RURAL FREEWAY EMERGENCY COMMUNICATIONS FOR STRANDED MOTORISTS: FINAL PHASE REPORT

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Various studies were conducted over a 2-year period directed toward determining the level of need for any motorist-aid system and the extent to which these needs were met by the system installed. This system proceeded from a research plan to system design and then to installation and operation. Many requirements and desirable aspects were detailed in the process for use in other system developments. Data of this nature have already been valuable to other states in their approaches to the stranded-motorist problem. This, of course, was one of the prime reasons that prompted the Federal Highway Administration to participate in this type of project and to create a data base in an area of conjecture in which realistic planning for the future would be possible. The studies show a vehicle stopping rate (over 12 min) of 0.825 stops per mile per day in the summer and 1 stop per 2 miles per day in the winter. It is possibly coincidental, but the stopping rates increased exactly the same as the increase in winter-to-summer average daily traffic volumes. On the basis of present knowledge of operating motorist-aid systems, we would recommend a telephone communication system. This approach, coupled with some patrol activity and ready reference to the appropriate commercial agency, seems to provide the most desirable elements of a system of aid for stranded motorists.

•THIS paper is a final phase report on a 2½-year experiment with a motorist-aid telephone system in Michigan. This project was a cooperative effort by the Michigan Department of State Highways and the Federal Highway Administration, which funded 90 percent of installation costs and, through the Highway Planning and Research Program, aided in the various research phases.

The study was designed to determine the usefulness of a roadside motorist-aid telephone system for stranded motorists on a rural freeway and to observe and record the needs of motorists who stop on the facility. A description of the system and its operation and maintenance was given in an earlier report (17).

The construction and operating costs are as follows:

Category	Cost
Total construction costs	$290,171
2-year maintenance	7,200
Approximate vehicle damage and vandalism in 2 years (about $1,800 recoverable)	5,000
Michigan Bell Telephone Company (6 pairs leased lines per year)	3,414
Consumers Power Company (power per year)	1,620

Sponsored by Committee on Communications and Committee on Motorist Services and presented at the 50th Annual Meeting.

The contractor incurred costs that were considerably more than the $7,200 maintenance cost bid in the original contract. The 1 big cost factor was the result of the complete encoder-decoder change, and the remainder of the cost was from system repair as a result of leased line problems, lightning, and water damage.

DISTRIBUTION OF AID PHONE CALLS AND STOPS OF 12 MINUTES OR MORE

The reasons for requesting aid (Table 1) show a great similarity to those reported on most motorist-aid systems. The number of calls for accident aid seems rather high for this type of need. These percentages, of course, are based on only the number of motorists who called for aid. The distribution of reasons given by drivers of stopped vehicles, as determined in our summer and winter interviews, are also given in Table 1. The differences in the tire failure percentages for the 2 groups confirm the fact that about half of the motorists change their own tires when they have this problem.

RATES OF CALLS AND STOPS RELATED TO VEHICLE-MILES AND ADT

The following rates for cars stopped 12 min or more were developed from data obtained during the winter and summer surveys on I-94:

Survey	Stop Rate	Call Rate
Summer 1968	1 per 33,000 vehicle-miles 0.825 per mile per day, 17,960 ADT	1 per 117,000 vehicle-miles 0.231 per mile per day 208 per month
Winter 1969	1 per 38,000 vehicle-miles 0.48 per mile per day, 10,445 ADT	1 per 85,000 vehicle-miles 0.208 per mile per day 187 per month

It could be a coincidence that the winter-to-summer stopping rates and the winter-to-summer ADT's both increased by 72 percent.

In the relationship between stops and calls, it is notable that, although the per-mile call rates are very close for winter and summer, the winter ADT is 42 percent less than the summer ADT. It is evident, therefore, that cold weather produces a much greater desire to call for aid. The number of motorists using the aid phone is given in Table 2.

