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EVALUATION OF MOTOR VEHICLE EMISSIONS INSPECTION AND MAINTENANCE PROGRAMS IN OHIO PHASE II

Final Report

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ABSTRACT

Recent data for the State of Ohio indicates that the National Ambient Air Quality Standards for CO and O_x will not be attained in all areas of the state by 1982, even if all reasonably available control technologies are applied. In view of this, it is likely that the state will request from U.S. EPA an extension of the compliance date beyond 1982. In order for this request to be considered, the state must, among other things, have adopted a firm schedule for implementing a motor vehicle inspection and maintenance (I/M) program in the highly urbanized nonattainment areas. In this connection, the State of Ohio is currently in the initial stages of planning for the implementation of an I/M program. As part of this initial effort, several candidate program configurations have been analyzed from the standpoint of costs, benefits, and other requirements. These analyses, which are reported herein, will provide the basis for the state to select one specific option that will eventually be implemented.

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SECTION 1

EXECUTIVE SUMMARY

INTRODUCTION

Need for Inspection/Maintenance Programs

Recent ambient air quality data for the State of Ohio indicates widespread and frequent violations of the National Ambient Air Quality Standards (NAAQS) for carbon monoxide (CO) and photochemical oxidants (O_x).[1] These national standards have been established in order to protect the health and welfare of the population.[2] Both CO and O_x are gases which in sufficient concentrations in the atmosphere are potentially harmful to the public health. A major source of CO and O_x in Ohio are the motor vehicles. Carbon monoxide is directly produced by gasoline-burning internal combustion engines and photochemical oxidants are indirect products, formed through a complex series of atmospheric reactions in which two other direct products of combustion, unburned gaseous hydrocarbons (HC) and oxides of nitrogen (NO_x) combined in the presence of sunlight. Inspection/maintenance programs are a cost-effective strategy to reduce these emissions from motor vehicles. Other strategies that have been suggested, such as restricting travel, are more difficult to enforce, tend to reduce individual mobility and may require major changes in driving habits. By significantly reducing the emission of HC and CO from in use motor vehicles in Ohio, an I/M program will enhance the likelihood of the attainment of NAAQS.

The Clean Air Act Amendments of 1977 have specific provisions that require the establishment of inspection/maintenance programs. According to the U.S. EPA, the state must submit by January 1979 revisions to its State Implementation Plan (SIP), which specifies methods to achieve the National Ambient Air Quality Standards. These methods include control of stationary sources of air pollution and various transportation control measures whose objective is to reduce vehicle miles traveled (VMT) and hence reduce pollution from sources such as motor vehicles. If in these revisions, the state cannot demonstrate attainment of the NAAQS by 1982 by using all reasonably available pollution control measures, then an extension to 1987 can be requested if several provisions are met. One such provision is the establishment of a specific schedule for the implementation of an I/M program. Because it is doubtful that the NAAQS can be attained in many areas of Ohio through other measures, an I/M program is likely to be required.

What Are Inspection/Maintenance Programs?

In the inspection phase of I/M the motor vehicle exhaust emissions are measured and compared to the applicable standards for the vehicle. If the vehicle fails the exhaust emission test then it must be repaired. This is the maintenance phase of I/M.

The Federal Motor Vehicle Control Program (FMVCP) under the Federal Clean Air Act of 1970 was established to ensure that new cars coming off the assembly line are designed to meet increasingly stringent emission standards. The FMVCP consists of three parts including certification of prototype vehicles prior to actual production, selective enforcement testing of vehicles at the assembly line, and testing of in-use vehicles around the country to discover design defects in emission controls as well as to provide data to recall vehicles with inadequate or defective emission devices. Federal testing of in-use vehicles throughout the United States, unfortunately, has demonstrated that motor vehicles are not meeting the emission standards for which they are designed. The primary reasons the vehicle exceed the standards include improper or inadequate maintenance, tampering, and defective emission control devices. Regardless of the cause, it has become clear that some in-use vehicle emission inspection programs are necessary to ensure that the emission controls continue to operate as they were intended over their useful life.

A variety of approaches have been used to run I/M programs, but the major types are generally in three organizational categories as follows:

1. Government - Centralized test facilities operated by state, city, or local government (as in New Jersey; Cincinnati, Ohio; Portland, Oregon; and Chicago, Illinois).

2. Contractor - Centralized facilities operated by a private corporation under contract to a government (as in Maricopa and Pima Counties, Arizona).

3. Private Garage - Decentralized facilities operated by private automobile service garages, certified or licensed by a government (as in Rhode Island and Nevada).

The major issues that need to be addressed in setting up an I/M program include the following:

1. Type of Emissions Test - Idle or Loaded
2. Geographical Coverage
3. Organizational Approach
4. Frequency of Inspection
5. Enforcement Procedure

The other program areas or issues which will require more attention in the detailed evaluation of the selected option and also during the program design phase are the following:

1. Type of Motor Vehicles To Be Tested
2. Vehicle Exemptions
3. Data Handling

4. Mechanic Training
5. Quality Assurance
6. Consumer Protection
7. Public Education

Background of This Study

In order to meet the requirements of the Clean Air Act Amendments of 1977 in establishing a schedule of implementation for an I/M program in Ohio, the Ohio Inspection/Maintenance Advisory Group was established early in 1978. The Ohio I/M Advisory Group met in March 1978 to initiate action on considering various possible I/M options and to select the option most suited to the needs and desires of the State of Ohio. The Advisory Group is composed of members of various agencies including representatives of the Ohio Environmental Protection Agency, the Department of Highway Safety which includes the Bureau of Motor Vehicles and the State Highway Patrol, the Department of Transportation, the Attorney General's Office, the Governor's Office, and the Department of Energy.

The initial effort of the I/M Advisory Group was the development of background data regarding the technical and administrative aspects of I/M programs. A summary report describing I/M program elements and other states' experience in I/M and various technical memoranda were produced to assist in the selection of a limited number of I/M options. In April 1978 the Advisory Group selected seven I/M program options, which will be described later in this section. The purpose of this report is to analyze these seven options in terms of their costs and benefits such that the Advisory Group may then select one option for detailed study, which will constitute the final task of the overall work program.

THE SEVEN I/M PROGRAM OPTIONS

As indicated earlier, the Ohio I/M Advisory Group has selected seven specific program options for evaluation. All seven options have in common these elements:

- Idle mode testing
- Annual inspection
- Motor vehicle registration enforcement
- Ohio Environmental Protection Agency and Bureau of Motor Vehicles as administrative agencies

The seven options are shown in Table 1.

TABLE 1. SEVEN OHIO I/M PROGRAM OPTIONS

- OPTION I
  - Statewide coverage
  - Contractor administers centralized lanes in urban areas
  - Private garages in rural areas
    - Alternate A - 12 urban counties - all counties with population greater than 200,000
    - Alternate B - 18 urban counties - 12 counties with population greater than 200,000 plus 6 adjacent counties
- OPTION II
  - Statewide coverage
  - State administers centralized lanes in urban areas
  - Private garages in rural areas
    - Alternate A - 12 urban counties
    - Alternate B - 18 urban counties
- OPTION III
  - Urban counties only
  - Contractor administers centralized lanes
    - Alternate A - 12 urban counties
    - Alternate B - 18 urban counties
- OPTION IV
  - Urban counties only
  - State administers centralized lanes
    - Alternate A - 12 urban counties
    - Alternate B - 18 urban counties
- OPTION V
  - Statewide coverage
  - Contractor administers centralized lanes in urban areas
  - State highway patrol conducts random inspection in rural areas
    - Alternate A - 12 urban counties
    - Alternate B - 18 urban counties

(continued)

TABLE 1 (continued). SEVEN OHIO I/M PROGRAM OPTIONS

- OPTION VI
  - Statewide coverage
  - State administers centralized lanes in urban areas
  - State highway patrol conducts random inspection in rural areas
    - Alternate A - 12 urban counties
    - Alternate B - 18 urban counties
- OPTION VII
  - Statewide coverage
  - Private garage testing in urban and rural areas
  - State or contractor conducts surveillance/quality control of garages

Urban Counties

The 12 urban counties with populations greater than 200,000 that would be covered in Alternate A are listed below:

1. Butler County
2. Cuyahoga County
3. Franklin County
4. Hamilton County
5. Lake County
6. Lorain County
7. Lucas County
8. Mahoning County
9. Montgomery County
10. Stark County
11. Summit County
12. Trumbull County

The six adjacent urban counties included in Alternate B are as follows:

1. Clermont County
2. Geauga County
3. Greene County
4. Medina County
5. Warren County
6. Wood County

The 12 urban counties with populations greater than 200,000 and six additional counties are shown in Figure 1.

In determining which counties should be included in the geographical coverage of the I/M program several factors were considered. According to the U.S. EPA the minimum acceptable area for an I/M program includes urbanized areas with populations greater than 200,000 for which extensions to 1987 have been requested for the attainment of CO and HC NAAQS. For enforcement purposes, counties were decided upon as jurisdictional boundaries. The smallest geographical coverage considered includes the 12 urban counties with populations greater than 200,000 (as in Alternate A). In addition, since the urban area definition includes portions of several adjacent counties where commuter travel is significant, six more counties were added, which resulted in the 18 county Alternate B.

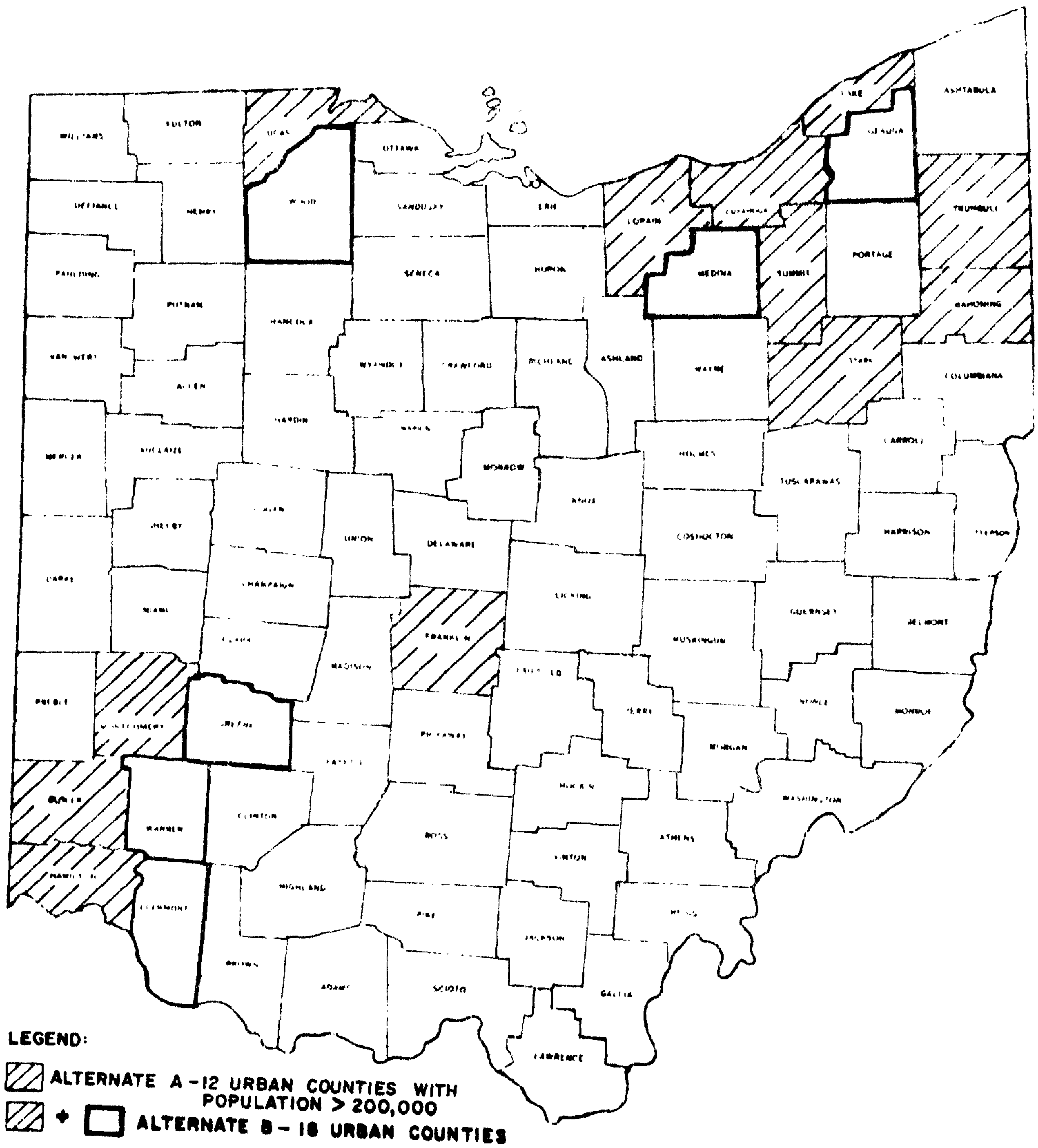

Figure 1. Urban counties in Ohio.

STUDY FINDINGS

Comparison of Emission Reduction Benefits

The levels of emission reduction that result from the implementation of I/M programs depends on the number of vehicles inspected in the program and also on the travel characteristics in the county where the vehicles are registered. This is because emission reduction credits are calculated as grams per mile multiplied by the VMT (vehicle miles traveled) per unit of time. The emission reductions ("tail pipe reductions") refer to the decrease in carbon monoxide (CO) and hydrocarbons (HC) from the I/M vehicles. The resulting change in the concentrations of these substances in the ambient atmosphere is not being considered here.

The emission reductions vary according to the geographical coverage. As the geographical coverage is increased, more vehicles are included in the program. However, the actual emission reductions are modified to a degree by the fact that, due to commuting patterns, there is overlap in travel among the counties. Vehicles traveling outside their county of registration, in other words, may either increase or decrease the emission reductions in the counties traveled to, depending on whether the counties traveled to or from have I/M programs. If vehicles registered in a county with I/M regularly travel to counties without I/M, then the county traveled to will experience a benefit in emission reduction. Conversely, if vehicles registered in counties without I/M travel to a county with I/M, then the county traveled to would experience less benefits. In the calculations made in this study (described in detail in Section 2 - Benefits, and Appendix A) all the above factors have been considered.

To estimate the emission reductions, the options have been grouped into three benefit scenarios as shown below:

BENEFIT SCENARIOS

	12 Most populous counties	6 Next populous counties	Remainder of state
First scenario: (Options I, II, VIIO	Mandatory inspection	Mandatory inspection	Mandatory inspection
Second Scenario: (Options III, IV, V, VI under Alternate B)	Mandatory inspection	Mandatory inspection	NO mandatory inspection
Third Scenario: (Options III, IV, V, VI, under Alternate A)	Mandatory inspection	NO mandatory inspection	NO mandatory inspection

Within each benefit scenario the geographic areas having mandatory inspection are identical. In benefit scenario 1, all I/M programs are statewide and mandatory. In the second and third scenarios there is mandatory inspection only in the urban; i.e., most populous areas, whereas in the remainder of the state there is no mandatory inspection. In Options V and VI the random pullover inspection program for the rural areas does not constitute mandatory inspection.

Table 2 presents the benefits (percent reduction in daily vehicle emissions) for 1987 that result from an I/M program beginning in 1982. In terms of carbon monoxide it may be seen that in scenario 1 the statewide mandatory inspection options bring about the highest level of emission reduction of 27 percent throughout the state. Next, the second scenario with mandatory I/M in the 18 urban counties gives the second highest reduction 25, 3, and 17 percent in the 18 urban counties, remaining rural, and statewide average, respectively. Finally, the third scenario, with mandatory inspection in the 12 urban counties with populations greater than 200,000 have the least emission reduction of 23, 3, and 15 percent for the 18 counties, remaining counties, and statewide average, respectively. As discussed earlier in both the second and third scenarios in the counties without I/M, there is some emission reduction due to inspected vehicles traveling to these counties. The reductions in hydrocarbons follows the same pattern as the carbon monoxide reductions, discussed above.

TABLE 2. PERCENT REDUCTION IN DAILY VEHICLE EMISSION RESULTING FROM I/M IN 1987*

	First Scenario (Options I, II and VII)	Second Scenario (Options III, IV, V, VI, under Alternate B)	Third Scenario (Options III, IV, V, VI, under Alternate A)
CARBON MONOXIDE			
18 Counties	27	25	23
Rural areas	27	3	3
Statewide	27	17	15
HYDROCARBONS			
18 Counties	22	21	19
Rural areas	22	2	2
Statewide	22	14	12

*No reductions in light-duty truck emissions was calculated because the credits for this particular vehicle category have yet to be established by EPA. Appropriate adjustments will be made when the credits are made available.

TABLE 3. EMISSIONS AND PERCENT REDUCTIONS IN SCENARIO 1, OPTIONS I, II, AND VII (kg/day)*

County	Hydrocarbons					Carbon monoxide				
	1977	1987 without I/M	1987 I/M	Percent† reduction between 1977 and 1987, I/M plus FMVPC	1987 reduction due to I/M	1977	1987 without I/M	1987 I/M	Percent† reduction between 1977 and 1987, I/M	1987 reduction due to I/M
Butler	26,495	10,676	8,277	68.8	22.5	195,628	106,494	77,712	60.3	27.0
Cuyahoga	144,270	54,544	42,772	70.4	21.6	1,090,073	554,660	397,580	63.5	28.3
Franklin	68,261	26,477	19,830	71	25.1	459,838	254,564	187,834	59.2	26.2
Hamilton	91,740	40,072	31,547	65.6	21.3	721,871	397,954	290,544	59.8	27.0
Lake	25,506	9,393	7,322	71.3	22.1	178,360	94,447	68,856	61.4	27.1
Loraine	10,132	3,659	2,884	71.5	21.2	68,283	37,066	27,375	59.9	26.1
Lucas	31,713	11,605	9,116	71.3	21.5	210,184	107,828	86,836	58.7	19.5
Mahoning	20,390	7,344	5,836	71.4	20.5	136,419	72,990	54,182	60.3	25.8
Montgomery	39,894	14,534	11,437	71.3	21.3	266,402	153,684	108,809	59.2	29.2
Stark	26,149	9,158	7,149	72.7	21.9	175,498	92,073	67,102	61.8	27.1
Summit	42,177	15,571	12,255	71	21.3	283,204	157,791	116,866	58.7	25.9
Trumbull	20,772	7,358	5,819	72	20.9	140,188	80,281	60,864	56.6	24.2
Total - 12 counties	547,499	210,391	164,244	70	21.9	3,925,948	2,109,832	1,548,554	60.6	26.6
Clermont	11,668	5,530	4,395	62.3	20.5	85,822	52,620	38,723	54.9	26.4
Geauga	4,330	1,531	1,192	72.5	22.2	31,163	15,348	11,107	64.4	27.6
Greene	5,720	2,111	1,673	70.6	20.8	38,361	22,849	17,361	54.7	24.0
Medina	8,040	3,360	2,642	67.1	21.4	54,832	33,512	25,525	53.4	23.8
Warren	12,938	6,719	5,307	59	21	91,231	67,871	50,395	44.8	25.7
Wood	9,563	3,792	3,044	68.2	19.7	63,849	38,760	29,457	53.9	24.0
Total - 6 counties	52,259	23,043	18,253	65.1	20.8	365,318	230,960	172,568	52.8	25.3
Total - 18 counties	599,758	233,434	182,497	69.6	21.8	4,291,266	2,340,792	1,721,122	59.9	26.5

*No reduction in light-duty truck emissions was included because the credits for this particular vehicle category have yet to be established by EPA. Appropriate adjustments will be made when the credits are made available.

†Reduction attributable to Federal Motor Vehicle Control Program (FMVCP) and I/M.

TABLE 4. EMISSIONS AND PERCENT REDUCTIONS IN SCENARIO 2, OPTIONS III, IV, V, AND VI UNDER ALTERNATE B (kg/day)*

County	Hydrocarbons					Carbon monoxide				
	1977	1987 without I/M	1987 I/M	Percent† reduction between 1977 and 1987, I/M plus FMVPC	1987 reduction due to I/M	1977	1987 without I/M	1987 I/M	Percent† reduction between 1977 and 1987, I/M	1987 reduction due to I/M
Butler Co.	26,495	10,676	8,370	68.4	21.6	195,628	106,494	78,846	59.7	17.4
Cuyahoga Co.	144,270	54,544	42,893	70.3	21.4	1,090,073	554,660	399,198	63.4	28.0
Franklin Co.	68,261	26,477	20,193	70.4	23.7	459,838	254,564	191,484	58.4	24.8
Hamilton Co.	91,740	40,072	32,157	65.0	19.6	721,871	397,954	301,762	58.2	24.2
Lake Co.	25,506	9,393	7,368	71.0	21.6	178,360	94,447	69,422	61.1	26.5
Lorain Co.	10,132	3,659	2,907	71.3	20.6	68,283	37,066	27,658	59.5	25.4
Lucas Co.	31,713	11,605	9,247	70.9	20.3	210,184	107,828	87,942	58.2	18.2
Mahoning Co.	20,390	7,344	5,891	71.1	19.8	136,419	72,990	54,867	59.8	24.8
Montgomery Co.	39,894	14,534	11,581	71.0	20.3	266,402	153,684	110,891	58.4	27.9
Stark Co.	26,149	9,158	7,313	72.0	20.2	175,498	92,073	68,151	61.2	26.0
Summit Co.	42,177	15,571	12,367	70.7	20.6	283,204	157,791	118,249	58.3	25.0
Trumbull Co.	20,772	7,358	5,874	71.7	20.2	140,188	80,281	61,555	56.1	23.3
Total - 12 counties	547,499	210,391	166,161	69.7	21.0	3,925,948	2,109,832	1,570,025	60.0	25.6
Clermont Co.	11,668	5,530	4,464	61.8	19.3	85,882	52,620	39,571	53.9	24.8
Geauga Co.	4,330	1,531	1,208	72.1	21.1	31,163	15,348	11,302	63.7	17.4
Green Co.	5,720	2,111	1,712	70.0	18.9	38,361	22,849	17,847	53.5	21.9
Medina Co.	8,040	3,360	2,684	66.6	10.8	54,832	33,512	25,996	52.6	22.4
Warren Co.	12,938	6,719	5,362	58.6	20.2	91,231	67,871	51,077	44.0	24.8
Wood Co.	4,563	3,792	3,093	67.7	18.4	63,849	38,760	30,062	52.9	17.8
Total - 6 counties	52,259	23,643	18,523	64.6	21.7	365,318	230,960	175,844	51.9	23.9
Total - 18 counties	599,758	233,434	184,684	69.2	20.9	4,291,266	2,340,792	1,745,880	59.3	25.4

*No reduction in light-duty truck emissions was included because the credits for this particular vehicle category have yet to be established by EPA. Appropriate adjustments will be made when the credits are made available.

†Reduction attributable to Federal Motor Vehicle Control Program (FMVCP) and I/M.

TABLE 5. EMISSIONS AND PERCENT REDUCTIONS IN SCENARIO 3, OPTIONS III, IV, V, AND VI UNDER ALTERNATE A (kg/day)*

County	Hydrocarbons					Carbon monoxide				
	1977	1987 without I/M	1987 I/M	Percent† reduction between 1977 and 1987, I/M plus FMVPC	1987 reduction due to I/M	1977	1987 without I/M	1987 I/M	Percent† reduction between 1977 and 1987, I/M	1987 reduction due to I/M
Butler Co.	26,495	10,676	8,407	68.3	21.3	195,628	106,494	79,292	59.5	25.6
Cuyahoga Co.	144,270	54,544	43,085	70.1	21.0	1,090,073	554,660	404,758	62.9	27.0
Franklin Co.	68,261	26,477	20,193	70.4	23.7	459,838	254,564	191,484	58.4	24.8
Hamilton Co.	91,740	40,072	32,458	64.6	19.0	721,871	397,954	305,712	57.7	23.2
Lake Co.	25,506	9,393	7,403	71.0	21.2	178,360	94,447	69,857	60.8	26.0
Lorain Co.	10,132	3,659	2,909	71.3	20.5	68,283	37,066	27,682	59.5	25.3
Lucas Co.	31,713	11,605	9,315	70.6	19.7	210,184	107,828	88,518	57.9	17.9
Mahoning Co.	20,390	7,344	5,891	71.1	19.8	136,419	72,990	54,867	59.8	24.8
Montgomery Co.	39,894	14,534	11,758	70.5	18.1	266,402	153,684	113,454	57.4	26.2
Stark Co.	26,149	9,158	7,233	72.3	21.0	175,498	92,073	68,151	61.2	26.0
Summit Co.	42,177	15,571	12,407	70.6	20.3	283,204	157,791	118,745	58.1	24.8
Trumbull Co.	20,772	7,358	5,876	71.7	18.0	140,188	80,281	61,579	56.1	23.3
Total - 12 counties	547,499	210,391	166,945	69.6	20.9	3,925,598	2,109,832	1,584,099	59.7	24.9
Clermont Co.	11,668	5,530	5,445	53.3	1.5	85,882	52,620	51,583	39.9	1.9
Geauga Co.	4,330	1,531	1,491	65.6	2.0	31,116	15,348	14,845	52.4	3.3
Greene Co.	5,720	2,111	2,053	64.1	2.7	38,361	22,849	22,118	42.4	3.2
Medina Co.	8,040	3,360	3,305	58.9	1.6	54,832	33,512	32,899	40.0	1.8
Warren Co.	12,938	6,719	6,582	49.1	2.0	91,231	67,871	66,169	27.5	2.5
Wood Co.	9,563	3,792	3,672	61.6	3.2	63,849	38,760	37,261	41.7	3.9
Total - 6 counties	52,259	23,643	22,548	56.9	2.0	365,318	230,960	224,875	38.5	2.6
Total - 18 counties	599,758	233,434	189,493	68.4	18.8	4,291,266	2,340,792	1,808,974	57.9	22.7

*No reduction in light-duty truck emissions was included because credits for this particular vehicle category have yet to be established by EPA. Appropriate adjustments will be made when the credits are made available.

†Reduction attributable to Federal Motor Vehicle Control Program (FMVCP) and I/M.

Tables 3 through 5 present much more detailed emissions and emission reduction figures by county both in actual emission levels by volume and in percent reduction levels with and without I/M programs. In the first three columns for HC and CO actual emissions are given. The first column for HC and CO shows total emissions in 1977, the base year. Next, the emissions expected in 1987 without an I/M program are given. The lower figures for 1987 as compared to 1977 are attributable to the Federal Motor Vehicle Emission Control Program (FMVCP) and changes in VMT. The third column, 1987 I/M, indicates the level of emissions that would occur with I/M in addition to the FMVCP. The fourth columns (HC and CO) percent reduction between 1977 and 1987 I/M give the percent reduction for the total vehicle population (not just the inspected vehicles) emissions that would occur as a result of FMVCP, and an I/M program. Finally, the fifth columns, 1987 reduction due to I/M, present the percent reduction on emissions from all vehicles that is attributable to I/M in addition to the FMVCP. In other words, this is the additional reduction above that which would have occured in 1987 without I/M.

Fuel Economy Benefits

One of the important benefits of I/M programs, in addition to the reduction in vehicular emissions, is potential fuel conservation. A properly tuned engine operates with greater efficiency and therefore, consumes less fuel. This improvement in fuel economy varies somewhat from one program to another but most sources agree that a 5 to 10 percent fuel economy improvement for the failed and maintained vehicles can be expected.[3] This may understate the overall fleet improvement as some motor vehicle owners are likely to schedule tune-ups just prior to having their cars inspected. One of the purposes of I/M is to give an incentive to motorists to maintain their cars better than they normally would in the absence of I/M.

A 7 percent fuel economy improvement was utilized in this study to calculate the fuel savings from the I/M program options. With a stringency (failure) rate of 30 percent, the amount of fuel saved averaged for the total motor vehicle population will amount to a 2.1 percent of total fleet fuel consumption. For a detailed discussion of the methodology used for calculating fuel savings the reader is referred to Appendix B - Estimated Fuel Savings Resulting from I/M in 1987. As shown below, for the 12 county Alternate A, 28,898,530 gallons of fuel would be saved in 1987. At $0.70 per gallon, vehicle owners will save $20,228,970 which is approximately $11.80 per failed vehicle. If coverage is extended to 18 counties as in Alternate A, motorists will consume 31,844,630 fewer gallons than without I/M saving a total of $22,291,241, which is approximately $11.85 per failed vehicle. The statewide program coverage provides the largest savings of 37,171,280 gallons which would amount to $26,019,896, which would be approximately $9.10 per failed vehicle.

ANNUAL FUEL SAVINGS (GALLONS)

	Total fuel savings	Dollar savings at $0.70 gallon	Savings per failed vehicle
Alternate A - 12 County	28,898,530	$20,228,970.00	$11.80
Alternate B - 18 County	31,844,630	$22,291,241.00	$11.85
Statewide	37,171,280	$26,019,896.00	$ 9.10

Comparison of Costs

The major cost components are summarized for all options in Table 6. In the first four columns are shown the cost components for the urban areas only, alternates A and B for Options I through VI. In Options I, III, and V the higher contractor costs result from taxes, which increase annual operating costs by over $1 million. However, when choosing between state and contractor run facilities, fee differences due to taxes should not be considered, since taxes are just transfers. The $1 million dollars that motorists pay the contractor for taxes will reduce the government's revenue requirements by $1 million dollars, and thus reduce taxes by $1 million. A second impact of taxes, redistribution of revenue between governmental bodies, should be considered. In particular, the loss of property tax revenue in communities with state-run I/M facilities may be politically important.

In terms of the start-up costs there is a cost saving of approximately $600,000 for a contractor approach in comparison to a state-run option. The reason for this is that the implementation period for a contractor is about 1-1/2 years in comparison to 2-1/2 years for the state.

In the fourth and fifth columns the state costs to administer and conduct surveillance of the private garage program in the rural areas are shown. The totals in columns six through nine reflect the urban and rural areas costs. Finally the last three columns show the costs to the state for administration and surveillance of a statewide private garage program. These costs are shown for three levels of participation. The first column is the minimum level of participation, when approximately 18 percent of the total service stations, garages, and car dealers participate. In the other two columns are shown a midlevel, 33 percent and maximum level of 45 percent. As explained in detail in Sections 4 and 10, these levels were derived on the basis of certain assumptions. The minimum participation level represents the minimum number of garages needed to actually conduct all the inspections working a full 8-hour day. As participation increases there would be fewer cars inspected per station. At the maximum participation level a participating station would just break even in terms of the total revenues being equal to the total expenses including salaries, overhead, analyzer costs, etc. The midlevel is a midpoint between the minimum and maximum levels.

TABLE 6. ANNUAL COSTS*

Annualized costs	Options: I, III, V (Contractor) urban areas†		II, IV, VI (State-run) urban areas†		I, II‡,§ Rural areas state costs		I Total		II Total		VII§ Total state costs		
	A	B	A	B	A	B	A	B	A	B	Min	Mid	Max#
I. Annualized Capital Costs													
1. Land	160,378	179,837	160,378	179,837	0	0	160,378	179,837	160,378	179,837	103,008	103,008	103,008
2. Building	1,046,442	1,159,747	1,046,422	1,159,747	0	0	1,046,422	1,159,747	1,046,422	1,159,747	47,502	76,734	104,748
3. Equipment	1,856,824	2,096,503	1,856,824	2,096,503	103,269	87,601	1,960,093	2,184,104	1,960,093	2,184,104	33,236	52,228	72,407
II. Annualized Start-Up Costs	1,124,953	1,219,102	1,259,981	1,354,129	176,323	157,745	1,301,276	1,376,847	1,436,304	1,511,874	898,685	1,070,634	1,242,583
III. Annual Operating Costs	11,725,853	12,788,409	10,667,013	11,609,803	577,856	496,788	12,303,709	13,285,197	11,245,681	12,106,591	2,409,777	2,625,977	2,833,377
IV. Annual Administrative Costs	1,469,576	1,547,608	1,469,576	1,547,608	1,123,920	970,920	2,593,496	2,518,528	2,593,496	2,712,938	2,712,938	3,314,720	3,917,043
Total Annual Costs	17,384,006	18,991,206	16,460,194	17,947,627	1,981,368	1,713,054	19,365,374	20,704,260	18,442,255	19,735,649	6,205,146	7,243,301	8,273,166

*Interest rate assumed to be 6 percent in absence of inflation.

†Urban areas - 12 most populous counties under Alternative A.
18 most populous counties under Alternative B.
Rural areas - counties not included in urban areas.

‡Rural costs are the additional costs for providing state support of rural private garage inspection.

§Does not include costs to the private garages.

#Minimum midlevel and maximum levels of participation of private garages in the inspection process.

In Table 7 are shown the comparison of possible fees. These are derived by dividing total costs in 1978 dollars by average 1981 through 1987 vehicle populations. The fees are to be used only to compare the options and do not represent what a motorist would actually pay when the program is operational in 1981.

In comparing the urbanized areas' fees, it can be seen first that the fees for Alternates A or B (12 and 18 counties) are very similar, only differing by 2 to 10 cents. The difference between the urban fees for the contractor or state options is also small, 18 to 26 cents and this results primarily from the taxes paid by the contractor, as discussed earlier.

TABLE 7. COMPARISON OF FEES*

Centralized lanes in urban areas			
Options I, III, V Contractor		Options II, IV, VI State-run	
Alternate A 12-County	Alternate B 18-County	Alternate A 12-County	Alternate B 18-County
$3.43	$3.33	$3.17	$3.15

Option	Private garages		
	Options I, II Alternate A rural areas only	Options I, II Alternate B rural areas only	Option VII statewide
Participation Level			
Minimum 18%	$2.88	$2.94	$2.92
Midlevel 33%	$4.13	$4.20	$4.41
Maximum 45%	$5.88	$6.04	$5.87

*Fees represent constant 1978 dollars in the absence of inflation. These figures are for comparison of options only and do not reflect what the motorists would have to pay. An annual interest rate of 0.06 is assumed.

Options I and II differ from Options III and IV or Options V and VI in the service provided in rural areas (the part of the state outside the urban areas discussed above). Rural areas Options I and II require mandatory emission inspection by private garages. In these two options, state incurs a cost of about \$0.64 to \$0.86 per paid private garage inspection depending on the number of garages participating in the system. This cost covers the administrative and monitoring network required to oversee the private garage operations. In addition, the motorist incurs the cost of the actual inspection.

Option VII is a statewide private garage approach. As is the case in the rural areas of Option I and II there are the state costs as well as the private garage charge which together equal the private garage fee. As the level of participation increases, the charge per vehicle increases to offset the fewer number of vehicles being inspected. If there were a mechanism to insure that the number of stations participating in inspections remained at a low level, somewhere between the minimum and midlevels, then, the fees charged in rural areas would equal the urban motorist fees for centralized state or contractor stations. Alternatively, the urban fees could be raised to equal the expected breakeven participation level. Limiting station participation levels through high license fees or other means would be difficult to implement and potentially unpopular. In reality some stations that would not breakeven on the inspection fee would nevertheless be willing to participate in order to increase business especially for the repairs needed for failed vehicles.

Except for the potentially higher fees for private garages in rural areas of Option I, and II or in statewide garage Option VII, the costs and fees are very similar among all options. Not shown are the state costs for the random emission inspection program conducted in rural areas by the Ohio State Highway Patrol in Options V and VI. The capital costs of these programs are estimated to be approximately \$827,500 in Alternate A and \$703,500 for Alternate B while the operating costs were estimated at \$2,792,200 and \$2,374,600 for Alternates A and B, respectively. These costs would probably be paid for through state revenues as is the cost of the present random safety program.

The costs were also estimated for a loaded mode option which was like Option III except for the test type. The fee calculations for the loaded test indicates that it would cost approximately \$0.20 more per inspection than the comparable idle mode test looked at in Option III. This cost is due to the addition of a dynamometer for each test lane. The test time is about the same and consequently, the actual number of inspection lanes would be the same. Also, the manpower requirements would be equal for either test type due to the use of automated equipment. There is no need for additional personnel to perform the loaded mode test.

Indirect Impacts and Political Issues

In addition to the primary benefits of reducing vehicular emissions and improving air quality inspection and maintenance programs have indirect impacts. Several aspects of an I/M program also have the potential of becoming political issues and hinder the legislative approval of one or more options. To discover what the potential impacts and issues might be, other states' I/M programs were studied and the options themselves were analyzed.

The findings of the research on these impacts and issues are discussed in detail in Section 12, Externalities: Indirect Impacts; Section 13, Legislative Considerations in I/M Implementation; and Section 14, Comparison of Options. A brief summary of some of the more salient issues is provided here.

Indirect Impacts--

There are several indirect impacts that do not relate to specific options but would result from the implementation of any I/M program option. These include the following:

- Health benefits
- Improvement in vehicle performance and vehicle life
- Impact of required maintenance
- Impact on repair and automotive parts industry

The improvement in air quality in those areas where the National Ambient Air Quality Standards are currently exceeded are likely to have some benefits in the health of the affected population. The amount and nature of the benefit would depend, of course, on the severity of air pollution prior to the implementation of the I/M program and the amount of reduction in air pollution resulting from I/M.

Fleet maintenance records indicate that emission inspection and regular maintenance of vehicles improves vehicle performance and decreases overall maintenance costs.[4] There is not yet sufficient data to specify the exact amount of this benefit to I/M programs, although there is currently research underway to help establish some quantified relationships.

Under an I/M program, the public is required to make necessary repairs so as to bring vehicles up to performance levels to pass the emissions test. Studies indicate that average repair costs are in the range of $16 to $32 per failed vehicle. Most repairs consist of carburator adjustment or a minor tune-up. Repair ceilings, ranging from $50 to $100, or a certain percent of the vehicle's value have been set in many states to mitigate against potential hardships for the small percentage of vehicles that require major repairs.

The mandatory repair of failed vehicles and the increased incentive for vehicle maintenance resulting from I/M programs is likely to produce direct and indirect benefits to the automobile repair and parts industry. There would be an increase in repair work and an increase demand for parts, especially tune-up parts and emission controls. At the beginning of the I/M program, the increased demand for repair work may cause some initial shortages, but with time should become ameliorated.

Travel to and from the inspection station and waiting time may vary among the options. Generally, the decentralized garage approach requires less travel time. However, there would be more inspection stations spread throughout the population, this is offset somewhat by the longer waiting time and the possible need to leave the car at the private garage.

Political Issues--

I/M programs, although producing significant benefits to the public such as improvement in air quality, have other potential impacts which the public may perceive as barriers and which may hinder the overall political acceptance of the program. Such issues or impacts include the following:

- Impacts on low income citizens.
- Potential overcharging for repairs and performance of unnecessary repair work.
- Problems of conflict of interest and uniformity of inspection in the private garage approach.

One of the fears expressed about I/M programs has been that it would place a burden on low income citizens by forcing them to make expensive repairs. This could potentially force people with marginal vehicles to give up the vehicle faced with repiar costs that exceed the value of the vehicle. This problem has been significantly ameliorated by instituting repair cost ceilings. Thus, if the cost of the repairs needed to meet the standard excwed the cost ceiling, say of $75 to $100, then the vehicle may receive an inspection waiver. Given the relatively small percentage of vehicles that have been found to need these major repairs, little is sacrificed in terms of air quality benefits by making these exemptions and much is gained in terms of overall public acceptance.

The problem of dealing with repair overcharging on unnecessary repair work can be dealt with in several ways. Some states have instituted formal repair procedures that are specified for various emission failure problems. Mechanics training programs address these problems by encouraging a generally higher level of repair competence and motivation. Quality assurance programs can be designed to identify those garages that charge significantly more than the average repair cost or identify garages generally drawing numerous consumer complaints. Such procedures can be relatively informal or can be tied in with formal licensing of garages or mechanics.

The options with inspection as well as repair in licensed, private garages may pose quality assurance and consumer protection problems. With a large number of garages having emission analyzers of varying degress of quality, and with less uniform supervision, there will probably be less uniformity in the inspection in garages. Moreover, there is an inherent conflict of interest in having the same station conduct both the testing and maintenance phase of I/M.

Comparison of Manpower Requirements

Alternate A--

Table 8 summarizes manpower requirements for all the options. Options III and IV, with smaller geographic coverage, require the fewest employees of any of the centralized system options. Because of the rural private garage networks incorporated in Options I and II, 52 more employees than for Options III and IV are required to perform complaints investigation and inspection and licensing functions. In Options V and VI, 212 state patrol employees are required to carry out the random roadside pullover inspection program in rural areas. Option VII requires by far the fewest state employees of all the options, but it must be remembered that thousands of private garage employees will also be required. Option VI has by far the greater number of state employees.

Alternate B--

Table 9 summarizes manpower requirements for all the options. Manpower requirements for Alternate B are all somewhat larger for all the centralized options due to the larger geographic area covered. Option VI with 846 people would have more state employees than any other option, although Options II and IV with 710 and 664 would rank close behind.

TABLE 8. MANPOWER REQUIREMENTS, ALL OPTIONS (NUMBER OF EMPLOYEES), ALTERNATE A

Level of employment	I	II	III	IV	V	VI	VII (mid)
State Administrative	10	12	10	12	10	12	11
State Regional	52	84	-	32	-	32	127
State Local	-	580	-	580	-	580	66
Contractor State	2	-	2	-	3	-	-
Contractor Regional	32	-	32	-	32	-	-
Contractor Local	580	-	580	-	580	-	-
State Patrol	-	-	-	-	212	212	-
Random Pullover Program	676						
Total - All	676	676	624	624	836	836	204
Total - State (includes State Patrol)	62	676	10	624	222	836	204

TABLE 9. MANPOWER REQUIREMENTS, ALL OPTIONS (NUMBER OF EMPLOYEES), ALTERNATE B

Level of employment	I	II	III	IV	V	VI	VII (mid)
State Administrative	10	12	10	12	10	12	11
State Regional	46	80	-	34	-	34	127
State Local	-	618	-	618	-	618	66
Contractor State	2	-	2	-	2	-	-
Contractor Regional	34	-	34	-	34	-	-
Contractor Local	618	-	618	-	618	-	-
State Patrol Random Pullover Program	-	-	-	-	182	182	-
Total - All	710	710	664	664	846	846	207
Total - State (includes State Patrol)	56	710	10	664	192	846	207

REFERENCES

1. The areas not meeting the National Ambient Air Quality Standards were reported in the Federal Register. Volume 43, No. 43. Friday March 3, 1978. p. 9026.

2. The National Primary and Secondary Ambient Air Quality Standards were promulgated by the U.S. Environmental Protection Agency in 40 CFR 50; FR 22384, November 25, 1971; as amended by the Code of Federal Regulations Volume 40, revised as of July 1, 1976; 41 FR 52686, December 1, 1976.

3. Personal communications with Bruce Everlane, U.S. EPA, Washington, D.C. May, 1978.

4. Automotive Fleet. Benefits of an Inspection/Maintenance Program. Reprinted for Hamilton Test Systems, Inc. July 1975.

SECTION 2

INTRODUCTION

BACKGROUND

Need for Inspection/Maintenance Programs

Recent ambient air quality data for the State of Ohio indicates widespread and frequent violations of the National Ambient Air Quality Standards (NAAQS) for carbon monoxide (CO) and photochemical oxidants (O_x). These national standards have been established in order to protect the health and welfare of the population. Both CO and O_x are gases which in sufficient concentrations in the atmosphere are potentially harmful to the public health. A major source of CO and O_x in Ohio are the motor vehicles. Carbon monoxide is directly produced by gasoline-burning internal combustion engines and photochemical oxidants are indirect products, formed through a complex series of atmospheric reactions in which two other direct products of combustion, unburned gaseous hydrocarbons (HC) and oxides of nitrogen (NO_x) combined in the presence of sunlight. Inspection/maintenance programs are a cost-effective strategy to reduce these emissions from motor vehicles. Other strategies that have been suggested, such as restricting travel, are more difficult to enforce, tend to reduce individual mobility and may require major changes in driving habits. By significantly reducing the emission of HC and CO from in-use motor vehicles in Ohio, an I/M program will enhance the likelihood of the attainment of NAAQS.

The Clean Air Act Amendments of 1977 have specific provisions that require the establishment of inspection/maintenance programs. According to the U.S. EPA, the state must submit by January 1979 revisions to its State Implementation Plan (SIP) which specifies methods to achieve the National Ambient Air Quality Standards. These methods include control of stationary sources of air pollution and various transportation control measures whose objective is to reduce vehicle miles traveled (VMT) and hence to reduce pollution by mobile sources such as motor vehicles. If in these revisions, the state cannot demonstrate attainment of the NAAQS by 1982 by using all reasonably available pollution control measures, then, an extension to 1987 can be requested, if several provisions are met. One such provision is the establishment of a specific schedule for the implementation of an I/M program. Because it is doubtful that the NAAQS can be attained in many areas of Ohio through other measures, an I/M program is likely to be required.

Background of This Study

The Ohio I/M Advisory Group was established in March 1978 to initiate action on considering various possible I/M options and to select the option most suited to the needs and desires of the State of Ohio. The Advisory Group is composed of members of various agencies including representatives of the Ohio Environmental Protection Agency, the Department of Highway Safety which includes the Bureau of Motor Vehicles and the State Highway Patrol, the Department of Transportation, the Attorney General's Office, the Governor's Office, and the Department of Energy.

The initial effort of the I/M Advisory Group was the development of background data regarding the technical and administrative aspects of I/M programs. A summary report describing I/M program elements and other states' experience in I/M and various technical memoranda were produced to assist in the selection of a limited number of I/M options. The Advisory Group in April 1978 selected seven I/M program options which will be described later in this section. The purpose of this report is to analyze these seven options in terms of their costs and benefits such that the Advisory Group may then select one option for detailed study, which will constitute the final report of the overall work program.

DESCRIPTION OF INSPECTION/MAINTENANCE PROGRAMS

Federal Motor Vehicle Control Program

Beginning with 1968 model-year vehicles, automobiles manufactured in or imported into the U.S. have had to comply with emission standards specified in the Federal Motor Vehicle (emission) Control Program (FMVCP). Under this program, maximum emission rates were established for new vehicles, and manufacturers had to demonstrate, through an auditing program, that their vehicles were in compliance with these emission limits. The emission standards specified by the FMVCP required progressively more stringent control of emissions with each subsequent model year.

The FMVCP consists of three parts including certification of prototype vehicles prior to actual production, selective enforcement testing of vehicles at the assembly line, and testing of in-use vehicles around the country to discover design defects in emission controls as well as to provide data to recall vehicles with inadequate or defective emission devices. Federal testing of in-use vehicles throughout the United States, unfortunately, has demonstrated that motor vehicles are not meeting the emission standards for which they are designed. The primary reasons the vehicles exceed the standards include improper or inadequate maintenance, tampering, and defective emission control devices. Regardless of the cause, it has become clear that some in-use vehicle emission inspection programs are necessary to ensure that the emission controls continue to operate as they were intended over their useful life.

Description of Inspection/Maintenance Programs

Inspection/maintenance programs, thus evolved through the need to ensure that in-use vehicles meet the emission standards for which they were designed. I/M programs consist of two basic components. In the inspection phase, the motor vehicle exhaust emissions are measured and compared to a test standard that relates to the model year of the vehicle. In the second phase, that is maintenance, those vehicles failing to meet the applicable standards are required to undergo repair or maintenance until the vehicle is able to pass the test.

I/M is not a new strategy and much operation information has been collected documenting the effectiveness of the program to reduce motor vehicle emissions. Several states now have I/M programs in operation and several are about to be implemented. A variety of approaches have been used to run I/M programs, but the major types fall generally into three organizational categories as follows:

1. Government - Centralized test facilities operated by state, city, or local government (as in New Jersey; Cincinnati, Ohio; Portland, Oregon; and Chicago, Illinois).

2. Contractor - Centralized facilities operated by a private corporation under contract to a government (as in Maricopa and Pima Counties, Arizona).

3. Private Garage - Decentralized facilities operated by private automobile service garages, certified or licensed by a government (as in Rhode Island and Nevada).

In addition to these primary types, there can be combinations. For example, a decentralized private system may also include one or several state-run facilities as quality control measures and to discourage unethical or ineffective testing or maintenance.

In Rhode Island, the system is the decentralized private garage approach but the state has one publicly run "challenge station" which acts as a referee to retest unsatisfied customers from any private station.

Each organizational approach has various advantages and disadvantages. The centralized state-run or contractor approaches allow for greater accuracy in testing, better quality assurance, and better consumer protection, but the centralized cases incur higher capital costs. The decentralized private garage approach, if properly planned may offer greater consumer convenience but due to the lack of separation between the inspection and maintenance function may offer less consumer protection. Also, there may be problems in quality assurance due to variability in testing equipment and calibration practices. The costs and benefits of the approaches are discussed in detail in the sections on the options.

Geographic Coverage

Another important issue in developing an I/M program concerns the geographical coverage of the program. In determining what area should be included in the Ohio I/M program, several factors were considered. According to U.S. EPA the minimum acceptable area for an I/M program includes urbanized areas with population greater than 200,000 which have requested an extension to 1987 for the attainment of CO and HC NAAQS. For enforcement purposes counties were established as jurisdictional boundaries. The smallest geographical coverage looked at were the 12 urban counties with population greater than 200,000 as in Alternate A. In addition, since the urban area definition includes portions of several adjacent counties where communter travel is significant, six more counties were added, resulting in the 18 county Alternate B.

The 12 urban counties with population greater than 200,000 which would be covered in Alternate A are listed below:

1. Butler County
2. Cuyahoga County
3. Franklin County
4. Hamilton County
5. Lake County
6. Lorain County
7. Lucas County
8. Mahoning County
9. Montgomery County
10. Stark County
11. Summit County
12. Trumbull County

The six adjacent urban counties included in Alternate B are as follows:

1. Clermont County
2. Geauga County
3. Greene County
4. Medina County
5. Warren County
6. Wood County

The 12 urban counties with population greater than 200,000 and six additional counties are shown in Figure 2.

The major issues which need to be addressed in setting up an I/M program include the following:

1. Type of Emissions Test - Idle or Loaded
2. Geographical Coverage
3. Organizational Approach
4. Frequency of Inspection
5. Enforcement Procedure

Type of Emissions Test

An important issue in I/M programs concerns the type of emissions test, idle or loaded-mode test. Basically, the idle-mode test consists of measuring gases from the vehicle at constant idle speed or at idle after the vehicle exhaust system has been purged by having it run at high idle (usually 2500 rpm). In the loaded-mode test, the drive wheels are placed on a chassis dynamometer which simulates actual driving conditions and the vehicle is driven at various speeds, such as 50 mph, 30 mph and then allowed to idle. Exhaust gas measurements are taken in each driving mode and at idle, although for the pass-fail decision the idle measurement is commonly used. There are several variations on the loaded-mode test, but the important distinctions concern the test accuracy, diagnostic data provided by the test, its ability to measure various exhaust gases, and the test time. If the idle test includes a high idle purge, it is approximately equal to the loaded-mode test in its ability to identify the vehicles exceeding the appropriate standards. The loaded-mode provides superior diagnostic information by simulating actual driving conditions during which many of the emission controls become active. Furthermore, the loaded-mode test can identify nitrogen oxide gases which the idle test cannot, since these gases are not easily detected at idle speed.

The loaded-mode may take 1/2 minute longer than the idle test, but if the idle test includes a purging high idle period, they are approximately equal. This issue of test time becomes critical when considering the design and cost of a large centralized network of inspection stations, because the more efficient and less time consuming test, other factors being equal, allows for a shorter throughput capacity per lane. This allows for greater lane capacity and the need to build fewer stations. A more detailed discussion of the idle versus loaded-mode test is provided in Appendix G. In this appendix, in addition to a discussion of the technical issues, a cost evaluation of an insepction network identical to the contractor run centralized lane approach analyzed in Option III, Section 6, has been included.

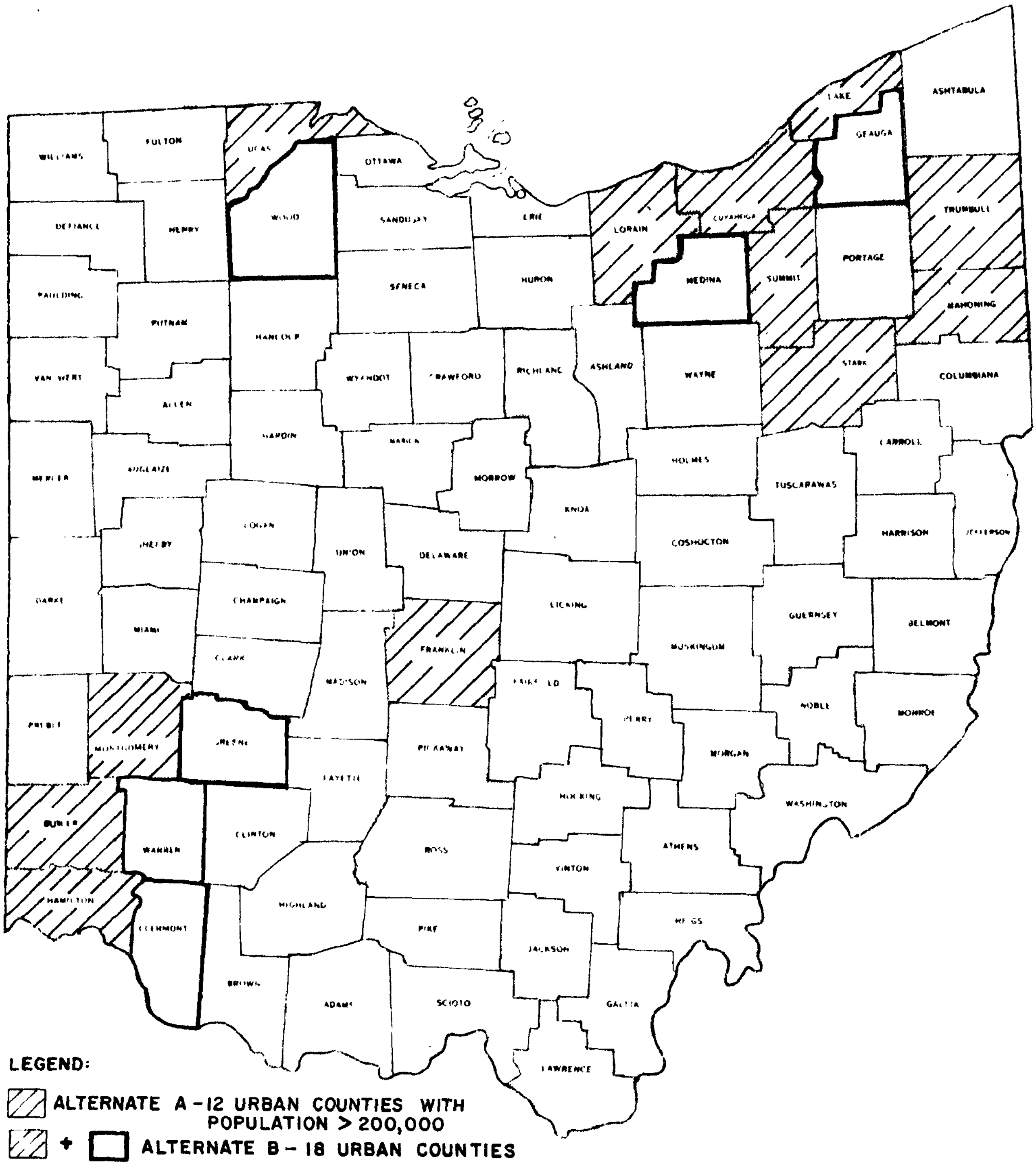

Figure 2. Urban counties in Ohio.

THE SEVEN I/M PROGRAM OPTIONS

As indicated earlier, the Ohio I/M Advisory Group has selected seven specific program options for evaluation. All seven options have in common these elements:

- Idle mode testing
- Annual inspection
- Motor vehicle registration enforcement
- Ohio Environmental Protection Agency and Bureau of Motor Vehicles as adminsitrative agencies

The seven options are shown in Table 10.

PROGRAM ASSUMPTIONS

In order to evaluate the costs and benefits of the seven program options, it was necessary to make certain assumptions about the option regarding certain program variables. These assumptions are listed below:

- Inspection Frequency - Annual inspections will be performed on a monthly staggered schedule.
- Stringency Factor - 30 percent of the vehicles inspected will be failed and hence require reinspection. Consequently, approximately 2.5 percent of the total vehicle population will need reinspection monthly.
- Vehicle Categories to be Inspected - Vehicles to be included in the mandatory I/M program include: (a) all light-duty, gasoline-powered vehicles other than those that are less than 1 year old (based on model year) or more than 12 years old; and (b) all light-duty, gasoline-powered trucks with a gross vehicle weight (GVW) of 8,500 pounds or less.
- Inspector and Mechanic Training - Regardless of the program option selected, a basic requirement would be that individuals performing either inspections or performing maintenance would be required to participate in a training program.
- Enforcement - For purposes of cost analysis, enforcement through motor vehicle registration will be assumed. A comparative analysis of sticker/ticketing versus motor vehicle registration was conducted and this appears in Section 16.

TABLE 10. SEVEN OHIO I/M PROGRAM OPTIONS

- OPTION I
  - Statewide coverage
  - Contractor administers centralized lanes in urban areas
  - Private garages in rural areas
    - Alternate A - 12 urban counties - all counties with population greater than 200,000
    - Alternate B - 18 urban counties - 12 counties with population greater than 200,000 plus 6 adjacent counties
- OPTION II
  - Statewide coverage
  - State administers centralized lanes in urban areas
  - Private garages in rural areas
    - Alternate A - 12 urban counties
    - Alternate B - 18 urban counties
- OPTION III
  - Urban counties only
  - Contractor administers centralized lanes
    - Alternate A - 12 urban counties
    - Alternate B - 18 urban counties
- OPTION IV
  - Urban counties only
  - State administers centralized lanes
    - Alternate A - 12 urban counties
    - Alternate B - 18 urban counties
- OPTION V
  - Statewide coverage
  - Contractor administers centralized lanes in urban areas
  - State highway patrol conducts random inspection in rural areas
    - Alternate A - 12 urban counties
    - Alternate B - 18 urban counties

(continued)

TABLE 10 (continued)

- OPTION VI
  - Statewide coverage
  - State administers centralized lanes in urban areas
  - State highway patrol conducts random inspection in rural areas
    - Alternate A - 12 urban counties
    - Alternate B - 18 urban counties
- OPTION VII
  - Statewide coverage
  - Private garage testing in urban and rural areas
  - State or contractor conducts surveillance/quality control of garages

BASIS AND ORGANIZATION OF THIS REPORT

The basic intent of this report is to provide a comparative analysis of the seven I/M program options selected by the Ohio I/M Advisory Group which have been outlined above. The approach of the report focuses on the costs, benefits, and manpower requirements of each of the seven program options. To familiarize the reader with the basic methodologies by which the benefits, costs, and manpower requirements were derived, Section 3, has been provided. The discussion encompasses (1) basic techniques, assumptions and data sources used to derive the costs associated with each program option; (2) benefits associated with the I/M programs in general and the specific benefits projected for Ohio; and (3) considerations used in developing estimates of personnel or manpower requirements including both the categories of personnel and organizational structure.

Sections 4 through 10 discuss the specific options themselves focusing on costs and personnel requirements. The discussions are option specific in each of these sections and are based on the methodologies defined in Section 3. The methodologies by which the specific lane requirements were derived appear in the first section in which a particular organizational approach appears. Thus, for example, the methodology whereby the requirements for the contractor run centralized networks are derived appear in Section 4. Also, as a split option with private garage testing in the rural areas, the methodology for deriving the requirements for the number of garages in the rural areas is also discussed in this section. In the following sections, the reader will be referred back to this section where appropriate to eliminate needless repetition of these methodological considerations.

Section 11, "Benefits" describes the emission reduction and fuel economy benefits which result from the various options. The emission reduction benefits are basically the same for each option. Fuel economy benefits in terms of fuel savings per vehicle are the same for each option, but the aggregate fuel savings increases as the geographical coverage expands.

Section 12, "Externalities: Indirect Impacts" and Section 13, "Legislative Considerations in I/M Implementation" deal with two important fields in evaluating the options and their potential impacts. Section 12, "Externalities: Indirect Impacts" deals with impacts, costs and benefits which are indirect, secondary, or somehow external to the primary effect of the I/M program which is of course the reduction of motor vehicle emissions. Impacts on the general population, impacts on vehicle owners, impacts on the repair industry, and impact of test type are included. In some cases the impact on the individual citizen or vehicle owner may be small but in the aggregate very large. In other cases, the indirect impacts are as yet poorly defined or the studies concerning them to date are inconclusive. Also, for the most part these impacts are not option specific, i.e., they either occur more or less uniformly over all options or the differential effect is not measurable or not clearly related to program elements. Even though difficult to measure, it was felt that these issues needed clarification at this early planning stage to identify them for study later in association with the detailed option evaluation.

Section 13, "Legislative Considerations in I/M Implementation" deals with legislative, legal or political issues which may potentially become roadblocks and which may adversely affect one or several options. Although the Ohio Legislature has not yet become involved in this early comparative evaluation stage, it was deemed important to look ahead based on an analysis of the options themselves and other state's experience, and anticipate what kind of problems or issues might be associated with one or another options.

Section 14 compares the seven options based on costs, benefits, manpower requirements, and other qualitative considerations such as externalities or legislative issues.

Section 15, "Public Information Programs" describes the general features of I/M public information program elements and discusses the basis for the cost estimates for public information included in the cost of each option.

Section 16 is a comparison of the motor vehicle registrations and the sticker/ticketing procedures for the basic enforcement of I/M programs.

Section 17 discusses the issues concerning whether the state government or a private contractor should conduct surveillance of the private garage inspection system.

Section 18 is a glossary of technical terms.

The appendix includes a technical analysis of the cost and benefit methodologies and an analysis of a loaded-mode option. This analysis looks at both the technical aspects of both idle and loaded-mode and the costs of a loaded-mode, centralized contractor-run option that is similar to Option III, described in Section 6 of the text.

SECTION 3

METHODOLOGIES

INTRODUCTION

This section provides a discussion of the factors used to analyze and compose each I/M program option, namely:

1. Air Quality Benefits
2. Costs
3. Personnel/Manpower Requirements

The purpose of the discussion is to provide background information on the assumptions and methodologies used to derive the costs and benefits of each option.

Air Quality Benefits

The primary benefit associated with an I/M program is the reduction in hydrocarbon and carbon monoxide emissions from mobile sources. To assess the reductions from the I/M program being considered here, emission inventories for 1977 and 1987 without I/M, and 1987 with I/M were prepared for each of the 18 largest counties in Ohio. Comparison of the two inventories without I/M indicates the general trend in vehicular emissions, taking into account both increases in travel and a general decrease in the average vehicle emission rate with time resulting from the increased stringency of the Federal Motor Vehicle Emission Control Program. The actual effectiveness of the I/M program is seen by comparing the two inventories reflecting 1987 emissions.

The emission inventories were developed using EPA's Mobile I computer routine. Credits for an I/M program are applicable only with mandatory inspection. Thus for the scenarios considered in this report, credits are applied to registered vehicles as follows:

USE OF I/M CREDITS FOR VEHICLES REGISTERED IN VARIOUS COUNTIES

Option considered	12 counties	6 counties	Remainder of state
Option III, IV, V, VI with Alternative A	applied	not applied	not applied
Option III, IV, V, VI with Alternative B	applied	applied	not applied
Option I, II with Alternative A or B and Option VII	applied	applied	applied

When the vehicles registered in a particular county are subject to mandatory inspection, there is still travel in that county by vehicles registered in counties without mandatory inspection. Thus for options that do not include mandatory inspection statewide, travel is divided between inspected and uninspected vehicles using U.S. Census Journey to Work Data. A complete description of the development of the inventories used in this report is provided in Appendix A.

In using Mobile I, several assumptions were made about the nature of the I/M program. As indicated previously, the I/M stringency level is at 30 percent and mandatory maintenance is required of failed vehicles. Since credits are presently available only for autos, autos are the only vehicles subject to I/M credits. Other assumptions were: inspection of vehicles between 1 and 13 years old, that the program is fully implemented by the end of 1982, and that temperature is 75°F. The last assumption yields inventories for a typical July day when daily emissions are most acute.

COSTS CONSIDERATIONS

The technique used in developing the cost analysis was to focus on specific cost categories so that very elemental comparisons among programs would be possible. The specific cost categories, and elements thereof, that were used are outlined in Table 11.

All the costs specified in Table 11 are reported in 1978 dollars. At this stage of the analysis, inflation is assumed to be nonexistent.

Initial Capital Costs

These costs reflect the initial outlay of money required for the design and implementation of a program. These costs are very sensitive to the type of program selected as well as to the specific features incorporated into any particular option. As indicated in Table 11, there are three primary elements associated with these costs.

TABLE 11. OUTLINE OF PROGRAM COST CATEGORIES AND ELEMENTS

Primary category	Principal Element	Items included
I. Initial Capital Costs	1. Land investment	a. Actual land cost b. Pavement and landscaping
	2. Building investment	a. Construction cost
	3. Equipment costs	a. Primary test equipment b. Ancillary equipment c. Office equipment/furnitures d. Maintenance equipment
II. One-Time Start-Up Costs	1. Land acquisition	a. Site location studies b. Title transfer costs
	2. Facilities planning	a. Design study b. Bid evaluation c. Construction monitoring
	3. Program design	a. Develop equipment specifications b. Develop subprograms (e.g., public information, surveillance, quality control, enforcement, etc.) c. Define personnel organizational structure d. Define data handling needs e. Plan program effectiveness studies
	4. Develop data handling systems software	
	5. Personnel training	a. Inspectors b. Managers c. Quality control personnel
	6. Personnel salaries and overhead prior to start-up	
	7. Initial public information program	
III. Annual Operating Costs	1. Facility personnel	a. Wages, benefits, etc.
	2. Maintenance	a. Equipment
	3. Utilities/services/supplies	a. Electric b. Heat c. Insurance d. Miscellaneous e. Taxes
IV. Annual Administrative Costs	1. Program administrative personnel	a. Wages, overhead
	2. Enforcement	
	3. Consumer protection/quality Assurance	
	4 Public information	
	5. Training, licensing, certification	

Land Investments--

A number of issues beyond the obvious one of land area are extremely crucial in estimating land costs. The basic unit cost, for example, is, in most instances, lot-specific to the extent that the cost per square foot within any block may vary by a factor of 3; within any city or town, the cost may vary by a factor of 10 or more. It is obvious, then that a precise unit cost for land cannot be provided here. Alternatively, estimates were developed by the Ohio Department of Economic and Community Development, based on the general requirements for each option in terms of lot size and configuration, access, zoning, etc., and were verified by private contractors who have built similar facilities.

Building Investments--

Building costs are obviously dependent on specific designs and features utilized, therefore the unit costs, generally on a dollar-per-square foot basis, can be expected to vary somewhat. For the centralized facility options being considered here, a general design description was developed and submitted to the Ohio Department of Transportation for an assessment of the likely unit cost. The general building design calls for a clear span, metal structure, utilizing metal sandwich panel walls with normal wall and ceiling finish for the administrative areas, and no wall or ceiling finish in the inspection area. Equipment such as an air exchange and forced, hot air heaters in the inspection area, and central heating and air-conditioning in the administrative areas is also included. No provisions are made for specialized systems such as exhaust fume collection, etc.; these are included in the equipment costs.

Based on the general design features described above and on the building size requirements, the Ohio Department of Transportation examined the most recent building cost figures for buildings of similar construction. Then, these figures based on five Ohio Department of Transportation (O.DOT) projects (four in 1971 and one in 1972) were updated to reflect 1978 costs. For mid 1978, the average cost figure was estimated at $27.75 per square foot. This value was used in the building cost evaluations for all centralized lane facilities. These estimates shown in Table 12 were developed on a statewide basis and broken down into three major subcategories: major metropolitan, 50,000 (core city) and rural. All the centralized lanes in Ohio being located in urbanized counties were considered as major metropolitan or core city, the majority being major metropolitan. Costs were reported in ranges and an average cost.

