The Public Cost of Motor Vehicle Fires in 1973: A Study in Fire Department Cost Allocation

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In 1972, Robert R. Nathan Associates were commissioned by the Insurance Institute for Highway Safety to conduct a field survey to provide the basis for estimates of the cost to public fire departments of motor vehicle-related fires. The survey covered 51 fire departments in 12 states, serving a population of 6.9 million. The information was recorded currently in a standard format by the fire departments over a period of several months; more than 6,000 incidents were reported and described. The results comprise the 1973 National Survey of Motor Vehicle Fires.

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Introduction

The large number of motor vehicle fires poses a hazard to citizens, a logistics problem to fire service administrators, and a cost burden to local governments. Between 1960 and 1970, the number of motor vehicle fires per 1,000 citizen population increased from a level of 1.27 to 2.26.[1/] Chart 1 illustrates the rapid rate of increase of these fires compared to the total number of building fires for the period 1963-1973.

In 1973, fire departments responded to some 2.9 million fires, of which motor vehicle fires accounted for 565,000, or one-fifth.[2/] Incidents in which there was a threat of vehicle fire accounted for an additional 600,000 fire department responses.[3/] In fact, these responses to motor vehicle fires and fire-related incidents comprised nearly one-fourth of all alarms in 1973.[4/]

Vehicular collisions in which a fire or threat of fire existed figured prominently in the distribution of responses

1/ National Fire Protection Association, Fire Journal, September 1972.
2/ See Chart 1 for sources.
3/ Estimated from results of the 1973 National Survey of Motor Vehicle Fires.
4/ Estimated from results of the 1973 National Survey of Motor Vehicle Fires and 1972 NFPA data on alarms per 1,000 population applied to 1973 U.S. population data.

to motor vehicle incidents, accounting for an estimated 205,000, or 18 percent of the total.[1/] Also, an estimated 39 percent of these collision-related incidents involved a ruptured fuel system.[2/]

The frequency of such incidents and the related social costs are not matters of common knowledge. The intent of this article is, first, to summarize the results of research in the fields of municipal fire protection finances and motor vehicle fires; second, to outline a cost allocation technique applicable to fire department operations; and, third, to indicate that the estimated public cost of motor vehicle fires and fire-related incidents exceeded $348.8 million in 1973.

The Public Cost of Fire Protection

The overall cost to communities of providing adequate fire protection services is not known with precision. Recent surveys have indicated that there are some 23,300 volunteer, paid, and combination paid-volunteer, or "mixed," fire departments in the United States and that the total fixed and variable operating expenditures of these departments exceeded $3.2 billion in 1973.[3/]

Table 1 presents an analysis of 1973 operating expenditures classified according to fire department pay status and

1/ Estimated from results of the 1973 National Survey of Motor Vehicle Fires and 1970-72 NFPA data on the number of motor vehicle fires.
2/ Ibid.
3/ See table 1 for sources.

Table 1. Estimated Number, Distribution, and Operational Expenditures of United States Fire Departments, 1973

Population of service area	Paid departments[a]			Volunteer departments		
	No. of departments	Average operational expenditures[b] (mil. dol.)	Total operational expenditures (mil. dol.)	No. of departments	Average operational expenditures[b] (thou. dol.)	Total operational expenditures (mil. dol.)
Over 1,000,000...	7	106.0	742.2	--	--	--
500,000 - 1,000,000...	20	18.0	359.0	--	--	--
250,000 - 500,000.....	30	9.5	283.9	--	--	--
100,000 - 250,000.....	107	3.9	417.8	--	--	--
50,000 - 100,000.....	254	1.7	434.1	3	65.0	.2
25,000 - 50,000.....	571	.74	419.9	24	55.0	1.3
10,000 - 25,000.....	1,110	.27	204.5	562	31.0	17.4
5,000 - 10,000.....	1,293	.08	102.8	2,079	23.7	49.3
2,500 - 5,000.....	618	.04	24.6	3,519	11.1	39.1
Under 2,500.....	315	.02	6.6	12,779	6.5	83.1
Total	4,325	--	3,095.4	18,966	--	190.4

Note: Due to rounding of average operational expenditures, total operational expenditures may not equal number of departments times average operational expenditures. Average operational expenditures of paid and mixed departments are weighted by the proportion of each type within a population category.

a/ Includes mixed, or partly paid departments.

b/ Excludes capital outlay.

