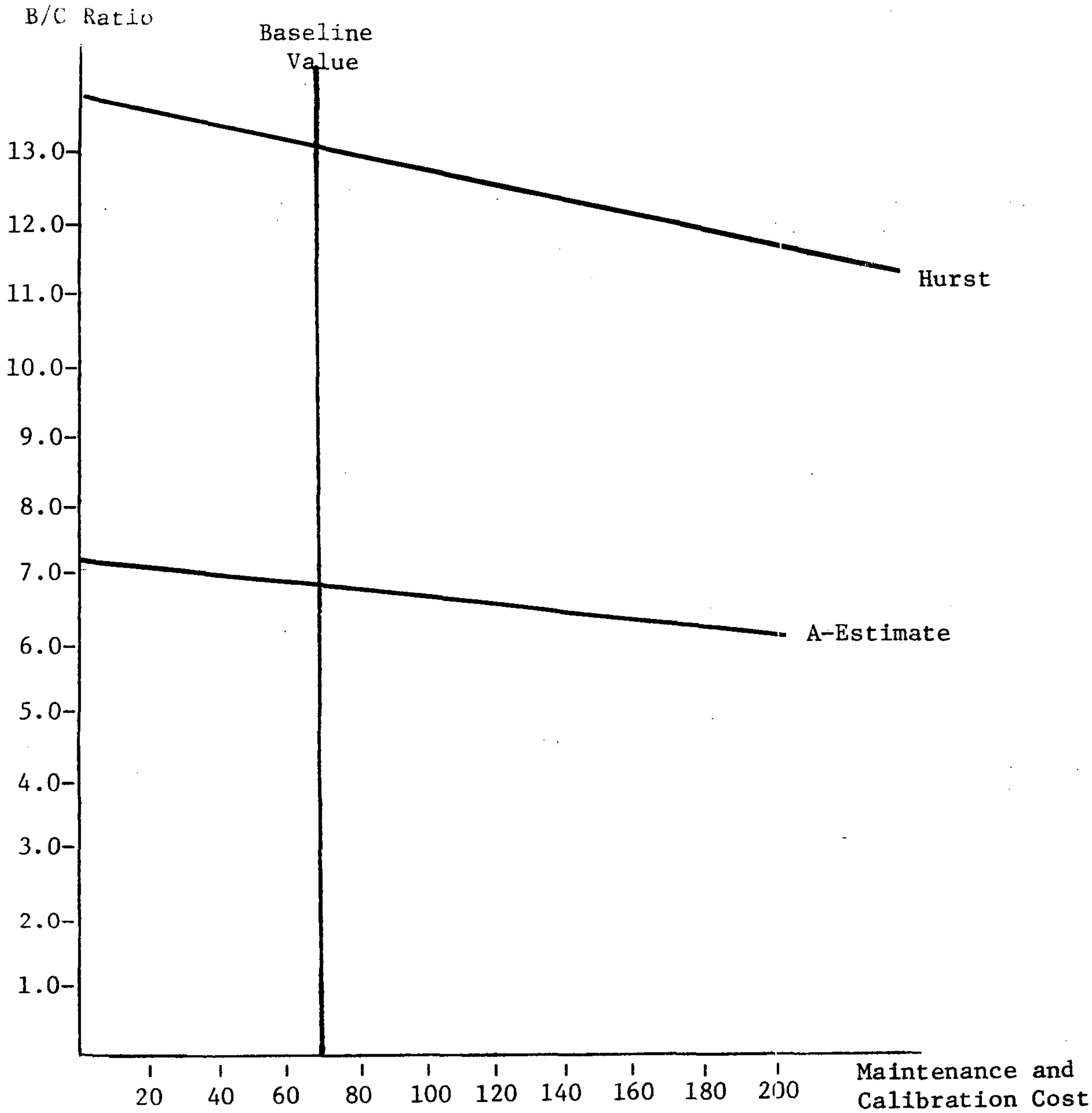

Fig. 17—Relationship Between Maintenance and Calibration Cost per Year and B/C Ratio - TSC Device

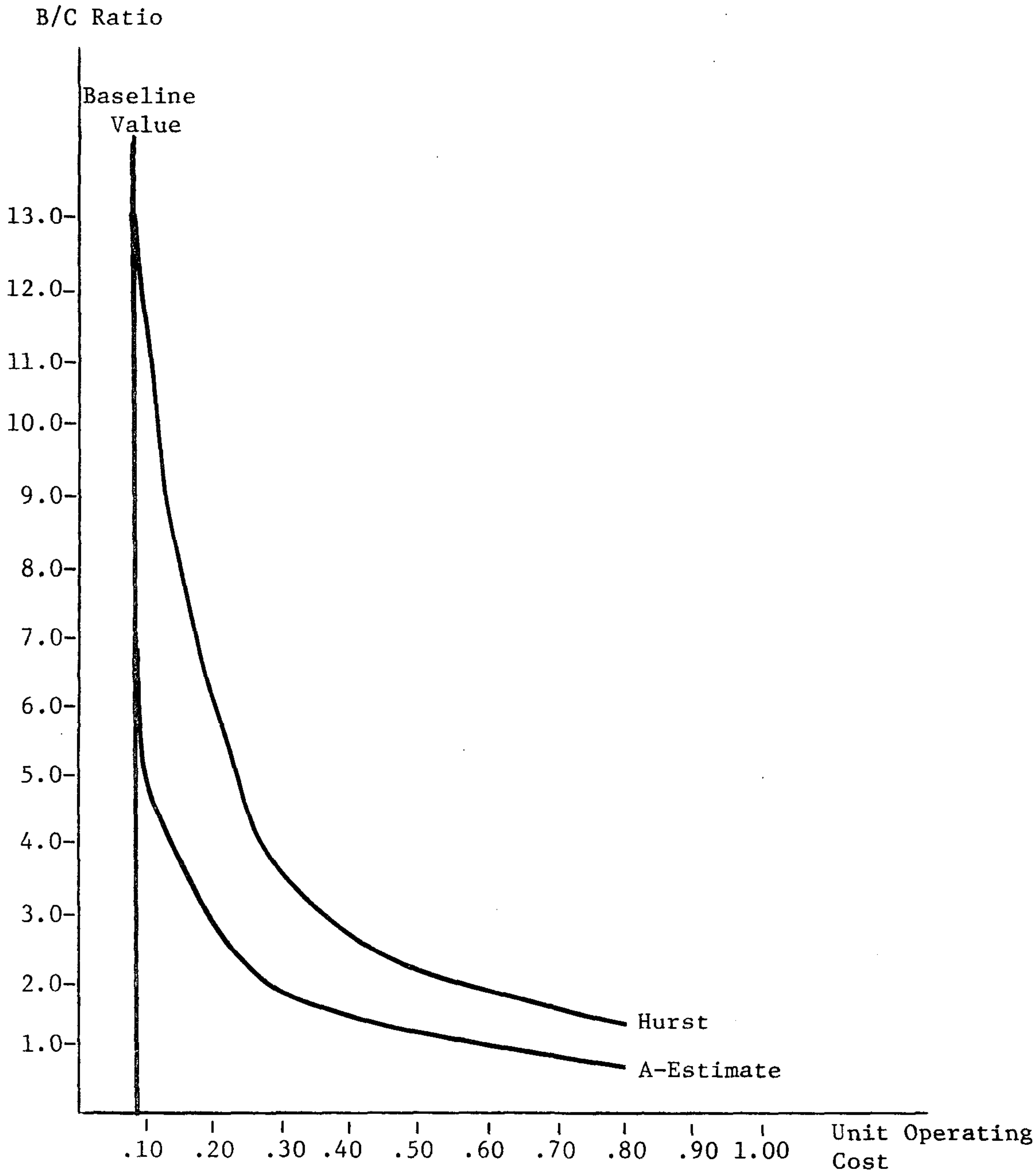

Fig. 18—Relationship Between Unit Operating Cost and B/C Ratio - TSC Device

5. Changes in unit price did not produce significant changes in the B/C ratio.

6. Maintenance cost significantly affected the B/C ratios and a cost of $5-$10 would be required for economic feasibility.

7. The B/C ratios for the alcosensor were generally not as high as those for the Balloon Tester and the TSC device.

8. Research and development cost, calibration, and public information cost were significant elements when the purchase rate exceeded .0001.

TSC Device:

1. The range of values for the benefit/cost ratios was .07 - 19.27.

2. In general, the B/C ratios were high, e.g., in excess of 3.0.

3. The number of units purchased did not affect economic feasibility, but the B/C ratios were significantly lower when the number of units dropped below 1,000.

4. The B/C ratios were sensitive to the effectiveness rates, however, an effective rate of only .2 produced economic feasibility using the A-Estimates.

5. The B/C rates were sensitive to the number of times each device is used per year. However, a minimum of 1,000 times per year per device will produce a favorable B/C ratio using both the Hurst and the A-Estimates.

6. Maintenance and calibration cost did not significantly impact the B/C ratios.

7. Research and development cost, manufacturing cost, and public information cost were not significant when the number of units installed exceeds 1,000.

EVIDENTIAL ROADSIDE TESTER AND NON-COOPERATIVE BREATH TESTER

DESCRIPTION AND PERFORMANCE CHARACTERISTICS

The evidential roadside tester and the non-cooperative breath tester are devices which permit breath analysis of a suspected drinking driver at the roadside. The evidential roadside tester is a device which will enable the law enforcement officers to obtain an accurate reading of BAC which is admissable as legal evidence against the arrested driver. The primary advantage of the evidential roadside tester is that it eliminates the need to make a time-consuming trip to the stationhouse (unless the driver tests to be above the legal limit) to test a suspected driver.

The non-cooperative breath tester is a screening device and would be used by the law enforcement officers to merely detect the presence of alcohol. Once the presence of alcohol has been detected, the officer may use the evidential roadside tester to obtain a more accurate reading which can be used as legal evidence against the arrested driver. If he does not have an evidential roadside tester, he will have to take the individual to the stationhouse for more accurate testing.

The primary way in which the evidential roadside testers and non-cooperative breath testers would act to reduce accidents is through increased enforcement effort. The devices would serve to identify drinking drivers and act as a deterrent in that as drivers perceive a greater risk of being apprehended, they will be more cautious about driving under the influence of alcohol. Figures 19 and 20 present a causal chain diagram for the evidential roadside tester and the non-cooperative breath tester illustrating how they would operate to reduce accidents.

One of the primary advantages of the evidential roadside tester will be the ability of the police officer to test the BAC of the individual at the roadside, and avoid a potential time-consuming trip to the stationhouse. In addition to its pre-arrest testing capabilities, under appropriate conditions (such as sober licensed passenger being available to drive the driver home), the booking could be conducted at the roadside instead of at the police station. Also, with the proper substantiation of the efficiency of the tester, the quality of the arrest for prosecution purposes can be increased.

It is essential that the results obtained by the roadside tester must be of sufficient quality and acceptability to the courts as to constitute valid evidence in the trial of the accused drinking driver. In a number of states, the courts have taken judicial notice of the effectiveness of some stationary testing devices (breath analyzers) and have not required the testimony of an expert to qualify the device at a trial of a drinking and driving offense (New York, People v. Donaldson, 1971; Minnesota, People v. Quinn, 1971; New Jersey, People v. Johnson, 1964). It will require

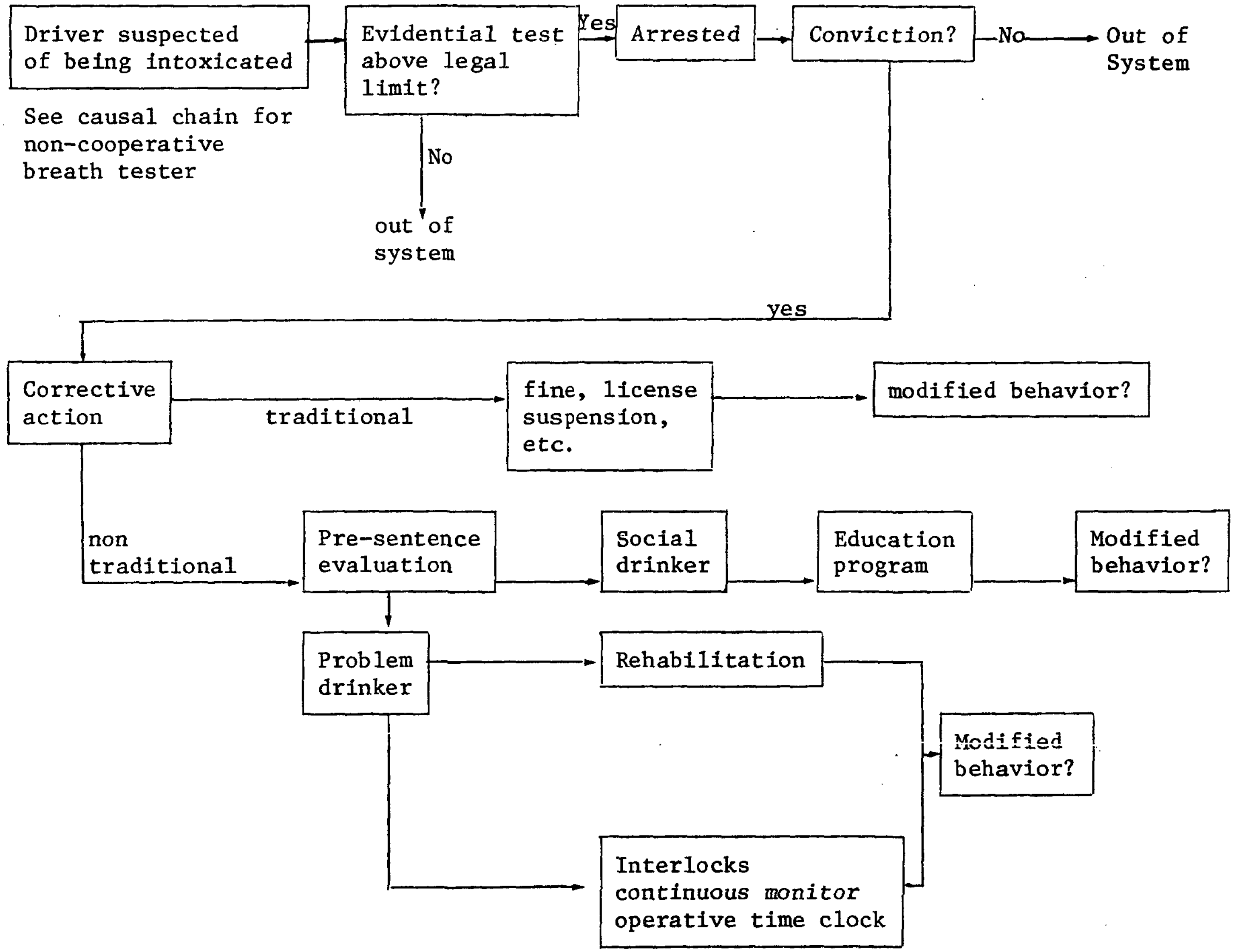

Fig. 19—Causal Chain for Evidential Roadside Tester

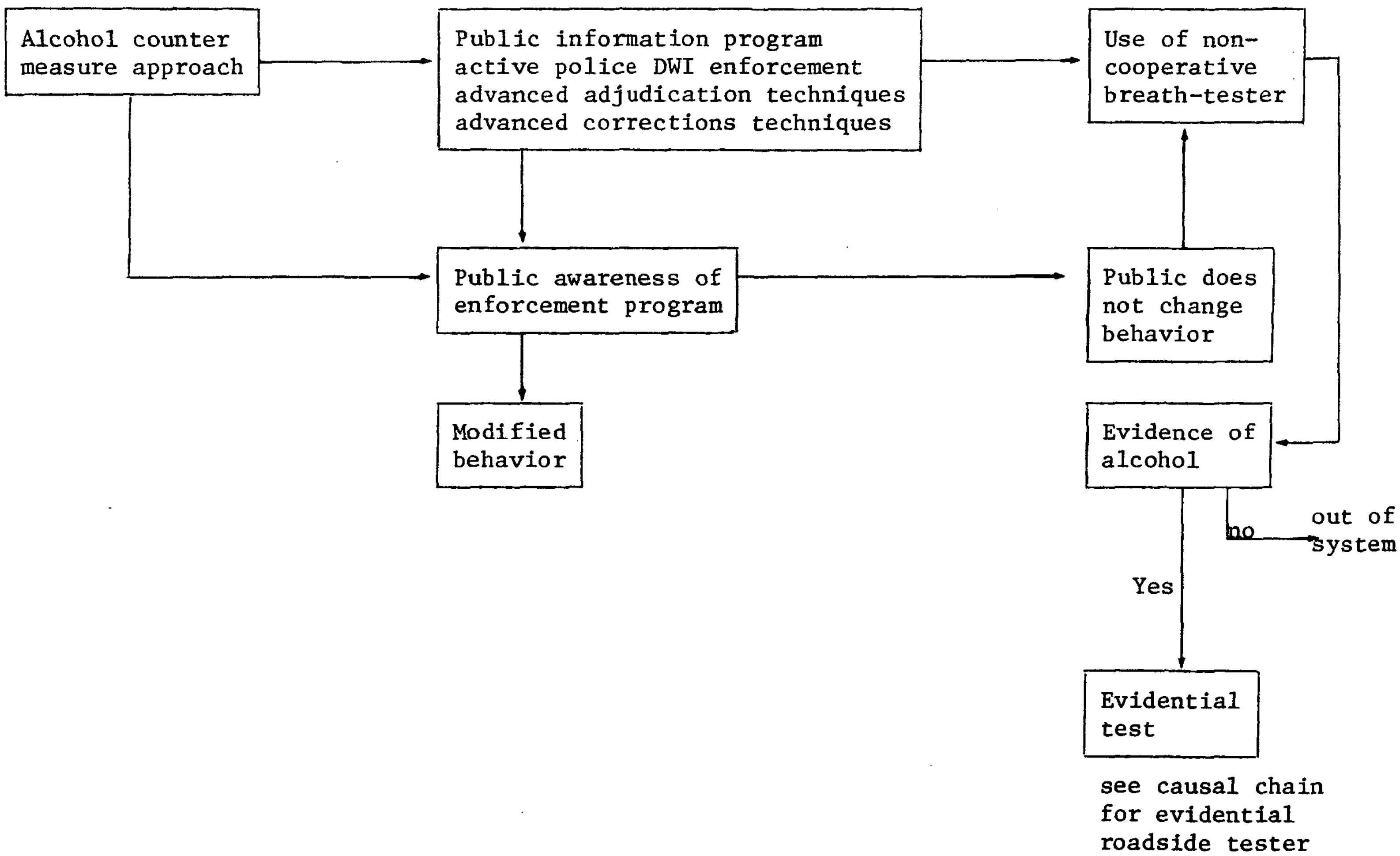

Fig.20—Causal Chain for Non-Cooperative Breath Tester

similar scientific substantiation of the accuracy of these evidential roadside testers before there will be such acceptance by the courts.

This issue becomes further magnified with the continued enactment of "illegal per-se" laws,[17] where there is no longer a presumption of intoxication, but rather it being illegal for a person to operate a motor vehicle with a specified BAC level (generally .10 percent). In the prosecution of these statutes, the level of proof for the reliability of the roadside tester must be high. A practical solution to the evidential problem would be for the tester to have the ability to produce a physical printout of the BAC level and also proof would be required that the operation of the instrument cannot be manually tampered with by the testing officers or operators.

While the roadside tester is to be used to obtain valid evidence of a violation of a traffic offense, the non-cooperative or passive breath tester is used to alert the stopping officer that there is a perceptible amount of alcohol in the vehicle.

Operationally, when a police officer would stop a motorist for a traffic violation, or any other reason, this passive breath tester, or "sniffer" device, would function as a qualitative breath-alcohol sensing tester to inform the police officer that alcohol may be present. No quantitative indication of BAC would be given and the test would not require the driver to cooperate in its administration. Such a determination would serve much the same purpose as the officer's smelling alcohol on the breath of the driver to establish reason to suspect an alcohol-involved driving offense. Upon positive findings of the "sniffer" device, the policy officer can further determine through the use of psychomotor tests, pre-arrest tests or the evidential roadside tester, the amount of alcohol in the driver. It has been demonstrated in previous research studies that police officers may miss through visual observation as many as one-half of all stopped drivers who are legally impaired.

[17] Delaware, Florida, Minnesota, Nebraska, New York, North Dakota, Utah, Vermont, Oregon, and North Carolina.

BENEFIT/COST MODEL

Assumptions

Evidential Roadside Tester:

1. The evidential roadside tester would be available for sale to law enforcement agencies by 1 July 1976.

2. It was assumed that the implementation of the evidential roadside tester would have a deterrence effect on the number of trips at illegal BAC levels and that the deterrence effect would be functionally related to the total number of devices used Nationally. The number of devices was assumed to have the following values: 100, 500, 2,000, 5,000, 10,000.

3. It was assumed that the average number of stops per day would increase from the current rate of 8.07 to X, where X could have the following values: 9.686, 10.493, and 11.3.

4. It was assumed that the percentage of convicted DWIs sent through rehabilitation could have the following values: .4, .5, and .6.

5. It was assumed that the percentage of stops resulting in arrests could have the following values: .09, .10, and .112.

6. It was assumed that the percentage of arrests resulting in convictions could have the following values: .5 and .6.

7. It was assumed that the deterrence rate would be a maximum of 15 percent.

8. It was assumed that the unit price of the device would be $400.

9. It was assumed that the unit operating cost would be $.07.

Non-Cooperative Breath Tester:

1. The non-cooperative breath tester would be available for sale to law enforcement agencies by 1 July 1976.

2. It was assumed that the effectiveness rate of the non-cooperative breath tester would be one-half that for the evidential roadside tester.

3. It was assumed that the average number of stops per day would increase from the current rate of 8.07 to X, where X could have the following values: 9.686, 10.493, and 11.3.

4. It was assumed that the percentage of convicted DWIs sent through rehabilitation could have the following values: .4, .5, and .6.

5. It was assumed that the percentage of stops resulting in arrests could have the following values: .09, .10, and .112.

6. It was assumed that the percentage of arrests resulting in convictions could have the following values: .5 and .6.

7. It was assumed that the deterrence rate would be a maximum of 7½ percent.

8. It was assumed that the unit price of the device would be \$100.

9. It was assumed that the unit operating cost would be \$.07.

Model Equations

The benefit/cost model for the evidential roadside tester is given as follows:

$$B/C_i = \frac{\text{Average Annual Savings in Societal Costs (SSC)}_i}{\text{Average Annual Total Cost (TC)}} \qquad i = 1,2$$

where

$$SSC_1 = CR \left[F_1 \ (200{,}000) + P_1 \ (7{,}200) + (300)\right]$$
$$SSC_2 = CR \left[F_2 \ (200{,}000) + P_2 \ (7{,}200) + (300)\right]$$

and

SSC_1, SSC_2, F_1, F_2, P_1, and P_2 are the same as defined previously.

$$CR = A \left[C_5 \left[\frac{R_5 - R_4}{R_5}\right] + C_6 \left[\frac{R_6 - R_4}{R_6}\right]\right]$$

where

CR is the average crash savings per year

$A = \frac{.245 \ X^{.975}}{100}$ is the effectiveness rate

X is the number of evidential roadside testers in service per year in thousands

C_5 and C_6 are annual crashes (see Table 6)

R_4, R_5, and R_6 are relative probabilities (see Table 5)

TC(Average Annual Total Cost) = Research and Development Cost (RD)
+ Manufacturing Cost (MN)
+ Maintenance and Calibration Cost (MT)
+ Public Information Costs (PI)
+ Operating Costs (OC)
+ Incremental Enforcement Costs (EC)
+ Incremental Court Costs (KC)
+ Incremental Rehabilitation Costs (RC)

$RD = .16275 (RD_T)$

$MN = .16275 \ (K) \ (X)(1{,}000)$

$MT = (KMT) \ (X)(1{,}000)$

$PI = PI_A$

$OC = (KOC)(DT)(365) \ (X)(1{,}000)$

$EC = EC_A$

$KC = (KKC)(IS) \ (X)(1{,}000)(365)(PA)$

$RC = (KRC)(PKC)(PNC)(IS) \ (X)(1{,}000)(365)(PA)$

where

.16275 is the amortization factor for determining the average annual cost over 10 years discounted at 10 percent

RD_T is the total research and development cost

K is the unit price of the evidential roadside tester

KMT is the annual maintenance and calibration cost

PI_A is the annual public information cost

KOC is the unit operating cost

DT is the average number of tests per cruiser per day

EC_A is the incremental enforcement costs per year

KKC is the incremental court cost per case

IS is the incremental increase in daily stops per cruiser resulting from the use of the evidential roadside tester

PA is the percentage of stops resulting in arrests

KRC is the incremental rehabilitation cost per case

PKC is the percentage of convictions sent through rehabilitation

PNC is the percentage of arrests resulting in convictions

The benefit/cost model for the non-cooperative breath tester is given as follows:

$$B/C_i = \frac{\text{Average Annual Savings in Societal Costs (SSC)}_i}{\text{Average Annual Total Cost (TC)}} \qquad i = 1,2$$

where

$$SSC_1 = CR \left[F_1 \ (200{,}000 \ + P_1 \ (7{,}200) + (300) \right]$$

$$SSC_2 = CR \left[F_2 \ (200{,}000 \ + P_2 \ (7{,}200) + (300) \right]$$

and

SSC_1, SSC_2, F_1, F_2, P_1, and P_2 are the same as previously defined.

$$CR = A \left[C_5 \left[\frac{R_5 - R_4}{R_5} \right] + C_6 \left[\frac{R_6 - R_4}{R_6} \right] \right]$$

where

CR is the average crash savings per year

$A = \frac{.245\ X^{.975}}{200}$ is the effectiveness rate

X is the number of non-cooperative breath testers sold in thousands

C_5 and C_6 are annual crashes (see Table 6)

R_4, R_5, and R_6 are relative probabilities (see Table 5)

The structure of the total cost equation for the non-cooperative breath tester is identical to that for the evidential roadside tester. The only difference is the values of the input parameters for unit price, maintenance and calibration cost and unit operating cost are different.

SUMMARY OF FINDINGS - BASELINE CASE AND SENSITIVITY ANALYSES

Tables 14 and 15 summarize the findings for the evidential roadside tester and the non-cooperative breath tester. Figures 21, 22, 23 and 24 present relationships for the evidential roadside tester and Figs. 25. 26, 27 and 28 present relationships for the non-cooperative breath tester.

The findings for the evidential roadside tester may be summarized as follows:

1. The range of values for the benefit/cost ratios was 1.41 - 67.67.

2. The Hurst estimates produced B/C ratios about twice as large as the A-Estimates.

3. All variations from the baseline case proved to be economically feasible.

4. The B/C ratios were not sensitive to changes in the number of units at levels above 500 units.

5. The B/C ratios were highly sensitive to changes in the assumption regarding the effectiveness rate. In general, the effectiveness rate must be at least .01 if the device is to be economically feasible. This means that 1 percent of the trips at illegal BAC levels must be affected.

6. The B/C ratios were sensitive to changes in the number of tests per day per device. The inverse relationship is due to the fact that the effectiveness level is held constant while tests and subsequently, arrests, convictions and rehabilitation increase. The implication is that a higher

Table 14

EVIDENTIAL ROADSIDE TESTER

	Baseline case	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Most favorable 15	Least favorable 16
Input Data																	
Number of units in use per year	5,000	100	500	2,000	10,000												
Effectiveness rate	.012	.00026	.00125	.0048	.023	.026	.117	.15								.15	.012
Research and development cost	100,000																
Unit manufacturing price	400																
Maintenance and calibration	75																
Public information cost	250,000																
Unit operating cost	.07																
Number of tests per day per device	9.686								10.493	11.30							11.30
Incremental law enforcement cost	0																
Incremental courst cost per case	58																
Incremental rehabilitation cost per case	48																
Percent convicted sent to rehabilitation	.50										.4	.6					.6
Daily increase in stops/cruiser	1.615								2.423	3.23							3.23
Percentage of stops with arrests	.112												.09	.10			
Percent of arrests resulting in conviction	.50														.6		.6
Annual Savings																	
Savings in crashes	14,647	317.4	1,525.7	5,858.8	28,073	31,735	142,808	183,087								183,087	
Savings in fatalities (average)	112.2	2.431	11.69	44.88	215.0	243.1	1,093.9	1,402.5								1,402.5	
Savings in fatalities (Hurst)	222.6	4.823	23.19	89.04	426.6	482.3	2,170.4	2,782.5								2,782.5	
Savings in personal injuries (average)	6,116.6	132.6	637.15	2,446.64	11,723.5	13,252.6	59,636.9	76.457								76.46	
Savings in personal injuries (Hurst)	12,233.2	265.05	1,274.3	4,893.3	23,447.0	26,505.3	119,274	152,915								152,915	
Savings in societal costs (average)	70,873,620	1,535,595	7,382,668	28,349,448	135,841,105	153,559,510	691,017,795	885,920,250								885,920,250	
Savings in societal costs (Hurst)	136,993,140	2,968,185	14,270,119	54,797,256	262,570,185	296,818,470	1,335,683,115	1,712,414,250								1,712,414,250	
Annual Costs																	
Research and development	16,275																
Manufacturing (.013)	325,500	6,510	32,550	130,200	651,000												
Maintenance and calibration (.015)	375,000	7,500	37,500	150,000	750,000												
Public information (.01)	250,000																
Operating costs (.05)	1,237,386	24,748	123,739	494,954	2,474,772				1,340,481	1,443,574							1,443,574
Enforcement costs	0																
Court costs (.76)	19,146,148	382,923	1,914,615	7,658,459	38,292,296				28,725,150	38,292,296			15,385,297	17,094,775			38,292,296
Rehabilitation costs (.16)	3,961,272	79,225	396,127	1,584,509	7,922,544				5,943,134	7,922,544	3,169,018	4,753,526	3,183,165	3,536,850	4,753,526		9,507,053
Total annual cost	25,311,581	767,181	2,770,806	10,284,397	50,356,887	25,311,581	25,311,581	25,311,581	36,975,540	48,625,189	24,519,327	26,103,835	20,772,623	22,835,786	26,103,835	25,311,581	50,209,698
B/C (average)	2.80	2.00	2.66	2.76	2.69	6.07	27.3	35.00	1.92	1.46	2.89	2.72	3.41	3.10	2.72	35.00	1.41
B/C (Hurst)	5.41	3.86	5.15	5.33	5.21	11.73	52.77	67.65	3.70	2.82	5.59	5.25	6.59	6.00	5.25	67.65	2.73
Crash/cost	.000579	.000414	.000551	.000570	.000557	.001254	.005642	.007233	.000396	.000301	.000597	.000561	.000705	.000641	.000561	.007233	.000242
	579/Mil	4.4/Mil	551/Mil	570/Mil	557/Mil	1254/Mil	5642/Mil	7233/Mil	396/Mil	301/Mil	597/Mil	561/Mil	705/Mil	641/Mil	561/Mil	7233/Mil	242/Mil

Table 15

NON-COOPERATIVE BREATH TESTER

	Baseline case	1	2	3	4	5	6	7	8	9	10	11	12	Most favorable 13	Least favorable 14
<u>Input Data</u>															
Number of units in use per year	5,000	100	1,000												
Effectiveness rate	.006	.00013	.001225	.013	.0585	.075								.075	.006
Research and development	100,000														
Unit manufacturing price	100														
Maintenance and calibration	10.61														
Public information cost	250,000														
Unit operating cost	.03														
Number of tests per day per device	9.686						10.493	11.30							11.30
Incremental law enforcement cost	0														
Incremental court cost per case	58														
Incremental rehabilitation cost per case	48														
Percent convicted sent to rehabilitation	.50								.4	.6					.6
Daily increase in stops/cruiser	1.615						2.423	3.23							3.23
Percentage of stops with arrests	.112										.09	.10			
Percent of arrests resulting in conviction	.4												.5		.5
<u>Annual Savings</u>															
Savings in crashes	7,323.6	158.7	1,495.2	15,867.8	71,405	91,545								91,545	
Savings in fatalities (average)	56.1	1.216	11.45	121.55	547.0	701.2								701.2	
Savings in fatalities (Hurst)	111.3	2.412	22.7	241.2	1,085.2	1,391.2								1,391.2	
Savings in personal injuries (average)	3,058.3	66.3	624.4	6,626.3	29,818	38,229								38,229	
Savings in personal injuries (Hurst)	6,116.6	132.5	1,248.8	13,252.6	59,637	76,458								76,458	
Savings in societal costs (average)	35,436,810	767,798	7,235,015	76,779,755	345,508,898	442,960,125								442,960,125	
Savings in societal costs (Hurst)	68,496,570	1,484,092	13,984,716	148,409,235	667,841,558	856,207,125								856,207,125	
<u>Annual Costs</u>															
Research and development	16,275														
Manufacturing (.0035)	81,375	1,627.5	1,627.5												
Maintenance and calibration (.002)	53,050	1,061	10,610												
Public information (.01)	250,000														
Operating costs (.02)	530,308	10,606.2	106,061				574,491	618,674							618,674
Enforcement cost	0														
Court costs (.82)	19,146,148	382,923	3,829,230				28,725,150	38,292,296			15,385,298	17,094,775			38,292,296
Rehabilitation costs (.14)	3,169,018	63,380	633,804				4,754,508	6,338,036	2,535,214	3,802,822	2,546,532	2,829,480	3,961,272		7,922,544
Total annual costs	23,246,174	725,873	4,862,255	23,246,174	23,246,174	23,246,174	34,454,849	45,649,706	22,612,370	23,879,978	18,862,838	20,855,263	24,038,428	23,246,174	47,234,214
B/C (average)	1.52	1.06	1.49	3.30	14.86	19.06	1.03	.78	1.57	1.48	1.88	1.70	1.47	19.06	.75
B/C (Hurst)	2.95	2.04	2.88	6.38	28.73	36.83	1.99	1.50	3.03	2.87	3.63	3.28	2.85	36.8	1.45
Crash/cost	.000315	.000219	.000308	.000682	.003072	.003938	.000213	.000160	.000324	.000307	.000388	.000351	.000305	.003938	.000155
	315/Mil	219/Mil	308/Mil	682/Mil	3072/Mil	3938/Mil	213/Mil	160/Mil	324/Mil	307/Mil	388/Mil	351/Mil	305/Mil	3938/Mil	155/Mil