Improvements to land including pavement and landscaping are also included in this category. Standard estimates for pavement and landscaping of $0.80 per square foot and $0.25 per square foot, respectively, were used.

Equipment Costs--

The equipment cost estimates used in this study were developed primarily from interviews with manufacturer's representatives. These interviews focused on identifying the most appropriate type and model for various major items and determining the general level of skill required to operate and maintain each. Specific costs are presented in the detailed discussion of each option.

TABLE 12. ESTIMATED VALUE FOR COMMERCIALLY-ZONED LAND IN OHIO

Population of county	Cost average (ft^2)	Cost range (ft^2)
Major metropolitan	\$0.92	\$0.57-1.95
50,000 (core city)	\$0.34	\$0.28-0.46
Rural	\$0.23	\$0.18-0.34

One-Time Start-Up Costs

Implementation of an I/M program will require the expenditure of monies for noncapital items and services on a one-time basis prior to the actual startup. Costs associated with this category are perhaps the most difficult to define at this point primarily because the elements involve services (program planning, design, and development), which are inherently much more variable in cost than, for instance, equipment or land costs. This is especially true for this analysis where a specific scope for these services has not been developed. Considerations used in developing cost estimates for each element are discussed below.

Land Acquisition--

Included in this element are the costs for locating candidate sites, negotiating the purchase, and completing title transfers. Costs for locating and negotiating the purchase of land reflect personnel time requirements of approximately 200 man-hours of professional technical time, plus 40 hours of professional legal time for each site. To translate the man-hours to cost, a \$20-per-hour and \$50-per-hour value were assigned to the technical and legal hours, respectively; this represents a total cost of \$6,000 per site for this component. The final component - title transfer - is considered to include physical surveys, title searches, site plan preparation, and miscellaneous support functions required to execute the purchase. The cost associated with this component was assumed to be 10 percent of the purchase price of the land.

Facilities Planning--

This element reflects the costs associated with engineering and design for the test facilities, bid review, and construction monitoring. The value of these services was estimated as a function of the total building cost for each option. Specifically, for total building construction costs of up to \$3 million, a value of 20 percent of the construction cost estimate was used; for building costs of \$3 million to \$6 million, 15 percent of the cost was used, while for building costs greater than \$6 million, 10 percent was used.

Program Design--

This element reflects the cost of additional planning studies required to establish specific formats for the operation and administration of both the actual inspection program and associated programs such as public information. These costs are, again, likely to be quite variable depending on factors such as the extent of in-house effort undertaken by the State; the relative cost is expected to vary somewhat as a function of the particular option selected. In deriving an estimate, the experiences of other states were considered primarily to complement our analyses.

Data Handling Software--

Regardless of the option selected for implementation, a data software package will be required to provide both basic recordkeeping and program analysis functions. Two cost estimates were derived for initial software development. For the centralized lanes, with fully automated data handling capabilities and minicomputers, representatives of several computer companies as well as companies who have put together emission testing plus computerized data handling systems were consulted. An average cost of $200,000 was estimated for a centralized system. For private garages, a manual data handling system would be required that ties in with the Ohio Bureau of Motor Vehicles registration data system computer. The Bureau of Motor Vehicles estimated that for any tie-in with the system being currently developed regardless of the size of the system - whether it be for the rural areas or for a statewide system - an initial software development cost of approximately $67,000 would be necessary.[1]

Personnel Training--

Although personnel training will require an ongoing effort, an initial, highly intensive program must be undertaken to essentially train and certify both the entire staff of inspectors and managerial personnel and mechanics from the private sector who will be performing the required maintenance. It is hoped that the maintenance phase of I/M programs is generally phased such that the first several months include voluntary maintenance; therefore, the intensity required to train mechanics is somewhat less than that for inspectors.

To develop cost estimates for training, it was considered that a logical approach would be for the State to provide instructors who would be trained at workshops or through vocational education programs designed specifically to meet the requirements of I/M. Already in Ohio there are 11 instructors who have participated in a workshop offered by Colorado State University, the university which has specialized in the development of in-depth, comprehensive programs in emissions training for instructors, inspectors, and mechanics involved in inspection/maintenance programs. These instructors now teach emissions inspection and automotive emissions repair and maintenance at vocational/technical schools and career development campuses as well as adult education centers. They are available to both set up special emissions inspection/maintenance courses as well as to train other instructors.

Cost estimates were developed based on information obtained from the literature and directly from Colorado State University. The training costs associated with the private garage option are likely to be higher than for the others. The primary reasons for this are that (1) more inspectors/mechanics will have to be trained, and (2) special facilities and equipment will have to be provided for training. The training considers three technical levels, including: (1) instructors, (2) investigators, and (3) inspector/mechanics. Based on a 40-hour program for both instructors and investigators, and a 12-hour program for inspectors/mechanics, the estimated per person cost of training, respectively, is $74.00, $59.00, and $22.00 for the private garage option. If centralized inspection facilities were used for training, the cost per instructor, investigator, and inspector/mechanic would be $53.00, $43.00, and $16.00, respectively.

Personnel Salaries--

The literature and interviews with both officials from states with existing I/M programs and private contractors involved in I/M program operation, indicate that for centralized programs, the managerial, support, and technical personnel should be phased into the program prior to beginning mandatory inspection. This phase-in would bring managerial personnel in 6 months prior to start-up, while inspectors would begin 1 month before the mandatory phase. Support personnel would be phased-in throughout this period. During this period, personnel would become familiar with their specific job functions and general procedures. This phase could include voluntary inspection, which would provide a realistic working environment without the stress of maintaining a rather rigid production schedule as required during the mandatory phase. This phase serves as a "shake-down" period for the equipment and test itinerary, as well.

The personnel cost of the first month operation, then, is included in the one-time start-up cost category for operations personnel (technical, managerial, and support) for centralized facility options. There is no parallel requirement for the private garage option.

The state administrative personnel function would begin 30 months and 18 months prior to start-up for the state-operated and contractor-operated centralized facility options, respectively. For the private garage option, administration at the state level would begin 30 months prior to start-up.

Initial Public Information Program--

The experience thus far with I/M program operation shows that there is a definite requirement for a rather vigorous public information effort prior to program start-up. While there are no specific requirements defined regarding the lead-time necessary for the program content and budgetary requirements, the general experience indicates that it would be reasonable to expect that the effort should begin anywhere from 6 to 12 months prior to start-up, and that a preimplementation budget based on \$0.10 to \$0.12 per vehicle (to be inspected) is warranted. These general assumptions were used in deriving an estimate of the initial public information program requirements for Ohio. Consequently, there will be variations among the options because the vehicle population varies between the urban area only and statewide options.

Annual Operating Costs

Annual operating costs include all costs associated with the actual operation of the program. For the purposes here, the costs of adjunctive programs such as ongoing public information and inspector/mechanic training programs are not included; rather, the costs associated with these programs are classified as annual administrative costs, which are discussed later.

Facility Personnel--

Annual determinants of costs associated with the operation of the inspection faicilities are (1) the total number of individuals and relative level of job responsibility, and (2) the per-unit personnel cost including both wages and overhead.

In computing the personnel costs, the actual number of persons required by skill level was derived for each option based on the specific level of work effort associated with the particular option. The per-hour wage rate for various categories was derived from data obtained from the Ohio Department of Administrative Services, Division of Personnel, and the overhead estimates were based on data from the U.S. Department of Labor and State data, and from conversations with private contractors involved in operating I/M programs. The hourly overhead rate was determined to be 25 percent of the basic hourly wage rate.

Maintenance--
Costs associated with equipment maintenance and replacement were based on the experience of other states. In this connection, it was found that these costs represent approximately 20 percent of the original equipment costs.

Calibration Cost--
The costs for calibration of emission analyzers are composed of the calibration/maintenance people salaries, the calibration runs, annual operating expenses for the runs (fuel, maintenance, insurance, etc.) plus the cost of calibration gases. The first two elements are discussed under operating personnel costs and equipment costs, respectively. The annual insurance and fuel costs were assumed to be $1,000 each annually, and the cost of calibration gases was obtained from a supplier.

Utilities/Services/Supplies--
Included in this element are the costs associated with electricity, heat, water, building services, insurance, office supplies, inspection forms, etc. These costs were estimated based on several sources concerning equipment and facility power requirements determined from manufacturers and the general literature and the prevailing utility rates in the state, average heating requirements data for similar facilities, insurance costs and general building service requirements from existing programs.

Annual Administrative Costs

The costs included in this category reflect the overall program administration effort. Specifically, the salaries of personnel involved in areas such as enforcement, consumer protection, public information, and training, licensing, and certification are included. For the private garage option, an additional item - data handling - becomes important since the effort is largely manual. The centralized facilities utilize a high degree of automation, therefore, data handling costs are reflected as utility and service costs, which are included as operating costs.

TOTAL COST METHODOLOGY

In order to compare the cost of the various options, all costs found in Table 11 are converted into annual figures. Appendix E contains a complete description of the metholology used. The more salient points follow.

Initial Capital Costs

The capital costs found in Table 11 occur at the beginning of the project. These costs - expressed in constant 1978 dollars - are converted to annual cost - also in 1978 dollars - by use of amortization factors. Amortization factors are determined for each of the three subclasses of capital costs - land, structures, and equipment. Different amortization factors arise from the various life expectancies of the three kinds of investments.

Land yields services in perpetuity. Thus the amortization factor (or yearly cost of one dollar of land investment) is the marginal rate of return on capital, i. The marginal rate of return on capital is the interest rate in an economy without inflation. This rate ranges from 0.03 to 0.06 depending on the source of financing - equity, debt, or taxes.

Structures last 20 years and yield equal services during each year of their life. Thus the annual cost of each dollar invested in building is $\frac{i}{1-(1+i)^{-20}}$.

Equipment lasts 5 years and yields equal services for each of the 5 years. Thus annual cost of each dollar invested in equipment is $\frac{i}{1-(1+i)^{-5}}$.

One-time Start-up Costs

One-time start-up costs, like capital costs, occur at the beginning of the project. The start-up costs are recouped over the first 5 years of the project. Thus the annual cost of each dollar of expenditure is the same as for capital equipment, $\frac{i}{1-(1+i)^{-5}}$.

Annual Operating and Administrative Costs

These costs are already presented as annual amounts. These figures are added to the annualized capital start-up costs, so as to arrive at the annual cost of the whole project.

Fee Calculations

A fee, f_c, has been calculated for each option by dividing the total annualized costs by the average motor vehicle population, 1981 through 1987. This assumes a free reinspection for each of the failed vehicles. The fee along with all other costs is expressed in real 1978 dollars. To get figures in actual dollars for years other than 1978, costs and fees must be increased by the amount of inflation since 1978. Consequently, these fees are for purposes of comparing the options only and would not reflect what the motorist would actually have to pay during the years 1981 through 1987.

A realistic fee will be estimated in the Phase III report after the Ohio Advisory Group selects one option for a more detailed analysis. In Appendix E another fee, (f_a) is presented. This fee is also expressed in 1978 dollars, however, it is uniform in actual dollars and will not increase with inflation for 5 years after the program begins.

Interest rates used with constant dollar calculations reflect the real return on capital. Actual interest rates include compensation to offset the diminished buying power of money under inflation, and thus, are inappropriate here.

PERSONNEL REQUIREMENTS

The basic requirements of an I/M program call for both operating and administrative personnel. Operating personnel are those directly involved in performing inspections or providing managerial functions at the inspection site. Administrative personnel are involved in operating support programs such as enforcement and quality control, or in providing overall program management and administration.

Operating Personnel

This category is more sensitive to a specific option than is the administrative category. The basis for determining the requirements for operating personnel include both analyses of tasks associated with each element of the program options, and the experiences of programs currently in operation. In general, the manpower allocation for centralized facilities consists of (1) three inspectors per lane for emission inspections, (2) one manager and one assistant manager for each facility, and (3) one equipment maintenance person for every three emission inspection facilities. Specific manpower requirements for each option are delineated in the sections discussing each option in detail. The requirements for the private garages are entirely different and will also be discussed in the report section describing the private garage option.

Administrative Personnel

A scenario of the administrative personnel requirements was developed based on the overall scope of each option, including geographic coverage and level of operational activity, other states operational programs of a similar scope and nature, and previous studies of I/M programs. The Ohio I/M program administration was formulated to fit with the existing Ohio EPA system.

A schematic diagram of an organizational network is presented in Figure 3. This figure indicates that the I/M program would be coordinated by an administrator who would oversee actions of supporting services and station operations sections. Each of these sections would be headed by a respective assistant administrator. The supporting services assistant in addition to supervising the legal, financial, engineering, and mechanic training officers, would be responsible for assisting the administrator in policy decisions. The station operations assistant would supervise regional managers and be directly responsible for overseeing the operation of state-operated challenge lane facilities (if utilized).

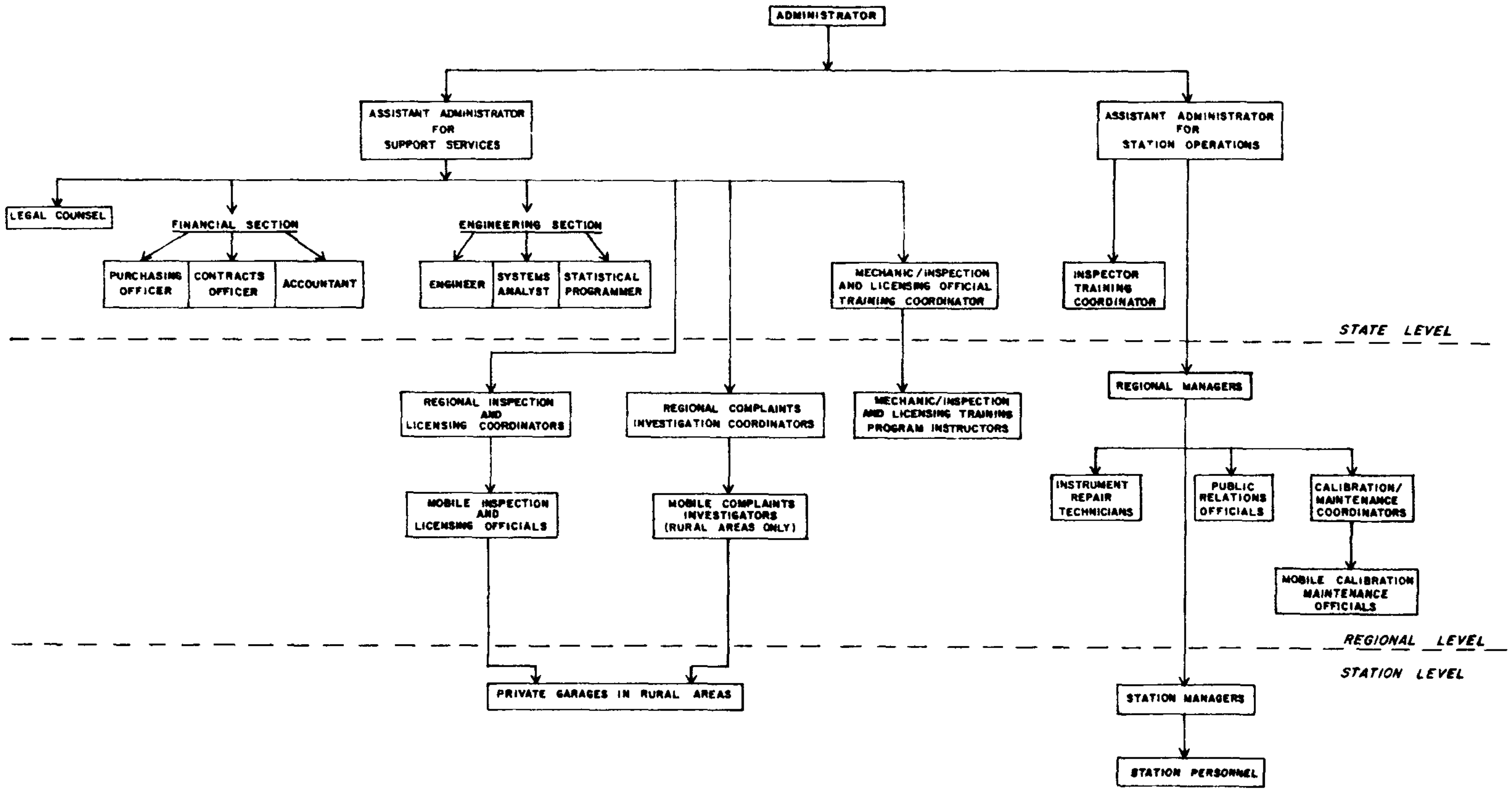

Figure 3. Administrative network Option II.

The legal counsel position, probably handled either by the Ohio EPA's Legal Counsel or the Ohio Attorney General's Office, would assist the administration in interpretation of any legal issues that might arise in the operation of the program.

The financial section of supporting services would consist of three positions: (1) a purchasing officer, (2) a contracts officer, and (3) an accountant. The purchasing officer, in addition to handling actual acquisition of equipment and supplies, would be responsible for formulation of current and future budget requirements.

The contracts officer would be responsible for negotiation and review of all contracts necessary to I/M system construction and operation. The accountant would be in charge of keeping records of all financial transactions involved in the system operation, possibly including receipt of registration fees from motorists.

The engineering section would consist of three positions: (1) a systems engineer, (2) a systems analyst, and (3) a statistician/programmer. The systems engineer formulates and reviews standards for inspection and stringency rates. The systems analyst reviews system performance and develops more efficient system operations methodology.

The statistician/programmer would perform statistical analyses and tabulations required for evaluation of station, regional, or statewide operations and design and update software for data handling.

The mechanics training program coordinator would be responsible for the hiring and education of instructors, arranging training programs, and devising tests for licensing of inspectors and repairmen.

The regional managers would supervise operation of all I/M facilities within each geographic district which would correspond to the five Ohio EPA districts. In the urban area only options, III and IV, only the Southeast EPA District would not have a corresponding I/M district. In all the other options, I, II, V, VI, and VII, there would be regional administrators and other regional personnel for each I/M region. The Ohio EPA district offices are shown in Figure 4. In addition to overall administration, the I/M regional managers would direct surveillance of operations and calibration of test equipment, as well as preparing budget requirements for the region.

The regional inspection and licensing supervisor would be responsible for certification of repair facilities, and assuring that repair industry analyzers are in proper calibration and working order. Serving under this position would be inspection and licensing officials.

The regional complaints investigator would be responsible for following up on consumer complaints in the geographic region.

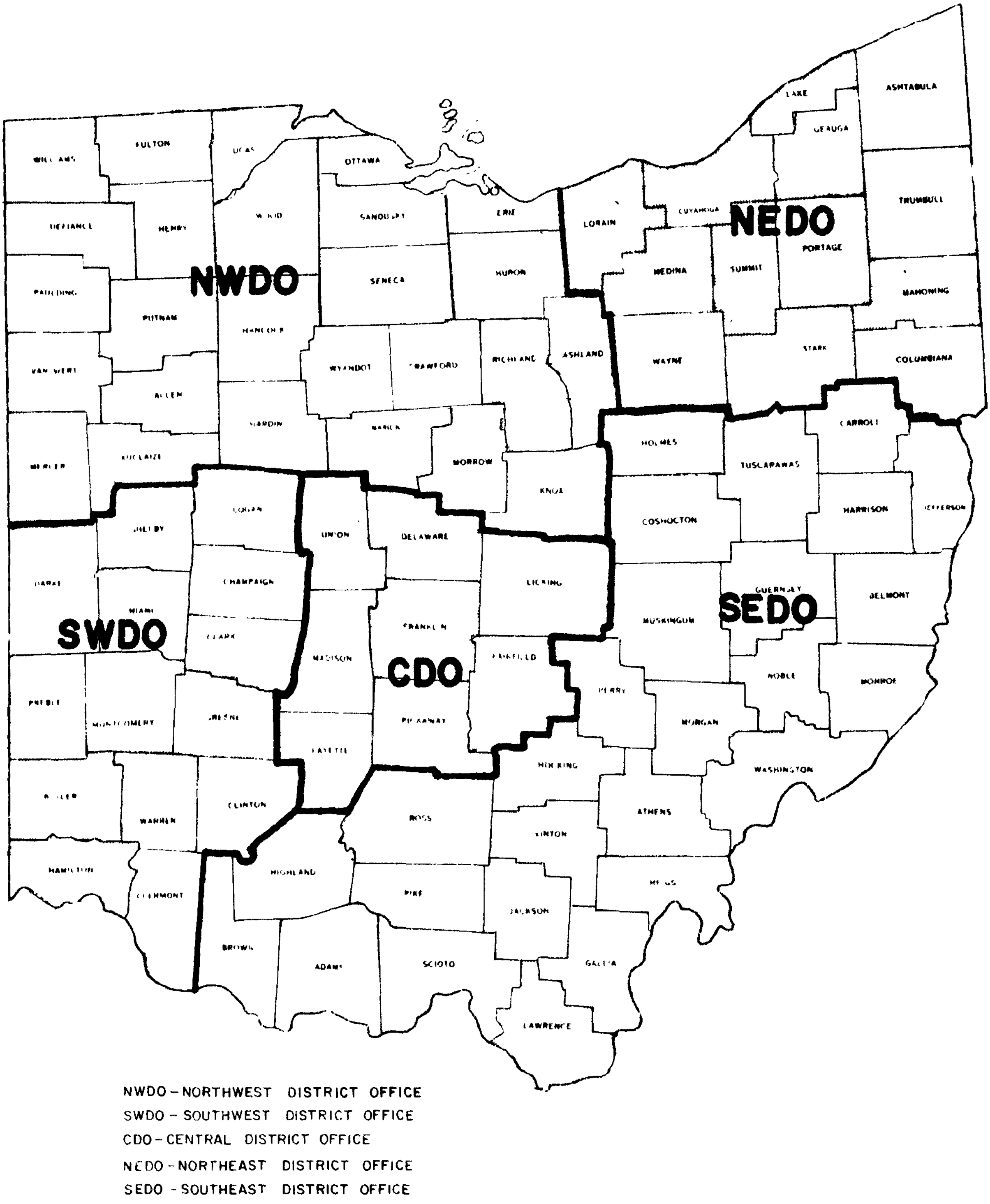

Figure 4. Ohio EPA district offices.

The regional public relations coordinator would serve as spokesperson for the program and provide the public with information to assure participation and support of I/M.

The mechanic training program instructor would develop and conduct classes for mechanics and conduct certification testing.

The instrument repair technician would be responsible for equipment repairs.

All of the above descriptions of administrative personnel apply to all the options. However, in the split options I and II in which private garages are used in rural areas and in option VII, statewide private garage option, the inspection and licensing officials are the investigators or surveillance people who visit each station to check equipment calibration, audit records, etc. Separate organization charts will be included in the option descriptions themselves to clarify these differences.

Personnel Costs

The costs for operating and administrative personnel were derived from the Ohio Revised Code 124.152 which lists the state civil service salary schedule. Essentially, I/M program personnel titles were matched with existing state positions as closely as possible. Salary levels used were those for "starting" personnel. There is one notable exception. The station managers duties included considerably more than the most comparably listed state position. Specifically, the manager would be involved in many aspects of computer operation necessary in a highly automated facility. It was for this reason that the station managers salary was assumed started at 25 percent more than the comparable position classification.

REFERENCES

1. Personal communication with Donald F. Cort, Data Systems Administrator, Bureau of Motor Vehicles, Columbus, Ohio, June 1978.

SECTION 4

OPTION I - • STATEWIDE COVERAGE

• CONTRACTOR ADMINISTERS CENTRALIZED LANES IN URBAN AREAS

• PRIVATE GARAGES IN RURAL AREAS

ALTERNATE A - 12 URBAN COUNTIES

ALTERNATE B - 18 URBAN COUNTIES

OPTION DEFINITION

This option involves a private contractor establishing a network of centralized well mode test lanes in either 12 urban counties with population greater than 200,000 (Alternate A) or in 18 urban counties (Alternate B), which consists of the 12 urban counties mentioned above plus 6 adjacent urban counties. In the remaining rural counties; i.e. outside of the 12 or 18 urban counties, emission inspection would be conducted in a decentralized network of private garages, new car dealers, and service stations. The Ohio Environmental Protection Agency and Bureau of Motor Vehicles are the administrative agencies. Ohio EPA would have overall administrative control of the contractor as well as overseeing the private garages. In Section 17 there is a discussion on the relative advantages and disadvantages of having the state or a private contractor oversee the private garages in the rural areas. The Bureau of Motor Vehicles would be primarily responsible for enforcement in this option. In the motor vehicle registration approach to obtain a valid annual motor vehicle registration the motor vehicle must have passed the emission inspection. In Section 16 there will be a discussion of motor vehicles registration enforcement versus the Sticker/Ticketing method.

NETWORK REQUIREMENTS

In order to derive the basic network requirements in this option for both the centralized lane and the private garages, it is necessary to determine the number of motor vehicles included in the inspection program and thus, to project these figures for 1982 and 1987.

Motor Vehicle Population

Motor vehicle registration data was obtained from the Ohio Motor Vehicle Registry for the most recent year available, 1975. The data for this year was broken down into these categories: passenger cars, trucks, farm trucks, trailers, house vehicles, motor cycles, dealers, buses, church buses, public owned, and total registration. Inspection/maintenance requirements include inspection of all gasoline passenger vehicles and gasoline light duty trucks less than 8500 pounds gross vehicle weight. In order to estimate the number of 1975 base year vehicles in these categories the following assumptions were made relative to Ohio Motor Vehicle Data:

- all "passenger cars" will be inspected
- 75 percent of the category "trucks or gasoline light duty vehicles less than 8500 lb GVW" will be included
- 80 percent of the "farm trucks" category estimated to be less than 8500 lb GVW will be included
- all publicly owned vehicles will be included; few vehicles in this class would exceed 8500 lb GVW
- all "trailers," "house vehicles," "motor cycles," "dealers," "buses," and "church buses" will not be included because they are either not required e.g. trailers or motor cycles or largely over 8500 lb GVW e.g. house trailers

In light of these assumptions the data was aggregated for 1975. Next the motor vehicle populations were projected to 1982 and to 1987. A growth rate of 3 percent per year was used to project motor vehicle populations based on recent trends in the state and the nation.

The following discussions describe how using this motor vehicle registration data the centralized network and the private garage network were derived.

Centralized System

The assumed stringency factor throughout this analysis is 30 percent, meaning that the program is designed to fail 30 percent of the vehicles tested. Assuming that all failed vehicles would have to be retested before registration, the actual number of inspections to be performed is 30 percent higher than the number of individual vehicles required to participate in the program. The actual number of inspections, then, is 1.3 times the affected vehicle population, as shown in Table 13 for both the 12- and 18-county urban area alternatives. By making various assumptions about the throughput capabilities of a single centralized facility inspection lane, the number of such lanes for each of the urban counties can be derived. The assumptions are as follows:

- One vehicle enters the inspection lane every two minutes. This figure was derived from studies of existing facilities in several states' program

TABLE 13. ANNUAL NUMBER OF INSPECTIONS REQUIRED BY COUNTY FOR 1987, CENTRALIZED SYSTEM

County	Number of annual inspections
Butler	270,500
Cuyahoga	1,775,900
Franklin	968,100
Hamilton	947,700
Lake	248,000
Lorain	318,400
Lucas	541,800
Mahoning	343,600
Montgomery	680,700
Stark	428,700
Summit	619,400
Trumbull	293,200
12-County Total	7,436,000
Clermont	132,800
Geauga	84,900
Greene	150,600
Medina	122,700
Warren	106,300
Wood	115,000
18-County Total	8,148,300

- Inspection facilities in urban counties are open for business 44 hr/wk, 52 wk/yr. This is a reasonable estimate based on actual operating times being used in Arizona and other states.
- An efficiency factor of 0.67 would be used to account for random arrival of motorists, equipment down time, etc. Several studies have coroborated this estimate. Hamilton Test Systems, Inc. which runs the program in Oregon also agrees with this figure as being reasonable.

Then the number of vehicles that can be inspected by one centralized lane per year is:

(30 cars/hour)(44 hours/week)(52 weeks/year)(0.67) = 45,989 vehicles

A detailed analysis of the individual tasks associated with the testing remains in centralized facilities and experience from similar programs in other states indicates that throughput time is 2 minutes. This means that the annual capacity for each inspection lane is almost 46,000 vehicles, as indicated above. The number of such lanes required for each of the urban counties, then, is the number of annual inspections divided by the lane capacity; the actual lane requirements are shown in Table 14.

The desirable allocation of inspection facilities throughout each county was determined based on identifying lane requirements for (1) the population center, or core city within an urban county, and (2) the rest of the county, using the following guidelines:

- Single-lane stations should be avoided due to their relatively low level of cost-effectiveness compared to multilane facilities; and
- The maximum station size should be limited to six lanes owing to the excessively high cost of, and probable difficulty in, acquiring parcels large enough to accommodate facilities larger than six lanes

Facilities required to handle core city populations were sited within these cities while the remaining facilities were sited in towns or cities that are most accessible to the remainder of the county. The resulting distribution of facilities, by size and by location (municipality) is shown in Tables 15 and 16.

TABLE 14. TOTAL CENTRALIZED INSPECTION LANES REQUIRED TO SATISFY 1987 URBAN INSPECTION DEMAND

County	Numbers of lanes required
Butler	6
Cuyahoga	39
Franklin	21
Hamilton	21
Lake	6
Lorain	7
Lucas	12
Mahoning	8
Montgomery	15
Stark	10
Summit	14
Trumbull	7
12-County Total	166
Clermont	3
Geauga	2
Greene	4
Medina	3
Warren	3
Wood	3
18-County Total	184

TABLE 15. INSPECTION NETWORK REQUIREMENTS FOR OPTION I - ALTERNATE A - 12-COUNTY

County	Town	Number of facilities	Configuration
Butler	Hamilton	1	3 lanes
	Middletown	1	3 lanes
Cuyahoga	Cleveland	6	6 lanes
	Cleveland	1	3 lanes
Franklin	Columbus	3	6 lanes
	Columbus	1	3 lanes
Hamilton	Cincinnati	3	6 lanes
	Norwood	1	3 lanes
Lake	Mentor-on-the-Lake	1	3 lanes
	Painsville	1	3 lanes
Lorain	Lorain	1	4 lanes
	Elyria	1	3 lanes
Lucas	Toledo	2	6 lanes
Mahoning	Youngstown	1	6 lanes
	Ellsworth	1	2 lanes
Montgomery	Dayton	2	6 lanes
	Englewood	1	3 lanes
Stark	Canton	1	6 lanes
	Alliance	1	4 lanes
Summit	Akron	2	6 lanes
	Cuyahoga Falls	1	2 lanes
Trumbull	Warren	1	4 lanes
	Niles	1	3 lanes
Total network		35	166 lanes

TABLE 16. INSPECTION NETWORK REQUIREMENTS FOR OPTION - ALTERNATE B, 18-COUNTY

County	Town	Number of facilities	Configuration
Butler	Hamilton	1	3 lanes
	Middletown	1	3 lanes
Clermont	Batavia	1	3 lanes
Cuyahoga	Cleveland	6	6 lanes
	Cleveland	1	3 lanes
Franklin	Columbus	3	6 lanes
	Columbus	1	3 lanes
Geauga	Chardon	1	2 lanes
Green	Fairborn	1	4 lanes
Hamilton	Cincinnati	3	6 lanes
	Norwood	1	3 lanes
Lake	Mentor-on-the-Lake	1	3 lanes
	Painsville	1	3 lanes
Lorain	Lorain	1	4 lanes
	Elyria	1	3 lanes
Lucas	Toledo	2	6 lanes
Mahoning	Youngstown	1	6 lanes
	Ellsworth	1	2 lanes
Medina	Medina	1	3 lanes
Montgomery	Dayton	2	6 lanes
	Englewood	1	3 lanes
Stark	Canton	1	6 lanes
	Alliance	1	4 lanes
Summit	Akron	2	6 lanes
	Cuyahoga Falls	1	2 lanes
Trumbull	Warren	1	4 lanes
	Niles	1	3 lanes
Warren	Lebanon	1	3 lanes
Wood	Bowling Green	1	3 lanes
Total network		41	184 lanes

Decentralized Systems

In establishing network requirements for a decentralized system of private inspection stations in rural counties, the vehicle population to be tested was estimated using the same assumptions as those used for the centralized system in urban counties as shown earlier.

Assuming a steady 3 percent per year growth rate in vehicle registrations, the 1987 vehicle population will be divided between urban and rural counties as shown in Table 17.

TABLE 17. VEHICLE REGISTRATIONS IN URBAN AND RURAL AREAS, 1987

Location	Number of registrations	
	12-County urban alternative	18-County urban alternative
Urban	5,720,000	6,267,900
Rural	3,839,700	3,291,800
Statewide Total	9,559,700	9,559,700

Making the same assumption about test stringency in rural areas as in urban, 30 percent more inspections than actual registrations will be required, as shown in Table 18.

TABLE 18. VEHICLE INSPECTIONS REQUIRED IN URBAN AND RURAL AREAS, 1987

Location	Number of inspections required	
	Alternate A - 12 County	Alternate B - 18 County
Urban	7,436,000	8,148,300
Rural	4,991,600	4,279,300
Statewide total	12,427,600	12,427,600

There are thousands of private garages in the rural counties of Ohio which could potentially serve as motor vehicle emissions inspection stations. Rather than arbitrarily choose an "optimum" number of such stations to comprise a rural I/M network, minimum and maximum levels of private garage participation were derived by making certain assumptions about private garage performance and profitability. Somewhere in the range of participation between these minimum and maximum levels is the level at which a network of private garages can reasonably be expected to operate; the average of the minimum and maximum levels (the "mid" level) has been chosen for analysis as one such participation level.

Minimum Rural Private Garage Network--

The formula below was used to calculate private participation in an I/M network:

$$G = \frac{I}{DN}$$

where G = the number of garages required to participate in an I/M program

I = the total number of inspections to be performed per year

D = the number of inspection days per year

N = the number of vehicles inspected by each garage per day.

Thus, G, the number of garages, and N, the daily throughput per garage, are inversely related. If I and D are held constant, then maximizing N will result in a minimum value for G, or the minimum network required to perform inspections. By making reasonable assumptions about inspection efficiency, and therefore the daily throughput rate of private garages, minimum values for G can be calculated as follows:

- All reinspections of failed vehicles are performed by private garages
- One work-day = 8 hours
- One work-year = 250 days
- The maximum possible throughput for a private garage with one HC/CO analyzer and one person performing inspections is one vehicle every 15 minutes. In an 8-hour day, if inspections are performed continuously, this means that (8 hours)x(4 vehicles/hour) = 32 vehicles can be inspected.
- An efficiency factor of 0.67 to account for equipment downtime, mechanic lunch breaks, random motorist arrival, etc. The daily throughput thus becomes (32 vehicles/day)×(0.67) = 21 vehicles per day, or 5,250 vehicles per year. Substituting this throughput for N in the above formula, yields the results shown in Table 19.

TABLE 19. MINIMUM PRIVATE GARAGE NETWORK IN RURAL AREAS

Urban area alternative	Number of garages
12-County	951
18-County	815

The following two characteristics are useful in describing a private garage network:

- Service Area Radius:

  Assume no motorist need drive more than a certain distance, R, to an inspection station. Assuming cars and garages are spread evenly across the landscape, this distance R is the radius of the service area of the station, and πR^2 is its service area. Given a certain number of garages within a given area, R can be calculated by the formula:

  $$R = \sqrt{\frac{A}{\pi G}}$$

  where R = service area radius

  A = given geographical area

  π = 3.14159...

  G = number of garages in area A.

- Market Participation:

  $$P = \frac{G}{T}$$

  where P = market participation, expressed as a percentage

  G = number of private garages serving as inspection stations in a given area

  T = total number of private garages within the same area.

Table 20 shows the service area radius and the market participation levels for the minimum private garage network derived above:

TABLE 20. SERVICE AREA RADIUS AND MARKET PARTICIPATION RATE, MINIMUM RURAL PRIVATE GARAGE NETWORK

Urban area alternative	Service area radius (mi)	Market participation rate (%)
12-County	3.45	18.0
18-County	3.58	17.6

Maximum Private Garage Network--

As the number of private garages increases, the service area and throughput rate for each garage will decline. The number of licensed inspection stations can increase beyond the minimum network described above. There is, however, a constraint on the total number of such stations that can exist at any one point in time. Private garages are motivated to participate in an I/M program by the potential profits which they can make by charging for inspections. The minimum revenue from I/M participation that is acceptable to private garages would be the costs they incur in performing inspections, as shown in Figure 5 below:

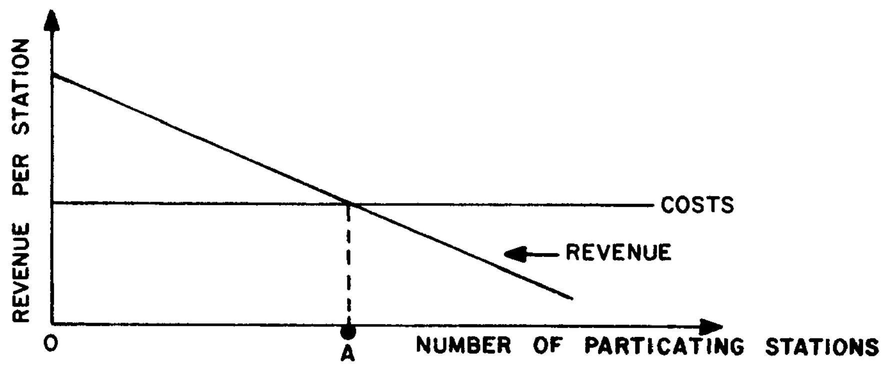

Figure 5. Market factors affecting private garage participation.

As the number of stations increases the number of inspections occurring at each station declines and revenues fall correspondingly. This is reflected by the negative slope of the revenue curve in Figure 5. Garages will continue to enter the I/M business (for that is what it is to them) until the total number of stations is equal to A. At this point each station makes zero return on its investment. Stations will operate at this seemingly irrational margin because repair business is likely to be generated for garages that have the capability to perform inspections. No stations are likely to operate in excess of A because to do so would be to operate at a loss. To the right of point A costs exceed revenues.

The formula that governs private garage market entry behavior is:

Total Revenue (TR) = Total Cost (TC)

This equation can be separated into component parts in the following manner:

$$M\ (C-F) = (A) + (S) + (L) + (O)$$

where: M = number of cars inspected per year

C = inspection charge, assumed to be \$5.00

F = state fee per inspection to cover administrative costs, assumed to be \$0.50

A = cost of analyzer and accessories. If a typical station purchases an analyzer and accessories costing \$3,000 over a 5-year period at 8 percent interest, its annual payment will be

$$\text{Payment} = \frac{3{,}000}{\left[\dfrac{(1.08)^5 - 1)}{0.08(1.08)^5}\right]} = \$751.88$$

S = the salary of the inspector. This can be calculated using the following formula. S can be further disaggregated into its components:

$$S = (H)\ (W)\ (D)$$

where: H = number of hours per day spent performing inspections

W = the hourly wage of the inspector

D = the number of days per year spent performing inspections

L = annual licensing fees, assumed not to exceed \$100.00.

O = station overhead, assumed to be 1/3 of inspector salary S.

substituting and solving for M:

$$M = \frac{(A + S + L + O)}{(C - F)}$$

$$= \frac{A + (4/3)\ (H)\ (W)\ (D) + L}{(C - F)}$$

recalling the formula:

$$G = \frac{I}{DN}$$

and solving for G yields the number of garages participating in an I/M network. Since the number of cars inspected per year for one station equals the number of inspection days per year times station throughput:

$$M = DN$$

Using the above cost assumptions the number of vehicle inspections necessary for a facility to cover its costs (M) can be calculated for various salary (S) rates and operating costs (O). The minimum quantity of vehicle inspections thus calculated determine the maximum number of private garages that can be licensed for the assumed 1987 vehicle population.

Tables 21a and 21b reveal the maximum number of garages that market forces will allow to operate for different inspector wages and hours per day devoted to I/M inspections, for both the 12- and 18-county urban area alternatives.

A reasonable combination of variables would be an inspector wage rate of $5.50 per hour and a 4-hour inspection day; a break-even throughput of 1,819 vehicles per station per year results. Table 22 shows the maximum network participation for both the 12- and 18-county urban area alternatives using the above assumptions.

Table 23 shows the service area radii and market participation rates associated with the above maximum levels.

Taking the average of the above-derived minimum and maximum participation levels yields what will be referred to as the "mid" level in the cost analysis of this option. Information concerning this "mid" level of participation is summarized in Table 24.

OPTION COSTS

The costs associated with the implementation and operation of this option are presented here. Reference should be made to the discussion in Section 3 concerning the analytical techniques used. In order to determine the costs for this combined option, one which has both centralized state run lanes in the urban areas and private garages in the rural areas, it was necessary to make some assumptions in the distribution of costs:

- Initial start-up costs would be paid for only by urban motor vehicle owners. These costs, including land investment, building investment, and equipment costs for central lanes add up to a very large amount and would raise the rural fee making it difficult for a private garage to break even without charging a fee higher than the one derived for the centralized lanes.

- One-time start-up costs would be paid for by the urban motor vehicle owners. It would be administratively difficult to estimate some of the costs attributable solely to the rural

TABLE 21a. MAXIMUM PRIVATE GARAGE PARTICIPATION (NUMBER OF GARAGES) - 12-COUNTY URBAN AREA ALTERNATIVE

Hours per day spent on inspections	Inspector hourly wage rate		
	$4.50	$5.50	$6.50
1	7,342*	6,432*	5,722*
2	4,485	3,825	3,330
3	3,229	2,719	2,348
4	2,523	2,111	1,814
5	2,070	1,725	1,477
6	1,755	1,458	1,246
7	1,523	1,262	1,078
8	1,345	1,113	949

*The number of garages indicated here exceeds the total number of rural garages; this combination of hours and wages is therefore not feasible.

TABLE 21b. MAXIMUM PRIVATE GARAGE PARTICIPATION (NUMBER OF GARAGES) - 18-COUNTY URBAN AREA ALTERNATIVE

Hours per day spent on inspections	Inspector hourly wage rate		
	$4.50	$5.50	$6.50
1	6,294*	5,514*	4,906*
2	3,845	3,278	2,855
3	2,768	2,332	2,013
4	2,163	1,810	1,555
5	1,775	1,479	1,266
6	1,505	1,250	1,068
7	1,305	1,082	924
8	1,153	955	814

*The number of garages indicated here exceeds the total number of rural garages; this combination of hours and wages is therefore not feasible.

TABLE 22. MAXIMUM PRIVATE GARAGE PARTICIPATION IN RURAL AREAS

Urban area alternative	Number of garages
12-County	2,111
18-County	1,810

TABLE 23. SERVICE AREA RADIUS AND MARKET PARTICIPATION RATE, MAXIMUM RURAL PRIVATE GARAGE NETWORK

Urban area alternative	Service area radius (mi)	Market participation rate (%)
12-County	2.32	40.1
18-County	2.40	39.1

TABLE 24. PRIVATE GARAGES IN RURAL AREAS: MID PARTICIPATION LEVELS

Urban area alternative	Number of garages	Service area radius (mi)	Market participation rate (%)
12-County	1,531	2.72	29.1
18-County	1,313	2.82	28.3

garage program. Those clearly attributable to the rural garage program would not raise the fees more than a few cents.

- Annual operating costs are solely costs related to operation of the centralized lanes.

- Annual administrative costs would be summed for both centralized and rural garage administration.

Capital Costs

Land Costs--

The primary determinants of land cost for any option are (1) the unit cost per square foot, and (2) the total size (square feet of the land to be acquired. In Section 3, unit cost estimates for land in each county were presented, and these will be used here.

The lot size requirements are a function of facility size (i.e., the number of lanes). A general relationship exists between the land area required and the floor area size of the test facility; this relationship is that the ratio of land area to building area is approximately 5:1. The building sizes can be defined as a function of the number of inspection lanes; therefore, since the number of facilities by configuration (i.e., number of lanes) has been defined, the land areas for each facility can be defined, as well. The total land costs, then, are presented in Tables 25 and 26.

A cost for land improvements is added to the basic land cost to obtain the total land investment. The primary elements involved in improvements are paving and landscaping. Based on analyses of parking requirements, standard pavement and landscaped areas have been developed for each type of facility. These are shown in Table 27.

Based on a unit price of $0.80 per square foot and $0.25 per square for paving and landscaping, the improvement costs for each facility type can be computed. These are shown in Table 28. The actual improvement costs associated with each facility are shown in Tables 29 and 30.

Building Costs--

As indicated in the discussion presented in Section 3, the types of buildings that are likely to be used are estimated to cost $27.75 per square foot to construct, regardless of which of the centralized facility options is considered. The problem, then, in developing an estimate of the building cost for any specific option is reduced to one of defining the basic size of the building.

For this option, an analysis of the specific inspection tasks (including equipment required) was made to define the general features required of an inspection facility. Literature searches and interviews with individuals involved in operating similar programs, were then contacted, which resulted in being able to define the specific building requirements and to dimension the various work areas. A conceptual floor plan for the basic type of facility

TABLE 25. LAND COSTS FOR EACH FACILITY IN OPTION I - ALTERNATE A, 12-COUNTY

County	Municipality	Facility configuration	Number of facilities	Total building area (ft^2)	Land area (ft^2)	Unit cost of land ($)	Total land cost ($)
Butler	Hamilton	3 lanes	1	7,785	38,925	0.92	35,811
	Middletown	3 lanes	1	7,785	38,925	0.92	35,811
Cuyahoga	Cleveland	6 lanes	3	47,070	235,350	0.34	80,019
	Cleveland	6 lanes	3	47,070	235,350	0.92	216,522
	Cleveland	3 lanes	1	7,785	38,925	0.92	35,811
Franklin	Columbus	6 lanes	1	15,690	78,450	0.34	26,673
	Columbus	6 lanes	2	31,380	156,900	0.92	144,348
	Columbus	3 lanes	1	7,785	38,925	0.92	35,811
Hamilton	Cincinnati	6 lanes	2	31,380	156,900	0.34	53,376
	Cincinnati	6 lanes	1	15,690	78,450	0.92	72,174
	Norwood	3 lanes	1	7,785	38,925	0.92	35,811
Lake	Mentor on the Lake	3 lanes	1	7,785	38,925	0.92	35,811
	Painsville	3 lanes	1	7,785	38,925	0.92	35,811
Lorain	Lorain	4 lanes	1	10,185	50,925	0.92	46,851
	Elyria	3 lanes	1	7,785	38,925	0.92	35,811
Lucas	Toledo	6 lanes	2	31,380	156,900	0.92	144,348
Mahoning	Youngstown	6 lanes	1	15,690	78,450	0.92	72,174
	Ellsworth	2 lanes	1	5,615	28,075	0. 2	25,829
Montgomery	Dayton	6 lanes	2	31,380	156,900	0.92	144,348
	Englewood	3 lanes	1	7,785	38,925	0.92	35,811
Stark	Canton	6 lanes	1	15,690	18,450	0.92	72,174
	Alliance	4 lanes	1	10,185	50,925	0.92	46,859
Summit	Akron	6 lanes	1	15,690	78,450	0.92	72,174
	Akron	6 lanes	1	15,690	78,450	0.34	26,673
	Cuyahoga Falls	2 lanes	1	5,615	28,075	0.92	25,829
Trumbull	Warren	4 lanes	1	10,145	50,925	0.92	46,851
	Niles	3 lanes	1	7,785	38,925	0.92	35,811
Total							1,675,296

TABLE 26. LAND COSTS FOR EACH FACILITY IN OPTION I - ALTERNATE B, 18-COUNTY

County	Municipality	Facility configuration	Number of facilities	Total building area (ft^2)	Land area (ft^2)	Unit cost of land ($)	Total land cost ($)
Butler	Hamilton	3 lanes	1	7,785	38,925	0.92	35,811
	Middletown	3 lanes	1	7,785	38,925	0.92	35,811
Clermont	Batavia	3 lanes	1	7,785	38,925	0.92	35,811
Cuyahoga	Cleveland	6 lanes	3	47,070	235,350	0.34	80,019
	Cleveland	6 lanes	3	47,070	235,350	0.92	216,522
	Cleveland	3 lanes	1	7,785	38,925	0.92	35,811
Franklin	Columbus	6 lanes	1	15,690	78,450	0.34	26,673
	Columbus	6 lanes	2	31,380	156,900	0.92	144,348
	Columbus	3 lanes	1	7,785	38,925	0.92	35,811
Geauga	Chardon	2 lanes	1	5,615	28,075	0.92	25,829
Green	Fairborn	4 lanes	1	10,185	50,925	0.92	46,851
Hamilton	Cincinnati	6 lanes	2	31,380	156,900	0.34	53,346
	Cincinnati	6 lanes	1	15,690	78,450	0.92	72,174
	Norwood	3 lanes	1	7,785	38,925	0.92	35,811
Lake	Mentor on the Lake	3 lanes	1	7,785	38,925	0.92	35,811
	Painsville	3 lanes	1	7,785	38,925	0.96	35,811
Lorain	Lorain	4 lanes	1	10,185	50,925	0.92	46,851
	Elyria	3 lanes	1	7,785	38,925	0.92	35,811
Lucas	Toledo	6 lanes	2	31,380	156,900	0.92	144,348
Mahoning	Youngstown	6 lanes	1	15,690	78,450	0.92	72,[illegible]
	Ellsworth	2 lanes	1	5,615	28,075	0.92	25,829
Medina	Medina	3 lanes	1	7,785	38,925	0.92	35,811
Montgomery	Dayton	6 lanes	2	31,380	156,900	0.92	144,348
	Englewood	3 lanes	1	7,785	38,925	0.92	35,811
Stark	Canton	6 lanes	1	15,690	78,450	0.92	72,174
	Alliance	4 lanes	1	10,185	50,925	0.92	46,859
Summit	Akron	6 lanes	1	15,690	78,450	0.92	72,174
	Akron	6 lanes	1	15,690	78,450	0.34	26,673
	Cuyahoga Falls	2 lanes	1	5,615	28,075	0.92	25,829
Trumbull	Warren	4 lanes	1	10,185	50,925	0.92	46,851
	Niles	3 lanes	1	7,785	38,925	0.92	35,811
Warren	Lebanon	3 lanes	1	7,785	38,925	0.92	35,811
Wood	Bowling Green	3 lanes	1	7,785	38,925	0.92	35,811
Total							1,891,218

TABLE 27. PAVEMENT AND LANDSCAPING REQUIREMENTS FOR OPTION B FACILITIES, ft^2

Facility configuration	Total area	Paved area	Landscaped area
1 lane	18,550	6,215	8,625
2 lane	28,075	12,430	10,030
3 lane	38,925	18,645	12,495
4 lane	50,925	24,725	16,015
5 lane	64,175	30,940	20,400
6 lane	78,450	37,020	25,740

TABLE 28. LAND IMPROVEMENT COSTS FOR INSPECTION FACILITY SITES UNDER OPTION I

Facility configuration	Pavement costs	Landscaping costs	Total improvement costs
1 lane	$ 4,972	$2,156	$ 7,128
2 lane	$ 9,944	$2,508	$12,452
3 lane	$14,916	$3,124	$18,040
4 lane	$19,780	$4,004	$23,784
5 lane	$24,752	$5,100	$29,852
6 lane	$29,616	$6,435	$36,051

TABLE 29. LAND IMPROVEMENTS COST FOR FACILITIES UNDER OPTION I - ALTERNATE A - 12-COUNTY

County	Municipality	Facility configuration	Number of facilities	Cost per facility ($)	Total improvements ($)
Butler	Hamilton	3 lanes	1	18,040	18,040
	Middletown	3 lanes	1	18,040	18,040
Cuyahoga	Cleveland	6 lanes	6	36,051	216,306
	Cleveland	3 lanes	1	18,040	18,040
Franklin	Columbus	6 lanes	3	36,051	108,153
	Columbus	3 lanes	1	18,040	18,040
Hamilton	Cincinnati	6 lanes	3	36,051	108,153
	Norwood	3 lanes	1	18,040	18,040
Lake	Menter-on-the-Lake	3 lanes	1	18,040	18,040
	Painsville	3 lanes	1	18,040	18,040
Lorain	Lorain	4 lanes	1	23,784	23,784
	Elyra	3 lanes	1	18,040	18,040
Lucas	Toledo	6 lanes	2	36,051	72,102
Mahoning	Youngstown	6 lanes	1	36,051	36,051
	Ellsworth	2 lanes	1	12,452	12,452
Montgomery	Dayton	6 lanes	2	36,051	72,102
	Englewood	3 lanes	1	18,040	18,040
Stark	Canton	6 lanes	1	36,051	36,051
	Alliance	4 lanes	1	23,784	23,784
Summit	Akron	6 lanes	2	36,051	72,102
Trumbull	Cuyahoga Falls	2 lanes	1	12,452	12,452
	Warren	4 lanes	1	23,784	23,784
	Niles	3 lanes	1	18,040	18,040
Total					997,676

TABLE 30. LAND IMPROVEMENTS COST FOR FACILITIES UNDER OPTION I - ALTERNATE B, 18 COUNTY

County	Municipality	Facility configuration	Number of facilities	Cost per facility ($)	Total improvements ($)
Butler	Hamilton	3 lanes	1	18,040	18,040
	Middletown	3 lanes	1	18,040	18,040
Clermont	Batavia	3 lanes	1	18,040	18,040
Cuyahoga	Cleveland	6 lanes	6	36,051	216,306
	Cleveland	3 lanes	1	18,040	18,040
Franklin	Columbus	6 lanes	3	36,051	108,153
	Columbus	3 lanes	1	18,040	18,040
Geauga	Chardon	2 lanes	1	12,452	12,452
Green	Fairborn	4 lanes	1	23,784	23,784
Hamilton	Cincinnati	6 lanes	3	36,051	108,153
	Norwood	3 lanes	1	18,040	18,040
Lake	Mentor on the Lake	3 lanes	1	18,040	18,040
	Painsville	3 lanes	1	18,040	18,040
Lorain	Lorain	4 lanes	1	23,784	23,784
	Elyria	3 lanes	1	18,040	18,040
Lucas	Toledo	6 lanes	2	36,051	72,102
Mahoning	Youngstown	6 lanes	1	36,051	36,051
	Ellsworth	2 lanes	1	12,452	12,452
Medina	Medina	3 lanes	1	18,040	18,040
Montgomery	Dayton	6 lanes	2	36,051	72,102
	Englewood	3 lanes	1	18,040	18,040
Stark	Canton	6 lanes	1	36,051	36,051
	Alliance	4 lanes	1	23,784	23,784
Summit	Akron	6 lanes	2	36,051	72,102
	Cuyahoga Falls	2 lanes	1	12,452	12,452
Trumbull	Warren	4 lanes	1	23,784	23,784
	Niles	3 lanes	1	18,040	18,040
Warren	Lebanon	3 lanes	1	18,040	18,040
Wood	Bowling Green	3 lanes	1	18,040	18,040
Total					1,106,072

required for safety, noise, and emission testing is shown in Figure 6. Although Figure 6 shows a one-lane facility, the total floor area for a multilane facility would increase primarily by the single inspection-area floor space, times the number of inspection lanes; additional space for waiting areas, rest areas, etc., would also be required. Table 31 shows the building area requirements for facility configurations ranging from one to six lanes.

The cost, then, is computed as the product of (1) the building area, and (2) the unit cost, assumed here to be $27.50 per square foot. The actual cost estimate for the facilities, then, can be computed. These are shown in Tables 32 and 33.

Equipment costs for any facility configuration, then, can be derived from Tables 32 and 33. A summary of equipment cost as a function of the facility configuration is shown in Table 34.

TABLE 34. EQUIPMENT COSTS AS A FUNCTION OF FACILITY CONFIGURATION FOR OPTION I

Number of lanes	Equipment cost ($)
1	107,500
2	135,000
3	162,500
4	190,000
5	217,500
6	245,000

The total cost for equipment can now be computed based on the number of facilities by configuration, developed previously. These costs are shown in Tables 35 and 36. Two additional items must be included with equipment costs; these include calibration vans and equipment, and a central computer. The number of vans is a function of the specific program scope, therefore will vary according to the particular option being considered. Only one computer is required for each option.

For Option I, it is estimated that twelve maintenance/calibration vans would be required. The estimated unit cost for the van plus calibrating gases and equipment is $14,000. The total cost, then, is $168,000.

An additional 25 vans are required for inspection and licensing officials, costing a total of $350,000.

A cost of $38,500 was suggested by a contractor from another state for installation of security systems.

A cost of $85,000 was included to cover 17 Complaint Investigators cars, estimated to cost $5,000 each.

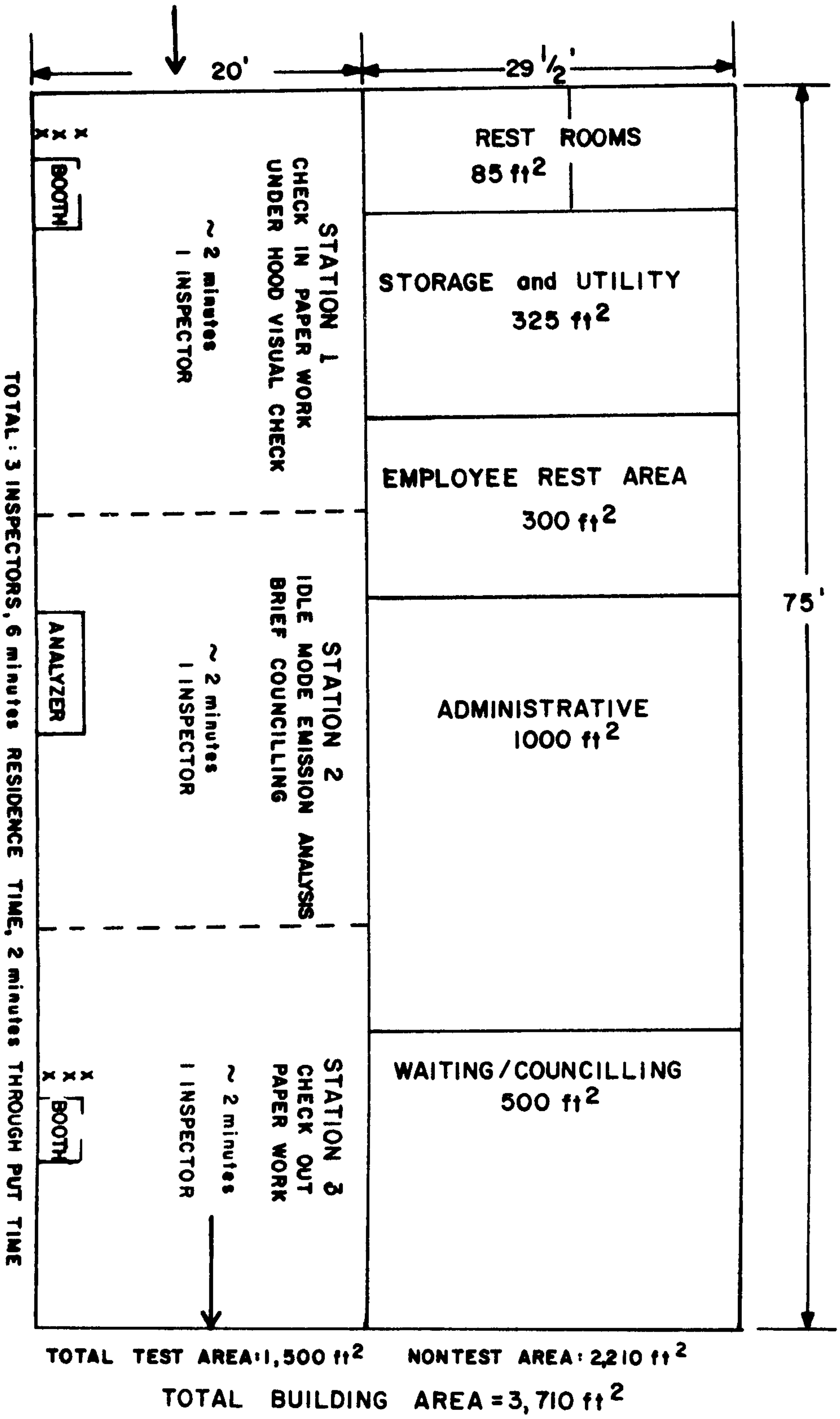

Figure 6. Conceptual floor plan for an idle mode inspection facility.

TABLE 31. BUILDING FLOOR AREA FOR VARIOUS FACILITY CONFIGURATIONS - OPTION I

Configuration	Floor area required (ft^2)						
	Test area	Administration	Employee rest	Storage	Waiting	Restrooms	Total
1-lane	1,500 ft^2	1,000 ft^2	300 ft^2	325 ft^2	500 ft^2	85 ft^2	3,710 ft^2
2-lane	3,000	1,000	330	350	850	85	5,615
3-lane	4,500	1,000	375	375	1,450	85	7,785
4-lane	6,000	1,000	400	400	2,300	85	10,185
5-lane	7,500	1,000	450	425	3,375	85	12,835
6-lane	9,000	1,000	480	425	4,700	85	15,690

TABLE 32. BUILDING COST ESTIMATES FOR OPTION I - ALTERNATE A 12-COUNTY

County	Facility configuration	Per facility cost ($)	Number of facilities required	Total cost ($)
Butler	3 lanes	216,034	2	432,068
Cuyahoga	6 lanes	435,398	6	2,612,388
	3 lanes	216,034	1	216,034
Franklin	6 lanes	435,398	3	1,306,194
	3 lanes	216,034	1	216,034
Hamilton	6 lanes	435,398	3	1,306,194
	3 lanes	216,034	1	216,034
Lake	3 lanes	216,034	2	432,068
Lorain	4 lanes	282,634	1	282,634
	3 lanes	216,034	1	216,034
Lucas	6 lanes	435,398	2	870,796
Mahoning	6 lanes	435,398	1	435,398
	2 lanes	155,816	1	155,816
Montgomery	6 lanes	435,398	2	870,796
	3 lanes	216,034	1	216,034
Stark	6 lanes	435,398	1	435,398
	4 lanes	282,634	1	282,634
Summit	6 lanes	435,398	2	870,796
	2 lanes	155,816	1	155,816
Trumbull	4 lanes	282,634	1	282,634
	3 lanes	216,034	1	216,034
Total				12,027,834

TABLE 33. BUILDING COST ESTIMATRS FOR OPTION I - ALTERNATE B 18-COUNTY

County	Facility configuration	Per facility cost ($)	Number of facilities required	Total cost ($)
Butler	3 lanes	216,034	2	432,068
Clermont	3 lanes	216,034	1	216,034
Cuyahoga	6 lanes	435,398	6	2,612,388
	3 lanes	216,034	1	216,034
Franklin	6 lanes	435,398	3	1,306,194
	3 lanes	216,034	1	216,034
Geauga	2 lanes	155,816	1	155,816
Greene	4 lanes	282,634	1	282,634
Hamilton	6 lanes	435,398	3	1,306,194
	3 lanes	216,034	1	216,034
Lake	3 lanes	216,034	2	432,068
Lorain	4 lanes	282,634	1	282,634
	3 lanes	216,034	1	216,034
Lucas	6 lanes	435,398	2	870,796
Mahoning	6 lanes	435,398	1	435,398
	2 lanes	155,816	1	155,816
Medina	3 lanes	216,034	1	216,034
Montgomery	6 lanes	435,398	2	870,796
	3 lanes	216,034	1	216,034
Stark	6 lanes	435,398	1	435,398
	4 lanes	282,634	1	282,634
Summit	6 lanes	435,398	2	870,796
	2 lanes	155,816	1	155,816
Trumbull	4 lanes	282,634	1	282,634
	3 lanes	216,034	1	216,034
Warren	3 lanes	216,034	1	216,034
Wood	3 lanes	216,034	1	216,034
Total				13,330,420

TABLE 35. EQUIPMENT COSTS FOR OPION I - ALTERNATE A, 12-COUNTY

County	Town	Facility configuration	Number of facilities required	Equipment cost per facility ($)	Total cost of equipment ($)
Butler	Hamilton	3 lanes	1	162,500	162,500
	Middletown	3 lanes	1	162,500	162,500
Cuyahoga	Cleveland	6 lanes	6	245,000	1,470,000
	Cleveland	3 lanes	1	162,500	162,500
Franklin	Columbus	6 lanes	3	245,000	735,000
	Columbus	3 lanes	1	162,500	162,500
Hamilton	Cincinnati	6 lanes	3	245,000	735,000
	Norwood	3 lanes	1	162,500	162,500
Lake	Mentor-on-the-Lake	3 lanes	1	162,500	162,500
	Painsville	3 lanes	1	162,500	162,500
Lorain	Lorain	4 lanes	1	190,000	190,000
	Elyra	3 lanes	1	162,500	162,500
Lucas	Toledo	6 lanes	2	245,000	490,000
Mahoning	Youngstown	6 lanes	1	245,000	245,000
	Ellsworth	2 lanes	1	135,000	135,000
Montgomery	Dayton	6 lanes	2	245,000	490,000
	Englewood	3 lanes	1	162,500	162,500
Stark	Canton	6 lanes	1	245,000	245,000
	Alliance	4 lanes	1	190,000	190,000
Summit	Akron	6 lanes	2	245,000	490,000
	Cuyahoga Falls	2 lanes	1	135,000	135,000
Trumbull	Warren	4 lanes	1	190,000	190,000
	Niles	3 lanes	1	162,500	162,500
Total					7,365,000
Central computer					250,000
Maintenance/calibration vans					168,000
Security systems					38,500
Inspection/licensing vans (14,000)(25)					350,000
Complaints Investigators cars (5,000)(17)					85,000
					8,256,500

TABLE 36. EQUIPMENT COSTS FOR OPTION I - ALTERNATE B, 18-COUNTY

County	Town	Facility configuration	Number of facilities required	Equipment cost per facility ($)	Total cost of equipment ($)
Butler	Hamilton	3 lanes	1	162,500	162,500
	Middletown	3 lanes	1	162,500	162,500
Clermont	Batavia	3 lanes	1	162,500	162,500
Cuyahoga	Cleveland	6 lanes	6	245,000	1,470,000
	Cleveland	3 lanes	1	162,500	162,500
Franklin	Columbus	6 lanes	3	245,000	735,000
	Columbus	3 lanes	1	162,500	162,500
Geauga	Chardon	2 lanes	1	135,000	135,000
Greene	Fairborn	4 lanes	1	190,000	190,000
Hamilton	Cincinnati	6 lanes	3	245,000	735,000
	Norwood	3 lanes	1	162,500	162,500
Lake	Mentor-on-the-Lake	3 lanes	1	162,500	162,500
	Painsville	3 lanes	1	162,500	162,500
Lorain	Lorain	4 lanes	1	190,000	190,000
	Elyra	3 lanes	1	162,500	162,500
Lucas	Toledo	6 lanes	2	245,000	490,000
Mahoning	Youngstown	6 lanes	1	245,000	245,000
	Ellsworth	2 lanes	1	135,000	135,000
Medina	Medina	3 lanes	1	162,500	162,500
Montgomery	Dayton	6 lanes	2	245,000	490,000
	Englewood	3 lanes	1	162,500	162,500
Stark	Canton	6 lanes	1	245,000	245,000
	Alliance	4 lanes	1	190,000	190,000
Summit	Akron	6 lanes	2	245,000	490,000
	Cuyahoga Falls	2 lanes	1	135,000	135,000
Trumbull	Warren	4 lanes	1	190,000	190,000
	Niles	3 lanes	1	162,500	162,500
Warren	Lebanon	3 lanes	1	162,500	162,500
Wood	Bowling Green	3 lanes	1	162,500	162,500
Total					8,340,000
Central computer					250,000
Maintenance/calibration vans					196,000
Security systems					45,100
Inspection/licensing official vans (21)					294,000
Complaints Investigators cars (15)					75,000
					9,200,100

One-Time Start-Up Costs

Land Acquisition--

Land acquistion costs reflect the effort required to locate and evaluate candidate sites, perform required surveying, negotiate price, and convey title. As explained in Section 3, these costs are computed on the basis of $6,000 per site to cover locating, evaluating, and performing surveys, plus 10 percent of tje purchase price to cover the costs associated with conveying the title. This is computed for Alternates A and B below:

Alternate A = (35 sites × $6,000) + (0.10) (1,675,294) = $377,529

Alternate B = (41 sites × $6,000) + (0.10) (1,891,218) = $435,122

Program Design--

Based on an analysis of likely requirements for Ohio I/M program and experiences in other states program estimates were derived of $100,000 for the centralized lane program and an additional $75,000 for the private garage program in the rural areas. The total program would cost $175,000.