Source: Number and distribution of municipal fire departments estimated from surveys of fire marshals and other state officials conducted by Robert R. Nathan Associates, Inc., and the National Fire Protection Association.

Average operational expenditures of paid departments with service populations greater than 10,000 estimated from a sample of 587 departments for which budget data were available in International City Management Association, The Municipal Year Book, 1970 and 1973 eds., Washington, D.C., 1970 and 1973. Averages for 1973 were estimated using fiscal year 1968 and 1971 data adjusted by average annual percent change.

Average operational expenditures of paid departments with service area populations less than 10,000 estimated from analyses of relationship of population and average operational expenditures for paid departments with service area populations greater than 10,000.

Average operational expenditures of volunteer departments estimated from results of a survey of 89 volunteer departments conducted by Robert R. Nathan Associates.

population of service area. Fully-paid and mixed departments have been grouped together due to the basic similarity of their cost structures.

Analysis of these figures indicates that total fire protection funds were not distributed evenly on a per capita basis. The seven largest metropolitan fire departments received more than 22 percent of total 1973 operating funds for the protection of less than 12 percent of the population of the United States.[1/] In fact, the funds which these departments had at their disposal were nearly four times greater than the operating expenditures of the nation's 18,966 volunteer fire departments combined.

This per capita disparity in expenditures probably reflects the high concentration of dwellings and other structures in densely populated areas and the comparative ability of municipalities to generate sufficient operating revenues to support paid or mixed departments. Typically, volunteer fire departments serve small communities or large rural areas which lack a high incidence of fire or a strong tax base. In the latter instance, sufficient funds are raised locally to provide for fire stations and equipment, but operational manpower must be supplied on a voluntary basis. The operational cost structure of volunteer departments therefore differs significantly from that of other departments. For this and other reasons which are discussed below, volunteer fire department costs have been independently allocated.

1/ Population data are for 1970. See U.S. Bureau of the Census, U.S. Census of Population: 1970, Number of Inhabitants, Final Report PC (1)-A1, United States Summary, U.S. Government Printing Office, Washington, D.C., 1971. The seven largest departments include those in the six central cities over 1,000,000 population and the Los Angeles County Fire Department, which serves a population of 1.9 million.

Paid and Mixed Fire Department Cost Allocation

The principal services rendered by municipal fire departments are the extinguishment and prevention of structural fires. In addition to these functions, nearly all departments perform a wide variety of other public services. These include extinguishment of other types of fires, chiefly motor vehicle fires and grass and trash fires; the provision of emergency medical assistance, pavement washdowns of debris, gasoline, hazardous chemicals, or other flammable liquids following motor vehicle collisions; and a number of other services appropriate to fire department capabilities. All departments also must respond to false alarms.

The public receives numerous benefits from the services provided by the nation's fire departments, measured both in savings of life and property. Every alarm which is answered diminishes the threat to public safety. By containing the spread of structural fires, preventing fuel tank explosions by extinguishing motor vehicle fires, or providing emergency rescue services, fire department activities justify the costs incurred by their operation.

Two methods have been examined for possible application to the measurement of motor vehicle fire costs. These are the incremental and fully distributed approaches to cost allocation.

The incremental approach to cost allocation assumes that fire department fixed costs, such as salaries and wages, would remain unchanged in both the short and long run, given an absolute reduction in the incidence of motor vehicle fires and related incidents. In other words, the

incremental approach would allocate to motor vehicle fires only short-run marginal, or running costs, such as gasoline consumed during the response and chemicals or other materials expended in the extinguishment effort.