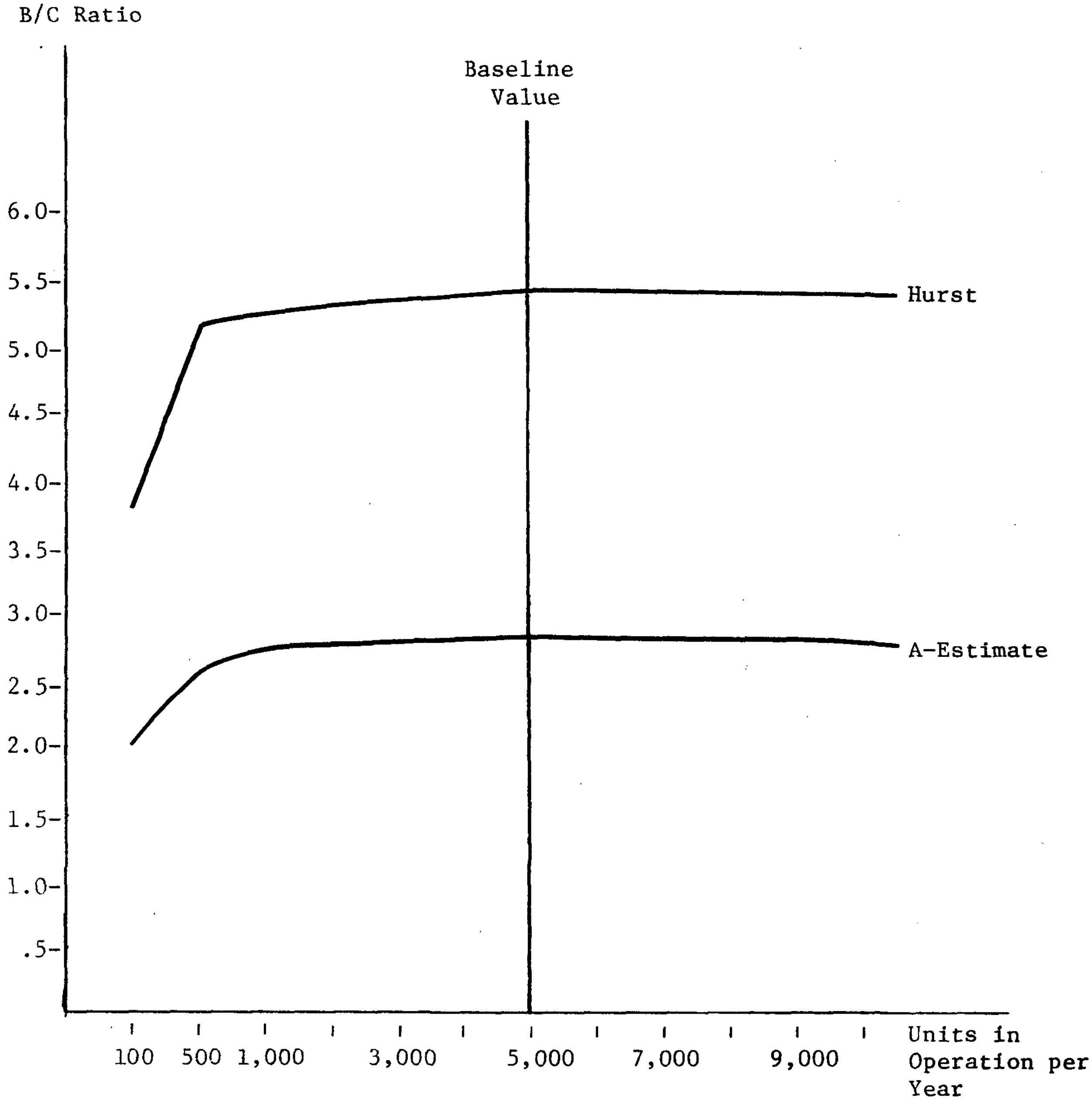

Fig. 21—Relationship Between Units in Operation per Year and the B/C Ratio - Evidential Roadside Tester

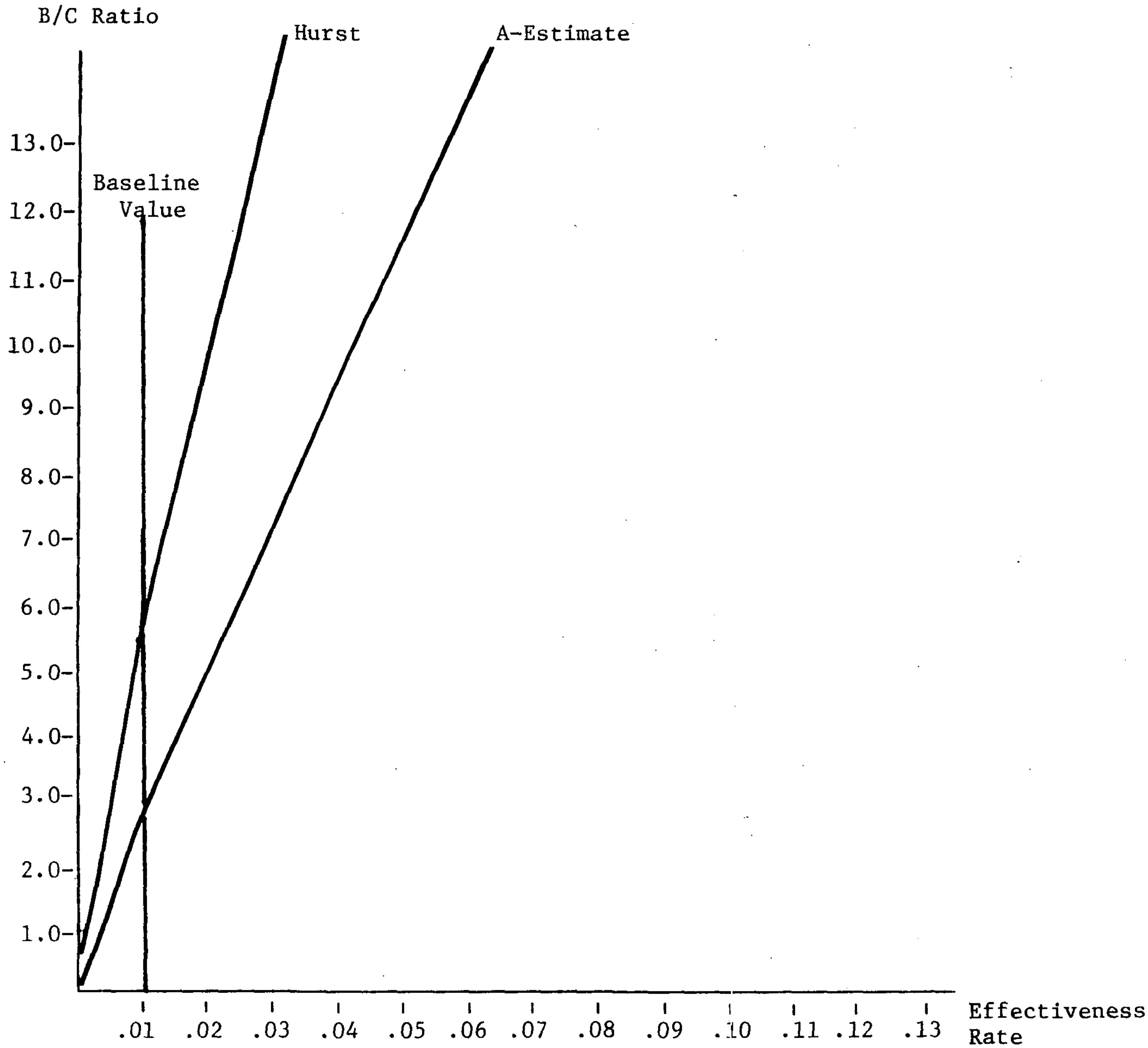

Fig. 22—Relationship Between Effectiveness Rate and B/C Ratio - Evidential Roadside Tester

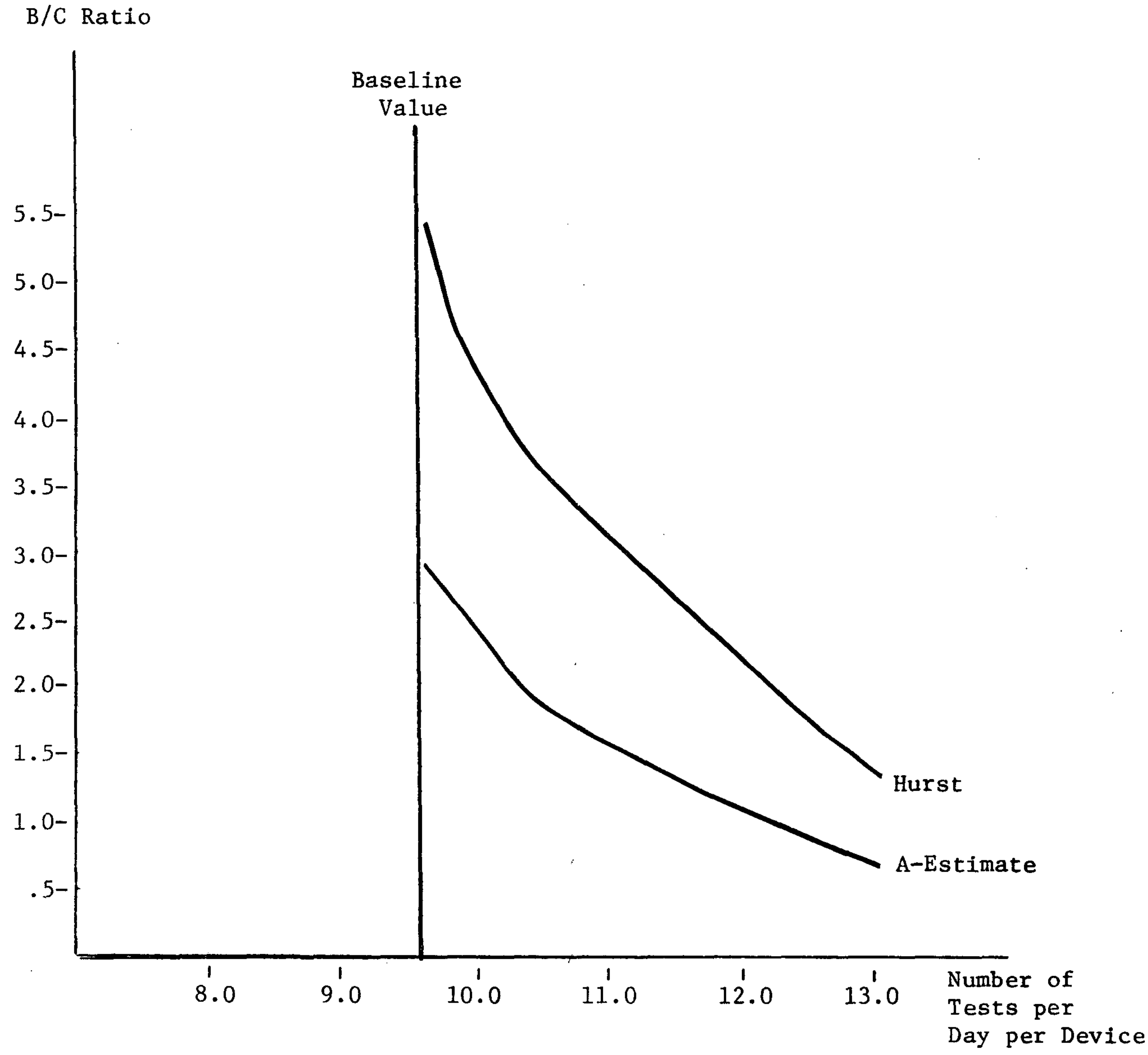

Fig. 23—Relationship Between Number of Tests per Day per Device and B/C Ratio - Evidential Roadside Tester

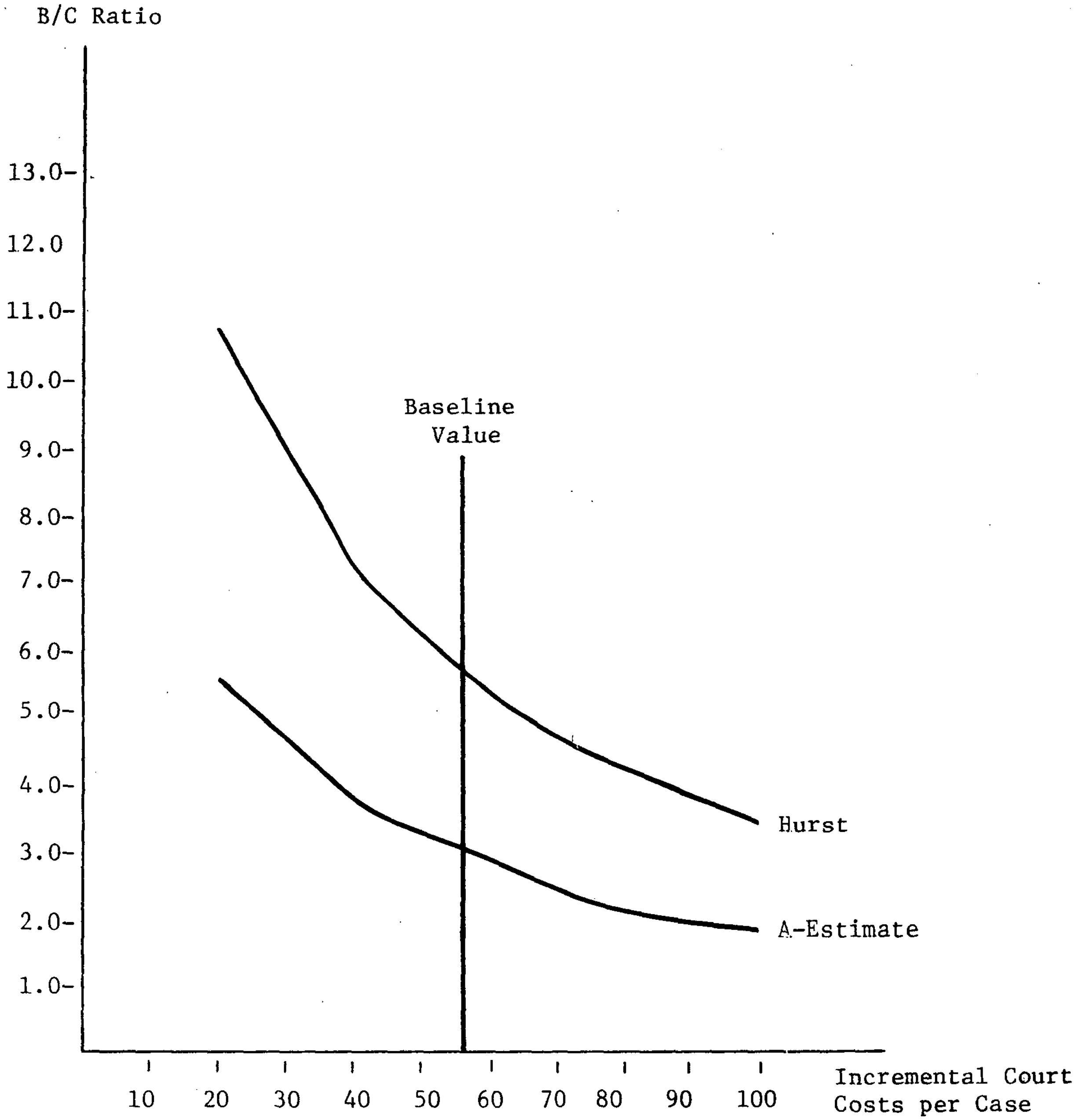

Fig. 24—Relationship Between Incremental Court Cost per Case and B/C Ratio - Evidential Roadside Tester

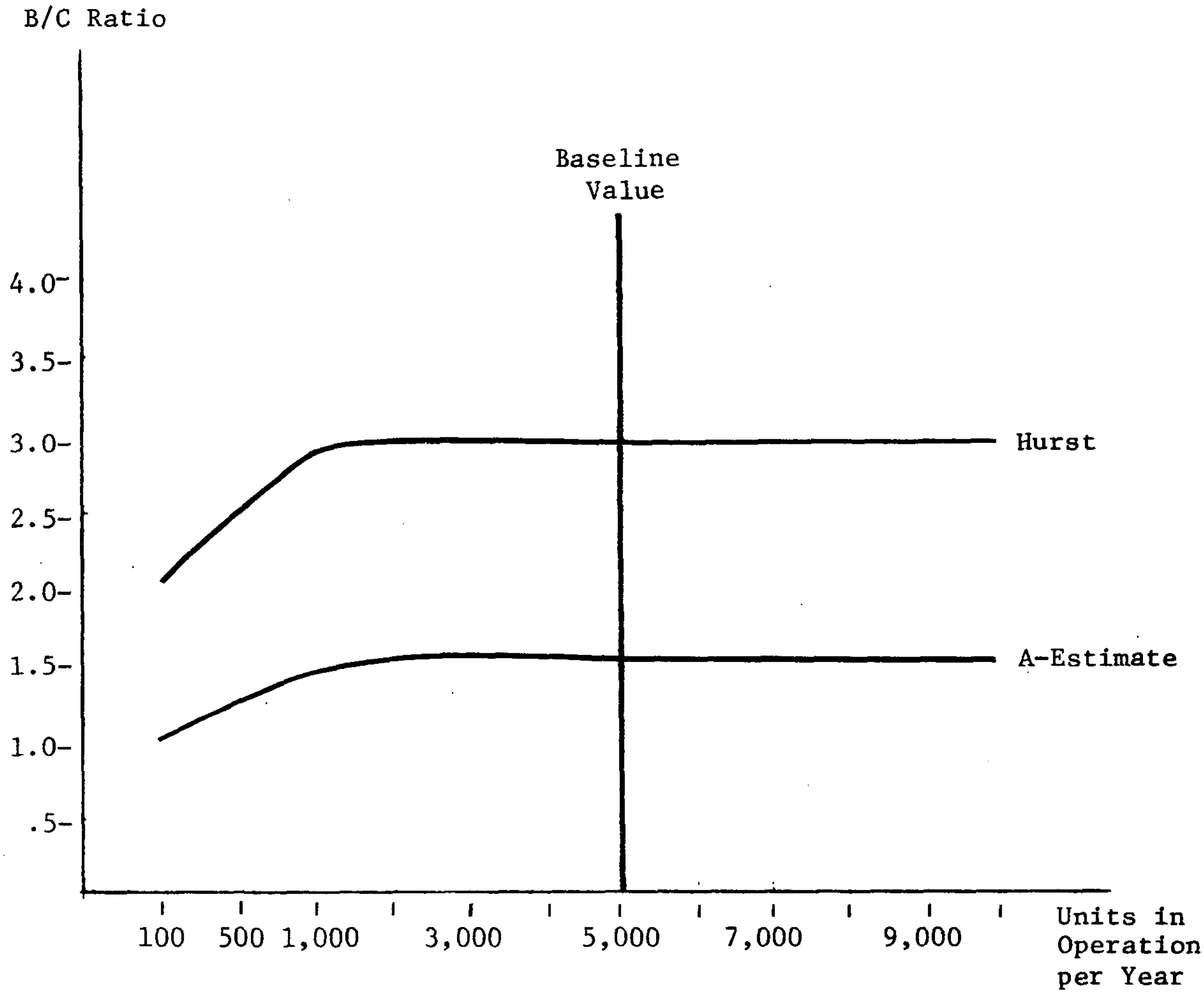

Fig. 25 — Relationship Between Units in Operation per Year and the B/C Ratio - Non-Cooperative Breath Tester

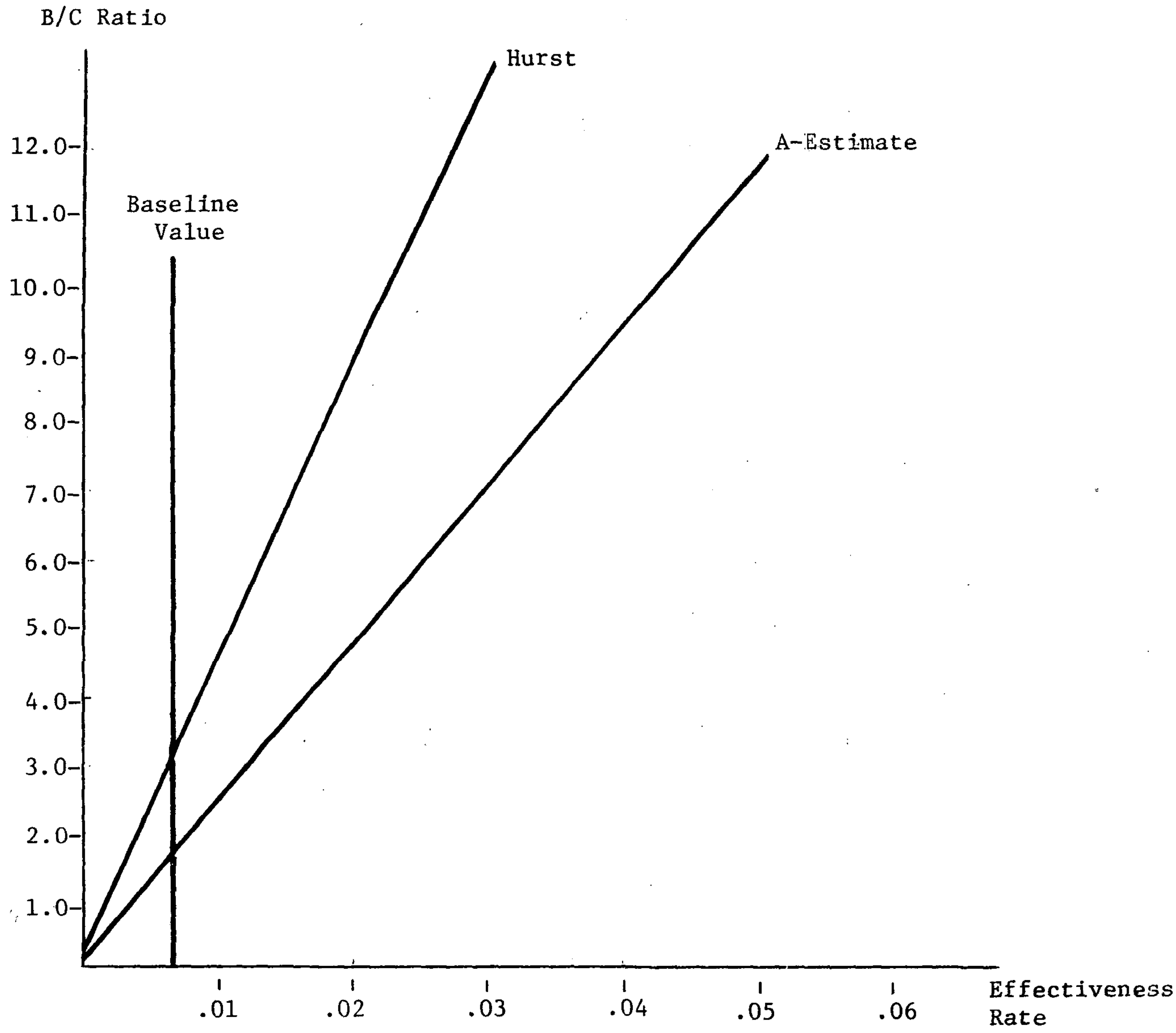

Fig. 26 — Relationship Between Effectiveness Rate and B/C Ratio
Non-Cooperative Breath Tester

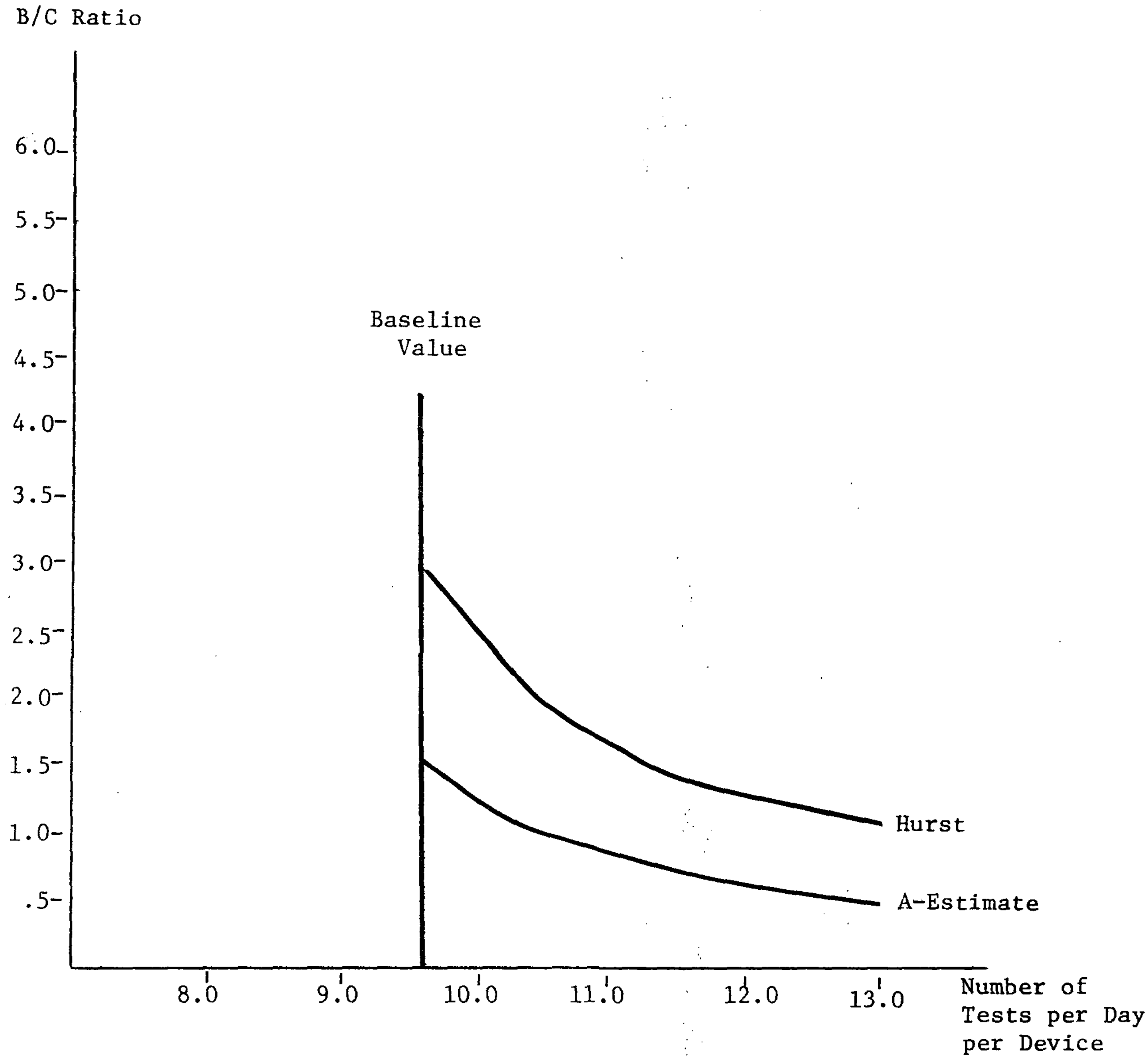

Fig. 27—Relationship Between Number of Tests per Day per Device and B/C Ratio - Non-Cooperative Breath Tester

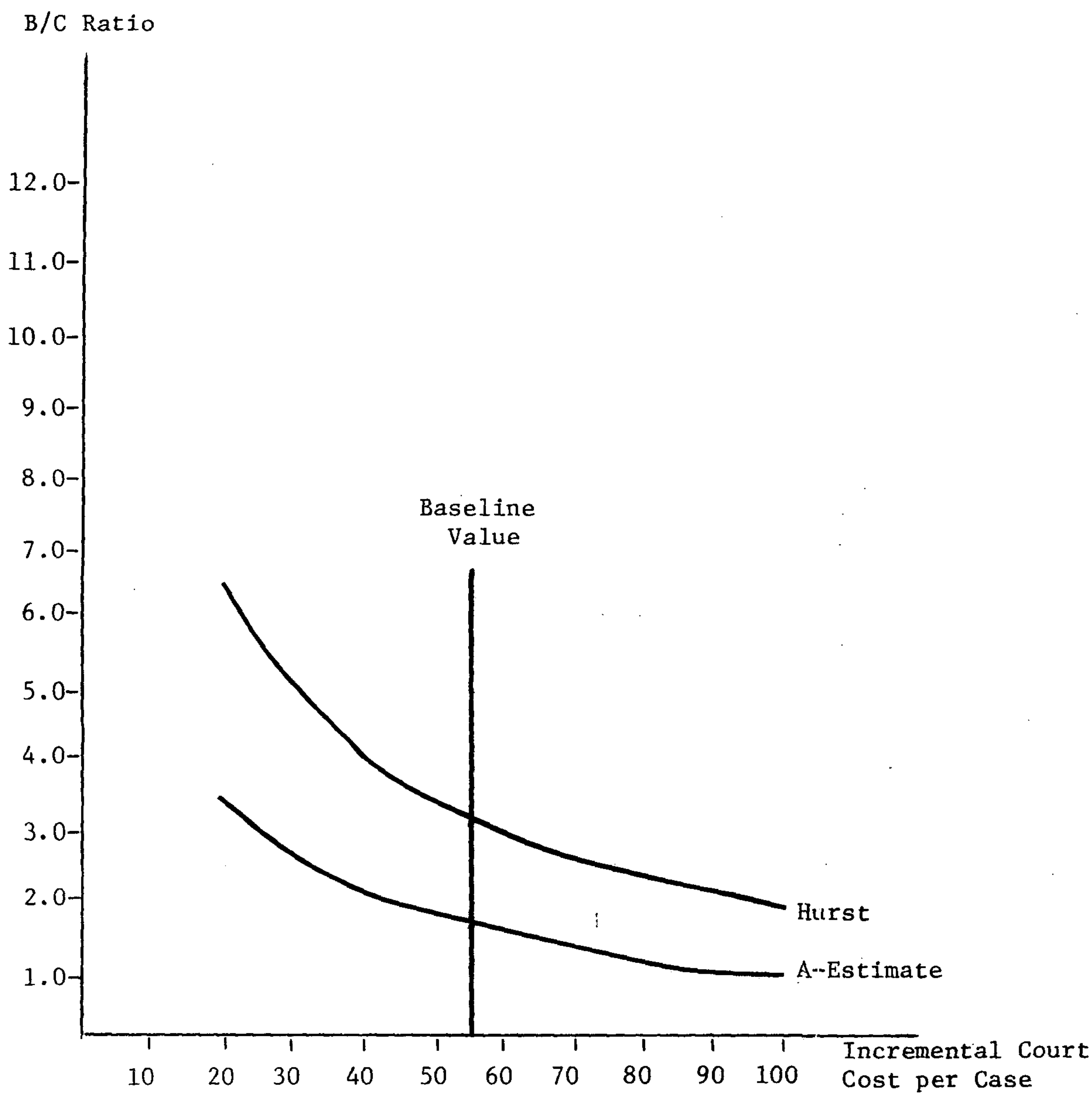

Fig. 28—Relationship Between Incremental Court Cost per Case and B/C Ratio - Non-Cooperative Breath Tester

number of arrests must be made to achieve a given level of effectiveness and consequently the benefit/cost ratios are lower.

7. The B/C ratios were sensitive to incremental court costs per case. However, both the Hurst ratio and the A-Estimate ratio exceeded unity when incremental court costs were assessed equal to $100.

8. The B/C ratios were uniformly higher for the evidential roadside tester than for the non-cooperative breath tester. This was due primarily to the assumption that the effectiveness rate for the evidential roadside tester would be twice that of the non-cooperative breath tester.

9. Research and development cost, manufacturing cost, public information cost, and operating costs were not significant when the number of units in operation exceeded 500.

The findings for the non-cooperative breath tester were parallel to those for the evidential roadside tester. The range of values for the B/C ratio was .75-36.8, and in general, the ratios were about one-half for the non-cooperative tester in each case.

ALCOHOL SAFETY INTERLOCK SYSTEMS

DESCRIPTION AND PERFORMANCE CHARACTERISTICS

The purpose of the alcohol interlock safety system is to prevent a person from starting his vehicle if his BAC level is above a specified limit, usually .10 percent. Two types of interlock systems have been developed. The first type relies on a breath test to determine if the driver is below the legal limit of .10 percent BAC before the interlock mechanism allows the vehicle to start. This device has a 100 percent discrimination rate in that all drivers who are .10 percent BAC and above are not permitted to start their vehicles, whereas all drivers below this limit are permitted to start.

The second type of interlock relies on a performance test which is correlated with BAC. The pass/fail criterion is the same, i.e., .10 percent BAC, but there are difficulties with both false negatives (cases where a person is above the legal limit and the device permits him to start the vehicle) and false positives (cases where a person is below the legal limit and the device does not permit him to drive).

Figures 29 and 30 present causal chain diagrams for the two alcohol safety interlock systems illustrating how they would operate to reduce accidents.

The need for the interlock device is continually re-emphasized by statistics which indicate that as many as 60 to 70 percent of drivers with suspended or revoked licenses continue to drive. It is apparent that the revocation of a person's driver's license and the penalties for driving without a valid license are little deterrence to these problem drivers.

There are a number of interlock devices that have been developed or are currently in the developmental stages and therefore, it was necessary to limit the analysis to those devices which offered the greatest promise of success. Interviews were held with cognizant NHTSA officials, and it was determined that these interlock devices should be included in the analysis:

1. Breath Analyzer
2. Critical Tracking Tester (Developed by General Motors)
3. Divided Attention Tester (Developed by DOT)

Each of these devices is described briefly.

1. Breath Analyzer. This interlock is a breath testing device which determines the BAC content of the driver before he starts the vehicle. Should the BAC reading show the driver is above a prescribed amount, the car will not be allowed to start. This type of device would measure the BAC level precisely, and would avoid the problem of false negatives and false positives. The BAC fixed limit can be regulated to represent the legal limit established by the state or municipality. Prototype testing at the Transportation Systems Center has shown the breath test interlock units to be highly reliable in terms of distinguishing drivers at BACs above the legal limits. The most serious problem involved with this device is the relatively simple method of defeating it when the driver introduces an amount of uncontaminated air into the device in place of his own breath. While strategies may be developed to reconcile this problem, this remains a serious drawback at this time.