Data Handling Software--

Based on discussions with computer systems analysts, an estimate of $200,000 was developed for the centralized lanes. For the rural areas, an additional $67,000 would be needed for batch mode software development. The total software development would then be $267,000 for the entire state.

Facilities Planning--

It is assumed that the cost of facilities planning will be equal to 10 percent of the buildings cost or $1,202,783 for Alternate A, and $1,333,042 for Alternate B.

Personnel training--

As indicated in Section 3, an initial intensive training effort is required prior to program startup. The personnel requirements for each facility was determined from discussions with state and private contractors involved with I/M programs. The allocation of personnel for the centralized facilities are:

- One manager and one assistant manager per facility
- Three inspectors per test lane
- One maintenance/calibration person for every three facilities
- One investigator for every region (five in total).

Additional personnel to be trained for the private garage supervision are:

- One inspection and licensing official for 70 garages
- One complaints investigator for every 100 garages.

The basic operating personnel requirements for Option I are:

- Alternate A

  - 35 managers
  - 35 assistant managers
  - 5 investigators
  - 12 maintenance/calibration people
  - 478 inspectors - centralized lanes
  - 25 inspection/licensing officials
  - 17 complaints investigators

  627

- Alternate B

  - 41 managers
  - 41 test managers
  - 5 investigators
  - 14 maintenance/calibration people
  - 522 inspectors - centralized lanes
  - 21 inspection and licensing offcials
  - 15 complaints investigators

  659

The training costs per individual as discussed in Section 3, are $53.00 for instructors, $43.00 for investigators, and $16.00 for emissions inspectors. Assuming that (1) managers need to be trained at the instructors level, (2) investigators, inspection and licensing officials, and claims investigators need training at the investigator level, and (3) assistant managers, maintenance calibration personnel and inspectors need training at the emission inspector level, then the costs of training may be calculated, as shown in Table 37.

Personnel Salaries--

Assuming (1) that all managerial personnel would be phased into the program 6 months prior to start-up; (2) inspectors would be phased into the program 1 month prior to start-up; and (3) the wage scale (a) for managers is $15,000 per year ($1,250 per month), (b) for assistant managers is $13,000 per year ($1,083 per month), (c) maintenance/calibration persons is $12,000 per year ($1,000 per month), and (d) for inspectors is $9,000 per year $1,000 per month). The total test personnel for startup can be derived. This is:

TABLE 37. COST OF TRAINING OPTION I

	Instruction level	Job titles	Number of positions: Alternate A	Number of positions: Alternate B	Costs ($): Alternate A	Costs ($): Alternate B
1.	Instructor level $53.00 each	Manager	35	41	1,855	2,175
2.	Investigator $43.00 each	Investigator Inspection/licensing Claims investigator	47	41	2,021	1,763
3.	Emission inspectors $16.00 each	Assistant Manager Maintenance calibration Inspectors	545	577	8,720	9,232
	Total		627	659	12,595	13,170

- Alternate A:

(35 managers) ($1,250/month) (6 months)	=	$ 262,500
+ (35 assistant manager) ($1,083/month) (6 months)	=	227,500
+ (12 maintenance/calibration people) ($1,000/ month) (1 month)	=	12,000
+ (498 inspectors) ($750/month) (1 month)	=	373,500
		$ 875,500
+ Overhead @ 25 percent		218,875
Total		$1,094,375

- Alternate B:

(41 managers) ($1,250/month) (6 months)	=	$ 307,500
+ (4 assistant managers) (1,083/month) (6 months)		266,418
+ (14 maintenance/calibration) ($1,000/month) (1 month)	=	14,000
+ (522 inspectors) ($750/month) (1 month)	=	391,500
		$ 979,418
+ Overhead @ 25 percent		244,855
Total		$1,224,273

The administrative personnel costs must also be included in the start-up phase. The administrative personnel needed in this option are discussed at the end of this section under manpower requirements. As discussed in the methodology section, salaries are based in correlations with existing civil service pay levels. Based on these salary levels for the 18-month period including a 25 percent overhead, the total administrative personnel costs for Option I both Alternates A and B, are $853,164.00.

Public Relations--

As explained in Section 3, the cost for initial start-up public relations would be approximately $0.12 per vehicle to be tested or $1,498,920 for Alternates A and B.

The total starting costs for Option I, Alternates A and B, are summarized in Table 38.

TABLE 38. START-UP COSTS FOR OPTION I

	Alternate A	Alternate B
Land acquisition	$ 377,529	$ 435,122
Facilities Planning	1,202,783	1,333,042
Data Handling Software	267,000	267,000
Program design	175,000	175,000
Test personnel salaries and overhead	1,094,375	1,224,273
Administrative salaries and overhead	853,164	853,164
Initial public relations	1,498,920	1,498,920
Personnel training	12,595	13,170
Total	5,481,366	5,799,691

Facility Personnel--

Based on the facility staffing requirements and annual salaries associated with job category, the annual personnel costs can be computed. This estimate for 12- and 18 county alternatives are shown in Tables 39 and 40.

Maintenance--

Primary costs for maintenance reflect equipment repair, replacement, and preventive maintenance. The yearly cost of these items was estimated to be 20 percent of the original cost of facility equipment:

- Alternate A

  (7,365,000) (0.20) = $1,473,000 annually

- Alternate B

  (8,340,000) (0.20) = $1,668,000 annually

Utilities, Services, Supplies

Utilities--

Annual cost for utilities were derived from electric usages experienced by other states. For Option I these were found to be 120 kWh/day per lane, plus 325 kWh/day per facility. Per kilowatt costs were obtained from several utilities companies and were found to be $0.05 kWh. The annual costs, then, for utilities are calculated below:

TABLE 39. ANNUAL PERSONNEL COSTS FOR FACILITY PERSONNEL - OPTION I, ALTERNATE A

Job title	Total number of positions	Annual salary ($)	Total annual salary for all positions ($)
Manager	35	15,000	525,000
Assistant Manager	35	13,000	455,000
Maintenance/Calibrators	12	12,000	144,000
Inspectors	498	9,000	4,482,000
Total salaries			5,606,000
Overhead @ 25 percent			1,401,500
			7,007,500

TABLE 40. ANNUAL PERSONNEL COSTS FOR FACILITY PERSONNEL - OPTION I, ALTERNATE B

Job title	Total number of positions	Annual salary ($)	Total annual salary for all positions ($)
Manager	41	15,000	615,000
Assistant Manager	41	13,000	533,000
Calibration/Maintenance	14	12,000	168,000
Inspectors	522	9,000	4,698,000
Total salaries			6,014,000
Overhead @ 25 percent			1,503,500
			7,517,500

- Alternate A - 12 Counties

(166 lanes)(120 kWh/day)($0.05)(250 operating days per year)	=	$ 249,000
+ (35 facilities)(325 kWh/day)($0.05)(250 operating days per year)	=	142,188
Total utilities cost annually		$ 391,188

- Alternate B - 18 Counties

(184 lanes)(120 kWh/day)($0.05)(250 operating days per year)	=	$ 276,000
+ (41 facilities)(325 kWh/day)(250 operating days per year)	=	166,563
Total utilities cost annually		$ 442,563

Insurance--

The owner of the centralized facilities would be required to carry liability and property insurance. Based on experiences of other states, it would cost approximately $1,500 per lane. Using this figure, total insurance costs for Alternates A and B are computed below:

Alternate A: (166 lanes) ($1,500 = $249,000

Alternate B: (184 lanes) ($1,500) = $276,000

Computer Operation and Test Forms--

Based on experience of other states, central computer operation costs for the centralized facilities have been estimated at $0.15 per test, and forms at $0.03 per test. The annual cost for the centralized facilities then can be easily computed, and are:

Alternate A = $1,338,475

Alternate B = $1,466,690

The additional cost for data handling for cars tested in the private garages are as follows:

	Alternate A	Alternate B
Data entering	$148,960	$129,360
Posting, storage, tape drive:	179,208	155,628
	$328,168	$284,988

The total data handling cost, then, is the sum of costs for centralized facilities, and private garages. They are:

Alternate A:	$1,338,475
	328,168
	$1,666,643
Alternate B:	$1,466,690
	284,988
	$1,751,678

Calibration Costs--

The recurring cost of equipment calibration is defined as the cost of calibration gases plus the operating cost of maintenance/calibration vans. The total annual calibration costs for Option I are outlined in Table 41 for Alternates A and B.

TABLE 41. ANNUAL CALIBRATION COSTS FOR OPTION I

Item	Cost ($)
Gases (20 sets per year at $200 per set)	4,000
Maintenance on vans	2,800
Insurance on van and equipment	1,000
Fuel, oil, etc.	1,000
Per calibration van	8,800
Alternate A = 12 vans = $105,600	
Alternate B = 14 vans = $123,200	

Taxes--

The annual cost for real estate and personnel property taxes were calculated based on full valuation rates for each municipality in which stations are to be located. Total annual taxes were found to be:

Alternate A (12 counties): $1,058,028

Alternate B (18 counties): $1,178,606

These are broken down for specific municipalities in Appendix I.

Uniforms--

Based on the experience of other states, an annual cost of $125.00 per uniformed employes is assumed. For Option I this cost is computed below:

Alternate A (622 unfiormed employes)($125) = $77,500

Alternate B (684 uniformed employes)($125) = $85,500

Security Systems--

The annual cost of maintaining security systems, based on experiences of other states, was assumed to be $850 per facility. The annual cost, thus can be computed for Alternates A and B:

Alternate A: (35 facilities) ($850) = $29,750

Alternate B: (41 facilities) ($850) = $34,850

Inspection and Licensing Vans

The annual cost of operating the Inspection/Licensing Vans is assumed to be the same as the annual cost of maintenance/calibration van operating, or: $8,800 each. The total cost, then, for operation of Inspection/Licensing Vans is computed below:

Alternate A: (25) ($8,800) = $220,000

Alternate B: (21) ($8,800) = $184,800

Complaints Investigators Cars

The cost of operating complaints investigators cars was assumed to be $0.15/mile, and it was assumed that they would be operated over 10,000 miles annually or $1,500 each. The total cost can be computed for Alternates A and B:

Alternate A; ($1,500) (17) = $25,500

Alternate B: ($1,500) (15) = $22,500

The total cost for Utilities, Services, and Supplies are summarized for Alternates A and B in Table 42.

TABLE 42. ANNUAL COST FOR UTILITIES, SERVICES, SUPPLIES

	Alternate A	Alternate B
Utilities	$ 391,188	$ 442,563
Insurance	249,000	276,000
Computer Operations and Forms	1,666,643	1,751,678
Calibration	105,600	123,200
Taxes	1,058,028	1,178,606
Uniforms	77,500	85,500
Security	29,750	34,850
Inspection/Licensing Vans	220,000	184,800
Complaints Investigator	25,500	22,500
Total	$3,823,209	$4,099,697

Annual Administrative Costs

The annual costs of Administrative Personnel were computed using the job titles described in Section 3, and salaries form Ohio Department of Administrative Services, Division of Personnel. The total cost for Alternates A and B were found to be $1,093,776 and $1,018,776, respectively. These figures include an overhead cost of 25 percent of the salaries.

Personnel Training--

Based on experiences of other states, it is assumed that a turnover of 10 percent of the inspectors or 50 new inspectors for Alternate A and 52 for Alternate B, is expected annually. This relates to an annual cost of training new inspectors of $800 for Alternate A and $832 for Alternate B. This is based on a $16 per inspector charge derived earlier.

Public Information--

The annual cost of public information is again assumed to be $0.12 per vehicle to be tested, or $1,498,920 annually for both Alternates A and B.

Cost Summary

The total costs for Option I are summarized in Tables 43 and 44.

FEE COMPUTATION

The fee to be charged a motorist for an emissions inspection in Option I for either urban area alternate will not necessarily be the same in rural areas as in urban areas. In this option, urban area motorists will be required to pay a fee that reflects the total annual costs incurred by the centralized, urban system. Rural area motorists will be charged a fee that is made up of two components: (1) a state fee, called the "sticker fee," which reflects the total an nual costs incurred by the state for administration of the I/M program in the rural counties, and (2) a private garage charge, called the "private garage fee," which will be used to defray equipment, labor, and other costs incurred by a private garage in performing emissions inspections.

Urban Motorist Fee Calculation

Tables 45, 46, 47, and 48 summarize the urban motorist fee calculation for social rates of discount $i = 0.03$ and $i = 0.06$ for both urban area alternates, using appropriate amortization rates as discussed in Section 3. The motor vehicle population used to calculate the urban motorist fee is the average 1981-1987 vehicle population. This assumes a free retest.

Rural Sticker Fee Calculation

The sticker fee charged to the rural motorist in Option I will be equal to the total annual costs incurred by the state divided by the total rural registrations; note that it is assumed that retests of failed vehicles in rural areas will be performed free of charge. Tables 49, 50, 51, and 52 present the rural sticker for calculation for social rates of discount $i = 0.03$ and $i = 0.06$ for both urban area alternates, using appropriate amortization rates as discussed in Section 3.

TABLE 43. COST SUMMARY OPTION I - ALTERNATE A

Primary category	Principal element	Element cost ($)	Total category cost ($)
Initial Capital Costs	1. Land investment	2,672,968	
	2. Building investment	12,027,834	
	3. Equipment costs (includes vans, computer, security systems)	8,256,500	22,957,302
One-Time Start-Up Costs	1. Land acquisition	377,529	
	2. Facilities planning	1,202,783	
	3. Program design	175,000	
	4. Development of data handling system software	267,000	
	5. Personnel training	12,595	
	6. Personnel salaries and overhead	1,947,539	
	7. Initial public information program	1,498,920	5,481,366
Annual Operating Costs	1. Facility personnel	7,007,500	
	2. Maintenance	1,473,000	
	3. Utilities, services, supplies	3,823,209	12,303,709
Annual Administration Costs	1. Program administrative salaries	1,093,776	
	2. Public information	1,498,920	
	3. Training	800	2,593,496

TABLE 44. COST SUMMARY OPTION I - ALTERNATE B

Primary category	Principal element		Total category cost ($)
Initial Capital Costs	1. Land investment	2,997,290	
	2. Building investment	13,330,420	
	3. Equipment costs (includes vans, computer, security systems)	9,200,100	25,527,810
One-Time Start-Up Costs	1. Land acquisition	435,122	
	2. Facilities planning	1,333,042	
	3. Program design	175,000	
	4. Development of data handling system software	267,000	
	5. Personnel training	13,170	
	6. Personnel salaries and overhead	2,077,437	
	7. Initial public information program	1,498,920	5,799,691
Annual Operating Costs	1. Facility Personnel	7,517,500	
	2. Maintenance	1,668,000	
	3. Utilities, Services, Supplies	4,099,697	13,285,197
Annual Administrative Costs	1. Program administrative salaries	1,018,776	
	2. Public information	1,498,920	
	3. Training	832	2,518.528

TABLE 45. URBAN MOTORIST FEE CALCULATION, OPTION I, i = 0.03, ALTERNATE A

Cost class	Cost ($)	Amortization factor	Annualized cost ($)
Capital costs			
1. Land	2,672,968	0.03	80,189
2. Buildings	12,027,834	0.067	805,865
3. Equipment	7,821,500	0.2184	1,708,216
Start-Up Costs	4,738,640	0.2184	1,034,919
Operating Costs	11,725,853		11,725,853
Administrative Costs	1,469,576		1,469,576

$$\text{Urban motorist fee} = \frac{\$16,824,618}{5,200,000}$$

$$= \$3.24$$

TABLE 46. URBAN MOTORIST FEE CALCULATION, OPTION I, i = 0.03, ALTERNATE B

Cost class	Cost ($)	Amortization factor	Annualized cost ($)
Capital Costs			
1. Land	2,997,290	0.03	89,919
2. Buildings	13,330,420	0.067	893,138
3. Equipment	8,831,100	0.2184	1,928,712
Start-Up Costs	5,135,224	0.2184	1,121,533
Operating Costs	12,788,409		12,788,408
Administrative Costs	1,547,608		1,547,608

$$\text{Urban motorist fee} = \frac{\$18,369,319}{5,700,000}$$

$$= \$3.22$$

TABLE 47. URBAN MOTORIST FEE CALCULATION, OPTION I, i = 0.06, ALTERNATE A

Cost class	Cost ($)	Amortization factor	Annualized cost ($)
Capital Costs			
1. Land	2,672,968	0.06	160,378
2. Buildings	12,027,834	0.087	1,046,422
3. Equipment	7,821,500	0.2374	1,856,824
Start-Up Costs	4,738,640	0.2374	1.124,953
Operating Costs	11,725,853		11,725,853
Administrative Costs	1,469,576		1,469,576

$$\text{Urban motorist fee} = \frac{\$17,834.006}{5,200,000}$$

$$= \$3.43$$

TABLE 48. URBAN MOTORIST FEE CALCULATION, OPTION I, i = 0.06, ALTERNATE B

Cost class	Cost ($)	Amortization factor	Annualized cost ($)
Capital Costs			
1. Land	2,997,290	0.06	179,837
2. Building	13,330,420	0.087	1,159,747
3. Equipment	8,831,100	0.2374	2,096,503
Start-Up Costs	5,135,224	0.2374	1,219,102
Operating Costs	12,788,409		12,788,409
Administrative Costs	1,547,608		1,547,608

$$\text{Urban motorist fee} = \frac{\$18{,}991{,}206}{5{,}700{,}000}$$

$$= \$3.33$$

TABLE 49. RURAL STICKER FEE CALCULATION, OPTION I, i = 0.03, ALTERNATE A

Cost class	Cost ($)	Amortization factor	Annualized cost ($)
Capital Costs			
1. Land	0	0.03	0
2. Beuildings	0	0.067	0
3. Equipment	435,000	0.2184	95,004
Start-Up Costs	742,724	0.2184	162,211
Operating Costs	577,856		577,856
Administrative Costs	1,123,920		1,123,920

$$\text{Rural sticker fee} = \frac{\$1{,}958{,}991}{3{,}500{,}000}$$

$$= \$0.56$$

TABLE 50. RURAL STICKER FEE CALCULATION, OPTION I, i = 0.03, ALTERNATE B

Cost class	Cost ($)	Amortization factor	Annualized cost ($)
Capital Costs			
1. Land	0	0.03	0
2. Buildings	0	0.067	0
3. Equipment	369,000	0.2184	80,590
Startup Costs	664,000	0.2184	145,120
Operating Costs	496,000		496,788
Administrative Costs	970,000		970,000

$$\text{Rural sticker fee} = \frac{\$1,693,418}{3,000,000}$$

$$= \$0.56$$

TABLE 51. RURAL STICKER FEE CALCULATION, OPTION I, i = 0.06, ALTERNATE A

Cost class	Cost ($)	Amortization factor	Annualized cost ($)
Capital Costs			
1 Land	0	0.06	0
2. Buildings	0	0.087	0
3. Equipment	435,000	0.2374	103,269
Start-Up Costs	742,724	0.2374	176,323
Operating Costs	577,856		577,856
Administrative Costs	1,123,920		1,123,920

$$\text{Rural sticker fee} = \frac{\$1,981,368}{3,500,000}$$

$$= \$0.57$$

TABLE 52. RURAL STICKER FEE CALCULATION, OPTION I, i = 0.06, ALTERNATE B

Cost class	Cost ($)	Amortization factor	Annualized cost ($)
Capital Costs			
1. Land	0	0.06	0
2. Buildings	0	0.087	0
3. Equipment	369,000	0.2374	87,601
Start-Up Costs	664,469	0.2374	157,745
Operating Costs	496,788		496,788
Administrative Costs	970,920		970,920

$$\text{Rural sticker fee} = \frac{\$1,713,054}{3,000,000}$$

$$= \$0.57$$

Private Garage Fee Calculation

The fee charged by private garages for performing an emissions inspection will be based on those cost factors discussed in the derivation of the three private garage network participation levels and on annual station throughput. The formula used to determine the total rural inspection charge, C, is the following:

$$C = \frac{A + S + L + O}{M} + F$$

where all the above cost variables are assigned the same values as those used previously. By dividing the total number of paid rural inspections (here assumed to be the same as registration levels since retests of failed vehicles are assumed to be free) by the total number of garages in the mid network (since this is the network assumed in all the preceding cost analysis), annual throughput rates per station for this network can be calculated. Substituting these throughput rates for M in the above equation, and using all the cost assumptions listed previously, the total inspection charge C for this network can be calculated. Subtracting the sticker fee, F, derived above, yields the private garage fee. Table 53 summarizes the calculations of the rural private garage fee for the mid network, Alternates A and B, in constant dollars, for $i = 0.03$ or $i = 0.06$.

TABLE 53. PRIVATE GARAGE FEE, OPTION I, ALTERNATES A AND B, i = 0.03 OR 0.06

Urban area alternative	Private garage fee
A	\$3.58
B	\$3.58

Tables 54 and 55 presents the total inspection fee for both urban and rural areas, assuming $i = 0.03$ and $i = 0.06$, respectively, and the mid private garage network, for both urban area alternatives.

TABLE 54. OPTION I: TOTAL INSPECTION FEE, i=0.03, MID PRIVATE GARAGE NETWORK

Fee element	Urban area alternative	
	A	B
Urban motorist fee	\$3.24	\$3.22
Rural motorist fee	\$4.14	\$4.20

TABLE 55. OPTION I: TOTAL INSPECTION FEE, i=0.06, MID PRIVATE GARAGE NETWORK

Fee element	Urban area alternative	
	A	B
Urban motorist fee	\$3.43	\$3.33
Rural motorist fee	\$4.13	\$4.20

Conclusion

Since higher levels of market participation mean smaller annual throughputs for each private garage, private garages must charge more per inspection to break-even as participation levels increase. From the preceding cost analysis, it can be seen that a rural motorist must pay approximately \$0.70 more for an emissions inspection than an urban motorist. This inequitable urban-rural difference can be eliminated by decreasing the rural private garage participation below the mid level, for which the preceding fees were calculated, to a level where the rural notorist fee equals the urbam motorist fee. This equitable participation rate is easily calculated using the above cost formulas. Table 56 presents this equitable participation rate for both urban area alternates and both social rates of discount.

It is, therefore, desirable, both from a state administrative viewpoint and a private motorist's viewpoint, to hold participation to the above levels.

Various controls which the state might exercise on the participation rate are as follows:

1. Establishment of a fixed number of inspection station licenses to be granted in a given year.

2. Establishment of a maximum garage charge, to be applied statewide, which would render inspections unprofitable at inefficient garages and profitable only at efficient garages; and

3. Regulation of annual licensing fees to be paid by inspection stations.

Alternatively, in view of some of the administrative and practical difficulties in holding the participation rates to s minimum level, the garages would be allowed to charge the same rate as the urban fee. Many stations while not breaking even on the inspection process would participate because of the increased business in repairs.

TABLE 56. EQUITABLE PARTICIPATION RATES FOR PRIVATE GARAGES IN RURAL AREAS, OPTION I

Urban area alternative	Social rate of discount			
	i = 0.03		i = 0.06	
	Number of garages	Participation rate (%)	Number of garages	Participation rate (%)
A	1,052	20.0	1,087	20.6
B	906	19.5	937	20.2

MANPOWER REQUIREMENTS

The methodology used in deriving the personnel requirements, discussed in Section 3, Methodologies, is based on an analysis of the tasks associated with each program element and from an examination of various programs in other states.

A schematic diagram of the basic organizational network shown in Figure 7 was derived, which is very similar to the basic scheme presented in the methodology section. The primary difference is the line which separates the state from the contractor functions. In Option I the personnel functions are divided by two basic criteria: (1) operating level - state level, regional level, and station level; and (3) primary control or responsibility - state or contractor. It should be noted here that although most of the basic responsibilities can be delineated, it was not possible to allocate all positions clearly to state or contractor responsibility for some of the regional positions. Such ambiguities, however, will not significantly alter the overall manpower allocations.

In the lower left quadrant of the diagram are the personnel which oversee the private garage operations in rural areas. These include regional inspection and licensing officials, inspection and licensing personnel, regional complaints officials, and complaints investigators. The same personnel are included in Option II.

Table 57 shows the actual number of personnel required for all the functions shown in the organizational chart. Summaries and comparisons of manpower needs for the various options will appear in the comparison of options, Section 14.

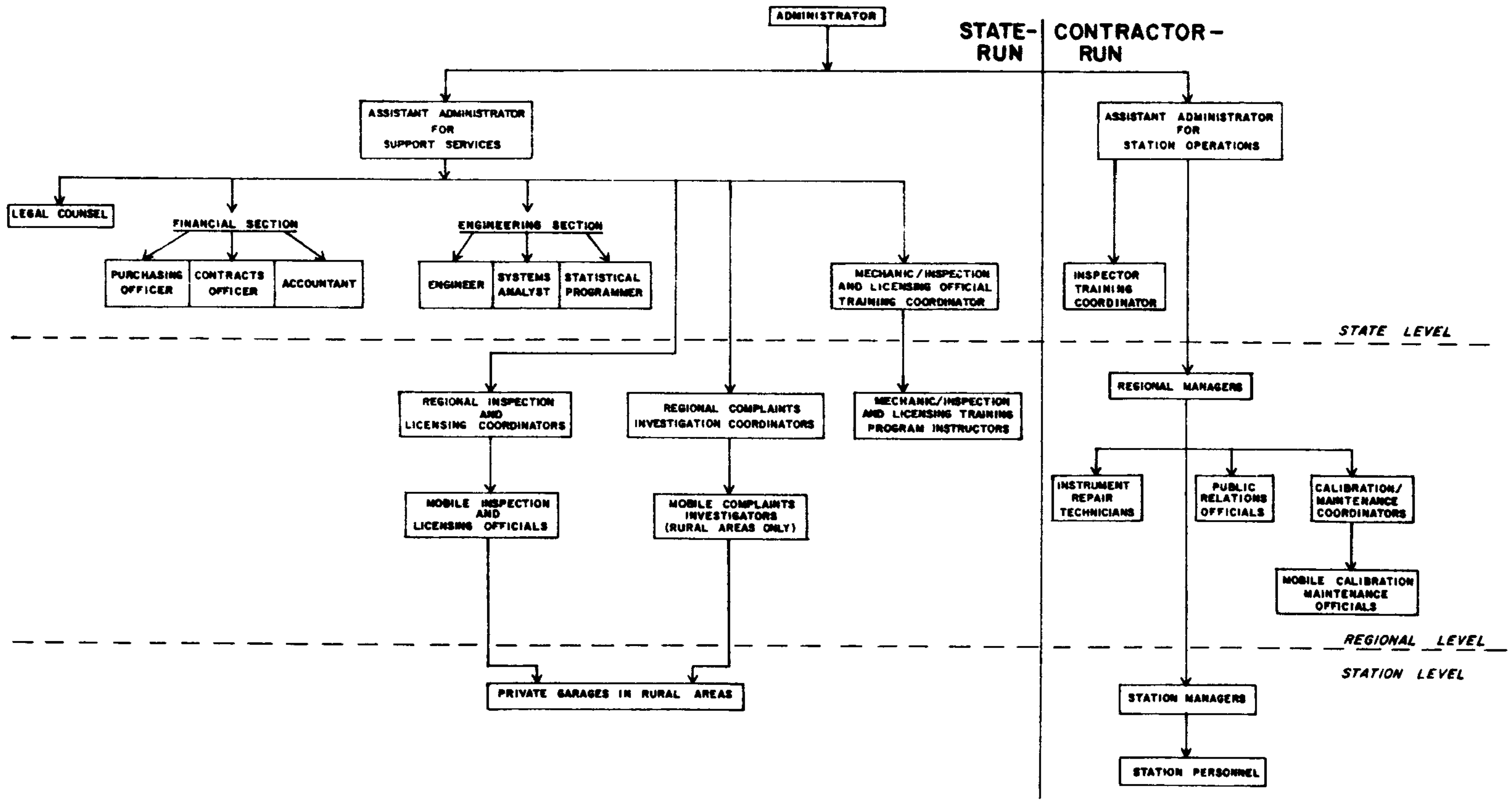

Figure 7. Administrative organization, Option I.

TABLE 57. MANPOWER REQUIREMENTS FOR OPTION I

Contractor/state personnel are state level personnel who work for the contractor

Contractor/State Personnel

Number	Position
1	Assistant Administrator for station operations
1	Inspector Training Coordinator

Contractor regional personnel work on the regional level for the contractor

Contractor/Regional Personnel

Number	Position
5	Regional managers
5	Instrument repair technicians
5	Public relations officials
5	Calibration/maintenance coordination
12-14	Mobile calibration/maintenance officials

Contractor local personnel work at the individual station level for the contractor

Contractor/Local Personnel

Number		Position
Alternate A	Alternate B	
35	41	Station managers
35	41	Assistant managers
498	522	Station inspectors
12	14	Station maintenance personnel

State administrative personnel are those working at the state level for the state

State Administrative

Number	Position
1	Administrator
1	Assistant Administrator for supporting services
1	Legal Council
1	Purchasing officer
1	Contracts officer
1	Accountant
1	Engineer
1	Systems analyst
1	Stastician/programmer
1	Mechanic/inspector and licensing official training coordinator

State regional personnel work on the regional level for the state

State Regional

Number		Position
Alternate A	Alternate B	
5	5	Regional inspection and licensing coordinators
25	21	Mobile inspection and licensing officials
5	5	Regional complaints investigator
17	15	Mobile complaints investigators

SECTION 5

OPTION II - • STATEWIDE COVERAGE

• STATE ADMINISTERS CENTRALIZED LANES IN URBAN AREAS

• PRIVATE GARAGES IN RURAL AREAS

ALTERNATE A - 12 URBAN COUNTIES

ALTERNATE B - 18 URBAN COUNTIES

OPTION DEFINITION

This option involves the State Government establishing a network of centralized idle mode test lanes in either 12 urban counties (Alternate A) or 18 urban counties (Alternate B). In the remaining rural counties; i.e., counties outside of the 12 or 18 urban counties, emission inspection would be conducted in a decentralized network of private garages, new car dealers, and service stations. The Ohio Environmental Protection Agency and the Bureau of Motor Vehicles are the Administrative Agencies. Ohio EPA would direct the overall program including purchasing land and equipment, building the test facilities, designing the program, training personnel, organizing a public relations campaign, manning the test lanes themselves, data handling and special studies, supervising the private garages, and in fact all program elements except enforcement. In Section 17 there is a discussion of the relative advantages and disadvantages of having the state or private contractor oversee the private garages. The Bureau of Motor Vehicles would be primarily responsible for enforcement in this option. In Section 16 there will be a discussion of the sticker/ticketing method of enforcement.

NETWORK REQUIREMENTS

The basic network requirements for centralized lanes in the urban areas, for Alternates A and B, and for private garages in the rural areas have been derived in detail in Section IV preceeding.

Centralized Network

For the centralized lanes in urban areas, Tables 58 and 59 show the number of inspections derived for 1987, assuming that 30 percent of the cars would fail the inspection by design.

TABLE 58. 1987 TOTAL INSPECTIONS

• Alternate A - 12 County	7,436,000
• Alternate B - 18 County	8,148,300

Next the number of centralized lanes needed for both alternatives were derived in Section IV which were:

TABLE 59. 1987 CENTRALIZED LANE REQUIREMENTS

• Alternate A - 12 County	166
• Alternate B - 18 County	184

Finally the actual inspection network in terms of the approximate locations and station size were computed. They are shown in Table 60.

Decentralized Network

The decentralized network was also derived and is explained in detail in the preceeding section. The following table shows the number of inspections required. This equals the 1987 motor vehicle registrations multiplied by 1.3 to include the failed vehicles.

TABLE 60. VEHICLE INSPECTIONS REQUIRED IN URBAN AND RURAL AREAS, 1987

	Number of inspections required	
Location	Alternate A - 12 County	Alternate B - 18 County
Urban	7,436,000	8,148,300
Rural	4,991,600	4,279,300
Statewide total	12,427,600	12,427,600

The next step was to derive a minimum, maximum, and mid-level participation rate for private garages based on assumptions concerning throughput rates, equipment and personnel costs, etc., all of which is explained in detail in the preceeding option. These participation levels are shown in Table 61.

TABLE 61. MINIMUM, MID-LEVEL AND MAXIMUM GARAGE PARTICIPATION IN RURAL AREAS

Urban area alternative	Minimum	Mid-level	Maximum
Alternate A - 12 county	951	1,531	2,111
Alternate B - 18 county	815	1,313	1,810

OPTION COSTS

In Option II, most of the costs are very similar to those described in Option I in the previous section. Rather than repeating each in detail, the approach used here will be to describe in detail only those costs where differences actually exist.

Initial Capital Costs

The initial capital costs for Option II for the state run approach are estimated to be exactly the same as those for the private contractor. These estimates are based on an analysis of the cost items themselves and on discussions with Hamilton Test Systems, the private contractors which has set up and is currently operating the I/M program in Arizona.

As described in the preceeding section, there is a difference between Alternate A, the 12 County Alternate and Alternate B, the 18 County Alternate. The following Table 62 illustrates the differences between the alternates:

TABLE 62. INITIAL CAPITAL COSTS, ALTERNATE A AND B

Principal element	Alternate A	Alternate B
	Element cost	Element cost
Land investment	2,672,960	2,997,290
Building investment	12,027,834	13,330,420
Equipment costs	8,256,000	9,200,100
Totals	22,957,294	25,527,810

Alternate B has more land and facilities, and consequently more equipment since it covers a larger number of counties than Alternate A.

One Time Start-up Costs

In Option II, the one time start-up costs are the same as in Option I, a contractor approach, with the exception of administrative personnel salaries. In the state run approach in this option the state will require a longer start-up or implementation period, namely a 2-1/2 year start-up, in contrast to the 1-1/2 year period required for a contractor in Option I. The reason for this has to do with the fact that the state must follow specific detailed procedures in letting out bids and making contracts for acquiring land, constructing the facilities, purchasing the equipment, etc. The state is required to get several bids on a contract for services or equipment, for example, whereas a contractor may acquire equipment on the private market. For this reason, the administrative salaries will be higher than for the contractor approach. In Table 63 which follows, a comparison has been made of Option I to illustrate these differences.

TABLE 63. COMPARISON OF ADMINISTRATIVE SALARIES FOR OPTION I AND II (INCLUDES 25 PERCENT OVERHEAD)

Option I (Alternates A & B)	Option II (Alternates A & B)
$853,164	$1,421,940
Difference: Option II - Option I =	$ 568,776

It should be noted that the salaries are for administrative state personnel and the differences between the contractor and state option are due entirely to the different start-up period as explained above. The personnel salaries for station and operating personnel are the same in both Option I and II. After an analysis of the job tasks and consultation with private contractors, it was decided that the salaries which the State of Ohio would pay were comparable to civil service positions, as explained in the methodology section. A summary of the total start-up costs for Option II, Alternates A and B, is provided in Table 64.

TABLE 64. START-UP COSTS FOR OPTION II

Item	Alternate A	Alternate B
Land acquisition	$ 377,529	$ 435,122
Facilities planning	1,202,783	1,333,042
Program design	175,000	175,000
Development of data handling software	267,000	267,000
Personnel training	12,195	13,170
Test personnel salaries and overhead	1,094,375	1,224,273
Administrative personnel salaries and overhead	1,421,940	1,421,940
Initial public information program	1,498,920	1,498,920
Total	$6,050,142	$6,368,467

Annual Operating Costs

Facility Personnel--

The costs for test personnel in Option II are identical to those discussed previously in Option I, Section 4. Again these are

Alternate A: $7,007,500

Alternate B: $7,517,500

Maintenance--

The costs for equipment repair, replacement, and the preventive maintenance of test equipment are exactly the same in Option II as they were in Option I, Section IV. Again, this is equal to 20 percent of the initial test equipment expeditive, or:

Alternate A: $1,473,000

Alternate B: $1,498,920

Utilities, Services, Supplies--

The annual cost for utilities, insurance, computer operation and forms, calibration, uniforms, security, inspection and licensing an operation, and operation of complaints investigators cars are exactly the same as those presented in Option I, Section 4. In Option II however, there will be no annual cost for taxes, as the facilities will be state owned and operated. The total annual cost for utilities, services, and supplies is presented in Table 65.

TABLE 65. ANNUAL COST FOR UTILITIES, SERVICES, SUPPLIES FOR OPTION II

Item	Alternate A	Alternate B
Utilities	$ 391,188	$ 442,563
Insurance	249,000	276,000
Computer operation and forms	1,666,643	1,751,678
Calibration	105,600	123,200
Uniforms	77,500	85,500
Security	29,750	34,850
Inspection/licensing vans	220,000	184,800
Complaints investigators cars	25,500	22,500
	$2,765,181	$2,921,091

Annual Administrative Costs--

The annual cost for program administrative salaries, public information, and inspector training are exactly the same as those presented for Option I in Section 4. These costs are presented in Table 66.

TABLE 66. ANNUAL ADMINISTRATIVE COSTS FOR OPTION II

Item	Alternate A	Alternate B
Program administrative salaries	$1,093,776	$1,093,776
Public information	1,498,920	1,498,920
Inspector training	800	800
Total	$2,593,496	$2,593,496

Summary

The total cost of Option II is summarized in Table 67a and 67b for Alternates A and B.

Initial capital costs and one-time start-up costs are converted to annual figures using the amortization factors discussed in Section 3. These annualized costs are added to annual operating costs and annual administrative costs to arrive at total annual costs in constant 1978 dollars. These totals are used in the computation of break-even fees.

FEE COMPUTATION

The fee to be charged a motorist for an emissions inspection in Option II for either urban area alternate will not necessarily be the same in rural areas as in urban areas. In this option, urban area motorists will be required to pay a fee that reflects the total annual costs incurred by the centralized, urban system. Rural area motorists will be charged a fee that is made up of two components: (1) a state fee, called the "sticker fee," which reflects the total annual costs incurred by the state for administration of the I/M program in the rural counties; and (2) a private garage charge, called the "private garage fee," which will be used to defray equipment, labor, and other costs incurred by a private garage in performing emissions inspections.

Urban Motorist Fee Calculation

Tables 68a, 68b, 68c, and 68d summarize the urban motorist fee calculation for social rates of discount i = 0.03 and i = 0.06 for both urban area alternates, using appropriate amortization rates as discussed in Section 3.

Rural Sticker Fee Calculation

The sticker fee charged to the rural motorist in Option II will be equal to the total annual costs incurred by the state divided by the total rural registrations; note that it is assumed that retests of tailed vehicles in rural areas will be performed free of charge. Tables 69a, 69b, 69c, and 69d present the rural sticker fee calculation for social rates of discount i = 0.03 and i = 0.06 for both urban area alternatives, using appropriate amortization rates as discussed in Section 3.

TABLE 67a. COST SUMMARY - OPTION II, ALTERNATE A

Primary category	Principal element	Element cost ($)	Total category cost ($)
Initial capital costs	1. Land investment	2,672,960	
	2. Building investment	12,027,834	
	3. Equipment costs (includes vans, computer, security systems)	8,256,000	
Total			22,957,294
One-time start-up costs	1. Land acquisition	377,529	
	2. Facilities planning	1,202,783	
	3. Program design	175,000	
	4. Development of data handling system software	267,000	
	5. Personnel training	12,195	
	6. Test personnel salaries and overhead	1,094,375	
	7. Administrative personnel salaries and overhead	1,421,940	
	8. Initial public information program	1,498,920	
Total			6,050,142
Annual operating costs	1. Facility personnel	7,007,500	
	2. Maintenance	1,473,000	
	3. Utilities, services, and supplies	2,765,181	
Total			11,245,681
Annual administrative costs	1. Program administration salaries	1,093,776	
	2. Public information	1,498,920	
	3. Training	800	
Total			2,593,496

TABLE 67b. COST SUMMARY - OPTION II, ALTERNATE B

Primary category	Principal element	Element cost ($)	Total category cost ($)
Initial capital costs	1. Land investment	2,997,290	
	2. Building investment	13,330,420	
	3. Equipment costs (includes vans, computer, security systems)	9,200,100	
Total			25,527,810
One-time start-up costs	1. Land acquisition	435,122	
	2. Facilities planning	1,333,042	
	3. Program design	175,000	
	4. Development of data handling system software	267,000	
	5. Personnel training	13,170	
	6. Test personnel salaries and overhead	1,224,273	
	7. Administrative personnel salaries and overhead	1,421,940	
	8. Initial public information program	1,498,920	
Total			6,368,467
Annual operating costs	1. Facility personnel	7,517,500	
	2. Maintenance	1,498,920	
	3. Utilities, services, and supplies	2,921,091	
Total			11,937,511
Annual administrative costs	1. Program administration salaries	1,093,776	
	2. Public information	1,498,920	
	3. Training	800	
Total			2,593,496

TABLE 68a. URBAN MOTORIST FEE CALCULATION, OPTION II, $i = 0.03$, ALTERNATE A

Cost class		Cost ($)	Amortization factor	Annualized cost
I.	Capital costs			
	1. Land	2,672,967	0.03	80,189
	2. Buildings	12,027,835	0.067	805,865
	3. Equipment	7,821,500	0.2184	1,708,216
II.	Start-up costs	5,307,418	0.2184	1,159,140
III.	Operating costs	10,667,013		10,667,013
IV.	Administrative costs	1,469,576		1,469,576

$$\text{Urban motorist fee} = \frac{\$15{,}889{,}999}{\$\ 5{,}200{,}000} = \$3.06$$

TABLE 68b. URBAN MOTORIST FEE CALCULATION, OPTION II, i = 0.03, ALTERNATE B

Cost class	Cost ($)	Amortization factor	Annualized cost
I. Capital costs			
1. Land	2,997,300	0.03	89,919
2. Buildings	13,330,400	0.067	893,138
3. Equipment	8,831,100	0.2184	1,928,712
II. Start-up costs	5,703,900	0.2184	1,245,753
III. Operating costs	11,609,803		11,609,803
IV. Administrative costs	1,547,608		1,547,608

$$\text{Urban motorist fee} = \frac{\$17,314,933}{\$\ 5,700,000} = \$3.04$$

TABLE 68c. URBAN MOTORIST FEE CALCULATION, OPTION II, i = 0.06, ALTERNATE A

	Cost class	Cost ($)	Amortization factor	Annualized cost
I.	Capital costs			
	1. Land	2,672,967	0.06	160,378
	2. Buildings	12,077,835	0.087	1,046,422
	3. Equipment	7,821,500	0.2374	1,856,824
II.	Start-up costs	5,307,418	0.2374	1,259,981
III.	Operating costs	10,667,013		10,667,013
IV.	Administrative costs	1,469,576		1,469,576

$$\text{Urban motorist fee} = \frac{\$16{,}460{,}194}{\$\ 5{,}200{,}000} = \$3.17$$

TABLE 68d. URBAN MOTORIST FEE CALCULATION, OPTION II, i = 0.06, ALTERNATE B

Cost class	Cost ($)	Amortization factor	Annualized cost
I. Capital costs			
1. Land	2,997,300	0.06	179,837
2. Buildings	13,330,400	0.087	1,159,747
3. Equipment	8,831,000	0.2374	2,096,503
II. Start-up costs	5,703,900	0.2374	1,354,129
III. Operating costs	11,609,803		11,609,803
IV. Administrative costs	1,547,608		1,547,608

$$\text{Urban motorist fee} = \frac{\$17{,}947{,}627}{\$\ 5{,}700{,}000} = \$3.15$$

TABLE 69a. RURAL STICKER FEE CALCULATION, OPTION II, i = 0.03, ALTERNATE A

Cost class	Cost ($)	Amortization factor	Annualized cost
I. Capital costs			
1. Land	0	0.03	0
2. Buildings	0	0.067	0
3. Equipment	435,000	0.2184	95,004
II. Start-up costs	742,724	0.2184	162,211
III. Operating costs	577,856		577,856
IV. Administrative costs	1,123,920		1,123,920

$$\text{Rural sticker fee} = \frac{\$1,958,991}{\$3,500,000} = \$0.56$$

TABLE 69b. RURAL STICKER FEE CALCULATION, OPTION II,
i = 0.03, ALTERNATE B

Cost class		Cost ($)	Amortization factor	Annualized cost
I.	Capital costs			
	1. Land	0	0.03	0
	2. Buildings	0	0.067	0
	3. Equipment	369,000	0.2184	80,590
II.	Start-up costs	664,469	0.2184	145,120
III.	Operating costs	496,788		496,788
IV.	Administrative costs	970,920		970,920

$$\text{Rural sticker fee} = \frac{\$1,693,418}{\$3,000,000} = \$0.56$$

TABLE 69c. RURAL STICKER FEE CALCULATION, OPTION II, i = 0.06, ALTERNATE A

	Cost class	Cost ($)	Amortization factor	Annualized cost
I.	Capital costs			
	1. Land	0	0.06	0
	2. Buildings	0	0.087	0
	3. Equipment	435,000	0,2374	103,269
II.	Start-up costs	742,724	0.2374	176,323
III.	Operating costs	577,856		577,856
IV.	Administrative costs	1,123,920		1,123,920

$$\text{Rural sticker fee} = \frac{\$1,981,368}{\$3,500,000} = \$0.57$$

TABLE 69d. RURAL STICKER FEE CALCULATION, OPTION II, i = 0.06, ALTERNATE B

	Cost class	Cost ($)	Amortization factor	Annualized cost
I.	Capital costs			
	1. Land	0	0.06	0
	2. Buildings	0	0.087	0
	3. Equipment	369,000	0.2374	87,601
II.	Start-up costs	664,469	0.2374	157,745
III.	Operating costs	496,788		496,788
IV.	Administrative costs	970,920		970,920

$$\text{Rural sticker fee} = \frac{\$1,713,054}{\$3,000,000} = \$0.57$$

Private Garage Fee Calculation

The fee charged by private garages for performing an emissions inspection will be based on those cast factors discussed in the derivation of the three private garage network participation levels and on annual station throughput. Recalling the formula used in Section 4 to determine the total rural inspection charge, C,

$$C = \frac{A + S + L + O}{M} + F$$

where all the above cost variables are assigned the same values as those used previously. By dividing the total number of paid rural inspections (here assumed to be the same as registration levels since retests of failed vehicles are assumed to be free) by the total number of garages in the mid network (since this is the network assumed in all the preceding cost analysis), annual throughput rates per station for this network can be calculated. Substituting these throughput rates for M in the above equation, and using all the cost assumptions listed previously, the total inspection charge, C, for this network can be calculated. Subtracting the sticker fee, F, derived above, yields the private garage fee. Table 70 summarizes the calculations of the rural private garage fee for the mid network, Alternates A and B, in constant dollars, for $i = 0.03$ or $i = 0.06$.

Table 71 presents the total inspection fee for both urban and rural areas, assuming $i = 0.3$, and the mid private garage network, for both urban area alternatives.

Table 72 presents the total inspection fee for both urban and rural areas, assuming $i = 0.06$, and the mid private garage network, for both urban area alternatives.

Conclusion

Since higher levels of market participation mean smaller annual throughputs for each private garage, private garages must charge more per inspection to break even as participation levels increase. From the preceding cost analysis, it can be seen that a rural motorist must pay approximately $1.50 more for an emissions inspection than an urban motorist. This inequitable urban-rural difference can be eliminated by decreasing the rural private garage participation below the mid level, for which the preceding fees were calculated, to a level where the rural motorist fee equals the urban motorist fee. This equitable participation rate is easily calculated using the above cost formulas; Table 73 presents this equitable participation rate for both urban area alternates and both social rates of discount.

TABLE 70. PRIVATE GARAGE FEE, OPTION II, ALTERNATES A AND B, i = 0.03 OR 0.06

Urban area alternative	Private garage fee
A	$3.58
B	$3.58

TABLE 71. OPTION II: TOTAL INSPECTION FEE, i = 0.03, MID PRIVATE GARAGE NETWORK

Fee element	Urban area alternative	
	A	B
Urban motorist fee	$3.06	$3.04
Rural motorist fee	$4.14	$4.14

TABLE 72. OPTION II: TOTAL INSPECTION FEE, i = 0.06, MID PRIVATE GARAGE NETWORK

Fee element	Urban area alternative	
	A	B
Urban motorist fee	$3.17	$3.15
Rural motorist fee	$4.15	$4.15

TABLE 73. EQUITABLE PARTICIPATION RATES FOR PRIVATE GARAGES IN RURAL AREAS, OPTION II

Urban area alternative	Social rate of discount			
	i = 0.03		i = 0.06	
	Number of garages	Participation rate, percent	Number of garages	Participation rate, percent
A	994	18.9	1,030	19.6
B	855	18.4	886	19.0

It is therefore desirable, both from a state administrative viewpoint and from a private motorist's viewpoint, to hold participation to the above levels.

Various controls which the state might exercise on the participation rate are as follows:

1. Establishment of a fixed number of inspection station licenses to be granted in a given year;

2. Establishment of a maximum garage charge, to be applied statewide, which would render inspections unprofitable at inefficient garages and profitable only at efficient garages; and

3. Regulation of annual licensing fees to be paid by inspection stations.

MANPOWER REQUIREMENTS

Manpower requirements for Option II remain the same as those for Option I; the state, however, assumes responsibility for all functions performed by the contractor in Option I. The resulting organizational network is shown in Figure 8. Table 74 lists total state manpower allocations.

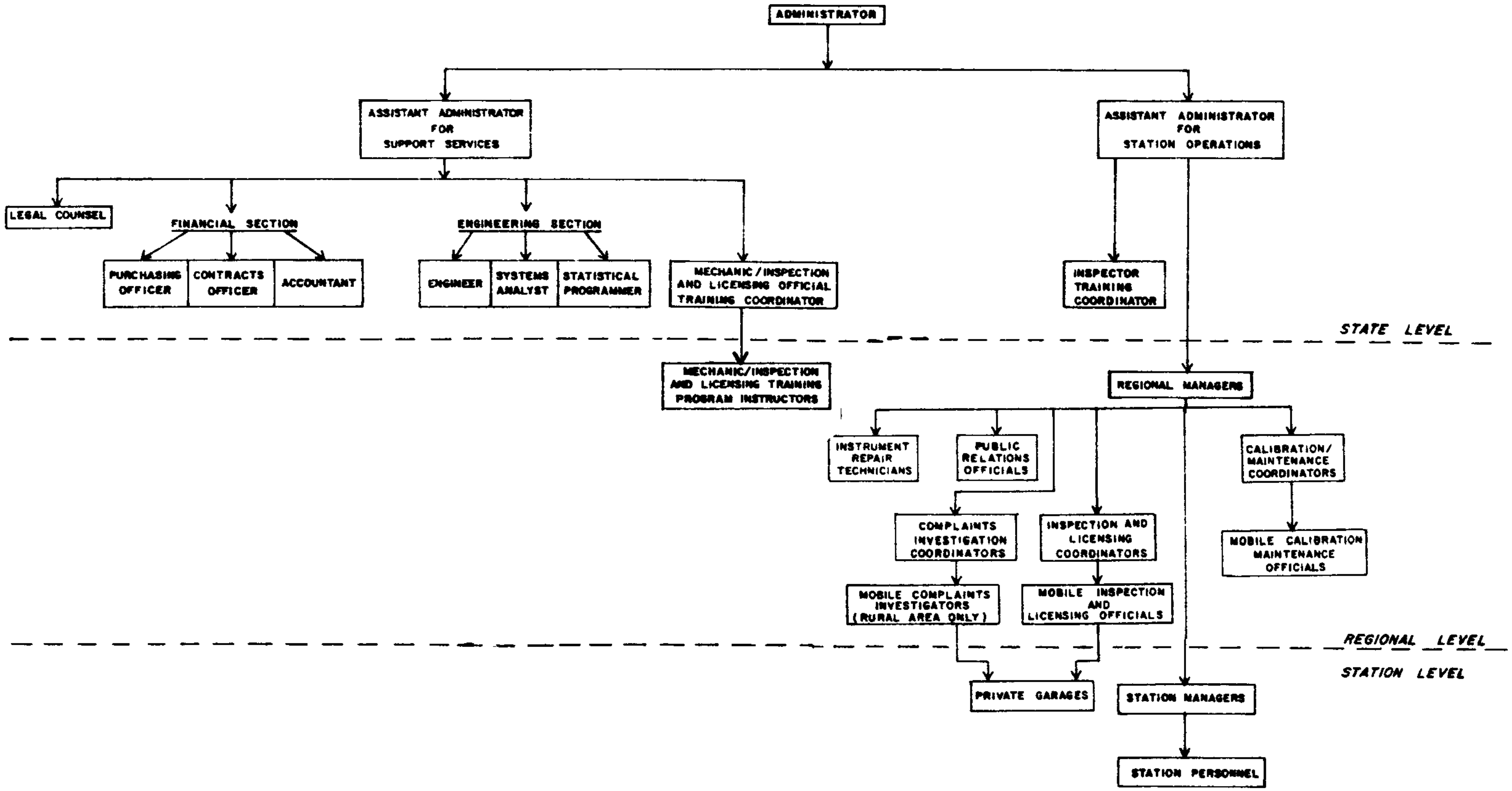

Figure 8. Administrative organization, Option II.

TABLE 74. MANPOWER REQUIREMENTS, OPTION II

State administrative personnel
1 Administrator
1 Assistant Administrator for Supporting Services
1 Legal Counsel
1 Purchasing Officer
1 Contracts Officer
1 Accountant
1 Engineer
1 Systems Analyst
1 Statistician/Programmer
1 Mechanical/Inspection and Licensing Training Coordinator
1 Assistant Administrator for Station Operations
1 Inspection Training Coordinator

State regional personnel
5 Regional Managers
5 Instrument Repair Technicians
5 Public Relations Officials
5 Calibration/Maintenance Coordinators

Number		
Alternate A	Alternate B	
12	14	Mobile Calibration/Maintenance Officials
5	5	Complaints Investigation Coordinators
17	15	Mobile Complaints Investigators (rural areas only)
5	5	Inspection and Licensing Coordinators
25	21	Mobile Inspection and Licensing Officials (rural areas only)

State local personnel

Number		
Alternate A	Alternate B	
35	41	Station Managers
35	41	Station Assistant Managers
498	522	Station Inspectors
12	14	Station Maintenance Personnel

SECTION 6

OPTION III • URBAN COUNTY COVERAGE
• CONTRACTOR ADMINISTERS CENTRALIZED LANES

ALTERNATE A - 12 URBAN COUNTIES

ALTERNATE B - 18 URBAN COUNTIES

OPTION DEFINITION

This option involves a private contractor establishing a network of centralized idle mode test lanes in either 12 urban counties (Alternate A) or 18 urban counties (Alternate B). A private contractor, under the direction of Ohio EPA, would assume responsibility for the overall program including purchasing land and equipment, building the test facilities, designing the program, training personnel, providing public information, operating the test lanes, data handling and analysis, and all other program elements with the exception of enforcement. The Bureau of Motor Vehicles would be primarily responsible for enforcement of this option. In Section 16 there will be a discussion of the sticker ticketing method of enforcement.

NETWORK REQUIREMENTS

The basic network requirements for Option III Alternates A and B are the same as for the centralized lanes in urban areas discussed in Options I and II, Sections 4 and 5 respectively. Again, the following numbers of inspections to be performed were derived from 1987 registration projections, assuming a 30 percent stringency rate. They are as follows:

	1987 Total Inspections
• Alternate A - (12 counties)	7,436,000
• Alternate B - (18 counties)	8,148,300

Next the number of centralized lanes needed for both alternates were derived in Section IV which were:

	1987 Centralized Lane Requirements
• Alternate A - (12 counties)	166 lanes
• Alternate B - (18 counties)	184 lanes

Again the actual inspection network in terms of the approximate locations and station size were computed. They are shown in Tables 75 and 76.

TABLE 75. INSPECTION NETWORK REQUIREMENTS FOR OPTION III ALTERNATE A (12 COUNTY)

County	Town	Number of facilities	Configuration
Butler	Hamilton	1	3 lanes
	Middletown	1	3 lanes
Cuyahuga	Cleveland	6	6 lanes
	Cleveland	1	3 lanes
Franklin	Columbus	3	6 lanes
	Columbus	1	3 lanes
Hamilton	Cincinnati	3	6 lanes
	Norwood	1	3 lanes
Lake	Merton on the Lake	1	3 lanes
	Painsville	1	3 lanes
Lorain	Lorain	1	4 lanes
	Elyria	1	3 lanes
Lucas	Toledo	2	6 lanes
Mahoning	Youngstown	1	6 lanes
	Ellsworth	1	2 lanes
Montgomery	Dayton	2	6 lanes
	Englewood	1	3 lanes
Stark	Canton	1	6 lanes
	Alliance	1	4 lanes
Summit	Akron	2	6 lanes
	Cuyahuga Falls	1	2 lanes
Trumbull	Warren	1	4 lanes
	Niles	1	3 lanes
TOTAL Network		35 facilities	166 lanes

TABLE 76. INSPECTION NETWORK REQUIREMENTS FOR OPTION III ALTERNATE B (18 COUNTY)

		Number of Facilities	Configuration
Butler	Hamilton	1	3 lanes
	Middletown	1	3 lanes
Clermont	Batavia	1	3 lanes
Cuyahoga	Cleveland	6	6 lanes
	Cleveland	1	3 lanes
Franklin	Columbus	3	6 lanes
	Columbus	1	3 lanes
Geauga	Chardon	1	2 lanes
Greene	Fairborn	1	4 lanes
Hamilton	Cincinnati	3	6 lanes
	Norwood	1	3 lanes
Lake	Mentor on the Lake	1	3 lanes
	Painsville	1	2 lanes
Lorain	Lorain	1	4 lanes
	Elyria	1	3 lanes
Lucas	Toledo	2	6 lanes
Mahoning	Youngstown	1	6 lanes
	Ellsworth	1	2 lanes
Medina	Medina	1	3 lanes
Montgomery	Dayton	2	6 lanes
	Englewood	1	3 lanes
Stark	Canton	1	6 lanes
	Alliance	1	4 lanes
Summit	Akron	2	6 lanes
	Cuyahoga Falls	1	2 lanes
Trumbull	Warren	1	4 lanes
	Niles	1	3 lanes
Warren	Lebanon	1	3 lanes
Wood	Bowling Green	1	3 lanes
Total network		41 facilities	184 lanes

OPTION COSTS

In Option III most of the costs are similar to those relating to the centralized facilities in Options I and II. Where costs are the same, the approach here will be to summarize the major cost categories. Where the costs differ, then that category will be broken down to illustrate actual cost figures.

Initial Capital Costs

The initial capital costs for land, land improvements, buildings, equipment, calibration vans, central computer, and security systems are the same as in Options I and II. As there is no private garage network in this option, there is no capital expenditure for Inspection and Licensing Officials' Vans, or Complaints Investigators' Cars. A summary of the capital costs for Option III is provided in Table 77.

TABLE 77. CAPITAL COSTS FOR OPTION III

Item	Alternate A	Alternate B
Land Investment (includes improvements)	\$ 2,672,970	\$ 2,997,290
Building Investment	12,027,834	13,330,420
Test Equipment	7,365,000	8,340,000
Central Computer	250,000	250,000
Maintenance/Calibration Vans	168,000	196,000
Security Systems	38,500	45,000
Totals	\$22,522,304	\$25,158,810

One Time Start Up Costs

Land Acquisition--

As explained for Option I, the costs of the site location and evaluation, surveying, price negotiation and title conveyance are assumed to be \$6,000 per site plus 10 percent of the purchase price of the land. For Alternates A and B this is:

Alternate A = (35 sites × \$6,000) + (0.10) (1,675,294) = \$377,529

Alternate B = (41 sites × \$6,000) + (0.10) (1,891,218) = \$435,122

Facilities Planning--

This element is computed in the same manner as for Option 1. For Alternates A and B the planning cost is 10 percent of the buildings cost or \$1,202,783 for Alternate A and \$1,333,042 for Alternate B.

Program Design--

As explained for Option I, a cost of $100,000 was used for the program design estimate.

Data Handling Software--

Based on discussions with computer systems analysts, an estimate of $200,000 was arrived at for development of data handling software.

Personnel Training--

As indicated in Section 3, an initial, intensive training effort is required prior to program startup. Facility personnel allocation rates are assumed to be the same as those presented in the discussion of Option I. Applying these rates to the facility requirements derived previously, the basic operating personnel requirements for Option III are:

Alternate A:

- 35 Managers
- 35 Assistant Managers
- 12 Maintenance/Calibration people
- 5 Investigators
- 498 Inspectors

Thus:

$$
\begin{aligned}
= \quad & (35)\ (\$53) = \$\ 1{,}855 \\
+ \ & (5)\ \ (\$43) = \quad\ \ 215 \\
+ & (545)\ (\$16) = \underline{\ \ 8{,}720} \\
& \qquad\qquad\quad \$10{,}790
\end{aligned}
$$

Alternate B:

- 41 Managers
- 41 Assistant Managers
- 14 Maintenance/Calibration people
- 5 Investigators
- 522 Inspectors

Thus:

$$
\begin{aligned}
= \quad & (41)\ (\$53) = \$\ 2{,}175 \\
+ \ & (5)\ \ (\$43) = \quad\ \ 215 \\
+ & (577)\ (\$16) = \underline{\ \ 9{,}232} \\
& \qquad\qquad\quad \$11{,}622
\end{aligned}
$$

Personnel Salaries--

The same assumptions for personnel requirements for Option I were used. The costs of test personnel for the start up period are calculated for Alternates A and B in Table 78 below.

TABLE 78. FACILITY PERSONNEL START-UP SALARIES

Alternate A:		
(35 managers) ($1,250/month) (6 mos.)	=	$ 262,500
+ (35 asst. managers) ($1,083/month) (6 mos.)	=	227,500
+ (12 maintenance/calibration people) (1,000/mo.) (1 mo.)	=	12,000
+ (498 inspectors) ($750/mo.) (1 mo.)	=	373,500
		875,500
+ Overhead @ 25 percent		218,875
Total		$1,094,375
Alternate B:		
(41 managers) ($1,250/mo.) (6 mos.)	=	307,500
+ (4 asst. managers) ($1,083/mo.) (6 mos.)	=	266,418
+ (14 maintenance/calibration people) (1,000/mo.) (1 mo.)	=	14,000
+ (522 inspectors) ($750/month) (1 mo.)	=	391,500
		979,418
+ Overhead @ 25 percent		244,855
Total		$1,224,273

The cost of administrative personnel will be the administrative salaries and overhead for 1-1/2 years or $853,164 for both Alternates A and B, as described in Option I.

Initial Public Relations Program--

As explained for Option I, the cost for initial start-up public relations would be approximatly $0.12/vehicle to be tested, or $900,000 for Alternate A, and $978,000 for Alternate B.

The total start-up costs for Option III Alternates A and B are summarized in Table 79.

TABLE 79. START-UP COSTS FOR OPTION III

	Alternate A	Alternate B
Land Acquisition	$ 377,529	$ 435,122
Facilities Planning	1,202,783	1,333,042
Data Handling Software	200,000	200,000
Program Design	100,000	100,000
Test Personnel Salaries + Overhead	1,094,375	1,224,273
Administrative Salaries + Overhead	853,164	853,164
Initial Public Relations Program	900,000	978,000
Personnel Training	10,790	11,622
Totals	$4,738,641	$5,135,223

Annual Operating Costs

Facility Personnel--

The annual cost for centralized facility personnel salaries and overhead is the same as for Options I and II; these are summarized in Table 80.

TABLE 80. ANNUAL COST FOR TEST FACILITY PERSONNEL

	Alternate A	Alternate B
Salaries	$5,606,000	$6,014,000
Overhead @ 25 percent	1,401,500	1,503,500
Total	$7,007,500	$7,517,500

Maintenance--

The annual cost of equipment repair, replacement and preventive maintenance is the same as for Options I and II, as this cost is a function (20 percent) of the initial equipment expenditures for the centralized lanes, which is also the same for Options I and II. These costs are summarized in Table 81.

TABLE 81. MAINTENANCE COSTS ANNUALLY FOR TEST EQUIPMENT IN OPTION III

	Alternate A	Alternate B
Annual Maintenance Costs	$1,473,000	$1,668,000

Utilities/Supplies/Services

Utilities--

Annual cost for utilities was derived from electric usage rates experienced by other states. For Option III these were found to be 120 kWh/day/lane, plus 325 kWh/day/facility. Per kilowatt costs were obtained from several utility companies and were found to be \$0.05/kWh. The annual costs, then, for utilities are calculated below:

Alternate A - 12 Counties

(166 lanes) (120 kWh/day) (\$0.05) (250 operating days/year)	= \$249,000
+ (35 facilities) (325 kWh/day) (\$0.05) (250 operating days/year =	142,188
Total Utilities Cost Annually	\$391,188

Alternate B - 18 Counties

(184 lanes) (120 kWh/day) (\$0.05) (250 operating days/year)	= \$276,000
+ (41 facilities) (325 kWh/day) (\$0.05) (250 operating days/year)=	166,563
Total Utilities Cost Annually	\$442,563

Insurance--

Based on the \$1,500/lane insurance costs assumed for Option I, total annual insurance costs for Option III are computed below for both alternates:

Alternate A - 12 Counties

(166 lanes) (\$1,500) = \$249,000

Alternate B - 18 Counties

(184 lanes) (\$1,500) = \$276,000

Computer Operation and Test Forms--

Central computer operation costs for automated inspection systems have been estimated at \$0.15/test, and forms at \$0.03/test as in Option I. The annual cost for these categories can then be easily computed:

Alternate A - 12 County = \$1,338,475

Alternate B - 18 County = \$1,466,690

Taxes--

The annual cost of real estate and personal property taxes were calculated based on full valuation rates for each municipality in which stations are to be located. Total annual taxes were found to be:

Alternate A - (12 counties) \$1,058,028

Alternate B - (18 counties) \$1,178,606

These are broken down for specific municipalities in Appendix I.

Uniforms--

Based on the assumption of $125 annual uniform cost/employee, as used in Option I, the total annual uniform costs for Alternates A and B are shown below:

Alternate A = (580 uniformed employees) ($125) = $72,500

Alternate B = (648 uniformed employees) ($125) = $81,000

Security--

The annual cost of maintaining security systems, as in Option I, is assumed to be $850/facility. The annual cost of this item for Alternates A and B are thus:

Alternate A: (35 facilities)($850) = $29,750

Alternate B: (41 facilities)($850) = $34,850

Calibration Costs--

The recurring annual cost of equipment calibration is defined as the cost of calibration gases plus the operating cost of maintenance/calibration vans. Using the annual cost/van derived in Option I as $8,800; the calibration costs for both alternates are shown below:

Alternate A: ($8,800)(12 vans) = $105,600

Alternate B: ($8,800)(14 vans) = $123,200

The total annual cost for utilities, services, and supplies is summarized in Table 82.

