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FOREWORD

On a controlled-access highway, the ability of a motorist in need to communicate with someone who can help him is of great importance. Systems to provide this communications capability have been developed and, in some cases, rather extensively tested. Reports of evaluations of such systems make up this RECORD, along with two papers dealing with related subjects. Highway administrators, communications specialists, and operations authorities will find these reports informative and useful in meeting their responsibilities to motorists needing assistance.

Emergency assistance was only one of many highway communication needs considered by Nutt in determining the entire requirements for a state highway department. His paper reports on the development of a step-by-step handbook that could aid any state in similarly assessing its needs.

In a paper that reviews the highway user communication systems currently in use, Quinn proposes development and implementation of a two-way mobile voice radio system. It would be basically an extension of the Citizens Radio Service, with hardware and system implementation available at relatively low cost.

Chiaramonte and Kreer describe the 1970-1971 statewide emergency communications test known as the Ohio REACT Emergency Network. The 2-year program was designed to test the effectiveness of volunteer citizens monitoring emergency communications and providing assistance to motorists. This paper tells of the organization and the first year's data and establishes the goals for the second year of the test. Three thoughtful discussions point out advantages and limitations of the volunteer system and suggest that the major decisions in emergency communications are not technological in nature.

Another system that depends on volunteer actions by third parties is described by Adler, Wisepart, and Emery. It is called FLASH (Flash Lights And Send Help) and has been tested on Interstate 4 in Florida. The authors conclude from a series of controlled experiments that FLASH is an effective motorist-aid communication system.

In the final paper, Wheeler and Dale report on their Missouri studies to devise a general plan for organizing a medical emergency service program for an entire state. The program is not limited to highway incidents, but these receive considerable attention. A coordinated communications system is concluded to be essential to the success of such a program.

COMMUNICATION HANDBOOK FOR HIGHWAY DEPARTMENTS

Sherel Z. Nutt, Division of Highways, Illinois Department of Transportation

This paper describes the application of a communications handbook to the Illinois Division of Highways. The purpose of this program was to augment the procedure model and data program in order to validate such a system and facilitate long-range communication planning by highway departments. The handbook procedure was to be followed as closely as possible. Any changes or improvements found were to be recorded separately and initiated to test their practicability. The highway department is a formal organization. The procedure for gathering information exchange followed a function-and-activities pattern. The committee developed a method of gathering the communication exchange relative to each function and activity by the use of preprinted forms. Information was compiled for use with a design data program. The revised handbook contains a step-by-step procedure for conducting a communications requirements study and for designing a communications system.

•THIS paper describes the development of a communications handbook entitled Communication System Handbook for State Highway Departments. The handbook outlines the procedures necessary in communications study for highway departments and includes appendixes containing the data base and detailed technical information.

The Federal Highway Administration recognized a need for long-range communication planning by state highway departments. A survey of state highway departments indicated insufficient staffing or budget allocations to conduct an in-depth, grass-roots communication survey. Because of this need, the Research Bureau of the Federal Highway Administration contracted with Computer Sciences Corporation to study highway communication requirements. In September 1968, this organization completed the study, which has been documented in a report entitled A Systems Analysis of Highway Communications. This report contained a procedure, model, and computer data base for use by highway communications planners in planning for a communications network. This report was distributed to the highway departments in all states. The next step in the program was to evaluate the procedure, model, and data base by conducting a communication study for an actual highway district. In selecting a highway district for study, we sought the following general conditions:

1. The state should be a willing and participating partner in the research;
2. The headquarters of the state highway department should be in the capital city;
3. The state highway division should include several districts;
4. The districts should contain a city other than the state capital that has a population of between 100,000 and 200,000;
5. The state should intend to develop specifications and contract for the implementation of some portion of the system that was designed as a result of this research; and
6. Because of the critical need to establish and validate the parameters of the highway user communications link, we would expect that the portion of the system to be implemented would include this link.

Sponsored by Committee on Communications.

The site selected was the Peoria district. This district includes the town of Peoria, which meets the population requirements, has rural areas, and lies between two rivers (the Mississippi and the Illinois). There is some rough terrain, and located remotely from the district office it has an office that performs a large amount of the maintenance responsibilities for the district. It is located approximately 70 miles from Springfield, the state capital; therefore, it is not too readily accessible to the central office.

Computer Sciences Corporation provided a full-time consultant to work with the Illinois Division of Highways in the evaluation of the study methodology and for the preparation of the handbook, which was an expansion of the original study report. The following criteria were established by the committee appointed to conduct this communication survey:

1. The researchers were to follow the original report as closely as possible;
2. Any recommended changes or improvements were to be recorded and initiated during the study to be held in the evaluation; and
3. A control study that was to be separate from the model and procedures used in the primary evaluation was to be conducted in the district and guided by the consultants.

COMMUNICATION REQUIREMENTS

The handbook establishes a set of parameters for communication requirements. A highway communication system must respond to any need to exchange information that falls within the sphere of interest of the highway department. This need may be something specific, such as the discovery of a damaged sign, or something implied, such as the date of a monthly report.

The communications system design engineer must rely on the highway planner to supply him with an accurate and comprehensive statement of requirements on which to base his design of the highway communications system. These requirements are difficult to determine because they are affected by such variables as systems use, traffic flow, growth potential, and external environment. However, because the highway department is a formal organization, its communication requirements can be defined by the planning procedures and functions developed by highway officials.

To help in estimating the use of the communications systems, we developed a method for organizing information exchanges. The events that cause an information exchange to take place are independent of the communications system, and their frequency of occurrence can be estimated without being influenced by communications systems or plans. Once the frequency of events that bring about a need to communicate is known, it can be combined with the highway department's procedure to determine the overall communication requirements.

COMMUNICATIONS EXCHANGE

State highway departments can be thought of as operating in the functional areas of design, maintenance, use, operation, planning, construction, and administration. Although each department executes the work covered by these areas, there may be considerable overlap among specific responsibilities of each department. To assist in the identification of these responsibilities, there are 68 functions with appropriate activities listed in the handbook.

An important characteristic of the function is the stimulus that causes it to be undertaken, i.e., the initiating event. Such a function as snow removal involves a sequence of activities, which would vary from state to state. The important part is the communication that happens in connection with this function. Table 1 gives a listing of the functions.

The procedure for gathering the data on information exchange was of great concern to the committee. Two forms were used for this purpose. The forms are requirement data for highway communication and a requirements survey of highway communications.

The first form (Fig. 1) was provided with the original study report, and the second or survey form was developed by the committee to organize the information and provide the interpretations that correspond with the highway engineer's terminology. A detailed

Table 1. Composite functions and states providing data.

Function No.	Title	California	Georgia	Illinois	Nebraska	New Jersey	New York	Ohio	Texas	Theoretical
1	Right-of-way acquisition authorization	X	X	X	X		X		X	
2	Right-of-way property appraisal	X	X	X	X		X		X	
3	Right-of-way acquisition negotiation	X	X	X	X		X		X	
4	Right-of-way acquisition condemnation	X	X	X	X		X		X	
5	Right-of-way acquisition property management	X	X	X	X		X		X	
6	Display model implementation			X						
7	Research and development project	X	X	X					X	
8	Review local government plans			X		X	X			
9	Traffic data collection, reduction, and analysis	X	X	X	X	X	X		X	
10	Master transportation plan			X						
11	Highway inventory	X	X	X		X	X		X	
12	Map preparation			X				X		
13	Project programming	X	X	X	X	X	X	X		
14	Budget preparation		X	X		X				
15	Truck weight survey		X	X	X	X	X	X		
16	Legislative liaison			X	X	X		X	X	
17	Road abandonment or transfer		X	X	X	X		X		
18	Route numbers and signs		X	X		X				
19	Advance planning			X		X				
20	Highway corridor and route survey		X	X			X			
21	Highway design		X	X	X		X	X	X	
22	Proposed construction coordination		X	X			X			
23	Highway construction standards		X	X			X			
24	Construction contract award			X		X	X			
25	Construction inspection	X	X	X	X	X	X	X		
26	Highway access construction permit		X	X		X	X			
27	Construction change approval		X	X	X	X	X			
28	As-built plans			X			X			
29	Bridge design		X	X			X			
30	Construction contract payment		X	X						
31	Permit issue		X	X	X	X	X	X	X	
32	Traffic flow control		X	X	X		X	X	X	
33	Speed-limit zoning	X	X	X	X			X		
34	Encroachment prevention			X						
35	Accident reporting and processing	X	X	X	X			X	X	
36	Emergency assistance	X	X	X						
37	Road condition information and restoral	X	X	X						
38	Administration, payroll, and purchasing		X	X	X	X		X	X	
39	Driver licensing		X					X	X	
40	Vehicle test and inspection		X					X	X	
41	Vehicle registration	X	X		X	X		X	X	
42	Highway maintenance and repair		X	X	X	X	X	X		
43	Maintenance contracting			X				X	X	
44	Highway improvement			X	X		X			
45	Equipment maintenance and supply inventory control		X	X		X		X	X	
46	Roadside park and rest area maintenance			X						
47	Traffic signals and signs		X	X				X	X	
48	Roadway line painting		X	X		X	X			
49	Bridge repair		X	X			X			
50	Landscaping			X						
51	Route information			X						
52	Route guidance system									X
53	Overtaking and passing information system									X
54	Merging and freeway control system									X
55	Personnel recruitment and placement			X						
56	Personnel training and safety			X						
57	Personnel administration			X						
58	Highway safety			X						
59	Soils and foundation investigation			X						
60	Material specification and certification			X						
61	Relocation assistance			X						
62	Property management			X						
63	Fiscal management			X						
64	Motor fuel tax distribution			X						
65	Federal-aid project control			X						
66	Auditing			X						
67	Claims and litigation			X						
68	Capital improvements			X						

description was furnished for all the blanks on the form. For example, in the column for communications from and to (Fig. 1), S is for the state or central office, D is for the district, and FE is for field engineer who is located remotely from the district office.

Zones were established to coordinate distance with quality and type. Proximities were as follows: zone 1—from the district office to the field; zone 2—district office local, inside a preset radius; zone 3—district office to the state office; zone 4—state office local; zone 5—interstate, i.e., any communication with neighboring states or the federal government; and zone 6—roadside (communications from which sources and destination are situated along the road network). A lengthy briefing session with personnel involved in completing the forms was necessary to provide a detailed explanation of the procedure.

To illustrate the composite function, consider the first function given in Table 1: right-of-way acquisition authorization. The description of the sequence of activities that take place in performing this function is as follows:

> A preliminary design plan is submitted showing the highway construction profile and right-of-way to be acquired. Copies of this plan are distributed to the District office, State and local government agencies having jurisdiction, and the regional office of the Federal Highway Administration, if appropriate. The plan is coordinated with these agencies. The District office prepares and submits to the State Office: a preliminary deed title search, a budgetary estimate of the total acquisition cost, and ROW maps identifying the parcels to be acquired. The ROW package of plans, estimates and maps is compiled and reviewed by the State office and distributed for approval to the same agencies as above. Notice of approvals is forwarded as required and authorization to acquire ROW is given to the District office.

The data collected in the surveys established 14 activities that, in a composite picture, were tabulated in the following logical sequence:

1. Submit preliminary design plan,
2. Distribute plan as required,
3. Coordinate with state agency,
4. Coordinate with Federal Highway Administration,
5. Coordinate with local government,
6. Make preliminary deed title search,
7. Estimate budgetary cost,
8. Show parcels on right-of-way maps,
9. Distribute package as required,
10. Obtain state agency approval,
11. Obtain Federal Highway Administration approval,
12. Obtain local government approval,
13. Forward approvals as required, and
14. Authorize parcel acquisition.

NETWORK CONFIGURATION

The information provided by the completed forms for all functions was compiled by zones. Table 2 gives zone 1 requirements. This information from all zones is given in Table 3.

For a procedure sample, we will consider telephone requirements. It is reasonable to assume that four out of five calls in zone 1 involve local communication; thus, 80 percent of 54,200 is traffic load on Peoria switchboards. This figure of 43,360 calls is added to zone 2 calls (11,000) for a total of 54,360. The call minutes divided by the number of calls for zones 1 and 2 equal 6.2 min per call. There are 2,000 work hours per year. From the total calls and hours we find 27.18 calls at a duration of 6.2 min. Telephone busy hours on the basis of empirical data are 2.5 times the average.

Because we are interested in confirming the procedure, we use the nine channels existing in Peoria and busy hour data. The Poisson formula is a widely used method of computing communication projection. Using Poisson's chart C, we can find the "probability of delay" or probability of a busy signal. We find that the probability of getting a busy signal is approximately one in every four calls. This projection was confirmed by Peoria personnel as correlating closely with their direct experience.

Figure 1. Sample data sheet.