RELATIONSHIP BETWEEN STRANDED MOTORISTS AND ALL MOTORISTS

Table 3 gives trip characteristics of all motorists and of stranded motorists according to 4 categories: trip length, frequency of road use, trip purpose, and location of vehicle registry. The percentage by category for the total number of vehicles and the stranded vehicles are similar. This seems to indicate that stranded motorists as a group may, in fact, be representative of all motorists in the traffic stream. The only noticeable variations occur in the summer survey data for trip length where the percentage of stranded motorists is less than the percentage of total motorists in the 0- to 100-mile trip category and is more in the 100- to 250-mile trip category. In addition, the percentage of stranded vehicles is less than that of total vehicles for the in-county reg-

TABLE 1

REASONS FOR STOPS OR CALLS ON AID PHONE

Reason	Calls[a] (percent)	Stops[b] (percent)
Tire failure	22.0	40.9
Gas, water, or oil	27.4	14.9
Mechanical, tow	19.2	16.3
Mechanical, no tow	16.8	21.1
Accident	7.3	2.4
Fire	1.3	1.0
Miscellaneous	6.0	3.4

[a]Derived from calls recorded by State Police dispatcher.
[b]From summer and winter surveys that include callers for aid, noncallers, and others.

TABLE 2

USE OF AID PHONES BY MOTORISTS IN SUMMER AND WINTER

Survey	Number Interviewed	Used Aid Phones		Not Aware of Aid Phones	
		Number	Percent	Number	Percent
Summer 1968	172	48	28	40	23
Winter 1969	36	16	44	4	11

TABLE 3

TRIP CHARACTERISTICS OF ALL MOTORISTS AND OF STRANDED MOTORISTS

Characteristic	Summer		Winter	
	All Motorists (percent)	Stranded Motorists (percent)	All Motorists (percent)	Stranded Motorists (percent)
Trip length, miles				
0 to 100	28.6	20.0	36.3	47.1
100 to 250	32.4	44.4	36.5	29.4
250 to 300	22.2	23.1	22.4	23.5
Over 500	16.7	12.5	4.8	0
Frequency of road use				
Almost every day	12.4	12.4	17.7	18.1
Almost every week	17.4	17.8	27.4	36.4
Almost every month	22.6	20.7	33.1	30.3
Once or twice a year	30.8	26.0	18.0	15.1
Less than once a year	16.9	23.1	3.8	0
Trip purpose				
Social and recreational	45.7	53.2	14.1	27.3
School	2.0	0.6	4.5	3.0
Shopping	2.3	0.6	1.3	3.0
Business	35.3	41.4	67.9	57.6
Miscellaneous	14.7	4.1	12.2	9.1
Vehicle registration				
In county	20.3	12.8	25.5	23.1
In state, out of county	47.8	47.1	56.2	48.7
Out of state	31.9	40.1	18.3	28.2

istration category and more for the out-of-state category.

The winter survey data are very similar to the summer data except that the percentage of stranded short-trip drivers (0 to 100 miles) was greater than the percentage of total drivers. Only 14.1 percent of total motorists and more than 27 percent of the stranded motorists, nearly twice as many, were in the social and recreational trip category.

TRIP-LENGTH DISTRIBUTIONS FROM INTERVIEWS OF STRANDED MOTORISTS

Table 4 gives the relationship of trip length of use of aid phones by stranded motorists. The percentage of motorists stranded in the summer appears only to reflect the increased number of longer trips during this season, with the 100- to 250-mile trips having the highest percentage of stranded motorists. The percentage of motorists stranded in the winter also seems to follow the seasonal trend with more short trips; however, twice the percentage of stranded motorists taking short trips used the phones in the winter. Stranded motorists taking long trips in the winter are too few to be meaningful.

DISTANCE FROM STOPPING POINT TO NEAREST AID PHONE

The data given in Table 5 show that, on the average, stranded motorists could reach an aid phone by walking less than 2,000 ft. However, in order to reach a phone, a

TABLE 4

USE OF AID PHONE RELATED TO TRIP LENGTH

Trip Length (miles)	Summer Survey: Used Aid Phone (percent)	Summer Survey: Did Not Use Aid Phone (percent)	Summer Survey: Stopped Vehicles (percent)	Winter Survey: Used Aid Phone (percent)	Winter Survey: Did Not Use Aid Phone (percent)	Winter Survey: Stopped Vehicles (percent)
0 to 100	27	21	23	56	29	41
100 to 250	40	35	36	38	33	35
250 to 500	23	33	30	0	19	11
500 and over	8	9	9	6	0	3
(missing data)	2	2	2	0	19	10