TABLE 82. ANNUAL COST FOR UTILITIES, SERVICES AND SUPPLIES OPTION III

	Alternate A	Alternate B
Utilities	$ 391,188	$ 442,563
Insurance	249,000	276,000
Computer Operation and Forms	1,338,475	1,466,690
Taxes	1,058,028	1,178,606
Uniforms	72,500	81,000
Security	29,750	34,850
Calibration	105,600	123,200
Totals	$3,244,541	$3,602,909

Annual Administrative Costs

Program Administrative Personnel--

Annual Administrative Personnel costs are essentially the same as for Option I minus the costs of complaints investigators and inspection/licensing officials. These are found to be $568,776 annually - for both Alternates A and B.

Public Information--

The annual cost for public relations is again assumed to be $0.12 for each vehicle to be inspected or $900,000 for Alternate A and $978,000 for Alternate B.

Personnel Training--

Using the same assumptions as for Option I, the annual turnover of 50 inspectors for Alternate A, and 52 for Alternate B is anticipated. This relates to an annual cost of $800 for Alternate A, and $832 for Alternate B based on a $16/need inspector charge.

COST SUMMARY

The total cost of Option III for Alternates A and B is summarized in Table 83a and 83b.

Initial capital costs and one-time start-up costs are converted to annual figures using the amortization factors discussed in Section 3. These annualized costs are added to annual operating costs and annual administrative costs to arrive at total annual costs in constant 1978 dollars.

A uniform fee in constant dollars (f_c) was calculated by dividing the annual costs by the average annual vehicle registrations for the period 1981 through 1987 (5,200,000 for Alternate A, 5,700,000 for Alternate B). This assumes a free retest. The fee calculations are provided in Tables 84a and 84b.

MANPOWER REQUIREMENTS

Manpower requirements are slightly smaller for Option III than for the preceding options due to the decrease in geographic coverage in this Option from Options I and II. Since there are no private garages participating in the I/M network under this Option, the inspection and licensing, as well as the complaints investigation functions are not required. The resulting organizational network is shown in Figure 9. Table 85 lists total state and contractor manpower allocations.

TABLE 83a. COST SUMMARY OPTION III ALTERNATE A (12 COUNTIES)

Primary category		Principal element	Element cost ($)	Total category cost ($)
Initial capital costs	1.	Land investment Plus improvements	$2,672,970	
	2.	Building investment	12,027,834	
	3.	Equipment costs (includes, vans, computer, security systems)	7,821,500	
				$22,522,304
One time startup costs	1.	Land acquisition	377,529	
	2.	Facilities planning	1,202,783	
	3.	Program design	100,000	
	4.	Development of data handling System structure	200,000	
	5.	Personnel training	10,790	
	6.	Personnel salaries and overhead	1,947,539	
	7.	Initial public information program	900,000	
				4,738,641
Annual operating costs	1.	Facility personnel	7,007,500	
	2.	Maintenance	1,473,000	
	3.	Utilities, services, supplies	3,244,541	
				11,725,853
Annual administrative costs	1.	Program administrative salaries	568,776	
	2.	Public information	900,000	
	3.	Training	800	
				1,469,576

(continued)

TABLE 83b. COST SUMMARY OPTION III ALTERNATE B

Primary category	Principal element	Element cost ($)	Total category cost ($)
Initial capital costs	1. Land investment (includes improvements	2,997,290	
	2. Building investment	13,330,420	
	3. Equipment costs (includes fans, computer, and security systems)	8,831,100	
			25,158,810
One time start-up costs	1. Land acquisition	435,122	
	2. Facilities planning	1,333,042	
	3. Program design	100,000	
	4. Development of data handling System structure	200,000	
	5. Personnel training	11,622	
	6. Personnel salaries and overhead	2,077,437	
	7. Initial public information program	978,000	
			5,135,223
Annual operating costs	1. Facility personnel	7,517,500	
	2. Maintenance	1,668,000	
	3. Utilities, services, supplies	3,602,909	
			12,788,409
Annual administrative costs	1. Program administrative salaries	568,776	
	2. Public information	978,000	
	3. Training	832	
			1,547,608

(continued)

TABLE 84a. f_c OPTION III ALTERNATE A

i = 0.03 Cost class	Cost ($)	Amortization factor for i = (0.03)	Annualized Cost (column) × (column 3)
Capital costs			
1. Land	$ 2,672,970	0.03	$ 80,189
2. Buildings	12,027,834	0.067	805,865
3. Equipment	7,821,500	0.2184	1,708,216
Start up costs	4,738,641	0.2184	1,034,919
Operating costs	11,725,853		11,725,853
Administrative costs	1,469,576		1,469,576
Total			$16,824,618
Fee_c		$16,824,618/5,200,000 = $3.24	

i = 0.06 Cost class	Cost ($)	Amortization factor for i = 0.06	Annualized Cost (column 2) × (column 3)
Capital costs			
1. Land	2,672,970	0.06	160,378
2. Buildings	12,027,834	0.087	1,046,422
3. Equipment	7,821,500	0.2374	1,856,824
Start up costs	4,738,641	0.2374	1,124,953
Operating costs	11,725,853		11,725,853
Administrative costs	1,469,576		1,469,576
Total			$17,384,006
Fee_c		$17,384,006/5,200,000 = $3.34	

TABLE 84b. f_c OPTION III ALTERNATE B

i = 0.03 Cost class	Cost ($)	Amortization factor for i = (0.03)	Annualized cost (column) × (column 3)
Capital costs			
1. Land	2,997,290	0.03	89,919
2. Buildings	13,330,420	0.067	893,138
3. Equipment	8,831,100	0.2184	1,928,712
Start-up costs	5,135,223	0.2184	1,121,533
Operating costs	12,788,409		12,788,409
Administrative costs	1,547,608		1,547,608
Total			18,369,319
	$18,369,319/5,700,000 = $3.22		

i = 0.06 Cost class	Cost ($)	Amortization factor for i = (0.06)	Annualized cost (column 2) × (column 3)
Capital costs			
1. Land	2,997,290	0.06	179,837
2. Buildings	13,330,420	0.087	1,159,747
3. Equipment	8,831,100	0.2374	2,096,503
Start-up costs	5,135,223	0.2374	1,219,102
Operating costs	12,788,409		12,788,409
Administrative costs	1,547,608		1,547,608
Total			18,991,206
	$18,991,206/5,700,000 = $3.33		

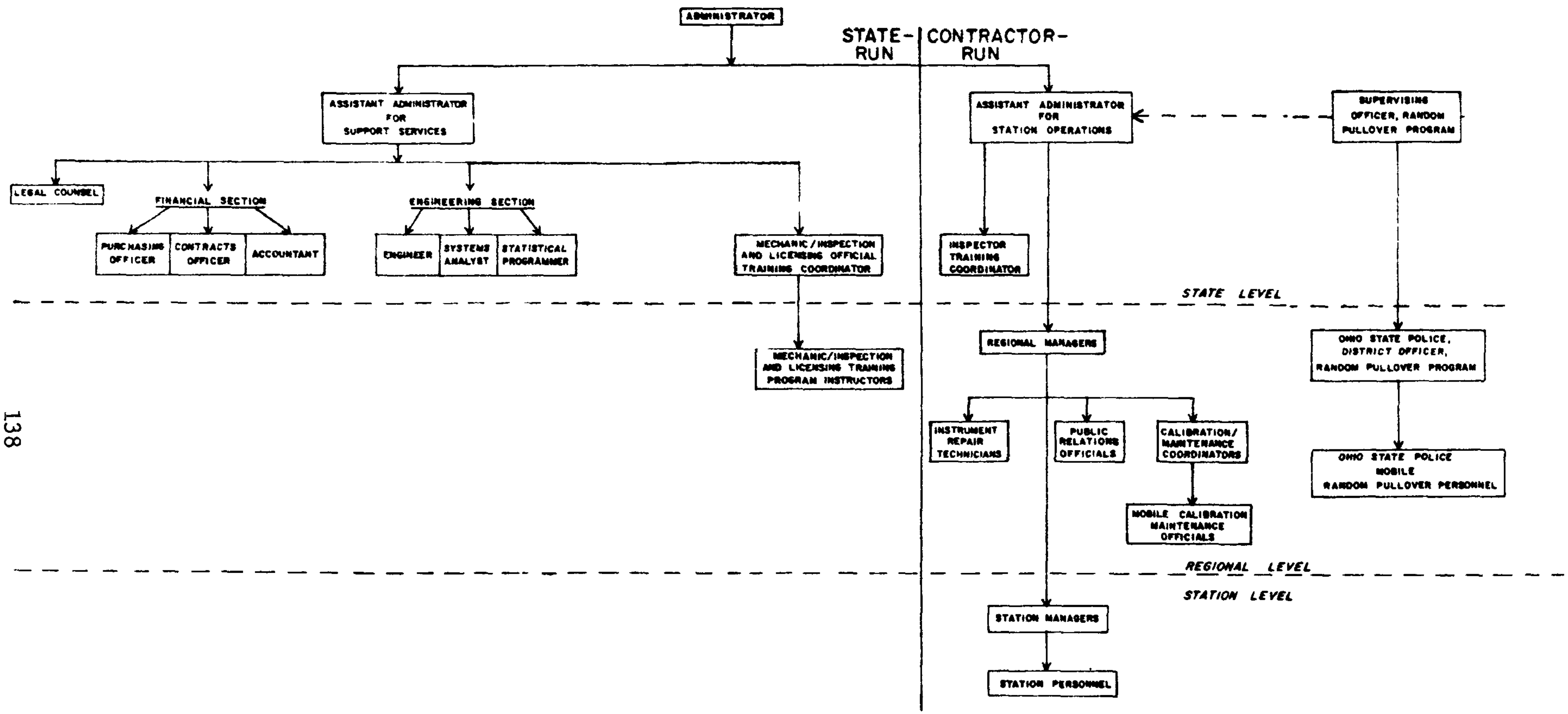

Figure 9. Administrative Organization, Option III.

TABLE 85. OPTION III MANPOWER REQUIREMENTS

State Administrative Personnel

1 Administrator
1 Assistant Administrator for Supporting Services
1 Legal Counsel
1 Purchasing Officer
1 Accountant
1 Contracts Officer
1 Engineer
1 Systems Analyst
1 Statistician/Programmer
1 Mechanic Training Program Coordinator

Contractor State Personnel

1 Assistant Administrator for Station Operations
1 Inspector Training Coordinator

Contractor Regional Personnel

Number		
Alternate A	Alternate B	
5	5	Regional Managers
5	5	Instrument Repair Technicians
5	5	Public Relations Officials
5	5	Calibration and Maintenance Coordinators
12	14	Mobile Calibration and Maintenance Officials
		Contractor Local Personnel
35	41	Station Managers
35	41	Station Assistant Managers
498	522	Station Inspectors
12	14	Station Maintenance Personnel

SECTION 7

OPTION IV - • URBAN COUNTY COVERAGE
• STATE ADMINISTERS CENTRALIZED LANES
ALTERNATE A - 12 URBAN COUNTIES
ALTERNATE B - 18 URBAN COUNTIES

OPTION DEFINITION

This option involves the Ohio State Government establishing a network of centralized idle mode test lanes in either 12 Urban Counties (Alternate A) or 18 Urban Counties (Alternate B). The Ohio Environmental Protection Agency and the Bureau of Motor Vehicles are the administrative agencies. Ohio EPA would direct the overall program including purchasing land and equipment, building the test facilities, designing the program, training personnel, providing public information, operating the test lanes, data handling and analysis, and all other program elements except enforcement. The Bureau of Motor Vehicles would be primarily responsible for enforcement in the option. In Section 16 there is a discussion of the sticker-ticketing method of enforcement. The basic network requirements for centralized lanes in the urban areas have already been discussed in detail in Section IV. Again, the following number of inspections were derived for 1987, assuming a 30 percent stringency factor:

<u>1987 Total Inspections</u>

• Alternate A (12 county)	7,436,000
• Alternate B (18 county)	8,148,300

Next the number of centralized lanes needed for both alternates were derived in Section IV:

<u>1987 Centralized Lane Requirements</u>

• Alternate A (12 county)	166
• Alternate B (18 county)	184

Finally the actual inspection network, both in terms of the approximate locations and station sizes, was computed. It is, of course, the same as in the previous options, and is shown in Tables 86 and 87.

TABLE 86. INSPECTION NETWORK REQUIREMENTS FOR OPTION IV - ALTERNATE A, 12 COUNTY

County	Town	Number of facilities	Configuration
Butler	Hamilton	1	3 lanes
	Middletown	1	3 lanes
Cuyahoga	Cleveland	6	6 lanes
	Cleveland	1	3 lanes
Franklin	Columbus	3	6 lanes
	Columbus	1	3 lanes
Hamilton	Cincinnati	3	6 lanes
	Norwood	1	3 lanes
Lake	Mentor on the Lake	1	3 lanes
	Painsville	1	3 lanes
Lorain	Lorain	1	4 lanes
	Elyria	1	3 lanes
Lucas	Toledo	2	6 lanes
Mahoning	Youngstown	1	6 lanes
	Englewood	1	2 lanes
Montgomery	Dayton	2	6 lanes
Stark	Canton	1	6 lanes
	Alliance	1	4 lanes
Summit	Akron	2	6 lanes
	Cuyahoga Falls	1	2 lanes
Trumbull	Warren	1	4 lanes
	Niles	1	3 lanes
Total Network		35	166 lanes

TABLE 87. INSPECTION NETWORK REQUIREMENTS FOR OPTION IV - ALTERNATE B, 18 COUNTY

County	Town	Number of facilities	Configuration
Butler	Hamilton	1	3 lanes
	Middletown	1	3 lanes
Clermont	Batavia	1	3 lanes
Cuyohoga	Cleveland	6	6 lanes
	Cleveland	1	3 lanes
Franklin	Columbus	3	6 lanes
	Columbus	1	3 lanes
Geauga	Chardon	1	2 lanes
Green	Fairborn	1	4 lanes
Hamilton	Cincinnati	3	6 lanes
	Norwood	1	3 lanes
Lake	Mentor on the Lake	1	3 lanes
	Painsville	1	3 lanes
Lorain	Lorain	1	4 lanes
	Elyria	1	3 lanes
Lucas	Toledo	2	6 lanes
Mahoning	Youngstown	1	6 lanes
	Ellsworth	1	2 lanes
Medina	Medina	1	3 lanes
Montgomery	Dayton	2	6 lanes
	Englewood	1	3 lanes
Stark	Canton	1	6 lanes
	Alliance	1	4 lanes
Summit	Akron	2	6 lanes
	Cuyohoga Falls	1	2 lanes
Trumbull	Warren	1	4 lanes
	Niles	1	3 lanes
Warren	Lebanon	1	3 lanes
Wood	Bowling Green	1	3 lanes
Total Network		41	184 lanes

OPTION COSTS

In option IV most of the costs are identical to those described in Option III. This is due to the fact that the program differs only by ownership and operation. Rather than report each cost in detail, the major cost categories will be summarized, and where costs differ from Option III, that cost category will be broken down to illustrate actual cost figures.

Initial Capital Costs

The initial capital costs are exactly the same for Option IV as previously discussed for option III. A summary of the capital costs is provided in Table 88.

TABLE 88. CAPITAL COSTS FOR OPTION IV

Item	Alternate A	Alternate B
Land Investment (includes improvements)	$ 2,672,970	$ 2,997,290
Building Investment	12,027,834	13,330,420
Test Equipment	7,365,000	8,340,000
Central Computer	250,000	250,000
Maintenance/Calibration Vans	168,000	196,000
Security Systems	38,500	45,000
Total	$22,522,304	$25,158,810

One Time Start-UP Costs--
All the elements in this category except one, personnel salaries and overhead, are the same as Option III in the preceding Section VI. For this option, it was assumed that the administrative salaries and overhead would be calculated for 30 months rather than 18 months. Reasons for the change are the same as those discussed in Option II, Section V. The total start-up costs for Option IV, Alternates A and B are summarized in Table 89.

TABLE 89. START-UP COSTS FOR OPTION IV

Item	Alternate A	Alternate B
Land Aquisition	$ 377,529	$ 435,122
Facilities Planning	1,202,783	1,333,042
Data Handling Software	200,000	200,000
Program Design	100,000	100,000
Test Personnel Salaries and Overhead	1,094,375	1,224,273
Administrative Salaries and Overhead	1,421,940	1,421,940
Initial Public Relations Program	900,000	978,000
Personnel Training	10,790	11,622
Total	$5,307,417	$5,703,999

Annual Operating Costs

The annual costs for facility personnel salaries and overhead, equipment repair, replacement and preventive maintenance, utilities, insurance, calibration, uniforms, and security are identical to option III. In option IV, unlike option III however, there would be no requirement to pay taxes. This is reflected in a different figure for the cost category "Utilities, Supplies, and Services". The cost for this category is provided in Table 90.

TABLE 90. ANNUAL COST FOR UTILITIES, SUPPLIES, AND SERVICES - OPTION IV, ALTERNATE A

Item	Alternate A	Alternate B
Utilities	$ 391,188	$ 442,563
Insurance	249,000	276,000
Computer Operation and Forms	1,338,475	1,466,690
Uniforms	72,500	81,000
Security	29,750	34,850
Calibration	105,600	123,200
Total	$2,186,513	$2,424,303

Annual Administrative Costs

Program Administrative Personnel--

Annual Administrative personnel costs are the same as for Option III. These are found to be $568,776 annually - for both Alternates A and B.

Public Information--

The annual cost for public relations is again assumed to be $0.12 for each vehicle to be inspected or $900,000 for Alternate A and $978,000 for Alternate B.

Personnel Training--

Using the same assumptions as for Option I, the annual turnover of 50 inspectors for Alternate A, and 52 for Alternate B is anticipated. This relates to an annual cost of $800 for Alternate A, at $832 for Alternate B based on a $16.00 per new inspector charge.

SUMMARY

The total costs of Option IV are summarized in Tables 91 and 92.

Initial capital costs and one time start up costs are converted to annual figures using the amortization factors discussed in Section 3. Those annualized costs are added to annual operating costs and annual administrative costs to arrive at total annual costs in constant 1978 dollars.

A uniform fee in constant dollars (f_c) was calculated by dividing the annual costs by the average annual motor vehicle registration for 1981 to 1987 (5,200,000 for Alternate A and 5,700,000 for Alternate B). This assumes a free retest. These calculations are provided in Tables 93 and 94.

TABLE 91. COST SUMMARY - OPTION IV, ALTERNATE A

Primary category	Principal element	Element cost ($)	Total category cost ($)
Initial capital costs	1. Land investment	$ 2,672,970	
	2. Building investment	12,027,834	
	3. Equipment costs (includes vans, computer, security systems)	7,821,500	
Total			$22,522,304
One-time startup costs	1. Land aquisition	377,529	
	2. Facilities planning	1,202,783	
	3. Program design	100,000	
	4. Development of data handling system software	200,000	
	5. Personnel training	10,790	
	6. Personnel salaries and overhead	2,516,315	
	7. Initial public information program	900,000	
Total			5,307,417
Annual operating costs	1. Facility personnel	7,007,500	
	2. Maintenance	1,473,000	
	3. Utilities, services, and supplies	2,186,513	
Total			10,667,013
Annual administrative costs	1. Program administrative salaries	568,776	
	2. Public Information	900,000	
	3. Training	800	
Total			1,469,576

TABLE 92. COST SUMMARY - OPTION IV, ALTERNATE B

Primary category	Principal element	Element cost ($)	Total cat gory cost ($)
Initial capital costs	1. Land investment	$ 2,997,290	
	2. Building investment	13,330,420	
	3. Equipment costs (includes vans, computer, security systems)	8,831,100	
Total			$25,158,810
One-time startup costs	1. Land aquisition	435,122	
	2. Facilities planning	1,333,042	
	3. Program design	100,000	
	4. Development of data handling system software	200,000	
	5. Personnel training	11,622	
	6. Personnel salaries and overhead	2,646,213	
	7. Initial public information program	978,000	
Total			5,703,999
Annual operating costs	1. Facility personnel	7,517,500	
	2. Maintenance	1,668,000	
	3. Utilities, services, supplies	2,424,303	
Total			11,609,803
Annual administrative costs	1. Program administrative salaries	568,776	
	2. Public information	978,000	
	3. Training	832	
Total			1,547,608

TABLE 93. f_c - OPTION IV, ALTERNATE A

	Cost class	Cost ($)	Amortization factor for i = 0.03	Annualized cost ($) (column 2)x(column 3)
	when i = 0.03			
I.	Capital Costs			
	1. Land	2,672,970	0.03	80,189
	2. Buildings	12,027,834	0.067	805,865
	3. Equipment	7,821,500	0.2184	1,708,216
II.	Startup Costs	5,307,417	0.2184	1,159,140
III.	Operating Costs	10,667,013		10,667,013
IV.	Adminsitrative Costs	1,469,576		1,469,576
	Total			15,889,999
	Fee_c	15,889,999 ÷	5,200,000	3.06

	Cost Class	Cost ($)	Amortization factor for i = 0.06	Annualized cost ($) (column 2)x(column 3)
	when i = 0.06			
I.	Capital costs			
	1. Land	2,672,970	0.06	160,378
	2. Buildings	12,027,834	0.087	1,046,422
	3. Equipment	7,821,500	0.2374	1,856,824
II.	Startup costs	5,307,417	0.2374	1,259,981
III.	Operating costs	10,667,013		10,667,013
IV.	Administrative costs	1,469,576		1,469,576
	Total			16,460,194
	Fee_c	16,460,194 ÷	5,200,000	3.20

TABLE 94. f_c - OPTION IV, ALTERNATE B

when i = 0.03

	Cost class	Cost ($)	Amortization factor for i = 0.03	Annualized cost ($) (column 2)x(column 3)
I.	Capital Costs			
	1. Land	2,997,290	0.03	89,919
	2. Buildings	13,330,420	0.067	893,138
	3. Equipment	8,831,100	0.2184	1,928,712
II.	Startup costs	5,703,999	0.2184	1,245,753
III.	Operating costs	11,609,803		11,609,803
IV.	Administrative costs	1,547,608		1,547,608
	Total			17,314,933
	Fee_c	17,314,933 ÷	5,700,000	= 3.04

when i = 0.06

	Cost class	Cost ($)	Amortization factor for i = 0.06	Annualized cost ($) (column 2)x(column 3)
I.	Capital costs			
	1. Land	2,997,290	0.06	179,837
	2. Buildings	13,330,420	0.087	1,159,747
	3. Equipment	8,831,100	0.2374	2,096,503
II.	Startup costs	5,703,999	0.2374	1,354,129
III.	Operating costs	11,604,803		11,609,803
IV.	Administrative costs	1,547,608		1,547,608
	Total			17,947,627
	Fee_c	17,947,627 ÷	5,700,000	= 3.15

MANPOWER REQUIREMENTS

Just as in Option II, the state will assume all functions in Option IV that were performed by the contractor in Option III; otherwise, overall personnel requirements remain the same for this option as for Option III. The resulting organizational network is shown in Figure 10. Table 95 lists total state manpower allocations.

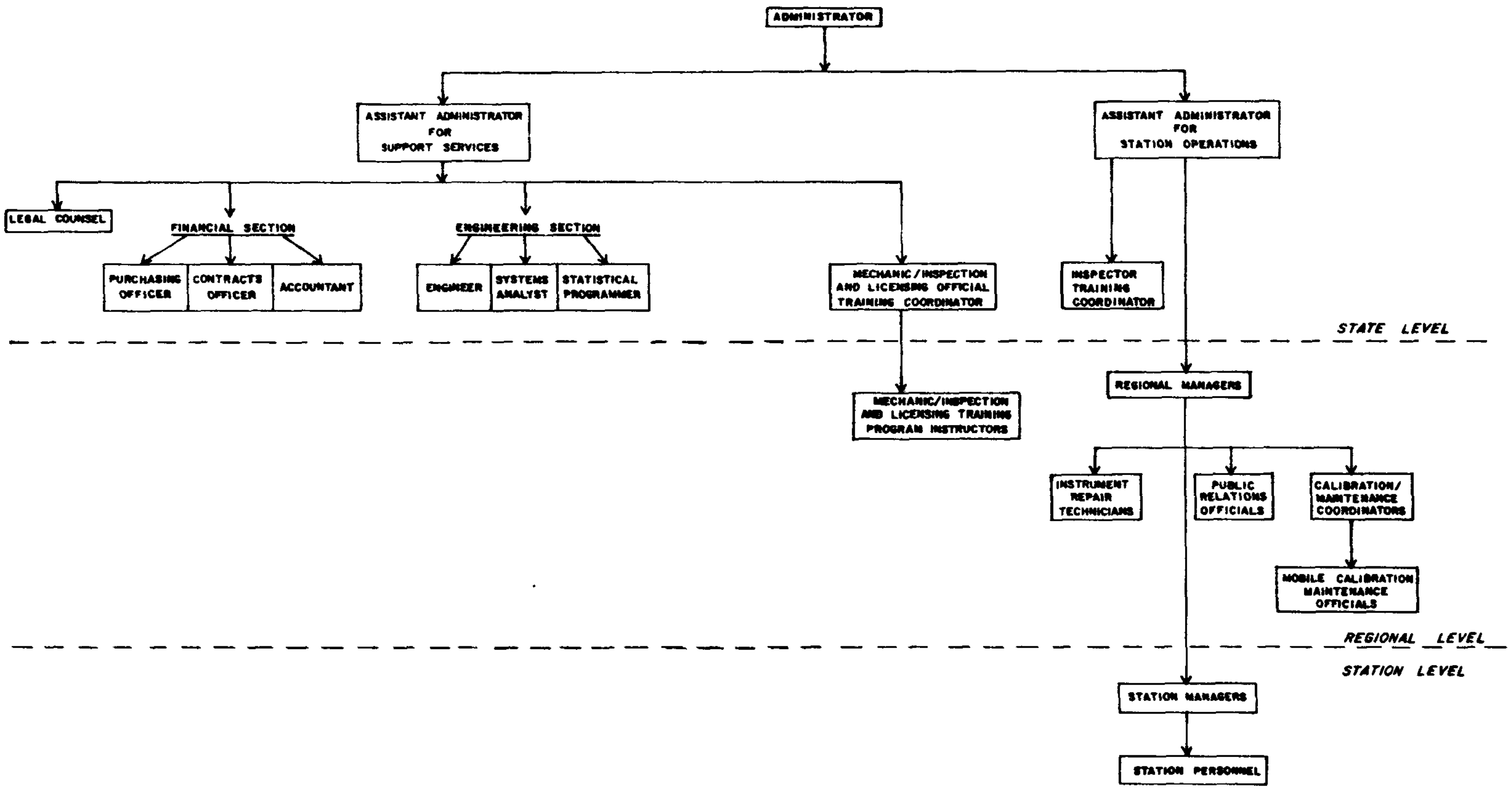

Figure 10. Administrative organization, Option IV.

TABLE 95. MANPOWER REQUIREMENTS, OPTION IV

State administrative personnel
1 Administrator
1 Assistant Administrator for Supporting Services
1 Legal Counsel
1 Purchasing Officer
1 Contracts Officer
1 Accountant
1 Engineer
1 Systems Analyst
1 Statistician/Computer Programmer
1 Mechanic Training Program Coordination
1 Assistant Administrator for Station Operations
1 Inspection Training Coordinator

State regional personnel
5 Regional Managers
5 Instrument Repair Technicians
5 Public Relations Officials
5 Calibration/Maintenance Coordinators

Number		
Alternate A	Alternate B	
12	14	Mobile Calibration and Maintenance Officials

State local personnel

Number		
Alternate A	Alternate B	
35	41	Station Managers
35	41	Station Assistant Managers
498	522	Station Inspectors
12	14	Station Maintenance Personnel

SECTION 8

OPTION V -
- STATEWIDE COVERAGE
- CONTRACTOR ADMINISTERS CENTRALIZED LANES IN URBAN AREAS
- RANDOM ROADSIDE PULLOVERS IN RURAL AREAS

ALTERNATE A - 12 URBAN COUNTIES

ALTERNATE B - 18 URBAN COUNTIES

OPTION DEFINITION

This option involves a private contractor establishing a network of centralized idle mode test lanes in either 12 urban counties (Alternate A) or in 18 urban counties (Alternate B). In the remaining rural counties, inspection will be conducted by the Ohio State Highway Patrol (OHP) in a random pullover program in conjunction with their random safety inspection program. Currently, the State Highway Patrol has a random pullover program in which 27 teams of safety inspectors go out in vans, two inspectors per van, accompanied by a State Trooper. It is estimated that over the last five years the State Highway Patrol has conducted approximately 600,000 inspections per year for the 27 teams in vans. This is roughly 30 percent of the total safety inspections conducted. In addition to special inspection teams, the OHP also performs safety inspections either through normal enforcement activities or by having a State Trooper individually pulling cars over without the vans. The total yearly safety inspections equal roughly 1,701,249 or about 25 percent of the total vehicle population. In Options V and VI the State Patrol would purchase enough additional vans and hire enough men to have sufficient numbers to achieve a 25 percent level of random pullover for the combined safety and emissions testing. The actual methodology used to estimate the costs of setting up such a system is discussed in the second half of this section, after centralized lane costs are discussed.

NETWORK REQUIREMENTS

The basic network requirements for Option V, Alternates A and B are essentially the same as for the centralized lanes in urban areas discussed in the previous four options. Again the following numbers of inspections to be performed were derived from 1987 registration projections, assuming a 30 percent stringency factor. They are as follows:

1987 Total Inspections

- Alternate A (12 counties) 7,436,000
- Alternate B (18 counties) 8,148,300

Next the number of centralized lanes needed for both alternates was derived. Again, these are the same as for all previously discussed options, and are as follows:

1987 Centralized Lane Requirements

- Alternate A (12 counties) 166 lanes
- Alternate B (18 counties) 184 lanes

In terms of approximate locations and station size, the actual inspection networks were computed previously. They are repeated in Tables 96 and 97.

TABLE 96. INSPECTION NETWORK REQUIREMENTS FOR OPTION III - ALTERNATE A, 12 COUNTIES

County	Town	Number of facilities	Configuration
Butler	Hamilton	1	3 lanes
	Middletown	1	3 lanes
Cuyohoga	Cleveland	6	6 lanes
	Cleveland	1	3 lanes
Franklin	Columbus	3	6 lanes
	Columbus	1	3 lanes
Hamilton	Cincinnati	3	6 lanes
	Norwood	1	3 lanes
Lake	Mentor on the Lake	1	3 lanes
	Painsville	1	3 lanes
Lorain	Lorain	1	4 lanes
	Elyria	1	3 lanes
Lucas	Toledo	2	6 lanes
Mahoning	Youngstown	1	6 lanes
	Ellsworth	1	2 lanes
Montgomery	Dayton	2	6 lanes
	Englewood	1	3 lanes
Stark	Canton	1	6 lanes
	Alliance	1	4 lanes
Summit	Akron	2	6 lanes
	Cuyohoga Falls	1	2 lanes
Trumbull	Warren	1	4 lanes
	Niles	1	3 lanes
Total Network		35	166 lanes

TABLE 97. INSPECTION NETWORK REQUIREMENTS FOR OPTION III - ALTERNATE B, 18 COUNTIES

County	Town	Number of facilities	Configuration
Butler	Hamilton	1	3 lanes
	Middletown	1	3 lanes
Clermont	Batavia	1	3 lanes
Cuyohoga	Cleveland	6	6 lanes
	Cleveland	1	3 lanes
Franklin	Columbus	3	6 lanes
	Columbus	1	3 lanes
Geauga	Chardon	1	2 lanes
Green	Fairborn	1	4 lanes
Hamilton	Cincinnati	3	6 lanes
	Norwood	1	3 lanes
Lake	Mentor on the Lake	1	3 lanes
	Painsville	1	3 lanes
Lorain	Lorain	1	4 lanes
	Elyria	1	3 lanes
Lucas	Toledo	2	6 lanes
Mahoning	Youngstown	1	6 lanes
	Ellsworth	1	2 lanes
Medina	Medina	1	3 lanes
Montgomery	Dayton	2	6 lanes
	Englewood	1	3 lanes
Stark	Canton	1	6 lanes
	Alliance	1	4 lanes
Summit	Akron	2	6 lanes
	Cuyohoga Falls	1	2 lanes
Trumbull	Warren	1	4 lanes
	Niles	1	3 lanes
Warren	Lebanon	1	3 lanes
Wood	Bowling Green	1	3 lanes
Total Network		41	184 lanes

OPTION COSTS

Option V central facility costs are exactly the same as in Option III, Section 6. The approach here will be to summarize the major cost categories for the centralized facilities. The cost of the roadside random inspection will be discussed at the end of Section 8.

Initial Capital Costs

The initial capital costs for land, land improvements, buildings, test equipment, central computer, maintenance/calibration vans, and security systems are the same for Option V as those discussed for Option III in Section 6. For convenience they are again provided in Table 98.

TABLE 98. CAPITAL COSTS FOR OPTION V

Item	Alternate A	Alternate B
Land Investment (including improvements)	$ 2,672,970	$ 2,997,920
Building Investment	12,027,834	13,330,420
Test Equipment	7,365,000	8,340,000
Central Computer	250,000	250,000
Maintenance/Calibration Vans	168,000	196,000
Security Systems	38,500	45,000
Total	$22,522,304	$25,158,810

One Time Start-up Costs

The initial expenditures for land acquisition, facility planning, data handling software development, program design, test and administrative personnel salaries and overhead, initial public relations program, and personnel training are the same as those presented for Option III, Section 6. A summary of total start-up costs for Option V is presented in Table 99.

Annual Operating Costs

Facility Personnel--

The costs for centralized facility personnel (salaries and overhead) are the same as Option V as were discussed for Option III in Section 6. These are summarized in Table 100.

Maintenance--

The annual costs for equipment repair, replacement, and preventive maintenance for Option V are the same as for Option III. Again, these are summarized in Table 101.

TABLE 99. START-UP COSTS FOR OPTION V

Item	Alternate A	Alternate B
Land Acquisition	$ 377,529	$ 435,122
Facilities Planning	1,202,783	1,333,042
Data Handling Software	200,000	200,000
Program Design	100,000	100,000
Test Personnel Salaries and Overhead	1,094,375	1,224,273
Administrative Salaries and Overhead	853,164	853,164
Initial Public Relations Program	900,000	978,000
Personnel Training	10,790	11,622
Total	$4,738,641	$5,135,223

TABLE 100. ANNUAL COST FOR TEST FACILITY PERSONNEL IN OPTION V

Item	Alternate A	Alternate B
Salaries	$5,606,000	$6,014,000
Overhead at 25 percent	1,401,500	1,503,500
Total	$7,007,500	$7,517,500

TABLE 101. ANNUAL MAINTENANCE COSTS FOR TEST EQUIPMENT IN OPTION V

Item	Alternate A	Alternate B
Annual Maintenance Costs	$1,473,000	$1,668,000

Utilities, Services and Supplies--

The annual cost for utilities, insurance, computer operation and forms, calibration, taxes, uniforms, and security systems are the same as those discussed in Section 6 for Option III. Table 102 summarizes these costs.

TABLE 102. ANNUAL COST FOR UTILITIES, SERVICES AND SUPPLIES FOR OPTION V

Item	Alternate A	Alternate B
Utilities	$ 391,188	$ 442,563
Insurance	249,000	276,000
Computer Operation and Forms	1,338,475	1,466,690
Taxes	1,058,028	1,178,606
Uniforms	72,500	81,000
Security	29,750	34,850
Calibration	105,600	123,200
Total	$3,244,541	$3,602,909

Annual Administrative Costs--

Option V annual costs for program administrative personnel salaries and overhead, public information, and personnel training are the same as those previously discussed in Option III. The annual administrative costs are summarized in Table 103.

TABLE 103. ANNUAL ADMINISTRATIVE COSTS FOR OPTION V

Item	Alternate A	Alternate B
Program Administrative Salaries and Overhead	$ 568,776	$ 568,776
Public Information	900,000	978,000
Inspector Training	800	832
Total	$1,469,576	$1,547,608

SUMMARY

The total costs of Option V are summarized in Tables 104 and 105.

Initial capital costs and one-time start-up costs are converted to annual figures using the amortization factors discussed in Section 3. These annualized costs are added to annual operating costs and annual administrative costs to determine total annual costs in constant 1978 dollars.

TABLE 104. COST SUMMARY OPTION V - ALTERNATE A, 12 COUNTIES

Primary cost category	Principal element	Element cost	Total category cost
Initial capital costs	1. Land investment plus improvements	$ 2,672,970	
	2. Building investment	12,027,834	
	3. Equipment costs (vans, computer, security systems)	7,821,500	
Total			$22,522,304
One-time start-up costs	1. Land acquisition	$ 377,529	
	2. Facilities planning	1,202,783	
	3. Program design	100,000	
	4. Development of data handling system software	200,000	
	5. Personnel training	10,790	
	6. Personnel salaries and overhead	1,947,539	
	7. Initial public information program	900,000	
Total			$ 4,738,641
Annual operating costs	1. Facility personnel	$ 7,007,500	
	2. Maintenance	1,473,000	
	3. Utilities/supplies/ services	3,244,541	
Total			$11,725,853
Annual administrative costs	1. Program administrative salaries	$ 568,776	
	2. Public information	900,000	
	3. Training	800	
Total			$ 1,469,576

TABLE 105. COST SUMMARY OPTION V - ALTERNATE B

Primary cost category	Principal element	Element cost	Total category cost
Initial capital costs	1. Land investment, includes improvements	$ 2,997,290	
	2. Building investment	13,330,420	
	3. Equipment costs (vans, computer, security systems)	8,831,100	
Total			$25,158,810
One-time start-up costs	1. Land acquisition	435,122	
	2. Facilities planning	1,333,042	
	3. Program design	100,000	
	4. Development of data handling system software	200,000	
	5. Personnel training	11,622	
	6. Personnel salaries and overhead	2,077,437	
	7. Initial public information program	978,000	
Total			$ 5,135,223
Annual operating costs	1. Facility personnel	$ 7,517,500	
	2. Maintenance	1,668,000	
	3. Utilities/supplies/services	3,602,909	
Total			$12,788,409
Annual administrative costs	1. Program administrative salaries	$ 568,776	
	2. Public information	978,000	
	3. Training	832	
Total			$ 1,547,608

A uniform fee in constant dollars (f_c) was calculated by dividing annual costs by the number of average annual vehicle registrations for the period 1981 to 1987 (5,200,000 for Alternate A and 5,700,000 for Alternate B). This assumes a free retest. These calculations are provided in Tables 106 and 107.

TABLE 106. f_c - OPTION V, ALTERNATE A

when i = 0.03

Cost class	Cost ($)	Amortization factor for i = 0.03	Annualized cost ($) (column 2)×(column 3)
Capital Costs			
1. Land	2,672,970	0.03	80,189
2. Buildings	12,027,834	0.067	805,865
3. Equipment	7,821,500	0.2184	1,708,216
Start-up costs	4,738,641	0.2184	1,034,919
Operating costs	11,725,853		11,725,853
Administrative costs	1,469,576		1,469,576
Total			16,824,618
Fee_c	16, 824,618	÷ 5,200,000	= 3.24

when i = 0.06

Cost class	Cost ($)	Amortization factor for i = 0.06	Annualized cost ($) (column 2)×(column 3)
Capital Costs			
1. Land	2,672,970	0.06	160,378
2. Buildings	12,027,834	0.087	1,046,422
3. Equipment	7,821,500	0.2374	1,856,824
Start-up costs	4,738,641	0.2374	1,124,953
Operating costs	11,725,853		11,725,853
Administrative costs	1,469,576		1,469,576
Total			17,384,006
Fee_c	17,384,006	÷ 5,200,000	= 3.34

TABLE 107. f_c - OPTION V, ALTERNATE B

when i = 0.03

Cost class	Cost ($)	Amortization factor for i = 0.03	Annualized cost ($) (column 2)×(column 3)
Capital Costs			
1. Land	2,997,290	0.03	89,919
2. Buildings	13,330,420	0.067	893,138
3. Equipment	8,831,100	0.2184	1,928,712
Start-up costs	5,135,223	0.2184	1,121,533
Operating costs	12,788,409		12,788,409
Administrative costs	1,547,608		1,547,608
Total			18,369,319
Fee_c	18,369,319 ÷	5,700,000 =	3.22

when i = 0.06

Cost class	Cost ($)	Amortization factor for i = 0.06	Annualized cost ($) (column 2)×(column 3)
Capital costs			
1. Land	2,997,290	0.06	179,837
2. Buildings	13,330,420	0.087	1,159,747
3. Equipment	8,831,100	0.2374	2,096,503
Start-up costs	5,135,223	0.2374	1,219,102
Operating costs	12,788,409		12,788,409
Administrative costs	1,547,608		1,547,608
Total			18,991,206
Fee_c	18,991,206 ÷	5,700,000 =	3.33

COST CALCULATIONS FOR RANDOM INSPECTION IN RURAL AREAS

Random pullover emission testing would be conducted by the State Patrol in mobile vans with two inspectors and one patrolman per team. Based on currently-reported pullover rates from the safety inspection program, a throughput of eight vehicles per hour per van was arrived at, or 16,640 inspections per van per year. Inspection of one-quarter of the rural vehicle population annually has been decided as the desirable goal. Then,

$$3,839,700 \times 0.25 = 959,900$$

$$3,291,800 \times 0.25 = 822,900$$

vehicles would have to be inspected annually for the 12- and 18-county urban area alternatives, respectively. Dividing these figures by the annual throughput per van yields the number of vans required. Assuming that an additional 15 percent of this total will actually be needed as a result of equipment breakdowns, repair, and maintenance, Table 108 shows the total number of vans required for each alternative.

TABLE 108. MOBILE INSPECTION VANS REQUIRED, STATE PATROL RANDOM PULLOVER PROGRAM

Urban area alternative	Number of vans required
12-County	58 + 9 = 67
18-County	49 + 8 = 57

Capital Costs

The cost of a fully equipped inspection van has been estimated at \$11,500. There would be a need for approximately one extra analyzer for every three vans to account for equipment failure and repair. Given the basic unit costs for analyzers as \$3,000 each, the total capital costs would be as shown in Table 109.

TABLE 109. CAPITAL COSTS, STATE PATROL RANDOM PULLOVER PROGRAM

Cost element	12-County urban alternative	18-County urban alternative
Inspection vans	\$770,000	\$655,500
Extra analyzers	\$ 57,000	\$ 48,000
Total capital cost	\$827,500	\$703,500

Annual Costs

One state patrolman and two inspectors are required for each van. The annual salary plus benefits for each van totals \$37,300. Estimates made for annual operating costs for each van are as follows:

Gasoline and oil	\$1,500
Insurance	\$ 500
Calibration gases	\$ 200
	\$2,200

Based on experiences in similar programs, it can be assumed that equipment repair costs will be 20 percent of the original purchase price annually. Then Annual Operating Costs will be as shown in Table 110.

TABLE 110. ANNUAL OPERATING COSTS, STATE PATROL RANDOM PULLOVER PROGRAM

Cost element	12-County urban alternative	18-County urban alternative
Inspection personnel	\$2,499,100	\$2,126,100
Van operation	\$ 127,600	\$ 107,800
Equipment repair	\$ 165,500	\$ 140,700
Total annual cost	\$2,792,200	\$2,374,600

The potential increases in costs for the Ohio State Highway Patrol to administer this program were not estimated. It is possible that given that the safety pullover program already exists, some of the administrative tasks could be combined with it, lowering the net cost of adding I/M testing to the safety inspections. However, what is contemplated under this option, and similarly in Option VI, is an expansion of the already existing program for random safety inspection. This program expansion would approximately double the number of inspection teams, although this is a conservative estimate because it does not include the number of vehicles that would continue in urban areas performing only safety inspections. A more likely scenario would be a statewide random emission and safety program in which the urban safety/emission test would be a quality assurance procedure, while in rural areas the random inspection would constitute the primary testing procedure. Given the number of uncertain variables and lack of data, it was then not possible to estimate any additional administrative costs for the random inspection program in rural areas.

Random Pullover Program Manpower Requirements

To determine the manpower requirements given the number of actual inspection teams and vans needed to reach a 25 percent pullover rate, an 85 percent manpower efficiency factor was utilized to account for sickness and turnover. This is the standard rate used throughout this report. The following calculations are made to arrive at the manpower needs:

12-County $2 \times 58 \times 1.15 \doteq 134$ Inspectors

Alternate $1 \times 58 \times 1.15 = 67$ Highway Patrolmen

18-County $2 \times 49 \times 1.15 = 114$ Inspectors

Alternate $1 \times 49 \times 1.15 = 66$ Highway Patrolmen

This does not include the need for additional administrative or supervisory personnel if they should be required. It was not possible within the scope of this study, to determine these needs.

Manpower Requirements

Manpower requirements for this option will consist of all the requirements presented previously for Option III plus additional personnel for the random pullover program in rural areas, to be supervised by the Ohio Highway Patrol. The resulting organizational network is shown in Figure 11. The following Table 111 lists total state and contractor manpower allocations.

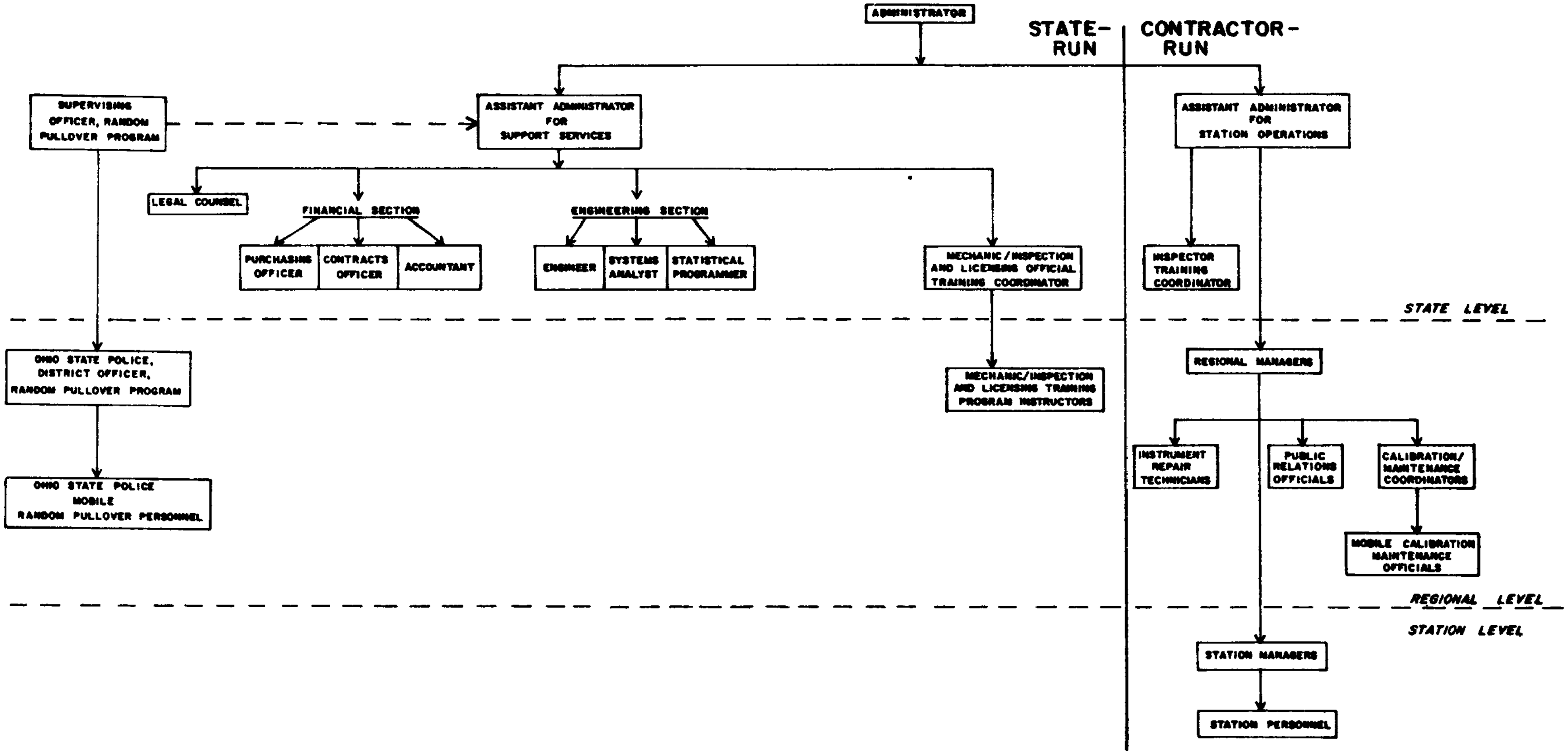

Figure 11. Administrative organization, Option V.

TABLE 111. MANPOWER REQUIREMENTS FOR OPTION V

State Administrative Personnel

1 Administrator
1 Assistant Administrator for Supporting Services
1 Legal Counsel
1 Purchasing Officer
1 Contracts Officer
1 Accountant
1 Engineer
1 Systems Analyst
1 Statistician/Programmer
1 Mechanic Training Coordinator

Contractor State Personnel

1 Assistant Administrator for Station Operations
1 Inspector Training Coordinator

Contractor Regional Personnel

Number		
Alternate A	Alternate B	
5	5	Regional Managers
5	5	Instrument Repair Technicians
5	5	Public Relations Officials
5	5	Calibration and Maintenance Coordinators
12	14	Mobile Calibration and Maintenance Officials
Contractor Local Personnel		
35	41	Station Managers
35	41	Station Assistant Managers
498	522	Station Inspectors
12	14	Station Maintenance Personnel
State Patrol Regional Personnel		
1	1	Supervising Officer, Random Pullover Program
State Patrol Regional		
10	10	District Officers, Random Pullover Program
67	66	State Troopers } in mobile vans
134	114	Inspectors } in mobile vans

SECTION 9

OPTION VI
- STATEWIDE COVERAGE
- STATE ADMINISTERS CENTRALIZED LANES IN URBAN AREAS
- RANDOM ROADSIDE PULLOVERS IN RURAL AREAS

  ALTERNATE A - 12 URBAN COUNTIES

  ALTERNATE B - 18 URBAN COUNTIES

OPTION DEFINITION

This option involves the Ohio State Government establishing a network of centralized idle mode test lanes in either 12 Urban Counties (Alternate A) or 18 Urban Counties (Alternate B). In the remaining rural counties, inspection will be conducted by the Ohio State Highway Patrol in a random pullover program, in conjunction with their random safety inspection program. A description of this program is in the preceeding Section 8. The Ohio Environmental Protection Agency and the Bureau of Motor Vehicles are the Administrative Agencies. Ohio EPA would direct the overall program including purchasing land and equipment, building and operating the test facilities, designing the program, training personnel, providing public information, data handling and analysis, and all other program elements except enforcement. The Bureau of Motor Vehicles would be primarily responsible for enforcement in this option. In Section 16 there is a dicsussion of the sticker-ticketing method of enforcement.

Network Requirements

The basic network requirements for centralized lanes in the urban areas have been derived previously in detail in Section 4. Again, the following number of inspections were derived for 1987 assuming a 30 percent stringency factor.

1987 Total Inspections

- Alternate A (12 County) 7,436,000
- Alternate B (18 County) 8,148,300

Next, the number of centralized lanes needed for both alternates were derived in Section 4 which were:

1987 Centralized Lane Requirements

- Alternate A (12 County) 166 lanes
- Alternate B (18 County) 184 lanes

Finally the actual inspection network in terms of the approximate locations and station size were computed. The networks are, again, the same as in the previous options, and are shown in Tables 112 and 113.

Option Costs

In Option VI the costs for the centralized facilities are exactly the same as in Option IV, Section 7. The approach here will be to summarize the major cost categories for the centralized facilities. The cost of the roadside random inspection will be discussed at the end of Section 9.

Initial Capital Costs

The initial capital costs for land, land improvements, buildings, test equipment, central computer, maintenance/calibration vans, and security systems are the same for Option VI as those discussed for Option IV in Section 7. For convenience they are again provided in Table 114.

TABLE 114. CAPITAL COSTS FOR OPTION VI

Item	Alternate A	Alternate B
Land investment (includes employments	$ 2,672,970	$ 2,997,290
Building investment	12,027,834	13,330,420
Test equipment	7,365,000	8,340,000
Control computer	250,000	250,000
Maintenance/calibration vans	168,000	196,000
Security systems	38,500	45,000
	$22,522,304	$25,158,810

One Time Start-Up Costs

The initial expenditures for land acquisition, facilities planning, data software development, program design, test and administrative personnel salaries and overhead, initial public relations program, and personnel training are exactly the same as those presented for Option IV Section 7. For convenience, a summary of the total start-up costs for Option VI is presented in Table 115.

Annual Operating Costs

The annual costs for facility personnel salaries and overhead, equipment repair, replacement and preventive maintenance, utilities, insurance, calibration, uniforms and security are identical to Option V. In Option VI, unlike Option V however, there would be no requirement to pay taxes. This reflects a different figure for the cost category "Utilities, Supplies, and Services." The cost for the category is provided in Table 116.

TABLE 112. INSPECTION NETWORK REQUIREMENTS FOR OPTION IV - ALTERNATE A, 12 COUNTY

County	Town	Number of facilities	Configuration
Butler	Hamilton	1	3 lanes
	Middletown	1	3 lanes
Cuyahoga	Cleveland	6	6 lanes
	Cleveland	1	3 lanes
Franklin	Columbus	3	6 lanes
	Columbus	1	3 lanes
Hamilton	Cincinnati	3	6 lanes
	Norwood	1	3 lanes
Lake	Mentor on the Lake	1	3 lanes
	Painsville	1	3 lanes
Lorain	Lorain	1	4 lanes
	Elyria	1	3 lanes
Lucas	Toledo	2	6 lanes
Mahoning	Youngstown	1	6 lanes
	Englewood	1	3 lanes
Montgomery	Dayton	2	6 lanes
Stark	Canton	1	6 lanes
	Alliance	1	4 lanes
Summit	Akron	2	6 lanes
	Cuyahoga Falls	1	2 lanes
Trumbull	Warren	1	4 lanes
	Niles	1	3 lanes
Total Network		35	166 lanes

TABLE 113. INSPECTION NETWORK REQUIREMENTS FOR OPTION IV - ALTERNATE B, 18 COUNTY

County	Town	Number of facilities	Configuration
Butler	Hamilton	1	3 lanes
	Middletown	1	3 lanes
Clermont	Batavia	1	3 lanes
Cuyohoga	Cleveland	6	6 lanes
	Cleveland	1	3 lanes
Franklin	Columbus	3	6 lanes
	Columbus	1	3 lanes
Geauga	Chardon	1	2 lanes
Green	Fairborn	1	4 lanes
Hamilton	Cincinnati	3	6 lanes
	Norwood	1	3 lanes
Lake	Mentor on the Lake	1	3 lanes
	Painsville	1	3 lanes
Lorain	Lorain	1	4 lanes
	Elyria	1	3 lanes
Lucas	Toledo	2	6 lanes
Mahoning	Youngstown	1	6 lanes
	Ellsworth	1	2 lanes
Medina	Medina	1	3 lanes
Montgomery	Dayton	2	6 lanes
	Englewood	1	3 lanes
Stark	Canton	1	6 lanes
	Alliance	1	4 lanes
Summit	Akron	2	6 lanes
	Cuyohoga Falls	1	2 lanes
Trumbull	Warren	1	4 lanes
	Niles	1	3 lanes
Warren	Lebanon	1	3 lanes
Wood	Bowling Green	1	3 lanes
Total Network		41	184 lanes

TABLE 115. START-UP COSTS FOR OPTION VI

Item	Alternate A	Alternate B
Land acquisition	$ 377,529	$ 435,122
Facilities planning	1,202,783	1,333,042
Data handling software	200,000	200,000
Program design	100,000	100,000
Test personnel salaries + overhead	1,094,375	1,224,273
Administrative salaries + overhead	1,421,940	1,421,940
Initial public relations program	900,000	978,000
Personnel training	10,790	11.622
	5,307,417	5,703,999

TABLE 116. ANNUAL COST FOR UTILITIES, SERVICES, SUPPLIES OPTION IV ALTERNATE A

	Alternate A	Alternate B
Utilities	$ 391,188	$ 442,563
Insurance	249,000	276,000
Computer operation and forms	1,338,475	1,466,690
Calibration	105,600	123,200
Uniforms	72,500	81,000
Security	29,750	34,850
	$ 2,186,513	$ 2,424,303

Annual Administrative Costs

Annual costs for program administrative personnel salaries and overhead, public information, and personnel training are the same for Option VI as were previously discussed in Option IV.

The Annual Administrative costs are summarized in Table 117.

TABLE 117. ANNUAL ADMINISTRATIVE COSTS FOR OPTION VI

Item	Alternate A	Alternate B
Program administrative salaries and overhead	$ 568,776	$ 568,776
Public information	900,000	978,000
Inspector training	800	832
	1,469,576	1,547,608

SUMMARY

The total costs of Option VI are summarized in Tables 118 and 119.

Initial capital costs and one-time start-up costs are converted to annual figures using the amortization factors discussed in Section 3. These annualized costs are added to annual operating costs and annual administrative costs to arrive at total annual costs in constant 1978 dollars.

A uniform fee in constant dollars (f_c) was calculated by dividing the annual costs by the average annual vehicle registrations for the period 1981 to 1987 (5,200,000 for Alternate A and 5,700,000 for Alternate B). This assumes a free retest. These calculations are recorded in Tables 120 and 121.

COST CALCULATIONS FOR RANDOM INSPECTION IN RURAL AREAS

The random pullover emission testing would be conducted by the State Patrol in mobile vans with two inspectors and one patrolman per team.

Based on currently reported pullover rates from the safety inspection program, a throughput of 8 vehicles/hr/van can be assumed, or 16,640 inspections/van/yr. Inspection of one-quarter of the rural vehicle population annually has been decided as the desirable goal. Then

$3,839,700 \times 0.25 = 959,900$

$3,291,800 \times 0.25 = 822,900$

Vehicles would have to be inspected annually for the 12- and 18-county urban area alternatives, respectively. Dividing these figures by the annual throughput per van gives the number of vans required.

Assuming that an additional 15 percent of this total will actually be needed as a result of equipment breakdowns, repair, and maintenance, Table 122 shows the total number of vans required for each alternate.

TABLE 118. COST SUMMARY OPTION VI ALTERNATE A

Primary category	Principal element	Element cost ($)	Total category cost ($)
Initial capital costs	1. Land investment	2,672,970	
	2. Building investment	12,027,834	
	3. Equipment costs (includes, vans, computer, security system)	$ 7,821,500	
			$22,522,304
One time start-up costs	1. Land acquisition	377,529	
	2. Facilities planning	1,202,783	
	3. Program design	100,000	
	4. Development of data handling System services	200,000	
	5. Personnel training	10,790	
	6. Personnel salaries and overhead	2,516,315	
	7. Initial public information program	900,000	
			$ 5,307,417
Annual operating costs	1. Facility personnel	7,007,500	
	2. Maintenance	1,473,000	
	3. Utilities, services, supplies	2,186,513	
			$10,667,013
Annual administrative costs	1. Program administrative salaries	568,776	
	2. Public information	900,000	
	3. Training	800	
			$ 1,469,576

TABLE 119. COST SUMMARY OPTION VI ALTERNATE B

Primary category	Principal element	Element cost ($)	Total category cost ($)
Initial capital costs	1. Land investment	$ 2,997,290	
	2. Building investment	13,330,420	
	3. Equipment costs (includes, vans, computer, security systems)	8,831,100	
			$25,158,810
One time start-up costs	1. Land acquisition	435,122	
	2. Facilities planning	1,333,042	
	3. Program design	100,000	
	4. Development of data handling System services	200,000	
	5. Personnel training	11,622	
	6. Personnel salaries and overhead	2,646,213	
	7. Initial public information program	978,000	
			$ 5,703,999
Annual operating costs	1. Facility personnel	7,517,500	
	2. Maintenance	1,668,000	
	3. Utilities, services, supplies	2,424,303	
			$11,609,803
Annual administrative costs	1. Program administrative salaries	568,766	
	2. Public information	978,000	
	3. Training	832	
			$ 1,547,608

TABLE 120. f_c OPTION VI, ALTERNATE A

when i = 0.03

	Cost class	Cost ($)	Amortization factor for i = 0.03	Annualized cost ($) (column 2)x(column 3)
I.	Capital Costs			
	1. Land	2,672,970	0.03	80,189
	2. Buildings	12,027,834	0.067	805,865
	3. Equipment	7,821,500	0.2184	1,708,216
II.	Startup Costs	5,307,417	0.2184	1,159,140
III.	Operating Costs	10,667,013		10,667,013
IV.	Administrative Costs	1,467,576		1,469,576
	Total			15,889,999
	Fee_c	15,889,999 ÷	5,200,000	3.06

when i = 0.06

	Cost Class	Cost ($)	Amortization factor for i = 0.06	Annualized cost ($) (column 2)x(column 3)
I.	Capital costs			
	1. Land	2,672,970	0.06	160,378
	2. Buildings	12,027,834	0.087	1,046,422
	3. Equipment	7,821,500	0.2374	1,856,824
II.	Startup costs	5,307,417	0.2374	1,259,981
III.	Operating costs	10,667,013		10,667,013
IV.	Administrative costs	1,469,576		1,469,576
	Total			16,460,194
	Fee_c	16,460,194 ÷	5,200,000	3.20

TABLE 121. f_c OPTION VI, ALTERNATE B

	Cost class	Cost ($)	Amortization factor for i = 0.03	Annualized cost ($) (column 2)x(column 3)
	when i = 0.03			
I.	Capital Costs			
	1. Land	2,997,290	0.03	89,919
	2. Buildings	13,330,420	0.067	893,138
	3. Equipment	8,831,100	0.2184	1,928,712
II.	Startup costs	5,703,999	0.2184	1,245,753
III.	Operating costs	11,609,803		11,609,803
IV.	Administrative costs	1,547,608		1,547,608
	Total			17,314,933
	Fee_c	17,314,933 ÷	5,700,000	= 3.04

	Cost class	Cost ($)	Amortization factor for i = 0.06	Annualized cost ($) (column 2)x(column 3)
	when i = 0.06			
I.	Capital costs			
	1. Land	2,997,290	0.06	179,837
	2. Buildings	13,330,420	0.087	1,159,747
	3. Equipment	8,831,100	0.2374	2,096,503
II.	Startup costs	5,703,999	0.2374	1,354,129
III.	Operating costs	11,609,803		11,609,803
IV.	Administrative costs	1,547,608		1,547,608
	Total			17,947,627
	Fee_c	17,947,627 ÷	5,700,000	= 3.15

TABLE 122. MOBILE INSPECTION VANS REQUIRED, STATE PATROL RANDOM PULLOVER PROGRAM

Urban area alternative	Number of vans required
12-County	58 + 9 = 67
18-County	49 + 8 = 57

Capital Costs

The cost of a fully equipped inspection van has been estimated at $11,500. There would be a need for approximately one extra analyzer for every three vans in order to account for equipment failure and repair. Given the basic unit cost for analyzers as $3,000 apiece, the total capital costs would be as shown in Table 123.

TABLE 123. CAPITAL COSTS, STATE PATROL RANDOM PULLOVER PROGRAM

Cost element	12-County urban alternative	18-County urban alternative
Inspection vans	$770,500	$655,500
Extra analyzers	$ 57,000	$ 48,000
Total capital cost	$827,500	$703,500

Annual Costs

One state patrolman and two inspectors are required for each van. The annual salary plus benefits for each van totals $37,300. Estimates made for annual operating costs for each van are as follows:

Gasoline and oil	$1,500
Insurance	$ 500
Calibration gases	$ 200
	$2,200

Based on experiences in similar programs, it can be assumed that equipment repair costs will be 20 percent of the original purchase price annually. Then Annual Operating Costs will be as shown in Table 124.

TABLE 124. ANNUAL OPERATING COSTS, STATE PATROL RANDOM PULLOVER PROGRAM

Cost element	12-County urban alternative	18-County urban alternative
Inspection personnel	$2,499,100	$2,126,100
Van operation	$ 127,600	$ 107,800
Equipment repair	$ 165,500	$ 140,700
Total Annual Cost	$2,792,200	$2,374,600

The potential increases in costs for the Ohio State Highway Patrol to administer this program were not estimated. It is possible that given a program already in existence, some of the administrative tasks would be absorbed into the system. However, what is contemplated under this option, and similarly in Optio VI, is an expansion of the already existing program for random safety inspection. This program expansion would be about a doubling of the number of inspection teams, although this is a conservative estimate because this does not include the number of vehicles that would continue during safety inspection in urban areas. A more likely scenario would be a statewide random emission and safety program in which the urban safety/emission test would be a quality assurance procedure, while in rural areas the random inspection would not be a quality assurance procedure but rather a primary testing procedure. Given the number of uncertain variables and lack of data, it was, then, not possible to estimate any additional administrative costs for the random inspection program in rural areas.

Random Pullover Program Manpower Requirements

To determine the manpower equirements give the number of actual inspection teams and vans needed to reach a 25 percent pullover rate, a 15 percent manpower efficiency factor was utilized to account for sickness and turnover. This is the standard rate used throughout this report. The following calculations are made to arrive at the manpower needs:

12-County $2 \times 58 \times 1.15 = 134$ Inspectors

Alternative $1 \times 58 \times 1.15 = 67$ Highway Patrolmen

18-County $2 \times 49 \times 1.15 = 114$ Inspectors

Alternative $1 \times 49 \times 1.15 = 66$ Highway Patrolmen

This would not include the need for additional administrative or supervisory personnel if they would be needed. It was not possible in this study to determine these needs.

Manpower Requirements

The manpower requirements for this option are exactly the same as for Option V, the only difference being that the state assumes all functions previously performed by the contractor. Figure 12 shows the resulting administrative organization. Table 125 lists total state manpower allocations.