REQUIREMENTS DATA FOR HIGHWAY COMMUNICATIONS

FUNCTION # 01 | TITLE: ROW ACQUISITION AUTHORIZATION | INITIATING EVENT: PRELIMINARY DESIGN PLAN | WORKLOAD PER YEAR (S) 150 (D) 30

Activity #	Activity Title	Communication From	Communication To	Zone	Mode	Message Length	Message #	State Lvl Wkload/Yr #	State Lvl Wkload/Yr Mag	Distr Lvl Wkload/Yr #	Distr Lvl Wkload/Yr Mag
1	DSGN PLAN	DESIGN (S)	ROW (S)	4	COUR	10p		150	1500		
2	DISTR PLAN	ROW (S)	STATE GV (S)	4	COUR	10p		150	1500		
			DOT-FHA (S)	4	MAIL	10		150	1500		
			ROW (D)	3	MAIL	10	2	300	3000	60	600
		ROW (D)	LCL GV (D)	2	MAIL	10				10	100
				1	MAIL	10				20	200
3	COORD STAT	ROW (S)	STATE GV	4	PERS	30m		150	4500		
				4	TLPH	5	2	300	1500		
4	COORD FHA	ROW (S)	DOT-FHA (S)	4	PERS	30m		75	2250		
				4	TLPH	5	2	150	750		
5	COORD LCL	ROW (D)	LCL GV (D)	2	PERS	30m				10	300
				2	TLPH	5	2			20	100
				1	PERS	30				20	600
				1	TLPH	5	2			40	200
6	TITLE SRCH	ROW (D)	TITLES (D)	2	MAIL	4p	2			20	80
				2	TLPH	15m				10	150
				1	MAIL	4p	2			40	160
				1	TLPH	15m				20	300
		ROW (D)	ROW (S)	3	MAIL	4p		150	600	30	120
		ROW (S)	TITLES (S)	4	MAIL	4p	2	300	1200		
				4	TLPH	15m		150	2250		
7	BUDGET EST	ROW (D)	ROW (S)	3	MAIL	5p		150	750	30	150
8	ROW MAPS	ROW (D)	ROW (S)	3	MAIL	5p		150	750	30	150
9	DISTR PKG	ROW (S)	STATE GV (S)	4	COUR	25p		150	3750		
			DOT-FHA (S)	4	MAIL	25		75	1875		
			ROW (D)	3	MAIL	25	2	300	7500	60	1500
		ROW (D)	LCL GV (D)	2	MAIL	25				10	250
				1	MAIL	25				20	500
10	STATE APRV	STATE GV (S)	ROW (S)	4	COUR	1p		150	150		
11	FHA APRVL	DOT-FHA (S)	ROW (S)	4	MAIL	1p		75	75		
12	LCL APRVL	LCL GV (D)	ROW (D)	2	MAIL	1p				10	10
				1	MAIL	1p				20	20
13	FWD APRVL	ROW (D)	ROW (S)	3	MAIL	1p		150	150	30	30
14	AUTH ACQSN.	ROW (S)	ROW (D)	3	MAIL	1p		150	150		

Table 2. Communication requirements for Peoria district, zone 1.

Function No.	In Person		Courier		U.S. Mail		Telephone		Radio	
	Number	Magnitude	Number	Magnitude	Number	Magnitude	Number	Magnitude	Number	Magnitude
1, 2, 3, 4, 5	13,000	703,000	335	670	9,700	91,000	6,900	204,000		
6	180	1,800	50	210	10	10				
8					1,148	9,725	300	2,375		
9	100	1,500	508	1,524	390	772	550	2,475		
10	5,100	154,000			5,300	26,900	108	580		
11	135	5,206	2	72	74	266	40	400	8	16
12					8	8				
15			1	1,000	3	3	8	60		
16					200	400	110	1,150		
18					15	20	22	55	29	29
19					40	120				
22					750	750	225	1,125		
26	2,082	120,000	1,479	4,739	6,180	12,647	365	3,650		
29					678	5,166	350	1,750		
32							107	447	150	150
33	30	600			50	65	15	150		
34	100	24,000			70	70	70	750		
35					160	320	500	5,000	750	1,500
37	1,200	12,000			1,704	1,728	19,774	59,600	18,248	20,728
38			24,300	31,900	12,800	20,500	1,080	4,750	75	75
42	1,000	240,000					8,770	31,000	4,030	7,440
45	14	63	14	182	14	14				
46			232	232	8	8	8	40		
47	90	450	762	902	1,094	1,254	5,700	18,800		
48			750	750	75	75	50	250	300	150
49			100	100			340	510	40	90
50	520	4,470	200	200	175	325	40	60		
51					300	7,600				
55	63	11,000	5	5	175	175	100	500		
56	46	7,260	50	100	65	69	350	3,000		
57					1,140	1,415	1,480	7,550	50	100
59	965	11,410	560	1,620	13,851	33,810	455	3,275		
60	1,080	5,400	10,966	23,448	8,060	16,630	3,080	15,400		
61	473	27,270	645	1,290	1,315	1,315	145	1,050		
62	67	3,420			59	59	6	30		
65	10	1,800		20	70	110	1,100			

For research purposes, other communication requirements by zones were confirmed in a similar manner.

Table 4 gives the method of computation for projecting future requirements based on a three percent annual expansion or 40 percent expansion over a decade. A percentage of upgrade is also shown. The total telecommunications requirement for the Peoria district is given in Table 5.

As a result of the handbook application, the communication requirements for 1970-1980 of the Peoria district are presented in terms of wire line requirements and mobile radio requirements for the various communication zones. These are as follows.

1. The number of channels between Peoria and Springfield must be increased from the existing three to eight within the next 10 years. The number of outside channels in the district must be increased from nine to 18.
2. The cost of channels or trunks between Peoria and Springfield and between Peoria and Monmouth or Carthage should be decreased by using the Tel-Pak service. This should be coordinated with the Illinois Telecommunications Commission.
3. Analyzation of radio channel requirements confirms the need for more than the present two frequencies; therefore, four channels are recommended to satisfy the projection requirements for the next decade (already in the planning).
4. Any recommendations for motorist aid are deferred to the present tests and evaluation being conducted by Illinois along Interstate 80.
5. Tests of keyboard and facsimile among Monmouth, Peoria, and Springfield should be initiated under a comprehensive system development plan.

HANDBOOK STRUCTURE AND CHANGES

The original report contained a great deal of reference material along with the model and procedures for determining communication requirements and for designing a communications network. It was found that the procedures required considerable time to perform, and some methods needed to be developed to speed up the process. As a result of the evaluation of the original study in the Peoria district, much knowledge was gained. The benefits gained for the handbook will be of great value to highway administrators and communication personnel throughout the country. The revised handbook has been completely reorganized so that it will be more readily understandable for the communication engineer and the highway engineer. It is essential that each of these professions understand the language of the other in order to intelligently design a communication system.

Communication System Handbook for State Highway Departments has been rewritten and reorganized. It is a streamlined handbook that contains a step-by-step procedure for determining the communication requirements of highway departments. The results of the evaluation study in Illinois are provided in a separate report that may be used as an illustrative example for conducting a communication study. Appendixes that contain the data base and technical reference material are provided.

The new handbook has better descriptions of each function and the activities within that function, which should make it much easier for the highway engineer to perform the study and thereby speed up the process. All facets of conducting a communication study are in chronological order. Communication charts that are commonly used by communication personnel and that are necessary for this type of study are included in an appendix. The survey forms are extremely important if computerized data are to be used at a later date. The new handbook also describes a method of computing the requirements by hand in case a computer is not available.

Highly recommended and of great importance is the need for a communication manager in the highway department. The handbook describes the duties and some of the qualifications expected of him. A good communications manager should be a person well acquainted with functions and activities within the highway department and should be of the administrative level. He need not be technically oriented but should have a working knowledge of communications.

In conducting this survey and evaluation of the handbook, we vividly realized that those providing the information about communication requirements were not sufficiently

Table 3. Total communication requirements by zone.

	In Person		Courier		U. S. Mail		Telephone		Radio	
Zone	Number	Magnitude	Number	Magnitude	Number	Magnitude	Number	Magnitude	Number	Magnitude
1[a]	26,000	1,335,000	41,000	69,000	70,900	239,000	54,200	378,000	23,700	29,900
2[b]	120,600	613,000	41,500	57,200	2,200	25,500	11,000	32,300	9,500	9,000
3[c]	500	25,800	360	6,490	40,000	125,000	3,200	24,600	980	2,800

[a]Field and district office. [b]District office locale. [c]District to state office.

Table 4. Projected telecommunication requirements for 1970 to 1980 for zone 1.

					Total Wire Line Requirement[a]			
Communication Medium	No. of Communications	Expansion			Upgrade			
		Percent	No.	Total	Percent	No.	Duration	Magnitude
In person	26,300[b]	40	10,520	36,820	12	4,420	3	13,260
Courier	41,000	40	16,400	57,400	27	15,500	5	77,500
U. S. mail	70,900	40	28,360	99,260	18	17,870	10	178,700
Telephone	54,200	40	21,680	75,880			7	531,160
Radio	23,700	40	9,480	33,180			1.3	

[a]Includes voice, telephone, keyboard, and facsimile.
[b]Assuming 5-min in-person exchange speaking at average rate of 60 words/min equals exchange of 300 words. This amount can be transmitted by keyboard or facsimile in 3 min.

Table 5. Total telecommunication requirements for the Peoria district projected for 1970 to 1980.

	Wire Line			Radio		
Zone	Number	Duration (min)	Magnitude	Number	Duration (min)	Magnitude
1	113,670	7	800,620	33,180	1.3	43,130
2	27,560	3.4	93,760	13,300	1.0	13,300
3	26,640	8.5	226,790	1,370	2.8	3,840

knowledgeable to predict or answer questions on the amount of time in which they would desire to have the communications completed. Most of the time they would choose the speed to which they were accustomed. Because of this tendency, it is necessary for the communications manager to brief personnel on the possible methods, even pointing out how new methods could be more economical and faster.

The original study described what was needed for a communications study. It was not entirely clear on how to gather the information needed or to convert it to a usable form. The information supplied concerning the various electronic communications media was adequate to provide necessary guidelines. A computer program was available along with all of the necessary data program cards. The committee found that data could be extracted from the computer printout sheets provided as the data base. It was therefore not necessary to use the computer program to make further selections.

Even though the original handbook provided a wealth of information, it was found that many improvements could be made to make it more useful. The following improvements and changes were recommended and have been incorporated in the new handbook:

1. Simplify the handbook and reorganize it into one volume plus appendixes;
2. Provide forms with which data can be gathered and summarized;
3. Provide descriptions that adequately cover the functions and activities in the highway engineering language; and
4. Supply simplified step-by-step procedures and examples whenever possible.

SUMMARY OF HANDBOOK

When the committee compared the control study done by consultants in the district with the handbook study conducted in the central office, it readily became apparent that, unless the recommended improvements in gathering data were initiated, there would be no advantage to using the handbook as it was intended. It became apparent that personnel well acquainted with highway department operations can do a more rapid, objective gathering of data than a communications consultant. However, a communications consultant can more adequately interpret the information gathered and apply the formulas and tables for a requirement analysis.

It is the consensus of the committee that this project was a success in that it determined the strong and weak points of the handbook. The handbook has been reorganized and rewritten. The benefits gained will be of great value to highway administrators and communication personnel throughout the country.

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A HIGHWAY COMMUNICATION SYSTEM FOR THE MOTORIST: THE CASE FOR TWO-WAY RADIO

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The author briefly reviews the communications systems currently in operation and those proposed by highway departments for users of American highways who find themselves stranded or in need of information. The paper reports on the volunteer two-way mobile voice radio system that has been developing in the U.S. in the 27 MHz Citizens Radio Service. The author proposes that a highway communication radio service be set up by federal agencies. The principal intent of this service is for aid to the motorist and for contact with him by highway, law enforcement, and other public service agencies. It is suggested that this service be implemented on an interim basis in the 26 to 30 MHz band using voice communication and readily available, inexpensive transceivers for communication on the emergency channel 9 of the CRS and on a minimum of five adjacent channels. No change in FCC citizens Class D license should be required. In conclusion, recommendations are made for the development of the hardware and implementation of the radio system.

• WITH the increase in highway travel, good roads, higher speeds, recreational areas, and limited-access highways, a motorist needing information, direction, or assistance is well aware of the necessity for communicating with other vehicles or an off-the-road terminal equipped to furnish necessary assistance.

Realizing this need, highway departments have been using and are continuing to install a minimal system of fixed terminals adjacent to the road for contact with a dispatcher who can furnish various types of assistance. These roadside terminals employ either the telephone or the single-direction radio call boxes (1). These are usually located on a ½- to 1-mile spacing. Another type employs the aid of another driver who receives instructions from a roadside sign to flash his headlights at a specific point in the road to bring aid to the driver in trouble. This signal is picked up by a photocell device that triggers an alarm at the central dispatcher's location. The dispatcher sends a patrol car to the area.

A system undergoing consideration at this time by several eastern states is one that employs the call-box system that can be activated from the vehicle. The driver uses in the vehicle a low-power transmitter that operates in the 450 MHz highway band. A coded transmission from the vehicle is received by the call box. The box transmits a coded signal to the central control operator to send aid to that area.

The foregoing systems in present use require the driver to leave the vehicle and go to the nearest communication terminal. Implementation of these terminals on all major highways would represent a staggering outlay for the state and federal agencies and would present a mammoth maintenance problem.

MOTORIST USE OF TWO-WAY RADIO

A motorist system employing 27 MHz citizens band radio has been developing during the past 10 years. Drivers have found that they could, at very moderate cost, obtain

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FCC licenses and equip their vehicles with transceivers. This equipment provides the driver with a means to contact a volunteer (2) or other monitor (4) to send aid, notify police, or give direction. The driver accomplishes this, in any location on any road and if necessary while in motion, without leaving the vehicle. In addition, the driver could, in many cases, keep in contact with home or office having similar equipment.

Since July 24, 1970, channel 9 of the Citizens Radio Service (CRS) has been set aside for aid to the motorist. Present limitations of this arrangement are interference from foreign skip and illegal operation, non-uniformity of channels monitored, and unreliability of volunteer personnel. In spite of these problems, a very worthwhile service is being provided on channel 9 of the CRS.

Why Two-Way Voice Radio Is Attractive to the Motorist

Results of tests using two-way radio as described have established the acceptance of voice communication with an off-the-road monitor. This assumption of public acceptance can be supported by the experience with the Detroit driver-aid network (3, 4, 5), the Ohio REACT Emergency Network (7, 8), and the national REACT operation (2). The ability for the driver (especially female drivers) to have voice communication with an operator who can send assistance or provide information gives the driver and her occupants a sense of security not felt with other means of communication. In support of voice communications as the transfer of information, one must remember that nearly all police patrol car-to-base communication is conducted by voice.

Driver-Aid Radio Systems in Use

General Motors Research Laboratories sponsored the programs listed below as research projects and as a public service to learn the answers to important questions concerning the average driver's use of a voice radio system:

1. An urban monitoring service for driver aid and traffic control (3, 4, 5);
2. A statewide volunteer monitoring service (7, 8); and
3. A nationwide volunteer monitoring service (1, 2).