The incremental approach is founded on the premise that the location and manpower requirements of fire stations are determined by structural fire insurance criteria, and that the cost of any increase in fire combat capabilities will be offset in the long run by lower fire insurance premiums for the community. Thus fixed costs would be allocated solely to structural fire protection.

One relevant variation of the incremental approach examines the extent to which fire departments operate specialized equipment to combat motor vehicle fires. For example, a city may employ "mini-pumpers," which are small pumping units installed on pick-up trucks. Unlike standard engines, only two men are required to operate a unit of this type, which is designed particularly for motor vehicle and other nonbuilding fires. The relatively low purchase price and personnel requirements of these units make them an attractive proposition for cities with a telephone alarm system, whereby the nature of an incident is usually known prior to the selective dispatch of equipment.[1/]

Ideally, an analysis of the public cost of motor vehicle fires should include an examination of the economic waste attaching to the use of standard equipment for nonbuilding fire extinguishment due to the nonselective dispatch of

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1/ Syracuse, New York, is the only city in the United States extensively utilizing mini-pumpers and a selective dispatch system.

equipment. Unfortunately, the absence of reliable cost data precludes a valid analysis of this type at present.

Another instance in which a modified incremental approach is particularly applicable occurs in cities which have constructed fire stations near the entrances to limited-access highways. In this case, although the total fixed and variable costs of station operation are directly allocable to motor vehicle fires, these costs are marginal with respect to the overall operational expenditures of the department prior to construction and operation of the station. This practice is so limited, however, that the costs are not yet significant.[1/]

There are two fundamental deficiencies in the application of an incremental analysis to fire department cost allocation. First, such an approach ignores the joint-product aspect of fire department deployment practices. Equipment and personnel are utilized for a wide variety of services, and the allocation of both direct and indirect costs should take explicit account of this fact. Second, an incremental cost approach discounts entirely the multiple societal benefits generated by fire department operations. Clearly, the public interest demands an instant response to each alarm in order to minimize any threat of injury to life and property. This is particularly true in the case of motor vehicle fires, which entail a serious risk of gasoline tank explosion. Consequently, an analysis of the public cost of these fires should allocate fire department costs in a manner which considers both the multiple uses of equipment

1/ Seattle, Washington, has constructed fire stations to extinguish motor vehicle fires on I-5, the major interstate route between California and Canada.

and manpower and the societal benefits attaching to fire department services.

In light of the limitations of incremental techniques, the validity of a fully-distributed cost analysis was explored. The principal advantage of this method lies in its apportionment of both fixed and variable costs across the spectrum of fire department services. This is consistent with the joint-product aspect of fire department personnel and equipment service allocation and takes implicit account of the value to society of adequate fire protection services. Given the multifarious demands imposed upon the fire service and the adaptability of its manpower and equipment, a cost allocation technique of this nature appeared to be suitable for the estimation of the public cost of motor vehicle fires.

The cost allocation technique developed for this study assigns to each type of response a portion of total costs. Responses to motor vehicle fire-related incidents have been included in the universe of motor vehicle fire responses for cost analysis. A typical fire-related incident involves a threat of fire following a collision in which the fuel system has been ruptured. When such an incident occurs, the fire department may provide standby services and traffic control in addition to a pavement washdown.

Several criteria were examined for possible application to the measurement of motor vehicle fire costs. One criterion, based on relative time input, compares total fire department man-hours engaged in motor vehicle fires and motor vehicle fire-related activities with the total attributable to all emergency responses and services. Another criterion contrasts the number of motor vehicle fire and fire-related responses

with total emergency responses. A third criterion compares total motor vehicle fire losses measured in dollars with total fire losses in 1973. This approach was dismissed for general application because more than one-third of total fires in 1973 were brush and trash fires with no assignable value of losses.[1/]

For purposes of applying cost criteria, paid and mixed fire department budgets were analyzed to determine the internal allocation of funds on a functional basis.

Capital costs were separated into outlays for apparatus and for new structures. Rather than allocate current outlays for apparatus, the 1973 depreciation charge for engines and ladder trucks was estimated as a measure of capital consumption. Also, it was assumed that the existing land on which fire department structures are located appreciates in value at an annual rate roughly equivalent to the depreciation charge of the buildings.