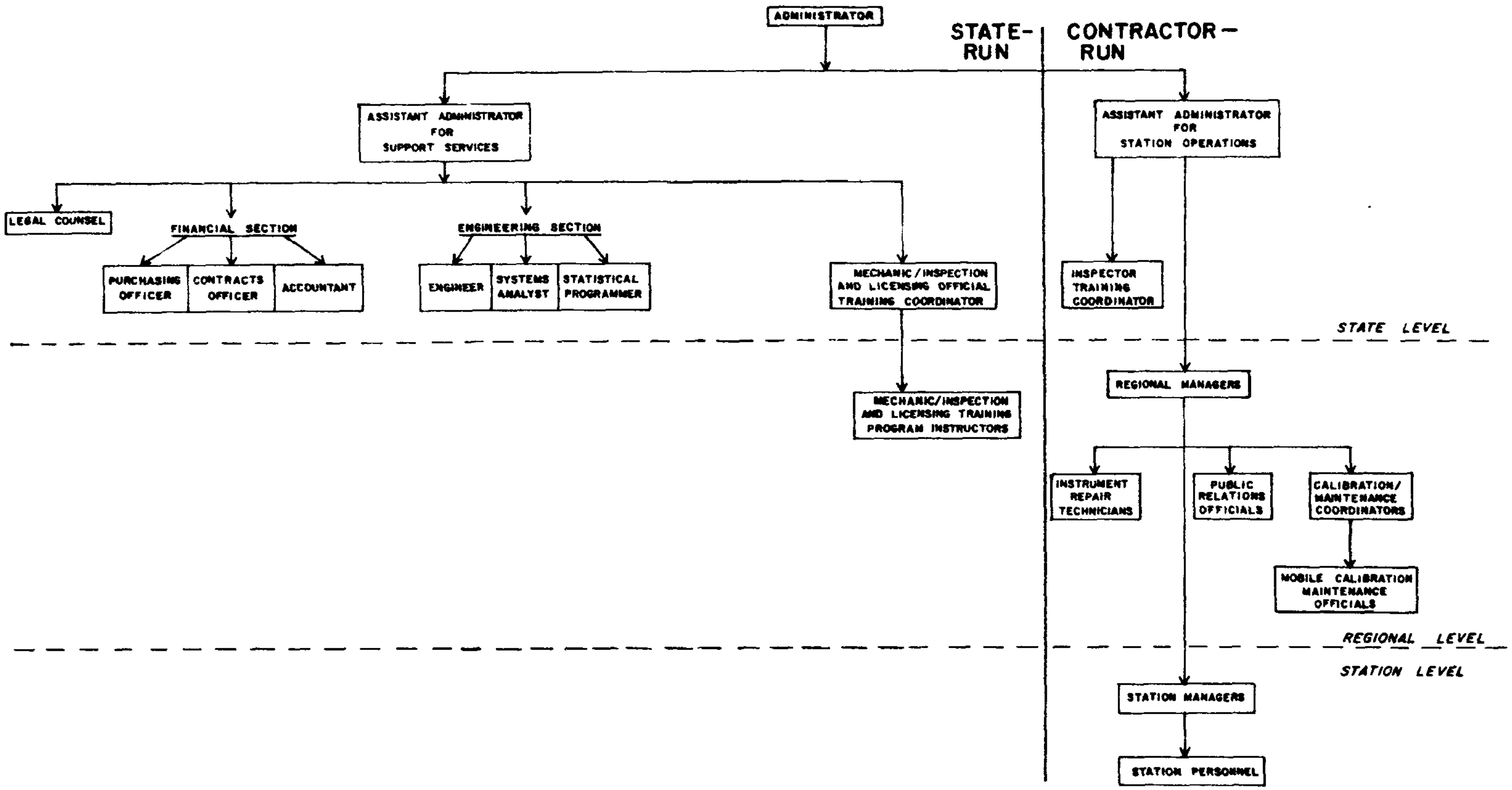

Figure 12. Administrative organization, Option VI.

TABLE 125. MANPOWER REQUIREMENTS FOR OPTION VI

State Administrative Personnel

1 Administrator
1 Assistant Administrator for Supporting Services
1 Legal Counsel
1 Purchasing Officer
1 Contracts Officer
1 Accountant
1 Engineer
1 Systems Analyst
1 Statistician/Programmer
1 Mechanic Training Program Coordinator
1 Assistant Administrator for Station Operation
1 Inspector Training Coordinator

State Regional Personnel

5 Regional Managers
5 Instrument Repair Technicians
5 Public Relations Officials
5 Calibration/Maintenance Coordinators

Number		
Alternate A	Alternate B	
12	14	Mobile Calibration and Maintenance Officials
State Local Personnel		
35	41	Station Managers
35	41	Station Assistant Managers
498	522	Station Inspectors
12	14	Station Maintenance Personnel
Ohio State Patrol - State Personnel		
1	1	Supervising Officer, Random Pullover Program
Ohio State Patrol - Regional Personnel		
10	10	District Officers, Random Pullover Program
67	66	State Troopers } in mobile vans
134	114	Inspectors } in mobile vans

SECTION 10

OPTION VII - • STATEWIDE COVERAGE

• PRIVATE GARAGE TESTING IN URBAN AND RURAL AREAS

• STATE OR CONTRACTOR CONDUCTS SURVEILLANCE/QUALITY CONTROL OF GARAGES

OPTION DEFINITION

In Option VII the state government would establish a decentralized network of licensed private stations to conduct emissions inspection in participating private garages, new car dealers, and service stations. The Ohio Environmental Protection Agency and the Bureau of Motor Vehicles would be the administrative agencies. Ohio EPA would be responsible for program design, licensing, mechanic/ inspector training, surveillance, quality control, building and running referee stations, and overall program administration. The issue of having the state versus a private contractor conduct the surveillance of private garages is discussed in Section 17. The Bureau of Motor Vehicles is primarily responsible for enforcement function under the motor vehicle registration enforcement approach. The issue of sticker/ticketing as an alternative approach is discussed in Section 16.

Network Requirements

In establishing network requirements for a completely decentralized system of private inspection stations statewide, the vehicle population to be tested was estimated using the same assumptions as those used for the previous six options, as described in Section 4, Option I.

Assuming a steady 3 percent per year growth rate in vehicle registrations, the 1978 vehicle population will be divided between urban and rural areas as shown in Table 126.

TABLE 126. VEHICLE REGISTRATIONS IN URBAN AND RURAL AREAS, 1987

Location	Number of registrations	
	12-county urban alternative	18-county urban alternative
Urban	5,720,000	6,267,900
Rural	3,839,700	3,291,800
Statewide	9,559,700	9,559,700

Making the same assumption about test stringency in rural areas as in urban, 30 percent more inspections than actual registrations will be required, as shown in Table 127.

TABLE 127. VEHICLE INSPECTIONS REQUIRED IN URBAN AND RURAL AREAS, 1987

Location	Number of inspections required	
	12-county urban alternative	18-county urban alternative
Urban	7,436,000	8,148,300
Rural	4,991,600	4,279,300
Statewide	12,427,600	12,427,600

There are thousands of private garages in Ohio that could potentially serve as motor vehicle emissions inspection stations. Rather than arbitrarily choose an "optimum" number of these stations to comprise an I/M network, we have derived minimum and maximum levels of private garage participation in such a network by making certain assumptions about private garage performance and profitability. Somewhere in the range of participation between these minimum and maximum levels is the level at which a network of private garages can reasonably be expected to operate; the average of the minimum and maximum levels, the "mid" level, has been chosen for analysis as one such participation level.

Minimum Statewide Private Garage Network--

Recalling the formula

$$G = \frac{I}{DN}$$

as used in the network derivations for Options I and II, and using the same assumptions about maximum private garage throughput as in those options (5,250 inspections per year, or 21 vehicles per day), the minimum network required to handle the entire statewide light-duty vehicle population is:

$$G = \frac{I}{DN} = \frac{12,427,600}{(250)(21)} = 2,367 \text{ garages.}$$

Table 128 shows the number of garages, service area radius, and market participation rate associated with this minimum network.

TABLE 128. NUMBER OF GARAGES, SERVICE AREA RADIUS AND MARKET PARTICIPATION RATE, MINIMUM STATEWIDE PRIVATE GARAGE NETWORK

Number of garages	Service area radius, miles	Market participation rate, percent
2,367	2.35	20.6

Table 129 shows the minimum private garage participation required in each of the 18 urban counties, as well as the corresponding market participation rate and service area radius for each.

Maximum Statewide Private Garage Network--

Recalling the cost-revenue discussion used in the derivation of the maximum private garage network for Options I and II, and making the same assumptions about the cost factors in the equation:

$$M(C-F) = A + S + L + O$$

a maximum statewide private garage network can be derived, as shown in Table 130.

A reasonable combination of wages and hours would be a wage rate of \$5.50 per hour and a 4-hour inspection work day; a break-even throughput of 1,819 vehicles per station per year results. Table 131 shows the number of garages, service area radius, and market participation rate associated with this maximum statewide network.

Table 132 shows the maximum private garage participation feasible in each of the 18 urban counties, as well as the corresponding market participation rate and service area radius for each.

Taking the average of the above-derived minimum and maximum participation levels yields what will be referred to as the "mid" level in the cost analysis of this option. Information concerning this "mid" level of participation is summarized in Table 133.

TABLE 129. MINIMUM URBAN PRIVATE GARAGE PARTICIPATION, OPTION VII

County	Inspections required	Number of garages	Market participation rate, percent	Service area radius, miles
Butler	270,500	52	20.6	1.70
Cuyahoga	1,775,900	338	25.5	0.66
Franklin	968,100	184	23.6	0.97
Hamilton	947,700	181	21.8	0.85
Lake	248,000	47	23.4	1.25
Lorain	318,400	61	23.9	1.61
Lucas	541,800	103	22.9	1.03
Mahoning	343,600	65	19.8	1.43
Montgomery	680,700	130	22.8	1.06
Stark	428,700	82	19.8	1.50
Summit	619,400	118	20.5	1.05
Trumbull	293,200	56	22.1	1.86
12-county total	7,436,000	1,416	20.7	1.10
Clermont	132,800	25	20.7	2.41
Geauga	84,900	16	26.7	2.85
Greene	150,600	29	24.2	2.13
Medina	122,700	23	20.5	2.43
Warren	106,300	20	22.0	2.55
Wood	115,000	22	18.6	2.99
18-county total	8,148,300	1,552	22.6	1.29

TABLE 130.. MAXIMUM PRIVATE GARAGE PARTICIPATION (NUMBER OF GARAGES), STATEWIDE PRIVATE GARAGE NETWORK

Hours per day spent on inspections	Hourly wage of inspectors		
	$4.50	$5.50	$6.50
1	18,278*	16,014*	14,247*
2	11,168	9,522	8,291
3	8,040	6,771	5,847
4	6,282	5,255	4,515
5	5,154	4,295	3,678
6	4,369	3,629	3,103
7	3,792	3,143	2,683
8	3,349	2,772	2,363

*The number of garages indicated here exceeds the total number of garages statewide; this combination of hours and wages is therefore not feasible.

TABLE 131. NUMBER OF GARAGES, SERVICE AREA RADIUS, AND MARKET PARTICIPATION RATE, MAXIMUM STATEWIDE PRIVATE GARAGE NETWORK

Number of garages	Service area radius, miles	Market participation rate, percent
5,255	1.58	45.7

TABLE 132. MAXIMUM URBAN PRIVATE GARAGE PARTICIPATION, OPTION VII

County	Inspections required	Number of garages	Market participation rate, percent	Service area radius, miles
Butler	270,500	115	45.6	1.14
Cuyahoga	1,775,900	751	56.7	0.44
Franklin	968,100	409	52.5	0.65
Hamilton	947,700	401	48.3	0.57
Lake	248,000	103	51.2	0.84
Lorain	318,400	135	52.9	1.08
Lucas	514,800	229	49.8	0.69
Mahoning	343.600	145	44.2	0.95
Montgomery	680,700	288	50.6	0.71
Stark	428,700	182	43.9	1.00
Summit	619,400	262	45.6	0.70
Trumbull	293,200	124	49.0	1.25
12-county total	7,436,000	3,144	50.4	0.74
Clermont	132,800	56	46.3	1.61
Geauga	84,900	36	27.8	1.90
Greene	150,600	64	53.3	1.42
Medina	122,700	52	46.4	1.59
Warren	106,300	45	49.5	1.73
Wood	115,000	48	40.7	1.64
18-county total	8,148,300	3,445	50.2	0.87

TABLE 133. PRIVATE GARAGES STATEWIDE MID PARTICIPATION LEVEL

Number of garages	Service area radius, miles	Market participation rate, percent
3,811	1.85	33.1

Option Costs

The costs associated with the implementation and operation of this option are presented here. Reference should be made to the discussion in Section 3 concerning the analytical techniques used.

Capital Costs

Referee Lanes--

Under Option VII, motorists whose vehicles fail inspection twice in private garages would be given the opportunity to have their vehicles inspected free in a state-owned and operated facility. These state facilities, or "referee lanes," would also investigate allegations of unnecessary or overpriced maintenance, and grant waivers for those vehicles exempted from inspection for various reasons (age, excessive repair costs, etc.). The inspection performed in a referee station would be more complete than the simple idle-mode inspection described for the other options. It would include a loaded-mode emissions test, an under-hood inspection of emissions equipment, and a diagnostic engine analysis. Based on a 30-minute throughput and a 0.67 efficiency factor, each station would be able to perform approximately 3,000 inspections per year. When compared with the throughput for a similar facility in another state, this throughput is adequate to handle demand from a vehicle population of approximately 1 million vehicles. Thus, for Option VII, a network of 12 such referee lanes, one in each of the counties having a population of 200,000 or greater, would be more than adequate to meet statewide demand for the services of such facilities; locating referee lanes in rural areas would not prove cost-effective from a program standpoint.

Capital costs for one referee lane are shown in Table 134. The assumptions made in deriving these costs are the same as those for state-owned facilities in the other options.

TABLE 134. CAPITAL COSTS FOR REFEREE LANE FACILITIES, OPTION VII

Cost element	Purchase price
Building	$102,000
Land	$ 17,066
Equipment:	
Diagnostic engine analyzer	$ 8,000
Chassis dynamometer	$ 14,000
Miscellaneous tools and supplies	$ 2,000
Total	$143,066

The total referee lane investment, then, is:

$$12 \times \$143,066 = \$1,716,792.$$

Inspection and Licensing Vans--

Based on discussions with manufacturers of vans and equipment, the purchase price of a fully-equipped state inspection and licensing van is $14,000. These vans will be used by inspection and licensing officials to review and evaluate applications of those private garages wishing to join an I/M program, as well as to perform monthly calibrations of the analyzers in garages already participating in an I/M network. They will contain two calibrated analyzers, one to be used as a spare in case of equipment failure. The total van investment by the state is dependent on the number of garages participating in an I/M program. Making the same assumptions as those discussed for Options I and II, one van will be required for every 70 private garages, plus an additional percentage of the total (15 percent) to replace those vans which break down or require scheduled maintenance. Table 135 shows the number of vans needed to service the minimum, mid, and maximum private garage networks derived previously, and their purchase prices.

TABLE 135. STATE INSPECTION AND LICENSING VANS REQUIRED, OPTION VII

Level of participation, private garage network	Number of garages	Number of vans required	Purchase price
Minimum	2,367	39	$546,000
Mid	3,811	63	$882,000
Maximum	5,255	86	$1,204,000

Complaints Investigation Vehicles--

Based on discussions with manufacturers, the purchase price of a complaint investigation vehicle is $5,000. These automobiles will be used by complaints investigation personnel in the performance of their duties. Table 136 shows the number of such vehicles required, and their purchase price to service the minimum, mid, and maximum levels of private garage participation derived previously, using the assumption of one vehicle required for every 100 garages in the private network and adding an additional 15 percent to cover replacement for breakdown or scheduled maintenance.

TABLE 136. STATE COMPLAINTS INVESTIGATION VEHICLES REQUIRED, OPTION VII

Level of participation, private garage network	Number of garages	Number of vehicles required	Purchase price
Minimum	2,367	28	$140,000
Mid	3,811	44	$220,000
Maximum	5,255	61	$305,000

One-Time Start-Up Costs

Land Acquisition--
Using the same assumptions as those used in the previously discussed options, land costs are computed on the basis of $6,000 per site to cover locating, evaluating, and performing surveys, plus 10 percent of the purchase price to cover the title conveyance costs. The acquisition cost for the 12 referee land sites, then, is

(12 facilities)($6,000/facility) + (0.10)($1,716,792)

= $72,000 + $171,679 = $243,679

Facilities Planning--
Since the construction costs of the 12 referee lanes in this option are less than $3,000,000, the facilities planning cost is assumed to be 20 percent of the construction cost, as discussed in the previous options. The facilities planning cost, then, is

(0.20) x (1,224,000) = $244,800

Program Design--
As discussed in the previous options, a cost of $200,000 will be estimated for program design.

Data Handling Software--
Based on discussions with State of Ohio officials, the initial costs of establishing a computerized data handling system for the state will be $25,000 to create the necessary files and $42,000 to reload them onto magnetic tape, or a total start-up cost of $67,000.

Personnel Training--
As previously indicated, an initial, intensive training effort is required prior to program start-up. Based on discussions with states and private contractors involved in I/M program operation, the personnel requirements for referee facilities will be as follows:

- One supervisor per facility;
- One test engineer per facility;
- One inspector per facility;
- One clerk per facility; and
- One station maintenance person per facility.

Applying these rates to facility requirements developed previously, the total referee station operating personnel requirements will be:

12 supervisors
12 test engineers
14 inspectors
14 clerks
14 station maintenance persons.

As discussed previously, Option VII will also require mobile state inspection and licensing personnel and complaints investigation personnel. Costs of training all the above-mentioned personnel will be as follows:

$53.00 for referee station managers
$43.00 for complaints investigators
$43.00 for inspection and licensing officials
$16.00 for inspectors
$53.00 for test engineers

Based on the above rates, personnel training costs can be calculated. Since the numbers of some of these personnel are dependent on the number of garages in the system, personnel training costs are shown in Table 137 for the minimum, mid, and maximum private garage networks derived previously.

TABLE 137. PERSONNEL TRAINING COSTS, OPTION VII

Level of participation, private garage network	Personnel training cost
Minimum	$4,377
Mid	$6,097
Maximum	$7,817

Personnel Salaries--

Assuming that (1) all referee station supervisory personnel would be phased into the program 6 months prior to start-up; (2) inspectors, test engineers, and other referee station personnel would be phased into the program 1 month prior to start-up; and (3) the salaries for inspection station personnel mentioned previously, a total test personnel cost of $210,338 can be derived.

The administrative personnel costs must also be included in the start-up phase. These positions would be phased in 18 months prior to start-up for this option. Based on the discussion of administrative personnel requirements in Section 3, the costs associated with 18 months of start-up can be computed. Based on salary estimates obtained from the State of Ohio, then costs will be as shown in Table 138. A factor of 25 percent for administrative overhead has been included.

TABLE 138. PERSONNEL SALARIES, START-UP PHASE, OPTION VII

Level of participation, private garage network	Personnel salaries
Minimum	$1,878,511
Mid	$2,601,091
Maximum	$3,323,671

Initial Public Information Program--

As in previous options, an estimate of $0.12 per vehicle inspected will be used for the initial public information program. This translates to a cost of $1,147,164.

Annual Operating Costs

Facility Personnel--

Based on the above-discussed referee station staffing requirements and salaries, the annual referee station personnel costs are $665,774.

Maintenance--

Based on the previously-discussed estimate of 20 percent of original equipment cost for maintenance, the yearly cost of equipment repair and replacement will be:

(12 facilities) x ($24,000) x (0.20) = $57,600

Utilities/Supplies/Services

Utilities--

Based on the utility costs derived previously for electric usage, the annual cost for utilities is calculated below:

(12 lanes)(166 kWh/day)($0.05)(250 operating days/year)

+ (12 facilities)(325 kWh/day)($0.05)(250 operating days/year)

= $24,900 + $48,750 = $73,650

Insurance--

Based on the $1,500 per lane estimate derived previously, insurance on the referee lanes will cost $18,000 annually.

Computer Operation--

Central computer operation costs for a totally decentralized system for vehicle inspections must include key punching, disc storage, and tape drives. Based on discussions with State of Ohio officials, these costs are the following:

Keypunching	$340,000
Keypunch machine rental	$ 52,000
Disc storage	$450,000
Tape drives	$ 21,600
Total	$863,600

Inspection Forms--

In addition to computer operation costs, a cost of $0.03 per test has been estimated based on experience in other states. This computes to a total statewide cost of $372,828 per year.

Calibration Costs--

The recurring annual cost of equipment calibration is defined as the cost of the calibration gases plus the operating cost of the inspection and licensing vans. The total annual calibration costs for Option VII are outlined in Table 139, for the three participation levels derived previously.

TABLE 139. ANNUAL CALIBRATION COSTS FOR OPTION VII

Level of participation, private garage network	Annual calibration costs
Minimum	$343,200
Mid	$554,400
Maximum	$756,800

Taxes--

Taxes will not be paid on the referee lane facilities, as it is assumed they will be owned by the state.

Uniforms--

Based on the $125.00 per year estimate of uniform costs previously discussed, Table 140 presents annual uniform costs for the three levels of private garage participation.

TABLE 140. UNIFORM COSTS, OPTION VII

Level of participation, private garage network	Annual uniform costs
Minimum	$15,125
Mid	$20,125
Maximum	$25,125

The total annual cost for utilities, supplies, and services is shown in Table 141 for the three levels of private garage participation derived previously.

Annual Administrative Costs

Based on the personnel requirements and salaries discussed previously, annual administrative salaries will represent a cost to the state which is shown in Table 142 for the three levels of garage participation.

TABLE 141. ANNUAL COST FOR UTILITIES, SUPPLIES, AND SERVICES, OPTION VII

Cost element	Minimum network	Mid network	Maximum network
Utilities	$ 73,650	$ 73,650	$ 73,650
Insurance	$ 10,000	$ 18,000	$ 18,000
Computer operation	$ 863,600	$ 863,600	$ 863,600
Forms	$ 372,828	$ 372,828	$ 372,828
Taxes	0	0	0
Uniforms	$ 15,125	$ 20,125	$ 25,125
Total	$1,686,403	$1,902,603	$2,110,003

TABLE 142. ANNUAL STATE ADMINISTRATIVE SALARY PAYMENTS, OPTION VII

Personnel level	Level of participation, private garage network		
	Minimum	Mid	Maximum
State administrative	$ 212,936	$ 212,936	$ 212,936
Regional administrative	$ 343,888	$ 343,888	$ 343,888
Inspection and licensing personnel	$ 587,096	$ 948,386	$1,294,623
Complaints investigation personnel	$ 421,505	$ 662,365	$ 918,279
Total	$1,565,425	$2,167,035	$2,769,186

Public Information--

The annual cost of an ongoing public relations program has been estimated to be the same as the program startup cost, $1,147,164 per year.

Personnel Training--

As discussed in the other options, it is assumed that the replacement rate for employees at the inspector and investigator levels will be 10 percent per year. Assuming a training cost of $16.00 for inspectors and $43.00 for investigators, Table 143 shows annual personnel training costs for the three levels of private garage participation.

TABLE 143. ANNUAL PERSONNEL TRAINING COSTS, OPTION VII

Level of participation, private garage network	Personnel training costs
Minimum	$349
Mid	$521
Maximum	$693

Summary

The total cost of Option VII is summarized in Tables 144a, b, and c, for the three levels of private garage participation.

Motorist Inspection Fees

The total cost to the motorist for an emissions inspection in Option VII will be made up of two components: (1) a state fee, which will be called the "state sticker fee," which will be used to defray all state expenses, both for administration and equipment; and (2) a private garage charge, which will be called the "private garage fee," which will be used to defray equipment, labor and other costs incurred by the private garage in performing emissions inspections.

Sticker Fee Computation--

Initial capital costs and one-time start-up costs are converted to annual figures using the amortization factors discussed in Section 3. These annualized costs are added to annual operating costs and annual administrative costs in order to arrive at total annual costs in constant 1978 dollars. Dividing this total by the number of vehicles to be inspected (approximately 8,700,000 which is the average 1981 to 1987 vehicle population) yields the sticker fee in constant dollars, F. Tables 145a, b, and c present the calculation of F for $i = 0.03$ and $i = 0.06$ for the three participation levels defined above.

TABLE 144a. COST SUMMARY, OPTION VII, MINIMUM PRIVATE GARAGE NETWORK

Primary category	Principal element	Element cost ($)	Total category cost ($)
I. Initial capital costs	1. Referee lanes	1,716,792	
	2. Inspection and licensing vans	546,000	
	3. Complaints investigation vehicles	140,000	
			2,402,792
II. One-time start-up costs	1. Land acquisition	243,679	
	2. Facilities planning	244,800	
	3. Program design	200,000	
	4. Development of data handling system software	67,000	
	5. Personnel training	4,377	
	6. Personnel salaries plus overhead	1,878,511	
	7. Initial public information program	1,147,164	
			3,785,531
III. Annual operating costs	1. Facility personnel	665,774	
	2. Maintenance	57,600	
	3. Utilities/services/supplies	1,686,403	
			2,409,777
IV. Annual administrative costs	1. Program administrative personnel salaries plus overhead	1,565,425	
	2. Public information	1,147,164	
	3. Personnel training	349	
			2,712,938

TABLE 144b. COST SUMMARY, OPTION VII, MIDLEVEL PRIVATE GARATE NETWORK

Primary category		Principal element		Element cost ($)	Total category cost ($)
I.	Initial capital costs	1.	Referee lanes	1,716,792	
		2.	Inspection and licensing vans	882,000	
		3.	Complaints investigation vehicles	220,000	
					2,818,792
II.	One-time start-up costs	1.	Land acquisition	243,679	
		2.	Facilities planning	244,800	
		3.	Program design	200,000	
		4.	Development of data handling system software	67,000	
		5.	Personnel training	6,097	
		6.	Personnel salaries plus overhead	2,601,091	
		7.	Initial public information program	1,147,164	
					4,509,831
III.	Annual operating costs	1.	Facility personnel	665,774	
		2.	Maintenance	57,600	
		3.	Utilities/services/supplies	1,902,603	
					2,625,977
IV.	Annual administrative costs	1.	Program administrative personnel salaries plus overhead	2,167,035	
		2.	Public information	1,147,164	
		3.	Personnel training	521	
					3,314,720

TABLE 144c. COST SUMMARY, OPTION VII, MAXIMUM PRIVATE GARAGE NETWORK

Primary category	Principal element	Element cost ($)	Total category cost ($)
I. Initial capital costs	1. Referee lanes	1,716,792	
	2. Inspection and licensing vans	1,204,000	
	3. Complaints investigation vehicles	305,000	
			3,225,792
II. One-time start-up costs	1. Land acquisition	243,679	
	2. Facilities planning	244,800	
	3. Program design	200,000	
	4. Development of data handling system software	67,000	
	5. Personnel training	7,817	
	6. Personnel salaries plus overhead	3,323,671	
	7. Initial public information program	1,147,164	
			5,234,131
III. Annual operating costs	1. Facility personnel	665,774	
	2. Maintenance	57,600	
	3. Utilities/services/supplies	2,110,003	
			2,833,377
IV. Annual administrative costs	1. Program administrative personnel salaries plus overhead	2,769,186	
	2. Public information	1,147,164	
	3. Personnel training	693	
			3,917,043

TABLE 145a. F = STATE STICKER FEE CALCULATION, OPTION VII, MINIMUM NETWORK

When i = 0.03

Cost class	Cost ($)	Amortization factor for i = 0.03	Annualized cost (column 2)x(column 3)
I. Capital costs			
1. Referee lanes	1,716,792	0.03	51,504
2. I/L vans	546,000	0.067	36,582
3. Complaints vehicles	140,000	0.2184	30,576
II. Start-up costs	3,785,531	0.2184	826,760
III. Operating costs	2,409,777		2,409,777
IV. Administrative costs	2,712,938		2,712,938
Total	$\frac{\$6,068,137}{\$8,700,000} = \$0.70 = F$		6,068,137

When i = 0.06

Cost class	Cost ($)	Amortization factor for i = 0.06	Annualized cost (column 2)x(column 3)
I. Capital costs			
1. Referee lanes	1,716,792	0.06	103,008
2. I/L vans	546,000	0.087	47,502
3. Complaints vehicles	140,000	0.2374	33,236
II. Start-up costs	3,785,531	0.2374	898,685
III. Operating costs	2,409,777		2,409,777
IV. Administrative costs	2,712,938		2,712,938
Total	$\frac{\$6,205,146}{\$8,700,000} = \$0.71 = F$		6,205,146

TABLE 145b. F = STATE STICKER FEE CALCULATION, OPTION VII, MIDLEVEL NETWORK

When i = 0.03

Cost class	Cost ($)	Amortization factor for i = 0.03	Annualized cost (column 2)x(column 3)
I. Capital costs			
1. Referee lanes	1,716,792	0.03	51,504
2. I/L vans	882,000	0.067	59,094
3. Complaints vehicles	220,000	0.2184	48,048
II. Start-up costs	4,509,831	0.2184	984,947
III. Operating costs	2,625,977		2,625,977
IV. Administrative costs	3,314,720		3,314,720
Total	$\frac{\$7,084,290}{\$8,700,000}$ = \$0.81 = F		7,084,290

When i = 0.06

Cost class	Cost ($)	Amortization factor for i = 0.06	Annualized cost (column 2)x(column 3)
I. Capital costs			
1. Referee lanes	1,716,792	0.06	103,008
2. I/L vans	882,000	0.087	76,734
3. Complaints vehicles	220,000	0.2374	52,228
II. Start-up costs	4,509,831	0.2374	1,070,634
III. Operating costs	2,625,977		2,625,977
IV. Administrative costs	3,314,720		3,314,720
Total	$\frac{\$7,243,301}{\$8,700,000}$ = \$0.83 = F		7,243,301

TABLE 145c. F = STATE STICKER FEE CALCULATION, OPTION VII, MAXIMUM NETWORK

When i = 0.03

Cost class	Cost ($)	Amortization factor for i = 0.03	Annualized cost (column 2)x(column 3)
I. Capital costs			
1. Referee lanes	1,716,792	0.03	51,504
2. I/L vans	1,204,000	0.067	80,668
3. Complaints vehicles	305,000	0.2184	66,612
II. Start-up costs	5,234,131	0.2184	1,143,134
III. Operating costs	2,833,377		2,833,377
IV. Administrative costs	3,917,043		3,917,043
Total	$\frac{\$8,092,338}{\$8,700,000}$ = \$0.93 = F		8,092,338

When i = 0.06

Cost class	Cost ($)	Amortization factor for i = 0.06	Annualized cost (column 2)x(column 3)
I. Capital costs			
1. Referee lanes	1,716,792	0.06	103,008
2. I/L vans	1,204,000	0.087	104,748
3. Complaints vehicles	305,000	0.2374	72,407
II. Start-up costs	5,234,131	0.2374	1,242,583
III. Operating costs	2,833,377		2,833,377
IV. Administrative costs	3,917,043		3,917,043
Total	$\frac{\$8,273,166}{\$8,700,000}$ = \$0.95 = F		8,273,166

Table 146, below, summarizes the results of these calculations.

TABLE 146. F, STATE STICKER FEE, OPTION VII, CONSTANT DOLLARS

Level of participation, private garage network	F	
	i = 0.03	i = 0.06
Minimum	\$0.70	\$0.71
Mid	\$0.81	\$0.83
Maximum	\$0.93	\$0.95

Garage Fee Computation--

The fee charged by private garages for performing an emissions inspection will be based on those cost factors discussed in the derivation of the three private garage network participation levels and on annual station throughput. Recalling the formula used to calculate the maximum private garage network,

$$M(C-F) = A + S + L + O,$$

it can easly be shown by manipulating this formula that the total inspection charge, C, can be calculated by using the following formula:

$$C = \frac{A + S + L + O}{M} + F$$

where: A = annual cost of an emissions analyzer; using the same assumptions as above, this cost is \$751.88 per year.

S = the salary of the emissions inspector. Assuming that he works 4 hours a day, 250 days per year, and earns \$5.50 per hour, this cost is \$5,500.00 per year.

L = annual licensing fees for the private garage, assumed not to exceed \$100.00.

O = overhead, assumed to be one-third of the inspector's salary, or \$1,833.33 per year.

M = the annual station throughput.

F = the state sticker fee in constant dollars.

By dividing the total number of paid inspections (here assumed to be the same as registration totals, since retests are assumed to be free for failed vehicles) by the total number of garages for the three participation levels defined above, annual throughput rates for each of the three levels can be calculated. Substituting these throughput rates for M in the above formula, and using all the cost assumptions listed above, the total inspection charge, C, for each of the three participation levels can be determined. Subtracting the state sticker fee, F, from the total charge yields the garage fee for each level of participation.

Table 147 summarizes the calculations of garage fee, sticker fee, and total inspection charge for each of the three levels of participation defined previously, assuming i = 0.03.

TABLE 147. STATE STICKER FEE, PRIVATE GARAGE FEE, AND TOTAL INSPECTION CHARGE, OPTION VII, ASSUMING i = 0.03

Motorist inspection fee component	Level of participation, private garage network		
	Minimum	Mid	Maximum
State sticker fee	$0.70	$0.81	$0.93
Private garage fee	$2.22	$3.58	$4.94
Total inspection charge	$2.92	$4.39	$5.87

Table 148 presents the same information as the previous table, but assumes a social rate of discount i = 0.06.

TABLE 148. STATE STICKER FEE, PRIVATE GARAGE FEE, AND TOTAL INSPECTION CHARGE, OPTION VII, ASSUMING i = 0.06

Motorist inspection fee component	Level of participation, private garage network		
	Minimum	Mid	Maximum
State sticker fee	$0.71	$0.83	$0.95
Private garage fee	$2.22	$3.58	$4.94
Total inspection charge	$2.93	$4.41	$5.89

Conclusion

Since higher levels of market participation mean smaller annual throughputs for each garage, private garages must charge more per inspection to break even as participation levels increase. From the preceding cost analysis, it is also obvious that state administrative costs increase significantly at higher market participation levels, due to the higher numbers of complaints investigators and inspection and licensing officials required. Thus, it is therefore desirable from both the average motorist's and the state's viewpoint to hold market participation to as low a level as possible and to maximize private garage efficiency in performing inspections. The minimum network derived above assumes a very high level of garage efficiency; it might well be used as a goal in establishing an I/M network. Various controls which the state might exercise on the participation rate are as follows:

1. Establishment of a fixed number of inspection station licenses to be granted in a given year;

2. Establishment of a maximum garage charge, to be applied state-wide, which would render inspections unprofitable at inefficient garages and profitable only at efficient garages; and

3. Regulation of annual licensing fees to be paid by inspection stations.

OPTION VII MANPOWER REQUIREMENTS

The manpower requirements for this option are quite different from the other options. Due to the fact that the inspection network is totally decentralized, the state will not need to hire station-level personnel except for the referee lanes. These personnel made up a significant percentage of the total manpower requirements for the preceding options. On the other hand, since the number of inspection stations in this option is very much larger than the number for the previous options, the state will have to hire a large number of complaints investigation and inspection and licensing personnel. The resulting administrative organization is shown in Figure 13. Table 149 shows total state manpower allocations for this option, including state referee lane personnel.

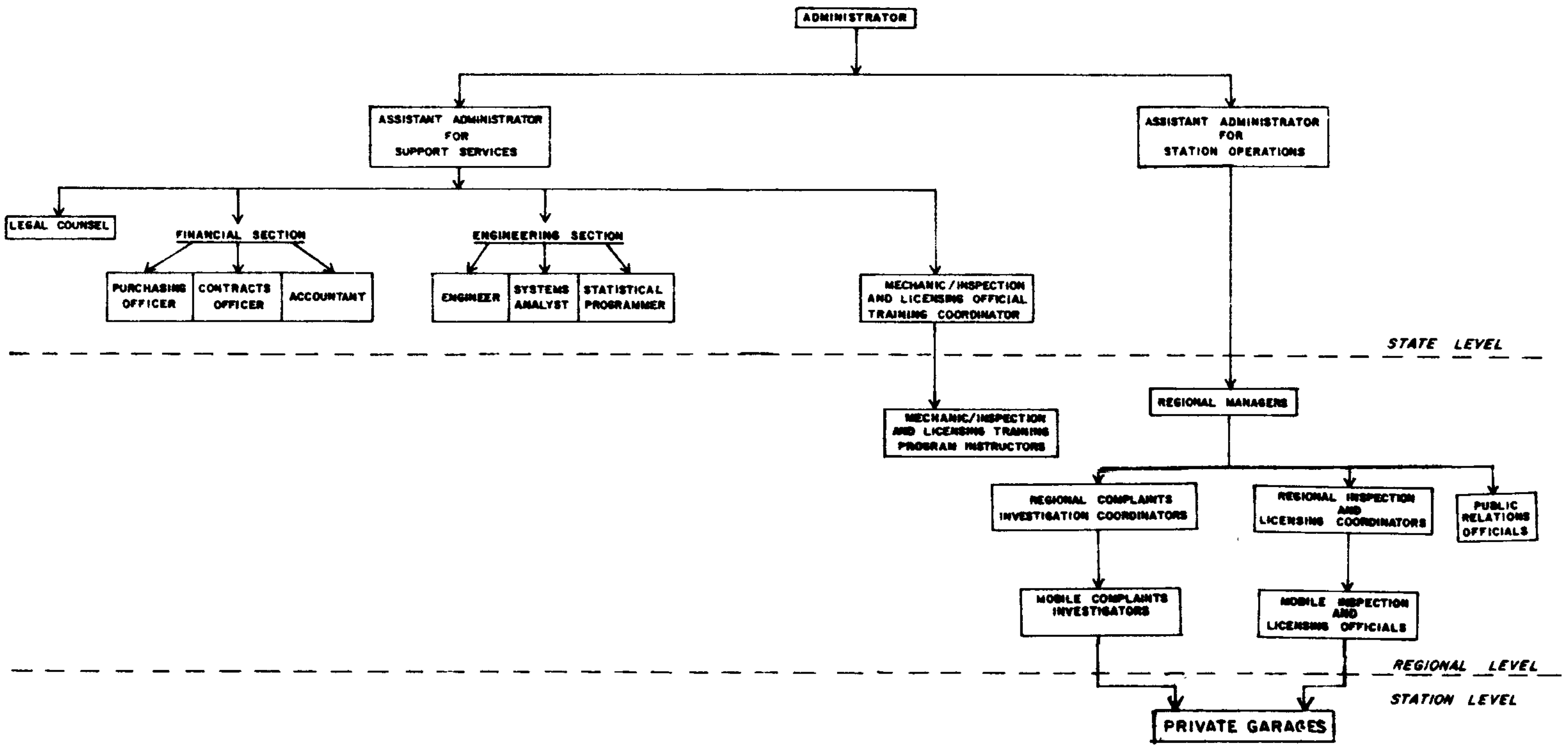

Figure 13. Administrative organization, Option VII.

TABLE 149. MANPOWER REQUIREMENTS, OPTION VII

State Administrative

1 Administrator

1 Assistant administrator for supporting services .

1 Legal counsel

1 Purchasing officer

1 Contracts officer

1 Accountant

1 Engineer

1 Systems Analyst

1 Statistician/programmer

1 Mechanic/I&L/Inspector Training Program coordinator

1 AA for station operations

State Regional

5 Regional manager

5 Public relations officials

5 Complaints investigation coordinators

5 Inspection and licensing coordinators

	Level of participation, private garage network		
	Minimum	Mid	Maximum
Mobile inspection and licensing officials	39	63	86
Mobile complaints investigators	28	44	61

State Referee Lane Personnel

12 Supervisors

12 Test engineers

14 Inspectors

14 Clerks

14 Station maintenance personnel

SECTION 11

BENEFITS

This section presents air quality and fuel economy benefits. Although the primary objective of an inspection and maintenance program is to reduce hydrocarbon and carbon monoxide emissions from mobile sources, an important secondary benefit of increased fuel economy also results from the improved maintenance to the motor vehicles inspected by the program.

EMISSION REDUCTION BENEFITS

Mobile source emission inventories are presented for each of the 18 most populous counties in Ohio. The impact of I/M on 1987 emission levels depends upon the proportion of a county's travel (VMT) driven by vehicles subject to mandatory emission inspection. All the options evaluated in this report fall into one of three benefit scenarios. Options I, II, and VII require mandatory inspection of all vehicles in the state. In this scenario all travel is by mandatorially inspected vehicles. The second scenario requires mandatory inspection of only those vehicles registered in the 18 most populous counties. Options III, IV, V and VI under Alternate B fall into this situation. Since each of the 18 counties analyzed are those with mandatory inspection, only a small proportion of the VMTs in these counties are generated by vehicles registered in areas without I/M. The third scenario requires mandatory inspection of only those vehicles registered in the 12 most populous counties. This situation includes Options III, IV, V and VI under Alternative A. In this scenario, emissions are analyzed for six counties without mandatory inspection. In each of these counties there is some emission reduction due to travel by vehicles coming from the 12 inspection counties. In the counties with inspection, this third scenario yields slightly increased emissions over the second scenario. These increases are the result of six additional counties from which uninspected vehicle trips can be generated. Emission inventories are presented for each of the three scenarios as follows:

BENEFIT SCENARIOS

Scenario	12 most populous counties	6 next populous counties	Remainder of state
First scenario: (Options I, II, VII)	Mandatory inspection	Mandatory inspection	Mandatory inspection
Second Scenario: (Options III, IV, V, VI under Alternate B)	Mandatory inspection	Mandatory inspection	NO mandatory inspection
Third Scenario: (Options III, IV, V, VI, under Alternate A)	Mandatory inspection	NO mandatory inspection	NO mandatory inspection

Table 150 presents the benefits (percent reduction in daily vehicle emissions) for 1987 which result from an I/M beginning in 1982. In terms of carbon monoxide it may be seen that in scenario one the statewide mandatory inspection options bring about the highest level of emission reduction of 27 percent throughout the state. Next, the second scenario with mandatory I/M in the 18 urban counties give the second highest reduction 25, 3, and 17 percent in the 18 urban counties, remaining rural, and statewide average respectively. Finally, the third scenario, with mandatory inspection in the 12 urban counties with population greater than 200,000 have the least emission reduction of 23, 3, and 15 percent for the 18 counties, remaining counties, and statewide average, respectively. As discussed earlier in both the second and third scenarios in the uninspection counties there is some emission reduction due to inspected vehicles traveling to these counties. The reductions in hydrocarbons although a few percent points less than carbon monoxide observe the same ranking, namely the statewide mandatory inspection having the highest level of emission reduction followed by the second and third scenarios.

TABLE 150. PERCENT REDUCTION IN DAILY VEHICLE EMISSION RESULTING FROM I/M IN 1987*

	First Scenario (Options I, II and VII)	Second Scenario (Options III, IV, V VI, under Alternate B)	Third Scenario (Options III, IV, V, VI, under Alternate A)
CARBON MONOXIDE			
18 Counties	27	25	23
Rural areas	27	3	3
Statewide	27	17	15
HYDROCARBONS			
18 Counties	22	17	19
Rural areas	22	2	2
Statewide	22	14	12

*No reduction in light-duty truck emissions was calculated because the credits for this particular vehicle category have yet to be established by EPA. Appropriate adjustments will be made when the credits are made available.

Tables 151 through 153 summarize hydrocarbon emissions, and Tables 154 through 156 present carbon monoxide emissions. All the tables give daily emissions on a typical July day of 75°F when mobile emissions are at a maximum. A general description of the methodology and assumptions used in calculating these inventories is included in Section 3. A detailed description is included in Appendix E.

Under the first scenario, the I/M program produces hydrocarbon emission reductions ranging from 19.7 to 25.1 percent for the 18 counties analyzed. Under the second scenario, hydrocarbon emission reductions drop slightly to 18.4 to

23.7 percent in the 18 counties analyzed and under the third scenario reductions drop to 18.0 to 23.7 percent in the 12 counties with inspection. Under the third scenario, the six counties without inspection will experience reductions from 1.5 to 3.2 percent.

Also under the first scenario, the I/M program produces carbon monoxide reductions ranging from 19.5 to 29.2 percent for the 18 counties analyzed. Under the second scenario, carbon monoxide emission reductions also drop slightly to 17.4 to 28.0 percent in the 18 counties analyzed, and under the third scenario reductions range from 17.9 to 27.0 percent in the 12 counties with inspection. Under the third scenario, the six counties without inspection will experience reductions from 1.8 to 3.9 percent.

Inventories were not calculated for areas outside the 18 most populous counties. However, the findings for the analyzed regions yield general conclusions and guidelines applicable to the remainder of the state. When rural counties have mandatory inspections (Options I, II and VII), emission reductions similar to those under the first scenario can be expected. When rural counties have no mandatory inspection (Options III, IV, V, and VI), emission reductions similar to those experienced by the six counties without mandatory inspection in the third scenario can be expected.

FUEL ECONOMY BENEFITS

One of the important benefits of I/M programs, in addition to the reduction in vehicular emissions is energy conservation. A properly-tuned motor operates with greater efficiency and therefore, consumes less fuel. This improvement in fuel economy varies somewhat from one program to another but most sources agree that a 5 to 10 percent fuel economy improvement for the failed and maintained vehicles can be expected. This may understate the overall fleet improvement as some motor vehicle owners are likely to schedule tune-ups just prior to having their cars inspected. One of the purposes of I/M is to give an incentive to motorists to maintain their cars better than they normally would in the absence of I/M.

A 7 percent fuel economy improvement was utilized in this study to calculate the fuel savings from the I/M program options. With a stringency (failure) rate of 30 percent, the amount of fuel saved averaged for the total motor vehicle population will amount to a 2.1 percent of total fleet fuel consumption. For a detailed discussion of the methodology used for calculating fuel savings the reader is referred to Appendix B, "Estimated Fuel Savings Resulting from I/M in 1987." As shown below, for the 12 county alternate A, 28,898,530 gallons of fuel would be saved in 1987. At $0.70 per gallon, vehicle owners will save $20,228,970 which is approximately $11.80 per failed vehicle. If coverage is extended to 18 counties as in Alternate A, motorists will consume 31,844,630 fewer gallons than without I/M saving a total of $22,291,241 which is approximately $11.85 per failed vehicle. The statewide program coverage provides the largest savings of 37,171,280 gallons which would amount to $26,019,896 which would be approximately $9.10 per failed vehicle.

ANNUAL FUEL SAVINGS (GALLONS)

	Total fuel savings	Dollar savings at $0.70 gallon	Savings per failed vehicle
Alternate A - 12 County	28,898,530	$20,228,970.00	$11.80
Alternate B - 18 County	31,844,630	$22,291,241.00	$11.85
Statewide	37,171,280	$26,019,896.00	$ 9.10

TABLE 151. DAILY HYDROCARBON EMISSIONS FOR OPTIONS I, II, AND VII (kg/day)

	Heavy-duty trucks						Light-duty vehicles									All vehicles				
	1977 diesel	1987 diesel	1977 gasoline	1987 gasoline	1977 total	1987 total	1977 auto	1987 without I/M auto	1987 I/M auto	1977 L-D truck	1987 without I/M L-D truck	1987 I/M L-D truck*	1977 total	1987 without I/M total	1987 I/M total	1977	1987 without I/M	1987 I/M	Percent† reduction 1977-1987 I/M	Percent‡ reduction 1987-1987 I/M
Butler Co	539	466	2,494	1,104	3,033	1,570	19,878	7,233	4,832	3,584	1,873	1,873	23,462	9,106	6,707	26,495	10,676	8,277	68.5	22.5
Cuyahoga Co.	1,597	1,405	13,997	6,891	15,594	8,296	108,432	36,731	24,959	20,244	9,517	9,517	128,676	46,248	34,476	144,270	54,544	42,772	70.4	21.6
Franklin Co	1,244	1,049	5,574	2,278	6,818	3,327	51,282	18,585	11,938	10,161	4,565	4,565	61,443	23,150	16,503	68,261	26,477	19,830	71	25.1
Hamilton Co	3,296	2,919	10,167	5,004	13,463	7,923	65,683	25,136	15,611	12,594	7,013	7,013	78,277	32,149	23,624	91,740	40,072	31,547	65.6	21.3
Lake Co	433	365	2,076	836	2,509	1,201	19,828	6,531	4,460	3,169	1,661	1,661	22,997	8,192	6,121	25,506	9,393	7,322	71.3	22.1
Loraine Co.	220	170	839	325	1,059	495	7,636	2,486	1,711	1,437	678	678	9,073	3,164	2,389	10,132	3,659	2,884	71.5	21.2
Lucas Co.	718	586	2,438	978	3,156	1,564	24,125	7,925	5,436	4,432	2,116	2,116	28,557	10,041	7,552	31,713	11,605	9,116	71.3	21.5
Mahoning Co.	633	509	1,648	615	2,281	1,124	15,282	4,897	3,389	2,827	1,323	1,323	18,109	6,220	4,712	20,390	7,344	5,836	71.4	20.5
Montgomery Co.	770	646	3,121	1,170	3,891	1,816	30,760	10,064	6,967	5,243	2,654	2,654	36,003	12,718	9,621	39,894	14,534	11,437	71.3	21.3
Stark Co.	410	314	2,008	757	2,418	1,071	20,145	6,425	4,416	3,586	1,662	1,662	23,731	8,087	6,078	26,149	9,158	7,149	72.7	21.9
Summit Co.	881	734	3,374	1,332	4,255	2,066	32,119	10,681	7,365	5,803	2,824	2,824	37,922	13,505	10,189	42,177	15,571	12,255	71	21.3
Trumbull Co.	503	406	1,777	662	2,280	1,068	15,634	4,965	3,426	2,858	1,325	1,325	18,492	6,290	4,751	20,772	7,358	5,819	72	20.9
Total - 12 counties	11,244	9,569	49,513	21,952	60,757	31,521	410,804	141,659	95,510	75,938	37,211	37,211	486,742	178,870	132,721	547,499	210,391	164,244	70	21.9
Clermont Co.	272	264	1,083	808	1,355	1,072	8,661	3,513	2,378	1,652	945	945	10,313	4,458	3,323	11,668	5,530	4,395	62.3	20.5
Geauga Co	57	43	355	141	412	184	3,353	1,083	744	565	264	264	3,918	1,347	1,008	4,330	1,531	1,192	72.5	22.2
Greene Co	145	116	478	186	623	302	4,277	1,415	977	820	394	394	5,097	1,809	1,371	5,720	2,111	1,673	70.6	20.8
Medina Co.	321	274	702	282	1,023	556	5,997	2,184	1,466	1,020	620	620	7,017	2,804	2,086	8,040	3,360	2,642	67.1	21.4
Warren Co	413	436	1,154	675	1,567	1,111	9,535	4,389	2,977	1,836	1,219	1,219	11,371	5,608	4,196	12,938	6,719	5,307	59	21
Wood Co.	355	303	814	328	1,169	631	7,003	2,451	1,703	1,391	710	710	8,394	3,161	2,413	9,563	3,792	3,044	68.2	19.7
Total - 6 counties	1,563	1,436	4,586	2,420	6,149	3,856	38,826	15,035	10,245	7,284	4,152	4,152	46,110	19,187	14,397	52,259	23,043	18,253	65.1	20.8
Total - 18 counties	12,807	11,005	54,099	24,372	66,906	35,377	449,630	156,694	105,755	83,222	41,363	41,363	532,852	198,057	147,118	599,758	233,434	182,497	69.6	21.8

*No reduction in light-duty emissions was calculated because the credits for this particular vehicle category have yet to be established by EPA. Appropriate adjustments will be made when the credits are made available.

†Reduction attributable to Federal Motor Vehicle Control Program (FMVCP) and I/M.

‡Reduction attributable to I/M.

TABLE 152. DAILY HYDROCARBON EMISSIONS FOR OPTIONS III, IV, V, AND VI UNDER ALTERNATIVE B (kg/day)

	Heavy-duty trucks						Light-duty vehicles									All vehicles				
	1977 diesel	1987 diesel	1977 gasoline	1987 gasoline	1977 total	1987 total	1977 auto	1987 without I/M auto	1987 I/M auto	1977 L-D truck	1987 without I/M L-D truck	1987 I/M L-D truck*	1977 total	1987 without I/M total	1987 I/M total	1977	1987 without I/M	1987 I/M	Percent reduction 1977-1987 I/M†	Percent reduction 1987-1987 I/M‡
Butler Co	539	466	2,494	1,104	3,033	1,570	19,976	7,233	4,927	3,584	1,873	1,873	23,462	9,106	6,800	26,495	10,676	8,370	68.4	21.6
Cuyahoga Co	1,597	1,405	13,997	6,891	15,594	8,296	108,432	36,731	25,080	20,244	9,517	9,517	128,676	46,248	34,597	144,270	54,544	42,893	70.3	21.4
Franklin Co	1,244	1,049	5,574	2,278	6,818	3,327	51,282	18,585	12,301	10,161	4,565	4,565	61,443	23,150	16,866	68,261	26,477	20,193	70.4	23.7
Hamilton Co	3,296	2,919	10,167	5,004	13,463	7,923	65,683	25,136	17,221	12,594	7,013	7,013	78,277	32,149	24,234	91,740	40,072	32,157	65.0	19.6
Lake Co	433	365	2,076	836	2,509	1,201	19,826	6,531	4,506	3,169	1,661	1,661	22,997	8,192	6,167	25,506	9,393	7,368	71.0	21.6
Lorain Co	220	170	839	325	1,059	495	7,636	2,486	1,734	1,437	678	678	9,073	3,164	2,412	10,132	3,659	2,907	71.3	20.6
Lucas Co	718	586	2,438	978	3,156	1,564	24,125	7,925	5,567	4,432	2,116	2,116	28,557	10,041	7,683	31,713	11,605	9,247	70.9	20.3
Mahoning Co	633	509	1,648	615	2,281	1,124	15,282	4,897	3,444	2,827	1,323	1,323	18,109	6,220	4,767	20,390	7,344	5,891	71.1	19.8
Montgomery Co	770	646	3,121	1,170	3,891	1,816	30,760	10,064	7,111	5,243	2,654	2,654	36,003	12,718	9,765	39,894	14,534	11,581	71.0	20.3
Stark Co	410	314	2,008	757	2,418	1,071	20,145	6,425	4,580	3,586	1,662	1,662	23,731	8,087	6,242	26,149	9,158	7,313	72.0	20.2
Summit Co	881	734	3,374	1,332	4,255	2,066	32,119	10,681	7,477	5,803	2,824	2,824	37,922	13,505	10,301	42,177	15,571	12,367	70.7	20.6
Trumbull Co	503	406	1,777	662	2,280	1,068	15,634	4,965	3,481	2,858	1,325	1,325	18,492	6,290	4,806	20,772	7,358	5,874	71.7	20.2
Total - 12 counties	11,244	9,569	49,513	21,952	60,757	31,521	410,804	141,659	97,429	75,938	37,211	37,211	486,742	178,870	134,640	547,499	210,391	166,161	69.7	21.0
Clermont Co.	272	264	1,083	808	1,355	1,072	8,661	3,513	2,447	1,652	945	945	10,313	4,458	3,392	11,668	5,530	4,464	61.8	19.3
Ceauga Co	57	43	355	141	412	184	3,353	1,083	760	565	264	264	3,918	1,347	1,024	4,330	1,531	1,208	72.1	21.1
Greene Co	145	116	478	186	623	302	4,227	1,415	1,016	820	394	394	5,097	1,809	1,410	5,720	2,111	1,712	70.0	18.9
Medina Co	321	274	702	282	1,023	556	5,997	2,184	1,508	1,020	620	620	7,017	2,804	2,128	8,040	3,360	2,684	66.6	20.1
Warren Co	413	436	1,154	675	1,567	1,111	9,535	4,389	3,032	1,836	1,219	1,219	11,371	5,608	4,251	12,938	6,719	5,362	58.6	20.2
Wood Co	355	303	814	328	1,169	631	7,003	2,451	1,752	1,391	710	710	8,394	3,161	2,462	9,563	3,792	3,093	67.7	18.4
Total - 6 counties	1,563	1,436	4,586	2,420	6,149	3,856	38,826	15,035	10,515	7,284	4,152	4,152	46,110	19,187	14,667	52,259	23,043	18,523	64.6	19.6
Total - 18 counties	12,807	11,005	54,099	24,372	66,906	35,377	449,630	156,694	107,944	83,222	41,363	41,363	532,852	198,057	149,307	599,758	233,434	184,684	69.2	20.9

*No reduction in light-duty truck emissions was calculated because the credits for this particular vehicle category have yet to be established by EPA. Appropriate adjustments will be made when the credits are made available.

†Reduction attributable to Federal Motor Vehicle Control Program (FMVCP) and I/M.

‡Reduction attributable to I/M

TABLE 153. DAILY HYDROCARBON EMISSIONS FOR OPTIONS III, IV, V AND VI UNDER ALTERNATIVE A (kg/day)

	Heavy-duty trucks						Light-duty vehicles									All vehicles				
	1977 diesel	1987 diesel	1977 gasoline	1987 gasoline	1977 total	1987 total	1977 auto	1987 without I/M auto	1987 I/M auto	1977 L-D truck	1987 without I/M L-D truck	1987 I/M L-D truck*	1977 total	1987 without I/M total	1987 I/M total	1977	1987 without I/M	1987 I/M	Percent reduction 1977-1987 I/M +	Percent reduction 1987-1987 I/M ++
Butler Co	539	466	2,494	1,104	3,033	1,570	19,878	7,233	4,964	3,584	1,873	1,873	23,462	9,106	[illegible]	26,495	10,676	8,427	68.3	21.3
Cuyahoga Co	1,597	1,405	13,997	6,891	15,594	8,296	108,432	36,731	25,272	20,244	9,517	9,517	128,676	46,248	34,789	144,270	54,544	43,085	70.1	21.0
Franklin Co	1,244	1,049	5,574	2,278	6,818	3,327	51,282	18,585	12,301	10,161	4,565	4,565	61,443	23,150	16,866	68,261	26,477	20,193	70.4	23.7
Hamilton Co	3,296	2,919	10,167	5,004	13,463	7,923	65,683	25,136	17,532	12,594	7,013	7,013	78,277	32,149	24,545	91,740	40,072	32,458	64.6	19.0
Lake Co	433	365	2,076	836	2,509	1,201	19,828	6,531	4,541	3,169	1,661	1,661	22,997	8,192	6,202	25.506	9,393	7,403	71.0	21.2
Lorain Co	220	170	839	325	1,059	495	7,636	2,486	1,736	1,437	678	678	9,073	3,164	2,414	10,132	3,659	2,909	71.3	20.5
Lucas Co	718	586	2,438	978	3,156	1,564	24,125	7,925	5,635	4,432	2,116	2,116	28,557	10,041	7,751	31,713	11,605	9,315	70.6	19.7
Mahoning Co	633	509	1,648	615	2,281	1,124	15,282	4,897	3,444	2,827	1,323	1,323	18,109	6,220	4,767	20,390	7,344	5,891	71.1	19.8
Montgomery Co.	770	646	3,121	1,170	3,891	1,816	30,760	10,064	7,288	5,243	2,654	2,654	36,003	12,718	9,942	39,894	14,534	11,758	70.5	18.1
Stark Co	410	314	2,008	757	2,418	1,071	20,145	6,425	4,500	3,586	1,662	1,662	23,731	8,087	6,162	26,149	9,158	7,313	72.3	20.2
Summit Co	881	734	3,374	1,332	4,255	2,066	32,119	10,681	7,517	5,803	2,824	2,824	37,922	13,505	10,341	42,177	15,571	12,407	70.6	20.3
Trumbull Co.	503	406	1,777	662	2,280	1,068	15,634	4,965	3,483	2,858	1,325	1,325	18,492	6,290	4,808	20,772	7,358	5,876	71.7	18.0
Total - 12 counties	11,244	9,569	49,513	21,952	60,757	31,521	410,804	141,659	98,213	75,938	37,211	37,211	486,742	178,870	135,424	547,499	210,391	166,945	69.6	20.9
Clermont Co	272	264	1,083	808	1,355	1,072	8,661	3,513	3,428	1,652	945	945	10,313	4,458	4,373	11,668	5,530	5,445	53.3	1.5
Geauga Co	57	43	355	141	412	184	3,353	1,083	1,043	565	264	264	3,918	1,347	1,307	4,330	1,531	1,491	65.6	2.0
Greene Co	145	116	478	186	623	302	4,277	1,415	1,357	820	394	394	5,097	1,809	1,751	5,720	2,111	2,053	64.1	2.7
Medina Co.	321	274	702	282	1,023	556	5,997	2,184	2,129	1,020	620	620	7,017	2,804	2,749	8,040	3,360	3,305	58.9	1.6
Warren Co.	413	436	1,154	675	1,567	1,111	9,535	4,389	4,252	1,836	1,219	1,219	11,371	5.608	5,471	12,938	6,719	6,582	49.1	2.0
Wood Co	355	303	814	328	1,169	631	7,003	2,451	2,331	1,391	710	710	8,394	3,161	3,041	9,363	3,792	3,672	61.6	3.2
Total - 6 counties	1,563	1,436	4,586	2,420	6,149	3,856	38,826	15,035	14,540	7,284	4,152	4,152	46,110	19,187	18,692	52,259	23,043	22,548	56.9	2.2
Total - 18 counties	12,807	11,005	54,099	24,372	66,906	35,377	449,630	156,694	112,753	83,222	41,363	41,363	532,852	198,057	154,116	599,756	233,434	189,493	68.4	18.6

*No reduction in light-duty truck emissions was calculated because the credits for this particular vehicle category have yet to be established by EPA. Appropriate adjustments will be made when the credits are made available.

+Reduction attributable to Federal Motor Vehicle Control Program (FMVCP) and I/M.

++Reduction attributable to I/M.

TABLE 154. DAILY CARBON MONOXIDE EMISSIONS FOR OPTIONS I, II, AND VII (kg/day)

	Heavy-duty trucks						Light-duty vehicles									All vehicles				
	1977 diesel	1987 diesel	1977 gasoline	1987 gasoline	1977 total	1987 total	1977 auto	1987 without I/M auto	1987 I/M auto	1977 L-D truck	1987 without I/M L-D truck[*]	1987 I/M L-D truck[*]	1977 total	1987 without I/M total	1987 I/M total	1977	1987 without I/M	1987 I/M	Percent[▲] reduction 1977-1987 I/M	Percent[‡] reduction 1987-1987 I/M
Butler Co	3,196	3,496	25,556	23,485	28,754	26,981	143,987	61,665	32,883	22,887	17,848	17,848	166,874	79,513	50,731	195,628	106,494	77,712	60.3	27.0
Cuyahoga Co.	10,012	8,271	142,443	115,577	152,455	123,848	814,248	336,663	179,583	123,370	94,149	94,149	937,618	430,812	273,732	1,090,073	554,660	397,580	63.5	28.3
Franklin Co.	7,381	7,978	67,638	62,713	75,019	70,691	332,196	142,788	70,058	52,623	41,085	41,085	384,819	183,873	117,143	459,838	254,564	187,834	59.2	26.2
Hamilton Co	19,592	21,986	99,431	85,666	119,023	107,652	516,273	221,720	118,310	86,575	68,582	68,582	602,848	290,302	152,892	721,871	397,954	290,544	59.8	27.0
Lake Co	2,578	2,778	24,290	21,778	26,868	24,556	131,326	54,652	29,061	20,166	15,239	15,239	151,492	69,891	44,300	178,360	94,447	68,856	61.4	27.1
Loraine Co.	1,259	1,262	9,746	8,952	11,005	10,214	49,127	20,686	10,995	8,151	6,166	6,166	57,278	26,852	17,161	68,283	37,066	27,375	59.9	26.1
Lucas Co.	4,214	4,425	31,376	28,772	35,590	33,197	152,859	55,616	34,624	21,735	19,015	19,015	174,594	74,631	53,639	210,184	107,828	86,836	58.7	19.5
Mahoning Co.	3,779	3,903	21,050	18,679	24,829	22,582	95,979	40,163	21,355	15,611	10,245	10,245	111,590	50,408	31,600	136,419	72,990	54,182	60.3	25.8
Montgomery Co	4,559	4,913	39,592	36,330	44,151	41,243	191,772	88,731	43,856	30,476	23,710	23,710	222,248	112,441	67,566	266,402	153,684	108,809	59.2	29.2
Stark Co.	2,362	2,344	23,764	21,332	26,126	23,676	129,109	53,312	28,341	20,263	15,085	15,085	149,372	68,397	43,426	175,498	92,073	67,102	61.8	27.1
Summit Co.	5,193	5,565	41,439	39,477	46,632	45,042	204,026	87,465	46,540	32,546	25,284	25,284	236,572	112,749	71,824	283,204	157,791	110,866	58.7	25.9
Trumbull Co	2,949	3,070	21,355	19,006	24,304	22,076	99,823	41,406	21,989	16,061	16,799	16,799	115,884	58,205	38,788	140,188	80,281	60,864	56.6	24.2
Total - 12 counties	67,074	69,991	547,682	481,767	614,756	551,758	2,860,725	1,204,867	643,595	450,464	353,207	353,207	3,311,189	1,558,074	996,796	3,925,948	2,109,832	1,548,554	60.6	26.6
Clermont Co.	1,586	1,973	11,510	12,151	13,096	14,124	62,658	29,740	15,843	10,128	8,756	8,756	72,786	38,496	24,599	85,882	52,620	58,723	54.9	26.4
Geauga Co.	323	314	3,886	3,545	4,209	3,859	22,094	9,065	4,824	4,860	2,424	2,424	26,954	11,489	7,248	31,163	15,348	11,107	64.4	27.6
Greene Co.	841	865	5,635	6,709	6,476	7,574	27,271	11,714	6,226	4,614	3,561	3,561	31,885	15,275	9,787	38,361	22,849	17,361	54.7	24.0
Medina Co	1,908	2,089	9,278	8,875	11,186	10,964	37,036	17,067	9,080	6,610	5,481	5,481	43,646	22,548	14,561	54,832	33,512	25,525	53.4	23.8
Warren Co.	2,410	3,275	13,110	15,862	15.520	19,137	64,768	37,332	19,856	10,943	11,402	11,402	75,711	48,734	31,258	91,231	67,871	50,395	44.8	25.7
Wood Co	2,110	2,307	10,635	10,282	12,745	12,589	43,473	19,882	10,579	7,631	6,289	6,289	51,104	26,171	16,868	63,849	38,760	29,457	53.9	24.0
Total - 6 counties	9,178	10,823	54,054	57,424	63,232	68,247	257,306	124,800	66,408	44,786	37,913	37,913	302,086	162,713	104,321	365,318	230,960	172,568	52.8	25.3
Total - 18 counties	76,252	80,814	601,736	539,191	677,988	620,005	3,118,025	1,329,667	710,003	495,250	391,120	391,120	3,613,275	1,720,787	1,101,117	4,291,266	2,340,792	1,721,122	59.9	26.5

[*] No reduction in light-duty truck emissions was calculated because the credits for this particular vehicle category have yet to be established by EPA. Appropriate adjustments will be made when the credits are made available

[▲] Reduction attributable to Federal Motor Vehicle Control Program (FMVCP) and I/M.

[‡] Reduction attributable to I/M.