At this point it should be understood that the only way a driver-aid two-way radio service could be tested was to use transceivers operating in the CRS. Not only is this advantageous for licensing, but also the transceivers are easily installed, simple to operate, inexpensive, and highly reliable solid-state devices for base and mobile service.

If there were a higher frequency part of the spectrum where transceivers of similar cost could legitimately operate, it would be highly desirable. Freedom from skip, medical, and industrial interference would be most welcome. The 450 MHz highway frequencies were not available at the time of these tests, and, had they been, the cost of transceivers for an equivalent range would have been and still appears to be prohibitive for the average driver.

Listed below are the results of the urban Detroit CB Radio Driver Aid Network program, including answers from a poll of over 100 participating drivers.

1. Could the average driver, with a little practice, use the two-way voice radio to make contact and report details of irregular situations, to request the proper aid, and to give the location in accident cases? The drivers polled answered in the affirmative. There was no problem after listening to others on the air and after a little operating practice.

2. Would drivers with two-way radios feel more secure knowing that they could make contact for assistance without leaving the vehicle? All drivers answered with a definite yes, and many indicated that they would buy a radio when the test was over for their security and convenience.

3. Would this facility reduce the time for an ambulance or wrecker or both to reach the scene of an accident? The report on the Detroit CB driver-aid program (5) indicates a saving of time for service agencies to reach an accident or tie-up. This could not be evaluated completely because the Detroit police had to confirm the aid request by sending a patrol car to the scene before ordering the service.

4. Would there be jamming of the frequency by a number of drivers trying to report the same situation? It was surprising to find that seldom was there any interference created by more than one driver trying to report the same situation. Often a driver hearing the report would add information when the first report was finished.

5. Would the lack of secrecy present a real problem for a voice radio system? The fears we had concerning secrecy as previously reported (4) have not materialized. No problem involving secrecy has shown up during the Detroit or Ohio programs to date. A check with REACT national headquarters files also shows no recorded complaints from the public. There have, however, been cases where two or more wreckers showed up at an accident or for service. This can be avoided by requesting identification of the company contacted for the service.

6. What would system maintenance be like for the mobiles, the fixed remote repeaters, and the connecting phone lines? When GM Research Laboratories were sponsoring the Detroit system (1966 through 1968), mobile radio maintenance was confined to antenna breakage or theft. System problems were wire line interruptions (approximately 10 per year) between the 10 remote repeaters and the master control. The remaining problems were confined to repeater antennae being blown down or tampered with by building maintenance personnel.

The statewide (8) and nationwide (2) REACT programs are sponsored by GM Research Laboratories as a public service. We are anxious to learn how volunteer monitors can cooperate with law enforcement, i.e., whether the police agencies could benefit from a volunteer surveillance group reporting to headquarters.

The report to the APCO Conference by Chiaramonte of the Ohio State Highway Patrol covering his experience with volunteer highway radio monitors speaks highly of the cooperation of REACT volunteers with his department and of the benefits to Ohio residents of having well-trained groups of volunteer radio operators.

We also wanted to know if volunteer operators can consistently monitor an emergency frequency during the major part of every day. Because these operators are volunteers, we have found inconsistencies in the frequency monitored and problems with their not being on duty. However, in a state police-operated program such as the one in Ohio, these problems are minimal.

FCC ACTION IN SUPPORT OF A MOTORIST-AID FREQUENCY

Realizing the convenience and need for a motorist radio service and for uninterrupted contact during emergency calls, the FCC reassigned channel 9 of the CRS for aid to the motorist and emergency use only after July 24, 1970. Therefore, the use of two-way voice radio for solving many highway communications problems has become recognized and important to several million vehicle owners who use the radio services described.

CONSIDERATION FOR A TOTAL RADIO SYSTEM

The highway communication systems described are concerned mainly with drivers stranded or in other trouble. A total system should offer much more for the driver and should satisfy the requirements of law enforcement, road patrols, and other public services.

There has always been one question in the minds of those considering driver-aid systems that use vehicle-mounted terminals: Would the driver purchase the equipment and keep it in operating condition? It has been the author's experience with these systems that, if the radio is only for use when the driver is in trouble, many drivers, due to their driving pattern, would not consider it worth the expense. However, if a total communication system that provides the driver with other needed services and the ability to use the equipment for personal communication is made available, the driver would have an incentive to own and maintain the equipment. There are also a large number of public-spirited drivers who would use a radio to help other drivers in trouble (4).

Advantages of a Radio System to Road Agencies

The total capability and advantages of the driver-aid radio system have not been realized to date as will be pointed out in the paragraphs to follow. If this capability is made available to public service agencies, they would realize the following gains over present and proposed highway communications systems:

1. The fixed monitoring equipment for communicating with vehicles can be installed at points remote from the highway, avoiding damage and vandalism;
2. One fixed transceiver installation can cover many miles of a specific highway and surrounding roads;
3. One master control operator can monitor at least 10 remote transceivers as has been demonstrated by the Detroit driver-aid network (4);
4. A standby channel as part of a mobile transceiver in each vehicle would provide the facility for road patrol and other public service agencies to contact the vehicle operator; and
5. The vehicle owner would own his own terminal.

Required Services for a Motorist Radio System

It has been adequately demonstrated by all working systems that the main service of any highway communication system is the ability for the driver to summon aid and obtain information and direction. It has also been demonstrated and evaluated (9, 10, 11) that a desirable if not necessary service as part of a total system is the transmission of traffic bulletins, weather reports, and emergency reports pertinent to the immediate and surrounding area by highway departments for driver safety.

This single-direction transmission is known as "audio signing." A third feature of a total system that has been tested and also suggested by highway operators is the ability for patrol cars, fire departments, and ambulances to make contact with all drivers (6). These requests have included devices to warn drivers of an approaching fire truck, ambulance, or patrol car. Due to the increasing use of air conditioning and improved soundproofing of passenger vehicles, the average horn is not effective under these and noisy traffic conditions. Sirens have an omnidirectional effect. Two examples of how the local audio sign, vehicle-to-vehicle system could work follow.

1. The in-car audio sign receiver is turned on with the ignition key. The driver has no control over the volume or received frequency in this mode. It is always on standby with the speaker muted to receive an encoded signal from mobile or fixed roadside transmitters.
2. The operator of a fire truck, ambulance, or patrol car en route transmits his direction and location such as "Proceeding north on Woodward Avenue." All vehicles within a reasonable distance and approaching cross streets would be warned of his approach. The voice could be augmented by a tone.

Summary of Service Requirements for a Highway Communication Radio System

The following is a summary of the communication services that appear to be required by both the motorist and public service agencies:

1. Two-way voice communications between the driver and a public service agency (this should be possible from an agency base or mobile station);
2. A vehicle receiver on standby to accept encoded local (immediate area) audio signing, i.e., transmission of emergency warnings from roadside transmitters and for verbal contact from public agency service vehicles to the motorist; and
3. Regional audio signing, i.e., broadcasts of traffic, weather, and emergency bulletins for motorist safety and convenience on selectable channels.

A PROPOSAL FOR A HIGHWAY COMMUNICATION RADIO SERVICE

Up to this point the report has reviewed the systems that are used in varying degrees by the driving public. They are as follows:

1. Roadside telephones and call boxes,
2. The cooperative driver or FLASH system,

Table 1. Proposed highway communications systems.

Intended Use	Type of Operation	Channel Number[a]	Equipment Required by Driver	Equipment Required by Public Service Vehicles	Fixed Public Service Station
Emergency car-to-car and car-to-base	Two-way simplex	A-9, B	Highway communication CRS transceiver	Highway communication transceiver with encoder and decoder	Highway communication transceiver, tri-channel monitor
Nonemergency car-to-car and car-to-base	Two-way simplex	C	Highway communication CRS transceiver	Highway communication transceiver with encoder and decoder	Highway communication transceiver, tri-channel monitor
Local audio sign and alerting[b]	One-way to traffic	D[c]	Highway communication CRS transceiver with encoder and decoder	Same	Low-power fixed roadside transmitters
Weather and emergency audio signing	One-way from public service base	E	Selectable channel in transceiver	Transmission not allowed	25-W base transmitter only
Traffic central audio signing	One-way from public service base	F	Selectable channel in transciever	Transmission not allowed	25-W base transmitter only

[a]Channels do not provide for personal communication; only public service agencies would be licensed to transmit voice on channels D, E, and F; emergency and audio signing channels should be allowed antennae heights as in business radio service.
[b]Provides for standby, fixed tuned channel in all vehicles to be turned on by ignition key; speaker is muted until turned on by encoded signal.
[c]Push button to activate the transmitter to radiate an encoded carrier; tone modulated for alerting drivers to nearby emergency situation; voice contact to be made on an emergency channel.

3. The urban Detroit CB Radio Driver Aid Network, and
4. REACT—volunteer CB radio channel 9 monitors.

It is obvious that none of these satisfies the requirements for a total motorist service as described in the summary of service requirements. Therefore, the author proposes that the U. S. Department of Transportation and the Federal Communications Commission establish a highway communication radio service and that frequencies be provided to implement the interim services for the motorist given in Table 1. The items given in the table satisfy the needs of today and the foreseeable future for a total voice communication system between the motorist and public service agencies.

The number of radio channels listed in the table represents the minimum for implementation of the system. Note that channel 9 of the CRS is included. This inclusion guarantees the participation of some 2,000,000 transceiver-equipped motorists and approximately 100,000 monitors nationwide with a majority already cooperating with public service agencies.

The intended use for the car-to-car and car-to-base systems is for contacting public service agency headquarters, their authorized monitor, or their patrol car. Of course, if no service is available to motorists in an area, other motorists may respond to emergency requests. However, no personal communication is intended for any CRS two-way frequencies. The proposed highway communication radio service is intended to be implemented between 26 and 30 MHz for compatibility with CRS equipment, thereby providing frequencies for personal communication.

The other systems given in the table are for outbound transmission only by public service agencies and for an emergency alerting service.

An important part of the Detroit network test revealed that, in times of heavy snow and rain, the ability to broadcast bulletins regarding traffic tie-ups and snowbound or flooded roads as soon as they occur reduced to a large degree the driver emergency calls. Channels D and E are intended for these purposes.

The new service to provide local audio signing will require the addition of encoders and decoders. It is also intended that the design of the decoder will permit any local encoded audio sign messages to override any other reception by the vehicle transceiver. A basic standby receiver that provides an access for communication with vehicle operators is part of this new service. The device is intended to be turned on at all times on a fixed frequency with volume set at a level high enough to override vehicle noise. Reception of an encoded signal would activate the speaker so the message could be heard.

Channel D provides for radiation of an encoded tone signal to be picked up by other vehicles in the immediate area.

The reception of the tone or possibly a beep tone is intended to inform the listener that someone is in trouble. When the tone stops, voice contact is made on the emergency channel. By this means the communication loop between vehicles is closed. The standby receiver with decoder provides a silent means to detect transmission of emergency warnings and information. The other items listed in the table are self-explanatory.

IMPLEMENTATION OF THE HIGHWAY COMMUNICATION RADIO SERVICE

As explained earlier, the basic emergency two-way CRS channel 9 is currently in operation and could become part of the proposed service. Five additional frequencies could be assigned adjacent to the 27 MHz CRS to accommodate the highway communication radio service. FCC reassignment of CRS channels 24, 25, 26, 27, and 28 (the little-used channels interspersed with the CRS Class D frequencies for remote control of models) would provide excellent compatibility with channel 9. Most of this remote-control service has moved to 72 MHz and in most cases would not cause trouble even if some areas shared the channel with the highway communication radio service.

The system therefore could start immediately to use A, B, D, and E services, and the additional service, encoders, and decoders for item C could be added as the system becomes implemented.

Note that the proposed system would also require only a Class D CRS license. Voice transmission from the motorist is allowed on only two-way systems using a 5-W transmitter. Special licenses would be required for the public service agencies to operate the one-way transmitters. Having a lower power requirement, the local audio sign system could also be covered under a Class D license. The addition of emergency and audio signing channels would provide increased coverage for highway base, repeater, and audio sign stations.

RECOMMENDATIONS

Past services of many kinds developed for the public have had the basic systems and specifications for the hardware and public service facilities worked out by a committee of knowledgeable engineers from industry, an excellent example being the National Television Systems Committee who worked out the national television system.

The author suggests that committees chaired by HRB and staffed by engineers from industry and members of AASHO, the National Highway Traffic Safety Administration, the International Municipal Signal Association, AT&T, and the FCC work out the technical and implementation details of the plan proposed here and a satisfactory licensing plan for the millions of motorists who will use the system.

CONCLUSION

The author has presented a workable solution for implementing a highway communication radio service. The service should satisfy the communication needs of the motorist and those of public service agencies for contact with him.

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MEASURING THE EFFECTIVENESS OF A VOLUNTEER EMERGENCY-MONITORING SYSTEM IN THE CITIZENS RADIO SERVICE

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This paper describes the experimental statewide emergency communications network utilizing the Citizens Radio Service conducted in Ohio during 1970-1971. A joint project of REACT National Headquarters and the Ohio State Highway Patrol, the program known as the Ohio REACT Emergency Network was established as an experimental 2-year program to test the effectiveness of volunteer citizens monitoring emergency communications and providing assistance to motorists in accordance with the Federal Communications Commission's establishment of channel 9 as the official emergency channel. A state director was appointed for REACT, and districts were established based on the Highway Patrol district boundaries. A district coordinator was appointed for both the Highway Patrol and REACT volunteers in each district to provide comparable levels of contact and authority. Log reports of calls received for emergencies and motorists' assistance are tabulated by computer at General Motors Research Laboratories. This paper describes the organization, presents the data gathered in the program's first year of operation, and establishes goals for the second year.