2. Critical Tracking Tester (CTT). This device is based on the driver illustrating that his performance level meets a given criteria be-

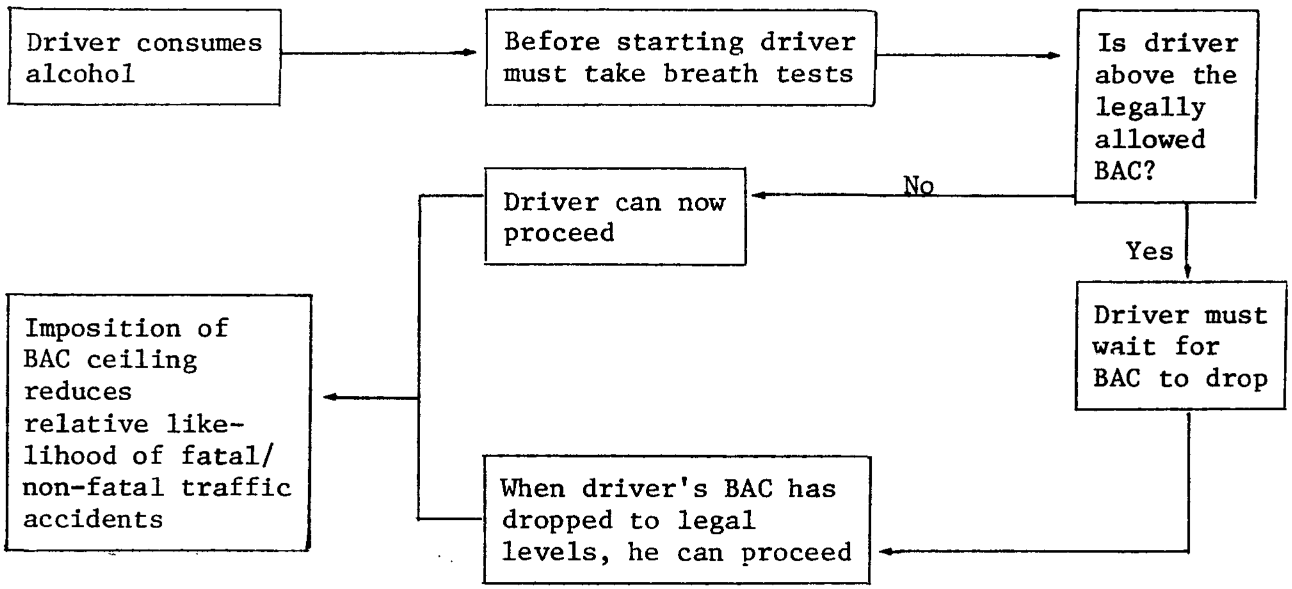

Fig. 29—Causal Chain for Breath Testing Interlock

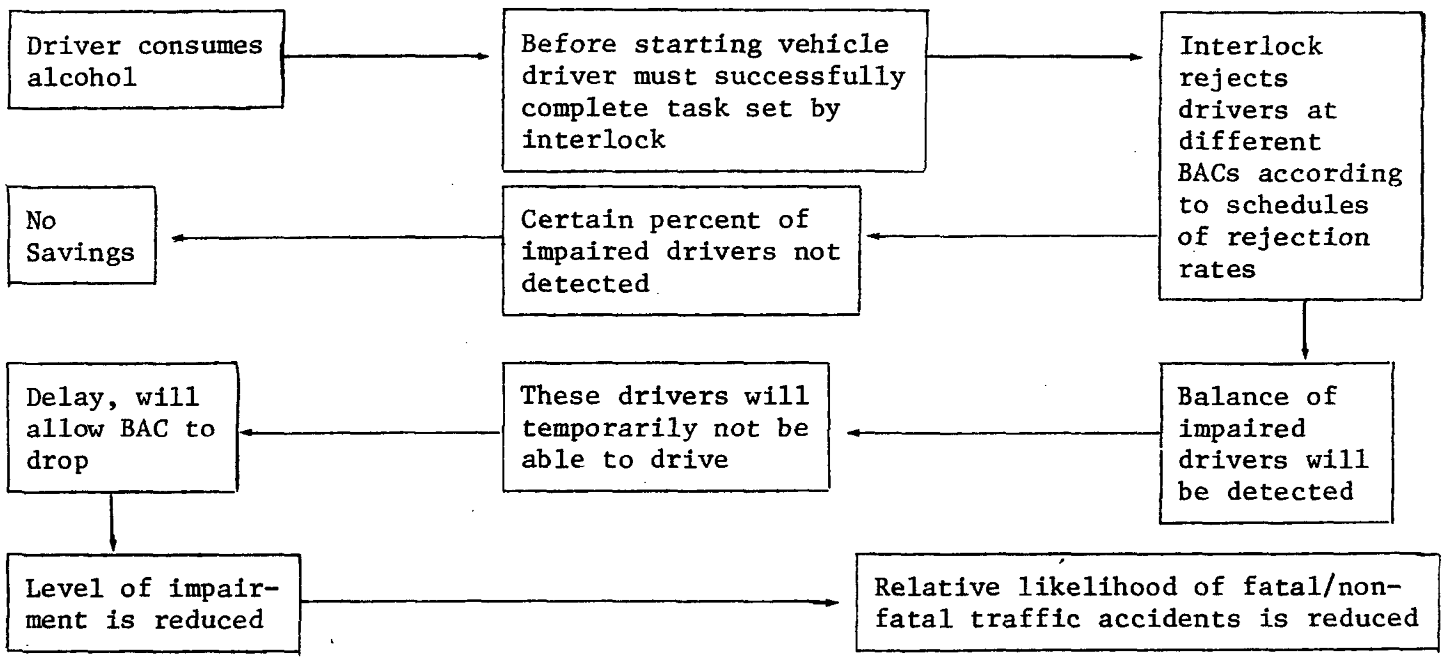

Fig. 30—Causal Chain for Performance Interlock

fore his vehicle can be started. The task of the driver is to stabilize a pointer undergoing random oscillations of increasing magnitude by turning the steering wheel to maintain/return the pointer to the rest position. The test would take about 25 seconds to complete, although an obvious failure will void the test at an earlier time. If the individual fails the test, he would have to wait about one-half hour before the test can be taken again. One of the major difficulties with the CTT is the relatively high rate of false negatives. While the false positive rate below .10 percent BAC is small, the false negative rate at .15 percent BAC is about 50 percent. This rate may be considered unacceptable by the courts in handling DWI convictions. In addition, there may be serious liability problems for the manufacturer in terms of breach of contract or malfunctions.

Another problem with this device is that repeated tests of the individual's performance ratings are required in order to reach the maximum performance thresholds. Since there is a learning curve involved in the performance of this test, the criterion must be increased at each stage of the learning process until the maximum is reached. This process is costly and timely for both the driver and control agency.

3. Divided Attention Tester (DAT). This device is similar to the CTT in that it requires a performance test of the driver prior to starting the vehicle. This test requires two separate tasks: one component is a pursuit tracking task, similar (but not as intense) to the CTT; the second component is a test of reaction time in the peripheral field of vision which requires the pressing of a button by the feet upon varying intervals of lights. Both of these tasks are to be performed at the same time, thereby making this test more difficult than the CTT. As in the case of the CTT, one of the major difficulties of the DAT is the false negatives and false positives. It is estimated that the number of false negatives would be reasonably low at a reading of .15 percent BAC (about 70 percent), and the number of false positives would be rather high at a finding of .10 percent BAC.

Also, associated with the use of the DAT interlock device are the problems of legal liability and learning curve performance.

While it would appear that the most practical and acceptable application of the alcohol safety interlock systems would be on a restricted basis resulting from a court order for a DWI arrest, the possibility exists that the alcohol interlock device, as in the case of the seatbelt interlocks, could be installed on all new passenger vehicles. The analyses performed included the use of the alcohol safety interlock systems under both restricted application and universal application where the devices would be installed on all new passenger vehicles.

BENEFIT/COST MODELS

Assumptions

Breath Interlock - Restricted Use:

1. The breath interlock device would be available for sale as a separate unit to be installed on any passenger vehicle by 1 July 1976.

2. The breath interlock would be installed on a restricted basis by court order following a DWI arrest and conviction.

3. It was assumed that the average number of breath interlocks in use per year would be equal to the following values: 100,000, 200,000, and 360,000 units.

4. It was assumed that the breath interlock would be 100 percent effective at BAC = .10-.14 and BAC = .15+ levels. This means that it would allow everyone below BAC = .10 to drive and prevent everyone equal or above BAC = .10 from driving.

5. It was assumed that the unit price would have the following values: $75, $100, $150, and $200.

6. It was assumed that the installation cost would have the following values: $15, $30 and $50.

7. It was assumed that the removal cost was equal to one-half the installation cost.

8. It was assumed that the annual maintenance and calibration cost per unit could have the following values: $25, $50, $75, $100, and $150.

9. It was assumed that the annual inspection cost per device could have the following values: 0, $10, $30, and $40.

10. It was assumed that 500 testing equipment stations would be required to provide installation, removal, maintenance, calibration and

inspection services, and that the equipment would cost $400 per station.

11. It was assumed that the device would malfunction once out of each 10,000 trials, and that the malfunction would result in a one hour delay valued at $5.73 per hour.[18]

12. It was assumed that each device would be installed and removed an average of once per year.

Breath Interlock - Universal Application:

1. The breath interlock would be installed on all new passenger vehicles manufactured after 1 July 1976.

2. It was assumed that 10,000,000 units would be installed each year.

3. It was assumed that effectiveness rates would be equal to those for restricted use.

4. It was assumed that the unit price could have the following values and would decline by 10 percent per year due to economics of large scale mass production: 50, 75, 100, and 150.

5. It was assumed that there would be no installation and removal costs and no inspection costs.

6. It was assumed that the annual maintenance and calibration costs could have the following values: 0, $25, $50 and $75.

7. It was assumed that 10,000 new testing equipment stations per year would be required to provide maintenance and calibration services and that the equipment would cost $400 per station.

8. It was assumed that the malfunction rate would be once out of 10,000 trials, and each malfunction would result in a one hour delay valued at $5.73 per hour.

Critical Tracking Tester (CTT) - Restricted Use:

1. The Critical Tracking Tester would be available for sale as a separate unit to be installed on any passenger vehicle by 1 July 1976.

2. The Critical Tracking Tester would be installed on a restricted basis by court order following a DWI arrest and conviction.

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[18]The $5.73 is the average hourly wage for US in 1973. Source: US Statistical Abstract.

3. It was assumed that the average number of CTT devices in use per year would be equal to the following values: 100,000, 200,000 and 360,000.

4. It was assumed that the effectiveness rates for the CTT at BAC = .10-.14 and BAC = .15+ could have the following values: .1389 and .5741, .3 and .75, .5 and .8, and .84 and 1.0.

5. It was assumed that the unit price could have the following values: $25, $50, $100, and $150.

6. It was assumed that the installation cost could have the following values: $15, $30, and $60.

7. It was assumed that the removal cost was equal to one-half the installation cost.

8. It was assumed that the annual maintenance and calibration cost per unit could have the following values: 0, $20 and $50.

9. It was assumed that the annual inspection cost per unit could have the following values: 0, $25 and $40.

10. It was assumed that 500 testing equipment stations would be required to provide installation, removal, maintenance, calibration and inspection services, and that the equipment would cost $100 per station.

11. It was assumed that the device could have the following malfunction rates: .0001, .0005, .001, and .01. Each malfunction would result in a one hour delay valued at $5.73 per hour. Also, it was assumed that the malfunction rate would increase as the effectiveness rate increased. This is consistent with the existing technology of this device.

12. It was assumed that each device would be installed and removed an average of once per year.

Critical Tracking Tester (CTT) - Universal Use:

1. The CTT would be installed on all new passenger vehicles manufactured after 1 July 1976.

2. It was assumed that 10,000,000 units would be installed each year.

3. It was assumed that the effectiveness rates would be equal to those for restricted use.

4. It was assumed that the unit price could have the following values and would decline by 10 percent per year due to economics of large scale

mass production: $25, $50, $100 and $150.

5. It was assumed that there would be no installation and removal costs and no inspection costs.

6. It was assumed that the annual maintenance and calibration costs could have the following values: 0, $20, and $50.

7. It was assumed that 10,000 new testing equipment stations per year would be required to provide maintenance and calibration services and that the equipment would cost $100 per station.

Divided Attention Tester (DAT) - Restricted Use:

1. The DAT device would be available for sale as a separate unit to be installed on any passenger vehicle by 1 July 1976.

2. The CTT interlock would be installed on a restricted basis by court order following a DWI arrest and conviction.

3. It was assumed that the average number of DAT interlocks in use per year would be equal to the following values: 100,000, 200,000 and 360,000 units.

4. It was assumed that the effectiveness rates for the DAT at BAC = .10-.14 and BAC = .15+ could have the following values: .37 and .852, .5 and .95 and .916 and 1.0.

5. It was assumed that the unit price could have the following values: $35, $50 and $100.

6. It was assumed that the installation cost could have the following values: $30, $50 and $75.

7. It was assumed that the removal cost was equal to one-half the installation cost.

8. It was assumed that the annual maintenance and calibration cost per unit could have the following values: 0, $25 and $50.

9. It was assumed that the annual inspection cost per unit could have the following values: 0, $25 and $40.

10. It was assumed that 500 testing equipment stations would be required to provide installation, removal, maintenance, calibration, and inspection services, and that the equipment would cost $100 per station.

11. It was assumed that the device could have the following malfunction rates: .00704, .01 and .05. Each malfunction would result in a one hour delay valued at $5.73 per hour. Also, it was assumed that the

malfunction rate would increase as the effectiveness rate increased. This is consistent with the existing technology of this device.

12. It was assumed that each device would be installed and removed an average of once per year.

Divided Attention Tester (DAT) - Universal Application:

1. The DAT would be installed on all new passenger vehicles manufactured after 1 July 1976.

2. It was assumed that 10,000,000 units would be installed each year.

3. It was assumed that the effectiveness rates would be equal to those for restricted use.

4. It was assumed that the unit price could have the following values and would decline by 10 percent per year due to economics of large scale mass production: \$35, \$50 and \$100.

5. It was assumed that there would be no installation and removal costs and no inspection costs.

6. It was assumed that the annual maintenance and calibration costs could have the following values: 0, \$25 and \$50.

7. It was assumed that 10,000 new testing equipment stations per year would be required to provide maintenance and calibration services and that the equipment would cost \$100 per station.

Model Equations

The benefit/cost models for the Breath Interlock, the Critical Tracking Testers and the Divided Attention Tester are the same, and the general model equations are given as follows:

Restricted Use

$$B/C_i = \frac{\text{Average Annual Savings in Societal Costs (SCC)}_i}{\text{Average Annual Costs (TC)}} \qquad i = 1,2$$

where

$$SSC_1 = CR\left[F_1\ (200{,}000) + P_1\ (7{,}200) + (300)\right]$$
$$SSC_2 = CR\left[F_2\ (200{,}000) + P_2\ (7{,}200) + (300)\right]$$

and

SSC_1, SSC_2, F_1, F_2, P_1, and P_2 are the same as defined previously.

$$CR = \left(\frac{N}{L}\right) \left[\left(A_1\right)\left(C_5\right)\left[\frac{R_5 - R_5}{R_5}\right] + \left(A_2\right)\left(C_6\right)\left[\frac{R_6 - R_4}{R_6}\right]\right]$$

where

CR is the average savings in crashes per year

N is the average number of devices in service per year

L is the number of licensed drivers

A_1 is the effectiveness rate at BAC = .10-.14

A_2 is the effectiveness rate at BAC = .15+

C_5 and C_6 are annual crashes (see Table 6)

R_4, R_5 and R_6 are relative probabilities (see Table 7)

TC (Average Annual Total Cost) = Research and Development Cost (RD)
+ Manufacturing Cost (MN)
+ Installation Cost (IC)
+ Maintenance and Calibration Cost (MT)
+ Inspection Cost (IN)
+ Testing Equipment Cost (TE)
+ Malfunction Cost (ML)
+ Removal Cost (RC)

$RD = .16275\ RD_T$

$MN = .16275\ (K)(N)$

$IC = (KI)(N)(AI)$

$MT = (KT)(N)$

$IN = (KN)(N)$

$TE = .16275\ (KE)(NS)$

$ML = (N)(ATD)(MLR)(KML)(1-B_5-B_6)$

$RC = (KR)(N)(AR)$

where

.16275 is the amortization factor for determining the average annual cost over 10 years discounted at 10 percent.

RD_T is the total research and development cost

K is the unit price of the interlock device

KI is the unit installation cost

AI is the average number of times per year each device is installed

KT is the annual maintenance and calibration cost per unit

KN is the annual inspection cost per unit

KE is the unit cost of testing equipment

NS is the annual number of testing equipment stations

ATD is the average number of trips per year per licensed drivers

MLR is the malfunction rate

KML is the cost per malfunction

KR is the removal cost

AR is the average number of times per year each device is removed

B_5 and B_6 are percentages of trips at BAC = .10-.14 and BAC = .15+ respectively (see Table 7)

Universal Application

The benefit/cost model for the interlock devices under universal application is given as follows:

$$B/C_i = \frac{\text{Average Annual Savings in Societal Costs (SSC)}_i}{\text{Average Annual Costs (TC)}} \qquad i = 1,2$$

where

$$SSC_1 = \sum_{i=1}^{10} \left(CR_i\right)\left(D_i\right) \left[F_1 \, (200{,}000) + P_1 \, (7{,}200) + (300)\right] \; (.16275)$$

$$SSC_2 = \sum_{i=1}^{10} \left(CR_i\right)\left(D_i\right) \left[F_2 \, (200{,}000) + P_2 \, (7{,}200) + (300)\right] \; (.16275)$$

and

SSC_1, SSC_2, F_1, F_2, P_1 and P_2 are the same as defined previously

.16275 is the amortization factor for determining the average annual cost over 10 years discounted at 10 percent

CR_i is crash savings in year i, i=1 ..., 10

D_i is the discount rate for the i^{th} year

The values for the discount factors for each year are given in Table 16.

Table 16

DISCOUNT FACTORS

Year	Discount Rate
1	.90909
2	.8264
3	.7513
4	.6830
5	.62092
6	.56447
7	.51316
8	.46651
9	.42410
10	.38554

$$CR_i = \left(\frac{N_i}{L}\right)\left[(A_1)(C_5)\left[\frac{R_5 - R_4}{R_5}\right] + (A_2)(C_6)\left[\frac{R_6 - R_4}{R_6}\right]\right]$$

$N_1 = 10{,}000{,}000$

$N_i = N_{(i-1)} + 10{,}000{,}000 \qquad i = 2,\ldots,10$

where

N_i is the average number of units in service in year i

L is the number of licensed drivers

A_1 is the effectiveness rate at BAC = .10-.14

A_2 is the effectiveness rate at BAC = .15+

C_5 and C_6 are annual crashes (see Table 6)

R_4, R_5 and R_6 are relative probabilities (see Table 7)

TC(Average Annual Cost) = Research and Development Cost (RD)
+ Manufacturing Cost (MN)
+ Maintenance and Calibration Cost (MT)
+ Testing Equipment Cost (TE)
+ Malfunction Cost (ML)

$$RD = .16275\left(RD_T\right)$$

$$MN = .16275\left[\sum_{i=1}^{10} (K_i)(N_i - N_{(i-1)})(D_i)\right], \quad K_i = .9\,K_{(i-1)} \qquad i = 1,\ldots 10$$

$$MT = KT\left[\sum_{i=1}^{10} N_i\, D_i\right]$$

$$TE = .16275 \left[KTE \left[\sum_{i=1}^{10} NTE_i \; D_i \right] \right]$$

where

RD_T is the total research and development cost

K_i is the unit manufacturing price in year i

N_i is the number of units in service in year i

D_i is the discount rate for year i (see Table 16)

KT is the maintenance and calibration cost per year

KTE is the unit cost of testing equipment

NTE is the number of testing equipment stations added each year

KML is the cost per malfunction

RML is the malfunction rate

ATD is the average trips per year per licensed driver

B_5 and B_6 are percentages of trips at BAC = .10-.14 and BAC = .15+ respectively (see Table 7)

SUMMARY OF FINDINGS - BASELINE CASE AND SENSITIVITY ANALYSES

Tables 17, 18 and 19 summarize the findings for restricted application of the alcohol safety interlock systems - Breath Interlock, Critical Tracking Tester, and Divided Attention Tester, and Tables 20, 21 and 22 summarize the findings for the universal application of the interlock systems - Breath Interlock, Critical Tracking Tester, and Divided Attention Tester. Figures 31, 32, 33, 34 and 35 present graphical relationships for the interlock devices under the assumption of restricted application and Figs. 36 and 37 present graphical relationships for the interlock devices under the assumption of universal application. Results for all three devices, the Breath Interlock, the Critical Tracking Tester and the Divided Attention Tester have been reported in each figure so that direct comparisons may be made. It is important to reiterate that all variations in parameters are made with respect to the baseline case for each device, and the results should be interpreted with the recognition that the baseline values, e.g., maintenance and calibration cost, may be different for the three devices.

The findings for the interlock devices under the assumption of restricted application, may be summarized as follows:

Table 17

ALCOHOL SAFETY INTERLOCK SYSTEM BREATH INTERLOCK (RESTRICTED)

	Baseline case	1	2	3	4	5	6	7	8	9	10	11	12	Most favorable 13	Least favorable 14
<u>Input Data</u>															
Number of units in service per year	360,000	100,000	200,000												
Effectiveness rate BAC=.10-.14	1.0														
Effectiveness rate BAC=.15+	1.0														
Research and development cost	500,000														
Manufacturing price	75			100	150	200								75	200
Installation cost	30						15	50						15	50
Average number of items needed	1														
Maintenance and calibration cost	75								50	100	150			25	150
Inspection cost	40											10	30	0	30
Unit cost of testing equipment	400														
Number of testing equipment stations	500														
Malfunction rate	.0001														
Cost per malfunction	5.73														
Unit removal cost	15													7.5	25
Average number of times removed	1.0						7.5	25							
<u>Annual Savings</u>															
Savings in crashes	3841.2	1066.9	2133.8												
Savings in fatalities (average)	29.42	8.17	16.34												
Savings in fatalities (Hurst)	58.39	16.22	32.44												
Savings in personal injuries (average)	1604.1	445.6	891.2												
Savings in personal injuries (Hurst)	3361.8	933.8	1867.7												
Savings in societal costs (average)	18,585,880	5,162,744	10,325,489												
Savings in societal costs (Hurst)	37,035,896	10,287,749	20,575,498												
<u>Annual Costs</u>															
Research and development (.001)	81,375														
Manufacturing (.07)	4,394,250	1,220,625	2,441,250	5,859,000	8,788,500	11,718,000								4,394,250	11,718,000
Installation (.17)	10,800,000	3,000,000	6,000,000				5,400,000	18,000,000						5,400,000	18,000,000
Maintenance and calibration (.43)	27,000,000	7,500,000	15,000,000						18,000,000	36,000,000	54,000,000			9,000,000	54,000,000
Inspection (.23)	14,400,000	4,000,000	8,000,000									3,600,000	10,800,000	0	10,800,000
Testing equipment (.0005)	32,250														
Malfunction (.003)	182,960	50,882	101,644												
Removal (.09)	5,400,000	1,500,000	3,000,000				2,700,000	9,000,000						2,700,000	9,000,000
Total annual cost	62,290.835	17,335,714	34,656,519	63,755,585	66,685,085	69,614,585	54,190,835	73,098,835	53,290,835	71,290,835	89,290,835	51,490,835	58,690,835	21,790,835	103,814,585
B/C (average)	.30	.30	.30	.29	.28	.27	.34	.25	.35	.26	.21	.36	.32	.85	.18
B/C (Hurst)	.59	.59	.59	.58	.56	.53	.68	.50	.70	.52	.42	.72	.64	1.70	.36
Crash/cost	.000062	.000062	.000062	.000060	.000058	.000055	.000071	.000052	.000072	.000054	.000043	.000075	.000065	.000176	.000037
	62/Mil	62/Mil	60/Mil	60/Mil	58/Mil	55/Mil	71/Mil	52/Mil	72/Mil	54/Mil	43/Mil	75/Mil	65/Mil	176/Mil	37/Mil

Table 18

ALCOHOL SAFETY INTERLOCK SYSTEM - CRITICAL TRACKING TESTER (RESTRICTED USE)

	Baseline case	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Most favorable 15	Least favorable 16
<u>Input Data</u>																	
Number of units in service per year	360,000	100,000	200,000														
Effectiveness rate, BAC=.10-.14	.1389			.3	.5	.84										.84	.1389
Effectiveness rate, BAC=.15+	.5741			.75	.8	1.0										1.00	.5741
Research and development cost	500,000																
Unit manufacturing price	100						25	50	150							25	150
Installation cost	60									15	30					15	60
Average number of times installed	1.0																
Maintenance and calibration cost	50											0	20			0	50
Inspection cost	40													0	25	0	40
Unit cost of testing equipment	100																
Number og testing equipment stations	500																
Malfunction rate	.0001			.0005	.001	.01										.001	.0001
Cost per malfunction	5.73																
Unit removal cost	30									7.5	15					7.5	30
Average number of times removed	1.0																
<u>Annual Savings</u>																	
Savings in crashes	1505.5	418.2	836.4	2157.4	2590.6	3583.9										3583.9	1505.5
Savings in fatalities (average)	11.53	3.2	6.4	16.52	19.84	27.45										27.45	11.53
Savings in fatalities (Hurst)	22.88	6.36	12.71	32.79	39.23	54.47										54.47	22.88
Savings in personal injuries (average)	628.62	174.62	349.23	900.82	1081.70	1496.45										1496.45	628.62
Savings in personal injuries (Hurst)	1317.43	365.96	731.91	1887.89	2266.98	3136.20										3136.20	1317.43
Savings in societal costs (average)	7,283,794	2,023,276	4,046,552	10,437,766	12,533,641	17,339,349										17,339,349	7,283,794
Savings in societal costs (Hurst)	14,513,176	4,031,437	8,062,875	20,797,559	24,973,652	34,549,167										34,549,167	14,513,176
<u>Annual Costs</u>																	
Research and development (.001)	81,375																
Manufacturing (.08)	5,859,000	1,627,500	3,255,000				1,464,750	2,292,500	8,788,500							1,464,750	8,788,500
Installation (.30)	21,600,000	6,000,000	12,000,000							5,400,000	10,800,000					5,400,000	21,600,000
Maintenance and calibration (.25)	18,000,000	5,000,000	10,000,000									0	7,200,000			0	18,000,000
Inspection (.20)	14,400,000	4,000,000	8,000,000											0	9,000,000	0	14,400,000
Testing equipment (.0001)	8,137																
Malfunction (.003)	183,960	50,822	101,644	914,800	1,829,600	18,296,005										1,829,600	182,960
Removal (.15)	10,800,000	3,000,000	6,000,000							2,700,000	5,400,000					2,700,000	10,800,000
Total annual cost	70,931,472	19,767,834	39,446,156	71,663,312	72,578,112	89,039,247	66,537,222	68,001,972	73,860,972	46,638,472	54,736,472	52,931,472	60,131,472	56,531,472	64,531,472	11,475,725	73,860,972
B/C (average)	.10	.10	.10	.15	.17	.19	.11	.11	.10	.16	.13	.14	.12	.13	.11	1.50	.10
B/C (Hurst)	.20	.20	.20	.30	.34	.39	.22	.22	.20	.31	.26	.28	.24	.26	.22	3.00	.20
Crash/cost	.000021	.000021	.000021	.000030	.000035	.000040	.000022	.000022	.000020	.000032	.000026	.000028	.000024	.000026	.000022	.00031	.000020
	21/Mil	21/Mil	21/Mil	30/Mil	35/Mil	40/Mil	22/Mil	22/Mil	20/Mil	32/Mil	26/Mil	28/Mil	24/Mil	26/Mil	22/Mil	310/Mil	20/Mil

Table 19

ALCOHOL SAFETY INTERLOCK SYSTEM - DIVIDED ATTENTION TESTER (RESTRICTED USE)

	Baseline case	1	2	3	4	5	6	7	8	9	10	11	12	Most favorable 13	Least favorable 14
<u>Input Data</u>															
Number of units in service per year	360,000	100,000	200,000												
Effectiveness rate, BAC=.10-.14	.37			.5	.916									.916	.37
Effectiveness rate, BAC=.15+	.852			.95	1.0									1.0	.852
Research and development cost	500,000														
Unit manufacturing price	100					35	50							35	100
Installation cost	75							30	50					30	75
Average number of times installed	1.0														
Maintenance and calibration cost	50									0	25			0	50
Inspection cost	40											0	25	0	40
Unit cost of testing equipment	100														
Number of testing equipment stations	500														
Malfunction rate	.00709			.01	.05									.00709	.00709
Cost per manfunction	5.73														
Unit removal cost	37.5							15	25					15	37.50
Average number of times removed	1.0														
<u>Annual Savings</u>															
Savings in crashes	2497.72	693.81	1387.62	2925.61	3708.60									3708.60	2497.72
Savings in fatalities (average)	19.11	5.32	10.62	22.38	28.37									28.37	19.11
Savings in fatalities (Hurst)	37.96	10.54	21.08	44.46	56.36									56.36	37.96
Savings in personal injuries (average)	1043.04	289.73	579.46	1221.73	1548.70									1548.70	1043.04
Savings in personal injuries (Hurst)	2185.99	607.22	1214.44	2560.48	3245.75									3245.75	2185.99
Savings in societal costs (average)	12,085,662	3,357,128	6,714,257	14,156,083	17,944,720									17,944,720	12,085,662
Savings in societal costs (Hurst)	24,081,513	6,689,309	13,378,618	28,206,971	35,756,089									35,756,089	24,081,513
<u>Annual Costs</u>															
Research and development (.0009)	81,375													81,375	81,375
Manufacturing (.064)	5,859,000	1,627,500	3 255,000			2,050,650	2,929,500							2,050,650	5,859,000
Installation (.29)	27,000,000	7,500,000	15,000,000					10,800,000	18,000,000					10,800,000	27,000,000
Maintenance and calibration (.20)	18,000,000	5,000,000	10.000,000							0	9,000,000			0	18,000,000
Inspection (.16)	14,400,000	4,000,000	8,000,000									0	9.000,000	0	14,400,000
Testing equipment (.00009)	8,137													8,137	8,137
Manfunction (.14)	12,971,867	3,603,296	7,206,593	18,296,005	91,480,023									12,971,867	12,971,867
Removal (.15)	13,500,000	3,750,000	7,500,000					5,400,000	9,000,000					5,400,000	13,500,000
Total annual cost	91,820,379	25,570,308	51,051,105	97,144,517	170,328,535	88,012,629	88,890,879	67,520.379	78,320,379	73,820,379	82,780,379	77,420,379	86,420.379	31,303,892	91,778,379
B/C (average)	.13	.13	.13	.14	.10	.14	.14	.18	.15	.16	.15	.16	.14	.57	.13
B/C (Hurst)	.26	.26	.26	.28	.21	.27	.27	.36	.30	.32	.29	.31	.28	1.13	.26
Crash/cost	.000027	.000027	.000027	.000028	.000021	.000028	.000028	.000037	.000037	.000031	.000030	.000032	.000029	.000117	.000027
	27/Mil	27/Mil	27/Mil	28/Mil	21/Mil	28/Mil	28/Mil	37/Mil	37/Mil	31/Mil	30/Mil	32/Mil	29/Mil	117/Mil	27/Mil

Table 20

ALCOHOL SAFETY INTERLOCK SYSTEM - BREATH INTERLOCK (UNIVERSAL)

	Baseline Case	1	2	3	4	5	6	Most Favorable	Least Favorable
Input Date									
Number of Units in Year 1	10,000,000								
Effectiveness Rate BAC = .10-.14	1.0								
Effectiveness Rate BAC = .15+	1.0								
Research and Development Cost	500,000								
Price in Year 1	75	50	100	150				50	150
Price in Year 2	67.50	45	90	135					
Price in Year 3	60.75	40.5	81	121.50					
Price in Year 4	54.68	36.45	72.9	109.35					
Price in Year 5	49.21	32.81	65.6	98.42					
Price in Year 6	44.29	29.52	59.05	88.57					
Price in Year 7	39.86	26.57	53.14	79.72					
Price in Year 8	35.87	23.91	47.83	71.74					
Price in Year 9	32.29	21.52	43.05	64.57					
Price in Year 10	29.06	19.37	38.74	58.11					
Maintenance and Calibration	75				0	25	50	0	75
Unit Cost of Testing Equipment	400								
Testing Equipment Stations in Year 1	10,000								
Malfunction Rate	.0001								
Malfunction Cost	5.73								
Annual Savings									
Savings in Crashes	586,843								
Savings in Fatalities (Avg)	4495.2								
Savings in Fatalities (Hurst)	8990.4								
Savings in Personal Injuries (Avg)	245,066								
Savings in Personal Injuries (Hurst)	490,131								
Savings in Societal Costs (Avg)	2,439,738,115								
Savings in Societal Costs (Hurst)	4,861,324,619								
Annual Costs									
Research and Development (-)	81,375								
Manufacturing (.024)	528,258,289	352,172,193	704,344,385	1,056,516,578				352,172,193	1,056,516,578
Maintenance and Calibration (.975)	21,776,782,250				0	7,258,927,500	14,517,855,000		
Testing Equipment (.0008)	4,789,186								
Malfunction (.001)	24,027,232								
Total Annual Cost	22,333,938,330	22,157,852,234	24,261,682,290	22,848,160,660	557,856,082	7,816,083,582	15,075,011,080	381,069,986	25,975,602,520
B/C (Average)	.11	.11	.10	.11	4.38	.31	.16	6.40	.09
B/C (Hurst)	.22	.21	.20	.22	8.72	.62	.32	12.76	.19
Crash/Cost	.000026	.000025	.000025	.000026	.001053	.000075	.000038	.001540	.000022
	26/MIL	25/MIL	25/MIL	26/MIL	1053/MIL	75/MIL	38/MIL	1540/MIL	22/MIL

Table 21

ALCOHOL SAFETY INTERLOCK SYSTEM - CRITICAL TRACKING TESTER (UNIVERSAL)

	Baseline Case	1	2	3	4	5	6	7	8	Most Favorable	Least Favorable
Input Data											
Number of units in year 1	10,000,000										
Effectiveness Rate BAC=.10-.14	.13891	.3	.5	.84						.84	.13891
Effectiveness Rate BAC = .15+	.5741	.75	.8	1.0						1.00	.5741
Research and Development Cost	500,000										
Price in year 1	100				25	50	150			25	150
Price in year 2	90				22.5	45	135				
Price in year 3	81				20.25	40.50	121.50				
Price in year 4	72.90				18.23	36.45	109.35				
Price in year 5	65.60				16.40	32.81	98.42				
Price in year 6	59.05				14.76	29.52	88.57				
Price in year 7	53.14				13.28	26.57	79.72				
Price in year 8	47.83				11.96	23.91	71.74				
Price in year 9	43.05				10.76	21.52	64.57				
Price in year 10	38.74				9.68	19.37	58.11				
Maintenance and calibration	50							0	20	0	50
Unit cost of testing equipment	100										
Testing equipment stations in year 1	10,000										
Malfunction rate	.0001	.0005	.001	.01						.001	.0001
Malfunction cost	5.73										
Annual Savings											
Savings in crashes	230,008	329,599	395,785	547,542						547,542	
Savings in fatalities (average)	1,761.9	2,524.8	3,031.8	4,194.3						4,194.3	
Savings in fatalities (Hurst)	3,496.1	5,009.9	6,015.9	8,322.6						8,322.6	
Savings in personal injuries (average)	96,051.6	137,640.9	165,280.5	228,654.3						228,654.3	
Savings in personal injuries (Hurst)	201,303.6	288,465.9	346,392.6	479,210.5						479,210.5	
Savings in societal costs (average)	956,236,701	1,370,277,080	1,645,441,635	2,276,356,162						2,276,356,162	
Savings in societal costs (Hurst)	1,905,359,017	2,730,359,324	3,278,641,214	4,535,776,272						4,535,776,372	
Annual Costs											
Research and development	81,375										
Manufacturing (.046)	704,344,385				176,086,096	352,172,192	1,056,516,576			176,086,096	1,056,516,576
Maintenance and calibration (.952)	14,517,855,000							0	5,807,142,000	0	
Testing equipment	1,197,297									1,197,297	
Malfunction (.002)	24,027,232	120,136,164	240,272,328	2,402,723,280						240,272,328	
Total Annual Cost	15,247,505,300	15,343,614,210	15,487,777,610	17,626,201,330	14,719,231,030	14,895,317,180	15,599,661,570	729,650,300	6,536,792,300	201,392,000	15,599,661,570
B/C (average)	.06	.09	.11	.13	.06	.06	.06	1.31	.15	11.30	.06
B/C (Hurst)	.12	.18	.21	.26	.13	.13	.12	2.61	2.9	22.52	.12
Crash/Cost	.000015	.000021	.000026	.000031	.000016	.000016	.000015	.000315	.000035	.002718	.000015
	15/MIL	21/MIL	26/MIL	31/MIL	16/MIL	16/MIL	15/MIL	315/MIL	35/MIL	2718/MIL	15/MIL