TABLE 155. DAILY CARBON MONOXIDE EMISSIONS FOR OPTIONS III, IV, V, AND VI UNDER ALTERNATIVE B (kg/day)

	Heavy-duty trucks						Light-duty vehicles									All vehicles				
	1977 diesel	1987 diesel	1977 gasoline	1987 gasoline	1977 total	1987 total	1977 auto	1987 without I/M auto	1987 I/M auto	1977 L-D truck	1987 without I/M L-D truck	1987 I/M L-D truck*	1977 total	1987 without I/M total	1987 I/M total	1977	1987 without I/M	1987 I/M	Percent reduction 1977-1987 I/M+	Percent reduction 1987-1987 I/M‡
Butler Co	3,196	3,496	25,558	23,485	28,754	26,981	143,987	61,665	34,017	22,887	17,848	17,848	166,874	79,513	51,865	195,628	106,494	78,846	59 7	26.0
Cuyahoga Co	10,012	8,271	142 443	115,577	152,455	123,848	814,248	336,663	181,201	123,370	94,149	94,149	937,618	430,812	275,350	1,090,073	554,660	399,196	63 4	28 0
Franklin Co	7,381	7,976	67,638	62,713	75,019	70,691	332,196	142,788	79,708	52,623	41,085	41,085	384,819	183,873	120,793	459,838	254,564	191,484	58 4	24 8
Hamilton Co	19,592	21,986	99,431	85,666	119 023	107,652	516,273	221,720	125,528	86,575	68,582	68,582	602,848	290,302	194,110	721,871	397,954	301,762	58 2	24 2
Lake Co	2,578	2,778	24,290	21,778	26,868	24,556	131,326	54,652	29,627	20,166	15,239	15,239	151,492	69,891	44,866	178,360	94,447	69,422	61 1	26 5
Lorain Co	1,259	1,262	9,746	8,952	11,005	10,214	49,127	20,686	11,278	8,151	6,166	6,166	57,278	26,852	17,444	68,283	37,066	27,658	59.5	25.4
Lucas Co	4,214	4,425	31,376	28,772	35,590	33,197	152,859	55,616	35,730	21,735	19,015	19,015	174,594	74,631	54,765	210,184	107,828	87,942	58 2	18 2
Mahoning Co.	3,779	3,903	21,050	18,679	24,829	22,582	95,979	40,163	22,040	15,611	10,245	10,245	111,590	50,408	32,285	136,419	72,990	54,867	59.8	24 8
Montgomery Co	4,559	4,913	39,592	36,330	44,151	41,243	191,772	88,731	45,938	30,476	23,710	23,710	222,248	112,441	69,648	266,402	153,684	110,891	58.4	27 9
Stark Co.	2,362	2,344	23,764	21,332	26,126	23,676	129,109	53,312	29,390	20,263	15,085	15,085	149,372	68,397	44,475	175,498	92,073	68,151	61.2	26 0
Summit Co.	5,193	5,565	41,439	39,477	46,632	45,042	204,026	87,465	47,923	32,546	25,284	25,284	236,572	112,749	73,207	283,204	157,791	118,249	58.3	25 0
Trumbull Co	2,949	3,070	21,355	19,006	24,304	22,076	99,823	41,406	22,680	16,061	16,799	16,799	115,884	58,205	39,479	140,188	80,281	61,555	56 1	23 3
Total - 12 counties	67,074	69,991	547,682	481,767	614,756	551,758	2,860,725	1,204,867	665,066	450,464	353,207	353,207	3,311,189	1,558,074	1,018,267	3,925,948	2,109,832	1,570,025	60.0	25 6
Clermont Co.	1,586	1,973	11,510	12,151	13,096	14,124	62,658	29,740	16,691	10,128	8,756	8,756	72,786	38,496	25,447	85,882	52,620	39,571	53.9	24 8
Geauga Co	323	314	3,886	3,545	4,209	3,859	22,094	9,065	5,019	4,860	2,424	2,424	26,954	11,489	7,443	31,163	15,348	11,302	63.7	17.4
Greene Co.	841	865	5,635	6,709	6,476	7,574	27,271	11,714	6,712	4,614	3,561	3,561	31,885	15,275	10,273	38,361	22,849	17,847	53.5	21 9
Medina Co	1,908	2,089	9,278	8,875	11,186	10,964	37,036	17,067	9,551	6,610	5,481	5,481	43,646	22,548	15,032	54,832	33,512	25,996	52.6	22 4
Warren Co.	2,410	3,275	13,110	15,862	15,520	19,137	64,768	37,332	20,538	10,943	11,402	11,402	75,711	48,734	31,940	91,231	67,871	51,077	44.0	24.8
Wood Co.	2,110	2,307	10,635	10,282	12,745	12,589	43,473	19,882	11,184	7,631	6,289	6,289	51,104	26,171	17,473	63,849	38,760	30,062	52.9	17 8
Total - 6 counties	9,178	10,823	54,054	57,424	63,232	68,247	257,306	124,800	69,695	44,786	37,913	37,913	302,086	162,713	107,608	365,318	230,960	175,855	51 9	23 9
Total - 18 counties	76,252	80,814	601,736	539,191	677,988	620,005	3,118,025	1,329,667	734,761	495,250	391,120	391,120	3,613,275	1,720,787	1,125,875	4,291,266	2,340,792	1,745,880	59.3	25 4

*No reduction in light-duty truck emissions was calculated because the credits for this particular vehicle category have yet to be established by EPA Appropriate adjustments will be made when the credits are made available

+Reduction attributable to Federal Motor Vehicle Control Program (FMVCP) and I/M.

‡Reduction attributable to I/M.

TABLE 156. DAILY CARBON MONOXIDE EMISSIONS FOR OPTIONS III, IV, V, AND VI UNDER ALTERNATIVE A (kg/day)

	Heavy-duty trucks						Light-duty vehicles									All vehicles				
	1977 diesel	1987 diesel	1977 gasoline	1987 gasoline	1977 total	1987 total	1977 auto	1987 without I/M auto	1987 I/M auto	1977 L-D truck	1987 without I/M L-D truck	1987 I/M L-D truck*	1977 total	1987 without I/M total	1987 I/M total	1977	1987 without I/M	1987 I/M	Percent[+] reduction 1977-1987 I/M	Percent[‡] reduction 1987-1987 I/M
Butler Co	3,196	3,494	25,558	23,485	28,754	26,981	143,987	61,665	34,463	22,887	17,848	17,848	166,874	79,513	52,311	195,628	106,494	79,292	59 5	25 5
Cuyahoga Co	10,012	[illegible]	142,443	115,577	152,455	126,848	814,248	336,663	183,761	12 337	94,149	94,149	937,618	430,812	277,910	1,090,073	554,660	404,755	62 9	27 0
Franklin Co	7,381	7,978	67,638	62,713	75,019	70,691	332,196	142,788	79,708	52,623	41,085	41,085	384,819	183,873	120,793	459,838	254,564	191,484	58 4	24 8
Hamilton Co	19,592	21,986	99,431	85,666	119,023	107,652	516,273	221,720	129,478	86,575	68,582	68,582	602,848	290,302	198,060	721,871	397,954	305,712	57 7	23 2
Lake Co	2,578	2,778	24,290	21,778	26,868	24,556	131,326	54,652	30,062	20,166	15,239	15,239	151,492	69,891	45,301	178,360	94,447	69,857	60 8	26 0
Lorain Co	1,259	1,262	9,746	8,952	11,005	10,214	49,127	20,686	11,302	8,151	6,166	6,166	57,278	26,852	17,468	68,283	37,066	27,682	59 5	25 3
Lucas Co	4,214	4,425	31,376	28,772	35,590	33,197	152,859	55,616	36,306	21,735	19,015	19,015	174,594	74,631	55,321	210,184	107,828	88,518	57 9	17 9
Mahoning Co	3,779	3,903	21,050	18,679	24,829	22,582	95,979	40,163	22,040	15,611	10,245	10,245	111,590	50,408	32,285	136,419	72,990	54,867	59 8	24 8
Montgomery Co	4,559	4,913	39,592	36,330	44,151	41,243	191,772	88,731	48,501	30,476	23,710	23,710	222,248	112,441	72,211	266,402	153,684	113,454	57 4	26 2
Stark Co	2,362	2,344	23,764	21,332	26,126	23,676	129,109	53,312	29,390	20,263	15,085	15,085	149,372	68,397	44,475	175,498	92,073	68,151	61 2	26 0
Summit Co	5,193	5,565	41,439	39,477	46,632	45,042	204,026	87,465	48,419	32,546	25,284	25,284	236,572	112,749	73,703	283,204	157,791	118,745	58 1	24 8
Trumbull Co	2,949	3,070	21,355	19,006	24,304	22,076	99,823	41,406	22,704	16,061	16,799	16,799	115,884	58,205	39,503	140,188	80,281	61,579	56 1	23 3
Total - 12 counties	67,074	69,991	547,682	481,767	614,756	551,758	2,860,725	1,204,867	676,134	450,464	353,207	353,207	3,311,189	1,558,074	1,029,341	3,925,948	2,109,832	1,584,099	59 7	24 9
Clermont Co	1,586	1,973	11,510	12,151	13,096	14,124	62,658	29,740	28,703	10,128	8,756	8,756	72,786	38,496	37,459	85,882	52,620	51,583	39.9	1 9
Geauga Co	323	314	3,886	3,545	4,209	3,859	22,094	9,065	8,562	4,860	2,424	2,424	26,954	11,489	10,986	31,163	15,348	14,845	52.4	3 3
Greene Co	841	865	5,635	6,709	6,476	7,574	27,271	11,714	10,983	4,614	3,561	3,561	31,885	15,275	14,544	38,361	22,849	22,118	42.4	3 2
Medina Co	1,908	2,089	9,278	8,875	11,186	10,964	37,036	17,067	16,454	6,610	5,481	5,481	43,646	22,548	21,935	54,832	33,512	32,899	40 0	1 8
Warren Co	2,410	3,275	13,110	15,862	15,520	19,137	64,768	37,332	35,630	10,943	11,402	11,402	75,711	48,734	47,032	91,231	67,871	66,169	27 5	2 5
Wood Co	2 110	2,307	10,635	10,282	12,745	12,589	43,473	19,882	18,383	7,631	6,289	6,289	51,104	26,171	24,672	63,849	38,760	37,261	41 7	3 9
Total - 6 counties	9,178	10,823	54,054	57,424	63,232	68,247	257,306	124,800	118,715	44,786	37,913	37,913	302,086	162,713	156,628	365,318	230,960	224,875	38 5	2 6
Total - 18 counties	76,252	80,814	601,736	539,191	677,988	620,005	3,118,025	1,329,667	794,849	495,250	391,120	391,120	3,613,275	1,720,787	1,185,969	4,291,266	2,340,792	1,808,974	57 9	22 7

*No reduction in light-duty truck emissions was calculated because the credits for this particular vehicle category have yet to be established by EPA. Appropriate adjustments will be made when the credits are made available.

+Reduction attributable to Federal Motor Vehicle Control Program (FMVCP) and I/M.

‡Reduction attributable to I/M.

SECTION 12

POSSIBLE EXTERNALITIES: INDIRECT IMPACTS

INTRODUCTION

The subject of indirect impacts arising from an I/M program is quite complex. To provide a complete picture of the program, indirect as well as direct impacts should be considered. The issues raised by these potential effects are extremely difficult to quantify. Many of these costs and benefits are qualitative and, as such, highly subjective. Also, much of the data that are available pertaining to these issues are either incomplete or inconclusive. In light of the problems inherent in these issues, attempts to completely quantify them would add confusion rather than provide useful information. In consideration of this, the discussion that follows is fairly general and primarily qualitative in nature. It is intended to identify some of the pertinent issues and the likely directions, if not the magnitudes, of various impacts.

I/M is designed to achieve a reduction in motor vehicle emissions levels. All other effects the program has are considered secondary or indirect. This section opens with a general discussion of these secondary impacts. General impacts on the vehicle user population and the repair industry are also noted. Some of the impacts of program implementation that are dealt with in this section are:

- Health benefits
- Impact on vehicle performance and vehicle life
- Impact of required maintenance costs
- Time costs of traveling to and from the inspection site
- Impact on repair industry employment

GENERAL PROGRAM IMPACTS

General Impacts

There are a number of benefits that are likely to accrue to society at large from a successfully implemented I/M program. Improving ambient air quality should create significant health benefits. A reduction in respiratory related medical problems is likely. This will, in turn, lead to a series of secondary or indirect effects. The average longevity of the population should increase slightly and fewer days of production in industry will be lost due to illness.[1]

To date, a substantial investment has been made in pollution control equipment on automobiles. This investment will continue to grow as new cars equipped with emissions control devices are produced to replace older vehicles lacking them. Emissions control systems deteriorate steadily in efficiency with use, unless they are periodically maintained. If unchecked, this deterioration can completely eliminate the benefits of installing the systems to begin with. As generally there are no visible signs of this equipment deterioration and, therefore, no incentive to correct these undetected malfunctions, the necessary maintenance is not likely to occur. An I/M program can have a major impact by insuring the integrity of these control devices and protecting a nationwide investment that (it is estimated) will reach $150 billion by 1980.[2] Benefits accruing from foregone pollution costs may run to several billions of dollars per year nationwide.

Should a vehicle safety inspection program be implemented in conjunction with an I/M program, substantial operating economies are possible. Combining these two programs in one facility can avoid duplication of personnel and fixed costs. Overhead can be shared, land requirements for a combined setup would be less than separate facilities require, etc. The incremental cost of adding safety inspections to an I/M network would be lower than the cost of establishing it independently. One private contractor estimates that the addition of safety inspections to a fully operational loaded-mode emissions testing facility would increase costs by roughly 20 to 30 percent. This estimate assumes the I/M facility has been designed with expansion in mind.

Impact on Vehicle Performance and Vehicle Life

The impact of I/M on these considerations is difficulty to quantify. The studies to date have not been conclusive. They have centered on the way I/M affects short and long run vehicle deterioration curves. The short run deterioration curve reflects the rate at which a vehicle deteriorates after it has been tuned, while the long run curve reflects the overall degradation in vehicle performance that occurs as it ages. Both curves, especially the short run deterioration curve, influence vehicle performance while the slope of the long run curve is more likely to be the primary determinant of vehicle longevity. To the extent that I/M influences the short run curve, it should have a positive impact on vehicle performance. If an engine stays closer to manufacturer's specifications, it should perform at a higher level due to I/M.

The influence on performance and longevity resulting from I/M's impact on the long run deterioration curve is unknown now. It seems sensible that a properly maintained vehicle will experience less wear than one that is not maintained to manufacturers' specifications. Assuming this relationship is true, I/M should have a positive effect on vehicle life.

At present there are no closely controlled studies which document the effects of I/M on vehicle performance and vehicle life. However, the City of Phoenix, Arizona, which has designed specific I/M programs for larger vehicle fleets, has reported that these fleet operators maintain detailed records of maintenance and operating costs for their vehicles over the life cycle of the vehicles. These records apparently document the decreased operating and maintenance costs they have experienced with I/M implementation, as well as improved vehicle reliability, as seen in towing records.[3]

Impact on Vehicle Owners

The improvement in fuel economy that results from an I/M program is an important benefit for vehicle owners. The total improvement in fuel economy varies according to the geographical coverage and is discussed in each individual alternative section. The vehicle owners view the fuel savings as an individual economic issue, whereas the total or aggregate fuel savings is actually an important energy conservation savings as well.

The cost savings that result from the improvement in fuel economy, the better engine performance and increased longevity are not readily apparent to the individual motorists, although the fleet owners who have good long-term records will be able to perceive these benefits over time. It is important, therefore, that the motoring public be made aware of these benefits.

On the other hand, the obvious costs of repairs for failed vehicles will be readily apparent to the vehicle owners. The question arises, however, as to how much of these repair costs should be directly attributable to the I/M program. While it is true that a vehicle owner is forced to make a repair if his vehicle does not comply, it is inaccurate to charge the entire cost of mandated repairs to I/M requirements. I/M will cause vehicles to be repaired more completely and frequently than they would be without it. Indeed, this is the purpose of I/M. But a fraction of the repair cost would have been incurred regardless. Estimates of the magnitude of this fraction vary from 25 to 75 percent.

This issue of mandated repairs is central to I/M program externalities. The costs of these repairs are a burden on the vehicle owner. These costs will not be distributed evenly throughout the population. It is safe to assume that older vehicles will generally be owned by individuals at the lower end of the economic spectrum. These vehicles are more likely to require repairs than newer vehicles. If these vehicles fail to meet I/M standards more frequently than newer vehicles, the burden of I/M could fall unevenly on lower income segments of the population. This uneven impact is partially mitigated by establishing exemptions to compliance based on vehicle age and ceilings on the dollar value of mandated repairs.

As the vehicle mix changes over time, this problem will become less severe than it may be now. As older vehicles, those that are costly to maintain to standards, dropout of the vehicle population, they will be replaced by used vehicles. Vehicles included in a mandatory I/M program are likely to be well maintained. It is possible that this may lower the overall cost of maintaining vehicles throughout their serviceable life.

This trend will be countered to a certain extent because vehicles filtering down via resale will be equipped with various emissions control devices. This equipment has been covered by a 50,000-mile guarantee by manufacturers as a result of federal warranty requirements. The useful life of emission control devices covered by warranty is not presently known. Of course, if these devices prove to be as durable as the vehicles in which they are installed, they will not create extra repair costs as these vehicles age. Should they require replacement after 50,000 miles but prior to the end of a vehicle's life, the cost of doing so will fall on the used car owner who is generally in a lower income category than the initial purchaser. Replacing control devices could become costly. Thus, if these devices do require extensive maintenance to be kept operating correctly near the end of a vehicle's life, I/M may impose a greater financial burden on the used vehicle owner than it will on the public at large. If this proves the case, it will add another reason for exempting vehicles reaching a certain age.

Establishing an accurate average cost for repairs that are induced by I/M is difficult. General data from existing programs can provide a starting point in contemplating the magnitude of this figure. For California's Riverside Trial Program, the average repair cost for a vehicle failing inspection, including parts, tax and labor was $11.42 when adjusted to remove voluntary repairs made at the time required repairs were performed.[4] This figure applies repair costs for a 40 percent stringency rate over the entire vehicle population tested. Average repair values for California were $27.33 and $32.08 for idle- and loaded-mode testing. In a similar study in Michigan these figures were $23.29 and $36.56.[5]

In these studies, the repair costs directly attributable to I/M may not be accurate. This is for two reasons. One reason, mentioned earlier, is that some of these repairs would have been made anyway, even if the I/M program was not in existence. Second, no accounting is made, nor can it be made with current data, of extra repair costs incurred in anticipation of inspection. It is likely that some vehicles that pass the first time through inspection have attained higher maintenance standards than they would have otherwise in order to avert failure and the inconvenience of traveling to the inspection site a second time for retesting.

The nature of repairs required to meet I/M standards for failed vehicles can help shed light on the burden noncomplying vehicle owners must bear. The Riverside Trial Program found that 66 percent of the diagnosed repair evaluations consisted of an imbalance in the idle air-to-fuel ratio. An additional 18 percent of vehicles failing were diagnosed as experiencing rich carburetion. These problems are neither difficult nor costly to rectify. Thus, the average repair cost figures may be somewhat misleading. Most vehicles requiring service will experience costs lower than the average reported figure. A small portion will have bills considerably in excess of the average reported figure. If these bills fall into waiver regions (either an absolute dollar limit on repair cost or a percentage of vehicle value figure), then assuming an average repair cost for all failed vehicles can overstate the total repair cost burden to vehicle owners; that is, the total cost of required repairs (those that do not exceed cost limit categories) may be less than the total cost of repairs reported by an I/M sequence.

There are other costs to vehicle owners relating to I/M in addition to repair costs and the vehicle inspection fee. Two major costs to consider are time and operating costs experienced traveling to and from inspection sites. Actual operating costs can be calculated fairly accurately. Time costs have a much more subjective nature.

The vehicle miles traveled (VMT) as a result of an I/M program depend on the size of the affected vehicle population, density of that population, siting of inspection stations, and so forth. A fairly reliable total VMT estimate can be used to determine total vehicle operating costs and time spent on those induced VMT. Applying an average emission level to these extra VMT can provide a rough estimate of emissions induced by the implementation of I/M.

An elusive but probably a more significant figure is the time cost of travel to and from, and waiting time at inspection facilities. There are evaluative decisions about the value of time spent traveling, waiting time, and so on that must be resolved before a dollar figure can be computed. The issue is complicated because different people value their time differently and even value different types of time differently (e.g., time spent driving versus time spent waiting at an inspection site). The value an individual places on his time is related to his income level. As income rises, an individual tends to value his time more highly.

Estimating operating and time costs is further complicated because it is difficult to determine what portion of these costs to assign directly to I/M requirements. Many times the trip to an inspection site is combined with other errands and stops. The total costs, time and operating, of such trips should be allocated between the different purposes served by them. It is also difficult to determine how circuitous the I/M stop is. It may require a substantial detour in some cases and none in others.

A potential benefit for the vehicle owner is money saved by utilizing diagnostic information provided by I/M to correct small problems before they become serious. By prompting repairs early on I/M can help eliminate substantial costs to the vehicle owner.

This brief overview of the impacts I/M may have for vehicle owners serves to emphasize the complex nature of program costs and benefits. A qualitative evaluation of them helps assure that they will be considered when implementing I/M.

Impact on the Automotive Repair and Parts Industry

It is safe to state that I/M implementation will result in an increased demand for repair activities and replacement parts. To the extent that I/M induces new repairs that would not have been performed otherwise, the repair industry will directly benefit from the program.

Job creation will be necessary to increase the supply of repair personnel to meet new demand. The ratio of mechanics to vehicles has been declining significantly over the last few decades. In 1950 there were 73 vehicles for every mechanic nationwide. By 1975 this ratio decreased to one mechanic available for every 146 vehicles. This trend cannot continue if I/M becomes a reality. As emissions regulations increase, vehicle complexity will extend repair times for existing components. New subsystems will also be created that will eventually require repair and the demand for mechanic time will increase for each vehicle.

In addition to recruiting and training new mechanics, existing personnel should undergo at least a limited retraining phase to orient them to the purposes and goals of I/M and emissions control. In some cases the needs of I/M are in conflict with maintenance standards now existing that emphasize high engine performance. It is important that the repair industry be aware of the different criteria demanded by I/M so that it may act accordingly.

No matter how responsive the supply of mechanics is to this increase in demand, some lag is inevitable. Because of this, windfall profits may accrue to existing members of the industry for an initial time period. The tight supply situation could result in some overcharging. This should be brief, as new mechanics will be trained and in turn enter the labor pool as the public becomes aware of the implications of I/M. As the supply of repair personnel expands, the consumer will again be able to choose between many repair shops. This will make overpricing practices more difficult. Also, a well supervised maintenance sequence should help deter potentially disruptive behavior by the repair industry.

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SECTION 13

LEGISLATIVE CONSIDERATIONS IN I/M IMPLEMENTATION

INTRODUCTION

Legislative requirements and potential roadblocks that are not applicable to all options, but which could adversely affect implementation of one or several options, were researched for the Ohio inspection/maintenance options. The reason for looking at these potential problem areas is to determine, at an early planning/evaluation stage, if there are any legal, legislative or other issues related to any option under consideration which could potentially hinder its acceptance by the state legislature.

METHODOLOGY

The methodology used to research this problem consisted of two stages. In the first stage the options themselves were studied in detail to determine what legal, organizational, or institutional problems, conflicts, or implications, if any, exist. Also, model legislation for inspection/maintenance programs provided by U.S. EPA was studied. U.S. EPA was also consulted to determine if they had uncovered problem areas which should be researched further. The second phase consisted of studies of inspection/maintenance programs in other states. Directors and staff members were asked to comment on particular problems they had encountered, and enabling legislation for several states was studied.

Because the state of Ohio has not involved the state legislature at this early stage in the program's planning stage it would not be able to provide appropriate comments on the options and was not contacted. At a later stage in the development of the I/M program, the legislature will become more directly involved and will presumably draft enabling legislation that minimizes potential problem areas.

POSSIBLE POLITICAL CONSTRAINTS

While the technical feasibility of I/M has been proven, many jurisdictions have experienced difficult problems enacting legislation. Program implementation has often been hindered by substantial secondary program impacts. While I/M is designed to help realize certain ambient air quality standards it also produces significant political, social and institutional impacts.

These indirect program impacts are discussed in Section 12. They illustrate the wide scope of the impact an I/M program has on the citizenry at large. Some of these impacts carry political implications that require consideration when I/M enabling legislation is passed. Among others, the following impacts are pertinent:

- Impact on low income citizens
- Impacts on the automotive repair and parts industry
- Potential overcharging for repairs and performance of unnecessary repair work
- General inconvenience of I/M compliance to the general public

Legislatures are quick to recognize how I/M programs directly affect the public. They realize that a few complaints about the program can result in widespread public attention by the press and various interest groups that are adversely affected by program implementation. These impacts must be carefully considered during the early phases of selecting an option and planning the program.

While these indirect program impacts are discussed in Section 12, it is worth mentioning some of the political aspects of these effects that are likely to affect the probability of successful implementation here.

A major argument likely to be made by consumer protection groups and legal aid societies, etc. is that low income citizens will be denied the right to operate an old vehicle because the cost of maintaining that vehicle's emissions level to I/M standards is prohibitive. This argument attacks the concept of imposing a mandatory maintenance scheme and will likely be made regardless of the option ultimately chosen.

A properly designed I/M program can take this issue into account and establish certain criteria to exempt just this type of vehicle from the mandatory maintanance phase, ameliorating the potentially regressive nature of the program. There are several types of compliance exemptions. A ceiling can be placed on repair costs that is based on either an absolute dollar figure or a percentage of vehicle value, whichever is lower. Also, all vehicles over a certain age are usually granted exemptions.

These exemptions will not have a significant effect on the ability of an I/M program to achieve a reduction in total vehicle emissions. A majority of the vehicles that are seriously out of compliance and costly to repair are older vehicles. They will not remain usable for long periods of time so they will tend to be quickly eliminated from the total vehicle population. The vehicles that filter down over time to replace these gross emitters will have been maintained as a result of I/M and should not be costly to keep in compliance towards the end of their usable life.

The automotive repair and parts industry has a great deal of lobbying strength that must be considered when designing a program. Members of the industry will want to know how I/M will affect their ability to maintain vehicle performance to standards their customers are accustomed to. There are likely to be doubts concerning the accuracy of HC/CO analyzers and the ability of private garages to profitably finance the program's equipment requirements.

Need for Public Information Program

Many of the questions raised by I/M can be properly answered with a well designed public information program (see Appendix C). It can go far towards gaining public acceptance for I/M and allaying fears about price gouging, varying program effectiveness, etc. Legislators are liable to be sensitive to problems similar to those that have been experienced in safety inspection programs. The intangible nature of program benefits makes the costs of I/M seem without reward. Emphasizing the checks and balances built into the program (i.e., equipment inspection and calibration schedules) and that, while not readily visible, health benefits from emission reductions are real will help smooth the implementation procedure.

A public information program can address other benefits to the vehicle owner. Improvements in fuel economy and the impact I/M has on vehicle performance and longevity are good points to stress. Control of offensive vehicles that emit high quantities of visible smoke and assurances that all vehicles will be tested and certified to comply with clean air requirements are also good points to stress. If the preconceptions held by the public and the repair industry can be successfully corrected by a public information program it will have gone a long way towards easing the legislative problems standing between a proposal for I/M and its final implementation.

POTENTIAL OPTION SPECIFIC ISSUES

The differences that exist between the various options raise the possibility that legislative roadblocks could exist that may adversely affect the implementation of one or more, but not all, options. Identifying such potential areas of friction at an early stage in the planning process is important. Proper consideration of these variations when drafting and enacting I/M anabling legislation should greatly reduce option specific legislative problems.

Designated Lead Agency

Not all variations between options affect the likelihood of implementation problems. A substantial difference in designated lead and administrative agencies from option to option could have an impact on the viability of certain options. All seven alternatives designated the Ohio Environmental Protection Agency (OEPA) and the Bureau of Motor Vehicles (BMV) as administrative agencies. Options V and VI also designate the Ohio Highway Patrol (OHP) as an enforcement agency. The OHP can be included either by amending the EPA supplied I/M sample regulation or designating it's task independently from the I/M program. The latter approach is probably more straight forward.

Geographic Coverage

Geographic coverage varies across options, from SMSA coverage only to state wide coverage. The sample I/M regulation specifies program applicability to all registered light duty vehicles (LDV) in certain Air Quality Control Regions (AQCR) enumerated in the enabling legislation. The criteria for approval for

1979 State Implementation Plan (SIP) revisions for nonattainment areas provide more flexibility in establishing the geographic scope of the program by allowing "a certain degree of flexibility" in defining the specific boundaries of an urban area. A major urban area is defined as having an urbanized population of 200,000 or greater. There appear to be no legal constraints at the state level regarding the establishment of the geographic scope of an I/M program. Thus, differences in geographic coverage between options are not affected in an option specific manner by state authority.

Mixed Options

Options I, II, V, and VI are really mixed options in the sense that there are both centralized and decentralized approaches and also different agencies having control over the program. In options I and II either a private contractor or the state would run centralized lanes in urban areas while private garages would conduct inspections in rural areas with the state maintaining administrative control. In options V and VI the Ohio Highway Patrol would operate a random emission testing program, along with the existing safety program presumably, while in the urban areas a contractor or the state would run centralized lanes. Dividing the type of approach used in urban versus rural areas can potentially capitalize on the particular advantage that each approach may have for that type of area, whether it be rural or urban. Centralized lanes which utilize high technology are most cost effective in high density urban areas. In rural areas, the low density of motor vehicles makes the fixed centralized lanes less cost effective, at least for the counties with fewer vehicles than the capacity of a one lane station. Consequently, there is a need for a different approach in rural areas. One possibility worth considering is the use of mobile vans. Another approach would be to locate centralized stations in a town which is accessible to one or more counties depending on the size and travel distances involved.

Whenever there is a totally different approach to inspection in the urban and rural areas there is the possibility of encountering an equity problem. In the options discussed above this would be the case. Motorists might perceive a difference in the quality control or accuracy of test procedures with private garages or the State Highway Patrol in rural areas. In either case it would be difficult to obtain the same level of control over the accuracy of the analyzer or the test procedure itself. Moreover, in the private garage system, there is a greater likelihood of a conflict of interest situation occurring. This will be discussed in more detail below.

Private Garages

It should also be recognized in general that any options which utilize private garages may create problems as discussed earlier. This is for two reasons. One is that there is more difficulty in keeping the large number of private garage analyzers in calibration. Hence, there are serious quality assurance problems in utilizing private garages, although with proper controls this can be somewhat ameliorated. The second reason has to do with the conflict of interest inherent in having the same garage do the testing and then perform the indicated maintenance. Also, the automobile repair industry is currently under attack from consumer groups and its reputation is at a low level. The fact that there have been difficulties with emission equipment in new cars simply adds to this problem as there is a long time interval between the manufacturing of the cars with more complicated emission controls and the automobile service industry's retraining to learn all the new procedures needed for adequate repair of emission controls. Routine maintenance will also become more complicated as the controls are added on.

Licensing Problems

Some options may encounter licensing problems, especially the private garage and contractor approaches. Both are subject to EPA licensing requirements that do not affect the state approach. An EPA-approved training and certification program for inspector/mechanics must be established by the state for these two approaches. A private garage must have a licensed inspector/mechanic present in order to be certified as an I/M inspection station. Facilities operated by private contractors must also have certified personnel on hand.

At this point, EPA officials have declined to elaborate on licensing requirements and procedures pending the release of a position paper that will deal explicitly with these issues. The licensing procedure should consist of similar requirements for the nongovernment options, contractor and private garage. These should be no problem from the state viewpoint regarding a licensing procedure of the type the EPA is contemplating.

The private garage approach incurs higher administrative costs because more facilities must be licensed and federally required periodic inspections of equipment in those facilities will be more costly than for centralized I/M lanes.

While licensing requirements reduce the attractiveness of private approaches, tax considerations favor them over state-operated facilities. From a municipal point of view, the contractor approach is most favorable while a state-run facility is least favorable. If the latter approach is chosen, the land on which inspection facilities are sited would be purchased by the state, removing it from municipal property tax rolls. While this is technically a transfer from the municipality to the state and not a cost or benefit, it is a real loss in funds to the municipality. This fact may generate opposition from the affected municipalities.

Personnel Requirements

Options that call for state-run facilities will demand a large state personnel commitment. This could prove unpopular, resulting in implementation difficulties. Adding a significant number of employees to the state payroll will incur a large expense that will be difficult to reduce in the future. Future pension requirements may not be covered by inspection fees, possibly leading to an ongoing deficit problem, depending on how the state deals with this problem.

Regarding personnel policies, more flexibility exists with the private approaches. If program manpower requirements change, a contractor will be able to respond more rapidly and with fewer political pressures than the state could.

Funding

A final consideration that may have option-specific implications is the different types of funding required for various options. The availability of funding for capital costs versus operating and administrative costs may have a significant impact on the probability of implementing certain options. Consideration may be given to leasing state facilities to contractors or leasing private facilities for state use to ameliorate adverse effects that funding problems may cause.

CONCLUDING REMARKS

In large part, legislative problems are likely to be political in origin. There are no purely legal federal or state roadblocks to any of the options presented. Rather, the nonlegal ramifications of the various options are more pertinent.

While it would be ideal if all potential problems could be anticipated when enacting I/M legislation, it is unlikely that all such difficulties will be taken into account. The enabling legislation should be flexible enough to allow a degree of discretion for the administrative agencies involved. Leeway on quality controls, cut points, etc. should improve program effectiveness considerably. Building such discretion into regulatory authority should shorten lead times and prove cost effective as well as flexible.

SECTION 14

COMPARISON OF OPTIONS

COMPARISON OF EMISSION REDUCTION BENEFITS

The levels of emission reduction that result from the implementation of I/M programs depend on the number of vehicles inspected in the program and also on the travel characteristics in the county where the vehicles are registered. This is because emission reduction credits are calculated as grams per mile multiplied by the VMT (vehicle miles traveled) per unit of time. The emission reductions ("tailpipe reductions") refer to the decrease in carbon monoxide (CO) and hydrocarbons (HC) from the I/M vehicles. The resulting change in the concentrations of these substances in the ambient atmosphere is not being considered here.

The emission reductions vary according to the geographical coverage. As the geographical coverage is increased, more vehicles are included in the program. However, the actual emission reductions are modified to a degree by the fact that, due to commuting patterns, there is overlap in travel among the counties. Vehicles traveling outside their county of registration, in other words, may either increase or decrease the emission reductions in the counties traveled to, depending on whether the counties traveled to or from have I/M programs. If vehicles registered in a county with I/M regularly travel to counties without I/M, then the county traveled to will experience a benefit in emission reduction. Conversely, if vehicles registered in counties without I/M travel to a county with I/M, then the county traveled to would experience less benefits. In the calculations made in this study (described in detail in Section 2 - Benefits, and Appendix A) all the above factors have been considered.

To estimate the emission reductions, the options have been grouped into three benefit scenarios as shown below:

BENEFIT SCENARIOS

	12 Most populous counties	6 Next populous counties	Remainder of state
First scenario: (Options I, II, VIIO	Mandatory inspection	Mandatory inspection	Mandatory inspection
Second Scenario: (Options III, IV, V, VI under Alternate B)	Mandatory inspection	Mandatory inspection	NO mandatory inspection
Third Scenario: (Options III, IV, V, VI, under Alternate A)	Mandatory inspection	NO mandatory inspection	NO mandatory inspection

Within each benefit scenario the geographic areas having mandatory inspection are identical. In benefit scenario 1, all I/M programs are statewide and mandatory. In the second and third scenarios there is mandatory inspection only in the urban; i.e., most populous areas, whereas in the remainder of the state there is no mandatory inspection. In Options V and VI the random pullover inspection program for the rural areas does not constitute mandatory inspection.

Table 157 presents the benefits (percent reduction in daily vehicle emissions) for 1987 that result from an I/M program beginning in 1982. In terms of carbon monoxide it may be seen that in scenario 1 the statewide mandatory inspection options bring about the highest level of emission reduction of 27 percent throughout the state. Next, the second scenario with mandatory I/M in the 18 urban counties gives the second highest reduction 25, 3, and 17 percent in the 18 urban counties, remaining rural, and statewide average, respectively. Finally, the third scenario, with mandatory inspection in the 12 urban counties with populations greater than 200,000 have the least emission reduction of 23, 3, and 15 percent for the 18 counties, remaining counties, and statewide average, respectively. As discussed earlier in both the second and third scenarios in the counties without I/M there is some emission reduction due to inspected vehicles traveling to these counties. The reductions in hydrocarbons follows the same pattern as the carbon monoxide reductions, discussed above.

TABLE 157. PERCENT REDUCTION IN DAILY VEHICLE EMISSION RESULTING FROM I/M in 1987*

	First Scenario (Options I, II and VII)	Second Scenario (Options III, IV, V, VI, under Alternate B)	Third Scenario (Options III, IV, V, VI, under Alternate A)
CARBON MONOXIDE			
18 Counties	27	25	23
Rural areas	27	3	3
Statewide	27	17	15
HYDROCARBONS			
18 Counties	22	21	19
Rural areas	22	2	2
Statewide	22	14	12

*No reductions in light-duty truck emissions was calculated because the credits for this particular vehicle category have yet to be established by EPA. Appropriate adjustments will be made when the credits are made available.

Tables 158 through 160 present much more detailed emissions and emission reduction figures by county both in actual emission levels by volume and in percent reduction levels with and without I/M programs. In the first three columns for HC and CO actual emissions are given. The first column for HC and CO shows total emissions in 1977, the base year. Next, the emissions expected in 1987 without an I/M program are given. The lower figures for 1987 as compared to 1977 are attributable to the Federal Motor Vehicle Emission Control Program (FMVCP) and changes in VMT. The third column, 1987 I/M, indicates the level of emissions that would occur with I/M in addition to the FMVCP. The fourth columns (HC and CO) percent reduction between 1977 and 1987 I/M give the percent reduction for the total vehicle population (not just the inspected vehicles) that would occur as a result of FMVCP. Finally, the fifth columns, 1987 reduction due to I/M, present the percent reduction in emissions for all vehicles that is attributable to I/M in addition to the FMVC.

FUEL ECONOMY BENEFITS

One of the important benefits of I/M programs, in addition to the reduction in vehicular emissions, is potential fuel conservation. A properly-tuned engine operates with greater efficiency and therefore, consumes less fuel. This improvement in fuel economy varies somewhat from one program to another but most sources agree that a 5 to 10 percent fuel economy improvement for the failed and maintained vehicles can be expected.[1] This may understate the overall fleet improvement as some motor vehicle owners are likely to schedule tune-ups just prior to having their cars inspected. One of the purposes of I/M is to give an incentive to motorists to maintain their cars better than they normally would in the absence of I/M.

A 7 percent fuel economy improvement was utilized in this study to calculate the fuel savings from the I/M program options. With a stringency (failure) rate of 30 percent, the amount of fuel saved averaged for the total motor vehicle population will amount to a 2.1 percent of total fleet fuel consumption. For a detailed discussion of the methodology used for calculating fuel savings the reader is referred to Appendix B. Estimated Fuel Savings Resulting from I/M in 1987. As shown below, for the 12 county Alternate A, 28,898,530 gallons of fuel would be saved in 1987. At $0.70 per gallon, vehicle owners will save $20,228,970 which is approximately $11.80 per failed vehicle. If coverage is extended to 18 counties as in Alternate A, motorists will consume 31,844,630 fewer gallons than without I/M saving a total of $22,291,241, which is approximately $11.85 per failed vehicle. The statewide program coverage provides the largest savings of 37,171,280 gallons which would amount to $26,019,896, which would be approximately $9.10 per failed vehicle.

TABLE 158. EMISSIONS AND PERCENT REDUCTIONS IN SCENARIO 1, OPTIONS I, II, AND VII (kg/day)*

County	Hydrocarbons					Carbon monoxide				
	1977	1987 without I/M	1987 I/M	Percent+ reduction between 1977 and 1987, I/M plus FMVPC	1987 reduction due to I/M	1977	1987 without I/M	1987 I/M	Percent+ reduction between 1977 and 1987, I/M	1987 reduction due to I/M
Butler	26,495	10,676	8,277	68.8	22.5	195,628	106,494	77,712	60.3	27.0
Cuyahoga	144,270	54,544	42,772	70.4	21.6	1,090,073	554,660	397,580	63.5	28.3
Franklin	68,261	26,477	19,830	71	25.1	459,838	254,564	187,834	59.2	26.2
Hamilton	91,740	40,072	31,547	65.6	21.3	721,871	397,954	290,544	59.8	27.0
Lake	25,506	9,393	7,322	71.3	22.1	178,360	94,447	68,856	61.4	27.1
Loraine	10,132	3,659	2,884	71.5	21.2	68,283	37,066	27,375	59.9	26.1
Lucas	31,713	11,605	9,116	71.3	21.5	210,184	107,828	86,836	58.7	19.5
Mahoning	20,390	7,344	5,836	71.4	20.5	136,419	72,990	54,182	60.3	25.8
Montgomery	39,894	14,534	11,437	71.3	21.3	266,402	153,684	108,809	59.2	29.2
Stark	26,149	9,158	7,149	72.7	21.9	175,498	92,073	67,102	61.8	27.1
Summit	42,177	15,571	12,255	71	21.3	283,204	157,791	116,866	58.7	25.9
Trumbull	20,772	7,358	5,819	72	20.9	140,188	80,281	60,864	56.6	24.2
Total - 12 counties	547,499	210,391	164,244	70	21.9	3,925,948	2,109,832	1,548,554	60.6	26.6
Clermont	11,668	5,530	4,395	62.3	20.5	85,822	52,620	38,723	54.9	26.4
Geauga	4,330	1,531	1,192	72.5	22.2	31,163	15,348	11,107	64.4	27.6
Greene	5,720	2,111	1,673	70.6	20.8	38,361	22,849	17,361	54.7	24.0
Medina	8,040	3,360	2,642	67.1	21.4	54,832	33,512	25,525	53.4	23.8
Warren	12,938	6,719	5,307	59	21	91,231	67,871	50,395	44.8	25.7
Wood	9,563	3,792	3,044	68.2	19.7	63,849	38,760	29,457	53.9	24.0
Total - 6 counties	52,259	23,043	18,253	65.1	20.8	365,318	230,960	172,568	52.8	25.3
Total - 18 counties	599,758	233,434	182,497	69.6	21.8	4,291,266	2,340,792	1,721,122	59.9	26.5

*No reduction in light-duty truck emissions was included because the credits for this particular vehicle category have yet to be established by EPA. Appropriate adjustments will be made when the credits are made available.

+Reduction attributable to Federal Motor Vehicle Control Program (FMVCP) and I/M.

TABLE 159. EMISSIONS AND PERCENT REDUCTIONS IN SCENARIO 2, OPTIONS III, IV, V, AND VI UNDER ALTERNATE B (kg/day)*

County	Hydrocarbons					Carbon monoxide				
	1977	1987 without I/M	1987 I/M	Percent[-] reduction between 1977 and 1987, I/M plus FMVPC	1987 reduction due to I/M	1977	1987 without I/M	1987 I/M	Percent[-] reduction between 1977 and 1987, I/M	1987 reduction due to I/M
Butler Co.	26,495	10,676	8,370	68.4	21.6	195,628	106,494	78,846	59.7	17.4
Cuyahoga Co.	144,270	54,544	42,893	70.3	21.4	1,090,073	554,660	399,198	63.4	28.0
Franklin Co.	68,261	26,477	20,193	70.4	23.7	459,838	254,564	191,484	58.4	24.8
Hamilton Co.	91,740	40,072	32,157	65.0	19.6	721,871	397,954	301,762	58.2	24.2
Lake Co.	25,506	9,393	7,368	71.0	21.6	178,360	94,447	69,422	61.1	26.5
Lorain Co.	10,132	3,659	2,907	71.3	20.6	68,283	37,066	27,658	59.5	25.4
Lucas Co.	31,713	11,605	9,247	70.9	20.3	210,184	107,828	87,942	58.2	18.2
Mahoning Co.	20,390	7,344	5,891	71.1	19.8	136,419	72,990	54,867	59.8	24.8
Montgomery Co.	39,894	14,534	11,581	71.0	20.3	266,402	153,684	110,891	58.4	27.9
Stark Co.	26,149	9,158	7,313	72.0	20.2	175,498	92,073	68,151	61.2	26.0
Summit Co.	42,177	15,571	12,367	70.7	20.6	283,204	157,791	118,249	58.3	25.0
Trumbull Co.	20,772	7,358	5,874	71.7	20.2	140,188	80,281	61,555	56.1	23.3
Total - 12 counties	547,499	210,391	166,161	69.7	21.0	3,925,948	2,109,832	1,570,025	60.0	25.6
Clermont Co.	11,668	5,530	4,464	61.8	19.3	85,882	52,620	39,571	53.9	24.8
Geauga Co.	4,330	1,531	1,208	72.1	21.1	31,163	15,348	11,302	63.7	17.4
Green Co.	5,720	2,111	1,712	70.0	18.9	38,361	22,849	17,847	53.5	21.9
Medina Co.	8,040	3,360	2,684	66.6	10.8	54,832	33,512	25,996	52.6	22.4
Warren Co.	12,938	6,719	5,362	58.6	20.2	91,231	67,871	51,077	44.0	24.8
Wood Co.	4,563	3,792	3,093	67.7	18.4	63,849	38,760	30,062	52.9	17.8
Total - 6 counties	52,259	23,643	18,523	64.6	21.7	365,318	230,960	175,844	51.9	23.9
Total - 18 counties	599,758	233,434	184,684	69.2	20.9	4,291,266	2,340,792	1,745,880	59.3	25.4

*No reduction in light-duty truck emissions was included because the credits for this particular vehicle category have yet to be established by EPA. Appropriate adjustments will be made when the credits are made available.

[-] Reduction attributable to Federal Motor Vehicle Control Program (FMVCP) and I/M.

TABLE 160. EMISSIONS AND PERCENT REDUCTIONS IN SCENARIO 3, OPTIONS III, IV, V, AND VI UNDER ALTERNATE A (kg/day)[*]

County	Hydrocarbons					Carbon monoxide				
	1977	1987 without I/M	1987 I/M	Percent[†] reduction between 1977 and 1987, I/M plus FMVPC	1987 reduction due to I/M	1977	1987 without I/M	1987 I/M	Percent[†] reduction between 1977 and 1987, I/M	1987 reduction due to I/M
Butler Co.	26,495	10,676	8,407	68.3	21.3	195,628	106,494	79,292	59.5	25.6
Cuyahoga Co.	144,270	54,544	43,085	70.1	21.0	1,090,073	554,660	404,758	62.9	27.0
Franklin Co.	68,261	26,477	20,193	70.4	23.7	459,838	254,564	191,484	58.4	24.8
Hamilton Co.	91,740	40,072	32,458	64.6	19.0	721,871	397,954	305,712	57.7	23.2
Lake Co.	25,506	9,393	7,403	71.0	21.2	178,360	94,447	69,857	60.8	26.0
Lorain Co.	10,132	3,659	2,909	71.3	20.5	68,283	37,066	27,682	59.5	25.3
Lucas Co.	31,713	11,605	9,315	70.6	19.7	210,184	107,828	88,518	57.9	17.9
Mahoning Co.	20,390	7,344	5,891	71.1	19.8	136,419	72,990	54,867	59.8	24.8
Montgomery Co.	39,894	14,534	11,758	70.5	18.1	266,402	153,684	113,454	57.4	26.2
Stark Co.	26,149	9,158	7,233	72.3	21.0	175,498	92,073	68,151	61.2	26.0
Summit Co.	42,177	15,571	12,407	70.6	20.3	283,204	157,791	118,745	58.1	24.8
Trumbull Co.	20,772	7,358	5,876	71.7	18.0	140,188	80,281	61,579	56.1	23.3
Total - 12 counties	547,499	210,391	166,945	69.6	20.9	3,925,598	2,109,832	1,584,099	59.7	24.9
Clermont Co.	11,668	5,530	5,445	53.3	1.5	85,882	52,620	51,583	39.9	1.9
Geauga Co.	4,330	1,531	1,491	65.6	2.0	31,116	15,348	14,845	52.4	3.3
Greene Co.	5,720	2,111	2,053	64.1	2.7	38,361	22,849	22,118	42.4	3.2
Medina Co.	8,040	3,360	3,305	58.9	1.6	54,832	33,512	32,899	40.0	1.8
Warren Co.	12,938	6,719	6,582	49.1	2.0	91,231	67,871	66,169	27.5	2.5
Wood Co.	9,563	3,792	3,672	61.6	3.2	63,849	38,760	37,261	41.7	3.9
Total - 6 counties	52,259	23,643	22,548	56.9	2.0	365,318	230,960	224,875	38.5	2.6
Total - 18 counties	599,758	233,434	189,493	68.4	18.8	4,291,266	2,340,792	1,808,974	57.9	22.7

[*] No reduction in light-duty truck emissions was included because credits for this particular vehicle category have yet to be established by EPA. Appropriate adjustments will be made when the credits are made available.

[†] Reduction attributable to Federal Motor Vehicle Control Program (FMVCP) and I/M.

ANNUAL FUEL SAVINGS (GALLONS)

	Total fuel savings	Dollar savings at $0.70 gallon	Savings per failed vehicle
Alternate A - 12 County	28,898,530	$20,228,970.00	$11.80
Alternate B - 18 County	31,844,630	$22,291,241.00	$11.85
Statewide	37,171,280	$26,019,896.00	$ 9.10

COMPARISON OF COSTS

The major cost components are summarized for all options in Table 161. In the first four columns are shown the cost components for the urban areas only, alternates A and B for Options I through VI. In Options I, III, and V the higher contractor costs result from taxes, which increase annual operating costs by over $1 million. However, when choosing between state and contractor run facilities, fee differences due to taxes should not be considered since taxes are just transfers. The $1 million dollars that motorists pay the contractor for taxes will reduce the government's revenue requirements by $1 million dollars, and thus reduce taxes by $1 million. A second impact of taxes, redistribution of revenue between governmental bodies, should be considered. In particular, the loss of property tax revenue in communities with state-run I/M facilities may be politically important.

In terms of the start-up costs there is a cost saving of approximately $600,000 for a contractor approach in comparison to a state-run option. The reason for this is that the implementation period for a contractor is about 1-1/2 years in comparison to 2-1/2 years for the state.

In the fourth and fifth columns the state costs to administer and conduct surveillance of the private garage program in the rural areas are shown. The totals in columns six through nine reflect the urban and rural areas costs. Finally the last three columns show the costs to the state for administration and surveillance of a statewide private garage program. These costs are shown for three levels of participation. The first column is the minimum level of participation, when approximately 18 percent of the total service stations, garages, and car dealers participate. In the other two columns are shown a midlevel, 33 percent and maximum level of 45 percent. As explained in detail in Sections 4 and 10, these levels were derived on the basis of certain assumptions. The minimum participation level represents the minimum number of garages needed to actually conduct all the inspections working a full 8-hour day. As participation increases there would be fewer cars inspected per station. At the maximum participation level a participating station would just break even in terms of the total revenues being equal to the total expenses including salaries, overhead, analyzer costs, etc. The midlevel is a midpoint between the minimum and maximum levels.

TABLE 161. ANNUAL COSTS*

Annualized costs	Options												
	I, III, V (Contractor) urban areas†		II, IV, VI (State-run) urban areas†		I, II‡,§ Rural areas state costs		I Total		II Total		VII§ Total state costs		
	A	B	A	B	A	B	A	B	A	B	Min	Mid	Max#
I. Annualized Capital Costs													
1. Land	160,378	179,837	160,378	179,837	0	0	160,378	179,837	160,378	179,837	103,008	103,008	103,008
2. Building	1,046,442	1,159,747	1,046,422	1,159,747	0	0	1,046,422	1,159,747	1,046,422	1,159,747	47,502	76,734	104,748
3. Equipment	1,856,824	2,096,503	1,856,824	2,096,503	103,269	87,601	1,960,093	2,184,104	1,960,093	2,184,104	33,236	52,228	72,407
II. Annualized Start-Up Costs	1,124,953	1,219,102	1,259,981	1,354,129	176,323	157,745	1,301,276	1,376,847	1,436,304	1,511,874	898,685	1,070,634	1,242,583
III. Annual Operating Costs	11,725,853	12,788,409	10,667,013	11,609,803	577,856	496,788	12,303,709	13,285,197	11,245,681	12,106,591	2,409,777	2,625,977	2,833,377
IV. Annual Administrative Costs	1,469,576	1,547,608	1,469,576	1,547,608	1,123,920	970,920	2,593,496	2,518,528	2,593,496	2,712,938	2,712,938	3,314,720	3,917,043
Total Annual Costs	17,384,006	18,991,206	16,460,194	17,947,627	1,981,368	1,713,054	19,365,374	20,704,260	18,442,255	19,735,649	6,205,146	7,243,301	8,273,166

*Interest rate assumed to be 6 percent in absence of inflation.

†Urban areas - 12 most populous counties under Alternative A.

18 most populous counties under Alternative B.

Rural areas - counties not included in urban areas.

‡Rural costs are the additional costs for providing state support of rural private garage inspection.

§Does not include costs to the private garages.

#Minimum midlevel and maximum levels of participation of private garages in the inspection process.

In Table 162 are shown the comparison of possible fees. These are derived by dividing total costs in 1978 dollars by average 1981 through 1987 vehicle populations. The fees are to be used only to compare the options and do not represent what a motorist would actually pay when the program is operational in 1981.

In comparing the urbanized areas' fees, it can be seen first that the fees for Alternates A or B (12 and 18 counties) are very similar, only differing by 2 to 10 cents. The difference between the urban fees for the contractor or state options is also small, 18 to 26 cents and this results primarily from the taxes paid by the contractor, as discussed earlier.

TABLE 162. COMPARISON OF FEES*

Centralized lanes in urban areas			
Options I, III, V Contractor		Options II, IV, VI State-run	
Alternate A 12-County	Alternate B 18-County	Alternate A 12-County	Alternate B 18-County
$3.43	$3.33	$3.17	$3.15

Option	Private garages: Options I, II Alternate A rural areas only	Private garages: Options I, II Alternate B rural areas only	Private garages: Option VII statewide
Participation Level			
Minimum 18%	$2.88	$2.94	$2.92
Midlevel 33%	$4.13	$4.20	$4.41
Maximum 45%	$5.88	$6.04	$5.87

*Fees represent constant 1978 dollars in the absence of inflation. These figures are for comparison of options only and do not reflect what the motorists would have to pay. An annual interest rate of 0.06 is assumed.

Options I and II differ from Options III and IV or Options V and VI in the service provided in rural areas (the part of the state outside the urban areas discussed above). Rural areas Options I and II require mandatory emission inspection by private garages. In these two options, state incurs a cost of about $0.64 to $0.86 per paid private garage inspection depending on the number of garages participating in the system. This cost covers the administrative and monitoring network required to oversee the private garage operations. In addition, the motorist incurs the cost of the actual inspection.

Option VII is a statewide private garage approach. As is the case in the rural areas of Option I and II there are the state costs as well as the private garage charge which together equal the private garage fee. As the level of participation increases, the charge per vehicle increases to offset the fewer number of vehicles being inspected. If there were a mechanism to insure that the number of stations participating in inspections remained at a low level, somewhere between the minimum and midlevels, then, the fees charged in rural areas would equal the urban motorist fees for centralized state or contractor stations. Alternatively, the urban fees could be raised to equal the expected breakeven participation level. Limiting station participation levels through high license fees or other means would be difficult to implement and potentially unpopular. In reality some stations that would not breakeven on the inspection fee would nevertheless be willing to participate in order to increase business especially for the repairs needed for failed vehicles.

Except for the potentially higher fees for private garages in rural areas of Option I, and II or in statewide garage Option VII, the costs and fees are very similar among all options. Not shown are the state costs for the random emission inspection program conducted in rural areas by the Ohio State Highway Patrol in Options V and VI. The capital costs of these programs are estimated to be approximately $827,500 in Alternate A and $703,500 for Alternate B while the operating costs were estimated at $2,792,200 and $2,374,600 for Alternates A and B, respectively. These costs would probably be paid for through state revenues as is the cost of the present random safety program.

The costs were also estimated for a loaded mode option which was like Option III except for the test type. The fee calculations for the loaded test indicates that it would cost approximately $0.20 more per inspection than the comparable idle mode test looked at in Option III. This cost is due to the addition of a dynamometer for each test lane. The test time is about the same and consequently, the actual number of inspection lanes would be the same. Also, the manpower requirements would be equal for either test type due to the use of automated equipment. There is no need for additional personnel to perform the loaded mode test.

Comparison of Manpower Requirements

Alternate A--

Table 163 summarizes manpower requirements for all the options. Options III and IV, with smaller geographic coverage, require the fewest employees of any of the centralized system options. Because of the rural private garage networks incorporated in Options I and II, 52 more employees than for Options III and IV are required to perform complaints investigation and inspection and licensing functions. In Options V and VI, 212 state patrol employees are required to carry out the random roadside pullover inspection program in rural areas. Option VII requires by far the fewest state employees of all the options, but it must be remembered that thousands of private garage employees will also be required. Option VI has by far the greater number of state employees.

Alternate B--

Table 164 summarizes manpower requirements for all the options. Manpower requirements for Alternate B are all somewhat larger for all the centralized options due to the larger geographic area covered. Option VI with 846 people would have more state employees than any other option, although Options II and IV with 710 and 664 would rank close behind.

COMPARISON OF POLITICAL ISSUES

Impacts on Low Income Groups and Impacts of Repair Costs

Impacts on low income people and impacts of repair costs were discussed earlier. These may have political ramifications. As to what degree the different geographical coverage in the options affect the political significance of these issues is not clear. It might be presumed that the perceived impacts would increase as the geographical coverage increases as in Options I, II, and VII being statewide. However, there may be other factors in a statewide program which includes a well-run public information program which would nullify these possible effects.

Private Garages Options

Options I, II, and VII may have political repercussions regardless of the geographical coverage or the exact nature of the impacts. This is because many people perceive that private garages might overcharge them for repairs, make unnecessary repairs, or that some people might not receive accurate or honest testing. Although the criticism of the repair industry may not, in many cases, be justified, the decrease in supply of mechanics and the increased difference of emission-related repairs may further reduce the acceptability of the private garage approach. These potential criticisms may be balanced by the increase in consumer convenience presumed by the decentralized nature of the private garage options.

Manpower Requirements

Those options in which the state administers the program with state-run lanes'in urban areas, namely, Options II, IV, and VI, would have the largest number of permanent state employees. In addition to the state employees required in the centralized lanes Option VI would necessitate state patrol officials (inspectors and patrolmen) for the rural areas. In view of the long-term financial commitment which the state must bear under these options they may have legislative problems.

TABLE 163. MANPOWER REQUIREMENTS, ALL OPTIONS (NUMBER OF EMPLOYEES), ALTERNATE A

Level of employment	I	II	III	IV	V	VI	VII (mid)
State Administrative	10	12	10	12	10	12	11
State Regional	52	84	-	32	-	32	127
State Local	-	580	-	580	-	580	66
Contractor State	2	-	2	-	3	-	-
Contractor Regional	32	-	32	-	32	-	-
Contractor Local	580	-	580	-	580	-	-
State Patrol	-	-	-	-	212	212	-
Random Pullover Program	676						
Total - All	676	676	624	624	836	836	204
Total - State (includes State Patrol)	62	676	10	624	222	836	204

TABLE 164. MANPOWER REQUIREMENTS, ALL OPTIONS (NUMBER OF EMPLOYEES), ALTERNATE B

Level of employment	I	II	III	IV	V	VI	VII (mid)
State Administrative	10	12	10	12	10	12	11
State Regional	46	80	-	34	-	34	127
State Local	-	618	-	618	-	618	66
Contractor State	2	-	2	-	2	-	-
Contractor Regional	34	-	34	-	34	-	-
Contractor Local	618	-	618	-	618	-	-
State Patrol	-	-	-	-	182	182	-
Random Pullover Program							
Total - All	710	710	664	664	846	846	207
Total - State (includes State Patrol)	56	710	10	664	192	846	207

Funding

The capital costs for land, building, and equipment under Options II, IV, and VI which all have state financed and operated lanes in urban areas may encounter difficulties depending on the budget situation and other political considerations in the state. The money to finance these capital costs would have to come from state revenues or state borrowing.

Unequal Geographical Coverage

Options III, IV, V, and VI may also present political roadblocks. With these options, rural residents are not subject to out-of-pocket expenditures for improving vehicular emissions. The burden of cleaner air is born only by the urban driver. Since 63 counties in Ohio fail to meet federal carbon monoxide or hydrocarbon standards, requiring active I/M participation by 12 or 18 counties may appear to be inequitable and unjust.

Local Tax Issue

As previously noted, a tax redistribution issue arises when choosing between a contractor and a state-run approach. With Options II, IV, and VI, the land used for inspection lanes is no longer in the local tax base. Communities with these facilities will be expected to provide municipal services, yet receive no compensation for their expenses. On the other hand, under Options I, III, and IV communities with inspection lanes have an indirect revenue source. Any motorist using an inspection lane contributes to the taxes the contractor pays the local community. Since taxes on commercial and industrial property exceed the cost of municipal services to such property, motorists from surrounding communities are contributing tax benefits to localities with contractor-run test facilities.

REFERENCES

1. Personal communication with Bruce Everlane, U.S. EPA, Washington, D.C. May 1978.

SECTION 15

PUBLIC INFORMATION PROGRAMS

Experiences in several states that recently established inspection/maintenance programs emphasize the importance of an effective public information program. A well-designed, comprehensive program that introduces the public to the basic need for, and benefits of, I/M and clarifies the misunderstandings that surround I/M is critical during the early stages of implementation. A well thoughtout program can help eliminate potentially adverse reactions that other states with inadequate public information programs experienced (e.g., Arizona, Cincinnati, Ohio, and Chicago).

METHODOLOGY

To estimate the costs of public information programs, all states with experience in I/M public information programs were contacted. This includes states with currently operational programs and those just beginning the early planning stages. The U.S. EPA was consulted to determine basic program elements and a literature search was conducted. From contacts and research, a full range of possible activities was established and basic cost figures derived. It is important to note, as will be explained later in this report, that the range of possible activities and comprehensiveness of public information programs varies considerably. Therefore, broad assumptions concerning the range of public information activities which Ohio will conduct must be made to present potential cost figures. These assumptions will be made clear in the following sections.

INITIAL PUBLIC RELATIONS PROGRAMS

The initial public information program may be conducted from several months to over a year prior to the actual beginning of mandatory inspection and maintenance. The range of activities among the various programs has varied considerably depending on the particular needs of each state.

The initial program serves to introduce the public to the basic needs and benefits of inspection/maintenance. It should clarify misconceptions regarding emissions controls and explain clearly why I/M is needed to ensure that in-use vehicles meet the emission standards for which they were designed. A well-conceived, initial public relations program can go a long way towards gaining public acceptance and minimizing resistance to the program.

The U.S. Environmental Protection Agency has recently made grants available for I/M public relations work through their regional offices. These grants have generally been $15,000, although this is subject to the total amounts made available by Congress in appropriating the funds. U.S. EPA cannot commit itself now to the exact amount which will be available in the future due to the uncertainties in appropriations. As examples of the types of programs utilizing these funds, both Rhode Island and Massachusetts are currently establishing public information programs with these $15,000 grants. Rhode Island is in the first year of a mandatory inspection and voluntary maintenance program. It is the first state to implement a private, decentralized garage approach. Massachusetts, as yet undecided as to which type of program to select, is also utilizing these funds. In both states the local lung association, a voluntary nonprofit citizens group presenting clean air programs and disseminating information on health and clean air, has been given the job of organizing the public information program. Massachusett's program involves several elements including a slide show for presentation to civic and other groups. A mobile van with an emission analyzer plus an informational display is being taken to major shopping centers and other key activity centers around the state. Automobile oriented groups including automobile associations are being contacted in order to solicit their support. Also, brochures are being prepared for mass circulation to citizens and motorists. These program elements are typical of the activities conducted early in the planning or implementation stage.

Similarly, Portland, Oregon has utilized mobile vans with emission analyzers. Oregon found that bumper stickers (at $0.10 to 0.15 each) were one of the most successful public information tactics. Another tactic commonly used in such campaigns was to depict an important public official such as the governor having his car inspected on television. It should be noted here that some tactics while successful in one area would not be particularly useful in other states.

In New Jersey, each new car dealer and garage which purchased an emission analyzer from a list of approved companies, was contacted by the state. A form was then sent out with questions for them to answer, and, upon its return to the state, the station would receive a poster to display, as well as being placed on an approved list of garages made up by the state. These lists were then made available to owners of failed vehicles, such that they might patronize those stations. This was an important element in their public information program.

Two program elements stand out as being widely used as I/M public information techniques. One is the use of radio and television spot announcements and newspaper advertisements. A second technique which is key to reaching the individual motorist is preparing an informational pamphlet and mailing it to all vehicle owners, usually along with motor vehicle registration forms to save extra mailing costs.

In relating these program elements to the specific options, the most useful cost figure is a per vehicle cost of $0.12; both California and Arizona have indicated costs in this range. Basically, these costs cover pamphlet preparation and distribution costs (to each motorist) and mass media announcements.

In Ohio, the cost would vary according to the geographic coverage chosen (Alternatives A, B, or statewide), as this would affect the vehicle population. Using the $0.12 per-vehicle tested figure, an average cost would be $481,400 for Alternative A (12-county), $527,500 for Alternative B (18-county), and $804,000 for a statewide program. This is considered to cover initial as well as ongoing costs, so would vary only as the vehicle population changed (these figures are for 1975 vehicle populations) or as the program itself is varied. It should be noted that these are only average costs. The program costs could change according to the details of the specific campaign Ohio chooses. At a later stage in implementation, Ohio may design a public information program with elements specified to a degree that will allow costs to be more closely estimated.

ONGOING PUBLIC RELATIONS

Ongoing public relations is a continuation of the initial program in that it seeks to reinforce the needs and benefits of the I/M program. However, the ongoing program is much more specific. It should give detailed information on the location of stations and inspection times. It should inform the public of all the necessary procedures for both the inspection and maintenance phases of the program. The ongoing program should include information on test times, repair price ceilings, consumer protection, and enforcement.

The ongoing public information program costs and elements are not as variable as the initial program elements. The major elements found in other state's programs are the same elements described above for the basic initial costs; a pamphlet mailed to each motorist and periodic mass media coverage, usually spot announcements and newspaper advertisements. Consequently, the annual cost of the ongoing public information program is estimated by multiplying the number of vehicles times $0.12. These costs are shown below in Table 165.

TABLE 165. ESTIMATED COST OF INITIAL/ONGOING PUBLIC RELATIONS PROGRAM FOR OHIO ALTERNATIVES*

Alternative	Geographic coverage: Urban ($)	Geographic coverage: Rural ($)
A	624,000	420,000
B	684,000	360,000
Statewide	1,044,000	

*The estimated cost per vehicle is 0.12¢. This same cost was used to estimate both for the initial startup program and for the ongoing public relations campaign.

SECTION 16

COMPARISON OF MOTOR VEHICLE REGISTRATION VERSUS STICKER/TICKETING AS ENFORCEMENT PROCEDURES

Motor vehicle registration as an enforcement procedure means that the motorist in order to register his motor vehicle must present to the motor vehicle registry proof that his vehicle passed the emission inspection program. Without proof of having passed the inspection, the motorist is simply denied the right to register and, hence, to operate his vehicle. This sytem assumes that the frequency of motor vehicle emission inspection correspond with the frequency of registration. In Ohio by 1982 this will be the case. In contrast, the sticker/ticketing approach means that upon passing the emission inspection, the motor receives a sticker which is prominently displayed, usually on the windshield of the vehicle. The actual enforcement is through levying fines to motorists who have not complied. Noncomplying vehicles are identified by a special police force or by local or state police - if so designated. Those vehicles without the appropriate sticker are given tickets much as vehicles illegally parked vehicles or police officers can pull cars over that do not have appropriate stickers. The violators then can have their cars inspected either avoiding all or part of the fine and if they do not comply can be subject to appropriate civil penalties accordingly. The stickers are issued during each inspection period which can be on a staggered basis to suit the needs of the inspection period.

Effectiveness

The primary issues in comparing these two approaches are effectiveness and cost. In terms of effectiveness, the motor vehicle registration procedure has generally been found to be a superior approach. Because motor vehicle registration is a legal prerequisite to vehicle operation, a high level of compliance can be expected. Other than avoiding the registration procedure altogether and operating the vehicle illegally, the only way to circumvent the procedure would be to forge or tamper with the forms used to demonstrate proof of having passed the emission test. It is unlikely, given sufficient checks and a well designed form, that motorists would do this. There does exist some possibility that in a private decentralized garage approach there would be falsified tests or illegal reporting but even in this system adequate quality assurance procedures would minimize this possibility. Any station passing or failing an unduly large number of vehicles would be investigated and if fraud were discovered the station could lose its license. In the centralized approach there would, in addition to these chekcs, be much closer supervision of the individual lanes.

Nearly all the states currently having operational I/M programs and those with pilot programs have new or will be using the motor vehicle registration procedure. This includes Arizona, New Jersey, Portland, Oregon, and Nevada. The only programs using sticker/ticketing for emission inspection are Cincinnati, Ohio, Chicago, Illinois, and Rhode Island. These programs will be discussed below.