•THE FOLLOWING observation was made by William N. Carey, Jr., Executive Director of the Highway Research Board: "The problems of developing an integrated nationwide highway communications system are more political, institutional, administrative, and managerial than technical. Nothing significant will be done until we find effective approaches to the nontechnical problems." The need for such a system is best documented by the fact that, once given the means to communicate via two-way radio from their vehicles, individual citizens instinctively develop their own highway communications system. The REACT system mobilizes this grass-roots movement to overcome the "nontechnical problems."

The Ohio State Highway Patrol, REACT National Headquarters, and General Motors Research Laboratories concurred that the Citizens Radio Service (CRS) is now providing thousands of motorists with highway communications. Furthermore, CRS offers a vast potential for an integrated nationwide system in a relatively short period of time. It was also felt that the concept of two-way radio for highway safety communications from individual motorists to volunteer citizen monitors deserved serious evaluation.

The key question seemed to be, "How effective could this system be?" Effectiveness would be measured through relatively simple data acquisition with computer analysis to project the raw data into significant statistics. This paper summarizes the first year of the operation of the Ohio REACT Emergency Network, the purpose of which was to measure the effectiveness of a volunteer emergency-monitoring CRS system.

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DEVELOPMENT OF CITIZENS RADIO SERVICE

As the 1950s came to a close, the Citizens Radio Service began. Putting two-way radios into ordinary passenger automobiles immediately produced the phenomenon that was potentially the key to a highway communications system.

Even with a single motorist in communication with his own base station, the concept of two-way radio for motorist assistance was in effect. As additional operators joined the citizens band ranks in a given community, they pooled their common interest into CB Clubs. One of the purposes of these clubs was to provide a means of emergency highway communications primarily to benefit the members of the group. Gradually, the reporting of accidents and stalled motorists and requests for various types of assistance from the highway were worked into a general pattern of emergency communications for the public as well. When local emergency situations arose such as fires, floods, tornadoes, hurricanes, snowstorms, or other serious conditions that curtailed ordinary telephone communications, the club was ready to serve community needs.

By 1962, the emergency communications potential of the CRS was well recognized by industry leaders. The possibility of providing a pattern for organized local emergency groups was recognized, and in that year REACT (Radio Emergency Associated Citizens Teams) was founded.

REACT is an entirely voluntary organization, and the individual groups agree to work toward a 24-hour monitoring system on channel 9 as part of their agreement with national headquarters. At the present time, approximately 40,000 active participants are organized into almost 1,000 local groups throughout the United States and Canada. Sponsorship of REACT was assumed 3 years ago by General Motors as a public service and as a highway safety research project (1).

As early as 1964, REACT required all of its teams to monitor a single channel, channel 9. All who needed assistance were encouraged to call on channel 9. Thus emerged the concept of a single national emergency channel.

REACT joined with other interested parties in petitioning the Federal Communications Commission to establish an official emergency channel on channel 9. The Commission acted favorably on this, effective July 24, 1970, by limiting the channel to "emergency communications involving the immediate safety of individuals or the immediate protection of property or communications necessary to render assistance to a motorist" (2).

Among the considerations the FCC took under advisement in establishing the official emergency channel was the prior voluntary use of the channel for emergency purposes. By 1969, thousands of volunteer monitors were handling emergency calls, with approximately two million radios in use. A REACT study showed that, as early as 1966, 1,800,000 incidents were handled annually on channel 9, including about 500,000 automobile accidents. In effect, what the FCC was doing was recognizing a de facto emergency channel that had developed through the wholly voluntary efforts of thousands of members of REACT and other individual licensees.

The key to this system is that people are listening and ready to help. This is how the REACT concept works: The motorist communicates his need for assistance to the REACT monitor on CB channel 9. The monitor contacts the proper service agency by telephone (police, fire, or road service). Finally, the REACT monitor reports the successful dispatch of assistance to the motorist on CB channel 9. The motorist then knows that help is on the way.

A pattern of research and official implementation of the emergency channel concept was already under way. The Detroit CB Radio Driver Aid Network was established in 1966 (3). It covers the metropolitan area of Detroit with a central monitor linked to strategically placed transmitter and receiver units by land line. After technical development by General Motors Research Laboratories, the system was turned over to the Detroit Department of Streets and Traffic for operation of the system. Tabulation of all calls received by the monitor has been made regularly and has been reported in previous papers.

A recent study of the Detroit network by the Civil Engineering Department of Wayne State University has brought out some additional data (4). A key product of this research was the time saved in reporting incidents. The study indicated that approximately 17 min could be saved in detection-reporting time by using the CRS on a city freeway as compared to waiting until a city police car or a county service vehicle appeared on the scene.

THE OHIO REACT PROGRAM

Before proceeding with a further description of the Ohio REACT program, it is appropriate that we review the various highway communications systems proposed. These include the following:

1. Visual distress signal such as a handkerchief on the automobile antenna or a raised hood,
2. Patrols of official vehicles—police and road service,
3. Headlight signaling,
4. Roadside call boxes,
5. Embedded sensors to detect traffic flow,
6. Roadside radio transmissions for in-vehicle audio or visual signaling or both,
7. Electronic vehicle locator system, and
8. Citizens two-way radio.

Although other means of communications are possible, these are very representative of the types of systems. Some are in actual use, and others are currently being tested and seriously considered singly, and in combination, for adoption on a national basis.

Because this paper deals only with citizens two-way radio, recognition of its relationship to other systems is important to the overall evaluation of results. Thus, by stating relative potentials, we can evaluate actual data with greater relevance. We will not attempt to evaluate all the possible systems in detail, but it is helpful to note the relative ability of the various systems to accomplish each of the following communication objectives:

1. Rush aid to accidents faster,
2. Keep traffic moving to prevent accidents,
3. Reduce walking on highway to seek assistance,
4. Report dangerous driving behavior or conditions to authorities,
5. Provide routing information for motorists, and
6. Provide emergency messages to the driver.

We believe that two-way radio inherently fulfills all of these objectives. The other currently proposed systems seem unable to provide this total capability.

A key advantage of citizens two-way radio is that the motorist makes the investment for the communications equipment involved. The motivation for such an investment is, to a great extent, the ability to communicate for personal and business uses other than in the emergency situation.

One of the difficulties with any communications system is convincing the motorist that an investment for purely emergency purposes is warranted. Thus, the desire for an in-vehicle device that is merely to receive special instructions from a highway control source, or for signaling an emergency, would not be as great as a general-purpose two-way radio, which in addition can be used for emergency communications.

Obviously, it would cost far less in terms of government funding to set up monitoring stations on an emergency radio frequency than to establish a national system of telephone or radio-telephone call boxes or to proceed with embedding sensors at major intersections either in the road or at roadsides. When the maintenance cost is added to the installation cost, a very expensive system is required in each case. In the REACT system, not only have we eliminated the equipment investment, but also our volunteer monitors appear on no payroll.

Recognizing the possibility of establishing a nationwide public monitoring system similar to the Detroit network, REACT proposed a research program that uses a limited geographical subdivision of sufficient size and complexity for the results to be projectable nationally. Ohio was selected for the following reasons:

1. It had many qualities of geography, topography, climate, highway types, and demography that could be projected nationwide;

2. The REACT structure in the state was reasonably well developed; and
3. The Ohio State Highway Patrol had some experience in working with CB radio groups and had exhibited willingness to cooperate with existing REACT teams.

In late 1969, REACT National Headquarters contacted the Ohio State Highway Patrol with the proposal for joint cooperation in a 2-year experimental program to study the ability of CB radio volunteer groups to provide an effective highway communications system (6). The State Highway Patrol agreed to cooperate in such a joint venture provided that REACT appoint a qualified state director to coordinate the program at the local level and that the Federal Communications Commission establish channel 9 as an official emergency channel at least for this program.

The terms were met when Frank Travis of Akron was appointed as the REACT State Director and by the previously mentioned Federal Communications Commission ruling establishing channel 9 nationwide as the emergency channel, effective July 24, 1970. That became the target date for launching the Ohio test program.

Organization for Ohio obviously required a higher level of sophistication than the broad-based national REACT structure, under which REACT National Headquarters directly charters local groups as REACT teams. It was evident that, for REACT to function effectively as a recognized emergency communications system, it was necessary to evolve more practical and standardized methods for local liaison, training, and operational techniques.

To solve these problems, the Ohio REACT Emergency Network was developed as a joint venture of the Highway Patrol and REACT National Headquarters. The Highway Patrol lent their prestige to the program as the key law enforcement agency in the state concerned with highway safety. To get the program under way, the Highway Patrol hosted two statewide meetings at the Patrol Academy in Columbus.

One meeting involved interested state officials representing the state highway department, the State Police Chiefs and Sheriffs Associations, the Ohio AAA, the Red Cross, Civil Defense, FCC, and the communications staff of the State Highway Patrol. The second meeting included representatives of all the REACT teams in the state.

Subsequently, joint meetings were held at each of the Highway Patrol District Headquarters with the existing REACT teams, other interested CB radio groups, and the key local law enforcement agencies in each district. The Highway Patrol appointed a volunteer REACT member in each district as coordinator to work with the communications technicians of the Highway Patrol who were assigned the responsibility of coordinating the program within the districts. Thus, at the end of the organizing phase of the program, the 60 REACT teams in the state were organized into 10 districts paralleling those of the Highway Patrol. The teams report to both the Highway Patrol and the REACT state director, all under the joint supervision of Patrol Headquarters and REACT National Headquarters (Fig. 1).

The value of this first round of meetings cannot be underestimated. All concerned parties were able to meet under favorable conditions at a Highway Patrol post to learn the objectives and procedures that were to be used in the program. With local police and sheriffs attending, the control of the program was firmly in the hands of law enforcement officials, with the volunteers directed to follow procedures acceptable to the authorities or risk losing official recognition.

Experiences bore out the effectiveness of this approach. Furthermore, bringing the local law enforcement agencies into direct contact with the volunteer groups at the Highway Patrol post has produced a higher level of cooperation between local officials and the volunteer groups than had heretofore been present.

A simple data gathering procedure was, of course, mandatory to effective evaluation of Ohio REACT. A standard report form was developed to permit simplified yet complete recording of information regarding each call received on the emergency channel by each REACT team monitor. In addition, a monitor guide was developed to provide instructions for the monitors. This was particularly important in view of special regulations established by the Federal Communications Commission governing the use of the official emergency channel.

The reports were to be collected by the individual teams and forwarded to General Motors Research Laboratories for tabulation by computer. These computer tabulation reports were published and distributed to all interested agencies by REACT National Headquarters. Figure 2 shows the results of the tabulations.

Because the reporting monitors are volunteers, the chief difficulty has been to get reports of all the calls received. Nonetheless, in the first year's operation, 9,968 calls were recorded. For statistical purposes, we are considering the period from June 24, 1970, through August 1971 as 1 year. This compensates for reports lost at the start of the program and the lag in receiving reports for August 1971. The figures are interesting. When one considers that over 60 percent of the calls involved either an accident or immediate threat to highway safety (specifically, stalled vehicles or road obstructions), it is easy to see why police and highway officials are encouraged by what these civilian volunteers can accomplish. The 23.3 percent of the calls describing "other incidents" are being identified in greater detail during the second year of the program with a new reporting form that will permit far more detailed tabulation.

There are several observations we would like to make regarding what the teams are reporting. Fist, there is a large variation in the number of calls received by the various teams; in fact, a good many teams failed to report any calls. Obviously, some volunteer groups are much more effective than others. On the other hand, there seems to be a correlation between team reporting frequency and population. The three top teams in calls reported 36 percent of the total, whereas their coverage area (county) includes nearly 28 percent of Ohio's population.

Second, some of the teams reporting very few calls or none at all claim that they have reported all the calls they have received. Thus, there is some question of the extent to which channel 9 is being used for motorist assistance and to report emergency communications in various areas. Also, some teams claim that it is difficult to receive the calls on channel 9 in their area because of illegal interference from various sources.

Third, one highly favorable result is a healthy increase in total REACT teams—from 60 to more than 80 in the first year.

A recent survey completed by Advanced Technology Systems, Inc., under contract to the FCC, points out that illegal use is the most serious problem in class D citizens radio (6). The ATS report recommends the establishment of a substantial enforcement program to curb violations such as use of excess power, off-frequency operation, long-distance "skip" communications, failure to be licensed, and failure to use identifying call signs, and we would add enforcement of the emergency channel rule.

We note with concern that, from the effective date of the emergency channel, July 24, 1970, until the time that this paper was written, there have been no violations of the emergency channel rule cited by the FCC. In view of that situation, we believe that self-policing and compliance with the rule have been remarkable. The FCC-sponsored study also indicates that an expanded education program is required to achieve understanding and cooperation of licensees. ATS also pointed out that, in spite of all the problems, 47 percent of the licensees report use of CB for emergencies an average of 17 times per year.

A survey of all REACT teams conducted in October 1971 sheds some additional light on the achievements of the Ohio REACT program. Ohio teams now have a decidedly more favorable relationship with official agencies than does the average REACT team nationally (Table 1), and public safety officials are far more interested in monitoring CB in the improved climate of Ohio (Table 2).

CONCLUSIONS

The chief conclusion of this experiment is that there is a reasonable potential for a volunteer monitoring system for highway communications utilizing the Citizens Radio Service. In spite of all of the difficulties encountered, e.g., illegal operations, atmospheric phenomena, unpredictable coverage, and the irregularities inherent in a volunteer program, the Ohio REACT Emergency Network proves that a significant amount of highway emergency traffic and motorist assistance can be conducted on channel 9. Volunteers who are dedicated to service, trained, and willing to train others in effective communications techniques can be the backbone of a workable emergency and motorist assistance system.

Figure 1. Organization of the volunteer emergency-monitoring system.