TABLE 5

DISTANCE FROM STRANDED VEHICLE STOPPING POINT TO NEAREST AID PHONE

Survey	Number Interviewed	Distance Range (ft)	Mean Distance (ft)	Standard Deviation
Summer				
Total motorists	172	0 to 4,390	1,240	994
Motorists who used aid phones	48		1,071	1,223
Winter				
Total motorists	36	0 to 4,970	1,523	1,013
Motorists who used aid phones	16		1,234	1,228

stranded motorist has to leave his automobile and become a pedestrian on the freeway, which some drivers are reluctant to do.

Indications are that those stranded motorists who used the phones walked a slightly shorter distance than those who did not use the phone, which would indicate that the walking distance to reach a phone is not a main reason for not using a phone within the study area.

FREQUENCY OF USE OF AID PHONES

Data accumulated during approximately 1½ years were analyzed to log the number of times phones were used. These data represent calls almost solely from stranded motorists as opposed to other informational calls. Of the 730 calls recorded, the analysis shows a mean of 11.77 calls per phone, a variance of 4.95, a minimum of 3, and a maximum of 25. Use appears to be rather uniform with some slightly greater use near each end of the highway section where the phones are installed.

The following is a listing of use of each of the phones for the group analyzed:

Phone Site	Calls	Phone Site	Calls	Phone Site	Calls
1	23	14	15	27	8
2	22	15	12	28	8
3	17	16	10	29	6
4	10	17	8	30	3
5	14	18	8	31	11
6	8	19	12	32	11
7	10	20	19	33	13
8	4	21	7	34	22
9	5	22	10	35	21
10	9	23	14	36	11
11	8	24	6	37	8
12	7	25	13	38	13
13	12	26	13	39	8

Phone Site	Calls	Phone Site	Calls	Phone Site	Calls
40	14	48	9	56	12
41	12	49	6	57	18
42	7	50	11	58	19
43	18	51	11	59	25
44	7	52	8	60	14
45	6	53	12	61	19
46	9	54	16	62	13
47	11	55	14		

SUMMARY OF TAPE RECORDER DATA

For approximately 6 months, tape recorders were activated whenever the State Police answered an incoming call from an aid phone. Table 6 gives a summary of the recorded data. The distributions given are perhaps not as reliable as data from the summer and winter surveys inasmuch as the needs could not be determined from all conversations; also, more than 1 call per accident would often be received.

TIME NEEDED FOR STRANDED MOTORIST TO REACH PHONE

Of the 48 stranded motorists interviewed in the summer, 30 had records of time needed to reach the phones. Based on these data, we found that most of the stranded motorists spent fewer than 10 min, but not more than 24 min, to reach the phones (Fig. 1). Ten out of 16 interviewed stranded motorists who used the phones in the winter had the records of time needed to reach the phone. This analysis, again, showed that in winter conditions motorists reached phones in about 12 min. Apparently, the phone system provided a fast way for the stranded motorists to report their troubles and ask for help. Those who were aware of the telephone system and could use the phones to excellent advantage but did not use them were probably afraid of unreasonable charges.

TIME NEEDED TO SECURE AID

Figure 2 shows the time from the vehicle stop to the time of aid arrival from January 1, 1968, to May 1, 1969. About 90 percent of the stranded motorists who used aid phones waited fewer than 45 min before the aid arrived; 85 percent of them waited only 30 min or less. Most of the service stations provided effective emergency aid to motorists stranded on the highway. Those stations that took more than 100 min to respond to a call were delayed probably because of a busy wrecker schedule in the winter.

TABLE 6

CALL INFORMATION TAPE-RECORDED DURING 6-MONTH PERIOD

Item	Number	Percent
Reason for call		
Request aid for themselves	595	70[a]
Request aid for others	137	16
Obtain or give information or satisfy curiosity	120	14
Test system	110	–
Total	962	100
Aid requested		
Tire		16.6
Gas		18.2
Water or oil		2.9
Mechanical		24.6
Accident		27.9
Medical		2.2
Directional information		7.6
Total		100.0

[a]Test calls not included.