Table 22

ALCOHOL SAFETY INTERLOCK SYSTEM - DIVIDED ATTENTION TESTER (UNIVERSAL)

	Baseline case	1	2	3	4	5	6	Most favorable 7	Least favorable 8
Input Data									
Number of units in Year 1	10,000,000								
Effectiveness rate, BAC=.10-.14	.37	.5	.916					.916	.37
Effectiveness rate, BAC=.154	.852	.95	1.0					1.0	.852
Research and development cost	500,000								
Price in Year 1	100			35	50			35	100
Price in Year 2	90			31.5	45				
Price in Year 3	81			28.35	40.50				
Price in Year 4	72.90			25.52	36.45				
Price in Year 5	65.60			22.96	32.81				
Price in Year 6	59.05			20.67	29.52				
Price in Year 7	53.14			18.60	26.57				
Price in Year 8	47.83			16.74	23.91				
Price in Year 9	43.05			15.07	21.52				
Price in Year 10	38.74			13.56	19.37				
Maintenance and calibration	50					0	20	0	50
Unit cost of testing equipment	100								
Testing equipment stations in Year 1	10,000								
Malfunction rate	.00709	.01	.05					.01	.00709
Malfunction cost	5.73								
Annual Savings									
Savings in crashes	381,597	446,969	566,593					566,593	
Savings in fatalities (average)	2923.0	3423.7	4340.1					4340.1	
Savings in fatalities (Hurst)	5800.3	6794.0	9612.3					8612.3	
Savings in personal injuries (average)	159,354.9	186,654.3	236,609.2					236,609.2	
Savings in personal injuries (Hurst)	333,973.6	391,187.4	495,882.0					495,882	
Savings in societal costs (average)	1,586,448,831	1,858,226,929	2,355,549,914					2,355,549,914	1,586,448,831
Savings in societal costs (Hurst)	3,161,094,510	3,702,628,682	4,693,574,599					4,693,574,599	3,161,094,510
Annual Costs									
Research and development (-)	81,375								
Manufacturing (.04)	704,344,385			246,520,534	352,172,192			246,520,534	
Maintenance and calibration (.86)	14,517,855,000					0	5,807,142,000	0	
Testing equipment (.00025)	1,197,297								
Malfunction (.10)	1,703,530,809	2,402,723,285	12,013,616,430					2,402,723,285	
Total annual cost	16,927,008,870	17,626,201,360	27,237,094,500	16,469,169,100	16,574,820,760	2,409,153,870	8,216,295,870	2,650,522,491	16,927,008,870
B/C (average)	.09	.11	.09	.10	.10	.66	.19	.89	.09
B/C (Hurst)	.19	.21	.17	.19	.19	1.31	.38	1.77	.19
Crash/cost	.000022	.000025	.000021	.000023	.000023	.000158	.000046	.000214	.000022
	22/MIL	25/MIL	21/MIL	23/MIL	23/MIL	158/MIL	46/MIL	214/MIL	22/MIL

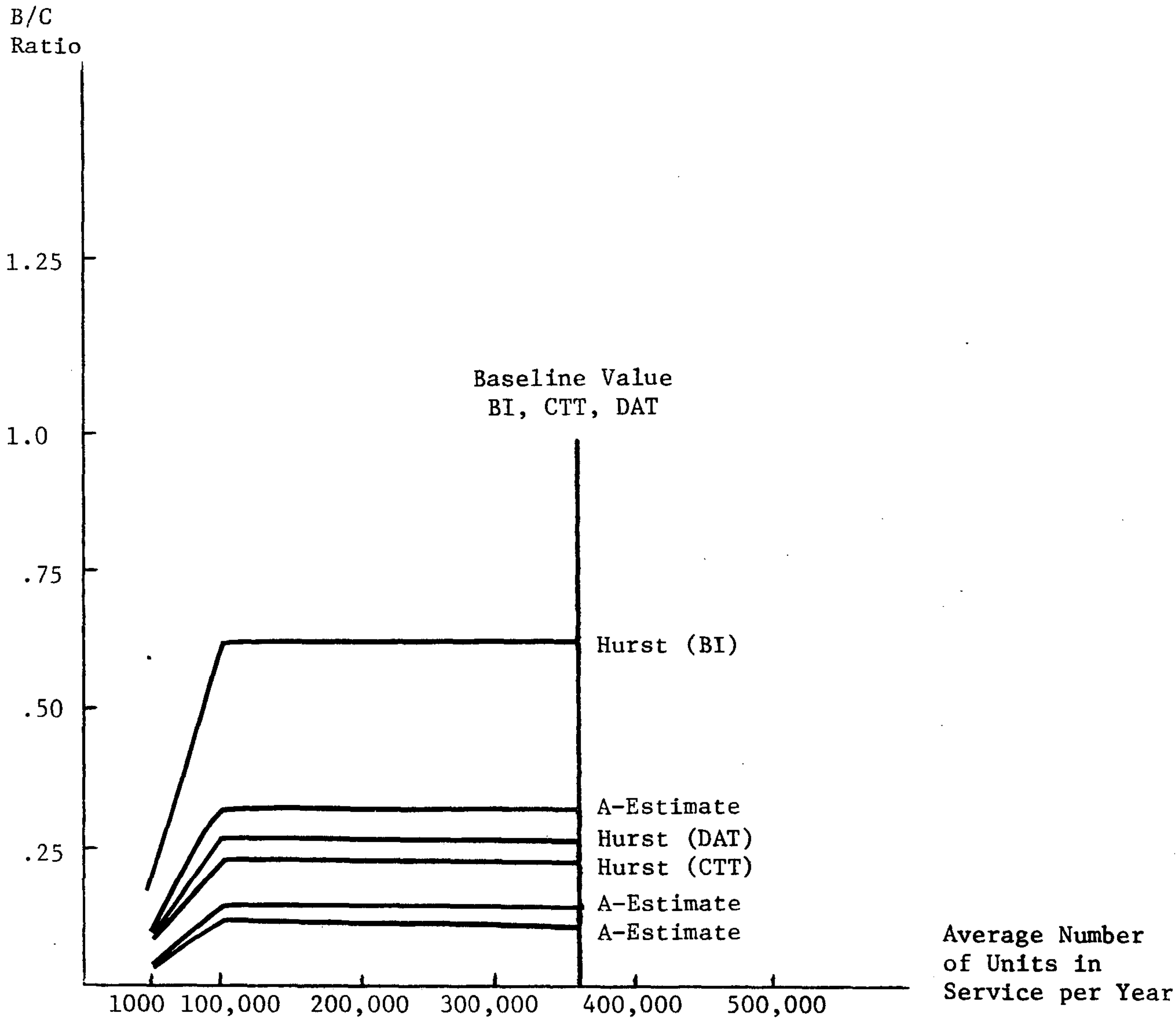

Fig. 31—Relationship Between Units Installed Per Year and B/C Ratio - Alcohol Safety Interlock Systems (Restricted Use)

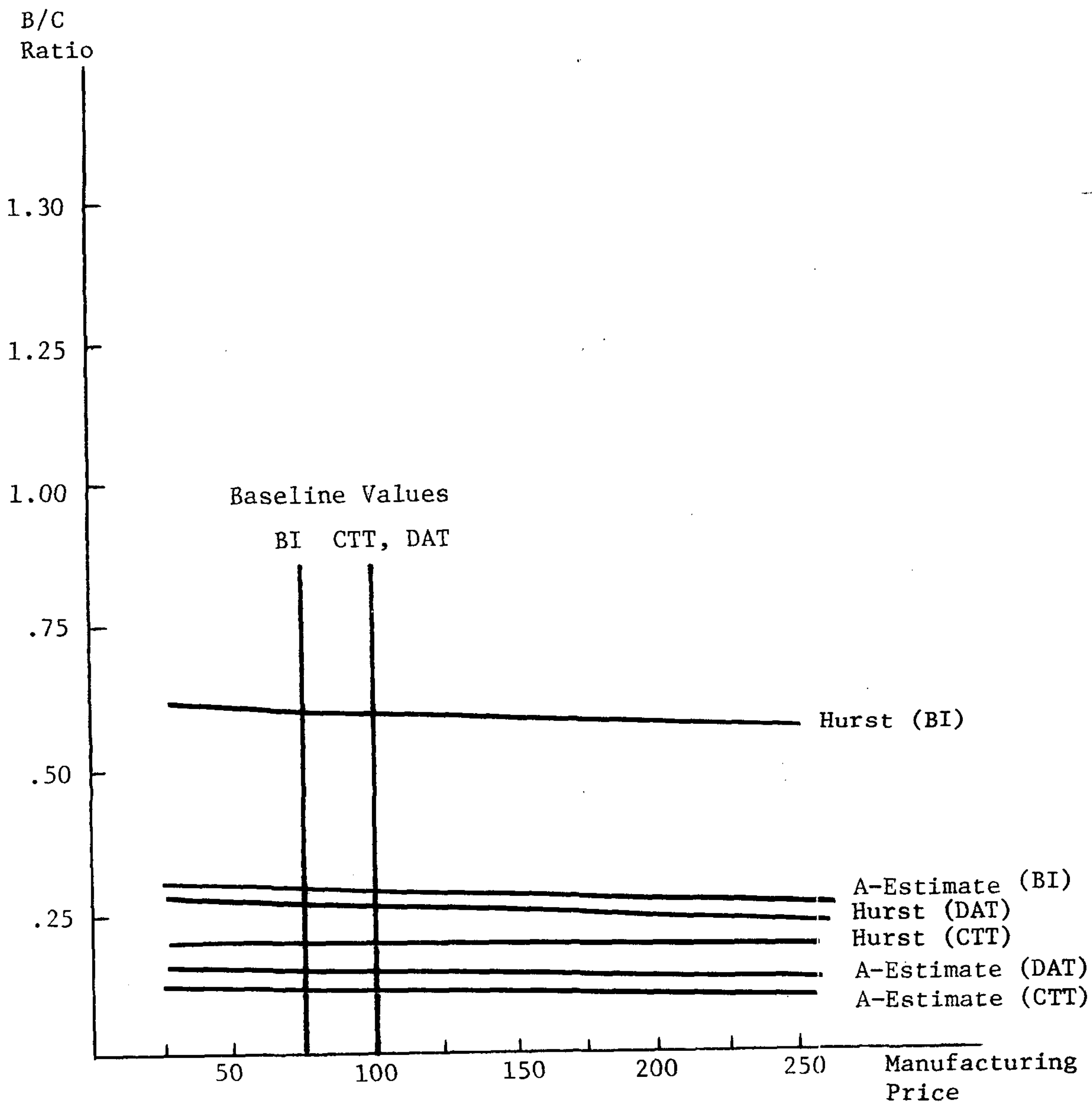

Fig. 32—Relationship Between Manufacturing Price and B/C Ratio - Alcohol Safety Interlock Systems (Restricted Use)

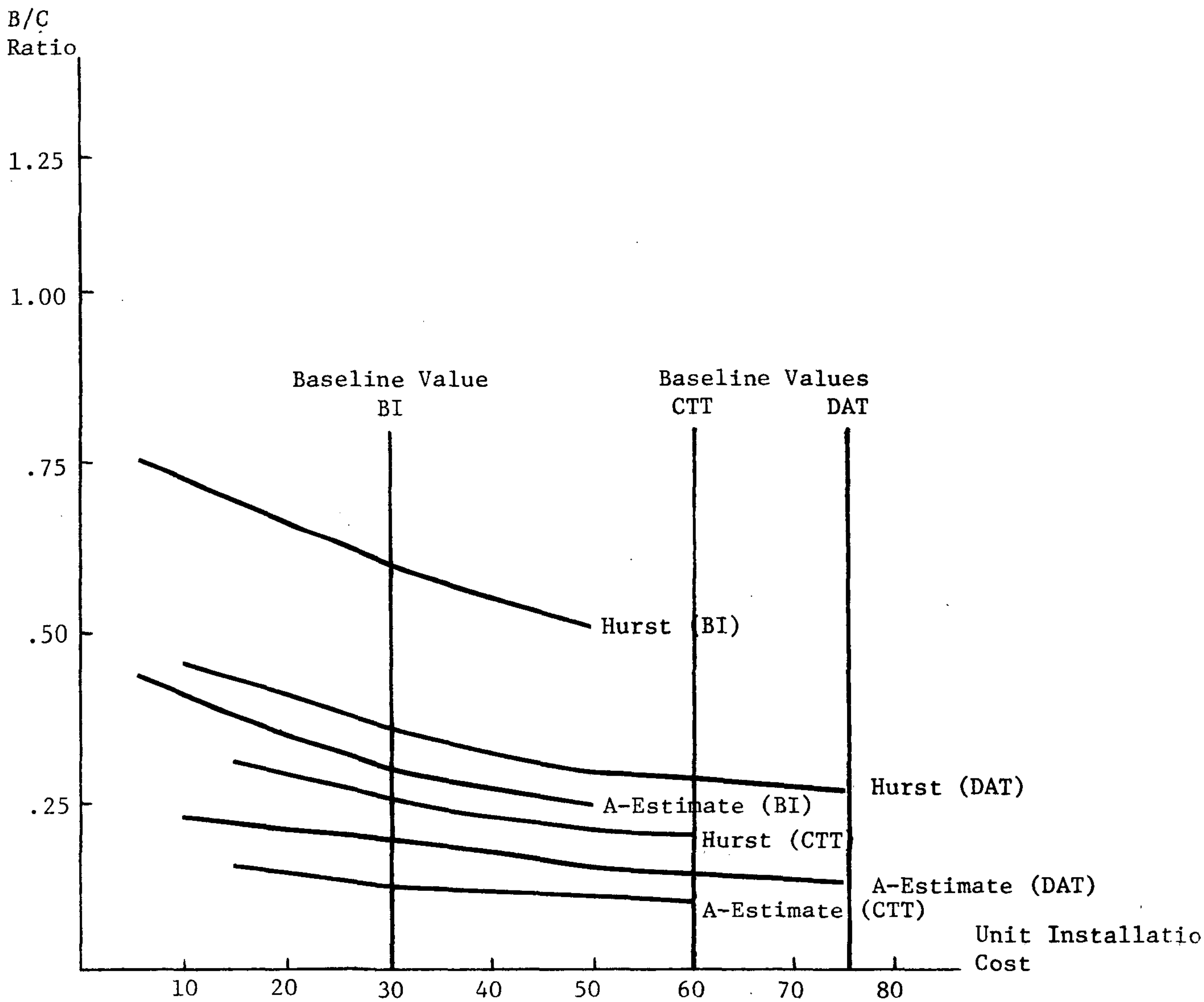

Fig. 33—Relationship Between Unit Installation Cost and B/C Ratio - Alcohol Safety Interlock Systems (Restricted Use)

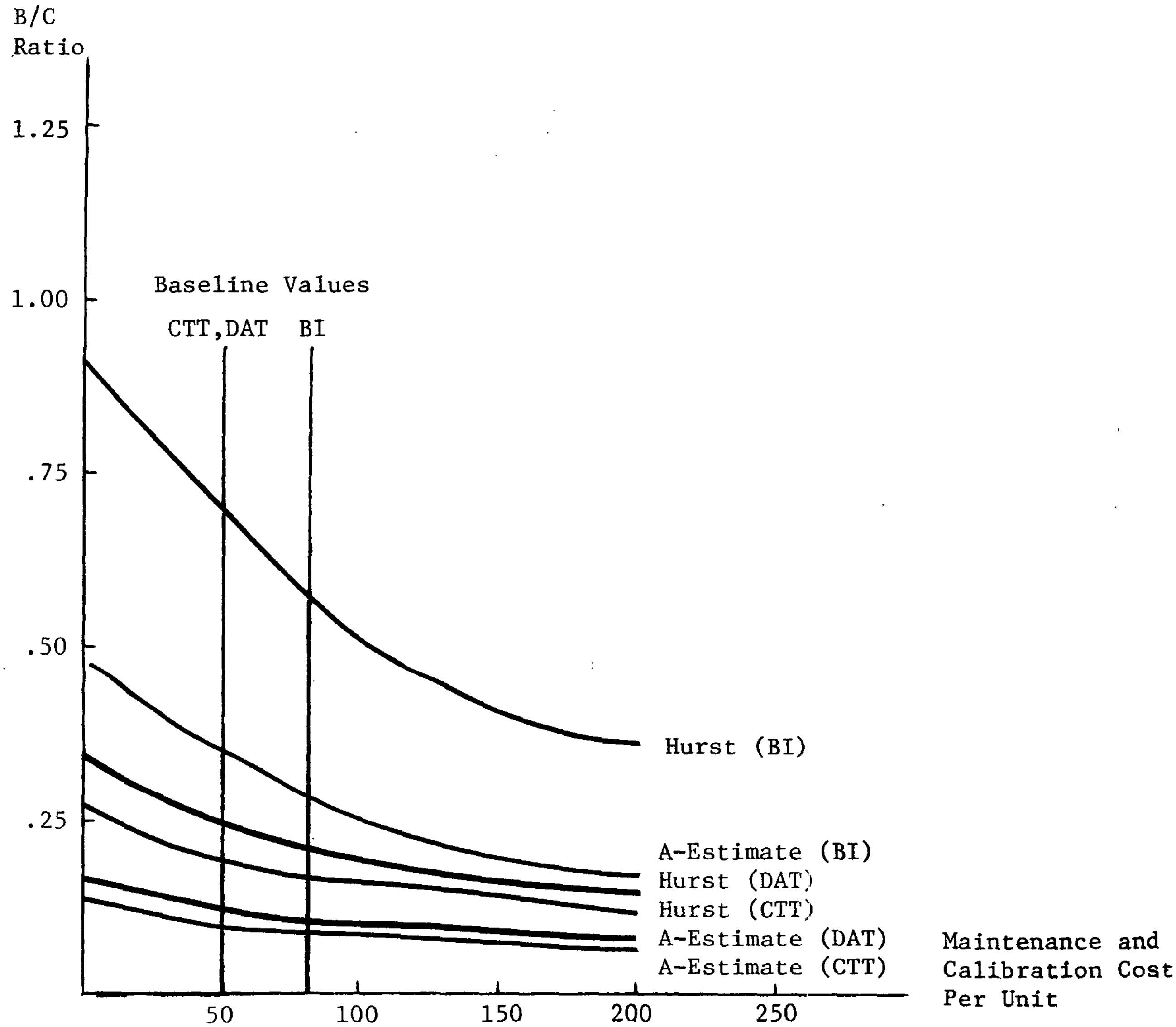

Fig. 34—Relationship Between Maintenance and Calibration Cost Per Unit and B/C Ratio - Alcohol Safety Interlock Systems (Restricted Use)

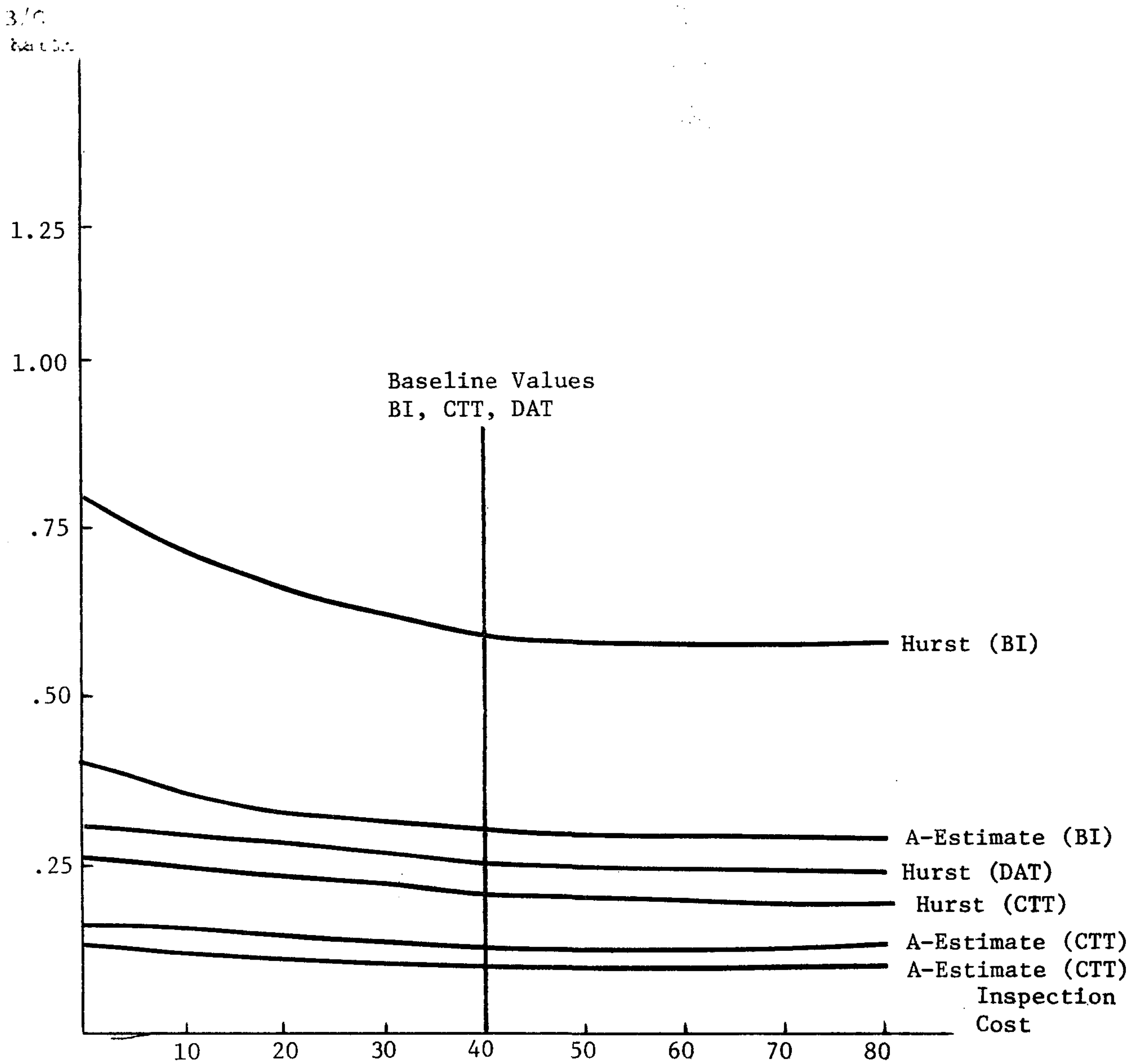

Fig. 35—Relationship Between Inspection Cost Per Unit and B/C - Alcohol Safety Interlock Systems (Restricted Use)

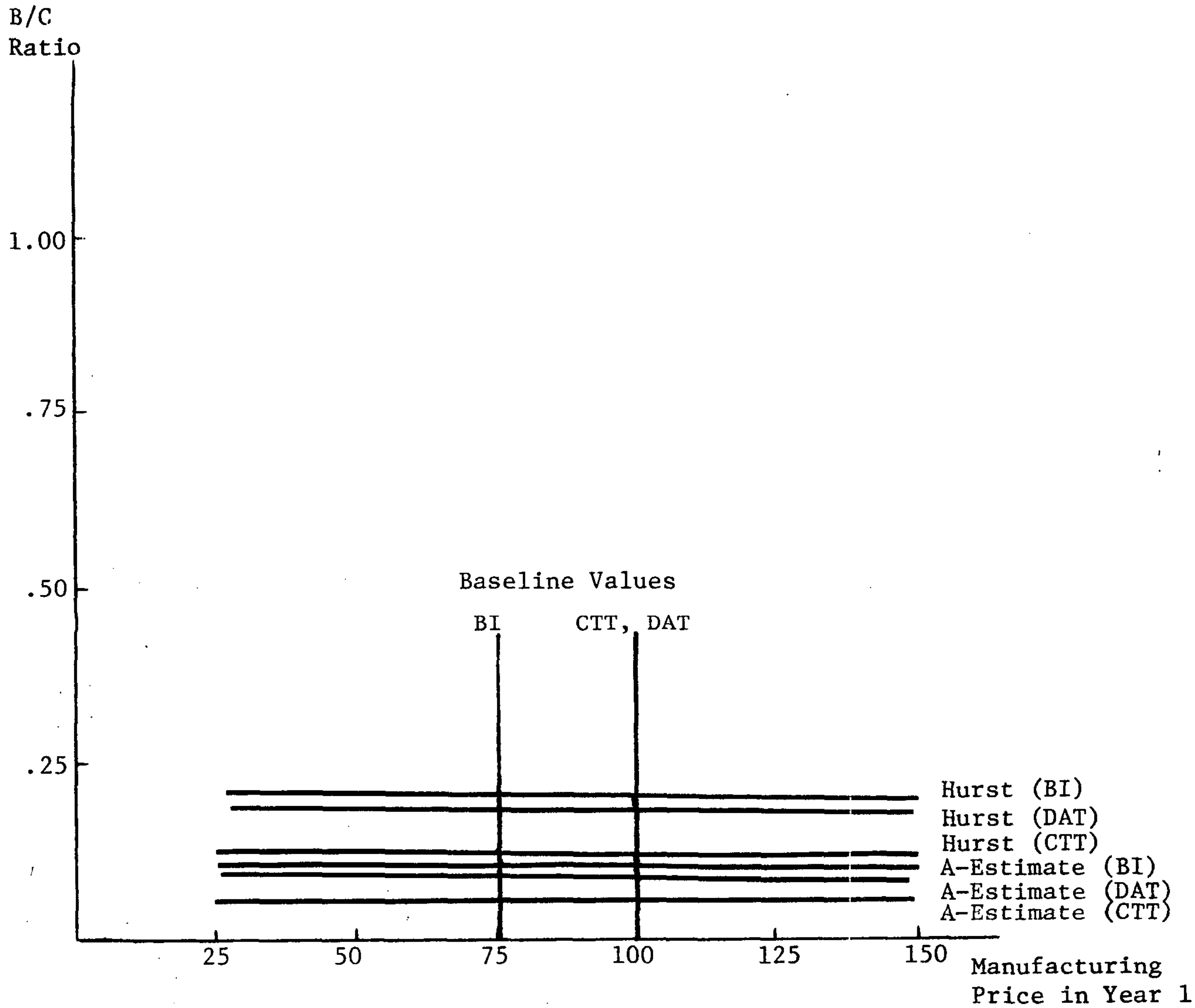

Fig. 36—Relationship Between Price in Year 1 and B/C Ratio - Alcohol Safety Interlock Systems (Universal Application)

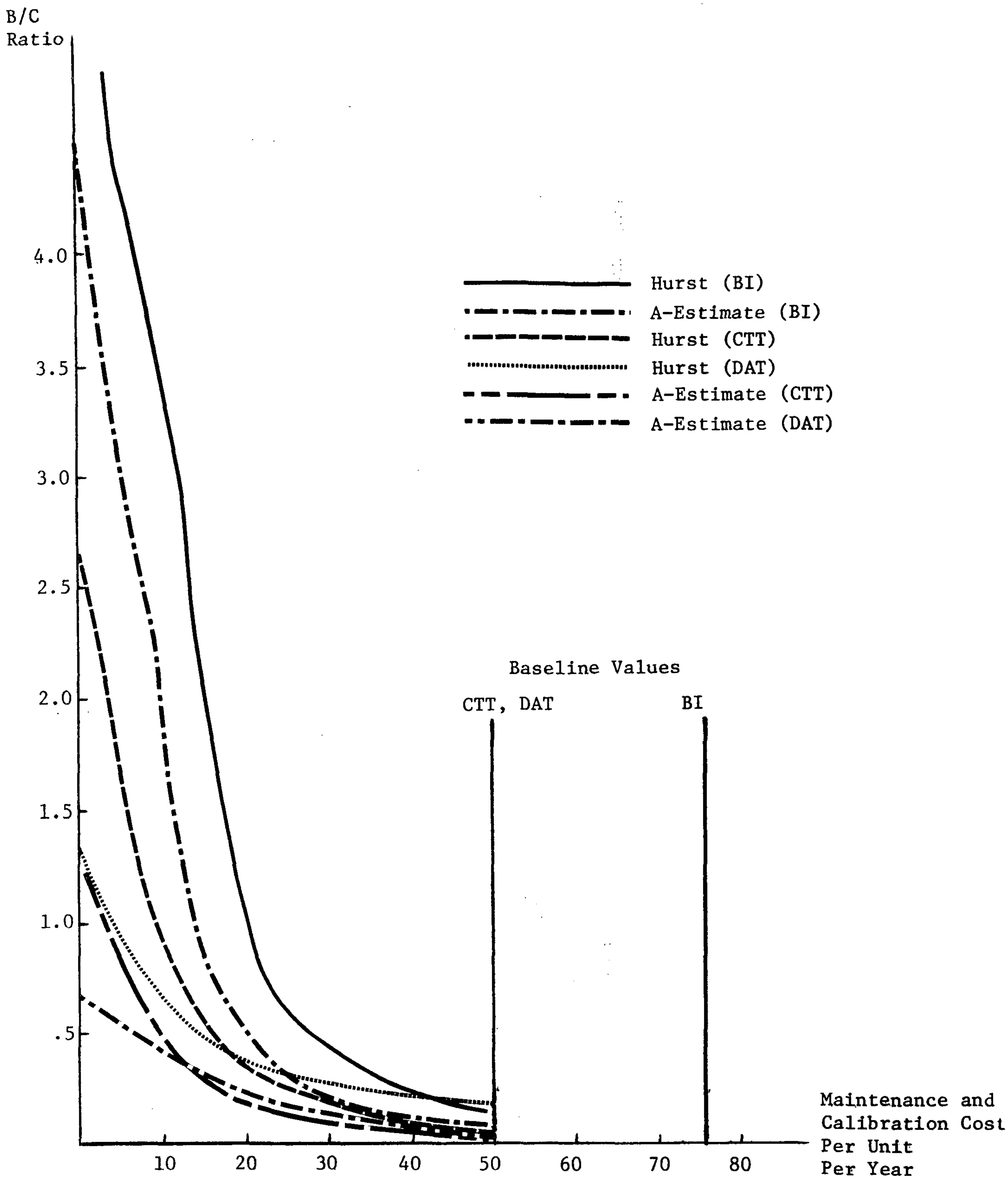

Fig. 37—Relationship Between Maintenance and Calibration Cost Per Unit Per Year - Alcohol Safety Interlock Systems (Universal Application)

1. The range of values for the benefit/cost ratios were:

   (a) Breath Interlock: .18 - 1.70

   (b) Critical Tracking Tester: .10 - 3.00

   (c) Divided Attention Tester - .13 - 1.13

2. In all cases, the Hurst estimates produced B/C ratios about twice as large as the A-Estimates.

3. In all instances, both using the Hurst estimates and the A-Estimates where only a single parameter was varied from the baseline case, the B/C ratio was less than one.

4. Economic feasibility was obtainable when two or more parameters were varied.

5. In general, the Breath Interlock system had the highest B/C ratio, the CTT was next, and the DAT had the lowest B/C ratio.

6. The Breath Interlock system had the highest ratios because it had the most favorable balance between false negatives (malfunction rate) and false positives (effectiveness rate).

7. The critical cost elements in each case were maintenance and calibration, installation, removal and inspection.

8. Manufacturing cost was not significant for the baseline case because of the dominance of maintenance and calibration costs, installation and removal costs, and inspection costs.

9. The B/C ratios were not sensitive to changes in the number of units in service per year when the number of units exceeded 100,000.

10. The B/C ratios were sensitive to changes in installation and removal costs for the Breath Interlock and the DAT, but were less sensitive for the CTT.

11. The B/C ratios were sensitive to changes in the maintenance and calibration cost.

12. The B/C ratios were only slightly sensitive to changes in the inspection cost per unit.

13. Research and development costs and public information costs at 100,000 units or more were insignificant compared to the remaining costs.

14. When the assumption of higher effectiveness rates for the CTT and DAT was applied the B/C ratios did not increase significantly because a parallel assumption was made that the malfunction rate would increase and this had a partial offset effect against the increase in effectiveness.

The findings for the interlock devices under the assumption of universal application may be summarized as follows:

1. The range of values for the benefit/cost ratios were:

   (a) Breath Interlock: .09 - 12.76

   (b) Critical Tracking Tester: .06 - 22.52

   (c) Divided Attention Tester: .09 - 1.77

2. In all cases the Hurst estimates produced B/C ratios about twice as large as the A-Estimates.

3. Maintenance and calibration cost was the determining factor in each case. In the baseline case, it accounted for the following percentages of total systems cost:

   (a) Breath Interlock: 97.5 percent

   (b) Critical Tracking Tester: 95 percent

   (c) Divided Attention Tester: 86 percent

4. Also, the B/C ratios were highly sensitive to changes in the annual maintenance and calibration costs in the range of economic feasibility. An annual cost of $10 or more resulted in a rate below unity for the DAT, and annual costs of $20 resulted in infeasibility for the Breath Interlock and the CTT.

5. The ratios were not sensitive to changes in manufacturing price due to the domineering influence of the maintenance and calibration cost in the baseline case.

6. Malfunction cost was significant for the DAT, accounting for 10 percent of total system cost.

CONTINUOUS MONITORING DEVICE

DESCRIPTION AND PERFORMANCE CHARACTERISTICS

The purpose of the continuous monitoring device is to assess the steering reversal rates of the driver during the operation of the vehicle. Upon the failure of the driver to maintain a previously established criterion level, an interior or exterior warning device would be sounded to alert the driver and/or the law enforcement officers of the reduction of the driver's safe performance. Figure 38 presents a causal chain diagram illustrating how the continuous monitoring device would operate to reduce accidents.