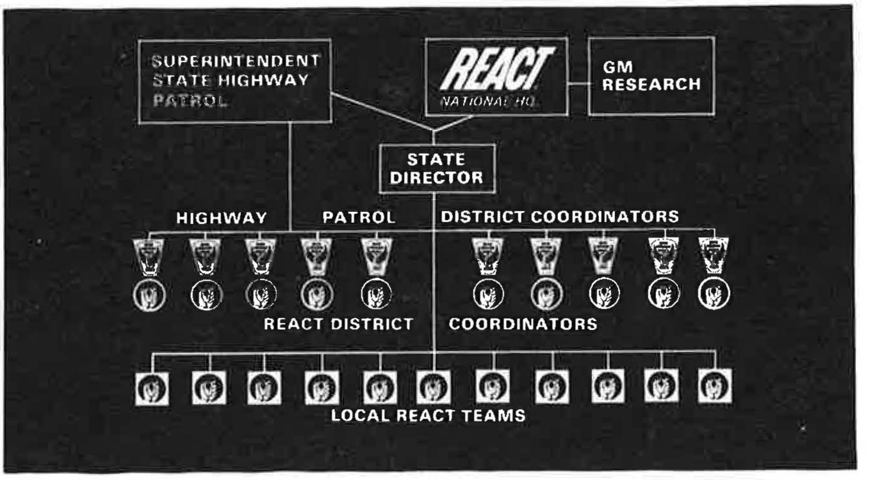

Figure 2. REACT log report.

FOR THE MONTHS OF:	JUN70	JUL70	AUG70	SEP70	OCT70	NOV70	DEC70	JAN71	FEB71	MAR71	APR71	MAY71	JUN71	JUL71	AUG71	CUMULATIVE TOTAL	PCT.
(BREAKDOWN OF REPORTS)																	
ACCIDENTS:	4	63	159	212	231	190	238	291	300	279	159	184	146	182	188	2826	28.4
. # OF VEHICLES	7	117	243	371	444	373	476	562	534	487	290	338	250	339	334	5165	
. WITH INJURY/S	1	14	27	55	41	29	40	33	35	40	29	43	27	37	39	490	
. WITH FATALITY/S	0	0	3	1	4	1	2	1	1	3	2	2	1	2	4	27	
REQUEST FOR INFO.	4	51	112	107	84	115	133	157	180	164	145	139	116	151	203	1861	18.7
STALLED VEHICLE	1	52	101	136	168	207	161	173	265	222	140	179	134	172	159	2270	22.8
ROAD OBSTRUCTION	2	24	46	81	60	43	55	63	95	85	51	73	69	66	58	871	8.7
FIRE	0	4	21	14	11	10	9	17	20	20	40	24	22	30	19	261	2.6
TORNADO	0	2	0	0	0	0	0	0	0	0	1	4	11	2	0	20	0.2
HURRICANE	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	
OTHER INCIDENT	1	79	179	141	168	178	161	202	209	165	139	153	146	175	222	2318	23.3
(ROAD CONDITIONS AND ACCIDENTS)																	
DRY PAVEMENT	1	37	103	133	125	81	96	71	41	86	130	138	119	105	130	1396	49.4
WET PAVEMENT	2	18	26	55	76	64	91	79	113	81	19	41	16	51	38	770	27.2
ICE AND/OR SNOW	0	0	2	3	5	32	41	156	138	119	1	1	1	1	1	501	17.7
FOG	0	0	5	4	5	4	6	4	7	5	1	1	0	5	1	48	1.7
OTHER ROAD COND.	0	0	3	3	6	5	6	3	7	2	0	1	0	0	0	36	1.3
ROAD COND:NO DATA	1	8	26	20	20	16	16	28	43	24	8	5	10	23	19	267	9.4
(ROAD TYPES AND ACCIDENTS)																	
INTERSTATE	2	20	50	55	59	61	71	107	95	87	48	59	45	58	54	871	30.8
FREEWAY	0	10	19	35	38	39	29	68	63	61	25	28	34	25	24	498	17.6
TOLL ROAD	0	3	0	0	0	0	0	2	1	0	0	2	2	3	0	13	0.5
BRIDGE	0	1	3	4	5	4	3	1	9	5	4	3	3	1	1	47	1.7
CITY STREET	0	15	61	89	88	72	111	78	85	82	54	66	46	61	75	983	34.8
SECONDARY ROAD	2	7	20	24	26	11	18	28	36	35	24	25	13	26	17	312	11.0
OTHER ROAD	0	10	14	13	13	9	8	2	10	7	6	4	3	5	5	109	3.9
ROAD TYPE:NO DATA	0	3	8	10	14	8	9	13	19	13	9	5	7	8	13	139	4.9
(AUTHORITIES NOTIFIED, EXCLUDING INFO. REQUESTS)																	
CITY POLICE	5	93	229	305	326	349	344	405	406	322	229	282	251	282	304	4132	51.0
SHERIFF	1	20	48	37	37	30	29	26	54	55	48	48	33	59	48	573	7.1
STATE PATROL	1	39	103	79	89	81	72	82	120	135	89	95	76	95	87	1243	15.3
FIRE DEPARTMENT	0	4	13	16	13	9	12	14	15	15	32	24	17	26	16	226	2.8
OTHER AUTHORITY	1	48	118	136	159	173	140	165	224	158	90	123	77	81	107	1800	22.2
AUTHORITY:NO DATA	0	19	39	35	50	56	66	69	67	72	50	69	69	102	82	845	10.4
(SOURCE OF CALL, EXCLUDING INFO. REQUESTS)																	
CALLER INVOLVED	0	18	34	30	36	28	25	56	54	48	21	32	24	42	28	476	5.6
PASSER BY	5	112	267	274	275	282	308	366	424	359	260	325	275	335	369	4236	49.6
REACT TEAM	3	39	102	139	150	185	141	180	208	211	161	170	146	163	156	2154	25.2
OTHER SOURCE	0	33	42	43	39	45	41	65	50	44	28	30	21	25	23	529	6.2
CALL ORGN:NO DATA	0	21	81	82	123	115	122	100	122	77	59	65	47	75	61	1150	13.5
REPORT TOTALS	12	251	592	638	675	739	738	865	995	870	646	745	614	768	820	9968	

Table 1. Working relationship with REACT.

Group	Nationwide (percent)	Ohio (percent)
Local police	70.6	65.2
Sheriff	63.7	71.7
State police	65.5	87.0

Table 2. Monitoring of CB channel 9 by public safety officials.

Group	Nationwide (percent)	Ohio (percent)
Local police	18.0	15.2
Sheriff	16.5	37.0
State police	13.7	60.9

The program demonstrated that two-way communications effectively provide the motorist with a means of communicating his problem in depth. It permits the helper, be he professional or volunteer, to determine the correct course of action to aid the motorist and report back to the motorist.

We have several objectives for the second year of the program, now well under way:

1. New reporting forms are being used to gather supplementary data not originally available;
2. A more concentrated effort will be made to expand the geographical coverage of the program by organizing additional REACT teams;
3. A greater effort will be made to publicize the program throughout the state and to those who may be traveling through;
4. Additional effort will be exerted to encourage the Federal Communications Commission to provide additional enforcement efforts to reduce interference on channel 9; and
5. The state director and district coordinators will be more involved in training and supervision of the teams to produce a higher level of monitor efficiency.

It is our hope to provide future reports showing how this basic program is being expanded to other states and eventually could result in an effective nationwide system for highway communications at almost no cost to the taxpayer.

ACKNOWLEDGMENTS

The authors wish to acknowledge the vital contributions of the following persons to this research project and to the development of this paper: Clifford Kimber and Rex Fleming, Ohio State Highway Patrol; Edward F. Weller, Head, Electronics and Instrumentation Department, General Motors Research Laboratories, and his staff members, Clark E. Quinn and William G. Trabold; and Gerald H. Reese, Managing Director, REACT National Headquarters. In addition, we acknowledge the invaluable efforts of all members of the State Highway Patrol and the thousands of REACT volunteers in Ohio.

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DISCUSSION

Peter F. Sielman, Communications Systems Department, AIL, Division of Cutler-Hammer, Inc.

In the past 25 years the use of highways by passenger vehicles, trucks, and buses has exceeded the highest forecasts made in the late 1940s. The growth of the suburbs, the decline of the railroads, and the extension of the middle class are all intricately interwoven with an explosion in the number of vehicles and miles of roadway.

Many feel that (for a variety of reasons) we are now entering a period of consolidation. More vehicles and more highways are creating more problems than they solve. Increasing efforts are being directed now toward alternative forms of transportation and toward increasing the safety, efficiency, and convenience of existing highways and vehicles. It is this latter interest that has spurred the emergence of highway communications.

The very nature of highways and the use of vehicles exclude parochial systems. What is sauce for the New York motorist must be sauce for the Virginia motorist because he is likely to be the same individual in the same vehicle displaced only a few hours in time. Highway systems in general, but most certainly highway communications in particular, must be national in scope and specification. Hence, this is clearly a field for federal responsibility. The response, so far, has been timorous.

The paper by Chiaramonte and Kreer is well written and clearly explains the project that is being reported on and its antecedents. It provides valuable statistical data on the nature of the need for highway communications, and its conclusions are objective.

The paper also clearly demonstrates the effort that has been expended by REACT groups and shows them to be imaginative, dedicated, and civic-minded.

For the purposes of my remarks, Figure 3 shows the REACT system in operation, giving the flow of information from and to the motorist requiring assistance. From the statistical data provided in Figure 1, a majority of the motorists have been involved in accidents or require mechanical assistance. Also from the same figure, a majority of the CB-equipped monitors are either passers-by or REACT team members.

In the days of the Western frontier, new territories were peopled and functioned acceptably before government services caught up. Law and justice services were often ad hoc in nature during the early days of the wild west. This ad hoc justice was uneven and in many ways less than ideal, but it was better than nothing; it filled a vital need temporarily.

I believe this analogy fits the REACT approach to highway communications. It represents a tremendous improvement over no highway communications. It is filling a vital need temporarily because, as in the past, the government is slow in catching up.

However, it would, in my opinion, be a mistake to agree with the statement by the authors that CRS "offers a vast potential for an integrated nationwide system. . . ." I feel more comfortable with their conclusion: "In spite of all the difficulties encountered, e.g., illegal operations, atmospheric phenomena, unpredictable coverage, and the irregularities inherent in a volunteer program, the Ohio REACT Emergency Network proves that a significant amount of highway emergency traffic and motorist assistance can be conducted on channel 9."

What then are the characteristics of a national highway communications system? Three basic criteria come to mind, and these in turn spawn a series of corollaries. The three criteria are as follows:

1. The system must provide two-way communications into (eventually) each motorist's vehicle;
2. Communications must be direct with the single agency that is responsible for the highway; and
3. The system must operate identically, without the necessity of switching, in all parts of the country.

Figure 4 shows such a system. Other crucial items that must be factored into system design are cost, limited spectrum, the laws of physics, and the realization that national systems do not descend on the country like a giant fishing net but rather evolve logically, growing here and there and finally merging into an overall system. With these factors in mind, the following major corollaries become obvious:

1. A single set of frequencies,
2. Digital plus emergency voice messages,
3. Low radio frequency power, and
4. Multiple use of links.

One system that meets these criteria has been designed and is currently undergoing tests on the Sagtikos Parkway (7). Table 3 gives a comparison of the performance of a national highway communications system with a volunteer emergency-monitoring system as described in the paper.

Figure 3. REACT system in operation.

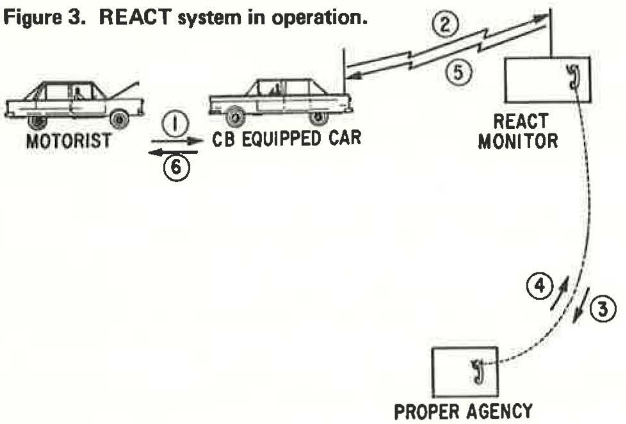

Figure 4. Operation of a national highway communications system.

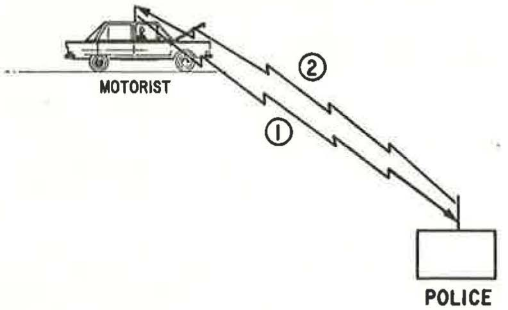

Table 3. Comparison of volunteer emergency-monitoring system and national highway communications.

Quality	Volunteer Emergency-Monitoring System	National Highway Communications System
Single national channel	X	X
Two-way communications	X	X
Communication type	Voice	Digital plus emergency voice
Decision-making	Volunteer	Professional
Response time	Statistical	Seconds
Interference	Significant problem	None

The authors and the thousands of REACT volunteers all deserve our gratitude for their initiative and dedication. It is my hope that these qualities coupled with their valuable experience can be harnessed to the evolution of a truly national highway communications system developed with strong federal support.

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Shirl J. Stephany, Rescue and Emergency Medical Programs Division, U. S. Coast Guard

The need for communication with motorists has been concluded in various studies and analyses conducted under government sponsorhip during the last decade. Collectively, the studies are diverse in subject and scope, covering many aspects of highway communication and ranging from the fundamental need to receive information to accident detection and location, reporting highway hazards, and coordination of public service agencies. In general, separate analyses have been made of systems that can satisfy one or the other requirements, and yet the system requires the composite if the full benefit is to be realized. Quantitatively, it has been estimated that fatalities can be reduced by 1,500, injuries reduced by 59,000, and reduction in delays by 160,000,000 hours by implementation of a motorist-aid communication system. It has been conservatively estimated that 50 to 75 percent of rural highway deaths need not have occurred if prompt and experienced emergency medical service had been available. Communication is an essential element in providing this service. Qualitatively, other benefits in reduction of chain-reaction accidents and better use of resources for law enforcement, national disasters, health services, and other public services will also derive. The message is clear: Motorist communications must be provided for safety and efficiency in highway travel, in addition to the other potential benefits to the American public.