Fixed and variable operating costs were divided into five major categories: fire suppression, fire prevention, training, administration, and other. Communications and maintenance expenditures were grouped with administrative expenditures. The proportional distribution of expenditures within these major categories was found to be a function of service area population. Table 2 illustrates the results of this budget analysis.

Fire suppression costs represent the bulk of fire department operational expenditures. While certain contractual services, fixed charges, and variable operating

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1/ Estimated from 1970-72 NFPA data.

Table 2. Estimated Allocation of Operational Expenditures, Fully Paid and Mixed Fire Departments by Population of Service Area, 1973

Allocation of expenditures[a]	Population of service area		
	Over 1,000,000	100,000-1,000,000	Less than 100,000
Fire suppression			
Percent	82.0	80.0	76.4
Millions of dollars	608.6	848.6	987.3
Administration, communications and maintenance			
Percent	9.6	8.3	8.0
Millions of dollars	71.3	88.1	103.4
Fire prevention			
Percent	3.4	3.8	4.0
Millions of dollars	25.2	40.3	51.8
Training			
Percent	2.0	1.6	1.4
Millions of dollars	14.8	16.9	18.1
Other[b]			
Percent	3.0	6.3	10.2
Millions of dollars	22.3	66.8	131.9
Total			
Percent	100.0	100.0	100.0
Millions of dollars	742.2	1,060.7	1,292.5

a/ Excludes capital outlay.
b/ Includes hydrant rental, ambulance service, fire boat service, weed abatement, and other miscellaneous expenditure items not allocable to motor vehicle fires.

Source: Total expenditure data from table 1. Distribution of expenditures for departments over 1,000,000 estimated from data supplied by three departments of this size. Distribution for departments between 100,000 and 1,000,000 estimated from analysis of 24 departmental budgets. Distribution for departments less than 100,000 estimated from analysis of 50 departmental budgets.

costs of fire-combat services are included, this category is composed chiefly of salaries and wages paid to firemen. In fact, it is not uncommon to find departments in which total salaries and wages comprise 95 percent or more of operational expenditures.[1/]

The portion of total expenditures allocated for administration, communications and maintenance did not vary significantly with respect to the population of service area. Training expenditures were observed to decrease slightly with population, while fire prevention expenditures were related inversely to population.

The most marked variation in the internal allocation of expenditures occurred in the "other" category, which includes items not germane to the allocation of motor vehicle fire costs. Hydrant rental charges were found to be the principal item influencing the relative magnitude of this expenditure category. The trend may be explained in part by the number of municipally-owned water systems within each major population group. Hydrant rental charges are not imposed by cities having such systems, and fire departments serving populations greater than 100,000 more commonly have access to city-owned water supplies than do those serving smaller populations.

The Public Cost of Motor Vehicle Fires in 1973

The allocative criteria described above may be applied to discrete cost areas to estimate the portion of each which

1/ This was the case in 42 percent of the 52 cities over 250,000 population for which FY 1972 fire department expenditures were reported in The Municipal Year Book, 1973. Of the 251 listed cities between 50,000 and 250,000 population, 62 percent reported that salaries and wages were 90 percent or more of total expenditures.

is allocable to motor vehicle fires and fire-related incidents.

Fire Suppression Costs

Fire suppression costs particularly lend themselves to allocation on the basis of relative time input. The fire suppression cost of motor vehicle fires and related incidents may be divided into direct and overhead portions, each determined by the fraction of emergency service time devoted to these incidents.[1/]

This allocation was accomplished in two steps. First, the portion of total available time spent in emergency service was estimated.[2/] This provided a conceptual framework for the separation of direct and overhead costs. Second, the fraction of total emergency service time represented by motor vehicle fires and related incidents was calculated and used to allocate both direct and overhead costs.[3/]