TOTAL ELAPSED TIME FOR STRANDED MOTORISTS

A mathematical model was derived that equated total elapsed time from the time the vehicle stopped until it departed to the various means of obtaining aid during the summer survey. Gamma distribution by maximum likelihood estimate (4) was chosen, and a computer program was run for the density functions on the categories of methods of obtaining aid.

For the various methods of obtaining aid, the following equations list these predicted gamma density func-

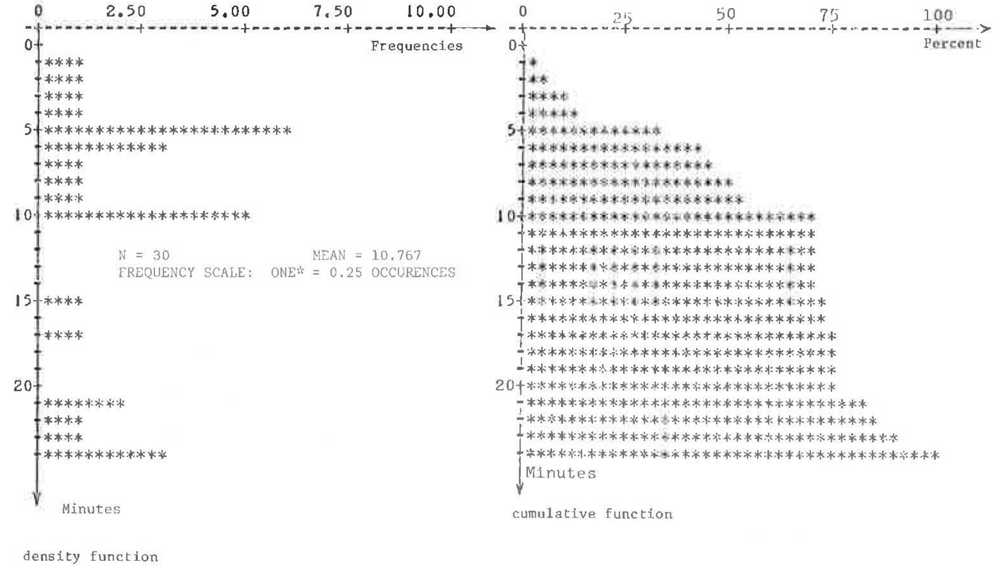

Figure 1. Time for motorists to reach aid phones in summer.