The ultimate solution to the accident assistance problem lies in a system that will enable the motorist to summon assistance from his car and be warned of hazardous conditions before reaching the point of danger. The system should also provide automatic detection and location for accidents, even if vehicle occupants are unable to do so; vehicle-to-vehicle communication to warn of approaching ambulances, fire trucks, and the like; and the capability for the highway safety system to communicate at will with vehicles requiring assistance.

Electronic advances and state-of-the-art developments can now meet these needs. The crucial task of integrating these developments into an effective national system is more political, institutional, administrative, and managerial than technical. The need is clearly demonstrated by activity of volunteer citizen groups such as REACT, who, once given the means to communicate via two-way radio, have instinctively developed their own highway communication system.

It should be recognized that the CB radio service was used because it was available. CB was never intended to fully meet highway communications requirements. The enormity of the problem is staggering when one realizes that there are approximately 100 million registered vehicles; each year six million additional vehicles are manufactured, and the number reaching the roads exceeds those being retired. Although not directly applicable, approximately 10,000 new registered drivers reach the road system daily. It is apparent that lack of effective control noted in the REACT article is a major problem to be overcome. The experience and other lessons to be learned are of direct value and can be applied in the development of a national highway communication system.

William G. Trabold, General Motors Research Laboratories, Warren, Michigan

The Chiaramonte and Kreer paper discusses the importance and effectiveness of CB radio using volunteer monitors for motorist aid and information relative to other systems in operation today. They present data that indicate the viability of the system.

The object of this discussion is to add information on the subject of the Chiaramonte and Kreer paper. An examination of the status and activity in highway communication reveals that two systems are partially in operation. The first system employs call boxes located along expressways and is the result of research, planning, and evaluation by state and federal highway agencies. The second operating system makes use of CB radio and volunteer monitors who respond to motorists' requests for aid and information on several CB channels. This system developed spontaneously as the population of privately owned base station and mobile transceivers grew.

Several forms of call boxes, both radio and telephone, are in operation, and many others are in planning and procurement stages. An NCHRP report (8) indicates that approximately 5,700 call boxes have been installed by 12 states. Another 13 states have definite plans to install them by 1974. Installation of call boxes is limited almost exclusively to Interstate and other expressways. Call boxes are a practical, manageable, and proven means by which expressway motorists in need of aid can communicate their distress to highway authorities.

Call boxes do nothing, however, for motorists stranded elsewhere in the U. S. road system. Further, they are not an adequate source of traffic and road information for either civil agencies or the motoring public.

The use of CB radio by volunteers to achieve highway communication on a national scale is an accomplished fact. The CB-equipped motorist (estimated at 1.8 million vehicles, or one in every 55 vehicles) has recognized his need for both aid and information. Volunteer monitors achieve enough satisfaction in serving others to make the system work. Technically it is an inferior system, and management of it will never be complete in the sense that call-box systems can be managed.

The fact remains that CB radio is the most massive highway communications system in operation today. Renner's analysis (6) of the 1969 FCC CB survey data gives some estimation of the extensive use of CB radio. It estimates over 5.25 million emergency uses of CB in 1969. Over 4 million of these were for automobile trouble. Seventy percent of the licensees indicate CB is usable for their needs. This has been achieved without the investment of public money.

The Federal Highway Administration has also recognized the need for the communication of more information on a wider scale than call boxes can achieve and has funded Renner to devise a comprehensive radio-based system (9). Quinn presented a paper that defines a similar system (10). Many of the observations of both investigators recognize the same needs. It is neither failure to recognize the motorist's needs for communication nor an ability to find technical solutions that meet those needs that delays implementation of such plans; it is economics.

We have recently compiled data from the 1971 National Survey of REACT teams on their use of CB radio (11). A questionnaire was sent to 780 affiliated U. S. teams of which 388 or 50 percent responded. The response from Ohio teams was 11.9 percent of the U. S. total.

Data reveal that 88.9 percent of the respondents find that channel 9 is suitable for the communication of emergencies. The 12.1 percent of respondents indicating that channel 9 is hard or impossible to use came from widely scattered states. We conclude that, although some local areas have difficulties with interference (illegal), the channel is very usable on a national basis. As Renner pointed out, user education and local action by the FCC would do much to improve this situation.

Channel 9 is by no means the only channel being used for emergency communication. More than 42 percent of REACT groups monitor other channels as well, with channel 11 being the most popular alternate. There is strong correlation between community population and the monitoring of channels by REACT teams. As community size decreases, channel 9 use decreases, and channel 11 use increases.

Use of other channels is believed to be caused primarily by the lack of channel 9 activity in rural areas and FCC constraints on the use of channel 9, which prevents monitors from communicating with each other. The answer to greater usage of channel 9 in rural areas is increased use of dual-channel monitoring equipment. However, the REACT survey indicates that only 7.2 percent of REACT monitors have any form of dual-channel equipment. Motorists seeking assistance via CB radio are advised to try channels 9 and 11 first and then other channels up through 15.

Many REACT teams report that they have already established working relationships with civil agencies, especially law enforcement agencies. These relationships for the most part are unofficial. In the case of Ohio, an official relationship has been established with the Ohio State Highway Patrol. This is reflected in the data by 87.0 percent of the Ohio respondents reporting a working relationship with the state police as compared to 65.5 percent of all U. S. respondents reporting such a relationship.

REACT does not enjoy the full cooperation of all Ohio teams and their members, particularly as regards the submission of monthly log reports. FCC survey data reveal that not more than one-third of the CB calls handled by REACT monitors are reported. This computation is based on 17 emergency uses of CB radio per year per licensee times the number of Ohio team members. We argue that REACT monitors would experience more than the average number of events per year.

As Chiaramonte and Kreer indicated, there is no direct knowledge of hours monitored in Ohio. At this time we can only represent coverage of the state by team location. At present there are 78 operating REACT teams located in 52 of 89 counties (58.6 percent). Of these, teams in 27 of the 89 counties (30 percent) have shown consistently good participation in the program.

CB radio and volunteer monitors are already operating on a large-scale national basis. This has come about through private initiative and good will. No public money has been used. Many REACT teams are establishing working relationships with civil agencies, especially state and local police. Thanks to the establishment of channel 9 as an emergency calling channel, 89 percent of REACT teams report that CB is usable to communicate emergencies.

The challenges that face REACT and other public-service-oriented CB radio groups are primarily managerial and motivational: How can intrateam and interteam cooperation be improved? How can monitors achieve a greater sense of satisfaction from their volunteer work? How can CB highway communications more effectively serve the needs of the motorist and civil agencies?

Technically superior and more manageable systems of highway communication than citizens radio have already been studied. We are anxious to see them realized. However, today there are many crisis demands on public money for more basic social needs such as education, poverty, crime, and environmental control. These needs compete strongly for available funds. Because of this competition, we feel that CB radio and volunteer monitors will continue to fulfill the bulk of the motorist-aid and information needs for some time to come.

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EVALUATION OF THE FIRST FLASH INSTALLATION

Bernard Adler and Ivor S. Wisepart, AIL, Division of Cutler-Hammer, Inc.; and Raleigh H. Emery, Federal Highway Administration

FLASH (Flash Lights And Send Help) is an electronic system that was installed on a 50-mile section of Interstate 4 in Florida to test the operational feasibility of cooperative motorists using their headlights to summon aid for distressed motorists. Signals from 20 roadside detectors are sent to the Florida Highway Patrol Troop Headquarters, which then renders the help needed. The evaluation program proved FLASH to be an effective motorist-aid system. Effectiveness measures included empirical data from a series of controlled experiments that showed that an operationally acceptable fraction (better than 12 percent) of passing motorists used the system properly. About 0.1 percent responded incorrectly, which is more than ample discrimination. Furthermore, detector spacings of up to 8 miles were found acceptable. Motorist acceptance and understanding of FLASH were determined from mail-back questionnaires distributed at exit ramps and rest areas. Motorists who had been disabled and were serviced as a result of FLASH indicated through similar mail-back questionnaires their satisfaction with the short (18-min average) waiting time for the highway patrol to arrive. During the evaluation period, design improvements were made to accommodate varying ambient light conditions and to allow for the fact that the test section had the heaviest concentration of thunderstorms in the country. To be implemented during the second half of 1971 are an improved communications system (frequency shift keyed) and more stable photodetectors. FLASH has proved to be the most economical and effective system for the detection and location of stranded motorists.

•AS THE Interstate Highway System has progressed toward completion, the federal government, who wrote the specifications, and the state governments, who designed, built, and currently operate the highway system, have become more concerned about ensuring the successful and comfortable completion of motorists' trips. Identifying and getting help to motorists whose vehicles have become disabled are an important aspect of this concern. Some years ago, the Federal Highway Administration asked AIL to investigate methods that would be cost-effective for locating disabled vehicles on limited-access highways in even the most rural areas as well as one that would be safe, simple, and convenient for motorists to use.

FLASH, an acronym for Flash Lights And Send Help, is a motorist-aid system that uses the passing motorist to convey information about vehicles needing help. Equipment was installed on a 50-mile segment of Interstate 4 between Lakeland and Orlando, Florida, to determine the operational feasibility of a system that relied on passing motorists to report motorists needing help by flashing their headlights and thereby alerting the Florida Highway Patrol to investigate the need. Figure 1 shows an artist's concept of the FLASH system.

This paper discusses system requirements and results of an evaluation program sponsored by the U. S. Department of Transportation, Federal Highway Administration, and operated by the Florida Department of Transportation and the Florida Highway Patrol. The evaluation program has included system performance, motorist attitudes, operational integration, and equipment maintenance. Because the I-4 installation is

Sponsored by Committee on Motorist Services.

first-generation equipment, an important aspect was to identify necessary system improvements as a result of on-the-road operating experience.

DESCRIPTION OF FLASH

The primary components of FLASH are roadside equipment and a central monitoring station at the Florida Highway Patrol Troop Headquarters. A detailed description of the system design and its operational specifications has been reported previously (2) and will not be repeated here. The nucleus of the roadside equipment is a detector that determines when a motorist flashes his lights. Twenty stations, 10 in each direction, are located along the 50-mile section of I-4 with detectors situated in advance of exit ramps (Fig. 2).

Along a typical section, a motorist, noting a disabled vehicle parked on the shoulder, continues until he reaches the next reporting location, at which time he flashes his bright lights three times. When a number of vehicles have proceeded accordingly, an indication appears at the monitoring station, and the radio operator dispatches a state trooper to that site to investigate.

INFORMING THE MOTORIST

Users of I-4 were initiated into the use of the FLASH system by two means: highway signs and mass media. It is intended that, when the FLASH system achieves widespread application, the only highway sign needed would be one designating the site of the reporting location. The FLASH sign was adopted for this purpose because it had a good potential for establishing an identity for the system and reminding the motorist what action needs to be taken and why. Because this was only a short segment of highway, two supplementary signs were designed for conveying more detailed information to the motorists (Fig. 1). The installation of the two signs was carefully selected to allow for experimental conclusions. It was found that there was no significant difference in motorists' responses when the road section contained all three signs or when the first sign (REPORT VEHICLES) was not present. However, the response was better on sections containing two or three signs than on sections containing just the FLASH sign. It was concluded that, at least for this installation, some form of supplemental signing is beneficial. Experiments with various sign messages are therefore continuing.

For this initial installation, a public information program was initiated and carried out throughout the entire evaluation period. We imparted knowledge of the FLASH system and proper operating techniques to drivers by radio, television, newspapers, and so on to provide a greater quantity of information to the motorist, which resulted in a larger driver population that would use FLASH correctly when the need arose.

The Governor of Florida declared November 13, 1969, as Electronic FLASH System Day, and opening day ceremonies were held at a rest area near Orlando.

Cooperation of the local press was secured, and articles highlighting the FLASH system appeared at regular intervals throughout the evaluation period, reinforcing public knowledge of the system and use of proper reporting techniques. Articles appeared in the major dailies of Tampa, Lakeland, and Orlando.

Several television features on FLASH appeared on news and public service broadcasts, running from a few minutes to a full half hour in length. Presentations to service clubs and organizations in the installation area were made at various meetings. Contact with groups such as these led to large word-of-mouth transmittal of information to other members of the local area population.

PUBLIC PARTICIPATION AND REACTION

Because drivers are an integral part of the system operation and acceptance, their participation and reaction helped determine FLASH system effectiveness. Two means of obtaining such information were controlled experiments and questionnaires.

Controlled Experiments

Basically, it was desired to measure the responses of the passing motorist to a stimulus such as a vehicle parked on the shoulder whose driver needed help. This was

Figure 1. FLASH system concept.