The sticker/ticketing approach is inherently more difficult to administer and less effective in terms of compliance levels. In the Hamilton County, Ohio program, compliance is 25 to 30 percent. One difficulty in the sticker/ticketing methodology derives from the very controversial nature of the program itself. With an effective public information program, wider geographical coverage and better public acceptance of I/M presumably higher levels than those currently experienced in Cincinnati would be experienced. However, there is much evidence from tampering studies and just from the public reactions to programs to cast serious doubt on the ability of this approach to reach an acceptable level of compliance.

In an I/M program in the urban areas only, sticker/ticketing approach would encounter more difficulties in enforcement. One problem would derive from the problem in identifying the vehicles. Presumably only vehicles actually registered in those urban counties with an I/M program would be subject to enforcement. There would consequently be a need to identify vehicles from the I/M counties. It is possible that under these circumstances, motorists would attempt to register their cars in counties without I/M in order to avoid inspection. From these considerations it may be seen that there are potential enforcement problems regardless of the enforcement procedure selected when there is I/M in urban areas only, but in the sticker/ticketing approach the identification of vehicles makes enforcement considerably more difficult than when registration enforcement is used.

The only major state program which is using sticker/ticketing is Rhode Island, the smallest state in the U.S. One major incentive for Rhode Island was that it already had safety inspection enforced with stickers and the public was used to this system. Also, the motor vehicle registration procedure is not on a staggered basis so that without charging this system, it would not be feasible to use annual registration. In addition, the state has used a random pullover for many years both as a direct enforcement tool and as a quality assurance technique. Any cars which had recently passed safety inspection and which had blatant problems had to be reinspected. In addition, the garage which performed the inspection would be visited by appropriate state personnel to check into the quality of their inspection procedures, recordkeeping, etc. Rhode Island is purchasing two vans to be equipped with emission analyzers and these vans will conduct random pullover emission tests similar to safety tests again both as enforcement.

In the soon-to-be released Appendix N, the U.S. EPA may either require or or encourage random roadside testing as a quality assurance/enforcement/ surveillance technique as a part of the decentralized private garage approach. In this stage of evaluation, given that the enforcement issue will be looked into in the final Task Y, the use of random pullover will be not be included in the private garage approach. The random pullover is being considered separately in Options V and VI.

Rhode Island considers the sticker/ticketing method to be quite suitable for their particular needs as it is already well established. State officials estimate compliance levels for safety inspection to be very high but there is yet no data for the added emission test. It should be remembered that for Ohio the efficiency of sticker/ticketing probably would be different than in a state such as Rhode Island which has already had an established sticker system in place for many years.

Program Costs

In terms of program costs the motor vehicle registration procedure is generally less costly than sticker/ticketing. Costs for the motor vehicle registration are very minimal assuming that the motor brings the proof of having passed the emission test to the motor vehicle registry prior to the annual registration. There may be some minor additional clerical personnel needed for recordkeeping depending on the manner in which the data handling system is set up, whether it be a manual or an automated system.

Sticker/ticketing costs may be very substantial, however, due to the need for enforcement personnel and other less obvious costs such as administrative and count costs involved in collecting fines. Some rough estimates may be made by looking at the Cincinnati program. The Cincinnati Air Pollution Control Board employs four special enforcement officers "Green Hornets" whose primary job is issuing tickets to vehicles without stickers or without of date ones. The costs of salaries plus the vehicles and other operating costs are estimated to be $100,000 per year, most of which is compensated for by the fines collected.[1] In addition, the Cincinnati City Policemen also issue tickets as a part of their normal routine daily activity. The city had estimated very roughly the cost to be 1/2 million dollars per year. Such costs are considered opportunity costs and are extremely difficult to measure because they basically represent the costs of forgone activities, or the costs of activities that the police force would have accomplished were it not busy issuing tickets.

Other additional costs would stem from the court costs, and other clerical personnel costs need to levy and collect for fines.

From the above discussion it may readily seen that not all the costs can be estimated in this methodology. However, these rough estimates from Cincinnati would indicate that for a statewide program in Ohio they could amount to several million dollars in direct costs and much more in indirect or opportunity costs. In the metropolitan areas the costs would presumably be less but enforcement might become more difficult because of the problem of commuters crossing over from areas not included into the urban counties. Much of the costs of the enforcement could be reimbursed through the fines, but it might require additional manpower nonetheless.

REFERENCES

1. Personal Communications with Marion Smith, Cincinnati Division of Air Pollution Control. Cincinnati, Ohio. May 1978.

SECTION 17

STATE VERSUS CONTRACTOR SURVEILLANCE OF PRIVATE GARAGES

GENERAL COMMENTS

Who would best administer, supervise, or conduct surveillance over the private garages under the various options? The state or a private contractor? To answer this question it is first necessary to more clearly define the supervisory or administrative function in the private garage approach. Later in this analysis the individual options will be considered. There are in fact at least the following functions that involve private garages:

- Licensing
- Mechanic Training
- Quality Assurance
- Special Studies
- Public Relations

In considering these functions, the licensing is all that would require state supervision because otherwise there would be legal problems since a contractor would not have the legal authority presumably to set standards and make policy decisions as well as to do the actual licensing itself. The other functions including quality assurance, special studies, mechanic training, and public relations could be administered or supervised by a designated private firm under contract to the state. For purposes of this discussion the quality assurance and special study function will be considered. A quality assurance program would probably include periodic regular visits and unannounced visits to each station, the regular visits being at least once a month. During the visit the quality assurance inspector or investigator would calibrate the emission analyzer, check the station records, and if necessary investigate any complaints or irregularities reported to the state (or contractor) concerning emission testing or repairs. If a contractor were hired for this function he would not be about to revoke a stations license but would have the authority to make recommendations to the state which in turn could revoke the license or do what is needed. In addition to calibrating analyzers or investigating complaints concerning various problems, the investigator would gather the emission test record forms unless they are sent directly to the state. Also, the contractor would conduct special studies of pass/fail levels, individual station performance, fleet studies, and other special studies as needed.

The question as to who would be better at these functions may be interpreted to refer to both cost and effectiveness.

At this time there is no data nor experience in other states' programs to indicate whether a contractor or state approach would cost less to perform the simultaneous function. As for the overall program, it appears that the contractor can conduct the inspection function at less cost than the state. In both Arizona and California, the contractor had under-bid the state. The reason for the presumed efficiencies in the contractor approach derive chiefly from the use of high technology which increases efficiency of operation. The sophisticated combined data gathering, emission analyzer, and control system allows for an easy to operate rapid inspection lane system. The rapid throughput rate allows for fewer lanes and lower capital costs. An additional and related advantage is the flexibility a private contractor has in hiring its employees and making use of part-time employees to cover peak operating hours. Given the lower training costs and the added personnel flexibility, the contractor seems to be able to operate at a lower cost.

In principle, can a private contractor accomplish the same efficiencies in supervising a private garage approach? There is no way at present that high technology can be used in the private garage approach. The supervision function as mentioned above does not lend itself to the same type of approach with its attendant cost savings. However, it may be possible for a private contractor to incur lower personnel costs due to this flexibility factor. It is generally considered a truism, though certainly not true for all areas and in all circumstances, that industry can achieve somewhat greater efficiencies than government. The civil service system conversely is considered less flexible and is designed to protect its employees from abuses inherent in the private system. Contractors have stated that the efficiencies which they achieve in the I/M programs are due to their ability to utilize part-time employees during demand periods. This is not an issue for the supervision function.

Another important question to look at in conjunction with costs is effectiveness. There is no reason that the state or a contractor would necessarily be more effective in performing the quality assurance or special studies. There is no necessary technological advantage a contractor offers in this function as it is largely a personnel or service function. These issues will be addressed below in regards to the various options.

Option I: In this option there is probably the greatest likelihood of obtaining a contractor to perform the supervision function. The contractor would already have a sizeable investment of capital aid personnel in the centralized lanes in the urban counties. Some of the quality assurance functions run parallel to functions in centralized lanes. Although the contractor might not be able to obtain much of a return on this type of supervisory work, at least he would already have established a base of operations in the nearby areas and would exercise control more easily than if he were not involved in the urban areas.

Option II: In this option the state would operate the centralized lanes and consequently, the contractor would only supervise garages in the rural area. This would involve disadvantages to contractor operations because of the spread nature of the supervision which is a less cost/effective operation and because the contractor would not have an already existing base of operations.

Option VII: In the statewide decentralized private garage approach, the contractor would realize some efficiencies in supervising urban areas because the stations are very close together and this reduces travel time considerably. The rural areas would be more problematical. However, without having centralized urban test lanes as both a base of operations and for providing an adequate return on investment a contractor may not view this job as potentially very attractive. In other words, given other more lucrative situations, a contractor would necessarily seek the situation where he is more likely to make use of his knowledge and technology.

This leads to a final consideration of interest to the potential contractors. From discussions with Hamilton Test Systems and an analysis of the situation, there is some doubt if the state could find a contractor who would be interested in performing the supervisory function if the contractor were not able to also conduct a larger centralized operation in the urban areas.

SECTION 18

GLOSSARY

accuracy: The degree by which an instrument is able to determine the true concentration of a pollutant in the exhaust gas sampled.

actual dollars: The face value of money in any particular year. With inflation, the buying power of actual dollars decreases.

air contaminants: Any fumes, smoke, particulate matter, vapor gas, or any combination, but excluding water vapor or stream condensate.

air-fuel ratio: The expression of the proportional mixture of air and gasoline created by the carburetor. Usually expressed as a numerical relationship such as 14:1, 13:1, etc.

ambient air: The surrounding or outside air.

amortization factor: The annual cost of 1 dollar of capital expenditure. Amortization factors are applied to capital costs to determine annual costs.

calibration gases: A blend of HC and CO gases using nitrogen as a carrier gas.

carbon monoxide: A nonirritating, colorless, odorless gas at standard conditions which has the molecular form of CO.

catalytic emission control system: Device to reduce automobile emissions by converting CO and HC emissions to harmless carbon dioxide and water.

certificate of compliance: A document which is issued upon completion of the inspection which records the results of the inspection and serves as proof of said inspection for vehicle owner.

certified mechanic: An individual licensed to install, repair and adjust motor vehicle engine emissions related components and pollution control devices in order that the motor vehicle meet applicable emissions standards.

certified station: A private facility licensed to install, repair and adjust motor vehicle engine emissions related components and pollution control devices in order that the motor vehicle meet applicable emissions standards.

chassis dynamometer: A machine equipped with two parallel rollers which support the rear wheels of a motor vehicle. When positioned on the dynamometer the vehicle may be "driven" to simulate the loadings the engine would experience when the vehicle is operated on the road. A power absorption unit is connected to the rollers to simulate the loading from the various sources of fluid and mechanical friction present during road operation. Weights can also be coupled to the rollers to simulate the inertial effects of vehicle mass during acceleration and decelleration.

crankcase emissions: The products of combustion emitted into the ambient air from portions of the engine crankcase ventilation or lubrication system.

degradation: The decreased effect of I/M on emission reduction due to normal wear of engine system.

deterioration: A synonym for degradation indicating an increase in emission levels due to wear.

drift: The amount of meter reading change over a period of time. Zero drift refers to change of zero reading. Span drift refers to a change in reading of a calibration point on the upper half of the scale. The calibration point is established by reading a calibration gas of known concentration.

emission inspection program: An inspection and maintenance program in which each vehicle is subjected at specified intervals to a test of its emissions under specified conditions. The emission levels are compared with a standard established for the vehicle class. If the emissions are higher than the standard, the vehicle is failed and must be adjusted or repaired to bring its emissions into compliance with the standards.

exhaust gas analyzer: An instrument for sensing the amount of air contaminants in the exhaust emissions of a motor vehicle.

exhaust emissions: The products of combustion emitted into the ambient air from any opening downstream of the exhaust ports of a motor vehicle engine.

fleet owner authorized stations: A permit issued to a qualified fleet owner to perform vehicle emissions inspection limited to his fleet only.

fleet operator: The owner of a fleet of a designated number of vehicles.

hang-up: HC which clings to the surface of the sampling and analyzer system in contact with the gas sample stream which causes an erroneous indication of HC in the measured value.

heavy-duty vehicle: Any motor vehicle designed for highway use which has a gross vehicle weight of more than 8,500 pounds.

hydrocarbons: A compound whose molecular composition consists of atoms of hydrogen and carbon only.

idle test: An emission inspection program which measures the exhaust emissions from a motor vehicle operating at idle. (No motion of the rear wheels.) A vehicle with an automatic transmission may be in drive gear with brakes applied or in neutral gear.

independent contractor: Any person, business firm, partnership or corporation with whom the state may enter into an agreement providing for the construction, equipment, maintenance, personnel, management and operation of official inspection stations.

inspection and maintenance program: A program to reduce emissions from in-use vehicles through identifying vehicles that need emissions control related maintenance and requiring that maintenance be performed.

inspection station: A centralized facility for inspecting motor vehicles and pollution control devices for compliance with applicable regulations.

inspector: An individual who inspects motor vehicles and pollution control devices for compliance with applicable regulations.

instrument: The system which samples and determines the concentration of the pollutant gas.

key mode test: A loaded mode test in which exhaust emissions are measured at high and low cruise speeds and at idle. The cruise speeds and dynamometer power absoprtion settings vary with the weight class of the vehicle. The dynamometer loading in the high cruise range is higher than normal load in order to more efficiently expose malfunctions leading to high emissions.

light-duty vehicle: A motor vehicle designed for highway use of less than 8,501 pounds gross vehicle weight. Further distinctions are sometimes made between light-duty automobiles and light-duty trucks such as pickup trucks.

loaded mode test: An emission inspection program which measures the exhaust emissions from a motor vehicle operating under simulated road load on a chassis dynamometer.

manufacturer's specifications: The specifications or settings established by the manufacturer for proper operation. These settings must be followed in order to maintain proper emission controls and vehicle performance.

market rate of interest: An interest rate that includes the real return on capital, a risk premium, and compensation for inflation.

model year of vehicle: The production period of new vehicle or new vehicle engines designated by the calendar year in which such period ends.

motorcycle: A motor vehicle having a seat or saddle for use of the rider and designed to travel on not more than three wheels in contact with the ground, but excluding a tractor.

motor vehicle: Any self-propelled vehicle which is designed primarily for travel on public right of ways and which is used to transport persons and property.

net present value (NPV): The present value of future benefits and cost. When actual dollars are used, benefit and costs are discounted by the market rate of interest. When real dollars are used, benefits and costs are discounted by the real return on capital.

nonattainment area: An area designated by the EPA which does not meet National Ambient Air Quality Standards for a specific pollutant.

photochemical oxidants: Those pollutants resulting from the chemical combination of reactive hydrocarbons with nitrogen oxides in the presence of sunlight. These produce ozone and other complex chemical compounds, which are dangerous to human health.

positive crankcase ventilation: A system designed to return blowby gases from the crankcase of the engine to the intake manifold so that the gases are burned in the engine. Blowby gas is unburned fuel/air mixture which leaks past the piston rings into the crankcase during the compression and ignition cycles of the engine. Without positive crankcase ventilation these gases, which are rich in hydrocarbons, escape to the atmosphere.

prescribed inspection procedure: Approved procedure for identifying vehicles that need emissions control related maintenance.

real dollars: (Sometimes called constant dollars.) Dollars that have the same buying power from year to year. To arrive at actual dollars, real dollars must be increased by the amount of inflation. For example: with an annual inflation of 7 percent, $100 in year x is equal to $107 actual dollars in year x + 1.

(real) rate of return on capital: The return on capital in the absence of inflation. This is equal to the marginal product of capital when combined with land and labor in production.

registered owner: An individual, firm, corporation or association whose name appears in the files of the motor vehicle registration division of the department of motor vehicles as the person to whom the vehicle is registered.

repeatability: The instrument's capability to provide the same value for successive measures of the same sample.

response time: The period of time required by an instrument to provide meangingful results after a step change in gas concentration level initiated at the tailpipe sample probe.

smoke: Small gasborne and airborne particles, exclusive of water vapor, arising from a process of combustion in sufficient number to be observable.

stringency factor: The percentage of total vehicles tested in an inspection/maintenance program in a given time period that fail inspection and are required to have maintenance performed.

tampering: The illegal alteration, modification, or disconnection of emission control devices or adjustments or manufacturer tuning specifications on motor vehicles for the purpose of controlling vehicle emissions.

vehicle dealer: An individual, firm, corporation or association who is licensed to sell motor vehicles.

vehicle emissions standard: A specific emission limit allowed for a class of vehicles. The standard is normally expressed in terms of maximum allowable concentrations of pollutants (e.g., parts per million). However, a standard could also be expressed in terms of mass emissions per unit of time or distance traveled (e.g., grams per mile).

APPENDIX A

DETAILED DESCRIPTION OF METHODOLOGY FOR CALCULATING EMISSION INVENTORIES

Emission inventories were calculated using the Mobile I computer program. The Mobile I routine is based upon vehicle-specific emission factors for vehicles operating through the EPA's Federal Test Procedure (FTP) urban driving cycle. The program, thus, contains tables of emission levels for each model year vehicle from 1951 to 1990 for various vehicle ages between 0 and 20 years old. Separate tables are used for light-duty vehicle (LDV), light-duty truck 1 (under 6,000 lbs gross) LDT-1, light-duty truck 2 (between 6,000 lbs and 8,500 lbs gross) LDT-2, heavy-duty diesel, and heavy-duty gasoline. Separate tables are also given for three geographic regions: California, high altitude areas, and the rest of the country. The latter tables are used for Ohio.

Since the basic emission factors are FTP specific, factors must be adjusted to reflect driving patterns in local areas. Mobile I contains correction factors for temperature, speed, hot/cold/stabilized travel, air conditioning, vehicle load, trailer towing, and humidity. Due to lack of reliable data for Ohio, default values (FTP-specific conditions) are used for air conditioning, vehicle load, and trailer towing. Humidity affects nitrogen oxide only, and thus, is irrelevant for our applications. Hot/cold/stabilized VMT is assumed to be the same as national averages: 21 percent/27 percent/ 52 percent. Temperature is taken at $75^{o}F$ - this represents a typical July day when vehicle emissions are most acute.

The most important correction factor is vehicle speed. Emissions are not linear with respect to speed, so whenever possible speed classes must be differentiated. Speed classes are created by dividing travel between freeways, arterials, and local roads.

For a particular year, say 1987, the above factors give emissions per mile traveled for vehicles of various ages. To get aggregate per mile emissions for 1987, the emission factors for the various aged vehicles are weighted by their travel proportion (e.g., see the last column of Table A-1). The data used in calculating travel proportions, the distribution of vehicle ages and the travel of vehicles by age, are national averages contained in Mobile I. An Ohio vehicle age distribution for a particular year is inappropriate since it would reflect low sales in periods of recession and these cyclic fluctuations would be projected into the future periods.

To get aggregate emissions per mile for a particular county or region, values must be combined across the various speed classes (freeways, arterials, local roads). This is achieved by taking weighted averages using vehicle

TABLE A-1. TRAVEL WEIGHTING FACTOR CALCULATION
LIGHT-DUTY VEHICLES

Vehicle age	(a) Fraction total registration	(b) Annual mileage accumulation rate	(a)*(b)	((a)*(b)/sum) Travel fraction
1	0.075	15,900	1,192.5	0.106
2	0.107	15,000	1,605.0	0.142
3	0.107	14,000	1,498.0	0.133
4	0.106	13,100	1,388.6	0.123
5	0.100	12,200	1,220.0	0.108
6	0.092	11,300	1,039.6	0.092
7	0.085	10,300	875.5	0.077
8	0.077	9,400	723.8	0.064
9	0.066	8,500	561.0	0.050
10	0.052	7,600	395.2	0.035
11	0.039	6,700	261.3	0.023
12	0.027	6,600	178.2	0.016
13	0.018	6,200	111.6	0.010
14	0.014	5,900	82.6	0.007
15	0.009	5,500	49.5	0.004
16	0.006	5,100	30.6	0.003
17	0.005	5,000	25.0	0.002
18	0.005	4,700	23.5	0.002
19	0.005	4,400	22.0	0.002
20	0.004	4,400	17.6	0.002
		Sum:	11,301.0	

miles traveled (VMT, for the weighting fractions. To calculate total daily emission levels (Table 11-1 through Table 11-6), emissions per mile are multiplied by VMT. The raw VMT and speed data used in this study are given in Table A-2 through Table A-4. These data are transformed to the analysis years of 1977 and 1987 by the procedures indicated in Table A-5. The data for 1977 and 1978 are reported in Tables A-6 and A-7.

To calculate the effort of an I/M program on emissions, EPA derived - Appendix N, credits (percent reductions) are applied to emission factors. I/M credits are given for carbon monoxide and hydrocarbons, various technologies of vehicles (technology 1 vehicles built prior to 1975, technology 2 vehicles built from 1976 to 1979, technology 3 vehicles built in 1980 and technology 4 vehicles built after 1981) with and without mandatory maintenance, with stringency levels of 10, 20, 30, 40 and 50 percent, and for the number of years I/M has been in effect. In this study, I/M included mandatory maintenance, was at a stringency level of 30 percent, and will be in effect for 5 years (from 1982 to 1987). These I/M credits are also specific to vehicle type. Table A-8 and Table A-9 contain the credits for light-duty vehicles found in the present version of Mobile I and are those anticipated for the final rulemaking of Appendix N. These credits differ substantially from those found in the May 1977 version of Appendix N. Current I/M credits are not yet available for other vehicle types, thus I/M is assumed to apply only to light-duty vehicles.

For any of the 18 counties analyzed, not all VMT will be by vehicles inspected under either alternative A or alternative B. Vehicles registered outside counties with I/M will travel in counties with I/M. To adjust inventories for travel by uninspected vehicles, an estimate of the proportion of VMT by uninspected vehicles is derived from U.S. Census journey to work data. Then the I/M credits mentioned above are applied to only the proportion of VMT by inspected vehicles.

Journey to work data are used to calculate the percent of VMT by uninspected vehicles. It is assumed that work trips constitute all VMT and each work trip is the same length. When the work trip is between counties with and without I/M, trip length is divided equally between the counties. Then the proportion of VMT by uninspected vehicles in a county with I/M is:

$$\frac{\text{(workers in county and living in counties without I/M)}}{\text{2 (workers in county)}}$$

and in a county without I/M is:

$$\frac{\text{(workers in county) - (workers in county and living in counties without I/M)}}{\text{2 (workers in county)}}$$

For both alternative A and B, Table A-10 summarizes these percentages for the 18 counties.

TABLE A-2. 1977 O.D.O.T. DATA

County	Daily VMT* (000) for 1977			
	Interstate	Major arterial	Minor arterial	Local
Lorain	175.3	1136.8	488.8	155.2
Geauga	-	204.1	530.7	74.5
Greene	185.7	613.3	293.8	24.9
Medina	831.3	491.9	298.9	51.1
Wood	902.4	528.6	465.3	36.5

Source: Ohio Department of Transportation

*Vehicle miles traveled.

TABLE A-3. 1975 O.D.O.T. DATA

Yearly growth rates of VMT by highway type:

Interstates	4.7%
Arterials	2.0%
Locals	1.4%

County	Daily VMT (000)	Average speed	LDV	LDT	HDG	HDD
Franklin						
Interstate	4,082	58	76.8	12.0	3.5	7.7
Major arterial	2,012	41	80.5	12.0	3.5	4.0
Minor arterial	960	36	85.0	10.0	3.5	1.5
Local	5,108	36	86.0	10.0	3.0	1.0
Cuyahoga						
Interstate	4,603	55	79.2	12.0	3.5	5.3
Major arterial	3,810	30	81.0	12.0	3.5	3.5
Minor arterial	1,619	25	83.0	12.0	3.5	1.5
Local	9,260	20	86.0	10.0	3.0	1.0
Lake						
Interstate	771	58	70.0	12	3.5	14.5
Major arterial	1,108	50	82.5	12	3.5	2.0
Minor arterial	793	35	86.0	10	3.0	1.0
Local	1,935	35	86.0	10	3.0	1.0
Lucas						
Interstate	1,431	58	74	12	3.5	10.5
Major arterial	1,693	47	79	12	3.5	5.5
Minor arterial	220	40	85	10	3.5	1.5
Local	2,627	40	86	10	3.0	1.0
Mahoning						
Interstate	758	60	67.0	12	3.5	17.5
Major arterial	1,114	52	77	12	3.5	7.5
Minor arterial	393	46	84	10	3.5	2.5
Local	1,640	40	86	10	3.0	1.0
Montgomery						
Interstate	1,962	58	74	12	3.5	10.5
Major arterial	1,582	45	81.5	12	3.5	2.5
Minor arterial	603	45	85.0	10	3.0	2.0
Local	3,532	45	86.0	10	3.0	1.0

(continued)

TABLE A-3 (continued).

County	Daily VMT (000)	Average speed	LDV	LDT	HDG	HDD
Stark						
Interstate	527	58	76.5	12.0	3.5	8.0
Major arterial	1,166	48	78	12	3.5	6.5
Minor arterial	633	45	84.0	12.0	3.0	2.0
Local	2,511	40	86.0	10.0	3.0	1.0
Summit						
Interstate	2,292	58	75.5	12	3.5	9.0
Major arterial	1,474	41	79.5	12	3.5	5.0
Minor arterial	713	37	85	10	3.0	2.0
Local	3,359	41	86	10	3.0	1.0
Trumbull						
Interstate	383	58	58.0	12.0	40.	26.0
Major arterial	1,503	49	79.5	12.0	3.5	5.0
Minor arterial	411	45	84.0	10.0	3.5	2.5
Local	1,605	40	86.0	10.0	3.5	0.5

Source: Ohio Department of Transportation, Columbus, Ohio (compiled from local planning data)

TABLE A-4. DATA FROM O.K.I.

	Freeway		Arterial		Locals	
	VMT (000)	Average speed	VMT (000)	Average speed	VMT (000)	Average speed
1975						
Hamilton	5,923	40.5	5,707	19.0	560	15.0
Butler	400	53.5	3,555	32.0	168	15.0
Clermont	280	53.5	1,607	34.5	45	15.0
Warren	824	54.0	1,241	34.5	54	15.0
1980						
Hamilton	8,406	41.5	6,587	20.5	627	15.0
Butler	492	54.0	4,081	31.0	177	15.0
Clermont	381	54.5	1,925	34.5	52	15.5
Warren	1,064	54.5	1,610	31.5	60	15.0
1985						
Hamilton	9,981	43.0	7,409	21.0	696	14.5
Butler	660	54.5	4,591	32.5	196	15.0
Clermont	563	56.0	2,261	35.0	58	16.0
Warren	1,485	55.0	2,084	33.0	67	15.0

Source: Ohio, Kentucky, Indiana Council of Governments, Cincinnati, Ohio

TABLE A-5. SOURCE OF VMT, AVERAGE SPEED, AND VEHICLE DATA FOR 1977 AND 1987

County	1977			1987		
	VMT	Average speed	VMT distribution by vehicle type	VMT	Average speed	VMT distribution by vehicle type
Butler	OKI 75-80	OKI 75	ODOT 75A	OKI 80-85	OKI 85	ODOT 75A
Cuyahoga	ODOT 75P	ODOT 75	ODOT 75	ODOT 75P	ODOT 75	ODOT 75
Franklin	ODOT 75P	ODOT 75	ODOT 75	ODOT 75P	ODOT 75	ODOT 75
Hamilton	OKI 75-80	OKI 75	ODOT 75A	OKI 80-85	OKI 85	ODOT 75A
Lake	ODOT 75P	ODOT 75	ODOT 75	ODOT 75P	ODOT 75	ODOT 75
Lorain	ODOT 77	ODOT 75A	ODOT 75A	ODOT 77P	ODOT 75A	ODOT 75A
Lucas	ODOT 75P	ODOT 75	ODOT 75	ODOT 75P	ODOT 75	ODOT 75
Mahoning	ODOT 75P	ODOT 75	ODOT 75	ODOT 75P	ODOT 75	ODOT 75
Montgomery	ODOT 75P	ODOT 75	ODOT 75	ODOT 75P	ODOT 75	ODOT 75
Stark	ODOT 75P	ODOT 75	ODOT 75	ODOT 75P	ODOT 75	ODOT 75
Summit	ODOT 75P	ODOT 75	ODOT 75	ODOT 75P	ODOT 75	ODOT 75
Trumbull	ODOT 75P	ODOT 75	ODOT 75	ODOT 75P	ODOT 75	ODOT 75
Clermont	OKI 75-80	OKI 75	ODOT 75A	OKI 80-85	OKI 85	ODOT 75A
Geauga	ODOT 77	ODOT 75A	ODOT 75A	ODOT 77P	ODOT 75A	ODOT 75A
Greene	ODOT 77	ODOT 75A	ODOT 75A	ODOT 77P	ODOT 75A	ODOT 75A
Medina	ODOT 77	ODOT 75A	ODOT 75A	ODOT 77P	ODOT 75A	ODOT 75A
Warren	OKI 75-80	OKI 75	ODOT 75A	OKI 80-85	OKI 85	ODOT 75A
Wood	ODOT 77	ODOT 75A	ODOT 75A	ODOT 77P	ODOT 75A	ODOT 75A

Notes:

- ODOT 77 — Ohio Department of Transportation - Actual county specific data for 1977 (from Table A-2)
- ODOT 75P — Ohio Department of Transportation - Projected county specific data using ODOT growth rates on 1975 ODOT data (from Table A-3)
- OKI 75-80 — Ohio, Kentucky, Indiana Council of Government - Interpolated county specific data from 1975 and 1980 OKI data (from Table A-4)
- OKI 80-85 — Ohio, Kentucky, Indiana Council of Government - Projected county specific data using 1980 - 1985 OKI growth rates on 1985 OKI data (from Table A-4)
- ODOT 75 — Ohio Department of Transportation - Actual county specific data for 1975 (from Table A-3)
- ODOT 75A — Ohio Department of Transportation - 9 county averages from 1975 ODOT data (average from Table A-3)
- OKI 75 — Ohio, Kentucky, Indiana Council of Government - Actual county specific data for 1975 (from Table A-4)
- OKI 85 — Ohio, Kentucky, Indiana Council of Government - Actual county specific data for 1985 (from Table A-4)

TABLE A-6. DERIVED DAILY VMT (000) FOR 1977 AND 1987

County	Freeway		Major arterial		Minor arterial		Locals		Totals	
	1977	1987	1977	1987	1977	1987	1977	1987	1977	1987
Butler	436.8	727.2	3,765.4	4,795	NA	NA	171.6	203.6	4,373.8	5,725.8
Cuyahoga	5,045.8	7,987.13	3,963.93	4,831.84	1,684.41	2,053.22	9,521.13	10,941.62	20,215.27	25,813.81
Franklin	4,474.69	7,083.09	2,093.29	2,551.62	998.79	1,217.47	5,252.05	6,035.61	12,818.82	16,887.79
Hamilton	6,916.2	10,611	6,059	7,737.8	NA	NA	586.8	723.6	13,562	19,072.4
Lake	845.17	1,337.84	1,152.76	1,405.17	825.04	1,005.68	1,989.57	2,286.4	4,812.54	6,035.09
Lorain	175.288	277.46	1,136.8	1,385.76	488.8	595.85	155.17	178.31	1,956.058	2,437 38
Lucas	1,568.66	2,483.07	1,761.40	2,147.06	228.89	279.0	2,701.08	3,104.06	6,260.03	8,013.19
Mahoning	830.92	1,315.28	1,159	1,412.78	408.88	498.4	1,686.25	1,937.83	4,085.05	5,164.29
Montgomery	2,150.745	3,404.63	1,645.91	2,006.29	627.36	764.73	3,631.6	4,173.41	8,055.62	10,349.06
Stark	577.7	914.45	1,213.11	1,478.72	689.79	840.82	2,581.81	2,967.0	5,062.41	6,200.99
Summit	2,512.49	3,977.08	1,533.55	1,869.33	741.81	904.23	3,453.72	3,969.01	8,241.57	10,719.64
Trumbull	419.85	664.58	1,563.72	1,906.11	427.61	521.23	1,650.26	1,896.47	4,061.44	4,988.39
Total - 12 counties	25,954.31	40,782.81	27,047.87	33,527.48	7,121.38	8,680.63	33,381.04	38,416.91	93,504.6	121,407.83
Clermont	320.4	635.8	1,734.2	2,395.4	NA	NA	47.8	60.4	2,102.4	3,091.6
Geauga	-	-	204.09	248.79	530.[illegible]8	646.9	74.47	85.57	809.24	981.26
Greene	185.70	293.95	613.29	747.6	293.77	358.11	24.94	28.66	1,117.7	1,428.32
Medina	831.35	1,315.94	491.94	599.68	298.9	364.36	51.13	58.75	1,673.32	2,338.73
Warren	920	1,653.4	1,388.6	2,273.6	NA	NA	56.4	69.8	2,365	3,996.8
Wood	902.404	1,428.42	528.62	644.39	465.28	567.18	36.54	41.99	1,932.84	2,681.98
Total - 6 counties	3,159.86	5,327.51	4,960.74	6,909.46	1,588.63	1,936.55	291.28	345.17	10,000.51	14,518.69
Total - 18 counties	29,114.17	46,110.32	32,008.61	40,436.94	8,710.01	10,617.18	33,672.32	38,762.08	103,505.11	135,926.52

Note: See Table A-5 for data sources

TABLE A-7. DERIVED AVERAGE SPEED AND VMT DISTRIBUTIONS FOR 1977 AND 1987

County	1977 Average speed	1987 Average speed	LDV	LDT1	LDT2	HDG	HDD
Butler							
Interstate	53.5	54.5	0.723	0.072	0.048	0.035	0.122
Arterial	32.0	32.5	0.822	0.066	0.044	0.034	0.034
Local	15.0	15.0	0.860	0.060	0.040	0.030	0.010
Cuyahoga							
Interstate	55.0	55.0	0.792	0.072	0.048	0.035	0.053
Major arterial	30.0	30.0	0.81	0.072	0.048	0.035	0.035
Minor arterial	25.0	25.0	0.83	0.072	0.048	0.035	0.015
Local	20.0	20.0	0.86	0.06	0.04	0.03	0.01
Franklin							
Interstate	58.0	58.0	0.768	0.072	0.048	0.035	0.077
Major arterial	41.0	41.0	0.805	0.072	0.048	0.035	0.04
Minor arterial	36.0	36.0	0.85	0.06	0.04	0.035	0.015
Local	36.0	36.0	0.86	0.06	0.04	0.03	0.01
Hamilton							
Interstate	40.5	43.0	0.723	0.072	0.048	0.035	0.122
Arterial	19.0	21.0	0.822	0.066	0.044	0.034	0.034
Local	15.0	14.5	0.860	0.060	0.040	0.030	0.010
Lake							
Interstate	58.0	58.0	0.7	0.072	0.048	0.035	0.145
Major arterial	50.0	50.0	0.825	0.072	0.048	0.035	0.02
Minor arterial	35.0	35.0	0.86	0.06	0.04	0.03	0.01
Local	35.0	35.0	0.86	0.06	0.04	0.03	0.01
Loraine							
Interstate	58.0	58.0	0.723	0.072	0.048	0.035	0.122
Major arterial	44.8	44.8	0.798	0.072	0.048	0.035	0.047
Minor arterial	39.0	39.0	0.846	0.060	0.04	0.033	0.021
Local	37.4	37.4	0.860	0.060	0.04	0.030	0.010
Lucas							
Interstate	58.0	58.0	0.74	0.072	0.048	0.035	0.105
Major arterial	47.0	47.0	0.79	0.072	0.048	0.035	0.055
Minor arterial	40.0	40.0	0.85	0.06	0.04	0.035	0.015
Local	40.0	40.0	0.86	0.06	0.04	0.03	0.01
Mahoning							
Interstate	60.0	60.0	0.67	0.072	0.048	0.035	0.175
Major arterial	52.0	52.0	0.77	0.072	0.048	0.035	0.075
Minor arterial	46.0	46.0	0.84	0.06	0.04	0.035	0.025
Local	40.0	40.0	0.86	0.06	0.04	0.03	0.01

(continued)

TABLE A-7 (continued).

County	1977 Average speed	1987 Average speed	LDV	LDT1	LDT2	HDG	HDD
Montgomery							
Interstate	58.0	58.0	0.74	0.072	0.048	0.035	0.105
Major arterial	45.0	45.0	0.815	0.072	0.048	0.035	0.025
Minor arterial	45.0	45.0	0.85	0.06	0.04	0.03	0.02
Local	45.0	45.0	0.86	0.06	0.04	0.03	0.01
Stark							
Interstate	58.0	58.0	0.765	0.072	0.048	0.035	0.08
Major arterial	48.0	48.0	0.78	0.072	0.048	0.035	0.065
Minor arterial	45.0	45.0	0.84	0.072	0.048	0.03	0.02
Local	40.0	40.0	0.86	0.06	0.04	0.03	0.01
Summit							
Interstate	58.0	58.0	0.755	0.072	0.048	0.035	0.09
Major arterial	41.0	41.0	0.795	0.072	0.048	0.035	0.05
Minor arterial	37.0	37.0	0.85	0.06	0.04	0.03	0.02
Local	41.0	41.0	0.86	0.06	0.04	0.03	0.01
Trumbull							
Interstate	58.0	58.0	0.58	0.072	0.048	0.4	0.26
Major arterial	49.0	49.0	0.795	0.072	0.048	0.035	0.05
Minor arterial	45.0	45.0	0.84	0.06	0.04	0.035	0.025
Local	40.0	40.0	0.86	0.06	0.04	0.035	0.005
Clermont							
Interstate	53.5	56.0	0.723	0.072	0.048	0.035	0.122
Arterial	34.5	35.0	0.822	0.066	0.044	0.034	0.034
Local	15.0	16.0	0.860	0.06	0.04	0.03	0.01
Geauga							
Interstate	58.0	58.0	0.723	0.072	0.048	0.035	0.122
Major arterial	44.8	44.8	0.798	0.072	0.048	0.035	0.047
Minor arterial	39.0	39.0	0.846	0.060	0.040	0.033	0.021
Local	37.4	37.4	0.860	0.060	0.040	0.030	0.010
Greene							
Interstate	58.0	58.0	0.723	0.072	0.048	0.035	0.122
Major arterial	44.8	44.8	0.798	0.072	0.048	0.035	0.047
Minor arterial	39.0	39.0	0.846	0.060	0.040	0.033	0.021
Local	37.4	37.4	0.860	0.060	0.040	0.030	0.010
Medina							
Interstate	58.0	58.0	0.723	0.072	0.048	0.035	0.122
Major arterial	44.8	44.8	0.798	0.072	0.048	0.035	0.047
Minor arterial	39.0	39.0	0.846	0.060	0.040	0.033	0.021
Local	37.4	37.4	0.860	0.060	0.040	0.030	0.010
Warren							
Interstate	54.0	55.0	0.723	0.072	0.048	0.035	0.122
Arterial	34.5	33.0	0.822	0.066	0.044	0.034	0.034
Local	15.0	15.0	0.860	0.060	0.040	0.030	0.010
Wood							
Interstate	58.0	58.0	0.723	0.072	0.048	0.035	0.122
Major arterial	44.8	44.8	0.798	0.072	0.048	0.035	0.047
Minor arterial	39.0	39.0	0.846	0.060	0.040	0.033	0.021
Local	37.4	37.0	0.860	0.060	0.040	0.030	0.010

Notes: See Table A-5 for data sources

LDT1 is taken as 0.6 of LDT and LDT2 is taken as 0.4 of LDT

TABLE A-8. HYDROCARBON I/M CREDITS

Without Maintenance

Technology	Stringency	Years of I/M: 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
I	0.10	3.	6.	11.	15.	19.	24.	27.	31.	35.	39.	41.	42.	44.	46.	47.	48.	49.	51.	52.
	0.20	4.	8.	13.	18.	22.	28.	30.	36.	40.	42.	45.	46.	49.	50.	51.	52.	54.	56.	57.
	0.30	7.	14.	20.	28.	34.	39.	43.	46.	49.	52.	54.	55.	57.	58.	59.	60.	61.	62.	63.
	0.40	8.	15.	22.	30.	36.	41.	46.	49.	52.	54.	56.	58.	59.	61.	62.	63.	64.	65.	65.
	0.50	8.	16.	23.	31.	37.	42.	46.	50.	53.	55.	57.	59.	60.	61.	62.	63.	64.	65.	66.
II	0.10	4.	6.	9.	11.	16.	19.	20.	23.	25.	28.	29.	30.	32.	33.	35.	36.	36.	37.	38.
	0.20	6.	11.	16.	20.	23.	27.	31.	33.	36.	38.	40.	41.	43.	44.	45.	46.	47.	48.	49.
	0.30	10.	18.	24.	28.	33.	36.	40.	42.	45.	47.	48.	50.	51.	53.	55.	55.	55.	57.	58.
	0.40	12.	20.	26.	32.	37.	40.	43.	46.	49.	51.	52.	54.	55.	56.	57.	58.	59.	60.	61.
	0.50	11.	22.	28.	34.	39.	43.	46.	49.	51.	54.	55.	57.	58.	59.	61.	61.	62.	63.	64.
III	0.10	4.	11.	22.	32.	42.	49.	54.	58.	62.	64.	66.	68.	69.	71.	72.	73.	74.	74.	75.
	0.20	4.	13.	25.	37.	46.	53.	58.	62.	65.	67.	69.	71.	72.	73.	74.	75.	76.	77.	77.
	0.30	4.	15.	28.	40.	49.	55.	60.	64.	67.	69.	71.	72.	74.	75.	76.	77.	77.	78.	79.
	0.40	5.	17.	31.	43.	51.	58.	63.	66.	69.	71.	73.	74.	75.	76.	77.	78.	79.	79.	80.
	0.50	5.	18.	32.	44.	53.	59.	63.	67.	70.	72.	73.	75.	76.	77.	78.	79.	79.	80.	81.
IV	0.10	3.	7.	14.	23.	31.	38.	44.	49.	53.	56.	58.	60.	62.	63.	65.	66.	67.	68.	69.
	0.20	3.	7.	15.	24.	33.	40.	46.	51.	54.	57.	60.	62.	63.	65.	66.	67.	68.	69.	70.
	0.30	3.	7.	16.	25.	34.	41.	47.	51.	55.	58.	60.	62.	64.	65.	67.	68.	69.	70.	71.
	0.40	3.	8.	17.	26.	35.	42.	48.	52.	56.	59.	61.	63.	65.	66.	68.	69.	70.	71.	71.
	0.50	3.	8.	17.	27.	36.	43.	49.	54.	57.	60.	62.	64.	66.	67.	68.	69.	70.	71.	72.

With Maintenance

Technology	Stringency	Years of I/M: 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
I	0.10	6.	13.	17.	20.	25.	32.	35.	40.	45.	47.	49.	50.	53.	53.	54.	56.	57.	57.	58.
	0.20	9.	14.	19.	25.	31.	36.	43.	45.	50.	51.	53.	54.	55.	56.	58.	60.	61.	63.	63.
	0.30	12.	19.	27.	35.	41.	48.	51.	53.	55.	57.	59.	61.	61.	63.	65.	65.	66.	66.	67.
	0.40	13.	24.	33.	40.	46.	50.	54.	57.	59.	61.	63.	65.	65.	66.	68.	68.	69.	70.	71.
	0.50	14.	25.	35.	42.	48.	53.	56.	59.	62.	64.	65.	66.	68.	69.	70.	70.	71.	72.	72.
II	0.10	9.	13.	15.	18.	22.	26.	28.	31.	33.	35.	37.	39.	40.	42.	44.	44.	44.	46.	48.
	0.20	13.	16.	20.	26.	31.	34.	38.	41.	43.	44.	45.	47.	48.	50.	52.	52.	53.	54.	55.
	0.30	14.	21.	28.	33.	38.	41.	45.	47.	50.	52.	53.	54.	56.	57.	59.	60.	61.	61.	62.
	0.40	15.	24.	31.	36.	41.	44.	48.	50.	52.	54.	56.	58.	58.	60.	61.	62.	63.	63.	65.
	0.50	16.	26.	33.	39.	43.	47.	50.	53.	55.	57.	59.	60.	61.	63.	64.	65.	65.	66.	67.
III	0.10	18.	33.	51.	59.	67.	70.	74.	76.	78.	80.	80.	81.	82.	83.	84.	84.	85.	85.	86.
	0.20	13.	36.	53.	62.	69.	73.	76.	78.	80.	81.	82.	83.	83.	84.	85.	85.	86.	86.	87.
	0.30	15.	38.	54.	64.	70.	74.	77.	79.	81.	82.	83.	84.	85.	85.	86.	86.	87.	87.	87.
	0.40	16.	39.	54.	64.	70.	74.	77.	80.	81.	83.	84.	85.	85.	86.	87.	87.	87.	88.	88.
	0.50	18.	34.	54.	64.	70.	74.	77.	80.	81.	83.	84.	85.	86.	86.	87.	87.	88.	88.	88.
IV	0.10	9.	26.	36.	52.	58.	65.	66.	69.	72.	75.	75.	75.	77.	79.	79.	80.	80.	81.	81.
	0.20	11.	29.	45.	56.	63.	68.	70.	74.	76.	76.	78.	80.	80.	81.	82.	82.	83.	84.	84.
	0.30	12.	32.	46.	58.	65.	69.	72.	75.	76.	77.	80.	81.	81.	82.	83.	83.	84.	85.	85.
	0.40	14.	36.	52.	62.	68.	73.	76.	78.	80.	81.	82.	83.	84.	85.	85.	86.	86.	87.	87.
	0.50	15.	38.	54.	64.	70.	74.	77.	79.	81.	83.	84.	85.	85.	86.	87.	87.	88.	88.	88.

TABLE A-9. CARBON MONOXIDE I/M CREDITS

Without Maintenance

Technology	Stringency	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
I	0.10	7	13	17	22	26	30	32	35	37	40	41	42	44	45	46	47	48	50	
	0.20	9	17	22	27	31	35	37	40	42	44	46	48	49	51	52	53	54	55	56
	0.30	12	21	27	32	36	40	44	47	49	52	53	55	56	58	59	60	61	62	62
	0.40	14	23	29	35	39	43	47	50	52	55	56	58	59	60	61	62	63	64	65
	0.50	15	25	31	36	41	45	49	52	54	56	58	59	61	62	63	64	65	65	66
II	0.10	10	15	20	23	26	28	31	32	34	35	37	37	38	40	41	41	42	43	44
	0.20	17	25	29	32	36	38	41	42	44	46	47	48	49	50	51	52	52	53	54
	0.30	21	31	36	40	44	47	49	51	53	55	56	57	58	59	60	61	62	62	63
	0.40	23	34	39	43	46	49	52	54	56	57	59	60	61	62	63	63	64	65	65
	0.50	25	36	41	45	49	52	54	56	58	60	61	62	63	64	65	66	67	67	68
III	0.10	0	4	8	14	20	26	30	33	35	39	42	44	45	48	49	50	50	53	55
	0.20	0	5	10	18	23	28	32	37	40	43	45	47	49	51	52	53	54	56	57
	0.30	1	6	13	21	27	33	38	42	45	48	50	52	54	56	57	59	60	61	62
	0.40	1	6	14	22	28	34	39	43	47	49	52	54	55	57	58	60	61	62	63
	0.50	2	7	14	22	29	35	40	44	47	50	52	54	56	58	59	60	61	62	63
IV	0.10	0	2	7	13	19	24	29	33	37	40	43	45	47	49	50	52	53	54	55
	0.20	0	4	11	19	26	32	37	42	45	48	51	53	55	56	58	59	60	62	62
	0.30	1	5	13	21	28	34	40	44	48	51	53	55	57	58	60	61	62	63	64
	0.40	2	8	18	28	36	42	47	52	55	58	60	62	63	65	66	67	68	69	70
	0.50	3	12	23	33	42	48	53	57	60	63	65	66	68	69	70	71	72	73	74

With Maintenance

Technology	Stringency	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
I	0.10	11	20	26	30	34	40	43	47	50	52	53	55	58	57	58	59	61	60	
	0.20	16	23	29	35	40	43	49	51	54	55	57	58	59	60	62	62	64	66	66
	0.30	20	29	37	42	47	49	55	57	59	61	62	64	64	66	67	68	68	68	70
	0.40	22	34	41	46	51	55	58	61	63	64	65	67	68	69	70	70	71	72	73
	0.50	23	35	42	48	53	57	60	62	65	66	68	69	70	71	72	72	73	74	74
II	0.10	17	25	27	31	35	38	40	43	44	45	49	50	50	53	54	54	55	56	58
	0.20	26	33	36	41	46	48	51	54	56	57	58	59	60	61	63	63	64	65	66
	0.30	30	41	47	50	54	57	59	61	63	65	65	66	67	68	69	70	71	71	71
	0.40	32	45	50	54	57	60	63	64	65	67	68	69	70	71	72	72	73	73	74
	0.50	33	47	52	56	60	62	65	67	68	69	70	71	72	73	74	74	75	75	76
III	0.10	5	24	40	48	56	60	65	67	69	72	72	74	75	76	77	78	78	79	79
	0.20	8	27	42	51	58	63	66	69	71	73	74	76	76	77	78	79	79	80	80
	0.30	11	29	43	52	59	64	67	70	72	74	75	76	77	78	79	80	80	81	81
	0.40	13	30	43	52	59	64	68	71	73	75	76	77	78	79	80	80	81	82	82
	0.50	14	30	43	52	59	64	68	71	73	75	76	77	78	79	80	81	81	82	82
IV	0.10	9	30	41	56	58	68	68	71	74	77	77	78	79	81	81	81	81	82	83
	0.20	15	37	51	60	66	70	72	76	77	78	80	82	82	82	83	84	84	85	85
	0.30	18	39	52	62	68	71	74	77	78	79	82	82	82	84	84	84	85	86	86
	0.40	21	43	57	66	71	75	78	80	81	83	84	85	85	86	86	87	87	88	88
	0.50	23	44	58	66	72	76	79	81	83	84	85	86	86	87	88	88	88	89	89

TABLE A-10. JOURNEY TO WORK DATA

County	Workers in county*	Workers living outside 12 counties*	Workers living outside 18 counties*	VMT not inspected alternative A‡	VMT not inspected alternative B‡
Butler	-†	-†	-†	0.0549†	0.0394†
Cuyahoga	529,660	28,138	10,893	0.0266	0.0103
Franklin	272,804	29,827	29,827	0.0547	0.0547
Hamilton	326,777	70,595	45,651	0.1080	0.0698
Lake	43,116	3,373	1,909	0.0391	0.0221
Loraine	68,440	4,333	3,991	0.0317	0.0292
Lucas	164,357	26,345	17,323	0.0801	0.0527
Mahoning	86,883	6,333	6,333	0.0364	0.0364
Montgomery	218,182	45,173	20,236	0.1035	0.0464
Stark	111,324	9,346	9,346	0.0420	0.0420
Summit	162,616	14,933	10,983	0.0459	0.0338
Trumbull	72,110	5,304	5,138	0.0368	0.0356
Clermont	9,577	8,149	1,168	0.9254	0.0610
Geauga	10,447	7,966	962	0.8813	0.0460
Greene	33,655	24,687	5,967	0.8668	0.0886
Medina	13,008	11,008	1,535	0.9232	0.0590
Warren	11,030	8,882	860	0.9026	0.0390
Wood	25,576	17,337	3,323	0.8389	0.0650

*Source: U.S. Census of Population, Subject Report, Journey to Work PC(2)-6D, Department of Commerce 1970

†Data is not available for Butler County, averages for the other 11 counties in alternative A are used.

‡See text for formulas used

REFERENCES

1. U.S. Environmental Protection Agency. Mobile Source Emission Factors. For Low-altitude areas. Final Document. EPA-400/9-78-006. March 1978.

2. U.S. Environmental Protection Agency. Appendix N - Emission Reduction Achievable Through Inspection and Maintenance of Light-Duty Vehicles, Motorcycles and Light- and Heavy-duty trucks. Proposed Rule. Federal Register 24(84):22177-22183. May 2, 1977.

3. U.S. Census of Population, Subject Report. Journey to Work PC(2)-6D. Department of Commerce, 1970.

APPENDIX B

ESTIMATED FUEL SAVINGS RESULTING FROM I/M FOR 1987

INTRODUCTION

There are no firm figures to date regarding the effect of an I/M program on fuel economy. It is generally accepted that the inspection sequence has a favorable influence on fuel economy by forcing vehicle owners to maintain their vehicles at higher standards than they would in the absence of I/M.

Estimates of fuel savings vary from a 4 percent improvement noted in California's Riverside Trial Program (idle mode)[1] to a 10 percent savings for the first 6 months that Hamilton Test Systems operated a program for Arizona.[2] These figures are for light-duty vehicles that failed the emissions test and have thus been forced to be repaired for compliance. Noting such studies as these, EPA has suggested a range of 5 to 10 percent[3] for expected fuel savings on repaired vehicles. A 7 percent figure is used here as an average for calculations. This figure may be revised if the results from an ongoing study in Oregon prove more conclusive.

It should be noted that these fuel economy figures may be misleading. If the 4 percent improvement figure noted in California is "deteriorated" over 1 year and distributed equally over the total vehicle population tested, fuel economy improvement is only 0.6 percent. Over time, the fuel economy realized by I/M will decline. This is particularly true for that segment of the vehicle population that upgraded maintenance levels to meet I/M standards.

There are also other important variables to be considered that influence fuel economy figures, and perhaps can be pointed to as the reasons for so many different study results thus far. These include test mode, characteristics of the pertinent vehicle population, geographic coverage of the program and stringency rate used as well as the amount of time the program has been in effect.

Keeping these in mind, some interesting facts and figures on I/M fuel savings may then be quoted. The U.S. Department of Transportation in the "Department of Motor Vehicle Diagnostic Inspection Program (DMVDIP)" projected nationwide impacts of I/M related fuel savings. These show a resulting conservation of 1.8 billion gallons of gasoline/year of $1.1 billion saved by consumers.[4] While the accuracy of this estimate is open to speculation, its magnitude is impressive. Hamilton Test Systems has noted a decrease in vehicle failure in the field, thus saving vehicle owners towing charges as well as other related expenses. The EPA has noted that improvement in fuel economy is greatest when the failure rate is minimized. This occurs because lowering the stringency rate isolates those vehicles farthest out of compliance. This segment of the population has the greatest potential for improvement since it is the least adequately maintained vehicle group.

A rough estimate of fuel savings for failed vehicles resulting from I/M implementation statewide in Ohio can be calculated for 1987. Assumptions include using a 30 percent stringency rate, an average improvement in fuel economy for failed vehicles of 7 percent, a predicted 1987 statewide vehicle population of 9,599,700 and VMT of 50,284,524,000 per year, an average fleet mileage figure of 24.49 miles per gallon and a cost of $0.70 per gallon for gasoline. The fuel savings for 1987 will be 37,171,280 gallons or $26,019,896. These savings would accrue to all vehicle owners particpating in the I/M program, providing they maintain their vehicles before (of after) inspection.

The estimated statewide fuel savings in 1987 in gallons can be compared with the 12 and 18 county alternatives as shown below in Table B-1.

TABLE B-1. ANNUAL FUEL SAVINGS (GALLONS)

	Total fuel savings	Dollar savings at $0.70 gallon	Savings per failed vehicle
Alternative A - 12 County	28,898,530	$20,228,970.00	$11.80
Alternative B - 18 County	31,844,630	$22,291,241.00	$11.85
Statewide	37,171,280	$26,019,896.00	$ 9.10

DETAILED CALCULATIONS

The total number of gallons of gasoline saved by implementation of I/M on a statewide basis in Ohio can be calculated for 1987. Four factors must be known to derive this estimate. First, the stringency rate established for the program is a prime determinant. Fuel savings will be calculated twice, once assuming a 30 percent stringency rate and again with a 20 percent stringency rate. The total VMT generated in 1987 by vehicles covered by Appendix N credits that are covered by an I/M sequence is also pertinent. Light-duty vehicle (LDV) appendix N credits have already been promulgated. Light-duty truck (LDT) credits are not yet availble. Thus, to be consistant with emission reduction benefits reported here, fuel savings will be calculated for LDVs only. The VMT by the LDV fleet in 1987 must be adjusted to eliminate VMT generated by LDVs that are exempt from I/M. Thus, VMT for LDV less than 1 year old and greater than 13 years old must be removed.

Table B-2 reports estimated LDV VMT figures for 1987 for 12 and 18 counties and statewide. Based on data in the Environmental Protection Agency's Mobile 1 computer program and EPA mileage standards, an average fleet mileage for vehicles covered by I/M in 1987 of 24.49 miles per gallon results. This data indicates that 86.2 percent of the 1987 LDV VMT are generated by vehicles covered by I/M (Tables B-3 and B-4).

TABLE B-2. ESTIMATED DAILY VMT FIGURES FOR SELECTED COUNTIES FOR 1987

County	Daily vehicle miles travelled (thousands)	Total
Butler	5,725.8	
Cuyahoga	25,813.81	
Franklin	16,887.79	
Hamilton	19,072.4	
Lake	6,035.09	
Loraine	2,437.38	
Lucas	8,013.19	
Mahoning	5,164.29	
Montgomery	10,349.06	
Stark	6,200.99	
Summit	10,719.64	
Trumbull	4,988.39	
12-County total VMTs		121,407.83
Clermont	3,091.6	
Geauga	981.26	
Greene	1,428.32	
Medina	2,338.73	
Warren	3,996.8	
Wood	2,681.91	
18-County total VMTs		135,926.52
Statewide VMTs	156,163,120	156,163,120

TABLE B-3. TRAVEL WEIGHTING FACTOR CALCULATION FOR LIGHT-DUTY VEHICLES

Year	Vehicle age	(a) Fraction total registration	(b) Annual mileage accumulation rate	(a) * (b)	{(a) * (b)/sum} travel fraction
1987	1	0.075	15900	1192.5	0.106
1986	2	0.107	15000	1605.0	0.142
1985	3	0.107	14000	1498.0	0.133
1984	4	0.106	13100	1388.6	0.123
1983	5	0.100	12200	1220.0	0.108
1982	6	0.092	11300	1039.6	0.092
1981	7	0.085	10300	875.5	0.077
1980	8	0.077	9400	723.8	0.064
1979	9	0.066	8500	561.0	0.050
1978	10	0.052	7600	395.2	0.035
1977	11	0.039	6700	261.3	0.023
1976	12	0.027	6600	178.2	0.015
Pre-1976	13+	0.066	5491	362.4	0.032

FROM: Mobile I, EPA; January 1978.

TABLE B-4. EPA MPG SPECIFICATIONS AND AVERAGE FLEET MILEAGE FOR LDVs COVERED BY I/M IN 1987

Year	EPA mileage standard	Travel fraction*	$\frac{\text{Column (1) x column (3)}}{0.968}$
1986	27.5	0.142	4.530
1985	27.5	0.133	4.243
1984	27	0.123	3.853
1983	26	0.108	3.258
1982	24	0.092	2.562
1981	22	0.077	1.965
1980	20	0.064	1.485
1979	19	0.050	1.102
1978	18	0.035	0.731
1977	17.5	0.023	0.467
1976	16.8	0.015	0.292
Total		0.862†	24.488

*From Table B-2.

†Note: This column totals less than 1 indicating that part of the vehicle population is 12 or more years old.

SOURCE: Federal Register, Book 1, Vol. 42, No. 126, p. 33534, Thursday, June 30, 1977 and Table B-1.

The final factor that determines the quantity of fuel saved is the level of fuel economy realized by vehicles undergoing required maintenance. Since this figure is not known precisely, estimates are derived for 2 to 10 percent improvements.

The formula used to calculate fuel savings is:

$$\text{Gallons saved per year} = \frac{(\text{VMT})(0.862)}{(\text{FM})} * S * F * 322$$

where: VMT = daily vehicle miles travelled by LDVs in 1987.

0.862 = portion of 1987 LDV VMTs generated by vehicles covered by I/M.

FM = average fleet mileage of LDVs covered by I/M.

S = stringency rate.

F = improvement in fuel economy realized by failed vehicles undergoing required maintenance.

322 = factor to adjust from daily to yearly savings.

The results of these calculations are reported in Table B-5.

TABLE B-5. POTENTIAL YEARLY FUEL SAVINGS FROM I/M FOR SELECTED COUNTIES IN 1987* (1000 GALLONS)

Increase in fuel economy for failed vehicles (%)	Geographic coverage of program			Average fleetwide fuel savings as a percentage of total fuel consumption†
	12 Counties	18 Counties	Statewide	
2	8,256.72	9,098.47	10,620.37	0.6%
3	12,385,08	13,647.70	15,930.55	0.9%
4	16,513,45	18,196.93	21,240.73	1.2%
5	20,641,81	22,746.17	26,550.92	1.5%
6	24,770.17	27,295.40	31,861.10	1.8%
7	28,898.53	31,844.63	37,171.28	2.1%
8	33,026.89	36,393.87	42,481.47	2.4%
9	33,155.25	40,943.10	47,791.65	2.7%
10	41,283.61	45,492.33	53,101.83	3%

*This table assumes a 30 percent stringency level for all different levels of geographic coverage.

†Fuel savings as a proportion of total fuel consumption is the same for different levels of geographic coverage for a specific increase in fuel economy.

REFERENCES

1. Rubestein, G. R. Ingels, R. Weis, and A. Wong. Vehicle Inspection and Maintenance. California Program. California Air Resources Board. SAE Paper No. 760557.

2. Automotive Fleet. Benefits of a Vehicle Inspection Program. Reprinted for Hamilton Test Systems, Inc. July 1975.

3. Telephone Conversation(s) - Bruce Everlane, U.S. Environmental Protection Agency, Washington, D.C. May 17, 1978.

4. U.S. Department of Transportation. Motor Vehicle Diagnostic Inspection Demonstration Program. October 1977.

APPENDIX C

SENSITIVITY OF BREAKEVEN FEES

The breakeven fees are dominated by the annual operating-costs in all of the centralized approaches. The annual operating cost is highly dependent on the test personnel cost. By changing the test personnel wages to reflect a 25 percent increase (perhaps due to unionization or a civil service raise, assumed over a time-span of 3 years), the resulting change in f_c (fee in constant 1978 dollars) would be a 10 to 13 percent increase. The current and increased breakeven fees are shown in Table C-1.

TABLE C-1. INCREASE IN BREAKEVEN FEES WITH A 25 PERCENT INCREASE IN PERSONNEL WAGES ($i = 0.03$)

Option	Alternate	Current f_c	f_c with 25 percent higher wages	Increase
I, III, or V	A	3.43	3.57	4.15%
	B	3.33	3.55	6.68%
II, IV, or VI	A	3.17	3.39	7.02%
	B	3.15	3.37	6.90%
I or II (rural)	A	0.56	0.60	7.32%
	B	0.56	0.61	8.19%

A policy of providing paid retests to consumers whose vehicles have failed the initial test will cause a decrease in the breakeven fee equal to the stringency factor, since the total annualized cost of the program would be split by that many more tests. In this example, using a 30 percent stringency factor, the cost for an inspection would be 30 percent higher in a program allowing for a free retest than in one requiring a paid retest. The breakeven fees for both alternatives are provided in Table C-2.

TABLE C-2. DECREASE IN f_c (BREAKEVEN FEE IN CONSTANT 1978 DOLLARS) WITH PAID RETEST POLICY, $i = 0.03$

Option	Alternate	f_c with paid retest (\$)	f_c with free retest (\$)
I, III or V	A	2.64	3.43
	B	2.56	3.33
II, IV or VI	A	2.61	3.39
	B	2.59	3.37
I or II	A	0.43	0.56
	B	0.43	0.56

APPENDIX D

DETAILED DESCRIPTION OF COSTS AND FEE CALCULATIONS

This appendix contains a detailed description of the methodology used in calculating annual costs and fees. First, capital and start-up cost are converted to annual figures in real dollars. These figures are then added to annual operating and administrative costs, so as to arrive at the yearly cost of the whole project. A uniform real dollar fee is then calculated, along with a second fee that is uniform in actual dollars.

INITIAL CAPITAL COSTS

The capital investment in equipment is assumed to yield equal benefits for each of 5 years and be fully depreciated thereafter. The interest rate is the marginal return on capital in the absence of inflation.

In annualizing equipment costs, the following formulas are employed. The net present value of an investment (NPV) that yields 1 dollar of service for each of n years at a capital growth rate of i is:

$$NPV = \sum_{k=1}^{n} \frac{1}{(1+i)^k} = 1 - \left[(1+i)^{-n}\right] \Big/ i \qquad (1)$$

Thus, an investment of 1 dollar yields annual benefits: $\frac{1}{NPV} = \frac{i}{1-(1+i)^{-n}}$ for each of n years. Thus $\frac{1}{NPV}$ represents amortized costs in constant dollars. In the case of $n = 5$ and $i = 0.03$, $NPV = 4.580$ and $\frac{1}{NPV} = 0.2184$, and in the case of $n = 5$ and $i = 0.06$, $NPV = 4.212$ and $\frac{1}{NPV} = 0.2374$.

For buildings and structures, investment is assumed to yield a constant flow of capital services for 20 years and be fully depreciated thereafter. The above formulas are employed with $n = 20$. This yields $NPV = 14.877$ and and $\frac{1}{NPV} = 0.067$ when $i = 0.03$; and $NPV = 11.469$ and $\frac{1}{NPV} = 0.087$ when $i = 0.06$. If structures are liquidated before 20 years, their sale price is assumed to be the capitalized flow of the remaining capital services (i.e., if sold after j years, the sale price will be:

$$\sum_{k=1}^{20-j} \left(\frac{1}{NPV(1+i)}\right)^k$$

for each dollar of initial investment). This assumption enables use of the above amortization factor, $\frac{1}{NPV}$, without making further adjustments.

Land is assumed to yield a constant level of services in perpetuity ($n = \infty$ in the above formulas). So a dollar investment yields $\frac{1}{NPV} = i$ dollars of service each year. Again, we assume the resale price of investment (in this case, land) is the capitalized flow of the remaining services. This implies that the value of land is unchanged from year to year, and the annual benefit (cost of capital service) is (land value) (i), regardless of when land liquidation occurs.

One-Time Start-Up Costs

One-time start-up costs, like capital costs, occur at the beginning of the project. However, these expenditures do not yield a flow of services or have a resale value, as do capital investments. Even still, start-up expenditures can be recouped over a period of time. We assume a 5-year period of repayment with equal yearly payments in constant dollars. Therefore, the annual cost of each dollar of start-up cost is: $\frac{1}{NPV} = \frac{i}{1-(1+i)^{-5}}$, which equals 0.2184 when $i=0.03$ and 0.2374 when $i=0.06$.

Annual Operating and Administrative Costs

These costs are presented as annual figures. To obtain total annual cost in constant dollars, the annual operating and administrative costs are added directly to the annual capital and start-up costs.

Fee Calculations

A fee, f_c, reflecting constant dollars, is calculated by dividing total annual costs by the number of paid inspections per year. This fee is designed to recoup all of the costs included in Table 3-1.

Interest Rates and Constant Dollars

All of the proceeding calculations are performed in constant 1978 dollars. To get figures in actual dollars for years other than 1978, all annual costs, amortized costs, and fees must be increased by the amount of inflation since 1978.

Interest rates used with constant dollars are those reflecting the real return on capital. Actual interest rates include compensation to offset the diminished buying power of money under inflation, and thus, are inappropriate here. In this study, we employ two real rates of return for capital, 3 percent and 6 percent. These rates are lower and upper bounds; the exact rate depends upon the source of financing (i.e., debt, equity, or taxpayers' foregone investment.)

Inflation

The above-mentioned fee is in real (constant) dollars and must be adjusted for inflation. These adjustments will cover increased operating costs as well as the difference between the market rate of interest and the real rate of return on capital.