1/ For a given alarm, emergency service time is defined as the total elapsed time from departure to return to the station or response to another alarm enroute to the station.
2/ This has been estimated as 1.4 to 4.6 percent depending upon population of service area. See table 3.
3/ This fraction was estimated as 11.4 percent. A frequency distribution by type of service performed and average man-hours was calculated for 6,051 responses in the 1973 National Survey of Motor Vehicle Fires and extrapolated upon projected total 1973 motor vehicle fire data. This indicated total 1973 MV man-hours to be 2.04 million. This figure was then divided by an estimate of 17.87 million total emergency service man-hours. Total emergency service man-hours were estimated as follows: Data from a sample of 15 departments reporting 175,000 alarms in 1972 established an average of 2.02 engine and ladder truck runs per alarm. This function was combined with projected 1973 total alarm data to estimate total 1973 heavy apparatus runs (10.5 million). Finally, an estimate of average man-hours per heavy apparatus run (1.7) was derived from a sample of 290,000 runs in 11 departments. These figures were then multiplied to estimate total emergency service man-hours.

The fraction of total emergency service time allocable to motor vehicle fires and related incidents is used to apportion direct and overhead fire suppression costs principally because the total service time of each alarm is a direct function of the severity of the incident. For example, a serious dwelling fire may require thirty or more man-hours, but a motor vehicle fire or gasoline washdown requires an average of less than 2 man-hours.[1/]

Treating total emergency service time as the universe of directly allocable fire department activity is also justified by fire department manning practices. Each city assesses the fire protection needs of particular areas in determining the location, equipment, and manpower of individual fire stations. Stations are usually manned with sufficient forces to combat multiple minor incidents or a single major incident without assistance from other fire companies or departments. Although the overhead portion of total allocable time is disproportionate with respect to emergency service time, much of the overhead time is expended for related activities, such as in-service training, so that excess manpower is rarely encountered. Consequently, the supply of fire service manpower is distributed according to the demand for fire protection services.

The allocation of total 1973 fire suppression costs of paid and mixed fire departments is presented in table 3. Due to the wide divergence between emergency service time and total available time, the direct portion of fire suppression costs allocable to motor vehicle fires, $7.7 million,

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1/ Results of the 1973 National Survey of Motor Vehicle Fires indicated an average of 1.8 man-hours per fire extinguishment and 1.6 man-hours per washdown.

Table 3. Estimated Allocation of Fire Suppression Expenditures, Paid and Mixed Fire Departments, by Population of Service Area, 1973

Item	Population of service area			
	Over 1,000,000	100,000-1,000,000	Less than 100,000	Total
Fire suppression expenditures ($ millions)	608.6	848.6	987.3	2,444.5
Available time allocation:				
Emergency service[a]				
Percent	4.6	3.0	1.4	--
Millions of dollars	28.0	25.5	13.8	67.3
Other[b]				
Percent	95.4	97.0	98.6	--
Millions of dollars	580.6	823.1	973.5	2,377.2
Expenditure allocation ($ millions):				
Motor vehicle fires and related incidents[c]				
Emergency service	3.2	2.9	1.6	7.7
Other	66.2	93.8	111.0	271.0
Other incidents[d]				
Emergency service	24.8	22.6	12.2	59.6
Other	514.4	729.3	862.5	2,106.2

a/ See footnote 1, p. 13 for definition of coverage.
b/ Other time is equal to total available company time (8,760 hours) annually) minus annual emergency service company time.
c/ Emergency service and other time is allocated to motor vehicle fires and related incidents on the basis of 11.4 percent of total emergency service time. See footnote 3, p. 13, for estimating methodology and sources.
d/ Fire suppression expenditures are allocated to other incidents on the basis of 89.6 percent of total emergency service time. This represents total emergency service time minus motor vehicle fire-related time.
Source: Total fire suppression expenditure data from table 2. Available time allocation for departments over 1,000,000 was estimated from data supplied by three departments of this size. Allocation for departments between 100,000 and 1,000,000 was estimated from data supplied by 10 departments. The standard deviation of entries from this group was 0.29. Allocation for departments less than 100,000 was estimated from data supplied by five departments. The standard deviation of entries from this group was 0.25.
See footnote 3, p. 13, for sources of allocation of emergency service time.

contrasts sharply with the overhead allocation of $271.0 million.