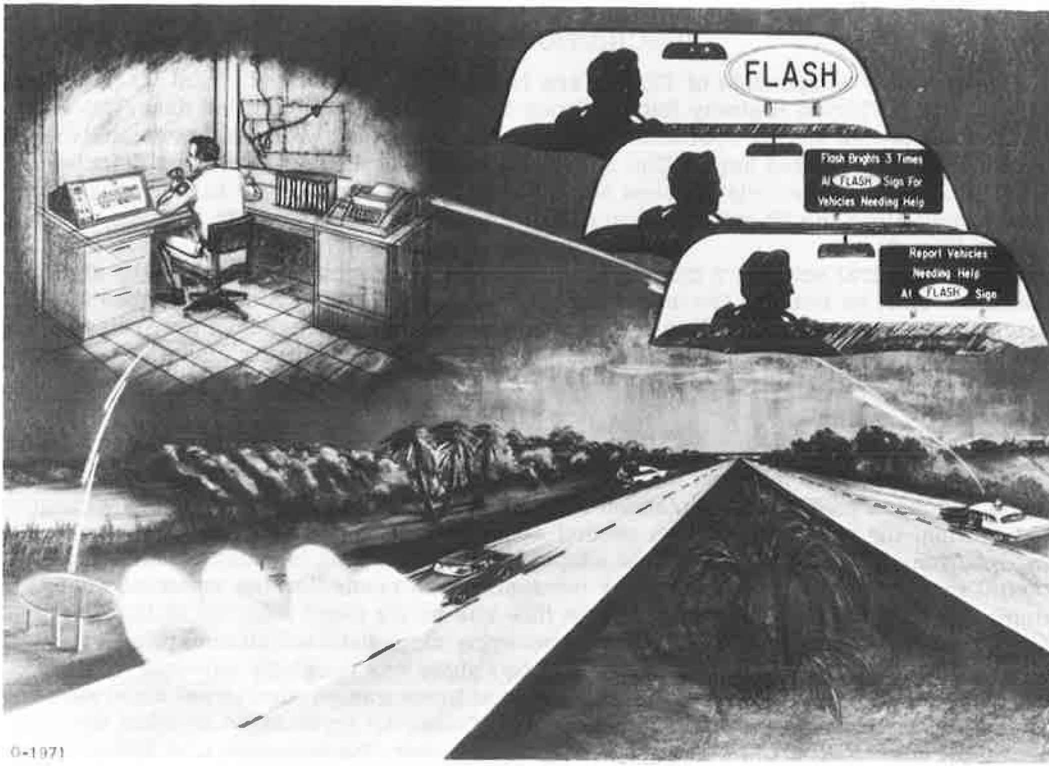
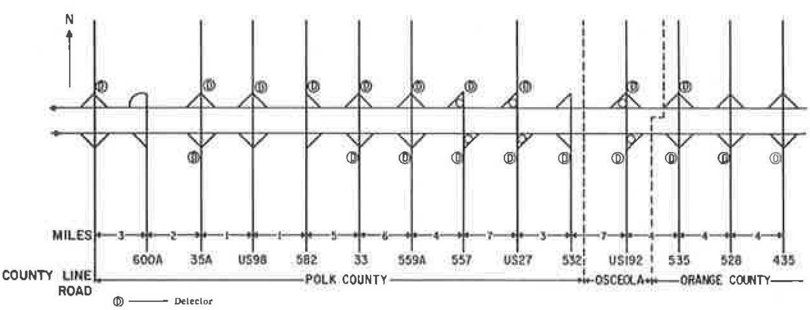


Figure 2. FLASH system location and layout.



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to be compared with the passing motorist's response to a vehicle parked on the shoulder whose driver did not need help or to no vehicle. Such responses form the basis of determining the alarm settings at the monitor station.

Two vehicles were used in the experiments. The patrol vehicle, containing one driver and one observer, constantly patrolled the test section. This served the dual purpose of experimental control and data collection for actual (uncontrolled) disablements within the test section. A second vehicle was used for the staged disablement. Motorist responses were monitored at an observation point near the detector. The vehicles were equipped with citizens band (CB) radio transceivers for communications. A graphic recorder connected to the detector continuously monitored and recorded driver responses to the experiment in progress, and a traffic counter was installed near the reporting station to measure vehicular traffic flow. One observer watched the traffic and noted the drivers' flashes on the recorder paper.

Experiments showed that even on this short 50-mile section, more than 12 percent of the motorists participated correctly. This was more than adequate, inasmuch as the false-alarm rate (motorists who responded when no help was needed) was two orders of magnitude lower (0.1 percent). The difference in the two rates allows for proper operation of the system.

One of the criteria for selecting this particular section of I-4 was that its 5-mile average interchange spacing is typical of rural Interstate highways. Because specific spacings vary from 1 to 10 miles (Fig. 2), the experiments conducted helped determine how far apart detectors can be spaced without sacrificing response rate or time. It was found that detector spacings up to 8 miles gave satisfactory results.

FLASH Questionnaires

To measure the motorists' understanding and reaction to the FLASH system, we developed two questionnaires. A questionnaire was distributed to passing motorists at exit ramps and rest areas, and a second questionnaire was given to disabled motorists when they were serviced by the highway patrol as a result of FLASH.

Passing Motorist Questionnaire—Nearly 3,000 questionnaires, distributed at rest areas and exit ramps, were returned and analyzed. Rest areas were selected because it was expected that responses received would be those of motorists from outside of the local area where the publicity was concentrated. The exit ramps selected were those that were more likely to be used by local motorists and that would represent all traffic patterns. Figure 3 shows the questionnaire used at both exit ramps and rest areas. Table 1 gives the responses to the questionnaire. The effectiveness of the signs in explaining the procedure adequately may be measured by the response to question 4. As expected, local drivers make up a majority of the driver population, but less than 50 percent use the road more than 1 day a week.

The questionnaires were distributed during three periods to determine motorists' learning curves in how they used this system and how they reacted to it. The results given in Table 1 are for the last distribution period.

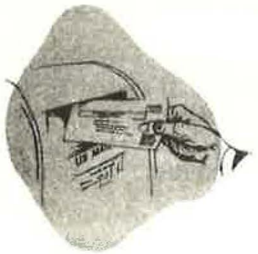
Data given in Table 2 indicate that public acceptance of FLASH increases with time. The results are the composite totals for the rest areas and exit ramps for each sample period.

Disabled Motorist Questionnaire—Disabled motorists assisted as a result of FLASH were given a questionnaire by the Florida Highway Patrol Trooper; it was used to determine the acceptability of the services received. The driver was asked to fill out the form at his leisure and to return it by mail and not to the trooper who had serviced him. In this way, an objective appraisal of the opinion of those serviced by FLASH could be obtained.

Figure 4 shows the questionnaire, and Table 3 gives the results. The numerous comments received overwhelmingly lauded the service rendered by the highway patrol and the speed of the response. The majority (60 percent) of the drivers made some attempt to fix their vehicle themselves but were either unsuccessful or still in the process of repair when the highway patrol arrived.

Public confidence in the ability of the FLASH system to promptly bring aid is measured by the fact that more than 83 percent of the people remained with their vehicle

Figure 3. Passing motorist questionnaire.



PLEASE HELP US HELP YOU

A new system called FLASH has been installed on this road. When passing motorists flash their bright lights at a FLASH location, the FLASH System quickly alerts the authorities so that they can dispatch service to the motorist needing help.

You can help us improve the FLASH System by filling out this questionnaire. Please answer the following questions and mail this card at your earliest convenience. No stamp is necessary.

Do not sign your name.

Thank you.

Budget Bureau No. 04-S69035
Approval Expires January 31, 1971

1. Did you know before today that this section of highway was equipped with a disabled vehicle aiding system (FLASH)?
   - ☐ Yes
   - ☐ No
2. Did you see the signs explaining the FLASH System?
   - ☐ Yes
   - ☐ No
3. Did you see a motorist needing help on this road?
   - ☐ Yes
   - ☐ No
4. How do you assist a motorist needing help on this road?
   - ☐ I do nothing to help him.
   - ☐ I stop to help him.
   - ☐ I flash my lights at the first FLASH Sign.
   - ☐ I flash my lights at more than one FLASH Sign.
   - ☐ I notify the authorities

     (Explain) ....

     ....
5. Do you drive this section of I-4 more than one day a week?
   - ☐ Yes
   - ☐ No
6. I am a resident of

   .... CITY .... STATE
7. I am a
   - ☐ male.
   - ☐ female.

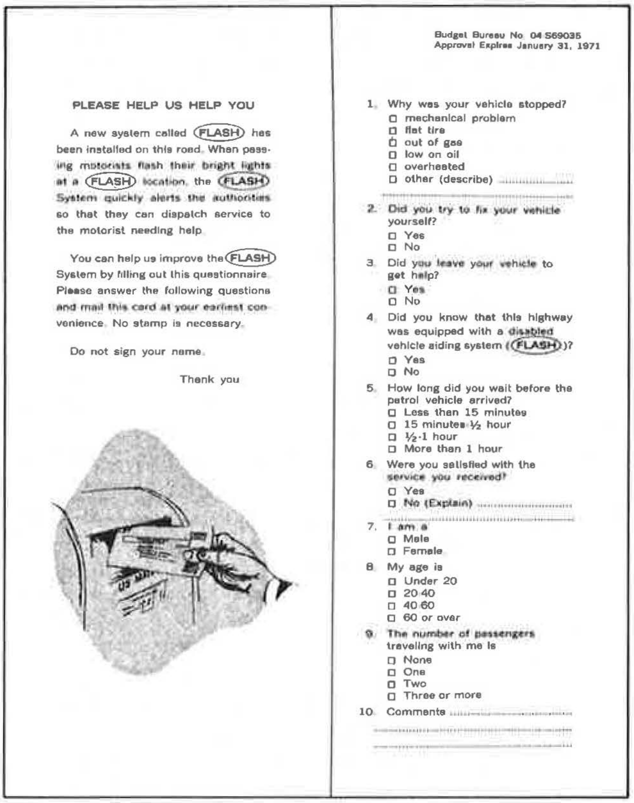
Table 1. Responses to passing motorist questionnaire (Fig. 3).

		Response (percent)	
Question	Alternatives	Exit Ramps	Rest Areas
1	Yes	93	82
	No	7	18
2	Yes	98	97
	No	2	3
3	Yes	42	34
	No	58	66
4	Do nothing	4	4
	Stop and help	12	18
	Flash lights at first sign	82	75
	Flash lights at more than one sign	6	13
	Notify authorities	5	7
5	Yes	50	33
	No	50	67
6	Local	75	45
	Nonlocal	25	55
7	Male	79	81
	Female	21	19

Table 2. Composite results of motorists attitudes toward FLASH.

Motorist Attitude	Fall 1969 (percent)	Spring 1970 (percent)	Fall 1970 (percent)
Knew before that day about FLASH	58	72	88
Saw signs explaining system	62	96	98
Willing to help other motorists	65	96	96
Uses FLASH	27	85	89

Figure 4. Assisted motorist questionnaire.



PLEASE HELP US HELP YOU

A new system called (FLASH) has been installed on this road. When passing motorists flash their bright lights at a (FLASH) location, the (FLASH) System quickly alerts the authorities so that they can dispatch service to the motorist needing help.

You can help us improve the (FLASH) System by filling out this questionnaire. Please answer the following questions and mail this card at your earliest convenience. No stamp is necessary.

Do not sign your name.

Thank you

Budget Bureau No. 04-S69035
Approval Expires January 31, 1971

1. Why was your vehicle stopped?
   - ☐ mechanical problem
   - ☐ flat tire
   - ☐ out of gas
   - ☐ low on oil
   - ☐ overheated
   - ☐ other (describe) ....
2. Did you try to fix your vehicle yourself?
   - ☐ Yes
   - ☐ No
3. Did you leave your vehicle to get help?
   - ☐ Yes
   - ☐ No
4. Did you know that this highway was equipped with a disabled vehicle aiding system ((FLASH))?
   - ☐ Yes
   - ☐ No
5. How long did you wait before the patrol vehicle arrived?
   - ☐ Less than 15 minutes
   - ☐ 15 minutes-½ hour
   - ☐ ½-1 hour
   - ☐ More than 1 hour
6. Were you satisfied with the service you received?
   - ☐ Yes
   - ☐ No (Explain) ....
7. I am a
   - ☐ Male
   - ☐ Female
8. My age is
   - ☐ Under 20
   - ☐ 20-40
   - ☐ 40-60
   - ☐ 60 or over
9. The number of passengers traveling with me is
   - ☐ None
   - ☐ One
   - ☐ Two
   - ☐ Three or more
10. Comments ....

Table 3. Responses to assisted motorist questionnaire (Fig. 4).

Question	Alternatives	Response (percent)
1	Mechanical problem	34
	Flat tire	29
	Out of gas	12
	Low on oil	1
	Overheated	10
	Other	14
2	Yes	60
	No	40
3	Yes	17
	No	83
4	Yes	81
	No	19
5	<15 min	67
	15 min to ½ hour	18
	½ hour to 1 hour	10
	>1 hour	5
6	Yes	97
	No	3
7	Male	85
	Female	15
8	Under 20	2
	20 to 40	51
	40 to 60	38
	60 or more	9
9	None	31
	One	31
	Two	18
	Three or more	19

and did not to seek aid. This corresponds very closely with the number (81 percent) who expressed previous knowledge of the FLASH installation. The desire is that, when the public has knowledge of, and confidence in, a reliable motorist-aid reporting system, they will remain with their disabled vehicles, thus reducing both the hazard to themselves and to their fellow motorists and the time in which they can expect to receive aid.

The answers to question 5 were used to arrive at a mean waiting time of nearly 18 min for motorists serviced by FLASH. This more than satisfied a system design goal of 30 min. Because the waiting time was so short, it was not surprising to find that over 96 percent of the drivers were satisfied with the service received. The mean age of drivers was found to be 40 years, which is to be expected inasmuch as there are many retirement communities nearby. A high mean vehicle occupancy of 2.3 people was similarly expected because of considerable tourist traffic on I-4.

OPERATING NEEDS

The principle requirement placed on the operating agency is manpower. In addition to providing a small amount of space for the equipment, manpower is needed to monitor the board, dispatch troopers, and investigate service reports 24 hours a day, 7 days a week.

Radio operator requirements have not proved to be a problem because the operators can normally intersperse the dispatching function with their other activities. Inasmuch as it requires about 7 min to process each report fully, the need for at least one dispatcher is indicated at very busy headquarters during peak periods when four or more reports are expected within 1 hour. This corresponds with a peak traffic load of 80,000 vehicle-miles per hour of congested traffic.