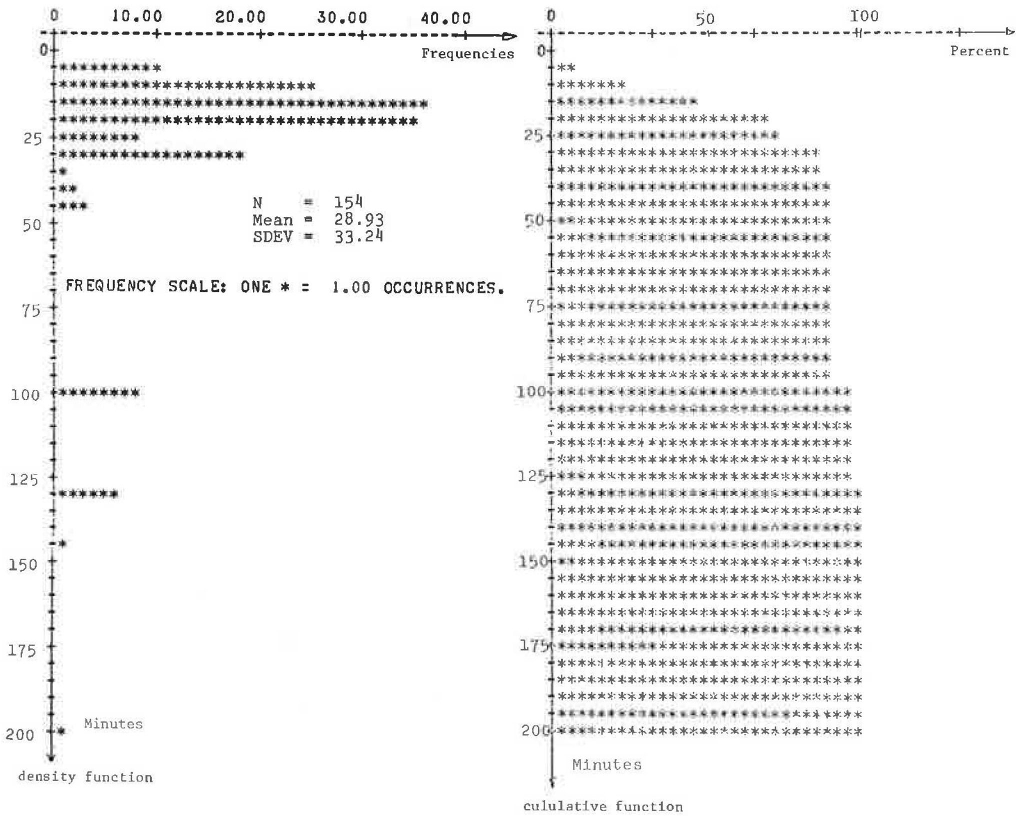

Figure 2. Time for aid to reach motorists who used aid phones.

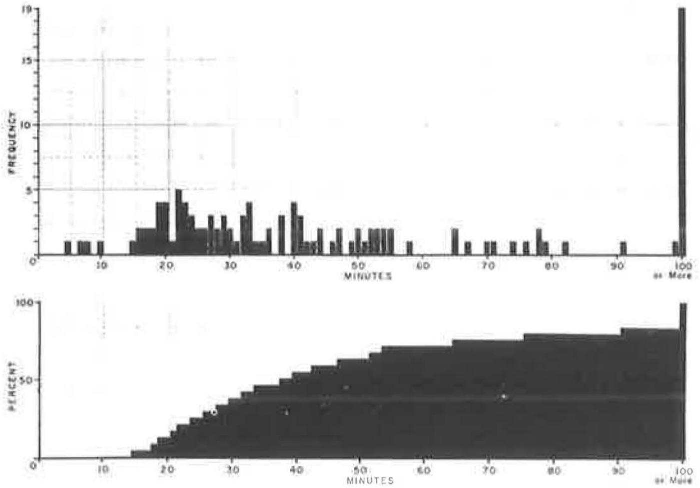

Figure 3. Total elapsed time for motorists who did not use phones in summer.

tions, where x is the elapsed time in minutes:

1. Aid phone used, no patrol aid, $f(x) = 0.0092456\ x^{0.108}\exp[-(x86.803)]$;
2. Aid phone used, with patrol aid, $f(x) = 0.0006792\ x^{0.951}\exp[-(x/45.386)]$;
3. Public phone used, no patrol aid, $f(x) = 0.0000139\ x^{1.60375}\exp[-(x/36.486)]$;
4. Walked, no patrol aid, $f(x) = 0.0018055\ x^{0.9264}\exp[-(x/29.305)]$;
5. Hitchhiked, no patrol aid, $f(x) = 0.0022847\ x^{0.75329}\exp[-(x/43.69)]$;
6. Miscellaneous, no patrol aid, $f(x) = 0.003074\ x^{0.0870}\exp[-(x/25.775)]$; and
7. Miscellaneous, with patrol aid, $f(x) = 0.0052012\ x^{0.455}\exp[-(x/59.109)]$.

Figures 3 and 4 show the relationship of total elapsed stranded time for users and nonusers of aid phones during the summer. When all needs are considered, no signifi-