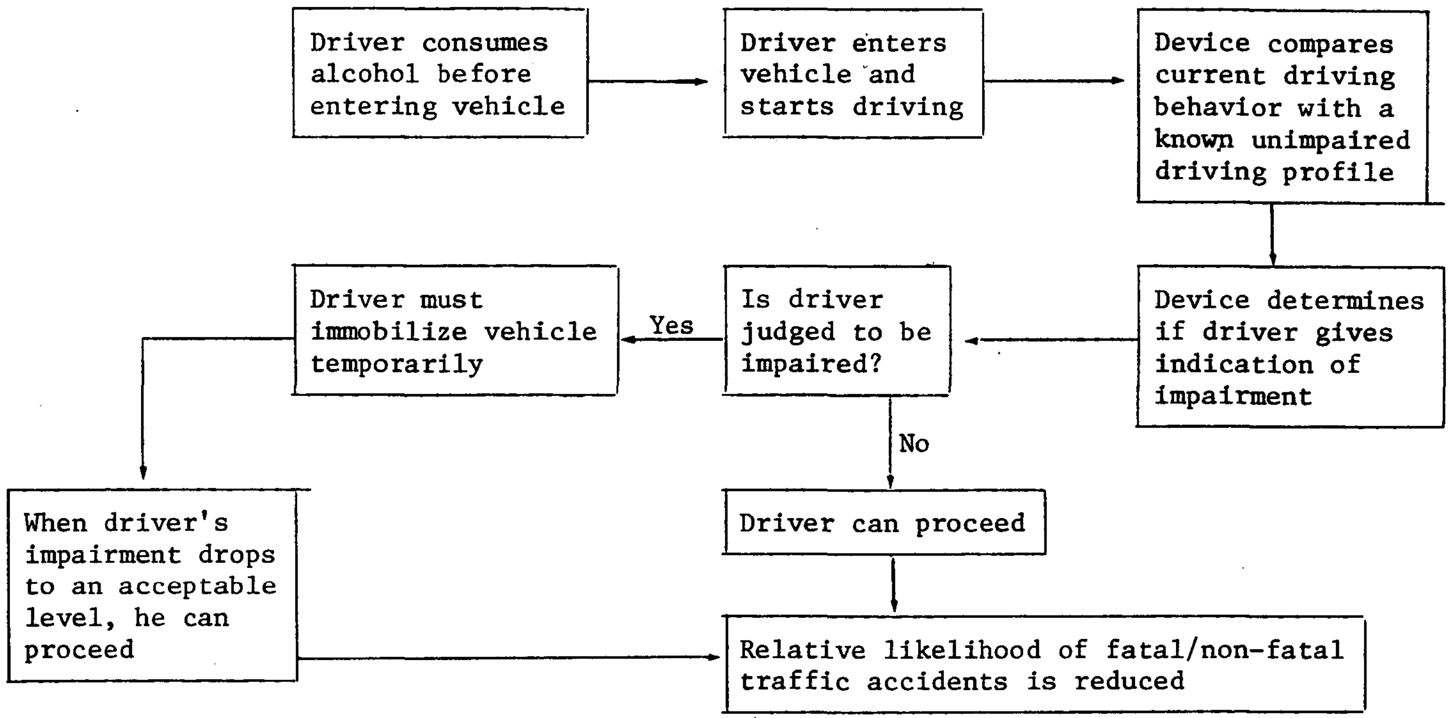

Fig. 38—Causal Chain for Continuous Monitoring Device

In a study to test for alcohol impairment of performance on steering control tasks, it was found that for the continuous task, the lane deviations of the car increase under alcohol. It stated in its results:[19]

"The driver's steering actions seem to be less responsive with longer periods of constant wheel position under alcohol, although wheel motion does roughly correspond to the input disturbance as it should for regulation against disturbance."

"Lane deviations increase with BAC level,which is explained by measures of lower driver control gain and increased remnant. Distraction of the sign response task further increased the impairment of path control by alcohol. These effects are consistent with increased indifference thresholds and/or control intermittency and significantly increase the probability of lane exceedances."

It appears that while there presently is no device on the commerical market which would monitor alcohol impairment, it would be technically feasible to develop such an instrument. There is in existance a monitoring device that is being manufactured and distributed by the Lear-Siegler Company in Oklahoma City, Oklahoma,known as the Owl System. It is designed for use in trucks engaged in long hauls to awaken a truck driver if he should become drowsey or fall asleep at the wheel. A bell or buzzer is activated when the driver's normal steering performance falls below its established criteria. Officials from the Lear-Siegler Company have indicated that it would not be difficult to restructure this device for use in an alcohol and driving program.

A potential problem with the continuous monitor is the requirement that each device would have to apply a separate performance criteria for each driver. This would involve a costly series of tests since the performance criteria involves a learning curve that will vary until the driver has reached his full learning capacity.

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[19] Jex, H.R., Allen, R.W., Dimarco, R.J., and McRuen, D.T., Alcohol Impairment of Performance on Steering and Discrete Tasks in a Driving Simulation, US Department of Transportation, National Highway Traffic Safety Administration, Washington, D. C., December, 1974.

Another potential problem would occur when other persons used the vehicle. Since the criterion threshold is established for the convicted drinking driver, any other driver who may have a different threshold may trigger the warning device during his normal driving operations.

Some consideration must be given to the manner in which the warning is to be given, and its effects upon the driver and general population. An interior warning, which startles the driver, may have some adverse effect upon his immediate driving. An exterior warning, which is designed to alert the police of improper driving, may create some confusion or hazard to other drivers on the roadway. The use of a "cutoff" of the operation of the vehicle, either through a mechanical device or by the driver, can place the vehicle in a dangerous condition on the highway.

This device may have potential as an alcohol interlock system. While the interlocks may prevent a person from starting his vehicle while over a certain BAC or under a certain performance level, it will not be effective when the driver's performance deteriorates after the car is in operation. The continuous monitoring device would measure the driver's performance level during the period of operation and as a result, would be a potentially effective countermeasure.

BENEFIT/COST MODEL

Assumptions

1. It is assumed that the continuous monitor would be for sale as a separate unit to be installed on any passenger vehicle by 1 July 1976.

2. The continuous monitor would be installed on a restricted basis by court order following a DWI arrest and conviction.

3. It was assumed that the average number of continuous monitoring devices in use per year would be equal to the following values: 100,000 200,000 and 360,000 units.

4. It was assumed that the continuous monitor would have the following effectiveness rates for BAC = .10-.14 and BAC = .15+; .75 and .95, .3 and .7, .6 and .9, and .9 and 1.0. The effectiveness rate is defined as the percentage of illegal BAC trips affected by the use of the device.

5. It was assumed that the unit manufacturing price would have the following values: \$50, \$100, \$200 and \$300.

6. It was assumed that the unit installation cost would have the following values: \$10, \$20 and \$30.

7. It was assumed that each device would be installed and removed an average of once per year.

8. It was assumed that the average maintenance and calibration cost per unit per year could have the following values: 0, \$10 and \$20.

9. It was assumed that the average inspection cost per unit per year could have the following values:

10. It was assumed that 500 testing equipment stations would be required to provide installation, removal, maintenance, calibration and inspection services, and that the equipment would cost \$50 per station.

Model Equations

The benefit/cost model for the continuous monitor are given as follows:

$$B/C_i = \frac{\text{Average Annual Savings in Societal Costs (SSC)}_i}{\text{Average Annual Costs (TC)}} \qquad i = 1,2$$

where

$$SSC_1 = CR \left[F_1\ (200{,}000) + P_1\ (7{,}200) + (300)\right]$$
$$SSC_2 = CR \left[F_2\ (200{,}000) + P_2\ (7{,}200) + (300)\right]$$

and

SSC_1, SSC_2, F_1, F_2, P_1 and P_2 are the same as defined previously.

$$CR = \frac{N}{L}\left[(A_1)(C_5)\left[\frac{R_5 - R_4}{R_5}\right] + (A_2)(C_6)\left[\frac{R_6 - R_4}{R_6}\right]\right]$$

where

CR is the average savings in crashes per year

N is the average number of devices in service per year

L is the number of licensed drivers

A_1 is the effectiveness rate at BAC = .10-.14

A_2 is the effectiveness rate at BAC = .15+

C_5 and C_6 are annual crashes (see Table 6)

R_4, R_5 and R_6 are relative probabilities (see Table 7)

TC (Average Annual Total Cost) = Research and Development Cost (RD)
+ Manufacturing Costs (MN)
+ Installation Costs (IC)
+ Maintenance and Calibration Costs (MT)
+ Inspection Costs (IN)
+ Testing Equipment (TE)
+ Removal Cost (RC)

$RD = .16275\ RD_T$

$MN = .16275\ (K)(N)$

$IC = (KIC)(ATI)(N)$

$MT = (KT)(N)$

$IN = (KN)(N)$

$TE = .16275\ (KTE)(NTE)$

$RC = (KRC)(ATR)(N)$

where

.16275 is the amortization factor for determining the average annual cost over 10 years discounted at 10 percent.

RD_T is the total research and development cost

K is the unit price of the continuous monitoring device

KIC is the unit installation cost

ATI is the average number of time each device is installed per year

KT is the annual maintenance and calibration cost

KN is the inspection cost per unit per year

KTE is the unit cost of the testing equipment

NTE is the annual number of testing equipment stations

KRC is the unit removal cost

ATR is the average number of times each device is removed each year

SUMMARY OF FINDINGS - BASELINE CASE AND SENSITIVITY ANALYSES

Table 23 summarizes the findings for the continuous monitoring device, and Figs. 39, 40, 41, 42, and 43 present graphical rélationships between key variables and the benefit/cost ratios. The findings for the continuous monitoring device may be summarized as follows:

1. The range of values for the benefit/cost ratios were: .21 - 4.22
2. In all cases the Hurst estimates produced B/C ratios about twice

Table 23

CONTINUOUS MONITORING DEVICE

	Baseline Case	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Most Favorable	Least Favorable
Input Data																	
Number of units installed	360,000	100,000	200,000														
Effectiveness BAC = .10-.14	.75			.3	.6	.9										.9	.3
Effectiveness BAC = .15+	.95			.70	.90	1.0										1.0	.7
Research and development cost	500,000																
Manufacturing price per unit	300						50	100	200							50	200
Installation cost per unit	20									10	30					10	30
Average number of times installed	1.0																
Maintenance and calibration cost	10											0	20			0	20
Inspection cost per unit	20													0	10	0	20
Unit cost of testing equipment	50																
Number of testing equipment stations	500																
Removal cost	10									5	15					5	15
Average number of times removed	1.0																
Annual Savings																	
Savings in crashes	3,327.5	924.3	1,848.6	2,045.7	2,974.7	3,680.4										3,680.4	2,045.7
Savings in fatalities (average)	25.5	7.08	14.17	15.68	22.80	28.20										28.20	15.68
Savings in fatalities (Hurst)	50.6	14.06	28.1	31.1	45.24	55.97										55.97	31.1
Savings in personal injuries (average)	1,389.6	386	772	854.3	1,242.3	1,536.97										1,536.97	854.3
Savings in personal injuries (Hurst)	2,912.3	809.0	1,618.0	1,790.4	2,603.5	3,221.17										3,221.17	1,890.4
Savings in societal costs (average)	16,099,937	4,472,204	8,944,409	9,898,013	14,392,932	17,807,425										17,807,425	9,898,013
Savings in societal costs (Hurst)	32,082,443	8,911,789	17,823,579	19,723,832	28,680,884	35,484,965										35,484,965	19,723,832
Annual Costs																	
Research and development (.002)	81,375																
Manufacturing (.45)	17,577,000	4,882,500	9,765,000				2,929,500	5,859,000	11,718,000							2,929,500	17,573,000
Installation (.18)	7,200,000	2,000,000	4,000,000							3,600,000	10,800,000					3,600,000	10,800,000
Maintenance and calibration (.09)	3,600,000	1,000,000	2,000,000									0	7,200,000			0	7,200,000
Inspection (.18)	7,200,000	2,000,000	4,000,000											0	3,600,000	0	7,200,000
Testing equipment	4,068																
Removal (.09)	3,600,000	1,000,000	2,000,000							1,800,000	5,400,000					1,800,000	5,400,000
Total annual cost	39,262,443	10,967,943	21,850,443				24,614,943	27,544,443	33,403,443	33,862,443	44,662,443	35,662,443	42,862,443	32,062,443	35,662,443	8,410,875	48,258,443
B/C (average)	.41	.41	.41	.25	.37	.45	.65	.68	.48	.48	.36	.45	.38	.50	.45	2.12	.21
B/C (Hurst)	.82	.81	.82	.50	.74	.90	1.30	1.16	.96	.95	.72	.90	.75	1.00	.90	4.22	.41
Crash/Cost	.000085	.000084	.000085	.000052	.000076	.000094	.000135	.000121	.000100	.000099	.000075	.000093	.000078	.000104	.000093	.000437	.000042
	85/Mil	84/Mil	85/Mil	52/Mil	76/Mil	94/Mil	135/Mil	121/Mil	100/Mil	99/Mil	75/Mil	93/Mil	78/Mil	104/Mil	93/Mil	437/Mil	42/Mil

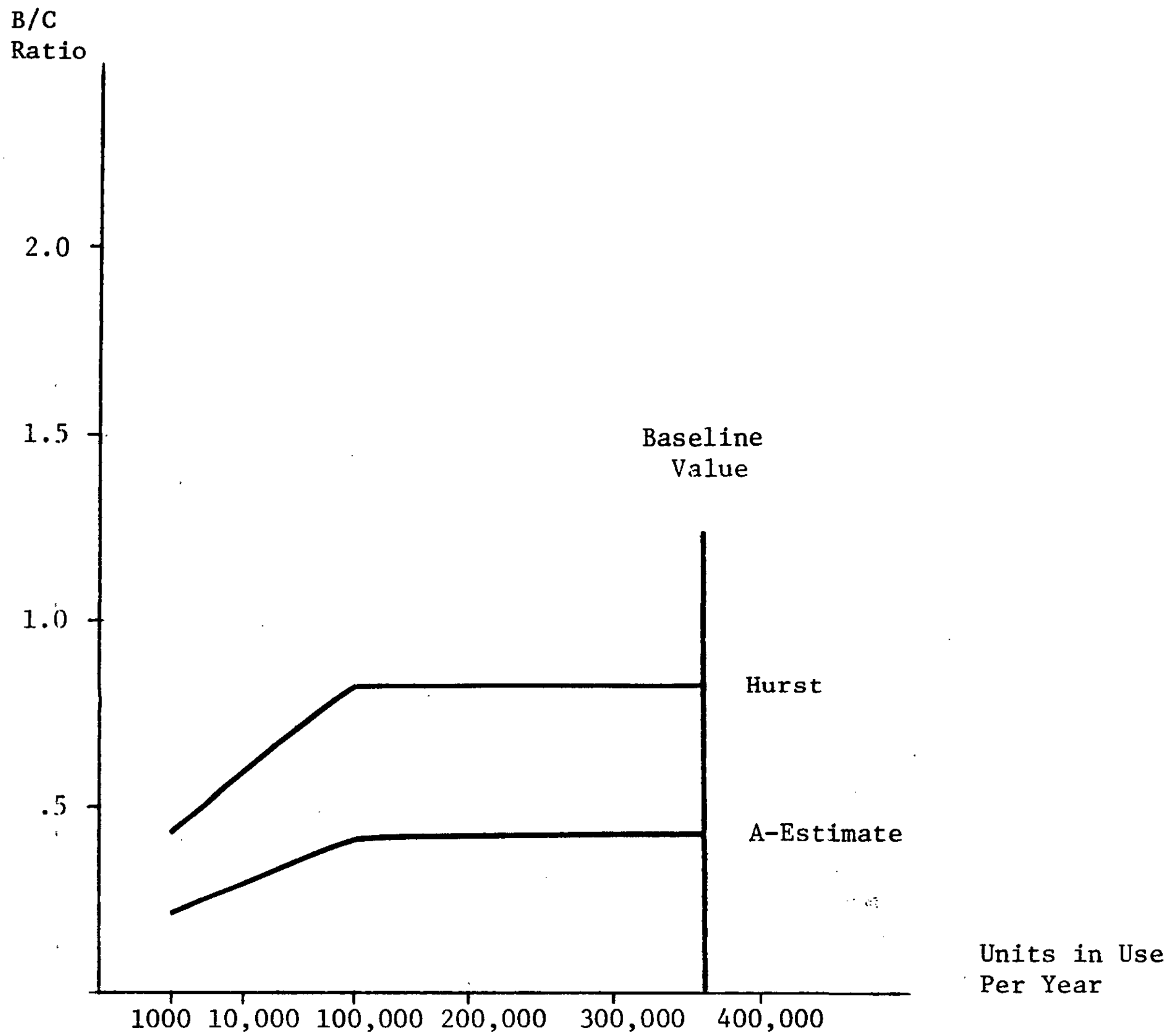

Fig. 39—Relationship Between Units in Use Per Year and B/C Ratio - Continuous Monitoring Device

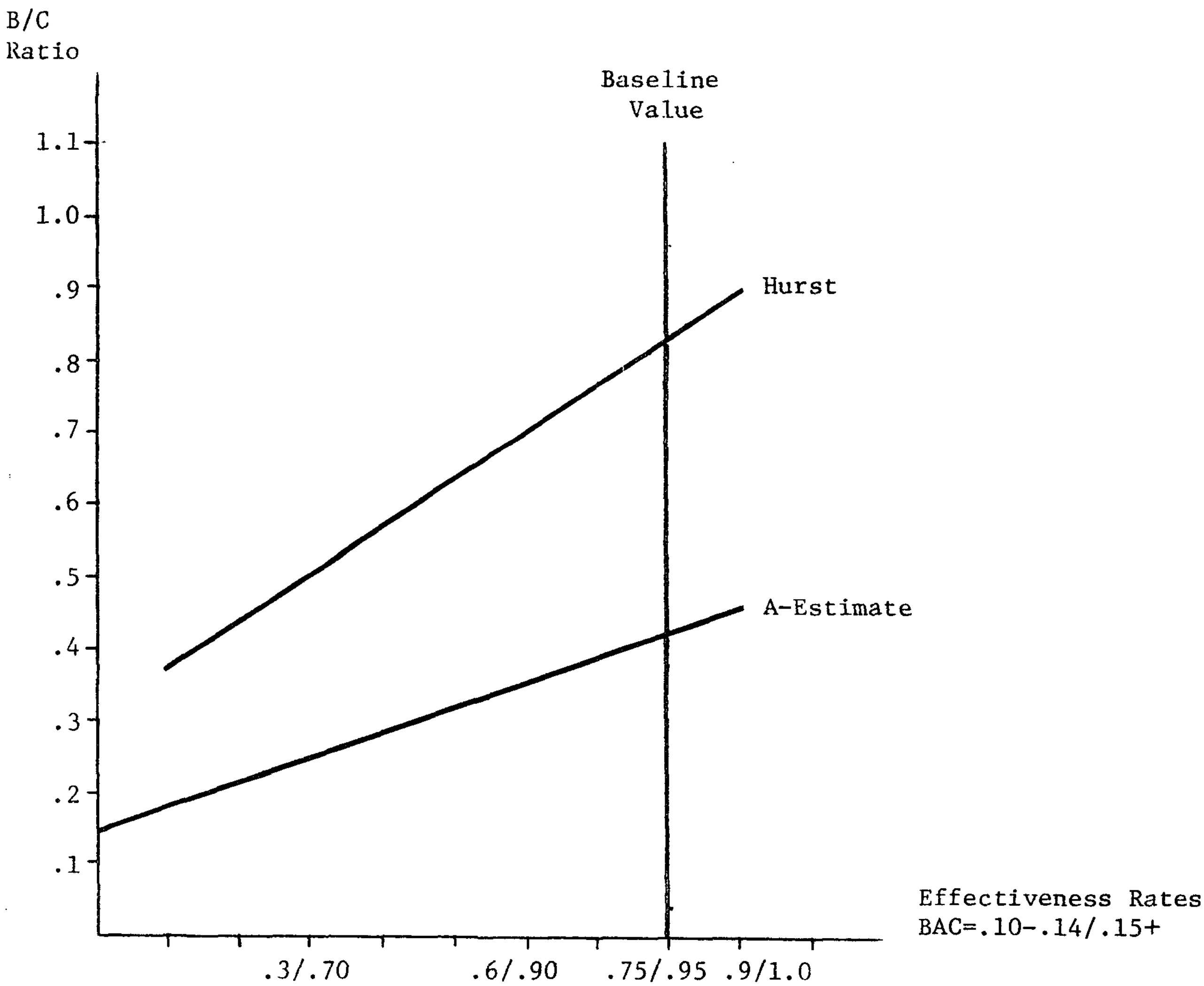

Fig. 40—Relationship Between Effectiveness Rates and B/C Ratio - Continuous Monitoring Device

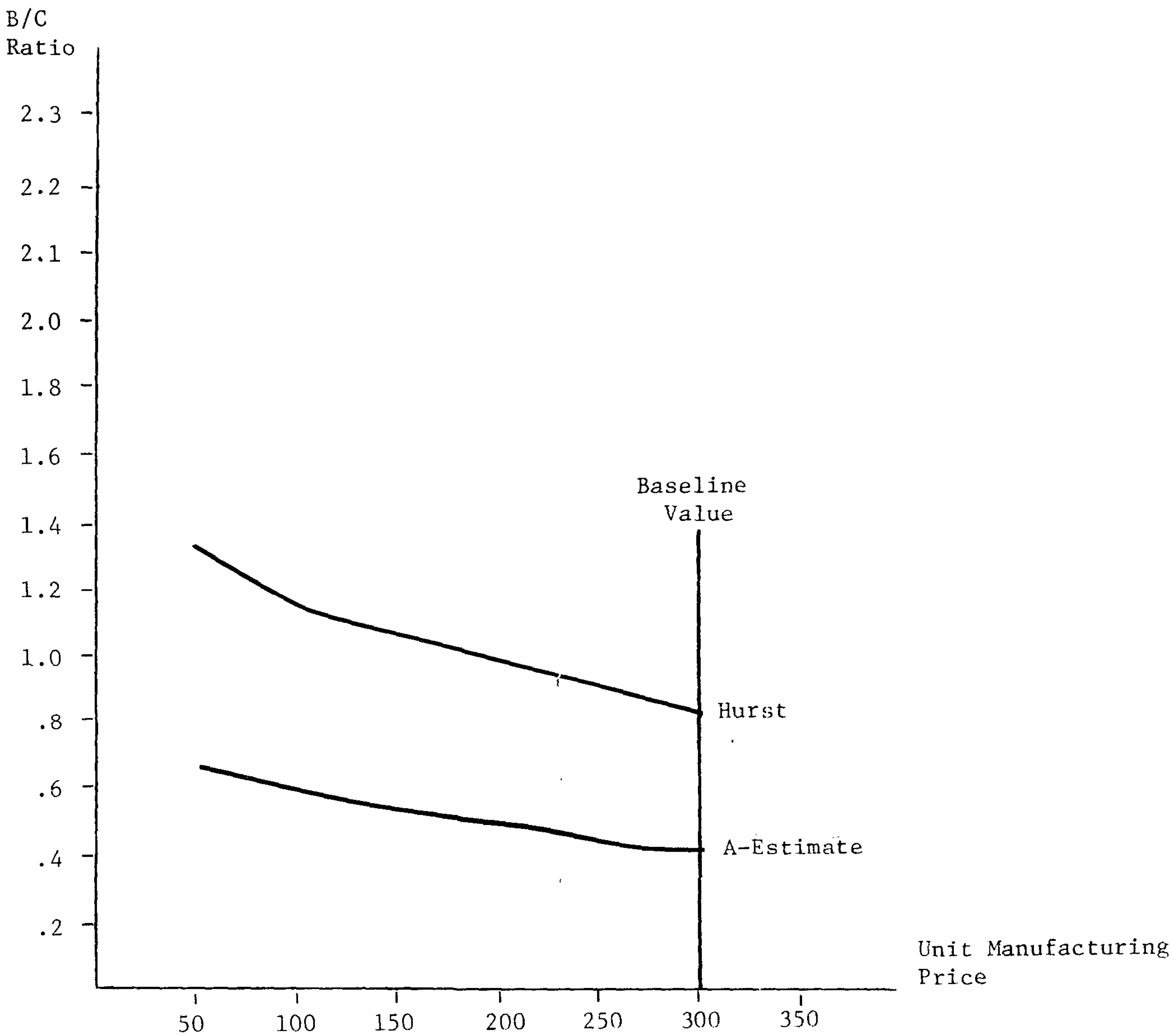

Fig. 41—Relationship Between Unit Manufacturing Price and B/C Ratio - Continuous Monitoring Device

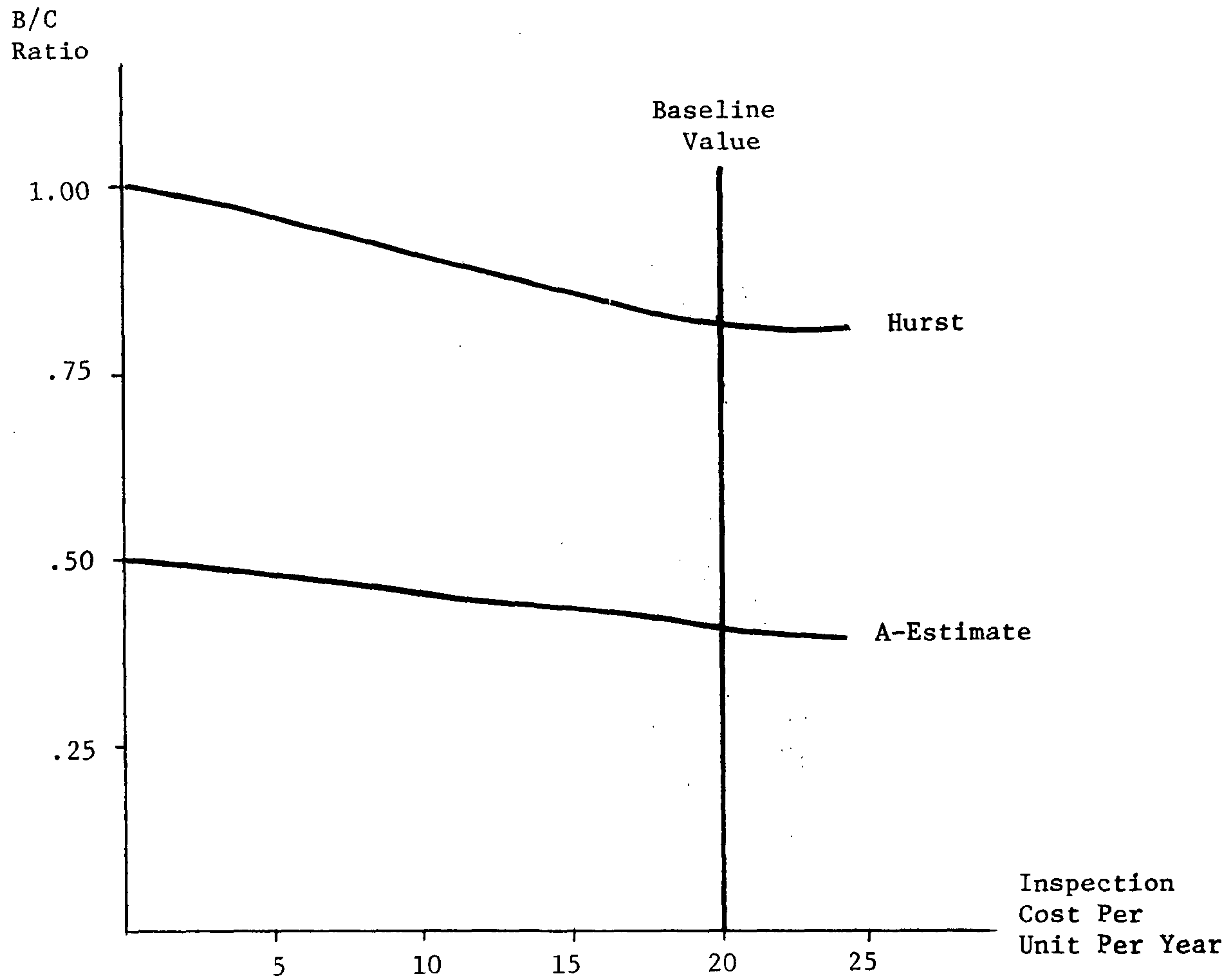

Fig. 42—Relationship Between Inspection Cost Per Unit Per Year and B/C Ratio - Continuous Monitoring Device

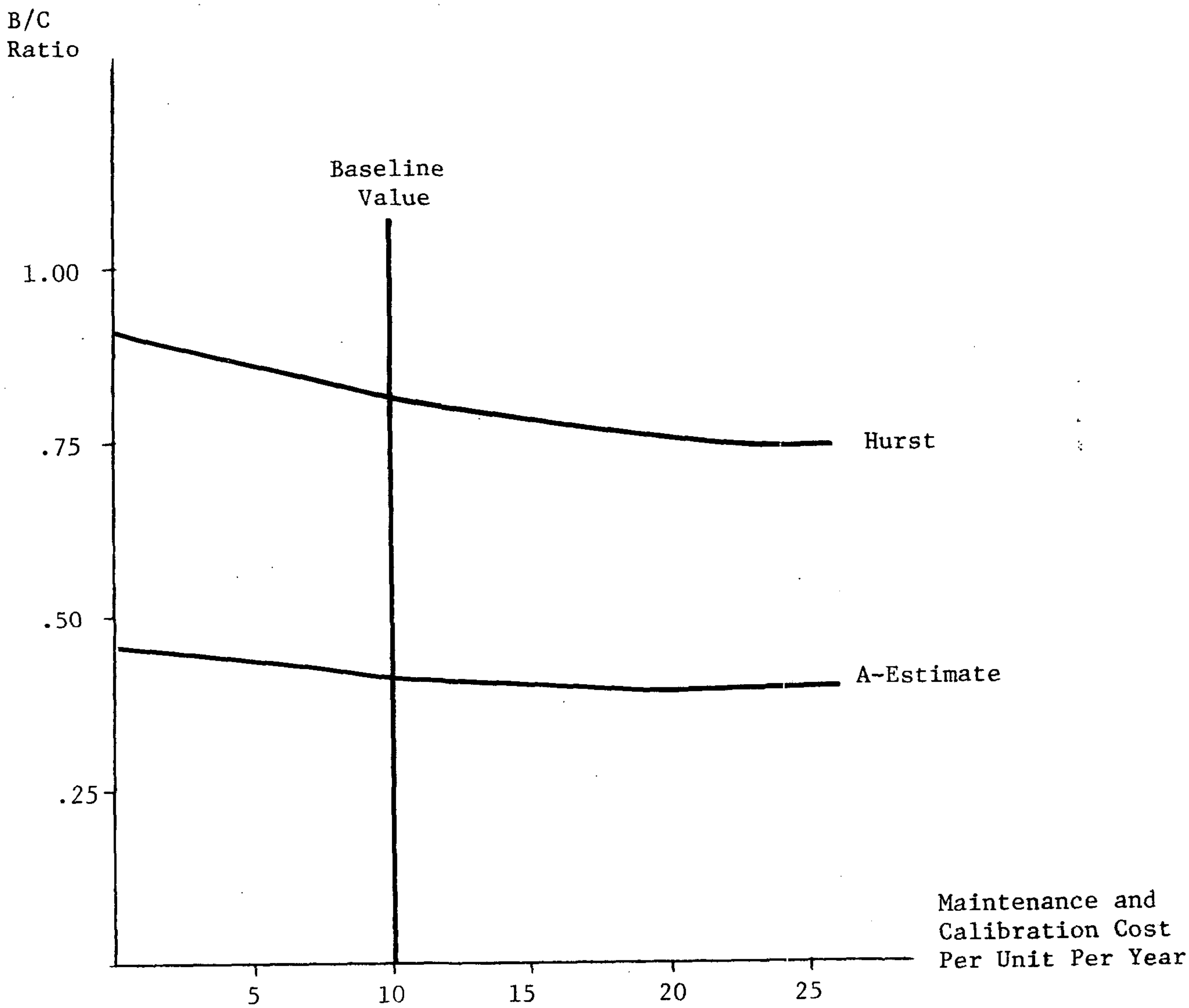

Fig. 43—Relationship Between Maintenance and Calibration Cost Per Year and B/C Ratio - Continuous Monitoring Device

as large as the A-Estimates.

3. In general, the ratios were less than unity, but when two or more parameters were varied simultaneously, it was possible to achieve economic feasibility.

4. The B/C ratios were not sensitive to the number of units in service per year when the number exceeded 100,000.

5. The B/C ratios were sensitive to changes in the effectiveness ratio. However, under the baseline assumptions, it was not possible to achieve economic feasibility even with 100 percent effectiveness rates.

6. The B/C ratios were sensitive to the manufacturing price. Economic feasibility was achievable using the Hurst estimates when the manufacturing price was equal to $100.

7. The B/C ratios were slightly sensitive to changes in the inspection cost per unit per year.

8. The B/C ratios were only slightly sensitive to maintenance and calibration costs per unit per year.

9. Manufacturing cost represented the most significant cost element for the baseline case, 45 percent of total system cost.

10. Research and development costs, testing equipment cost, and maintenance and calibration costs were not significant when 10,000 or more units were in service per year.

OPERATING TIME RECORDER

DESCRIPTION AND PERFORMANCE CHARACTERISTICS

The operating time recorder is a device designed to prevent a convicted DWI from driving during certain hours of the day when the likelihood of an alcohol related crash is highest. One of the major countermeasures in an alcohol program is the ability of a judge to issue a limited drivers license to a convicted DWI which would allow the person to drive during certain specified hours. The license is usually issued if the person cooperates with the court and alcohol rehabilitation programs. A major impediment in this program has been the reluctance of judges to issue such licenses (or the legislatures to enact laws which would enable the court or Department of Motor Vehicles to issue such licenses) because of the inability to monitor driving during the restricted hours.

This device can be utilized in two fashions. The first system, which is relatively simple, would be to develop a time-recorder which would be designed to record an instance when the car is being driven during the restricted or unlawful time. While this would require a certain number of inspections to determine any unlawful operation, the knowledge of such a recording, in most instances, will discourage driving during those hours. The second system, which would be more complicated but technically feasible, would be to attach an interlock to the vehicle which would prevent the vehicle from being driven during the restricted hours. The second system is a countermeasure combination and has been evaluated separately.

Figure 44 presents a causal chain diagram illustrating how the operation time recorder would reduce accidents.

BENEFIT/COST MODEL

Assumptions

1. It is assumed that the operating time recorder would be available for sale as a separate unit to be installed on any passenger vehicle by 1 July 1976.