A second fee, f_a, will also be calculated. This fee will be uniform in actual dollars over time. In calculating this fee, an inflation rate ρ must be assumed.* In this report, it will be assumed that $\rho = 0.07$. For notational convenience, let r = market rate of interest and i = real return on capital ($r = i+\rho$). Then, for investments (capital costs and start-up costs) an assumption of uniform capital services in actual dollars allows the use of the previous formulae for $\frac{1}{NPV}$ with r substituted for i.† The factors for amortization are shown in Table D-1 below:

TABLE D-1. FEE, f_a, AMORTIZATION FACTORS

Cost category	$\frac{1}{NPV}$	i=0.03	i=0.06
Land	r	0.10	0.13
Buildings and structures	$\frac{r}{1-(1+r)^{-20}}$	0.117	0.143
Equipment and start-up costs	$\frac{r}{1-(1+r)^{-5}}$	0.264	0.284

Annual operating and administrativd costs must be transformed from constant to actual dollars. Actual annual cost, is equal to the product of (1) constant annual cost and (2) a transformation factor, T; this transformation factor is determined from:

*It shall be noted that the first fee, f_c, was independent of ρ.

†Capital investments no longer yield uniform services, but now yield accelerated depreciation.

$$T = \frac{1}{\sum_{k=1}^{n}\left(\frac{1}{1+r}\right)^k} \sum_{k=1}^{n}\left(\frac{1+\rho}{1+r}\right)^k = \frac{r}{1-(1+r)^{-n}} \sum_{k=1}^{n}\left(\frac{1}{1+\frac{1+r}{1+\rho}-1}\right)^k$$

$$= \frac{r(1+\rho)}{i}\left(\frac{1-(1+i/1+\rho)^{-n}}{1-(1+r)^{-n}}\right)$$

where n = number of years = 5. Therefore, when $i = 0.03$ then $T = 1.215$, and when i = 0.0t then $T = 1.210$.

The fee, f_a, is calculated in a manner similar to the original fee, f_c. Annualized costs are summed and divided by the annual number of paid inspections to arrive at f_a.

APPENDIX E

UNIFORM FEE IN ACTUAL DOLLARS FOR OPTIONS

Fees that will remain constant over the first 5 years of I/M program operation have been calculated for the various options. These figures have been derived in 1978 dollars and are reported in Tables E-1 and E-2. A complete description of the methodology used and the assumptions that these figures are based on appear in Appendix D.

Since these figures are reported in 1978 dollars, they must be adjusted for inflation to arrive at the actual dollar amounts for the year in which the program is initiated. Once that figure is determined it will remain constant for 5 years. This rests on the assumption that the average rate of inflation over that 5-year period will be 7 percent.

The actual fees (f_a) reported in this appendix apply separately to the urban and rural components of program coverage for Options I and II. Desaggregating the options in this fashion provides information on the incremental cost of including rural inspection along with the 12-county (Alternate A) and 18-county (Alternate B) urban area program coverages.

As would be expected, the cost of rural inspections is lower than the cost of urban inspections. For Option I (contractor run facilities in urban areas and private garage testing in rural areas) the urban f_a for Alternate A is \$4.04 while rural inspections run lower at \$0.68 each (assuming an interest rate of 3 percent). For the 18-county alternate of Option I the urban f_a is \$4.03 and the rural f_a is \$0.69.

Option II varies from I because urban area facilities are state-run. This change results in slightly different f_a figures. For Alternate A the urban f_a is \$3.82 and the rural f_a is \$0.68. These figures for Alternate B are \$3.80 and \$0.72 respectively (assuming a 3 percent interest rate).

Options III and V consist of contractor-run and state-run urban area coverage only. Their f_a figures are similar. For 12-county coverage average test costs are \$4.04. This figure is similar for 18-county coverage at \$4.03.

For Options I through VI f_a is calculated to cover either the state or the contractor costs, whichever is appropriate. It also assumes that reinspections totalling 30 percent of the vehicle population are conducted on a paid basis and that no vehicle fails reinspection.

Private garage inspections statewide have also been examined (Option VII). f_a varies with this option by the level of private garage participation. As the proportion of garages providing I/M testing increases, the throughput per facility declines. Because of the high fixed costs associated with testing, the cost per inspection increases as facility throughput increases. Assuming a 3 percent interest rate, f_a varies with the level of participation from \$0.91 to \$1.15.

TABLE E-1. f_a AND COST COMPONENTS WITH i = 0.03 (ALL FIGURES ARE 1978 DOLLARS)

Cost components for f_a*	OPTIONS										
	I Rural		II Rural		I, III, V Urban		II, IV, VI Urban		VII		
	A	B	A	B	A	B	A	B	min	mid	max
I. Capital Costs											
1. Land	0	0	0	0	267,297	299,729	267,297	299.729	171,679	171,679	171,679
									(referee lanes)		
2. Buildings	0	0	0	0	1,407,256	1,559,659	1,407,257	1,559,659	63,882	103,194	140,867
									(inspection & licensing vans)		
3. Equipment	114,840	97,416	114,708	97,416	2,064,876	2,331,410	2,064,876	2,331,410	36,960	58,080	80,520
									(complaints/investigation vehicles)		
II. Start-Up Costs	196,080	175,419	191,080	175,419	1,251,001	1,355,699	1,401,158	1,505,856	999,380	1,190,595	1,381,784
III. Operating Costs	702,095	603,597	703,081	603,597	14,246,911	15,537,917	12,960,421	14,105,911	2,927,874	3,190,562	3,442,553
IV. Administrative Costs	1,365,563	1,179,668	1,365,563	1,270,754	1,785,535	1,880,344	1,785,535	1,880,344	3,296,220	4,027,385	4,759,207
Total Component Costs	2,378,579	2,056,100	2,379,431	2,147,186	21,022,876	22,964,758	19,886,544	21,682,909	7,496,000	8,741,495	9,976,611
(f_a)	0.68†	0.69†	0.68†	0.72†	4.04	4.03	3.82	3.80	0.913†	1.01†	1.15†

*These figures are not to be construed as annual costs.

†Rural areas in Options I and II and all areas in Option VII have been retested. All other cases have free retests.

Note: f_a = Uniform fee in actual dollars.

TABLE E-2. f_a AND COST COMPONENTS WITH $i = 0.06$ (ALL FIGURES ARE 1978 DOLLARS)

Cost components for f_a*	OPTIONS										
	I Rural		II Rural		III and V Urban		IV and VI Urban		VII		
	A	B	A	B	A	B	A	B	min	mid	max
I. Capital Costs											
1. Land	0	0	0	0	347,486	389,648	347,486	389,648	223,183	223,183	223,183
										(referee lanes)	
2. Buildings	0	0	0	0	1,707,952	1,892,920	1,707,952	1,892,920	77,532	125,244	170,968
										(inspection and licensing vans)	
3. Equipment	123,540	104,796	123,398	104,796	2,221,306	2,508,032	2,221,306	2,508,032	39,760	62,480	86,620
										(complaints/investigation vehicles)	
II. Start-Up Costs	210,934	188,709	210,934	188,709	1,345,774	1,458,403	1,507,306	1,619,936	1,075,091	1,280,792	1,486,493
III. Operating Costs	699,206	601.113	700,188	601,113	14,188,282	15,473,975	12,907,086	14,047,862	2,915,830	3,177,432	3,428,386
IV. Administrative	1,359,943	1,174,813	1,359,943	1,265,524	1,778,187	1,872,606	1,778,187	1,872,606	3,282,655	4,010,811	4,739,622
Total Component Costs	2,393,623	2,069,431	2,394,459	2,160,142	21,588,987	23,595,584	20,469,326	22,331,004	7,614,051	8,879,942	10,135,272
(f_a)	0.68†	0.69†	0.64†	0.72†	4.15	4.14	3.94	3.92	0.88†	1.02†	1.17†

*These figures are not to be construed as annual costs.

†Rural areas in Options I and II and all areas in Option VII have free retests; all other cases have paid retests.

Note: f_a = Uniform fee in actual dollars.

APPENDIX F

TAX RATES AND ANNUAL TAXES

A private contractor in Options I, III, and V would be required to pay taxes on centralized facilities. Specifically the land, buildings and equipment are subject to taxation. Tax rates for each municipality were obtained from 1976 Actual Tax Rates to All Property and Effective Tax Rates on Real Property for Current Expenses and Debt in Ohio Cities, Table PR-5 No. 2 (1978), published by Ohio Department of Taxation, Research and Statistics Section. Rates used in calculation were effective rates computed by the Research and Statistics Section. Taxable property consists of land, buildings including all facility furnishings, and equipment (assumed assessed at full value). Tax rates, taxable property, and annual taxes itemized by county and municipality are shown in Table F-1.

TABLE F-1. TAX RATES AND ANNUAL TAXES FOR OPTIONS I, III AND V

Alternate A 12 county option	City	Taxable property (facilities/ca. lanes)	Tax rate	Annual taxes ($)
Butler County				
Metropolitan	Hamilton	(1/3) 414,345	0.03837	15,898
Metropolitan	Middletown	(1/3) 414,345	0.03416	14,154
Cuyahoga County				
Core	Cleveland	(3/6) 2,121,213	0.06493	137,730
Metropolitan	Cleveland	(3/6) 2,257,716	0.06493	146,594
Metropolitan	Cleveland	(1/3) 414,345	0.06493	26,903
Franklin County				
Core	Columbus	(1/6) 707,071	0.04040	28,566
Metropolitan	Columbus	(2/6) 1,505,144	0.04040	60,808
Metropolitan	Columbus	(1/3) 414,345	0.04040	16,740
Hamilton County				
Core	Cincinnati	(2/6) 1,414,142	0.05044	71,329
Metropolitan	Cincinnati	(1/6) 752,572	0.05044	37,960
Metropolitan	Norwood	(1/3) 414,345	0.05022	20,808
Lake County				
Metropolitan	Mentor on the Lake	(1/3) 414,345	0.05043	20,895
Metropolitan	Painsville	(1/3) 414,345	0.04778	19,797
Loraine County				
Metropolitan	Loraine	(1/4) 519,485	0.04215	21,896
Metropolitan	Elyria	(1/3) 414,345	0.04113	17,042
Lucas County				
Metropolitan	Toledo	(2/6) 1,505,144	0.03609	54,321
Mahoning County				
Metropolitan	Youngstown	(1/6) 752,572	0.04820	36,274
Metropolitan	Ellsworth	(1/2) 316,645	0.04796*	15,186
Montgomery County				
Metropolitan	Dayton	(2/6) 1,505,144	0.05744	86,455
Metropolitan	Englewood	(1/3) 414,345	0.05676	23,518
Stark County				
Metropolitan	Canton	(1/6) 752,572	0.03840	28,899
Metropolitan	Alliance	(1/4) 519,845	0.04160	21,626

(continued)

TABLE F-1 (continued).

Alternate A 12 county option	City	Taxable property (facilities/ca. lanes)		Tax rate	Annual taxes ($)
Summit County					
Metropolitan	Akron	(2/6)	1,505,144	0.04985	75,031
Metropolitan	Cuyahoga Falls	(1/2)	316,645	0.06180	19,569
Trumbull County					
Metropolitan	Warren	(1/4)	519,845	0.04520	23,497
Metropolitan	Niles	(1/3)	414,345	0.03990	16,532
Total - 12 counties Alternate A					1,058,028
Alternate B - 6 counties					
Clermont County	Batavia	(1/3)	414,345	0.04796*	19,872
Geauga County	Chardon	(1/2)	316,645	0.04796*	15,186
Greene County	Fairborn	(1/4)	519,845	0.05500	28,591
Medina County	Medina	(1/3)	414,345	0.05720	27,701
Warren County	Lebanon	(1/3)	414,345	0.03435	14,233
Wood County	Bowling Green	(1/3)	414,345	0.03619	14,995
Total - 6 counties Alternate B					120,578
Total - 18 counties					1,178,606

*Where no actual figures were available, averages for all cities were used.

APPENDIX G

TECHNICAL CONSIDERATIONS AND COSTS OF A LOADED-MODE OPTION

INTRODUCTION

This appendix discusses the technical considerations and costs of a loaded-mode test option essentially similar to Option III, in which a contractor conducts emission inspection in urban areas only. Although the Ohio Advisory Group did not initially choose to evaluate a loaded mode option, as the study progressed, new information derived from the Advisory Group visits and from the Arizona program, and other sources indicated that the loaded mode test procedure could offer some advantages and not cost much more than a comparable idle mode test. Although the loaded mode has several variations two of which are discussed below, the one chosen for evaluation in this Appendix, namely the "key" loaded mode (called simply loaded mode) has the same thruput rate and same manpower requirements as the idle mode evaluated in all the centralized lane options in the main text of this report.

TEST MODE DESCRIPTIONS

Idle Mode

The idle mode test consists of sampling exhaust gases while the vehicle is idling; no attempt is made to determine the actual idle speed while the exhaust sample is being taken; heretofore, there is no requirement to open the vehicle's hood. The actual test time based on some programs being conducted today (New Jersey, for example), can be as short as 30 seconds (not including the movement of the vehicle into and out of the bay).

There has been some discussion presented concerning the reliability of the basic idle mode test when engine preconditioning* is not performed prior to analyzing the exhaust sample. For this reason, EPA has specified (in the draft Appendix N, at least) that: "At a minimum, the idle test should consist

*Preconditioning is simply allowing the engine to run at a speed of approximately 2,500 rpm for 60 to 90 seconds immediately before the exhaust is sampled. This purges the exhaust system and also reduces some of the heat build-up that occurs under the hood during long idle periods (these could be encountered while waiting for an inspection), which could affect the air-to-fuel ratio and hence, the CO and HC exhaust levels.

of the following procedure carried out on a fully warmed-up engine; a measurement of the exhaust emission concentrations for a period of time of at least 15 seconds, shortly after the engine was run at 2,000 to 2,500 rpm with no load for approximately 60 seconds." This results in the actual test time being closer to 90 seconds, assuming that preconditioning will in fact be required when Appendix N is finalized.

High Idle Mode

This test mode is very similar to the basic idle test mode with respect to equipment required and the fact that exhaust pollutants are measured with the engine idling rather than under a load. The difference, however, is that rather than conducting the test at the normal (for the particular vehicle) idle speed, the engine is adjusted to a speed of 2,250 to 2,500 rpm and allowed to run at that speed for 60 to 90 seconds prior to testing. Since the engine speed is specified for this test mode, a tachometer must be attached to the engine prior to testing. After attaching the tachometer, the inspector would insert the probe into the exhaust pipe and then speed the engine up to 2,250 to 2,500 rpm. The engine speed would be held constant until the exhaust analyzer stabilizes. At that point, the engine is returned to normal idle and sampling continues until the analyzer again stabilizes. CO and HC readings are recorded when the analyzer stabilizes both during the high-idle and normal-idle phase of the test. The complete test time for the high-idle mode test (again, excluding moving the vehicle into and out of the test bay) is 2-1/2 to 3 minutes.

Loaded Mode

Loaded-mode testing involves analyzing exhaust pollutants while the vehicle is being operated under load (through the use of a dynamometer). For the purposes of I/M, exhaust pollutants are measured only at specific steady state conditions; these typically are at 50 mph, 30 mph, and at idle. This is referred to as the Key Mode Test. Some test programs are designed to perform engine diagnostics only at 50 and 30 mph, and the pass-fail test is based on the idle emissions characteristics.

A very high degree of automation has been built into a complete loaded-mode test system by at least one manufacturer. This enables a complete loaded mode test to be conducted in 2 minutes or less.

Modified Loaded Mode

This test mode is identifical to the basic loaded mode test described above, except that the 30 mph phase is eliminated. The primary reason for eliminating this phase is that the total test time is reduced to approximately 100 seconds with very little sacrifice in either test reliability or diagnostic information produced. Modified loaded-mode testing can generally be performed in less than 90 seconds.

DISCUSSION

Table G-1 below summarizes the test times discussed for each test mode.

TABLE G-1. ESTIMATED TEST TIME REQUIREMENTS FOR FOUR I/M TEST MODES

Mode	Test time (seconds)
Idle	30 - 90*
High idle	150 - 180
Loaded	120
Modified loaded	90

*30 seconds without engine preconditioning, 90 seconds with preconditioning.

The test times shown in Table 1 indicate that there actually may be very little differnece in total throughput time between the modified loaded mode and the idle mode tests. This tends to substantiate Hamilton Test System's conclusion that the actual cost differential between the two types of tests can be minimal, essentially reflecting only differences of a few thousand dollars in equipment costs, since the basic requirement for facilities would be identical.*

It is noted here that the very short loaded mode tests do not provide detailed diagnostic information regarding engine performance. Inferences can be made, however, concerning which system is most likely to be causing the emission problem based on the readings at various points in the test. As an example, an excessively high HC level at 50 mph with a normal level at idle indicates that there may be a problem in the ignition system; normal HC levels at 50 mph and abnormally high levels during idle, on the other hand, would indicate that the carburetor is not adjusted properly. If more detailed diagnostic information is desired, an engine analyzer must be integrated into the system. Since this would involve attaching leads to the engine, additional time would be required for each test. The additional time required would be about 90 seconds resulting in a total time of about 3 minutes.

A LOADED MODE ALTERNATIVE

- Urban County Coverage
- Loaded Mode Emission Testing
- Contractor Administers Centralized Lanes

*It is noted, too, that Hamilton Test Systems generally assumes that the actual inspection bay sizes for both idle and loaded are equal; this would allow a switch-over from idle loaded-mode testing to be made easily if the need arose.

Alternate A - 12 Urban Counties

Alternate B - 18 Urban Counties

OPTION DEFINITION

This option involves a private contractor establishing a network of centralized loaded key mode test lanes in either 12 urban counties (Alternate A), or 18 urban counties (Alternate B). A private contractor, under the direction of Ohio EPA, would assume responsibility for the overall program including purchasing land and equipment, building the test facilities, designing the program, training personnel, providing public information, operating the test lanes, handling and analyzing data, and administering all other program elements with the exception of enforcement. The Ohio Bureau of Motor Vehicles would be primarily responsible for enforcement of this option. Appendix G has provided a discussion of the comparison of two methods of enforcement, registration and sticker-ticketing.

NETWORK REQUIREMENTS

The basic network requirements for this option are the same as for the centralized idle mode lanes in urban counties discussed in Sections 4 through 6 for Options I, II, and III respectively. Again, the following numbers of inspections to be performed were derived from 1987 registration projections, assuming a 30 percent stringency rate. They are as follows:

1987 TOTAL INSPECTIONS

•	Alternate A - 12 counties	7,436,000
•	Alternate B - 18 counties	8,148,300

Next, the number of centralized lanes needed for both alternates were derived. Since the idle mode test defined earlier has a throughput time of 2 minutes, and the time requirements of the loaded (key) mode test is also 2 minutes, the centralized lane requirements for this option are the same as those derived in Section 4, which were:

1987 CENTRALIZED LANE REQUIREMENTS

•	Alternate A - 12 counties	166 lanes
•	Alternate B - 18 counties	184 lanes

Again, the actual inspection network in terms of approximate locations and station size was determined. It is shown in Tables G-2 and G-3 for Alternates A and B, respectively.

TABLE G-2. INSPECTION NETWORK REQUIREMENTS FOR ALTERNATE A (12 COUNTY)

County	Town	Number of facilities	Configuration
Butler	Hamilton	1	3 lanes
	Middletown	1	3 lanes
Cuyahuga	Cleveland	6	6 lanes
	Cleveland	1	3 lanes
Franklin	Columbus	3	6 lanes
	Columbus	1	3 lanes
Hamilton	Cincinnati	3	6 lanes
	Norwood	1	3 lanes
Lake	Merton on the Lake	1	3 lanes
	Painsville	1	3 lanes
Lorain	Lorain	1	4 lanes
	Elyria	1	3 lanes
Lucas	Toledo	2	6 lanes
Mahoning	Youngstown	1	6 lanes
	Ellsworth	1	2 lanes
Montgomery	Dayton	2	6 lanes
	Englewood	1	3 lanes
Stark	Canton	1	6 lanes
	Alliance	1	4 lanes
Summit	Akron	2	6 lanes
	Cuyahoga Falls	1	2 lanes
Trumbull	Warren	1	4 lanes
	Niles	1	3 lanes
Total network		35 facilities	166 lanes

TABLE G-3. INSPECTION NETWORK REQUIREMENTS FOR ALTERNATE B (18 COUNTY)

County	Town	Number of facilities	Configuration
Butler	Hamilton	1	3 lanes
	Middletown	1	3 lanes
Clermont	Batavia	1	3 lanes
Cuyahuga	Cleveland	6	6 lanes
	Cleveland	1	3 lanes
Franklin	Columbus	3	6 lanes
	Columbus	1	3 lanes
Geauga	Chardon	1	2 lanes
Greene	Fairborn	1	4 lanes
Hamilton	Cincinnati	3	6 lanes
	Norwood	1	3 lanes
Lake	Merton on the Lake	1	3 lanes
	Painsville	1	2 lanes
Lorain	Lorain	1	4 lanes
	Elyria	1	3 lanes
Lucas	Toledo	2	6 lanes
Mahoning	Youngstown	1	6 lanes
	Ellsworth	1	2 lanes
Medina	Medina	1	3 lanes
Montgomery	Dayton	2	6 lanes
	Englewood	1	3 lanes
Stark	Canton	1	6 lanes
	Alliance	1	4 lanes
Summit	Akron	2	6 lanes
	Cuyahoga Falls	1	2 lanes
Trumbull	Warren	1	4 lanes
	Niles	1	3 lanes
Warren	Lebanon	1	3 lanes
Wood	Bowling Green	1	3 lanes
Total network		41 facilities	184 lanes

OPTION COSTS

The costs associated with the implementation of this option are presented below. Reference should be made to Section 3, Methodologies, concerning analytical techniques used.

Capital Costs

Buildings--

As discussed in Section 3, a building cost of $27.75 per square foot was assumed for this option. An analysis of specific inspection tasks to be performed, including dimensions of equipment required, was made to define the general features that would be included in an inspection facility. A conceptual floor plan for a basic one-lane facility for loaded mode emissions inspection is shown in Figure G-1. Table G-4 shows building area requirements for facilities ranging from one to six lanes. The actual cost estimates for network facilities, based on $27.75 as a unit building cost per square foot, are shown in Tables G-5 and G-6 for Alternates A and B, respectively.

Land Investment--

The primary determinants of land cost for either alternate are the unit cost per square foot and the total size (in square feet) of the land to be acquired. A per-square foot cost of $0.92 for major metropolitan areas and $0.34 for core city areas has been derived in Section 3, as well as has a 5:1 lot building ratio. Total land investment costs, including improvements are provided in Table G-7 and G-8 for Alternates A and B, respectively.

Equipment Costs--

The major equipment items required to operate a loaded mode emission test facility were identified based on an analysis of the test requirements and conversations with individuals currently involved in this type of testing. Costs were obtained through manufacturers' representatives. Outlined in Table G-9 are the equipment requirements and associated costs for a loaded mode emi-sion test.

Equipment costs for any facility configuration, then, can be derived from Table G-8. A summary of equipment cost as a function of the facility configuration is provided in Table G-10.

TABLE G-10. EQUIPMENT COSTS AS A FUNCTION OF FACILITY CONFIGURATION FOR LOADED-MODE EMISSION TESTING

Number of lanes	Equipment cost
1	$126,500
2	173,000
3	219,500
4	266,000
5	312,500
6	359,000

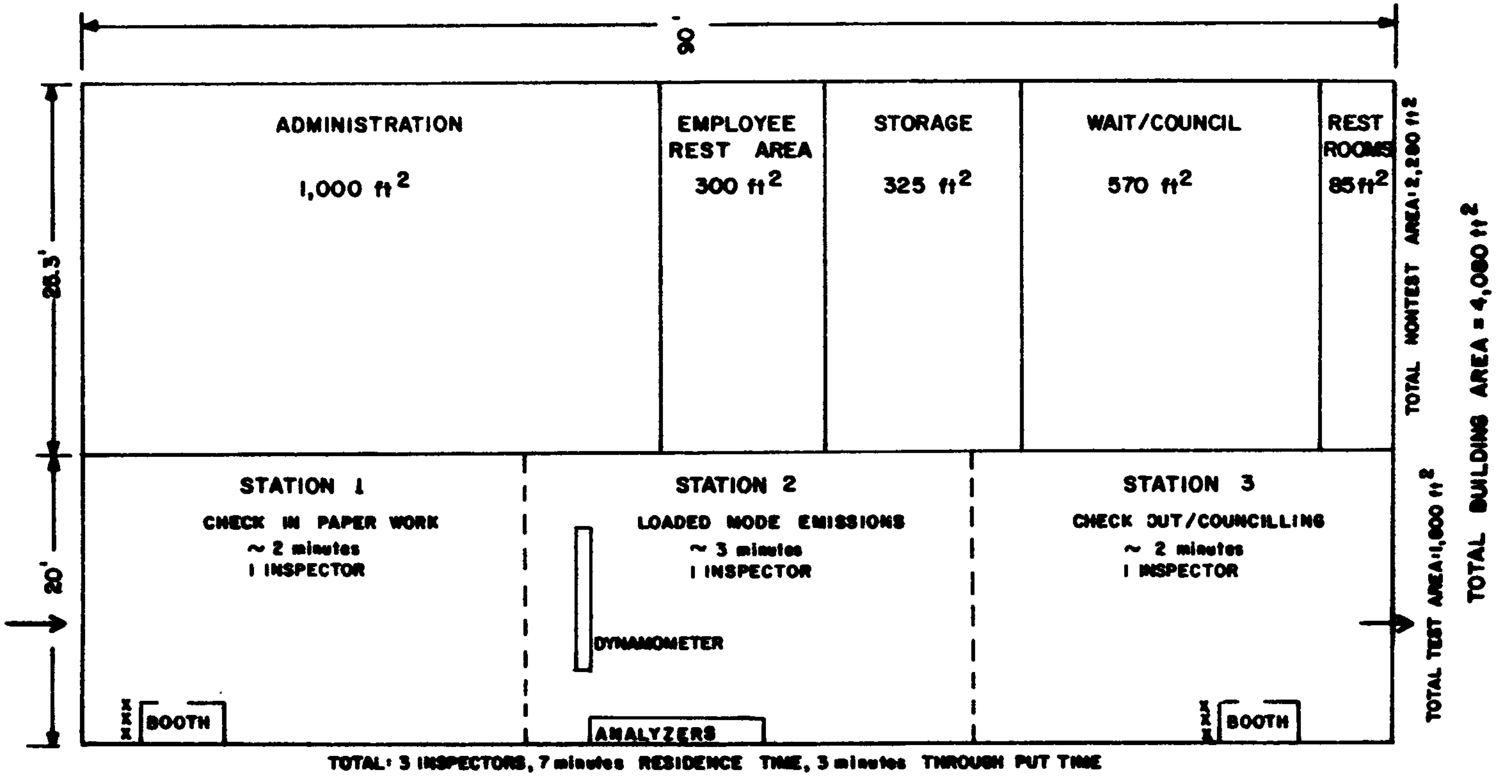

Figure G-1. Conceptual floor plan for a one lane loaded mode inspection facility.

TABLE G-4. BUILDING FLOOR AREA FOR VARIOUS FACILITY CONFIGURATIONS

Configuration	Floor Area Required (ft^2)						
	Test Area	Administration	Employee Rest	Storage	Wait	Rest Rooms	Total
1 lane	1,800	1,000	300	325	570	85	4,080
2 lane	3,600	1,000	350	350	930	85	6,315
3 lane	5,400	1,000	400	380	1,530	85	8,795
4 lane	7,200	1,000	440	410	2,370	85	11,505
5 lane	9,000	1,000	485	435	3,450	85	14,555
6 lane	10,800	1,000	525	465	4,770	85	17,645

TABLE G-5. BUILDING COSTS FOR ALTERNATE A

County	Municipality	Facility Configuration	Per Facility Cost ($)	Number of Facilities	Total Cost ($)
Butler	Hamilton	3 lanes	244,061	1	244,061
	Middletown	3 lanes	244,061	1	244,061
Cuyahuga	Cleveland	6 lanes	489,649	6	2,937,893
	Cleveland	3 lanes	244,061	1	244,061
Franklin	Columbus	6 lanes	489,649	3	1,468,947
	Columbus	3 lanes	244,061	1	244,061
Hamilton	Cincinnati	6 lanes	489,649	3	1,468,947
	Norwood	3 lanes	244,061	1	244,061
Lake	Mentor on the Lake	3 lanes	244,061	1	244,061
	Painsville	3 lanes	244,061	1	244,061
Lorain	Lorain	4 lanes	319,264	1	319,264
	Elyria	3 lanes	244,061	1	244,061
Lucas	Toledo	6 lanes	489,649	2	979,298
Mahoning	Youngstown	6 lanes	489,649	1	489,649
	Ellsworth	2 lanes	175,241	1	175,241
Montgomery	Dayton	6 lanes	489,649	2	979,298
	Englewood	3 lanes	244,061	1	244,061
Stark	Canton	6 lanes	489,649	1	489,649
	Alliance	4 lanes	319,264	1	319,264
Summit	Akror	6 lanes	489,649	2	979,298
	Cuyahoga Falls	2 lanes	175,241	1	175,241
Trumbull	Warren	4 lanes	319,264	1	319,264
	Niles	3 lanes	244,061	1	244,061
Total Network		166 lanes		35	13,541,863

TABLE G-6. BUILDING COSTS FOR ALTERNATE B

County	Municipality	Facility Configuration	Per Facility Cost ($)	Number of Facilities	Total Cost ($)
Butler	Hamilton	3 lanes	244,061	1	244,061
	Middletown	3 lanes	244,061	1	244,061
Clermont	Batavia	3 lanes	244,061	1	244,061
Cuyahuga	Cleveland	6 lanes	489,649	6	2,937,893
	Cleveland	3 lanes	244,061	1	244,061
Franklin	Columbus	6 lanes	489,649	3	1,468,947
	Columbus	3 lanes	244,061	1	244,061
Geauga	Chardon	2 lanes	175,241	1	175,241
Green	Fairborn	4 lanes	319,264	1	319,264
Hamilton	Cincinnati	6 lanes	489,649	3	1,468,947
	Norwood	3 lanes	244,061	1	244,061
Lake	Mentor on the Lake	3 lanes	244,061	1	244,061
	Painsville	3 lanes	244,061	1	244,061
Lorain	Lorain	4 lanes	319,264	1	319,264
	Elyria	3 lanes	244,061	1	244,061
Lucas	Toledo	6 lanes	489,649	2	979,298
Mahoning	Youngstown	6 lanes	489,649	1	489,649
	Ellsworth	2 lanes	175,241	1	175,241
Medina	Medina	3 lanes	244,061	1	244,061
Montgomery	Dayton	6 lanes	489,649	2	979,298
	Englewood	3 lanes	244,061	1	244,061
Stark	Canton	6 lanes	489,649	1	489,649
	Alliance	4 lanes	319,264	1	319,264
Summit	Akron	6 lanes	489,649	2	979,298
	Cuyahoga	2 lanes	175,241	1	175,241
Trumbull	Warren	4 lanes	319,264	1	319,264
	Niles	3 lanes	244,061	1	244,061
Warren	Lebanon	3 lanes	244,061	1	244,061
Wood	Bowling Green	3 lanes	244,061	1	244,061
Total Network		184 lanes		41	15,012,612

TABLE G-7. LAND INVESTMENTS FOR EACH FACILITY IN ALTERNATE A, 12-COUNTY

County	Municipality	Facilities required	Number of lanes	Lot size per facility (ft^2)	Land cost per ft^2 ($)	Cost per facility ($)	Total cost ($)	Total queue area (ft^2)	Total parking area (ft^2)	Total paved area (ft^2)	Paving cost per ft^2 ($)	Total paving cost ($)	Total landscaped area (ft^2)	Cost per ft^2	Total landscaping costs ($)	Total improvements ($)	Total land investment ($)
Butler	Hamilton	1	3	43,975	0.92	40,457	40,457	15,000	4,320	19,320	0 80	15,456	15,860	0.25	3,965	19,421	59,878
	Middletown	1	3	43,975	0.92	40,457	40,457	15,000	4,320	19,320	0.80	15.456	15,860	0.25	3,965	19,421	59,878
Cuyahoga	Cleveland	3	6	88,225	0.34	29,997	89,990	90,000	24,705	114,705	0.80	91,764	97,035	0.25	24,259	116,023	206,013
	Cleveland	3	6	88,225	0.92	81,167	243,501	90,000	24,705	114,705	0.80	91,764	97,035	0.25	24,259	116,023	359,524
	Cleveland	1	3	43,975	0.92	40,457	40,457	15,000	4,320	19,320	0.80	15,456	15,860	0.25	3,965	19,421	59,878
Franklin	Columbus	1	6	88,225	0.34	29,997	29,997	30,000	8,235	38,235	0.80	30,588	32,345	0.25	8,086	38,674	68,671
	Columbus	2	6	88,225	0.92	81,167	162,334	60,000	16,470	76,470	0.80	61,176	64,690	0.25	16,172	77,348	239,682
	Columbus	1	3	43,975	0.92	40,457	40,457	15,000	4,320	19,320	0.80	15,456	15,890	0.25	3,965	19,421	59,878
Hamilton	Cincinnati	2	6	88,225	0.32	29,997	59,994	60,000	16,470	76,470	0.80	61,176	64,690	0.25	16,172	77,348	137,342
	Cincinnati	1	6	88,225	0.92	81,167	81,167	30,000	8,235	38,235	0.80	30,588	32,345	0.25	8,086	38,674	119,841
	Norwood	1	3	43,975	0.92	40,457	40,457	15,000	4,320	19,320	0.80	15,656	15,890	0.25	3,965	19,421	59,878
Lake	Mentor on the Lake	1	3	43,975	0.92	40,457	40,457	15,000	4,320	19,320	0.80	15,456	15,890	0.25	3,965	19,421	59,878
	Painsville	1	3	43,975	0.92	40,457	40,457	15,000	4,320	19,320	0.80	15,456	15,890	0.25	3,965	19,421	59,878
Lorain	Lorain	1	4	57,520	0.92	52,918	52,918	20,000	5,620	25,620	0.80	20,536	20,346	0.25	5,087	25,623	78,541
	Elyria	1	3	43,975	0.92	40,457	40,457	15,000	4,320	19,320	0.80	15,456	15,890	0.25	3,965	19,421	59,878
Lucas	Toledo	2	6	88,225	0.92	81,167	162,334	60,000	16,470	76,470	0.80	61,176	64,690	0.25	16,172	77,348	239,682
Mahoning	Youngstown	1	6	88,225	0.92	81,167	81,167	30,000	8,235	38,235	0.80	30,588	32,345	0.25	8,086	38,674	119,841
	Ellsworth	1	2	31,575	0.92	29,049	29,049	10,000	3,105	13,105	0.80	10,484	12,155	0.25	3,039	13,523	42,572
Montgomery	Dayton	2	6	88,225	0.92	81,167	162,334	60,000	16,470	76,470	0.80	61,176	64,690	0.25	16,172	77,348	239,682
	Englewood	1	3	43,975	0.92	40,457	40,457	15,000	4,320	19,320	0.80	15,456	15,890	0.25	3,965	19,421	59,878
Stark	Canton	1	6	88,225	0.92	81,167	81,167	30,000	8,235	38,235	0.80	30,588	32,345	0.25	8,086	38,674	119,841
	Alliance	1	4	57,520	0.92	52,918	52,918	20,000	5,620	25,620	0.80	20,536	20,346	0.25	5,087	25,623	78,541
Summit	Akron	1	6	88,225	0.34	29,997	29,997	30,000	8,235	38,235	0.80	30,588	32,345	0.25	8,086	38,674	68,671
	Akron	1	6	88,225	0.92	81,167	81,167	30,000	8,235	38,235	0.80	30,588	32,345	0.25	8,086	38,674	119,841
	Cuyahoga Falls	1	2	31,575	0.92	29,049	29,049	10,000	3,105	13,105	0.80	10,484	12,155	0.25	3,039	13,523	42,572
Trumbull	Warren	1	4	57,520	0.92	52,918	52,918	20,000	5,620	25,620	0.80	20,536	20,346	0.25	5,087	25,623	78,541
	Niles	1	3	43,975	0.92	40,457	40,457	15,000	4,320	19,320	0.80	14,456	15,890	0.25	3,965	19,421	59,878
							1,886,571									1,071,607	2,958,178

TABLE G-8. LAND INVESTMENTS FOR EACH FACILITY IN ALTERNATE B, 12-COUNTY

County	Municipality	Facilities required	Number of lanes	Lot size per facility (ft^2)	Land cost per ft^2 ($)	Cost per facility ($)	Total cost ($)	Total queue area (ft^2)	Total parking area (ft^2)	Total paved area (ft^2)	Paving cost per ft^2 ($)	Total paving cost ($)	Total landscaping costs ($)	Total improvements ($)	Total land investment ($)
Butler	Hamilton	1	3	43,975	0.92	40,457	40,457	15,000	4,320	19,320	0.80	15,456	3,965	19,421	59,878
	Middletown	1	3	43,975	0.92	40,457	40,457	15,000	4,320	19,320	0.80	15,456	3.965	19,421	59,876
Clermont	Batavia	1	3	43,975	0.92	40,457	40,457	15,000	4,320	19,320	0.80	15,456	3,965	19,421	59,878
Cuyahoga	Cleveland	3	6	88,225	0.34	29,997	89,990	90,000	24,705	114,705	0.80	91,764	24,259	116,023	206,013
	Cleveland	3	6	88,223	0.92	81,167	243,501	90,000	24,705	114,705	0.80	91,764	24,259	116,023	359,524
	Cleveland	1	3	43,975	0.92	40,457	40,457	15,000	4,320	19,320	0.80	15,456	3,965	19,421	59,878
Franklin	Columbus	1	6	88,225	0.34	29,997	29,997	30,000	8,235	38,235	0.80	30,588	8,086	38,674	68,671
	Columbus	2	6	88,225	0.92	81,167	162,334	60,000	16,470	76,470	0.80	61,176	16,172	77,348	239,682
	Columbus	1	3	43,975	0.92	40,457	40,457	15,000	4,320	19,320	0.80	15,456	3,965	19,421	53,878
Geauga	Chardon	1	2	31,575	0.92	29,049	29,049	10,000	3,105	13,105	0.80	10,484	3,039	13,523	42,572
Green	Fairborn	1	4	57,520	0.92	52,918	52,918	20,000	5,620	25,120	0.80	20,536	5,087	25,623	78,541
Hamilton	Cincinnati	2	6	88,225	0.34	29,997	59,994	60,000	16,470	76,470	0.80	61,176	16,172	77,348	137,342
	Cincinnati	1	6	88,225	0.92	81,167	81,167	30,000	8,235	38,235	0.80	30,588	8,086	38,674	119,841
	Norwood	1	3	43,975	0.92	40,457	40,457	15,000	4,320	19,320	0.80	15,456	3,965	19,421	59,878
Lake	Mentor on the Lake	1	3	43,975	0.92	40,457	40,457	15,000	4,320	19,320	0.80	15,456	3,965	19,421	59,878
	Painsville	1	3	43,975	0.92	40,457	40,457	15,000	4,320	19,320	0.80	15,456	3,965	19,421	59,878
Lorain	Lorain	1	4	57,520	0.92	52,918	52,918	20,000	5,620	25,620	0.80	20,536	5,087	25,623	78,541
	Elyria	1	3	43,975	0.92	40,457	40,457	15,000	4,320	19,320	0.80	15,456	3,965	19,421	59,878
Lucas	Toledo	2	6	88,225	0.92	81,167	162,334	60,000	16,470	76,470	0.80	61,176	16,172	77,348	239,682
Mahoning	Youngstown	1	6	88,225	0.92	81,167	81,167	30,000	8,235	38,235	0.80	30,588	8,086	38,674	119,841
	Ellsworth	1	2	31,575	0.92	29,049	29,049	10,000	3,105	13,105	0.80	10,484	3,039	13,523	42,572
Medina	Medina	1	3	43,975	0.92	40,457	40,457	15,000	4,320	19,320	0.80	15,456	3,965	19,421	59,878

(continued)

TABLE G-8 (continued).

County	Municipality	Facilities required	Number of lanes	Lot size per facility (ft^2)	Land cost per ft^2 ($)	Cost per facility ($)	Total cost ($)	Total queue area (ft^2)	Total parking area (ft^2)	Total paved area (ft^2)	Paving cost per ft^2 ($)	Total paving cost ($)	Total landscaped area (ft^2)	Cost per ft^2	Total landscaping costs ($)	Total improvements ($)	Total land investment ($)
Montgomery	Dayton	2	6	88,225	0.92	81,167	162,334	60,000	16,470	76,470	0.80	61,176	64,690	0.25	16,172	77,348	239,682
	Englewood	1	3	43,975	0.92	40,451	40,457	15,000	4,320	19,320	0.80	15,456	15,890	0.25	3,965	19,421	59,878
Stark	Canton	1	6	88,225	0.92	81,167	81,167	30,000	8,235	38,235	0.80	30,588	32,345	0.25	8,086	38,674	119,841
	Alliance	1	4	57,520	0.92	52,918	52,918	20,000	5,620	25,620	0.80	20,536	20,346	0.25	5,087	25,623	78,541
Summit	Akron	1	6	88,225	0.34	29,997	29,997	30,000	8,235	38,235	0.80	30,588	32,345	0.25	8,086	38,674	68,671
	Akron	1	6	88,225	0.92	81,167	81,167	30,000	8,235	38,235	0.80	30,588	32,345	0.25	8,086	38,674	119,841
	Cuyahoga Falls	1	2	31,575	0.92	29,049	29,049	10,000	3,105	13,105	0.80	10,484	12,155	0.25	3,039	13,523	42,572
Trumbull	Warren	1	4	57,520	0.92	52,918	52,918	20,000	5,620	25,620	0.80	20,536	20,346	0.25	5,087	25,623	78,541
	Niles	1	3	43,975	0.92	40,457	40,457	15,000	4,320	19,320	0.80	14,456	15,890	0.25	3,965	19,421	59,878
Warren	Lebanon	1	3	43,975	0.92	40,457	40,457	15,000	4,320	19,320	0.80	15,456	15,890	0.25	3,965	19,421	59,878
Wood	Bowling Green	1	3	43,975	0.92	40,457	40,457	15,000	4,320	19,320	0.80	15,456	15,890	0.25	3,965	19,421	59,878
							2,130,366									1,188,437	3,318,803

TABLE G-9. MAJOR EQUIPMENT ITEMS REQUIRED FOR LOADED-MODE EMISSIONS TESTING

Program element		Item	Remarks	Unit cost ($)
I.	Emissions	1. Chassis dynamometer	Needed for loaded-mode emission test. One unit per test lane required. Cost based on conversations with manufacturers (Clayton, Maxwell).	14,000
		2. Emission analyzer	Since loaded-mode is used, analyzer should be capable of measuring CO, HC, and NO_x. Extremely wide range in analyzer costs; cheaper analyzers found to be inadequate. Analyzers should be capable of being tied into computer data handling system. Costs based on discussions with manufacturers (Olson-Horiba, Hamilton Test Systems). One unit per test lane required.	26,500
II.	Data System	1. CRT Terminals	Two required per lane. Costs based on literature and discussions with manufacturer's representatives (Honeywell, Digital, Olivetti, Sperry Univac), and experiences of other states.	2,500
		2. Minicomputer	One required per facility (equivalent to Digital PDP-11-05). Generally assumed to be included in the cost of facility furnishings.	80,000
III.	Miscellaneous	1. Miscellaneous tools	As required.	1,000

TABLE G-11. EQUIPMENT COSTS FOR ALTERNATE A, 12-COUNTY

County	Municipality	Facility configuration (lanes)	Number of facilities required	Equipment cost per facility ($)	Total equipment cost ($)
Butler	Hamilton	3	1	219,500	219,500
	Middletown	3	1	219,500	219,500
Cuyahoga	Cleveland	6	6	359,000	2,154,000
	Cleveland	3	1	219,500	219,500
Franklin	Columbus	6	3	359,000	1,077,000
	Columbus	3	1	219,500	219,500
Hamilton	Cincinnati	6	3	359,000	1,077,000
	Norwood	3	1	219,500	219,500
Lake	Mentor on the Lake	3	1	219,500	219,500
	Painsville	3	1	219,500	219,500
Lorain	Lorain	4	1	266,000	266,000
	Elyria	3	1	219,500	219,500
Lucas	Toledo	6	2	359,000	718,000
Mahoning	Youngstown	6	1	359,000	359,000
	Ellsworth	2	1	173,000	173,000
Montgomery	Dayton	6	2	359,000	718,000
	Englewood	3	1	219,500	219,500
Stark	Canton	6	1	359,000	359,000
	Alliance	4	1	266,000	266,000
Summit	Akron	6	2	359,000	718,000
	Cuyahoga Falls	2	1	173,000	173,000
Trumbull	Warren	4	1	266,000	266,000
	Niles	3	1	219,500	219,500
Total network		166	35		10,519,000
Central computer					250,000
Maintenance/calibration vans (12)					168,000
Security systems					38,500
					10,975,500

TABLE G-12. EQUIPMENT COSTS FOR ALTERNATE B, 18-COUNTY

County	Municipality	Facility configuration (lanes)	Number of facilities required	Equipment cost per facility ($)	Total equipment cost ($)
Butler	Hamilton	3	1	219,500	219,500
	Middletown	3	1	219,500	219,500
Clermont	Batavia	3	1	219,500	219,500
Cuyahoga	Cleveland	6	6	359,000	2,154,000
	Cleveland	3	1	219,500	219,500
Franklin	Columbus	6	3	359,000	1,077,000
	Columbus	3	1	219,500	219,500
Geauga	Chardon	2	1	173,000	173,000
Greene	Fairborn	4	1	266,000	266,000
Hamilton	Cincinnati	6	3	359,000	1,077,000
	Norwood	3	1	219,500	219,500
Lake	Mentor on the Lake	3	1	219,500	219,500
	Painsville	3	1	219,500	219,500
Lorain	Lorain	4	1	266,000	266,000
	Elyria	3	1	219,500	219,500
Lucas	Toledo	6	2	359,000	718,000
Mahoning	Youngstown	6	1	359,000	359,000
	Ellsworth	2	1	173,000	173,000
Medina	Medina	3	1	219,500	219,500
Montgomery	Dayton	6	2	359,000	718,000
	Englewood	3	1	219,500	219,500
Stark	Canton	6	1	359,000	359,000
	Alliance	4	1	266,000	266,000
Summit	Akron	6	2	359,000	718,000
	Cuyahoga Falls	2	1	173,000	173,000
Trumbull	Warren	4	1	266,000	266,000
	Niles	3	1	219,500	219,500
Warren	Lebanon	3	1	219,500	219,500
Wood	Bowling Green	3	1	219,500	219,500
					11,836,000
Central computer					250,000
Maintenance/calibration vans (14)					196,000
Security systems					45,100
					12,327,100

Total costs for equipment can now be computed based on the number of facilities by configuration, developed previously. These costs are shown in Tables G-11 and G-12 for Alternates A and B, respectively.

The cost for a central computer, maintenance/calibration vans, and security systems are the same as for Option III, and are also reported in Table G-11 and G-12 for Alternates A and B, respectively.

A summary of the capital costs is provided in Table G-13.

TABLE G-13. CAPITAL COSTS FOR LOADED-MODE ALTERNATIVE

Item	Alternate A ($)	Alternate B ($)
Land investment (includes improvements)	2,958,178	3,318,803
Building investment	13,541,863	15,012,612
Test equipment	10,519,000	11,836,000
Central computer	250,000	250,000
Maintenance/calibration vans	168,000	196,000
Security systems	38,500	45,100
Total	27,475,541	30,658,515

One-Time Startup Costs

Land Acquisition--

As explained previously, the costs of the site location and evaluation, surveying, price negotiation and title conveyance are assumed to be $6,000 per site plus 10 percent of the purchase price of the land. For Alternates A and B this is:

$$\text{Alternate A} = (35 \text{ sites} \times \$6{,}000) + (0.10)\ (1{,}886{,}571) = \$398{,}657$$

$$\text{Alternate B} = (41 \text{ sites} \times \$6{,}000) + (0.10)\ (2{,}130{,}366) = \$459{,}037$$

Facilities Planning--

This element is computed in the same manner as for the other options. For Alternates A and B the planning cost is 10 percent of the buildings cost or $1,354,186 for Alternate A and $1,501,261 for Alternate B.

Program Design--

As explained in Section 3, a cost of $100,000 was used for the program design estimate.

Data Handling Software--

Based on discussions with computer systems analysts, an estimate of $200,000 was arrived at for development of data handling software.

Personnel Training--

As indicated in Section 3, an initial, intensive training effort is required prior to program startup. Facility personnel allocation rates are assumed to be the same as those presented in the discussion of Option I. Applying these rates to the facility requirements derived previously, the basic operating personnel requirements for this option are:

Alternate A:
- 35 Managers
- 35 Assistant Managers
- 12 Maintenance/Calibration people
- 5 Investigators
- 498 Inspectors

Thus:

=	(35) ($53) =	$ 1,855
+	(5) ($43) =	215
+	(545)($16) =	8,720
		$10,790

Alternate B:
- 41 Managers
- 41 Assistant Managers
- 14 Maintenance/Calibration people
- 5 Investigators
- 522 Inspectors

Thus:

=	(41) ($53) =	$ 2,175
+	(5) ($43) =	215
+	(577)($16) =	9,232
		$11,622

Personnel Salaries--

The same assumptions for personnel requirements for Option I were used. The costs of test personnel for the startup period are calculated for Alternates A and B in Table G-14.

TABLE G-14. FACILITY PERSONNEL STARTUP SALARIES

Alternate A		
(35 manager) ($1,250/month) (6 mo)	=	$ 262,500
+ (35 asst. managers) ($1,083/month) (6 mo)	=	227,500
+ (12 maintenance/calibration people) (1,000/mo) (1 mo)	=	12,000
+ (498 inspectors) ($750/mo) (1 mo)	=	373,500
		$ 875,500
+ Overhead @ 25 percent		218,875
Total		$1,094,375
Alternate B		
(41 managers) ($1,250/mo) (6 mo)	=	$ 307,500
+ (4 asst. managers) ($1,083/mo) (6 mo)	=	266,418
+ (14 maintenance/calibration people) (1,000/mo) (1 mo)	=	14,000
+ (522 inspectors) ($750/month) (1 mo)	=	391,500
		$ 979,418
+ Overhead @ 25 percent		244,855
Total		$1,224,273

The cost of administrative personnel will be the administrative salaries and overhead for 1-1/2 years or $853,164 for both Alternates A and B, as described in Option I.

Initial Public Relations Program--

As explained for Option I, the cost for initial startup public relations would be approximately $0.12/vehicle to be tested, or $900,000 for Alternate A, and $978,000 for Alternate B.

The total startup costs for Alternates A and B are summarized in Table G-15.

TABLE G-15. STARTUP COSTS FOR LOADED-MODE EMISSION TESTING

	Alternate A ($)	Alternate B ($)
Land acquisition	398,657	459,037
Facilities planning	1,354,186	1,501,261
Data handling software	200,000	200,000
Program design	100,000	100,000
Test personnel salaries + overhead	1,094,375	1,224,273
Administrative salaries + overhead	853,164	853,164
Initial public relations program	900,000	978,000
Personnel training	10,790	11,622
Total	4,911,172	5,327,357

Annual Operating Costs

Facility Personnel--

The annual cost for centralized facility personnel salaries and overhead is the same as for Options I, II, and III; these are summarized in Table G-16.

TABLE G-16. ANNUAL COST FOR TEST FACILITY PERSONNEL

	Alternate A ($)	Alternate B ($)
Salaries	5,606,000	6,014,000
Overhead at 25 percent	1,401,500	1,503,500
Total	7,007,500	7,517,500

Maintenance--

The annual cost of equipment repair, replacement and preventive maintenance is the same for Options I and II, since this cost is estimated at 20 percent of the initial equipment expenditures for the centralized lanes, which is also the same for Options I to III. These costs are summarized in Table G-17.

TABLE G-17. MAINTENANCE COSTS ANNUALLY FOR TEST EQUIPMENT

	Alternate A ($)	Alternate B ($)
Annual maintenance costs	2,103,800	2,367,200

Utilities/Supplies/Services

Utilities--

Annual cost for utilities was derived from electric usage rates experienced by other states. For this option these were found to be 120 kWh/day/lane, plus 325 kWh/day/facility. This per-kilowatt costs were obtained from several utility companies and were found to be $0.05/kWh. The annual costs, then, for utilities are calculated below:

Alternate A - 12 Counties

(166 lanes) (120 kWh?day) ($0.05) (250 operating days/year) = $249,000

\+ (35 facilities) (325 kWh/day) ($0.05) (250 operating days/year = 142,188

Total utilities cost annually $391,188

Alternate B - 18 Counties

(184 lanes) (120 kWh/day) ($0.05) (250 operating days/year) = $276,000

\+ (41 facilities) (325 kWh/day) ($0.05) (250 operating days/year) = 166,563

Total utilities cost annually $442,563

Insurance--

Based on the $1,500/lane insurance costs assumed for Option I, total annual insurance costs for this option are computed below for both alternates:

Alternate A - 12 Counties

(166 lanes) ($1,500) = $249,000

Alternate B - 18 Counties

(184 lanes) ($1,500) = $276,000

Computer Operation and Test Forms--

Central computer operation costs for automated inspection systems have been estimated at $0.15/test, and forms at $0.03/test as in Options I to III. The annual cost for these categories can then be easily computed:

Alternate A - 12-County = $1,338,475

Alternate B - 18-County = $1,466,690

Taxes--

The annual cost of real estate and personal property taxes were calculated based on full valuation rates for each municipality in which stations are to be located. Total annual taxes were found to be:

Alternate A - (12 counties) = $1,290,716

Alternate B - (18 counties) = $1,436,249.

Uniforms--

Based on the assumption of $125 annual uniform cost/employee, as used in Options I to III, the total annual uniform costs for Alternates A and B are shown below:

Alternate A: (590 uniformed employees) ($125) = $72,500

Alternate B: $648 uniformed employees) ($125) = $81,000

Security--

The annual cost of maintaining security systems, as in Options I to III, is assumed to be $850/facility. The annual cost of this item for Alternates A and B are thus:

Alternate A: (35 facilities) ($850) = $29,750

Alternate B: (41 facilities) ($850) = $34,850

Calibration Costs--

The recurring annual cost of equipment calibration is defined as the cost of calibration gases plus the operating cost of maintenance/calibration vans. Using the annual cost/van derived in Options I to III, as $8,800, the calibration costs for both alternates are shown below:

Alternate A: ($8,800) (12 vans) = $105,600

Alternate B: ($8,800) (14 vans) = $123,200

The total annual cost for utilities, services, and supplies is summarized in Table G-18.

TABLE G-18. ANNUAL COST FOR UTILITIES, SERVICES AND SUPPLIES

	Alternate A ($)	Alternate B ($)
Utilities	391,188	442,563
Insurance	249,000	276,000
Computer operation and forms	1,338,475	1,466,690
Taxes	1,290,716	1,436,249
Uniforms	72,500	81,000
Security	29,750	34,850
Calibration	105,600	123,200
Total	3,477,299	3,860,552

Annual Administrative Costs

Program Administrative Personnel--

Annual administrative personnel costs are essentially the same as for Option I less the costs of complaints investigators and inspection/licensing officials. These are found to be $568,776 annually - for both Alternates A and B.

Public Information--

The annual cost for public relations is again assumed to be $0.12 for each vehicle to be inspected or $900,000 for Alternate A and $978,000 for Alternate B.

Personnel Training--

Using the same assumptions as for Options I to III, the annual turnover of 50 inspectors for Alternate A, and 52 for Alternate B, is anticipated. This relates to an annual cost of $800 for Alternate A and $832 for Alternate B based on a $16 training cost per inspector.

COST SUMMARY

The total cost of this option is summarized in Table G-19.

Initial capital costs and one-time startup costs are converted to annual figures using the amortization factors discussed in Section 3. These annualized costs are added to annual operating costs and annual administrative costs to arrive at total annual costs in constant 1978 dollars.

A uniform fee in constant dollars (f_c) was calculated by dividing the annual costs by the average motor vehicle population, 1981 through 1987 ($5,200,000 for Alternate A and $5,200,000 for Alternate B). These calculations are provided in Table G-20 and G-21.

TABLE G-19. COST SUMMARY ALTERNATE A (12 COUNTIES)

Primary category	Principal element	Element cost ($)	Total category cost ($)
Initial capital costs	1. Land investment plus improvements	2,958,178	
	2. Building investment	13,541,863	
	3. Equipment costs (includes vans, computer, security systems)	10,975,500	
			27,475,541
One-time startup costs	1. Land acquisition	398,657	
	2. Facilities planning	1,354,186	
	3. Program design	100,000	
	4. Development of data handling System structure	200,000	
	5. Personnel training	10,790	
	6. Personnel salaries and oberhead	1,947,539	
	7. Initial public information program	900,000	
			4,911,172
Annual operating costs	1. Facility personnel	7,007,500	
	2. Maintenance	1,473,000	
	3. Utilities, services, supplies	3,477,299	
			11,957,799
Annual administrative costs	1. Program administrative salaries	568,776	
	2. Public information	900,000	
	3. Training	800	
			1,469,576

(continued)

TABLE G-19 (continued).

Primary category	Principal element	Element cost ($)	Total category cost ($)
Initial capital costs	1. Land investment (includes improvements)	3,318,803	
	2. Building investment	15,012,612	
	3. Equipment costs (includes vans, computer, and security systems)	12,327,100	
			30,658,515
One-time startup costs	1. Land acquisition	459,037	
	2. Facilities planning	1,501,261	
	3. Program design	100,000	
	4. Development of data handling system structure	200,000	
	5. Personnel training	11,622	
	6. Personnel salaries and overhead	2,077,437	
	7. Initial public information program	978,000	
			5,327.357
Annual operating costs	1. Facility personnel	7,517,500	
	2. Maintenance	1,668,000	
	3. Utilities, service, supplies	3,860,552	
			13,046,052
Annual administrative costs	1. Program administrative salaries	568,776	
	2. Public information	978,000	
	3. Training	832	
			1,547,608

TABLE G-20. f_c ALTERNATE A (12 COUNTIES)

i=0.03

Cost class	Cost ($)	Amortization factor (for i=0.03)	Annualized cost ($)
Capital Costs			
1. Land	2,958,178	0.03	88,745
2. Buildings	13,541,863	0.067	907,305
3. Equipment	10,975,500	0.2184	2,397,049
Startup costs	4,911,172	0.2184	1,072,600
Operating costs	11,957,799	1.0	11,957,799
Administrative costs	1,469,576	1.0	1,469,576
Total			17,893,074
f_c	17,893,074/5,200,000 = $3.44		

i=0.06

Cost class	Cost ($)	Amortization factor (for i=0.06)	Annualized cost ($)
Capital Costs			
1. Land	2,958,178	0.06	177,491
2. Buildings	13,541,863	0.087	1,178,142
3. Equipment	10,975,500	0.2374	2,605,584
Startup costs	4,911,172	0.2374	1,165,912
Operating costs	11,957,798	1.0	11,957,799
Administrative costs	1,469,576	1.0	1,469,576
Total			18,554,504
f_c	18,554,504/5,200,000 = $3.57		

TABLE G-21. f_c ALTERNATE B (18 COUNTIES)

i=0.03

Cost class	Cost ($)	Amortization factor (for i=0.03)	Annualized cost ($)
Capital Costs			
1. Land	3,318,803	0.03	99,564
2. Buildings	15,012,612	0.067	1,005,845
3. Equipment	12,327,100	0.2184	2,692,239
Startup costs	5,327,357	0.2184	1,163,495
Operating costs	13,046,052	1.0	13,046,052
Administrative costs	1,547,608	1.0	1,547,608
Total			19,554.803
f_c	19,554,803/5,700,000 = $3.43		

i=0.06

Cost class	Cost ($)	Amortization factor (for i=0.06)	Annualized cost ($)
Capital Costs			
1. Land	3,318,803	0.06	199,128
2. Buildings	15,012,612	0.087	1,306,097
3. Equipment	12,327,100	0.2374	2,926,454
Startup costs	5,327,357	0.2374	1,264,715
Operating costs	13,046,052	1.0	13,046,052
Administrative costs	1,547,608	1.0	1,547,608
Total			20,290,054
f_c	20,290,054/5,700,000 = $3.56		

MANPOWER REQUIREMENTS

The manpower requirements for this option are the same as for Option III.

Since there are no private garages participating in the I/M network under this option, the inspection and licensing, as well as organizational network, is shown in Figure G-2. Table G-22 lists total state and contractor manpower allocations.

SUMMARY

The option analyzed here is identical to Option III, Section 6, with the exception of the test mode. Since this option involves loaded-mode testing, the following changes result:

1. The test lanes are slightly larger in order to accommodate chassis dynamometers.
2. Additional equipment expenditures are required to cover the dynamometers and emission analyzers capable of NO_x measurement.

Despite these additional costs, the breakdown fees, f_c, for a loaded-mode alternate are only 6 to 7 percent higher than for idle mode. This is demonstrated in Table G-23.

TABLE G-23. INCREASE IN BREAK-EVEN FEES (f_c) WITH A CHANGE IN TEST MODE (IDLE TO LOADED)

Alternate	i value	f_c for idle mode (Option III) ($)	f_c for loaded mode ($)	Increase (%)
A	0.03	3.24	3.44	6.2
B	0.03	3.22	3.43	6.5
A	0.06	3.34	3.57	6.9
B	0.06	3.33	3.56	6.9

While costing the consumer only a few cents more, the loaded-mode alternative will provide more comprehensive diagnostic information than the idle mode. This information could enable the required maintenance to be performed more efficiently. This potential cost savings could make up for all or part of the additional cost for the test, assuming that the industry is trained to make use of the additional diagnostic data.

The loaded-mode alternative might have some additional benefits. In the draft Appendix N, EPA has specified a preconditioning requirement of idling the engine at 2,000 to 2,500 rpm for approximately 60 seconds. It is not clear at this point if this means that tachometer leads will have to be attached

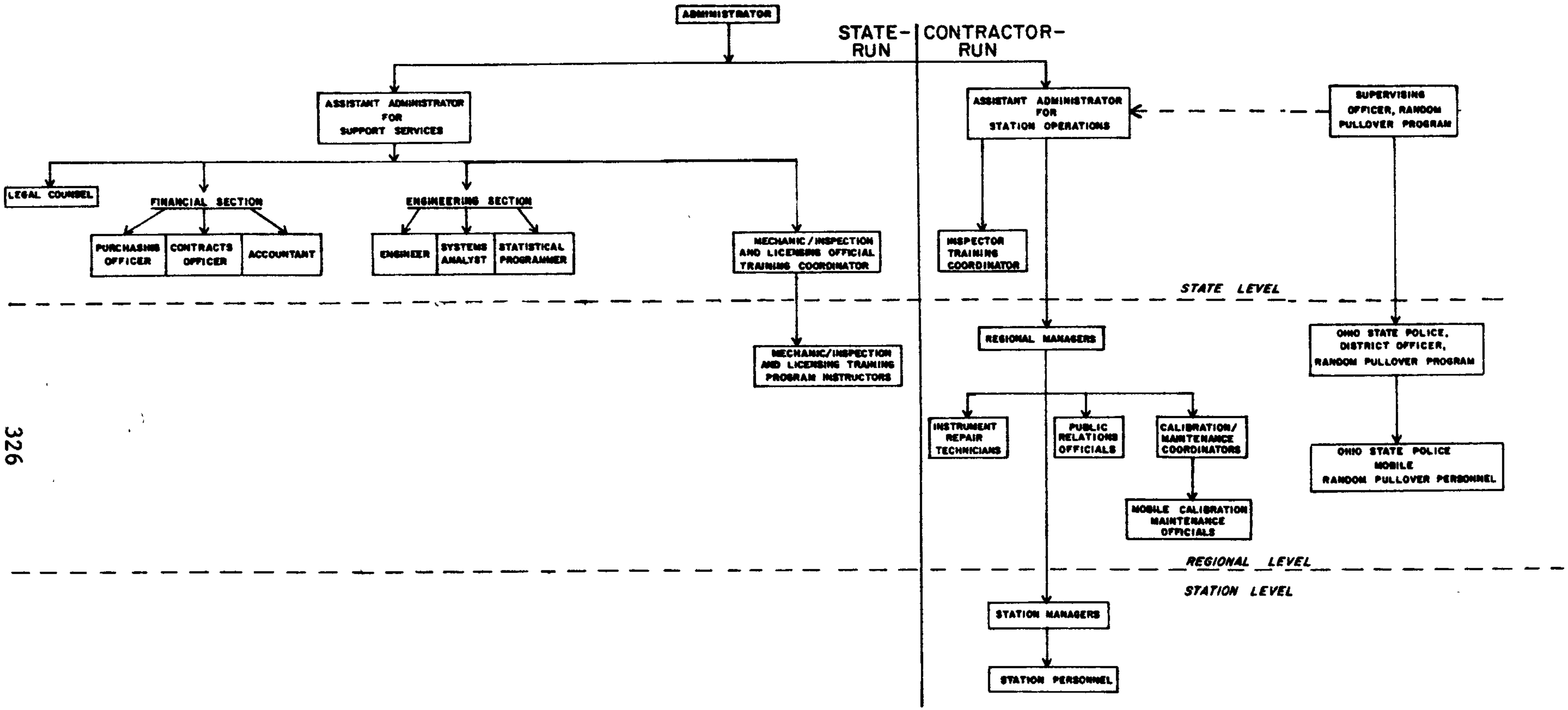

Figure G-2. Administrative organization.

TABLE G-22. MANPOWER REQUIREMENTS

State Administrative Personnel

1 Administrator
1 Assistant Administrator for Supporting Services
1 Legal Counsel
1 Purchasing Officer
1 Accountant
1 Contracts Officer
1 Engineer
1 Systems Analyst
1 Statistician/Programmer
1 Mechanic Training Program Coordinator

Contractor State Personnel

1 Assistant Administrator for Station Operations
1 Inspector Training Coordinator

Contractor Regional Personnel

Number		
Alternate A	Alternate B	
5	5	Regional Managers
5	5	Instrument Repair Technicians
5	5	Public Relations Officials
5	5	Calibration and Maintenance Coordinators
12	14	Mobile Calibration and Maintenance Officials
		Contractor Local Personnel
35	41	Station Managers
35	41	Station Assistant Managers
498	522	Station Inspectors
12	14	Station Maintenance Personnel

under the hood. If such a procedure is required, the throughput time will probably be increased enough to require that more facilities be constructed for an idle-mode program than for a comparable loaded-mode alternative. In addition to raising consumer costs, this procedure of opening the hood presents potential problems. One problem concerns the additional training needed to correctly attach the tachometer lead and to avoid possible personnel injuries. In Arizona, after a number of hood latches were broken and there were many complaints, this procedures was terminated.

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

Recent data for the State of Ohio indicates that the National Ambient Air Quality Standards for CO and O_x will not be attained in all areas of the state by 1982, even if all reasonably available control technologies are applied. In view of this, it is likely that the state will request from EPA an extension of the compliance date beyond 1982. In order for this request to be considered, the state must, among other things, have adopted a firm schedule for implementing a motor vehicle inspection and maintenance (I/M) program in the highly urbanized nonattainment areas. In this connection, the State of Ohio is currently in the initial stages of planning for the implementation of an I/M program. As part of this initial effort, several candidate program configurations have been analyzed from the standpoint of costs, benefits, and other requirements. These analyses, which are reported herein, will provide the basis for the state to select one specific option that will eventually be implemented.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Automobile engines	Automobile emissions	
Exhaust detection	Inspection/maintenance	
Exhaust emissions	Mobile source control	

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