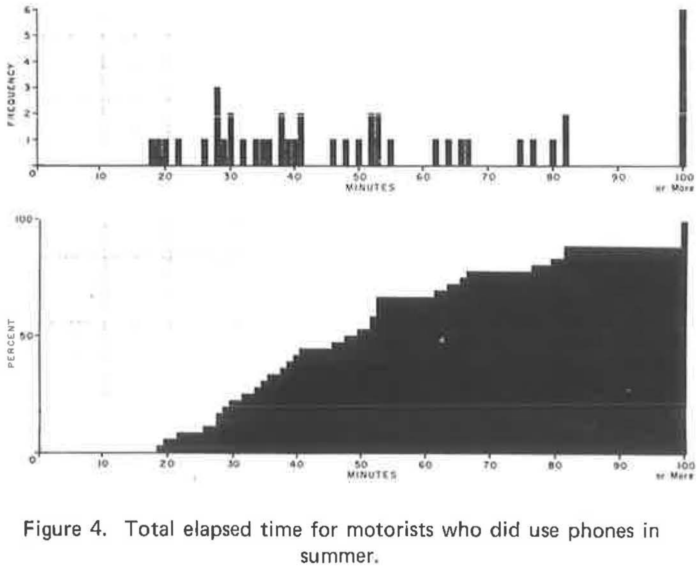

Figure 4. Total elapsed time for motorists who did use phones in summer.

cant differences occur between total stranded times of users and nonusers of phones. However, as stated earlier, times for specific needs will vary greatly for use or nonuse of phones. Elapsed times during the winter were very similar except that waiting times for aid for both users and nonusers were increased for more people.

CONCLUSIONS AND RECOMMENDATIONS

These studies have provided an intensive review of the stranded motorist problem at 2 relatively short rural locations on Michigan's freeway system. This look into the problem has provided much more information than was previously available.

The instrumented 30-mile section on I-94 has been generating 150 to 250 calls per month to the State Police posts. Many more stops occur because only 30 to 50 percent of all drivers in need of help call for assistance. Many factors of the system concerning motorist needs and benefits, telephone use, costs, and operation have been outlined. If the average rural stopping rate is expanded to cover the state's 1,400 miles of freeway, then on the average day, approximately 840 vehicles in the state will be stopped on the shoulders for 12 min or more. The stopping rates from Michigan studies varied directly with traffic volumes.

Many of the early telephone system operational problems have been resolved; however, some false ringing still occurs. At least part of the problem is caused by leased-line operating difficulties. Approximately 1 of every 6 phone sites has been struck by out-of-control vehicles, and some vandalism occurs sporadically.

Relative use of the system with and without area illumination was not a part of the study; however, the system would have cost 40 to 50 percent less had power needs for lights at the phone sites been eliminated. A study of the 135-mile system being installed on I-80 in Illinois should answer part of the question concerning the need for lights at each site. The Illinois study should also define whether operational problems may be avoided by not using leased telephone lines. It was recently found that the Michigan system has been operating for $2\frac{1}{2}$ years without the leased lines connecting the system to each State Police post being shown on the telephone company's engineering charts. Periodically these lines were used as test circuits by the phone company, and extraneous signals would trigger the system equipment.

It appears that further investigations of operating characteristics and costs are merited to determine the efficacy of a leased telephone system operation as opposed to one that is wholly state owned. Information from a Battelle Memorial Institute report for the Ohio Department of Highways (11) indicates that some leased telephone systems without lighting are costing as much or more during a 10-year period as Michigan's test system. Also, some cost projections for regular official patrols appear to be several times more costly than a voice-by-wire communications system.

The studies have shown that a high percentage of freeway drivers desire some system that will provide positive communication for aid for stranded motorists, and drivers seem to favor the Michigan type of telephone system.

This study shows that a number of freeway drivers have problems that cause them to stop their vehicles and that the magnitude of these problems can now be estimated. The criticality of the problems is based on variables such as individual physical ability, nature of need, geographic location, weather, and even time of day.

A telephone system, combined with partial State Police patrol activity plus referral to a commercial agency, is recommended for servicing the stranded motorist. It should be noted that we do not believe that any system can necessarily be shown to be cost-effective in monetary terms. It should be considered as a necessary public service with system selection judged on the basis of operation and cost factors of other candidate systems. Based on a 10-year operation of this system, 150 calls per month, and $15,000 annual costs, each call would average $25.00.

If a statewide telephone network were to be constructed, certain economies in addition to those of this experimental system could be accomplished through selective grouping and intermediate terminations of circuits, possibly at rest areas or information centers, and then transmitting by direct wire to a nearby State Police post. In a large network, other design economies would be possible.

As a means of comparison, if a motorist-aid telephone system without lighting were extended to the state's rural freeways, it could be installed for an estimated cost of about $3 million. This $3 million would buy approximately 1,000 ft of urban freeway.

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