2. The operating time recorder would be installed on a restricted basis by court order following a DWI arrest and conviction.

3. It was assumed that the average number of operating time recorders in use per year would be equal to the following values: 100,000, 200,000 and 360,000 units.

4. It was assumed that the operating time recorder would have the following effectiveness rates: .90, .50, and .75.

5. It was assumed that the percentage of alcohol related crashes covered would have the following values: .70, .5, and .6. This parameter refers to the percentage of alcohol related accidents that occur during the restricted hours. For example, if 70 percent of the alcohol related accidents occur between the hours of 6:00 p.m. and 6:00 a.m. and the restricted driving time corresponds to these hours, then the appropriate value to use in the model is .7.

6. It was assumed that the unit manufacturing price would have the following values: $15, $25 and $30.

7. It was assumed that the unit installation cost would have the following values: $10, $15 and $20.

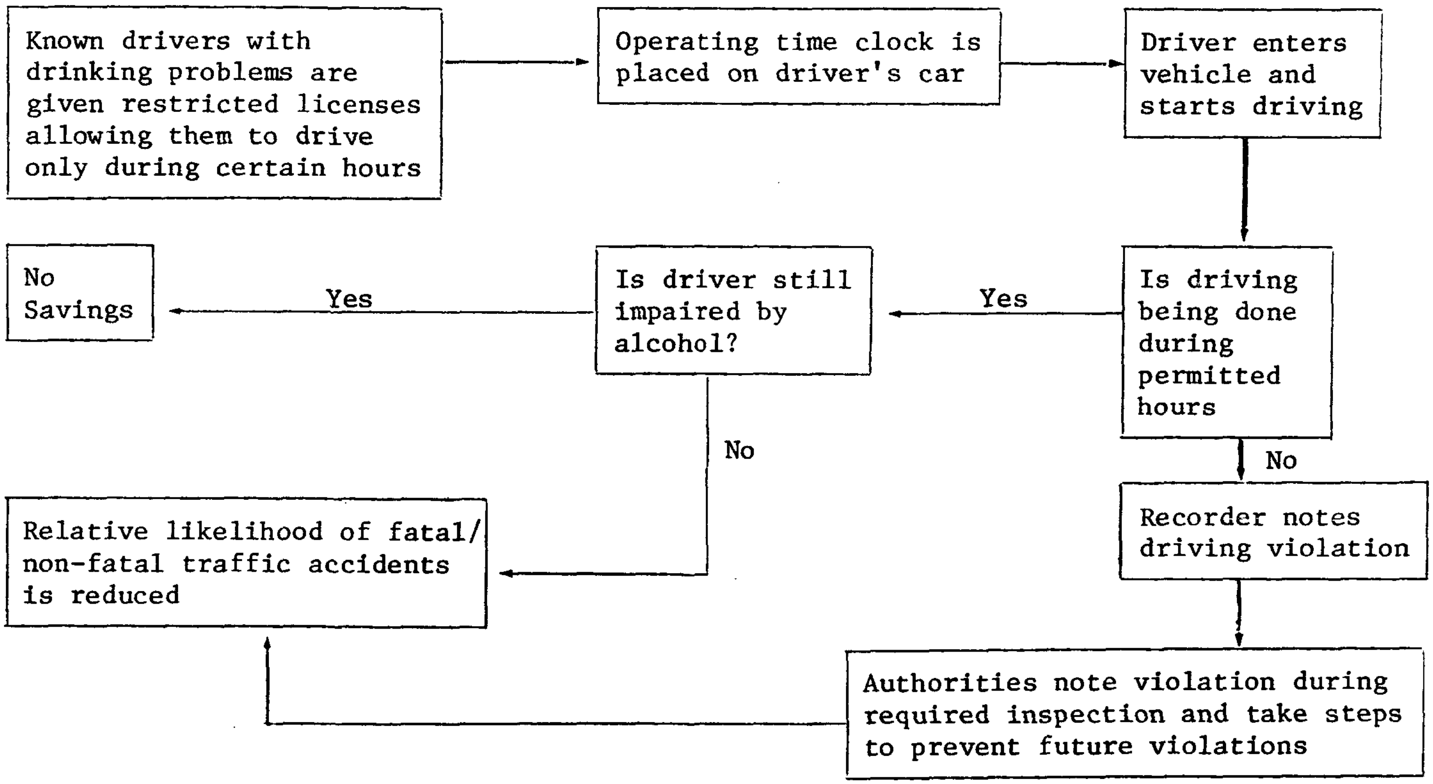

Fig. 44—Causal Chain for Operating Time Recorder

8. It was assumed that each device would be installed and removed an average of once per year.

9. It was assumed that the average maintenance and calibration cost per unit per year could have the following values: 0, $15 and $25.

10. It was assumed that the average inspection cost per unit per year could have the following values: 0, $10 and $20.

11. It was assumed that 500 testing equipment stations would be required to provide installation, removal, maintenance, calibration and inspection services, and that the equipment would cost $50 per station.

12. It was assumed that the removal cost would be equal to one-half the installation cost.

Model Equations

The benefit/cost model for the operating time record is given as follows:

$$B/C_i = \frac{\text{Average Annual Savings in Societal Costs (SSC)}_i}{\text{Average Annual Costs (TC)}} \qquad i = 1,2$$

where

$$SSC_1 = CR \left[F_1 \ (200{,}000) + P_1 \ (7{,}200) + (300)\right]$$
$$SSC_2 = CR \left[F_2 \ (200{,}000) + P_2 \ (7{,}200) + (300)\right]$$

and

SSC_1, SSC_2, F_1, F_2, P_1 and P_2 are the same as defined previously.

$$CR = \frac{(A)(P)(N)}{L} \left[C_3 \left[\frac{R_3 - R_1}{R_3}\right] + C_4 \left[\frac{R_4 - R_1}{R_4}\right] + C_5 \left[\frac{R_5 - R_1}{R_5}\right] + C_6 \left[\frac{R_6 - R_1}{R_6}\right]\right]$$

where

CR is the average savings in crashes per year

A is the effectiveness rate

P is the percent of alcohol related crashes covered

N is the average number of devices in use per year

L is the number of licensed drivers

C_3, C_4, C_5 and C_6 are annual crashes (see Table 6)

R_3, R_4, R_5 and R_6 are relative probabilities (see Table 7)

It is to be noted that the operating time clock is designed to prevent all trips with the vehicle during the restricted hours, and if the device is effective, crash savings will occur at the BAC = .05-.07 and BAC = .08-.09 levels in addition to the savings at the illegal BAC levels, e.g., above BAC = .10. This fact accounts for the appearance of C_3 and C_4 in the crash saving equation.

TC (Average Annual Total Cost) = Research and Development Cost (RD)
+ Manufacturing Cost (MN)
+ Installation Cost (IC)
+ Maintenance and Calibration Cost (MT)
+ Inspection Cost (IN)
+ Testing Equipment (TE)
+ Removal Cost (RC)

$RD = .16275\ RD_T$

MN = .16275 (K)(N)

IC = (KIC)(ATI)(N)

MT = (KT)(N)

IN = (KN)(N)

TE = .16275 (KTE)(NTE)

RC = (KRC)(ATR)(N)

where

.16275 is the amortization factor for determining the average annual cost over 10 years discounted at 10 percent.

RD_T is the total research and development cost

K is the unit price of the operating time recorder

KIC is the unit installation cost

ATI is the average number of times each device is installed per year

KT is the annual maintenance and calibration cost

KN is the inspection cost per unit per year

KTE is the unit cost of the testing equipment

NTE is the annual number of testing equipment stations

KRC is the unit removal cost

ATR is the average number of times each device is removed per year

SUMMARY OF FINDINGS - BASELINE CASE AND SENSITIVITY ANALYSES

Table 24 summarizes the findings for the operating time recorder, and Figs. 45, 46, 47, 48, 49 and 50 present graphical relationships between key variables and the benefit/cost ratios. The findings for the operating time recorder may be summarized as follows:

1. The range of values for the benefit/cost ratios were: .22 - 5.10

2. In all cases, the Hurst estimates produced B/C ratios about twice as large as the A-Estimates.

3. In all cases when average values per alcohol related crash were used the benefit/cost ratio was less than one. However, in all cases except two, the B/C ratio exceeded one when the Hurst estimates were used.

4. The B/C ratios were not sensitive to the number of units in service per year when the number exceeded 100,000.

5. The B/C ratios were sensitive to changes in the effectiveness rate. Using the Hurst estimates it was possible to achieve economic feasibility with an effectiveness rate of 75 percent, whereas using the A-Estimates, economic feasibility was not possible at 100 percent effectiveness.

6. The B/C ratios were highly sensitive to the percent of alcohol related crashes covered by the restricted times. It is anticipated that 70 percent coverage would represent the maximum possible under most circumstances.

7. The B/C ratios were slightly sensitive to changes in the cost of installation and removal.

8. The B/C ratios were sensitive to changes in maintenance and calibration costs per year. If maintenance and calibration costs were eliminated, the B/C ratio using the Hurst estimates would be equal to 1.92 and the B/C ratio using the A-Estimates would be .97.

9. The B/C ratios were sensitive to changes in the cost of inspection.

10. Research and development costs, testing equipment cost, and maintenance and calibration costs were not significant when 10,000 or more units were in service per year.

Table 24

OPERATING TIME CLOCK

	Baseline case	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Most favorable 15	Least favorable 16
Input Data																	
Number of units installed	360,000	100,000	200,000														
Effectiveness rate	.90			.50	.75											.90	.50
Percent of alcohol crashes covered	.70					.50	.60									.70	.50
Research and development cost	250,000																
Unit manufacturing price	25							15	30							15	30
Unit installation cost	15									10	20					10	20
Average number of times installed	1.0																
Maintenance and calibration cost	25											0	15			0	25
Unit inspection cost	20													0	10	0	20
Unit cost for testing equipment	50																
Number of testing equipment stations	500																
Unit removal cost	7.50								5	10						5	10
Average number of times removed	1.0																
Annual Savings																	
Savings in crashes	3,342.7	928.5	1,857.06	1,857.06	2,785.6	2,387.6	2,867.2									3,342.7	1,326.47
Savings in fatalities (average)	25.6	7.11	14.22	14.22	21.3	18.3	21.9									25.6	10.16
Savings in fatalities (Hurst)	50.8	14.11	28.22	28.22	42.3	36.3	43.5									50.8	20.16
Savings in personal injuries (average)	1,395.9	387.75	775.5	775.5	1,163.25	997.1	1,196.5									1,395.9	553.93
Savings in personal injuries (Hurst)	2,925.5	812.6	1,625.3	1,625.3	2,437.9	2,089.6	2,507.6									2,925.5	1,160.91
Savings in societal costs (average)	16,173,290	4,492,580	8,985,161	8,985,161	13,477,741	11,552,350	13,862,820									16,173.290	6,417,972
Savings in societal costs (Hurst)	32,226,410	8,951,781	17,903,561	17,903,561	26,855,341	23,018,861	27,622,637									32,226,410	12,788,257
Annual Costs																	
Research and development (.002)	40,687																
Manufacturing (.06)	1,464,750	406,875	813,750					878,850	1,757,000							878,850	1,757,700
Installation (.21)	5,400,000	1,500,000	3,000,000							3,600,000	7,200,000					3,600,000	7,200,000
Maintenance and calibration (.35)	9,000,000	2,500,000	5,000,000									0	5,400,000			0	9,000,000
Inspection cost (.28)	7,700,000	2,000,000	4,000,000											0	3,600,000	0	7,200,000
Testing equipment cost	4,068																
Removal (.10)	2,700,000	750,000	1,500,000							1,800,000	3,600,000					1,800,000	3,600,000
Total annual cost	25,809,505	7,201,630	14,358,505	25,809,505	25,809,505	25,809,505	25,809,505	25,223,605	26,102,455	23,109,505	28,509,505	16,809,505	22,209,505	18,609,505	22,209,50[illegible]	6,323,605	28,802,455
B/C (average)	.63	.62	.63	.35	.52	.45	.54	.64	.62	.70	.57	.96	.73	.87	.73	2.56	.22
B/C (Hurst)	1.25	1.24	1.25	.69	1.04	.89	1.07	1.28	1.24	1.39	1.13	1.92	1.46	1.74	1.46	5.10	.44
Crash/cost	.000130	.000129	.000130	.000072	.000108	.000093	.000111	.000133	.000128	.000145	.000117	.000199	.000151	.000180	.000151	.000529	.000046
	130/Mil	129/Mil	130/Mil	72/Mil	108/Mil	93/Mil	111/Mil	133/Mil	128/Mil	.145/Mil	117/Mil	199/Mil	151/Mil	180/Mil	151/Mil	529/Mil	46/Mil

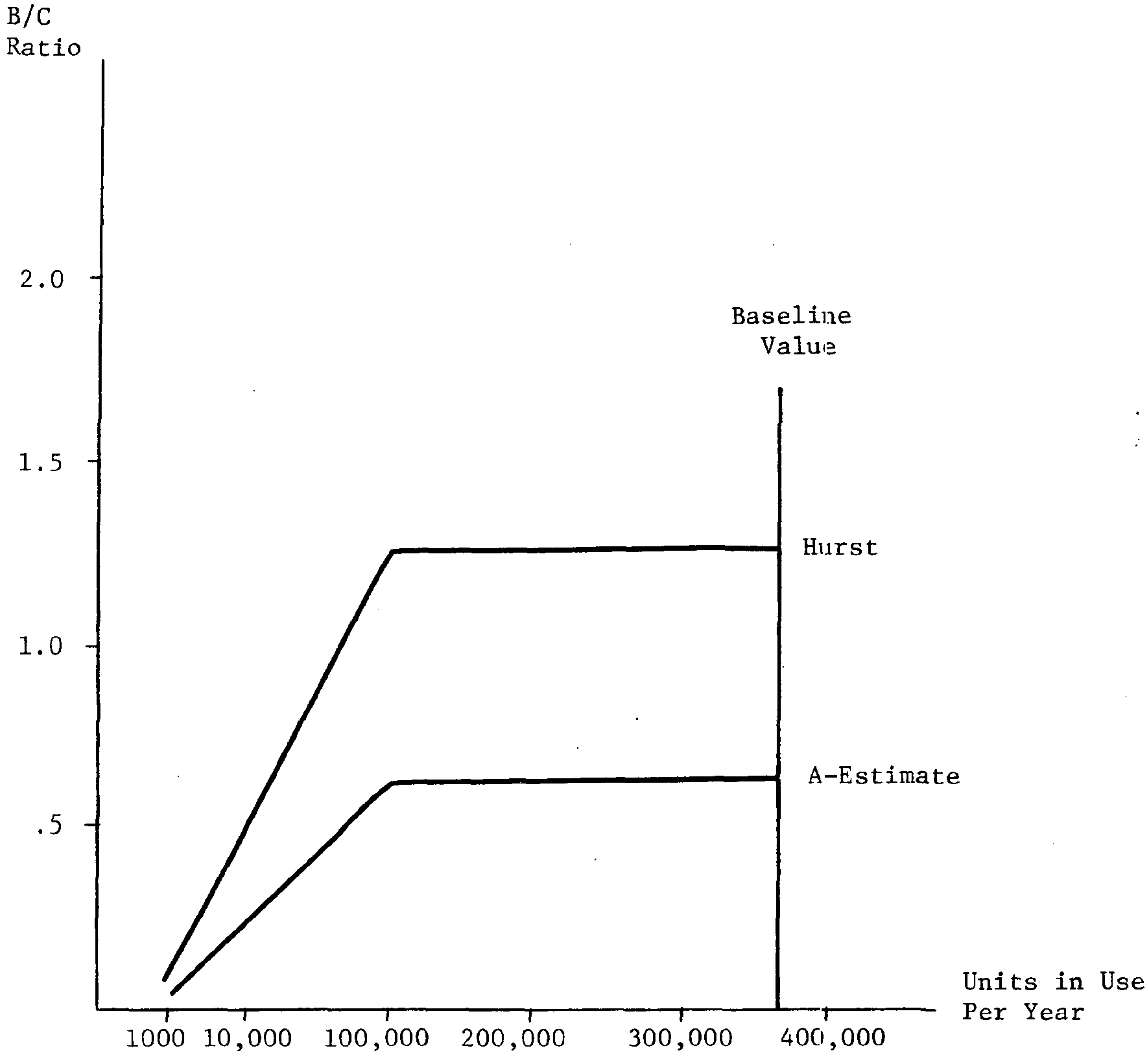

Fig. 45 —Relationship Between Units in Use Per Year and B/C Ratio - Operating Time Clock

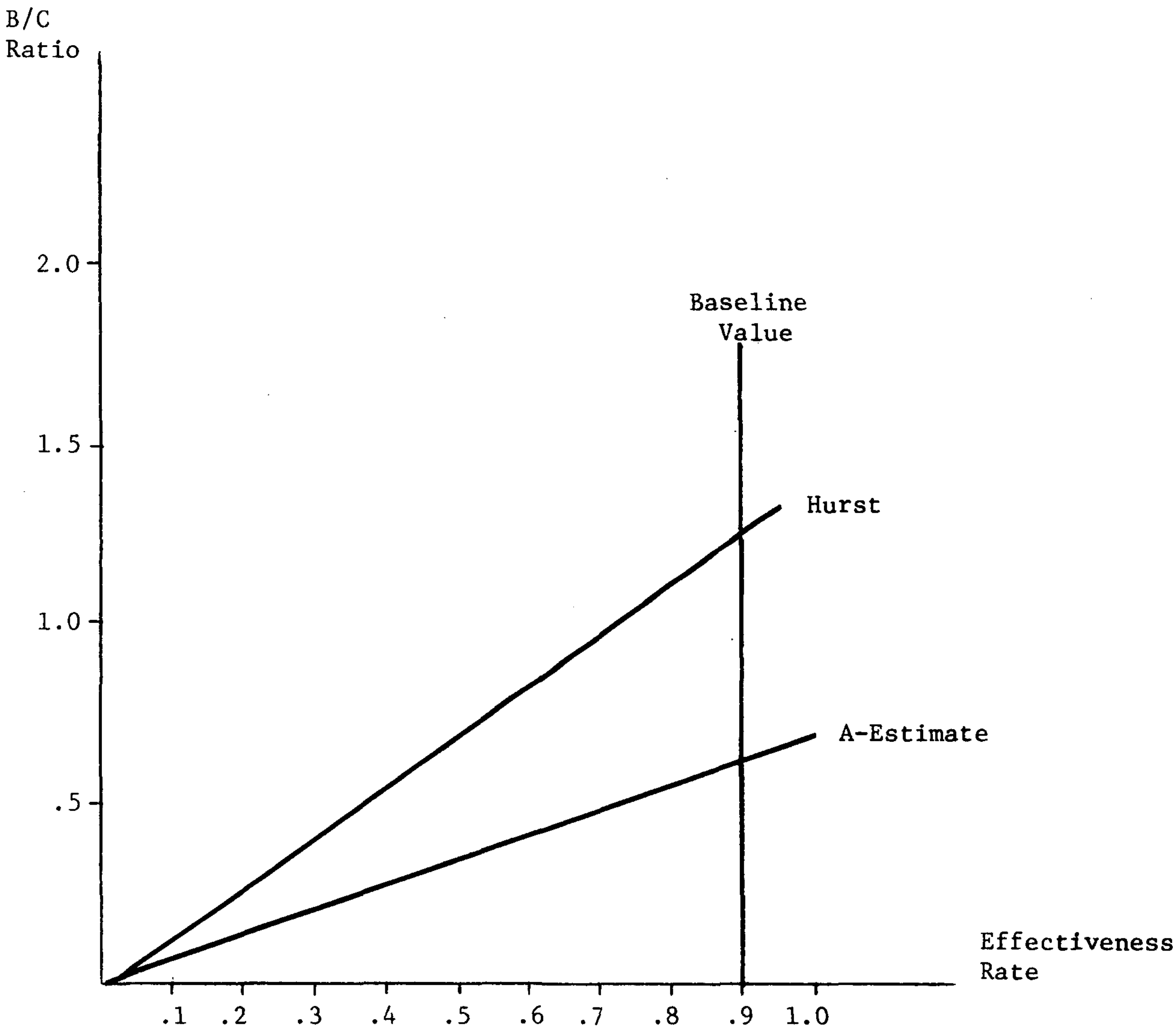

Fig. 46—Relationship Between Effectiveness Rate and B/C Ratio - Operating Time Clock

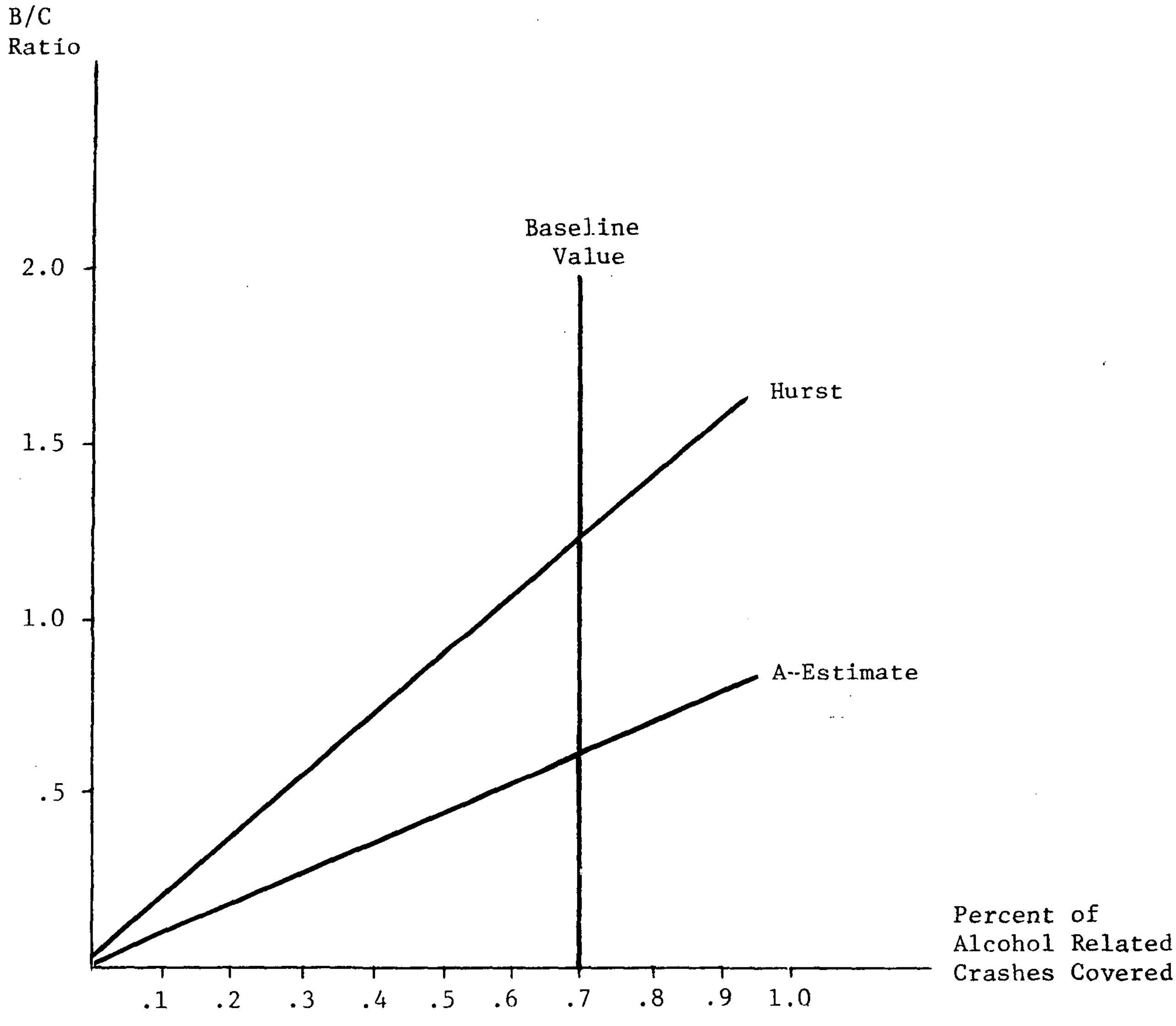

Fig. 47 —Relationship Between Percent of Alcohol Related Crashes Covered and B/C Ratio - Operating Time Clock

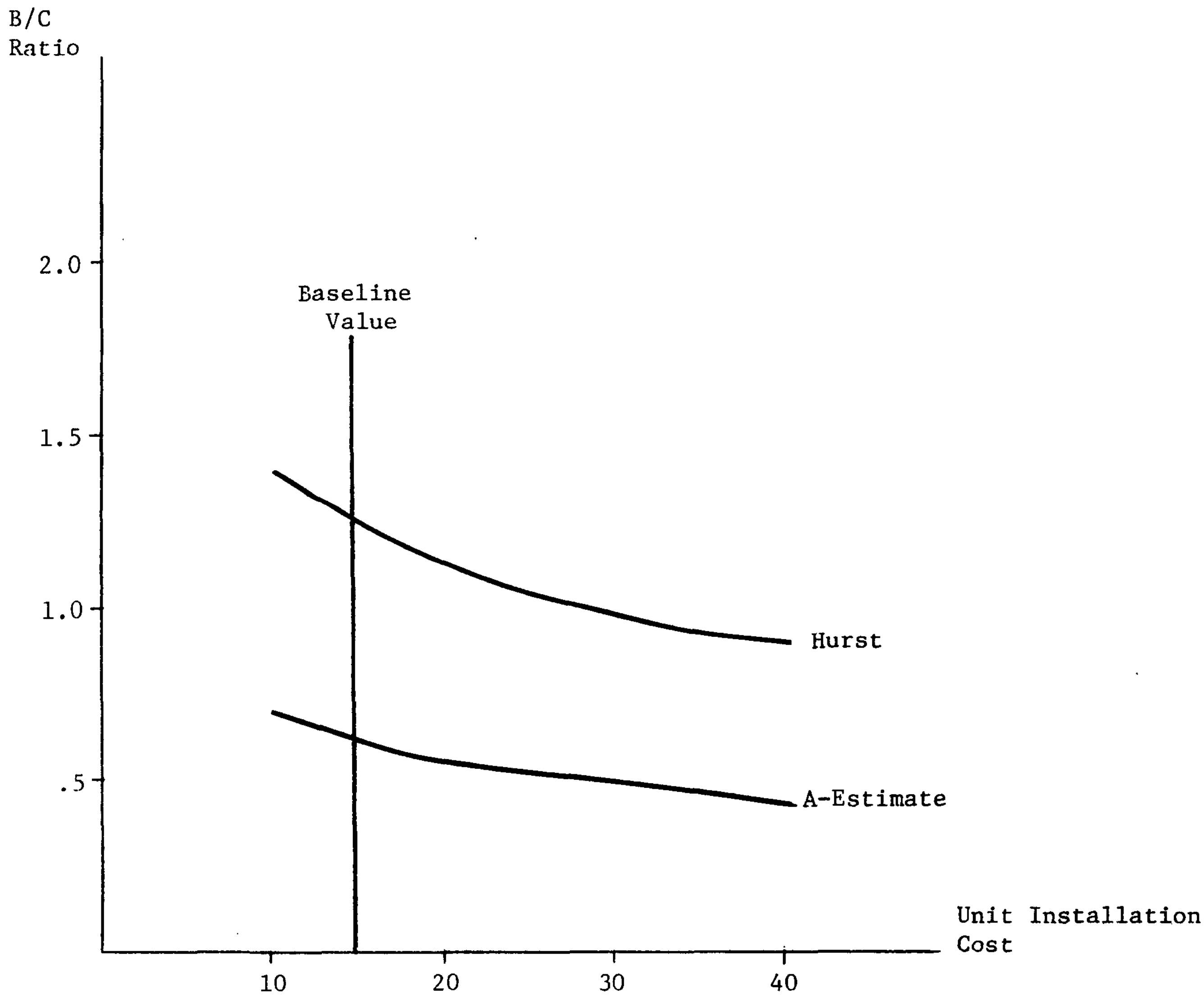

Fig. 48—Relationship Between Unit Installation Cost and B/C Ratio - Operating Time Clock

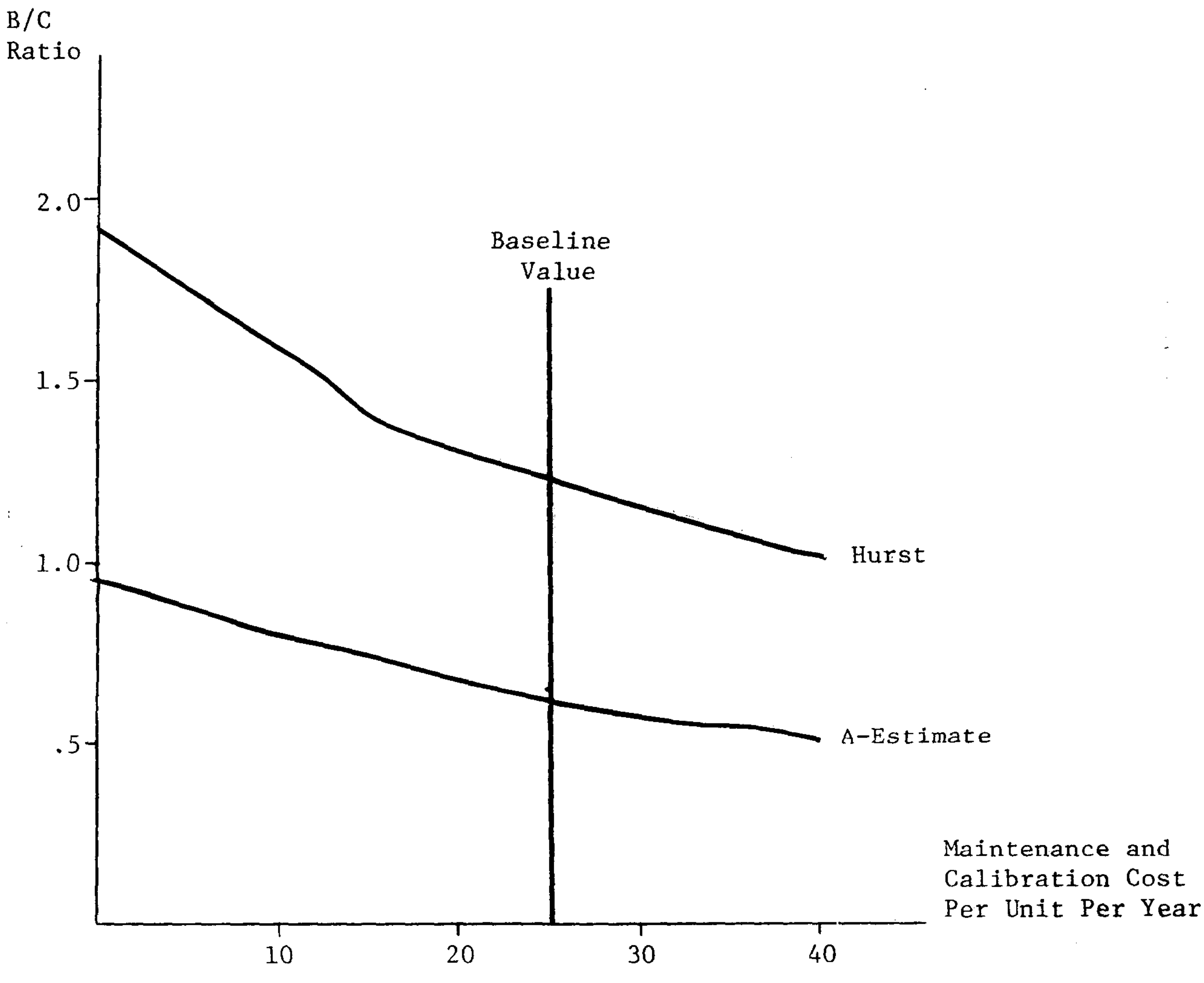

Fig. 49 —Relationship Between Maintenance and Calibration Cost Per Unit Per Year and B/C Ratio - Operating Time Clock

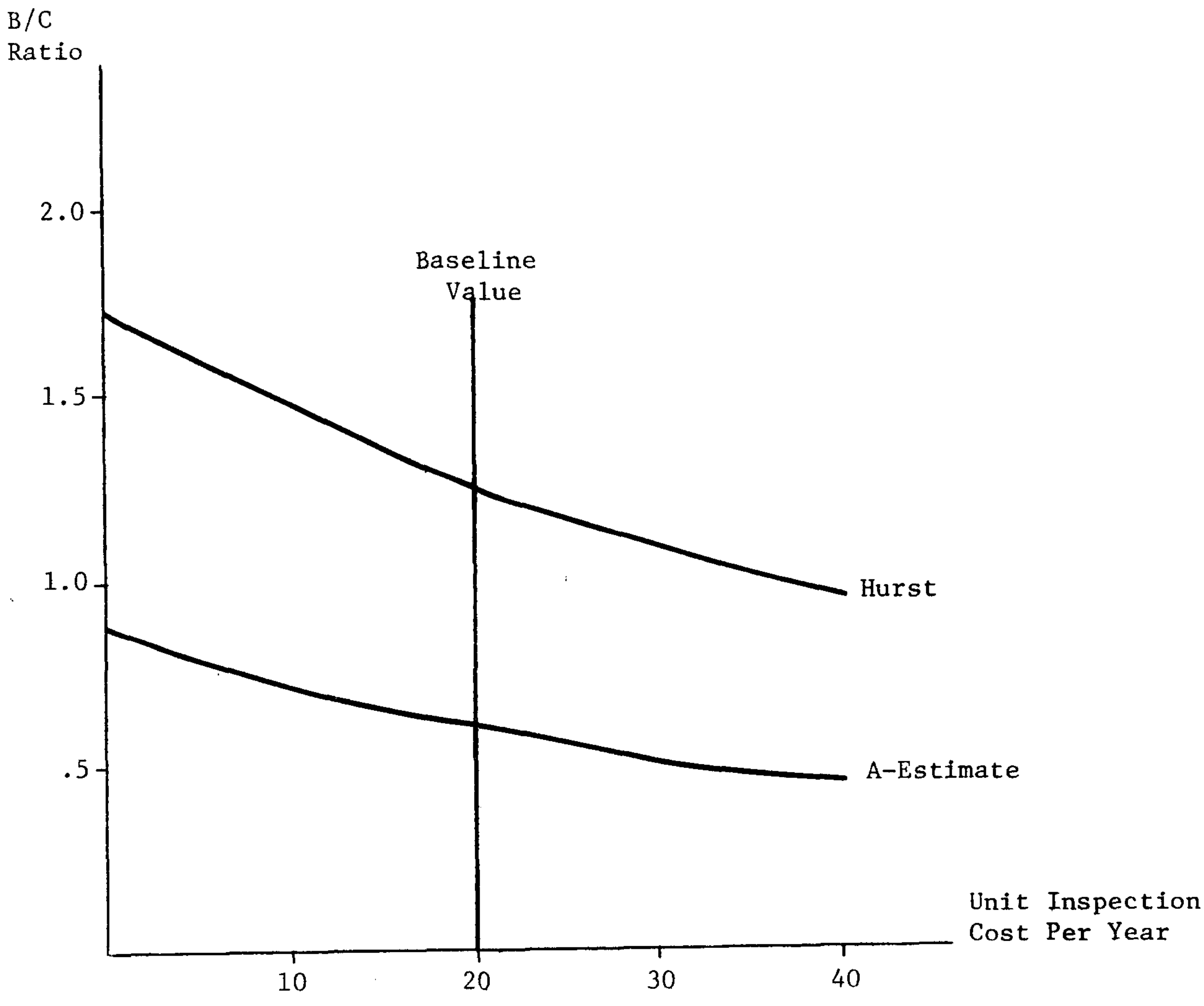

Fig. 50—Relationship Between Unit Inspection Cost Per Year and B/C Ratio - Operating Time Clock

IV. COUNTERMEASURE COMBINATIONS

This chapter describes the analysis of countermeasure combinations. While a substantial number of countermeasure combinations would be possible, it was decided to limit the analysis to the following:

1. Sober Pill and Self Tester
2. Evidential Roadside Tester and Non-Cooperative Breath Tester
3. Alcohol Safety Interlocks and Operating Time Recorder
4. Alcohol Safety Interlocks and Continuous Monitoring Device

The rationale for limiting the selection was based on the constraints imposed by the time and funding under the contract, and also the fact that many assumptions had to be made to analyze each countermeasure separately, and to analyze countermeasure combinations would require a compounding of already uncertain results. Thus, it was felt that more effort should be spent on trying to develop better estimates for the individual countermeasures rather than devote a substantial amount of time to the countermeasure combination.