Administration, Communication and Maintenance Costs

The portion of total administration, communications, and maintenance costs allocable to motor vehicle fires and related incidents may be determined by selective application of the relative frequency of response and comparative value of losses criteria.

Administration costs are separable into upper and lower strata, namely, management and record keeping. The relative frequency of response method is generally applicable to the latter, in which both direct and overhead costs of recording activities may be apportioned directly among homogenous groups of responses. In 1973, the estimated total number of fire department responses to motor vehicle fires and related incidents comprised 22.5 percent of all responses.[1/] This fraction was applied to an estimated total lower level administration cost of $26.3 million in order to allocate $5.9 million to motor vehicle fire incidents.

Managerial costs, however, should not be similarly allocated. Rather, the upper echelon costs of fire department administration, usually incurred by operation of the office of the fire chief and his deputies and staff, should be allocated in a manner which reflects its major purpose: minimization of fire losses.

Assuming causal factors to be equal, the comparative value of losses approach provides a rough approximation of

1/ See footnote 4, p. 1 for sources.

the relative value of properties protected. Allocation of upper level administrative costs by this method distributes expenditures among the various properties proportionate to the losses of each. In 1973, estimated motor vehicle fire losses totaled $131.9 million, or 4.3 percent of total fire losses.[1/] Application of this criterion to an estimated total upper level administration cost of $78.8 million indicated that some $3.4 million could be allocated to motor vehicle fires and related incidents.

Direct and overhead communications costs are allocable in the same manner as record keeping, according to relative frequency of response. Salaries and wages paid to dispatchers represent the bulk of these costs, and the activities of a communications section may be prorated among the discrete groups of alarms received and equipment dispatched to various incidents. Allocation of the estimated $65.7 million communications cost along these lines added $14.7 million to the public cost of motor vehicle fires.

Maintenance costs are primarily for vehicular upkeep, and may be divided generally between engine and ladder trucks. Because vehicular service requirements are largely a function of utilization, the relative frequency of response method is pertinent for cost allocation purposes.

Two additional factors, however, must be taken into account before maintenance costs may be allocated to motor vehicle fires. First, the unit maintenance cost of ladder trucks is greater than that of engines. To compensate for this imbalance, it has been estimated that ladder truck

1/ Estimates based on 1970-72 NFPA fire loss data adjusted by average annual percent change.

maintenance costs are 40 percent of total maintenance costs, although the total number of trucks is roughly one-fifth that of engines. Second, the average frequency of ladder truck response to motor vehicle fires and fire-related incidents is only 7 percent.[1/] Thus, the estimated portion of total ladder truck maintenance costs allocable to motor vehicle fires and related incidents was 7 percent of 22.5 percent, the comparative frequency of motor vehicle fire responses. Accordingly, only $600,000 of the estimated $36.8 million maintenance cost of these vehicles could be allocated to motor vehicle fires and related incidents.

Because motor vehicle fire incidents are attended on the average by a single engine, the $55.2 million maintenance cost of these vehicles was allocated according to the standard relative frequency of response. A total of $12.4 million of this sum was apportioned to motor vehicle fire incidents.

Fire Prevention and Training Costs

None of the criteria employed to allocate fire suppression, administration, communications, or maintenance costs is appropriate for the allocation of fire prevention and training costs. These costs have been allocated to motor vehicle fires and fire-related incidents on the bases of 1.0 and 1.5 percent, respectively, as representative of the concentration of each on the prevention and suppression of motor vehicle fires.[2/]

1/ Results of the 1973 National Survey of Motor Vehicle Fires.
2/ Estimates supplied by Mr. Donald M. O'Brien, General Manager, International Association of Fire Chiefs.

The 1.5 percent of fire training costs allocable to motor vehicle fires is based upon the estimated portion of total classroom training hours devoted to motor vehicle fires. In addition to training time focusing on the suppression of automotive fires, this estimate includes instruction concerned with the special problems posed by truck transportation of hazardous cargoes. An allocation of training costs by this formula produced an estimated 1973 cost of $750,000 allocable to motor vehicle fires.