In general, the decision to implement (or encourage as in the case of voluntary countermeasures such as the sober pill and self tester) a countermeasure combination rather than a single countermeasure, would be based on whether the incremental savings in societal costs resulting from combining the two countermeasures exceeds the incremental costs of combining the countermeasures. When combining two countermeasures, the incremented step should be that countermeasure which has the lowest benefit/cost ratio. For example, if countermeasures A and B are to be combined and A has a ratio of 2.0 and B has a ratio of 1.5, the appropriate veiwpoint to take would be to assume that B is added to A and benefits are measured as - total benefits of A and B minus total benefits of A, and costs are measured as total costs of A and B minus total costs of A. Thus, it would be necessary to combine the countermeasure combination model with the separate countermeasure models in order to determine the economic feasibility of the decision.

The application of the Hurst model to the countermeasure combinations is essentially an integration of the separate countermeasure models. The primary difference in benefit estimation will be that different assumptions regarding the effectiveness and utilization rates and that there would be some cost savings due to the combining of the manufacturing, installation, and maintenance operations.

Since the economic feasibility of the countermeasure combinations is a function of the individual countermeasure taken separately and the assumption regarding the interactions of the effectiveness and costs of the two together, it seemed somewhat meaningless to speculate about the effectiveness values and costs in view of the already sizeable amount of uncertainty associated with these estimates. Rather than perform a set of calculations which would be largely redundant with respect to the individual countermeasure calculations, it was determined that it would be more appropriate to describe how the countermeasures would interact to increase or reduce the individual effectiveness rates and what cost economies could be achieved by combining the countermeasures.

SOBER PILL AND SELF TESTER

The combined use of the sober pill and the self tester presumably would have a higher impact on trips at elevated BAC levels than either countermeasure taken separately in that a person would be able to monitor his BAC level and could determine when he reaches illegal levels. Being able to determine when he is at or reaching an illegal BAC level may encourage the individual to moderate or stop his drinking and also he may take a sober pill before driving.

While it is probable that the combined effect would result in more crash savings than with the use of either countermeasure taken singularly, it is questionable that it would be a cost/effective countermeasure. The reason is that there would be little or no cost savings resulting from combining the two countermeasures. (The cost saving would result when an individual tests sober, stops drinking, and subsequently does not take a sober pill, whereas otherwise he might have taken one). Based on $.25 per dose for the sober pill and $1.00 per test for the balloon tester, the cost to an individual of adding the balloon tester to the sober pill (assuming that both devices exist) will increase by 400 percent. It is unlikely that the incremental effectiveness rate would be high enough to offset the increase in cost.

While other considerations such as the technological feasibility, legal implications of relying on a sober pill, use preference, etc., clearly must be taken into account, it would appear on a priori grounds that combining the two countermeasures would not increase the effectiveness rate and the accident reducing potential by more than the increase in cost.

EVIDENTIAL ROADSIDE TESTER AND NON-COOPERATIVE TESTER

The combined use of the evidential roadisde tester and the non-cooperative tester presumably would have a higher impact on trips at elevated BAC levels than either countermeasure taken separately in that the arresting officer would be more capable of detecting the presence of alcohol, and this should increase the number of tests he can make with the evidential roadside tester. While this would increase the number of arrests and convictions, the real issue is "what effect would it have on the number of illegal BAC trips?" Since the savings are based primarily on the deterrence effect of the devices perception of being apprehended, the resulting feasibility of combining the two devices is dependent upon whether the effectiveness rate can be increased enough to offset the resulting increase in cost. Since the devices are separate units, there would be no cost savings resulting from combining the two, except for the possibility of increasing the officer's efficiency and thereby lowering the enforcement cost per arrest.

As in the case of the sober pill and self tester, the combined effectiveness rate must represent a substantial improvement in order to offset the increased cost.

ALCOHOL SAFETY INTERLOCK SYSTEM AND OPERATING TIME RECORDER

The combined use of the alcohol safety interlock system (restricted use) and the operating time recorder presumably would have a higher inpact on trips at elevated BAC levels than either countermeasure taken separately in that the operating time recorder would preclude (if effective) a number of trips during the restricted driving time.

Unlike the case of the previous two countermeasure combinations, there are potentially significant cost savings in combining the two devices. Installation, removal, maintenance and calibration, and inspection could be combined into one operation, and furthermore there would be significant economies in producing both devices in one unit. Thus, the incremental cost of combining the countermeasures would not be nearly as large as the sum of the two costs taken independently.

The crucial question is "would the combined effectiveness increase enough to more than offset the increase in cost?" While it is not possible to answer this question on a priori grounds, it does seem that it is worth pursuing in more depth as it may provide an efficient method of utilizing the interlock devices.

ALCOHOL SAFETY INTERLOCK SYSTEM AND CONTINUOUS MONITORING DEVICE

The combined use of the alcohol safety interlock system (restricted use) and the continuous monitoring device presumably would have a higher impact on trips at elevated BAC levels than either countermeasure taken separately in that the continuous monitor would be able to detect impaired driving after the vehicle were set in motion. This combination would have the advantage of reducing the problem of the false/positive where the interlock system permits an individual to start the vehicle when he is above the legal limit, and also provides a test which is related to driving performance rather than an ability to pass a breath test (as in the case of the breath interlock) or a psychometric test.

As in the case of the combination of the interlock systems and the operating time recorder, substantial cost economies could result from combining the time. Also, the increase in combined effectiveness must be sufficient to offset the increase in cost.

SUMMARY OF COUNTERMEASURE COMBINATIONS

The analysis of the individual countermeasures involved a first order approximation of both costs and effectiveness rates, and the extrapolation of these estimates to countermeasures combinations would involve, at best, a second order approximation. This aspect is especially crucial with respect to the effectiveness rates, and therefore, it was determined that the most appropriate method of handling them would be to describe the effects of combining the two.

Based upon this preliminary assessment, it appears infeasible to implement countermeasure combinations such as the sober pill and the self-tester and the evidential roadside tester and the non-cooperative breath tester where few, if any, cost economies are achievable. The offsetting requirement of an increase in effectiveness seems unlikely under the circumstances.

Also, it appears that countermeasure combinations that offer substantial cost economies such as the interlock system, the operating time recorder, and the continuous monitoring device would be economically feasible if a reasonable increase in effectiveness could be achieved. It is recommended that the application of these combinations be explored in more detail when more reliable data become available regarding the singular effectiveness of these devices.

V. FEASIBILITY OF THE COUNTERMEASURES

One of the primary objectives of the benefit/cost analysis is to assess the economic feasibility, e.g., determine if the benefit/cost ratio exceeds one, and the major emphasis of this study was involved with the completion of this task. However, the determination of the economic feasibility of a countermeasure does not provide adequate justification for policy makers to implement the countermeasure. Economic feasibility is a necessary condition, but not a sufficient condition to implement a countermeasure and a number of other aspects relating to feasibility must be evaluated before implementation should be undertaken. For the purposes of this report, the other aspects of feasibility are defined to include:

1. The social aspects
2. The technological aspects
3. The legal aspects

These aspects for each of the countermeasures are described briefly in the ensuing discussion.

SOBER PILL

SOCIAL ASPECTS

The sober pill may be the most socially acceptable of the countermeasures. The sober pill would be simple to administer, would be readily available at little cost and would have virtually no social stigma attached to its use. With the development of a proven drug, it is conceivable that the use of the pill would be promoted by hosts, bartenders, wives, and other social contacts, when a need had been shown.

It will be important that a favorable and widely publicized information and education campaign be developed to precede and accompany this product as the public must be aware not only of the advantages but also of the limitations of the sober pill.

TECHNOLOGICAL ASPECTS

In a study recently completed by Dr. Ernest P. Noble of the University of California, Irvine, evidence was produced that a chemical agent for blocking the affect of alcohol on the central nervous system may be technologically feasible.[20] While further research will be required to determine the technological feasibility of a sober pill, the results of Dr. Noble's work are promising and hopefully in the near future an effective sobering agent will be developed.

LEGAL ASPECTS

A number of questions regarding the use of the sober pill have been raised as potential legal issues. The major concern has been the potential liability on the part of the manufacturer (and possibly against a municipality, should it be part of their program) in regard to the reliance of a motorist on the sobering effect of the drug. Should a crash occur after the motorist has taken the pill, the question of product liability falls upon the manufacturer. While the law in this regard is not clear, if sufficient warnings are placed on the product container or accompanying inserts, this problem may be avoided.

Another legal issue is the question of guilt on a charge of driving under the influence after a person has taken the sober pill. Ostensibly, the drug will lower the driving performance of the driver, but it will not lower the blood alcohol concentration of the driver. Therefore, if a person who has taken the drug (at .15 percent BAC) is stopped for some reason, and submits to a breath or blood analysis, the findings of 0.15 percent BAC will be presumptive evidence of his driving while under the influence. While he may try to rebut the presumption by claiming he was not

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[20] Noble, Ernest P., Testing for a Sobering Pill, prepared for US Department of Transportation, October 31, 1974.

under the influence as the result of taking the sober pill, it will create many serious problems of law enforcement and judicial conduct. This will be even more difficult in those states which have "illegal per se" statutes, where the finding of a specific BAC (generally above 0.10 percent) is conclusive evidence of guilt. Should a successful sober pill be developed, these issues will have to be studied, and some resolution of the potential problems be recommended.

SELF-TESTERS

SOCIAL ASPECTS

The use of self-testers, as in the case of the sober pill, will strongly depend upon the acceptability of these devices by the general drinking population. Since its use would be voluntary, the population must be convinced that the use of the self-tester will either prevent them from being involved in a crash, or that it will lessen the chance of being arrested for drinking and driving. In those areas where law enforcement for DWI is high, the probability of use will be respectively high. Where arrests on these charges are minimal, the impetus for its use will be substantially less.

The general public would probably use the small, disposable "balloon" type testers, as opposed to the more expensive mechanical devices. If the mechanical devices are used, they would probably be in bars, halls, fraternal groups, and similar environments.

A major public information program would be required for any substantial use by the general public. Not only would it be necessary for the public to become aware of its existence but in addition, there should be some compelling reasons for such usage. This can be accomplished only through an extensive learning process.

TECHNOLOGICAL ASPECTS

The devices that have been developed and marketed are predominantly practical and feasible for general population use, and their appears to be no technological difficulties in the implementation of the device.

LEGAL ASPECTS

The self-tester, as in the case of the sober pill, has an element of product liability on the part of manufacturers. It would not be an identical situation since the device would not propose to change the condition of the driver, but would be used to measure the driver's BAC level. There may be an issue on the question of the reliance of the driver on the accuracy of the device. Also, it is possible that wide use of the device may lead to defenses raised by defendants charged with DWI that they tested themselves prior to driving, found themselves to be below the legal limit, and therefore proceeded to drive. Whether this becomes a viable argument will depend largely upon the willingness of judges and juries in various communities to convict. While it is not a valid defense to the charge, it can be sufficient to sway an otherwise lenient judge or jury.

EVIDENTIAL ROADSIDE TESTERS

SOCIAL ASPECTS

It is conceivable that the use of evidential roadside testers will become acceptable by the general public. If the driving population is aware of both the accuracy and the use of these instruments, they should be more reluctant to drive while intoxicated. As a practical matter, it may prove to be of substantial value to many drivers, wherein the test may show the BAC to be below the legal limit, and obviate the requirement of an arrest and booking at the stationhouse prior to the BAC test. Certainly the police officers will look upon these testers as substantial time-savers, and will endorse their use.

The roadside test itself would not eliminate the task of bringing the driver to the stationhouse or other detention facility if the driver is not capable of driving his vehicle. Under certain circumstances (such as a sober passenger), the police officer can issue a citation to the drinking driver and not require him to be brought to the police station. The police officer cannot allow the driver to continue driving if he is found to be legally intoxicated, and even if the driver is brought to the stationhouse, a citation can be issued (rather than a formal booking) and the defendant can call someone to pick him up at the station. The summons or citation method of charging a driver is presently being used in a number of jurisdictions.

TECHNOLOGICAL ASPECTS

The state-of-the art in breath testing equipment is currently advanced to allow widespread use of this program. The only difficulty at this time is that the prosecutors and judges are not sufficiently aware of the reliability of the instruments and an educational campaign will be necessary to provide these assurances. These testers would be more accepted by legal officials if an automatic printout of the results would be provided which will report the precise BAC, and the date and time of the test.

LEGAL ASPECTS

In addition to the legal matters stated above, a major challenge to be anticipated by defense counsel will be an attack on the reliability of the devices when used under variations of weather and light conditions. If the evidential device is used in an enclosed van (such as in Fairfax County, Virginia and Baton Rouge, Louisiana) where the conditions of the testing are controlled, the courts may uphold its use. On the other hand, if the device is to be used in all police cars, it will be necessary to validate the reliability and capabilities of the roadside testers.

NON-COOPERATIVE BREATH TESTER

SOCIAL ASPECTS

It is anticipated that the introduction of this device would raise severe criticisms regarding the violation of individual privacy. The Nation is presently underoging serious entanglements on issues of the right of privacy versus the police powers of the state. Since the public will be made aware of the practices of the law enforcement officers, it can be expected that some public responses will be made. The American people have always encouraged the support of the individual's right to privacy and have resented the intrusion of technology into their daily lives. The driving public has strongly opposed the use of unmarked cars for these reasons, and has restricted successfully its use in many jurisdictions through public pressure. In order for these testers to be acceptable by the public, a strong educational program will be required to demonstrate the need for its application to reduce the deaths and injuries on the highways.

TECHNOLOGICAL ASPECTS

The non-cooperative breath tester is a technologically feasible instrument, and a prototype of this device is expected to be developed shortly. There still may be technical problems in regard to the size of the device, which will be applicable as to the convenience of use by the police officers. In addition, another potential problem may be its capability of detecting alcohol at arm's length distance.

LEGAL ASPECTS

This countermeasure has serious problems in the legal area. The basic issue is whether this test is an illegal search and seizure as defined by the provisions of both state and the Federal constitutions. It is well defined that the conduct of a search of physical evidence (as opposed to testimonial evidence) is an acceptable practice under certain conditions (Schmerker vs California, 384 US 757). However, one of the requirements of search is that the defendant be under arrest at the time of the search. When a search is conducted of a person's privacy without a warrant or without "probable cause" of a crime being committed, the question of an illegal search and seizure will almost certainly be raised (Mapp vs Ohio, 367 US 643) as a violation of the Fourth Amendment of the US Constitution. Since this gathering of information (there is no question that this constitutes a search of the person) will be conducted randomly, without there being "probable cause" of the person driving under the influence, it would appear that this practice will not be allowed by the courts. However, the courts have recognized certain contingencies when exceptions to the general rule have been authorized by the courts. Some of these exceptions have been: the request by a police officer for the drivers license or vehicle registration without there being any probable cause of a traffic violation; the random inspection of a vehicle (pulling a wheel) without probable cause of a defect; "stop-and-frisk" laws, which authorize a police officer to search a person for weapons under certain conditions (without probable cause); border patrol searches, and other such situations. These areas have been restricted narrowly by the courts, and it will require great persuasion on the part of the proponents of this measure to allow an additional exception. Should there be no valid authority to conduct the initial search, it is possible that all other evidence obtained thereafter can be excluded at a trial of the defendant under the "exclusionary rule."

In order for the search to be acceptable to the courts as an exception to the general rule, there would have to be shown a substantial public need for this intrusion into the privacy of individuals. It would appear on the basis of some recent decision of the US Supreme Court, this approach may be an acceptable theory of law.

OPERATING TIME RECORDER

SOCIAL ASPECTS

Generally, there should be little public resistance to this type of countermeasure. Since this would involve convicted drinking drivers (as opposed to universal use) and would be a part of the terms of probation, the voluntariness of the program should eliminate most of the objections. As a practical matter, the court would be offering the convicted defendant an opportunity to use his motor vehicle during certain required hours (for employment purposes) rather than totally "grounding" the vehicle and/or the driver. One potential social problem deals with the use of the vehicle by other members of the family during the restricted hours. If the vehicle is "locked" during the restricted hours, it may create serious logistics problems for the entire family. It may be possible for this circumstance to be avoided through the use of an "override" system, with the provision that its use be carefully documented to explain the violation of the terms of probation.

TECHNOLOGICAL ASPECTS

There does not appear to be any problems in the technical features of this countermeasure. The theory is relatively simple, and does not involve complex systems to accomplish its tasks. As stated earlier, it will be essential that special means of the detection of tampering be available so that the defendant will not have the means of defeating the system.

LEGAL ASPECTS

Since the use of an operating time recorder is a voluntary one, there does not appear to be any major legal problems involved in its operation.

In the case of the recording of the vehicle's use (without the "locking" of the vehicle), there are no serious legal issues. In the case of physical restricted use of the vehicle during certain times, should the device fail and the vehicle be allowed to be operated, it is possible that some cause of actions may be available against the manufacturer and the municipality on the basis of reliance on the part of the user, but since this is not a measuring device (not dependent upon a performance rating) it is not probable that this cause of action will be sustained by the courts. (This aspect is explored in a discussion of this liability problem in the section dealing with alcohol interlocks.)

CONTINUOUS MONITORING DEVICE

SOCIAL ASPECTS

It is anticipated that the continuous monitoring device would be used by convicted drinking drivers and there should be minimal objections to its use by the general public. There may be some social problems for family use since the threshhold level will be established for the convicted drinking driver and it may conflict with the performance criteria of other users of the vehicle. It is technically possible for there to be multiple threshholds recorded by the device so that more than one person can operate the vehicle. The practical difficulty would be that this may no longer serve as a restriction of the driving of the convicted person.

TECHNOLOGICAL ASPECTS

This device, although not in actual use for these purposes (performance criteria for alcohol impairment), would appear to be technically feasible on the basis of existing systems presently in use.

LEGAL ASPECTS

The major legal problem dealing with the use of the continuous monitoring device is the driver's reliance on the device to indicate if his performance is impaired. Should the driver be involved in a crash, the damages that result from the crash conceivably can be attributed to the error of the device. The driver can contend that according to the device his performance was acceptable, and therefore, he assumed he was capable of safely operating the vehicle, relying on the device to indicate otherwise. Should the decision be made to implement the continuous monitoring device, it may be necessary to enact special legislation which will create special immunities from civil or criminal prosecution against these parties from any resulting damages.

ALCOHOL SAFETY INTERLOCK SYSTEMS

SOCIAL ASPECTS

It is necessary to distinguish between restricted use by the courts for convicted drivers, and universal use where the device would be installed in all manufactured motor vehicles. In the first instance, use would be limited to convicted drivers and there would not be any general objections to it. On the other hand, the probability of the installation of these devices in all newly manufactured vehicles is remote. The general public has indicated already its unwillingness in accepting universal safety requirements that cause inconvenience in operating their vehicles. This has been demonstrated in the recent rejection by Congress (caused by the public furor) of the interlock system in seat belts. The requirement for all motorists at all times to conduct performance tests before their vehicle can become operative would likely create a strong public reaction to the use of the device.

TECHNOLOGICAL ASPECTS

There are problems in the ability of these devices to discriminate between sober and intoxicated drivers. While the breath-analyzer is the most reliable, it is subject to defeat by the driver introducing a false amount of uncontaminated air into the analyzer in the place of his own breath. For the CTT and the DAT the number of false negatives and false positives creates severe technical and legal problems that may be insoluble. Unless the number of false positives and false negatives is brought within tolerable levels, the use of these interlocks would be impractical.

LEGAL ASPECTS

There are several legal implications regarding the use of the alcohol safety interlock devices. The major problem deals with the concept of the reliance of the driver on being prevented from starting his vehicle if his performance is below the prescribed limit. Should the driver pass a performance or breath test and is, in fact above the legal BAC limit (false negative) and a crash results from this operation, the damages that result from the crash conceivably can be attributed to the error of the device. The driver can contend that when the vehicle started after his successful performance test, he assumed that he was capable of safely operating the vehicle, relying on the operation of the device to prevent him from driving if he were incapable of doing so. This position is reasonable and although there have been no decisions on this issue, it is conceivable that this argument would be upheld by the court. Therefore, it would be probable that the local municipalities involved with the countermeasure, the state and even the Federal government, could be made third-party defendants in tort liability actions that are filed as a result of a crash. Also, this liability may be imposed upon the manufacturer of the device.

Should the decision be made to implement the alcohol safety interlock system, it may be necessary to enact special legislation which will create special immunities from civil or criminal prosecution against these parties from any resulting damages.

VI. ANALYSIS AND INTERPRETATION OF RESEARCH FINDINGS

In Chapter IV the benefit/cost ratios for the alternative countermeasures were compared and discussed, and in Chapter V the feasibility of the countermeasures was discussed with respect to the social aspects, the technological aspects and the legal aspects. In this chapter, the research findings are interpreted and summarized. For each countermeasure the implications of the critical assumptions and variables are explored and the minimum requirements for feasibility are defined. The feasibility for a countermeasure is defined in this context to be economic, social, technological, and legal feasibility. In effect, these requirements must be met before policy makers should consider implementing a countermeasure.

SOBER PILL

Although the sober pill is not a technological reality at this time, it is likely that it would be acceptable socially, if available and if it did not produce unpleasant side effects. Also, it would be relatively inexpensive, easy to use, and could have a large payoff in terms of accident reducing potential. Of particular significance is the finding that an agent with an effectiveness rate as low as .02-.03 could be economically feasible if the cost per dose was about $.50.

With the exception of the technological feasibility of the sober pill, the most critical variable is unit dosage cost. The benefit/cost ratio was highly sensitive to changes in the unit dosage cost (see Fig. 6), and amounts in excess of one dollar per dose resulted in ratios below one. A random sample of prices of psychostimulant drugs was selected, and it was determined that the average price per tablet was in the range of $.10-.20. Using these estimates as a basis for determining the expected dosage cost, it would seem reasonable for the unit dosage cost to remain below $.50.

For the baseline case (unit dosage cost = $.25) dosage cost accounted for 98.2 percent of total system cost. It can be seen from Fig. 6 that small changes in price can result in large changes in the benefit/cost ratio. It is important to note that the benefit/cost ratio was not sensitive to changes in the utilization rate (except at levels below 1 out of 17,000 trips at elevated BAC levels), and therefore the question of feasibility is not dependent upon the demand schedule, e.g., the quantity demanded by the public at each price level. It is clear from these findings that the overall requirement for feasibility for the sober pill is the development of an agent which will reduce the effective BAC by at least .02-.03 without unpleasant side effects and which will cost no more than .50 per dose.

SELF-TESTERS

All three of the self testers analyzed are technologically feasible and currently are at a stage of development where they could be marketed to the public or an alcohol safety countermeasure. The balloon testers and the alcosensor devices would be sold for individual use whereas the TSC devices would be sold commercially to drinking establishments.

Two assumptions were critical in determining the economic feasibility of the balloon testers:

1. The effectiveness rate
2. The unit manufacturing price.

The assumption of a relatively high effectiveness rate appears to have reasonable validity in that if a person voluntarily spends the $.60-1.00 to use a balloon tester, he shows a concern for the problem and would be likely to abide by the results. As in the case of the sober pill, total system cost is nearly proportional to the use cost, and therefore, the benefit/cost ratio is not sensitive to changes in the utilization rate except at low levels of use. Research and development costs and public information costs were not significant, except at extremely low utilization rates.

For the baseline case, manufacturing costs (at 1.00 per unit) accounted for 99 percent of total system cost, and relatively small changes in the unit manufacturing price resulted in large changes in the benefit/cost rates (see Fig. 9). In order to be economically feasible, the effectiveness rate for the balloon tester would have to be a minimum of .75 and the unit manufacturing price would have to be \$.60 or less. Four assumptions were critical in determining the economic feasibility of the alcosensor devices:

1. Manufacturing price
2. Maintenance cost
3. Effectiveness rate
4. Utilization rate

For the baseline case, manufacturing cost (at \$1.00 per unit) accounted for 25 percent of total system cost. While this price might be economically feasible with a high effectiveness rate, a low maintenance cost, and a high utilization rate, it is doubtful that public acceptance or voluntary purchase of the device would result at \$100 per unit, and consequently, the purchase rate would be low. The alcosensor device is characterized by a relatively high fixed initial cost and a low usage cost and in order to be a cost effective countermeasure, it must be used a large number of times per year. It seems logical to assume that the utilization rate would be at least 75 or 80 percent if a person were willing to spend \$25 to \$100 to purchase it in the first place. While the alcosensor device may have an acceptable benefit/cost ratio with the appropriate rates for maintenance cost and effectiveness, it would probably have only a small impact on the total number of alcohol related crashes due to the low purchase rate.

Maintenance cost is the most critical element (see Fig. 13) of total systems cost, and in order to be economically feasible, it would be necessary to reduce maintenance to a maximum of \$10 per unit per year. Since the alcosensor device operates with a fuel cell, it is unlikely with the existing technology that this level of cost can be achieved.

One aspect which might increase the effectiveness of the alcosensor device is the fact that individuals who are convinced enough to spend \$25-\$100 for the device may be high-frequency drinker/drivers. The analyses for all countermeasures were conducted on the basis of average number of trips at each BAC level. The individuals who purchase alcosensor devices would likely have a higher than average number of trips at elevated BACs, and the devices would have a proportionally higher value for reduction in societal costs. For example, if this group of drivers had twice the number of trips at elevated BAC levels as the average, then the B/C ratio for the baseline case would be 1.07 instead of .54.

To summarize, economic feasibility for the alcosensor device would require that the device be effective (.80 or greater), inexpensive to maintain (10 percent per year or less), used frequently (80 percent or greater), and cost no more that $50 per unit.

The TSC device had favorable results under virtually all assumptions. The most critical variable was operating cost. At $.07 per use operating cost accounted for 86 percent of total systems cost for the baseline case, and changes in the unit operating cost resulted in large changes in the benefit/cost ratio. However, it was possible for the unit operating cost to be as high as $.35 before the benefit/cost ratio approached unity.

The reason the TSC device gives higher ratios than the other countermeasures is that it has an extremely high use rate per unit of fixed cost. Whereas the alcosensor device would be used only occasionally by the individual (or family and friends), the TSC device would be used by several people every day and therefore the fixed charge per unit is spread over a large number of uses. Even under the assumption of .25 (1 out of 4) effectiveness rate the benefit/cost ratio was projected to be 2.25-4.36.

It is important to mention that a number of assumptions had to be made regarding the use of the TSC device, e.g., effectiveness rate, percent who normally would reach elevated BAC levels, average number of times each device is used per year, and the average number of times the device is used per driver per visit, and it must be recognized that the worst values for these assumptions taken in combination produced unfavorable benefit/cost ratios .07-.13 (see Table 13).

Due to the relatively low cost of operation and the high exposure to individuals who drink and drive, it is anticipated that the TSC device could have a high impact on the total number of alcohol related trips, especially if measures were taken to either subsidize drinking establishments in the purchase of the devices or to require by law that they purchase the devices.

Finally, the technology currently exists for these devices and they could be available for sale in the near future.

EVIDENTIAL ROADSIDE TESTER AND NON-COOPERATIVE BREATH TESTER

The same models were used to assess the evidential roadside tester and the non-cooperative breath tester. The only differences were in the assumptions used for the effectiveness rates, the manufacturing price, unit operating costs, maintenance and calibration costs, and the percentage of arrests resulting in convictions.

The benefit/cost ratios for the evidential roadside tester were greater than unity under all assumptions, including the combination assumptions for the least favorable case. A significant aspect of this model is that the effectiveness rate is predicated on the assumption that the use of the evidential roadside tester will have a deterrent effect in addition to the immediate effect of remaining arrested drivers from the road. The assumption is based on the notion that an increased number of arrests and convictions in conjunction with a substantial public information campaign alerting the public of the increased probability of apprehension and conviction will be effective in reducing the number of trips at illegal BAC levels. The assumption for the baseline case is that the total effectiveness rate is a function of the total number of evidential roadside testers in service each year. The maximum number of testers would be 22,000 (the approximate number of patrols Nationally), and if the maximum were in use the effectiveness rate would be 5 percent of the trips at the above BAC = .10, and the effectiveness rate in general would be proportioned to the number of testers in service. Thus, if 11,000 roadside testers were in service the effectiveness rate would be 2 1/2 percent. The maximum effectiveness rate assumed for the plausible case was 2 percent.

An examination of the elements in the cost equation revealed that the incremental court costs accounted for 76 percent and 16 percent of the total system cost for the baseline case. The unit costs per case for court and rehabilitation were derived from ASAP data and should be representative. However, it must be recognized that changes in these cost elements would affect significantly the estimates for the benefit/cost ratios. Furthermore, the effectiveness rate over time is likely to be a direct function of the arrests, convictions and rehabilitations, and therefore it may be necessary to increase the level of enforcement activity, e.g., increase the number of stops per day, in order to achieve a higher effectiveness rate. Since experimental data were not available for estimating the relationships among these functions and the effectiveness rate, a value had to be assumed. The approach was conservative and it is anticipated that a comprehensive public information campaign in conjunction with increased enforcement could achieve an effectiveness rate of 2 to 5 percent.

Since the evidential roadside tester will increase the efficiency of the police force by being able to test on the roadside rather than the stationhouse, it was assumed that the increased enforcement effort would be achieved at no additonal cost. Future analysis will be needed to determine if significant cost increases or decreases would result.

It was estimated from the Uniform Crime Reports that the average number of stops per cruiser per day is 7.75.[21] The assumption for the baseline case was that enforcement activity is increased by 20 percent and 9.686 stops per day are made. It can be seen from Fig. 23 that as the number of tests per day (stops per day)increase, the benefit/cost ratio declines dramatically. The reason is that court and rehabilitation costs are increased dramatically as the number of arrests and subsequent convictions are increased. The figure should not be interpreted to mean that the number of stops should be decreased, but rather it shows the relationship between stops and benefit/cost ratio for a constant effectiveness level. The figure can be used to determine the minimum acceptable relationships between the number of stops and the effectiveness rates. For example, in the baseline case the effectiveness rate is assumed to be .012, Fig. 23 may be interpreted to mean that if 12 or more tests per day are required (assuming the other parameters are constant) to achieve an effectiveness rate of .012, then the evidential roadside tester may not be economically feasible.

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[21]"Crime in the United States," Uniform Crime Reports. US Government Printing Office, 1973.

The interpretation of findings for the non-cooperative breath tester are analogous to those for the evidential roadside tester. As mentioned above, the pricing difference is in the assumptions regarding the values for the input parameters.

Finally, it is important to mention that the use of the evidential roadside tester and the non-cooperative breath tester may not be legally or socially feasible. There are potential problems associated with illegal search and seizure and the invasion of privacy. These aspects may precipitate serious objectives from both the public and the courts and, therefore, may be detremental to the total impact of the device.

ALCOHOL SAFETY INTERLOCK SYSTEMS (RESTRICTED USE)

The restricted use of the alcohol safety interlock system would be when a convicted DWI driver voluntarily selects this option over a more stringent form of punishment, and therefore, there should not be problems associated with the social acceptance of the device. Technologically, these devices are advanced to the stage where they could be available for use in the near future. However, the CTT and the DAT will require further testing to increase the performance capabilities, e.g., lower the number of false negatives and false positives.

The results of the analyses indicated benefit/cost ratios less than one for most of the alternatives explored for the interlock devices. The reason was due primarily to the extensive cost of maintenance and calibration, installation and removal and inspection. The extent of this impact can be seen in the matrix below which gives the percentage of total system for each of these elements for each device.

Cost Element / Interlock	Maintenance/ Calibration	Installation	Inspection	Removal	Malfunction
Breath Interlock	43%	17%	23%	9%	.003
CTT	25%	30%	20%	15%	.003
DAT	20%	29%	16%	15%	14%

Malfunction cost is included in the matrix to illustrate its significance for the DAT.

While the performance of the CTT and the DAT interlocks could be increased, as Tables 18 and 19 indicate, 100 percent effectiveness would not be sufficient to produce a benefit/cost ratio of one. Clearly, if the interlock devices are to be economically feasible it will be necessary to design a lower cost device.

One obvious area for cost savings would be inspection cost. If the device could be designed so that tampering could be detected when the devices were removed at the end of the probation period, then the threat of serious reprecussions may be an effective deterrence to tampering and the inspection phase could be eliminated as a separate step.

The elimination of inspection cost would not be adequate to produce economic feasibility and it would be necessary to lower the cost of maintenance and calibration and installation and removal. Accordingly, it will be necessary to lower maintenance and calibration cost to $15-20 percent per year for the Breath Interlock and to $0-10 per unit per year for the CTT and the DAT. Also, it will be necessary to lower installation and removal costs to $15 and $7.50 for each device. In the case of the DAT, it will be necessary to lower the malfunction rate as well.

Manufacturing cost, research and development cost and the cost of testing equipment were not significant with respect to the other elements of cost. As Fig. 31 indicates, the benefit/cost ratios are not significantly affected as the number of units in service increases beyond 100,000.