Fire prevention activities are directed toward the prevention of structural fires through building inspections and the enforcement of fire codes. Despite the high frequency of motor vehicle fire incidents, most departments have no program designed to alert the public to the fire dangers present in the family car. Coverage under the estimated one percent fire prevention allocation includes general educational programs, such as lectures delivered to high school classes, in which the subject of motor vehicle fires is broached. At this rate, 1973 fire prevention costs allocable to motor vehicle fires amounted to $1.2 million.

Heavy Apparatus
Depreciation Charge

This cost element was defined first by estimating the total number, average purchase price and expected active service life of engines and ladder trucks for each of the ten major population groups outlined in table 1. Second, a straight line depreciation technique was employed to determine the total 1973 depreciation charge of these vehicles. This was based upon a three-part population breakdown reflecting major variations in expected service life.

The criterion of relative frequency of response was employed to estimate that $6.1 million of a $27.0 million 1973 engine depreciation charge was allocable to motor vehicle fires and related incidents. However, the allocable portion of the ladder truck depreciation charge had to take into account the frequency of ladder truck response to motor vehicle fire incidents. Therefore, the same procedure used to estimate ladder truck maintenance costs was applied to the estimated 1973 ladder truck depreciation charge of $7.9 million. The resultant cost allocation indicated that $120,000 of this sum was allocable to motor vehicle fires and related incidents.

Volunteer Fire Department Cost Allocation

Volunteer departments may be broadly aggregated by wage practices. Many departments provide direct monetary compensation for services rendered on a "point" or hourly basis. Generally, such expenditures are the largest segment of the budget in these departments, outweighing total running costs and equipment maintenance charges. Other departments make no provision for volunteer compensation, or reimburse for out-of-pocket expenses only. In these departments, operational and maintenance costs are the only significant expenditure items.

The operational expenditures of each type of volunteer department may be allocated according to the relative frequency of response to motor vehicle fire incidents. This method is well suited for allocation of volunteer wages determined on a point basis, and also provides a good index of activity separation in departments which pay by the hour.

Running costs and equipment maintenance also may be equitably apportioned among emergency services by a frequency of response technique. The allocation is performed on this basis since these variable costs are more sensitive to the frequency of equipment utilization than to differential emergency service times, as expressed by a time-input analysis.

Results of a questionnaire survey indicated that the average frequency of motor vehicle fire response in volunteer departments varied directly in relation to population of service area. Departments serving populations less than 2,500 reported that the average frequency of motor vehicle fire and fire-related responses was 9 percent, while larger departments indicated that these incidents comprised up to one-fifth of total responses. The allocations of volunteer fire department expenditures according to relative frequency of response within each population group are presented in table 4.

The techniques used to estimate and allocate the 1973 depreciation charge of volunteer fire department heavy apparatus incorporated two major departures from the method applied to apparatus of paid and mixed departments. First a uniform straight-line depreciation of 20 years for engines and 25 years for ladder trucks was substituted for a population-sensitive depreciation policy. In the seven largest paid departments, the service lives of engines and ladder trucks average 12 and 15 years, respectively. The same service life policy usually followed by paid and mixed departments serving populations less than 100,000 was applied to volunteer departments, as this reflects expected equipment

Table 4. Estimated Allocation of Volunteer Fire Department Operational Expenditures by Frequency of Response, 1973

Population of service area	Number of departments	Total expenditures ($ million)	Distribution of total responses (percent)		Allocation of expenditures ($ million)	
			MV[a/]	Other	MV[a/]	Other
50,000-100,000 .	3	0.2	24.6	75.4	0.05	0.15
25,000-50,000 ..	24	1.3	21.9	78.1	.28	1.0
10,000-25,000 ..	562	17.4	19.0	81.0	3.3	14.1
5,000-10,000 ...	2,079	49.3	12.5	87.5	6.2	43.1
2,500-5,000	3,519	39.1	9.9	90.1	3.9	35.2
Less than 2,500	12,779	83.1	9.0	91.0	7.4	75.7
Total	18,966	190.4	--	--	21.1	169.3

a/ Includes motor vehicle fires and fire-related incidents.

Source: Total expenditures and number of departments from table 1. Frequency of response data estimated from survey of 89 volunteer fire departments.

life under normal service conditions. Second, no part of the estimated depreciation charge of ladder trucks was allocated to motor vehicle fires and related incidents. In the paid and mixed departments participating in the 1973 National Survey of Motor Vehicle Fires, ladder trucks responded to 7 percent of such incidents. The bulk of these truck responses could be attributed to non-selective dispatch, in which a full complement of men and equipment was dispatched in response to a box alarm. However, nearly all alarms received by volunteer departments are reported by telephone, and in the case of a vehicle fire the department will respond with a single engine. Thus, only the depreciation charge of engines could be allocated to motor vehicle fires and related incidents.

The 1973 engine depreciation charge was estimated under different purchase price assumptions for each volunteer population category and allocated to motor vehicle fire incidents on the same proportional frequency of response basis as operational expenditures. Of the estimated total 1973 depreciation charge of $36.5 million for these vehicles, $3.9 million was allocated to motor vehicle fires and fire-related responses.

Conclusion

Table 5 presents a summation of the cost elements comprising the estimated total 1973 public cost of fire protection and the portion allocated to motor vehicle fires and related incidents under a fully distributed cost analysis.

The overhead cost allocation of paid and mixed fire suppression expenditures dominates both the overall social

Table 5. The Estimated Public Cost of Motor Vehicle Fires and Fire-Related Incidents, 1973

Item	Cost ($ million)	
	Total United States	Allocable to motor vehicle fires and fire-related incidents
Fully-paid and mixed fire departments		
Fire suppression:		
Emergency service time	67.3	7.7
Other time	2,377.2	271.0
Administration, communications and maintenance	262.8	37.0
Fire prevention	117.3	1.2
Training	49.8	.7
Other[a/]	221.0	--
Heavy apparatus depreciation charge	34.9	6.2
Volunteer fire departments		
Total expenditure	190.4	21.1
Heavy apparatus depreciation charge	40.3[b/]	3.9
Total	3,361.0	348.8

a/ Not allocable to motor vehicle fires or fire-related incidents. See table 2 for description of contents.
b/ Includes estimated ladder truck depreciation charge of $3.8 million not allocable to motor vehicle fires or fire-related incidents.

Source: Tables 1, 2, 3, and 4. See text for discussion of derivation of other figures.

cost of fire protection and the portion represented by motor vehicle fires and related incidents. This allocation of direct and overhead costs particularly underscores the importance of fire service preparedness, that a fire department is ready when needed to respond to any contingency which may arise. The importance of this emergency preparedness certainly cannot be overemphasized with respect to fires in motor vehicles, as the potential for a serious gasoline fire or explosion is inherent in each.

It should be noted that the allocation techniques applied here on a macroeconomic scale also may be used to estimate the allocable cost of motor vehicle fires on a municipal basis, and are susceptible to further development and modification so that the cost of any fire department emergency activity may be estimated on a local or national basis.

In addition to their high frequency and considerable cost, vehicle fires and fire-related incidents pose special problems for local authorities. Unlike buildings, which can be required to conform with local fire codes and can also be inspected by local authorities to determine whether they pose special problems with regard to fires, motor vehicles are designed and built in only a few locations and consequently cannot be adequately controlled at a local level. Thus, the extent to which vehicle fires can be eliminated or ameliorated by better vehicle design and construction -- including special attention to preventing and limiting crash-caused fuel spillage -- can only be solved at the national level through the authority of the U.S. Department of Transportation.

Finally, it is hoped that the data and analytical tools presented will serve a two-fold purpose: first, to provide

an impetus for development of adequate countermeasures designed to reduce the number of vehicle fires; and second, to stimulate further research in the field of fire department cost analysis.