It might be argued that the cost of malfunction is not a direct societal cost and should be borne by those individuals using the device, thereby increasing the benefit/cost ratio. While this argument might have validity, the elimination of the malfunction cost for the Breath Interlock and the CTT would not significantly improve the results, although it would significantly improve the ratios for the DAT.

There is a significant aspect which should be mentioned regarding the BAC trip distribution of these individuals using the interlock systems on a restricted basis. By definition they have been identified as potential problem drinking drivers, and therefore, they may have a much higher than average number of trips at elevated BAC levels. As in the case of the Alcosensor device, the higher frequency of trips at elevated BAC levels can be translated into a proportionally higher savings in crashes. Thus, if DWI drivers accounted for 3 or 4 times the average in elevated BAC trips then the benefit/cost ratios would be 3 or 4 times as large. The result would be that the interlock system would appear much more favorable in comparison to the other countermeasures.

The upshot of this discussion is that in order to be economically feasible, an interlock device must be developed which is performance effective and has a low level of maintenance and calibration, is easy to install and remove, and is virtually tamper proof. While the Breath Interlock device had higher benefit/cost ratios overall, it would appear that the CTT or the DAT would offer a greater potential for success because with the technology in electronics these devices may be refined to where they do not require extensive maintenance and calibration. Since the Breath Interlock works on the basis of the fuel cell, it is not likely that the maintenance and calibration phases could be eliminated.

ALCOHOL SAFETY INTERLOCK SYSTEMS (UNIVERSAL USE)

The same general conclusions regarding the performance of the interlock systems applies for the universal application as in the case of restricted use. However, there are a few significant differences which should be mentioned. In the first instance, substantial cost savings per unit could be achieved as a result of large scale economies of mass production, the elimination of inspection costs and installation and removal costs.

With the elimination of installation and removal costs and inspection costs, the maintenance and calibration costs the single most important element in the cost equation, and as Fig. 37 illustrates the benefit/cost ratio is highly sensitive to changes in maintenance and calibration costs, especially in the range of $0-20 per unit per year. Maintenance and calibration cost as a percentage of total systems cost are given as follows:

	Maintenance and Calibration of Percentage of Total System Cost
Breath Interlock	97.5
CTT	95.4
DAT	86.

While it is likely that social pressure would never allow the universal application of the interlock systems, it is clear that in order to be acceptable a device would have to be developed which has an almost zero malfunction rate, e.g., are out of one million starts. Under these circumstances, it is likely that the DAT interlock or a system of similar complexity would not be acceptable. The CTT even with a relatively low effectiveness rate might be acceptable if the malfunction rate were negligible. The Breath Interlock might be able to meet this requirement, however, it requires frequent maintenance and calibration.

Also, in order to achieve social acceptance, the maintenance and calibration service would have to be negligible. This aspect would probably preclude the Breath Interlock for Universal application. Overall, it would appear that the CTT interlock system would have the greatest probability (although small) of the interlock systems of being applied on a universal basis.

Finally, it is important to indicate that the universal application of the interlock device, if acceptable to the public, could have a tremendous impact on the total number of alcohol related crashes. As seen in Tables 20, 21 and 22, the total savings in societal costs for the universal application of the interlock systems far exceeds that for any of the other countermeasures (although the costs are proportionally much greater as well). Drinking and driving is a universally practiced event in this nation, and if a significant impact on alcohol related crashes is to be achieved, a countermeasure or group of countermeasures with universal coverage must be developed.

OPERATING TIME RECORDER

The operating time clock would be used in cases where convicted DWI drivers elected to have the device installed in their vehicles in lieu of more stringent punishment. The use would be voluntary, as in the case of the interlock systems, and would not involve any legal or social acceptance problems.

The results of the benefit/cost analysis indicate that the operating clock may be an economically feasible device. It would be relatively simple to install and remove and would be inexpensive to manufacture. The analysis revealed that the most sensitive parameters were maintenance and calibration cost, installation and removal cost, inspection cost, and the effectiveness rate.

In the baseline case it was assumed that the maintenance and calibration cost per unit per year would be $25. However, it is likely with the relative simplicity of the device that the maintenance and calibration cost could be much lower, if not almost eliminated. If the device was reliable enough to require maintenance at intervals such as a year or longer, then routine maintenance and calibration could be performed when the device is removed from the vehicle and would be substantially less than if a special trip has to be made for the service.

The operation time recorder would be relatively simple to install and remove, and it should not cost more than $15 and $7.50, respectively. Also, if the device is designed so that tampering can be detected, e.g., a wax seal, and if the threat of severe punishment is imposed, then it would be possible to eliminate the inspection cost.

The effectiveness of the device in keeping the driver off the road during restricted hours is an important aspect and it would be necessary for the device to be at least 80 percent effective in order to be economically feasible. While it is not possible to assess what the effectiveness rate would be until the device can be evaluated in an experimental test situation, it does seem reasonable that with the appropriate threat of punishment and a high probability of violation detection the device would be effective.

As in the case of the interlock systems, the operating time clock would be focused upon a target population that has been identified as a serious drinker/driver, and as such these drivers are likely to account for a larger than average percentage of the trips at illegal BAC levels. To the extent that this is true, the benefit/cost ratios would be proportionally higher and the results would be more favorable.

CONTINUOUS MONITORING DEVICE

The continuous monitoring device would be used in cases where convicted DWI drivers elected to have the devices installed on their vehicles in lieu of more stringent punishment. The use would be voluntary, and it would not involve social acceptance problems. As noted previously, there may be legal problems associated with the use of the device when the driver relies on it to determine if he is sober and is subsequently involved in an accident. The legal ramifications of the use of this device should be explored in more detail.

The results of the benefit/cost analysis revealed that the critical parameters were manufacturing price, effectiveness rate, installation and removal cost, and the inspection cost. The benefit/cost ratio was sensitive to changes in the manufacturing price and a price of approximately $175 per unit would be required for economic feasibility.

The effectiveness rate was a critical parameter in determining the economic feasibility of the continuous monitoring device. As Fig. 40 reveals, an effectiveness rate of 100 percent would not achieve economic feasibility with the baseline values for the cost elements. However, it can be seen that the benefit/cost ratio is highly sensitive to changes in the effectiveness rate and an overall rate of about 80 percent in conjunction with a lower cost structure would be required for economic feasibility. No experimental data were available directly to indicate the effectiveness of the continuous monitoring device. However, simulation studies by Martin reveal that steering wheel reversal rates can be correlated with BAC levels, and this evidence does suggest that a continuous monitor would have potential as an alcohol countermeasure.[22] While it will be necessary to demonstrate that a continuous monitor can descriminate between sober and intoxicated drivers, the real issue in estimating the effectiveness is the determination of the behavioral characteristics of the driver, e.g., will they abide by the results. Further, research and testing will be required before the concept of a continuous monitor can be considered as an alcohol countermeasure.

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[22] Martin, Gary. L., "The Effects of Small Doses of Alcohol on a Simulated Driving Task," Journal of Safety Research, March 1971.

As in the case of the operating time clock, the device must be relatively easy to install and must be tamper proof. Installation and removal cost should be more than $15 and $7.50, respectively and inspection costs should be eliminated.

There are two aspects which may have caused the analysis to understate the benefit/cost ratios for the continuous monitoring device. The first is that the target population would be DWI convicted drivers, and this group may account for a larger than average number of trips at illegal BAC levels. As in the case of the interlock systems, and the operating time clock, to the extent that this aspect is true, the benefit/cost ratio will be proportionally higher.

The second aspect is that the continuous monitoring device may have significant potential as a general countermeasure against fatigue related accidents. While experimental data or the effectiveness of the device in reducing fatigue-related accidents have not been derived, Lear Siegler, Inc., in Oklahoma City, Oklahoma is currently marketing such a device to trucking companies. Thus, if the device were to prove to be an effective countermeasure to combat fatigue related accidents as well as alcohol related accidents, it would bare a correspondingly higher benefit/cost ratio. It is recommended that the utility of this device be explored and evaluated for potential both as an alcohol countermeasure and as a general countermeasure.

SUMMARY OF RESULTS

This chapter has discussed the analysis and interpretation of the research findings. The overall results are summarized in Table 25. The first column gives the specific countermeasure, the second column gives the critical assumptions or variables, and the last column gives the conditions or values of the parameters in order for the countermeasure to be feasible. Feasibility refers to the legal, social, and economic feasibility of the device. Since more than one parameter is involved with each countermeasure, economic feasibility could be achieved with an infinite number of values for the parameters, e.g., increasing price might be offset by increasing effectiveness, and therefore, the requirements for feasibility must be interpreted as representative values with the understanding that adverse circumstances for one parameter may be offset by more favorable circumstances for some other. The values given in the table are meant to be general guidelines and should be interpreted as such.

As indicated earlier, several assumptions had to be made and reliable data were not available for estimating most of the parameters. In order to provide a general indication of the reliability of the data (assumptions) for the models, Table 26 lists the sources used to devise the values for the assumptions for each countermeasure. Finally, it is to be noted, for Table 26, that when "analyst" is cited as the data source, the implication is that an outright assumption with respect to the value of the parameter was made by the analyst. In all other cases, supporting factual data were available.

Table 25

SUMMARY OF CRITICAL ASSUMPTIONS AND VARIABLES FOR COUNTERMEASURES

Countermeasure	Critical Assumptions or Variables	Minimum Requirement for Feasibility
1. Sober Pill	A. Technological Feasibility	A. An agent must be developed which can reduce the effective rate by at least .02-.03.
	B. Dosage Cost	B. Unit dosage cost must not exceed $.50.
2. Self-Tester - Balloon Tester	A. Unit Manufacturing Price	A. Manufacturing price must not exceed $.60.
	B. Effectiveness Rate	B. Effectiveness rate should be at least .75.
3. Self-Tester - Alcosensor Device	A. Maintenance Cost	A. Maintenance cost should not exceed $10.
	B. Effectiveness Rate	B. Effectiveness rate should be at least .75.
	C. Utilization Rate	C. Utilization rate should be at least .80.
	D. Manufacturing Price	D. Cost may be deterrent to social acceptance. Also, price should not exceed $50.
4. Self-Tester - TSC Device	A. Operating Cost	A. Operating cost should not exceed $.35.
5. Evidential Roadside Tester	A. Effectiveness Rate	A. Effectiveness rate must be 1-2 percent of trips at BAC = .10+. This assumption is most critical for feasibility.
	B. Legal Feasibility	B. Laws must be passed which are conducive to the intensive use of these devices.
	C. Court Costs	C. With an effectiveness rate of 1-2 percent court costs, and
	D. Rehabilitation Costs	D. Rehabilitation costs are not limiting factors and could triple or quadruple without affecting feasibility.
	E. Interaction Among Arrests, Public Information, Convictions and Deterrence	E. This interaction determines the effectiveness rate.
6. Non-Cooperative Breath Tester	A. Effectiveness Rate	A. Effectiveness rate must be 1 percent of trips at BAC = .10+ - this assumption is most critical for feasibility.
	B. Court Costs	B. With an effectiveness rate of 1 percent court costs, and
	C. Rehabilitation	C. Rehabilitation costs are not limiting factors and could triple or quadruple without affecting feasibility.
	D. Interaction Among Arrests, Public Information, Convictions and Deterrence	D. This interaction determines the effectiveness rate.
	E. Legal Feasibility	E. Laws must be passed which are conducive to the intensive use of these devices.
7. Alcohol Safety Interlock System Breath Interlock - Restricted Use	A. Maintenance and Calibration Cost	A. Maintenance and calibration cost must be reduced to $15-20 per unit per year
	B. Inspection Cost	B. Inspection cost must be eliminated.
	C. Installation and Removal Cost	C. Installation and removal cost must be no more than $15 and $7.50 respectively.
	D. Effectiveness Rate	D. The device must be virtually tamper-proof.
	E. Legal Feasibility	E. The courts must support the use of the device and special liability laws may ahve to be enacted.
8. Alcohol Safety Interlock System CTT - Restricted Use	A. Maintenance and Calibration Cost	A. Maintenance and calibration cost must be reduced to $0-10 per unit per year
	B. Effectiveness Rate	B. The effectiveness rate must be increased to .80 or greater without a significant increase in the malfunction rate.
	C. Installation and Removal Cost	C. Installation and removal cost must be no more than $15 and $7.50 respectively.
	D. Inspection Cost	D. Inspection cost must be eliminated.
	E. Legal Feasibility	E. The courts must support the use of the device and special liability laws may have to be enacted.

Table 25 (continued)

Countermeasure	Critical Assumptions or Variables	Minimum Requirement for Feasibility
9. Alcohol Safety Interlock System DAT - Restricted Use	A. Installation and Removal Cost	A. Installation and removal cost must not exceed $15 and $7.50 respectively.
	B. Maintenance and Calibration Cost	B. Maintenance and calibration cost must be reduced to $0-10 per unit per year.
	C. Inspection Cost	C. Inspection cost must be eliminated.
	D. Malfunction Cost	D. Malfunction rate must be lowered to .001 or less.
	E. Effectiveness Rate	E. The effectiveness rate must be increased to .80 or greater while reducing the malfunction rate to .001 or less.
	F. Legal Feasibility	F. The courts must support the use of the device and special liability laws may have to be enacted.
10. Alcohol Safety Interlock System Breath Interlock - Universal Use	A. Social Feasibility	A. The greatest deterrent to the feasibility of this device is social acceptance. It seems unlikely.
	B. Maintenance and Calibration Cost	B. Maintenance and calibration cost would have to be less than 5.00 per unit per year.
	C. Malfunction Rate	C. The malfunction rate would have to be extremely low, e.g., 00001, in order for this device to be acceptable socially.
	D. Effectiveness Rate	D. The effectiveness rate would have to be above .95. This means virtually a tamper-proof device.
	E. Legal Feasibility	E. Special liability laws may have to be enacted and it may be necessary to enact laws against tampering with the device.
11. Alcohol Safety Interlock System CTT - Universal Application	A. Social Feasibility	A. The greatest deterrence to the feasibility of this device is social acceptance. It seems unlikely.
	B. Maintenance and Calibration Cost	B. Maintenance and calibration cost would have to be less than 5.00 per unit per year.
	C. Effectiveness Rate	C. The effectiveness rate would have to be increased to .9 or greater and at the same time reducing the malfunction rate.
	D. Malfunction Rate	D. The malfunction rate would have to be extremely low, e.g., .00001, in order for the device to be acceptable socially.
	E. Legal Feasibility	E. Special liability laws may have to enacted and it may be necessary to enact laws against tampering with the device.
12. Alcohol Safety Interlock System DAT - Universal Application	A. Social Feasibility	A. The greatest deterrence to the feasibility of this device is social acceptance. It seems unlikely.
	B. Maintenance and Calibration Cost	B. Maintenance and calibration cost would have to be less than $5.00 per unit per year.
	C. Malfunction Rate	C. The malfunction rate would have to be reduced substantially, e.g., .00001, in order for this device to be acceptable socially.
	D. Effectiveness Rate	D. The effectiveness would have to be at least .9.
	E. Legal Feasibility	E. Special liability laws may have to be enacted and it may be necessary to enact laws against tampering with the device.
13. Operating Time Recorder	A. Maintenance and Calibration Cost	A. Maintenance and calibration cost per unit per year would have to be $10 or less.
	B. Installation and Removal Cost	B. Installation and removal cost must be no more than $15 and $7.50 respectively.
	C. Inspection Cost	C. Inspection cost must be eliminated.
	D. Effectiveness Rate	D. The effectiveness rate must be at least .80.
14. Continuous Monitoring Device	A. Manufacturing Price	A. Manufacturing price should not exceed $175 per unit.
	B. Effectiveness Rate	B. The effectiveness rate must be at least .80.
	C. Installation and Removal Cost	C. Installation and removal cost must be no more than $15 and $7.50 respectively.
	D. Inspection Cost	D. Inspection cost must be eliminated.
	E. Analysis only Performed for Alcohol Countermeasures	E. This device would have significant potential as a general countermeasure against fatigue related crashes and therefore, the potential benefits may be understated. If this is true, the minimum requirements for feasibility would be relaxed accordingly.

Table 26

DATA SOURCES FOR COUNTERMEASURES

SOBER PILL	
1. Utilization Rate	Analyst
2. Unit Dosage Cost	Health Application Systems
3. Research and Development Cost	NHTSA
4. Public Information	Analyst
5. FDA Cost	Analyst
6. Effective Reduction in BAC	Analyst
SELF-TESTER - BALLOON	
1. Utilization Rate	Analyst
2. Purchase Rate	Analyst
3. Unit Price of Tester	TSC-DOT
4. Research and Development Cost	TSC-DOT
5. Public Information Cost	Analyst
SELF-TESTER - ALCOSENSOR	
1. Effectiveness Rate	Analyst
2. Utilization Rate	Analyst
3. Purchase Rate	Analyst
4. Unit Manufacturing Price	TSC-DOT
5. Research and Development Cost	TSC-DOT
6. Public Information Cost	Analyst
7. Maintenance Cost	TSC-DOT
8. Calibration Cost	TSC-DOT
9. Average Times used per Trip	Analyst
SELF-TESTER - TSC DEVICE	
1. Average Units in Service per Year	Analyst
2. Effectiveness Rate	Analyst
3. Percent Normally Reaching BAC = .10-.14	Analyst
4. Percent Normally Reaching BAC = .15+	Analyst
5. Average Times Devices Used per Year	Analyst
6. Average Use per Device per Trip	Analyst
7. Research and Development	TSC-DOT
8. Maintenance and Calibration	TSC-DOT
9. Unit Manufacturing Price	TSC-DOT
10. Public Information Cost	Analyst
11. Unit Operating Cost	TSC-DOT
EVIDENTIAL ROADSIDE TESTER	
1. Average Number of Units in Service	Uniform Crime Reports
2. Effectiveness Rate (Max = 2%)	Analyst
3. Research and Development Cost	TSC-DOT
4. Unit Manufacturing Price	TSC-DOT
5. Maintenance and Calibration Cost	TSC-DOT
6. Public Information	Analyst
EVIDENTIAL ROADSIDE TESTER (continued)	
7. Unit Operating Cost	TSC-DOT
8. Number of Tests per Day per Device	Uniform Crime Reports
9. Incremental Law Enforcement Cost	Analyst
10. Incremental Court Cost	ASAP Evaluation Reports
11. Incremental Rehabilitation Cost	ASAP Evaluation Reports
12. Percent Convicted Sent to Rehabilitation	ASAP Evaluation Reports
13. Daily Increase in Stops per Cruiser	Analyst
14. Percent of Stops with Arrests	ASAP Evaluation Reports
15. Percent of Arrests Resulting in Convictions	ASAP Evaluation Reports
NON-COOPERATIVE BREATH TESTER	
1. Average Number of Units in Service	Uniform Crime Reports
2. Effectiveness Rate (Maximum 1.6%)	Analyst
3. Research and Development Cost	TSC-DOT
4. Unit Manufacturing Price	TSC-DOT
5. Maintenance and Calibration Cost	TSC-DOT
6. Public Information	Analyst
7. Unit Operating Cost	TSC-DOT
8. Number of Tests per Day per Device	Uniform Crime Reports
9. Incremental Law Enforcement Cost	Analyst
10. Incremental Court Cost	ASAP Evaluation Reports
11. Incremental Rehabilitation Cost	ASAP Evaluation Reports
12. Percent Convicted Sent to Rehabilitation	ASAP Evaluation Reports
13. Daily Increase in Stops per Cruiser	Analyst
14. Percent of Stops with Arrests	ASAP Evaluation Reports
15. Percent of Arrests Resulting in Convictions	ASAP Evaluation Reports
BREATH INTERLOCK (RESTRICTED)**	
1. Average Number of Units in Service	Analyst
2. Effectiveness Rate BAC = .10-.14	Dunlop Associates/TSC-DOT
3. Effectiveness Rate BAC = .15+	Dunlop Associates/TSC-DOT
4. Research and Development Cost	TSC-DOT
5. Manufacturing Price	TSC-DOT
6. Installation Cost	TSC-DOT
7. Average Number of Times Installed	Analyst
8. Maintenance and Calibration	TSC-DOT
9. Inspection Cost	TSC-DOT
10. Unit Cost Testing Equipment	TSC-DOT
11. Number of Testing Equipment Stations	TSC-DOT
12. Malfunction Rate	Dunlop Associates
13. Cost per Malfunction	Analyst
14. Unit Removal Cost	TSC-DOT
15. Average Number of Time Removed	Analyst

*These general information sources for the countermeasures were defined in Table 4

**The same sources apply to the assumptions for the interlock under universal applications

Also, when analyst is cited as the source, the implication is that an outright assumption with respect to the value of the parameter was made by the analyst. In all other cases, supporting factual data were available.

Table 26 (continued)

CTT (RESTRICTED)*	
1. Average Number of Units in Service	Analysts
2. Effectiveness Rate BAC = .10-.14	Dunlop Associates/TSC-DOT
3. Effectiveness Rate BAC = .15+	Dunlop Associates/TSC-DOT
4. Research and Development Cost	TSC-DOT
5. Manufacturing Price	TSC-DOT
6. Installation Cost	TSC-DOT
7. Average Number of Times Installed	Analyst
8. Maintenance and Calibration Cost	TSC-DOT
9. Inspection Cost	TSC-DOT
10. Unit Cost of Testing Equipment	TSC-DOT
11. Number of Testing Equipment Stations	TSC-DOT
12. Malfunction Rate	Dunlop Associates
13. Cost per Malfunction	Analyst
14. Unit Removal Cost	TSC-DOT
15. Average Number of Times Removed	Analyst
DAT (RESTRICTED)*	
1. Average Number of Units in Service	Analysts
2. Effectiveness Rate BAC = .10-.14	Dunlop Associates/TSC-DOT
3. Effectiveness Rate BAC = .15+	Dunlop Associates/TSC-DOT
4. Research and Development Costs	TSC-DOT
5. Manufacturing Price	TSC-DOT
6. Installation Cost	TSC-DOT
7. Average Number of Times Installed	Analyst
8. Maintenance and Calibration	TSC-DOT
9. Inspection Cost	TSC-DOT
10. Unit Cost Testing Equipment	TSC-DOT
11. Number of Testing Equipment Stations	TSC-DOT
12. Malfunction Rate	Dunlop Associates/TSC-DOT
13. Cost per Malfunction	Analyst
14. Unit Removal Cost	TSC-DOT
15. Average Number of Times Removed	Analyst

OPERATING TIME CLOCK	
1. Average Number of Units in Service	Analyst
2. Effectiveness Rate	Analyst
3. Percent Alcohol Related Crashes Covered	Analyst
4. Research and Development Cost	TSC-DOT
5. Unit Manufacturing Price	TSC-DOT
6. Average Number of Times Installed	Analyst
7. Maintenance and Calibration Cost	TSC-DOT
8. Unit Inspection Cost	TSC-DOT
9. Unit Installation Cost	TSC-DOT
10. Unit Cost of Testing Equipment	TSC-DOT
11. Number of Testing Equipment Stations	TSC-DOT
12. Removal Cost	TSC-DOT
13. Average Number of Times Removed	Analyst
CONTINUOUS MONITORING DEVICE	
1. Average Number of Units in Service	Analyst
2. Effectiveness Rate BAC = .10-.14	Analyst
3. Effectiveness Rate BAC = .15+	Analyst
4. Research and Development Cost	TSC-DOT
5. Unit Manufacturing Price	Lear Siegler Inc.
6. Unit Installation Cost	TSC-DOT
7. Average Number of Times Installed	Analyst
8. Maintenance and Calibration	TSC-DOT
9. Unit Inspection Cost	TSC-DOT
10. Unit Cost Testing Equipment	TSC-DOT
11. Number of Testing Equipment Stations	TSC-DOT
12. Removal Cost	TSC-DOT
13. Average Number of Times Removed	Analyst

*The same sources apply to the assumptions for the interlocks under universal application.

VII. CONCLUSIONS AND RECOMMENDATIONS

In Chapter VI the analysis and interpretation of the research findings were discussed. In this chapter, the conclusions and recommendations are summarized. While there is a significant amount of uncertainty in many of the estimates and the range for the benefit/cost ratios for each countermeasure is large, the general conclusion is that each countermeasure would be cost/effective if certain technological, performance, and cost conditions are met. The conclusions are as follows:

SOBER PILL

The sober pill would be cost/effective (B/C range = 4.0 - 5.0) at $.25 per dose and an effective reduction in impairment of .04-.05 BAC. The critical considerations in determining the cost effectiveness of the sober pill are:

1. It must be technologically feasible.
2. It must not have undesirable side effects.
3. Use must be at least 1 out of 17,000 trips at BAC $\geqq$.05 percent.
4. Dosage cost - maximum $1.00.

It is recommended that NHTSA sponsor additional research:

1. To develop a drug that can reduce impairment by .04-.05 BAC without undesirable side effects.
2. To develop implementation procedures.

SELF-TESTERS

Self-testers would be cost effective (B/C range = 1.0 - 2.0) if users do not drive 75 percent of the time the BAC indication is greater than or equal to .10 percent. The critical considerations in determining the cost effectiveness of the self-testers are:

1. The driver deterrence rate is unknown.
2. Use must be at least 1 out of 10,000 trips at BAC $\geqq$.10 percent.
3. Cost per use must not exceed $.80.

It is recommended that NHTSA sponsor additional research:

1. To determine the expected public usage and deterrence under different conditions.
2. To develop implementation procedures.

EVIDENTIAL ROADSIDE TESTER

The evidential roadside tester would be cost/effective (B/C range = 1.0 - 2.0) if the deterrence impact is 1-2 percent of illegal BAC trips ($\geqq$.10 percent). The critical considerations in determining the cost effectiveness of the evidential roadside tester are:

1. Driver deterrence is unknown.
2. Acceptance and use by law enforcement agencies is unknown.
3. A minimum of 100 units must be in service per year.
4. Incremental court costs per case must not exceed $100.
5. Incremental rehabilitation costs per case must not exceed $250.

It is recommended that NHTSA sponsor additional research:

1. To determine the deterrence potential.
2. To determine the police/court willingness to use the device.
3. To develop implementation procedures.

NON-COOPERATIVE BREATH TESTER

The non-cooperative breath tester would be cost/effective (B/C range = 1.0 - 2.0) if deterrence impact is 1-2 percent of illegal BAC trips. The critical considerations in determining the cost effectiveness of the non-cooperative breath tester are:

1. The driver deterrence rate is unknown.
2. Use must comply with existing legal constraints (e.g., illegal search and seizure laws).
3. A minimum of 100 units must be in service per year.
4. Incremental court costs per case must not exceed $75.
5. Incremental rehabilitation costs per case must not exceed $200.

It is recommended that NHTSA sponsor additional research:

1. To determine the deterrence potential.

2. To develop a device that meets the specified performance and cost specifications.

3. To assess the legal constraints.

4. To develop implementation procedures.

ALCOHOL SAFETY INTERLOCK SYSTEM

The alcohol safety interlock system would be cost effective (B/C range = 1.0 - 2.0) if a device could be developed with at least a 50 percent effectiveness rate at BAC $\geqq$.10 percent, is tamperproof, and requires minimal maintenance and installation cost. The critical considerations in determining the cost effectiveness of the alcohol safety interlock systems are:

1. The effectiveness rate must be at least 50 percent.

2. The courts must be willing to impose its use (restricted use).

3. The annual maintenance cost must not exceed $10 per unit.

4. Installation and removal cost must not exceed $15 and $7.50 respectively (restricted use).

5. There must be no inspection cost.

6. If used on a restricted basis, a minimum of 1,000 units per year must be in service.

It is recommended that NHTSA sponsor additional work:

1. To develop a device that meets the stated performance and cost requirements.

2. To determine the deterrence potential.

3. To determine the court's willingness to use the device (restricted use).

4. To determine the social acceptance potential (universal use).

5. To develop implementation procedures.

CONTINUOUS MONITORING DEVICE

The continuous monitoring device would be cost effective (B/C = 1.0 - 1.5) if DWI drivers abide by the warning 50-60 percent of the time. The critical considerations in determining the cost effectiveness of the continuous monitoring device are:

1. It must be technologically feasible.
2. The driver deterrence rate is unknown.
3. The courts must be willing to impose its use.
4. A minimum of 10,000 units must be in service per year.
5. The manufacturing price must not exceed $175 - $200 per unit.
6. Installation and removal cost must not exceed $15 and $7.50 respectively.

It is recommended that NHTSA sponsor additional research:

1. To develop a device that correlates driving impairment with BAC level.
2. To determine the deterrence potential.
3. To determine the court's willingness to use the device.
4. To develop implementation procedures.

OPERATING TIME RECORDER

The operating time recorder would be cost effective (B/C = 1.0 - 2.0) if it were 50-60 percent effective in eliminating illegal BAC trips during restricted hours. The critical considerations in determining the cost effectiveness of the operating time recorder are:

1. The driver deterrence rate is unknown.
2. The courts must be willing to impose its use.
3. The restricted hours must encompass 50 percent of alcohol trips.
4. A minimum of 10,000 units must be in service per year.
5. The annual maintenance and calibration cost must not exceed $10 per unit.
6. The installation and removal cost per unit must not exceed $15 and $7.50 respectively.

It is recommended that NHTSA sponsor additional work:

1. To determine the deterrence potential.
2. To determine the court's willingness to use the device.
3. To develop implementation procedures.

APPENDIX A

GENERATION OF BAC DISTRIBUTIONS

As noted previously, existing BAC data were collected for night/weekend periods and it was necessary to make estimates for the BAC distributions for day/week, day/weekend, and night/week. The existing data from the National Roadside Survey were used as the starting point, and the following steps were followed:

1. A two dimensional matrix for BAC = .00 - .01 was established. Day was defined to be 6:00 a.m. - 6:00 p.m. Night was defined to be 6:00 p.m. - 6:00 a.m. Week was defined to be Monday, Tuesday, Wednesday, and Thursday. Weekend was defined to be Friday, Saturday, and Sunday.

	Day	Night	Totals
Week			
Weekend		.774	.855
Totals		.797	

2. It was determined from the National Roadside Survey data that 36 percent of all driving is at night and 64 percent of driving is during the day. Also, from Zylman, it was determined that weekend BAC = .00-.01 is equal to .855 and night BAC = .00-.01 is equal to .797.[23] Furthermore, it was assumed that trips were proportional to crashes and from the Grand Rapids data, it was determined that 35 percent of crashes were on the weekend and 65 percent during the week.

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[23] Zylman, Richard, "Analysis of Studies Comparing Collision-Involved Drivers and Non-Involved Drivers," Journal of Safety Research, September 1971, p. 116.

	Day	Night	Totals	
Week				65%
Weekend		.774	.855	35%
Totals		.797		
	64%	36%		

3. The information in step #2 was adequate to solve for the remaining values in the matrix.

$$.774\ (.35) + X(.65) = .797$$

$$X = .809$$

$$.774\ (.36) + Y(.64) = .855$$

$$Y = .901$$

$$\frac{.809}{.774}\ .901 = .941$$

	Day	Night	Totals
Week	.941	.809	
Weekend	.901	.774	.855
Totals		.797	

4. The next step was to determine the percentage of trips made for the four categories. A review of the fatal crash and injury crash data for the Delaware ASAP site revealed that the actual percentages for day/week cells were within 5 to 10 percent of the products of the total percentages. Maintaining the assumption that trips are proportional to crashes, the trip percentages were determined as follows:

Percent of trips day/week = (.64)(.65) = .416
Percent of trips day/weekend = (.64)(.35) = .224
Percent of trips night/week = (.36)(.65) = .234
Percent of trips night/weekend = (.31)(.35) = .126

5. Assuming 114,397,000 licensed drivers and 912.5 trips per year, the distribution of total trips by time of day/day of week is as follows:

Total Trips = (114,397,000)(912.5)
= 104,387,262,500

	Day	Night	Totals
Week	43,425,101,200	24,426,619,430	67,851,720,630
Weekend	23,382,746,800	13,152,795,080	36,535,541,880
Totals	66,807,848,000	37,579,414,510	104,387,262,300

6. The distribution of total trips by BAC is given as follows. The values for BAC = .00-.01 are taken from above, e.g., .773, .809, .901 and .941, and it was assumed that the distribution of trips for the night/week, day/weekend, and day/week period were proportional to the distribution for the night/weekend period. Relying on this assumption, the distribution of trips by BAC can be readily calculated and is given below.

Trips at BAC	Night/Weekend	Night/Week	Day/Weekend	Day/Week	Totals
.00-.01	10,167,110,600	19,761,135,120	21,067,854,870	40,863,020,230	91,859,120,820
.02-.04	1,210,057,146	1,880,849,696	935,309,872	1,042,202,419	5,068,419,133
.05-.07	802,320,500	1,245,757,591	631,334,164	694,801,619	3,374,213,874
.08-.09	315,667,081	488,523,389	233,827,468	260,550,607	1,298,568,545
.10-.14	473,500,622	757,225,202	374,123,949	390,825,911	1,995,675,684
.15+	184,139,131	293,119,433	140,296,481	173,700,405	791,255,450
Totals	13,152,795,080	24,426,619,430	23,382,746,800	43,425,101,200	104,387,262,500

The aggregate BAC distribution of trip totals is given as:

Trips at BAC	Percentage
.00-.01	.879
.02-.04	.049
.05-.07	.032
.08-.09	.013
.10-.14	.020
.15+	.008

APPENDIX B
QUALIFICATION AND PARTICIPATION OF RESEARCHERS

This study was performed by the following individuals:

Wm. Shepherd Moore, Ph.D.
Jose F. Imperial, M.A.
Joan Tunstall, B.S.
Marvin H. Wagner, LLM
Paul M. Hurst, Ph.D.

Dr. Moore is the Associate Director for the Policy Analysis Department, General Research Corporation. Dr. Moore is an economist and operations research analyst, and as project director for this study, he was responsible for coordinating the activities with NHTSA and directing the research team throughout the contract period. Dr. Moore developed the benefit/cost methodologies for the countermeasures and was responsible for the documentation of the final report.

Ms. Tunstall is a senior programmer analyst for the Policy Analysis Department, General Research Corporation. She developed the programs which were used to computerize the benefit/cost models for the countermeasures.

Mr. Imperial is an economist for the Policy Analysis Department, General Research Corporation. Mr. Imperial contributed in the areas of data collection, review of literature, cost estimation, benefit measurement, and estimation of accident-reducing potential of the countermeasures. Also, Mr. Imperial contributed to the documentation of the final report.

Mr. Wagner is an attorney and President of M.H. Wagner Company, a private consulting firm. Mr. Wagner contributed in the areas of data collection, literature review, assessment of the social, technological and legal feasibility of the countermeasures and he also contributed to the documentation of the final report.

Dr. Hurst is President of the Institute for Highway Safety. He is an experimental psychologist and he has had extensive experience in the area of highway safety. Dr. Hurst developed the relative probability model used to estimate the accident-reducing potential for each of the countermeasures, and he contributed to the overall methodology for assessing the countermeasures.

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