When the Florida highway patrol assists stranded motorists as they do on I-4, additional manpower is required. Just how much depends on several factors, including assistance in locating stranded motorists through a communication system such as the FLASH system. Previous Federal Highway Administration studies (1, 3) showed that one motorist needs assistance for every 40,000 vehicle-miles traveled under the traffic conditions that exist on I-4. A peak season ADT of 14,000 yields an estimated 700,000 peak vehicle-miles of travel per day for an estimated hourly peak of 70,000. Thus, as many as 18 motorists may need help on a peak day. Because it may require 25 min for each assist, about 8 hours per day must be devoted to disabled vehicle assistance on this 50-mile segment of highway. It is therefore reasonable to assume that at least one additional state trooper per day will be required by the highway patrol just to assist the distressed motorists (not including the time spent getting to the stranded motorist). This does not mean that an additional trooper should be brought on just to handle disabled vehicles; this can be shared by all the men on duty, depending on which trooper is nearest the disabled vehicle. It does mean that the total patrol work load over a 24-hour day is increased by an additional one-man shift for this 50-mile segment of I-4.

FLASH cannot reduce the time required to service stranded motorists, but it can reduce the patrol time required to find them. In addition, the 1969 study (3), before FLASH was installed, showed a 134-min average waiting time before help arrived. Thus, the 18-min average waiting time, after FLASH was installed, shows an almost order-of-magnitude improvement.

OPERATOR PARTICIPATION

The Florida Highway Patrol in Lakeland operates the FLASH system. The monitor equipment in the radio communications room receives the incoming reports from all detector stations and processes, records, and displays the disabled vehicle status.

The Florida Highway Patrol recorded any function that they performed related to FLASH. Data from the radio operator's log were used to evaluate the operational status of the system. From October 1970 through January 1971, each alarm was examined to determine whether it was valid. Of the total number of 497 alarms, 131 were due to spurious telephone signals. This large number of spurious signals resulted in a thorough investigation into their nature and methods of resolution. A recommendation was made and accepted to replace the original communications technique with a frequency-shift-keyed (FSK) system. The FSK system, which was installed and has been operating since September 1971, has almost eliminated spurious signals of all origins, permits the Florida Highway Patrol to more easily monitor the system operation, and allows the system to operate in a more sensitive region, thereby detecting more distressed motorists more quickly.

The average number of alarms per day has been 4.4 with the initial communications technique. This compares quite favorably with the design goal of between 8 and 12 for this section of highway. These factors either equal or exceed the performance figures that have been reported for either of the more expensive telephone or call-box systems (4).

To accurately gauge the extent of the disabled vehicle problem as it exists on Florida I-4, state troopers who investigate any source of disablement within the test section filled out a Highway Patrol log. Entries on the form provided information on the time of day of disablement, day of week, vehicle location method, location, and cause of vehicle disablement. The causes of vehicle disablement, as entered on the log forms, are similar to the disabled questionnaire results and are as follows:

Cause	Percentage of Disabled Vehicles
Mechanical	42
Flat tire	22
Overheated	14
Out of gas	12
Low on oil	1
Abandoned	5
Other	4

MAINTENANCE

During the evaluation period of the FLASH system, continuous records of equipment failure causes were maintained. The major contributing factors to system outage have been lightning and telephone service problems. The effects of lightning are listed under two categories: events in which components of the roadside equipment were damaged and occasions on which fuses or circuit breakers were blown but no other damage was suffered. Measures to protect the roadside equipment from lightning damage were completed in September 1970. Present routine checkout is performed once a week by a person driving the 50-mile loop and flashing at each detector. After automatic-system checkout equipment is installed, routine checkout will automatically be performed daily. Maintenance functions will then be limited to response and, possibly, to a monthly visual system check. Because the roadside detectors are situated in the same place as roadside delineators, they are similarly subject to being knocked over by vehicles running off the shoulder and onto the grass. In the 21 months of system operation, 11 detectors have been damaged in such a manner. If the damage is no more serious than a knockdown, the detector can be placed back in operation by epoxying the two pieces together. All but 3 of the 20 original detectors installed are still in operation.

CONCLUSIONS

Evaluation of the FLASH system has demonstrated that a motorist-aid system that relies on the flashing headlights of passing vehicles to report stranded motorists is viable. Acceptance and participation by the motoring public has been both enthusiastic and significantly higher than required to maintain a viable system.

The Florida Highway Patrol, operator of the system, has responded diligently to distressed motorists' needs and has helped identify needed system improvements, such as additional lightning protection, more reliable communications, and improved detector response to varying ambient light conditions.

The Florida Department of Transportation assisted with the system design and installation and is currently working on highway sign content to improve motorists' knowledge of how to use the FLASH system. This has two aspects: Passing motorists need to know how, when, and where to flash, and distressed motorists should know how to convey their need for help, such as by using standard distress signals (e.g., raise hood and display white handkerchief or use flares). Although present response rate is adequate, increased response will further reduce response time and improve system accuracy. It is anticipated that, as the FLASH system application becomes more widespread, motorists' knowledge and participation will increase.

This program has demonstrated that FLASH can be the most economical (4) and effective system for the detection and location of stranded motorists.

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A PLAN FOR A CASUALTY CARE AND TRANSPORTATION PROGRAM

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•SINCE World War II, the public has been hesitant to acknowledge the antiquated state of services available in the United States for the immediate care and transport of the sick and injured. The recent succession of wartime experiences has repeatedly emphasized that prompt and skilled emergency care and evacuation are the primary requisites for diminishing morbidity and lowering mortality, and this very pointedly underlines the chaotic state of civilian emergency care in America. It would seem reasonable that the American in his own country should have the right to emergency care equal to that afforded the serviceman on a foreign battlefield. That the average accident victim in this country should be first treated by well-meaning, but almost completely untrained, personnel who are often incapable of rendering basic first aid seems almost inconceivable in the light of current medical expertise. Perhaps even more astounding is a comparison of the serviceman, who is placed in a vehicle specifically designed and equipped for the proper management of the injured, and the civilian, who is picked up for emergency transport by a hearse and thus rides to his fate in what may be an all too appropriately named vehicle.

To raise the standards of emergency care in the United States to those currently existing in war zones is a challenge that must be met inasmuch as accidental death on our highways far outstrips deaths from wars, pestilence, and pollution.

The major effort in improving emergency care and transportation should first be directed to the planning of the physical location of ambulance services, emergency rooms for primary care, and centers for definitive treatment. Without an overall plan, improvements in the detailed operation of each of these components will be of little avail. This has particular pertinence in rural or sparsely populated areas where a remarkable percentage of vehicular accidents occur.

The need to develop a well-organized system of ground transportation for the sick and injured is basic to any discussion of a sound emergency medical service (EMS) system. Awareness of this has evolved from the authors' research into the current status of emergency care and transport facilities and development of a model program for the state of Missouri. It is recognized that, both in rural areas remote from medical centers and in traffic-congested, densely populated metropolitan centers, air transport can be beneficial, but we will discuss only the fundamental ground system because this can readily be supplemented by aircraft and operational crews as they become available and economically feasible.

Experience has shown that every EMS area differs in economic, manpower, and ancillary support resources and that organization or reorganization must reflect these considerations. Therefore, any independent action taken to develop an EMS area should be a coordinated procedure on a regional or statewide basis so that support will be suitable and continuing. Such cooperative efforts can be highly cost-effective.

It has been documented that a population of 80,000 people is needed to underwrite an ambulance service purely from a financial point of view. In Missouri, only four metropolitan areas can completely support a profit-making emergency medical service. The

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Sponsored by Committee on Motorist Services.

remaining areas will and do require public or private subsidization or volunteer efforts or both. Approximately one-third of the counties in Missouri are without a hospital, and an additional 50 percent of the counties have hospitals with bed capacities of less than 100. In only five counties do the hospitals have all medical specialties represented.

A hospital bed capacity of more than 100 appears to be necessary to sustain a minimally staffed and equipped emergency room on a 24-hour basis; therefore, it is obvious that in 80 percent of the state of Missouri only basic care can be obtained, while comprehensive care in an emergency room can be secured in less than 5 percent of the state. It is unfortunate and often disastrous for people living in rural Missouri and for the considerable numbers of people in transit that the areas without hospital facilities and, thus, those that provide inadequate emergency medical services cover large blocks of the state. With there sometimes being more than 200 miles between emergency rooms, careful planning is imperative to ensuring that there will be adequate mechanisms for immediate care and transport of accident victims.

At present, the basic and most reliable emergency medical transport system is the highway vehicle. Uncertain weather conditions in Missouri and high operational costs would currently preclude an attempt to develop an airborne system. It is possible, however, that air transfer of patients from a primary first aid area to the final treatment center could be incorporated gradually into a well-planned and smoothly functioning regional or statewide ground system. For the present, however, the basic focus must be on the location of ambulance squads, the proper selection and training of ambulance personnel, and the development of appropriate emergency vehicles.

The initial care of an accident victim who is an hour or more away from even basic medical treatment is a greater determinant of consequent morbidity or mortality than is the definitive care that may be only minutes away in a city. In Missouri, as it is throughout the nation, the death rate is four times greater in the country than in the city, even though injuries are usually more extensive in the city.

The life of the injured patient, then, is dependent in large part on the initial care he receives. This, in turn, is dependent on the equipment and type of emergency vehicle available to transport him.

PERSONNEL

The most important elements in an ambulance service are the drivers and attendants. On the basis of a 5-day, 40-hour week, a minimum of nine persons is needed to operate each vehicle, and because of vacations and sick leave an additional person is required.

It is imperative that the turnover of employees be kept to an absolute minimum because appropriate training not only is difficult to provide on a continuing basis but also is very time-consuming. Because driver-attendants are given such grave responsibilities, very careful and well-planned selection procedures are necessary. We believe that a driver-attendant should be more than 21 years old and have no record of moving traffic violations; no police record for other than simple misdemeanors; a high school diploma; evidence of maturity, stability, and dependability as accrued from work records, financial records, church attendance, and community efforts; and good physical health.

We have found that intelligence testing and other commonly used written evaluation procedures are quite disappointing in governing the selection of ambulance personnel inasmuch as these scores tend to reflect learned material rather than innate intelligence. Assuming the previously mentioned qualifications, we feel that a personal in-depth interview is a much more satisfactory way of assessing the applicant's suitability. Because this vocation seems to attract people with various types of personality problems, the interviewer should inquire specifically why the applicant desires this type of employment. The replies, though not always factual, can certainly help in eliciting the more blatant of the undesirable traits that can so seriously affect the individual's ability to function in emergencies.

The applicant should have a thorough physical examination. Persons suffering from heart disease, hypertension, diabetes, seizures, or other conditions that might interfere with proper handling of a vehicle or a patient should be considered undesirable.

The applicant must have a chauffeur's license to operate the ambulance, but it is also desirable that he attend the National Safety Council's course in defensive driving because all too frequently the driver will need to operate the vehicle under difficult circumstances.

Salaries for drivers and attendants are the largest single item in the overall budget. Because it is futile to attempt to develop a sophisticated emergency medical service without able, well-trained attendants, the positions must be made sufficiently attractive financially to secure people who are deeply interested in and satisfied with their careers. Salaries for these positions will necessarily be higher than those usually proposed under present conditions and should be commensurate with those offered registered nurses.

Inasmuch as the financial requirements for salaries alone are considerable, only a few areas in the state can fully support an emergency service system operated by career driver-attendants. Under these circumstances and, of course, dependent on the level of services required and on available financing, various combinations of personnel may be the only appropriate solution.

In areas of low population density, there may not be sufficient moneys available to support salaried personnel even on a tax-supported basis. Here the service may need to depend almost exclusively on volunteers. Because of business and other everyday commitments of volunteers, a minimum of 30 people should be trained for such an operation. Duty schedules must be arranged well in advance with backup personnel available, and these schedules should be rigidly adhered to. If properly planned, this approach can be publicized and can actually become a valued and rewarding civic duty that carries considerable prestige for the participants. Whenever possible, the service should include one salaried full- or part-time member who would arrange schedules, order supplies, secure vehicle maintenance, and perform other continuing duties of an administrative nature.

In some communities, the county hospital can consider the inclusion of an ambulance service as part of its operation; it is possible to lower costs materially by assigning ambulance personnel to other duties in various areas of the hospital between ambulance calls. Appropriate duties would be in emergency rooms, intensive care units, recovery rooms, and inhalation therapy and delivery units. The training and expertise of these individuals would make their services invaluable in these areas. It is an important requisite that such duties not interfere with the primary function of these individuals or prevent their immediate departure on an ambulance call. The drivers and attendants should carry pocket pagers to permit immediate contact with them. Ancillary hospital duties can be rewarding for ambulance personnel; such duties would fulfill, at least partially, the need for continuing education under supervision.

It is clear that the proportion of salaried and volunteer personnel will vary considerably depending on local requirements and financing, but it is vital that a similar quality of training be given to all.

Combining emergency medical service planning with the operations of other emergency services has been successful in some areas. In our opinion, a combination with the police is undesirable because, following an accident, the duties of policemen in traffic diversion and participation in the mechanics of wrecker operations do not give them the needed freedom to join the immediate management and transport of the injured. Combined operations with fire departments appear to be more reasonable because there are fewer coincidences of fires and accidents.

During the past 10 years, many programs have been proposed for training ambulance attendants. In our opinion, however, the majority have serious deficiencies. In most instances, attempts have been made to train attendants in a 3- or 4-day period because it has been almost completely erroneously assumed that these individuals had some previous knowledge of the subject. Even after exposure to the current basic and advanced first aid courses, there are few attendants who can be expected, after so brief a training program, to act promptly, rationally, and without supervision in the variety of emergent life and death situations that they are likely to encounter.

A few institutions have proposed a 2-year course leading to an associate degree in emergency nursing, and this, followed by a 1-year internship, would seem to be quite adequate for training of career personnel. In the first year, basic science courses would be offered, followed by a year of clinical science and supervised clinical practice. With such a background, the career status of the emergency medical technician would, in all probability, be ensured. A course similar to the one offered LPNs for a 12- to 18-month period might be acceptable but would really be less desirable. In any event, the basic science courses should be similar to those offered in regular nursing courses, whereas during the clinical experience emphasis should be placed on emergency situations such as accidents, intensive care problems, cardiac arrest, childbirth, and acute psychiatric syndromes. Upon graduation, the technician would be accepted as a competent worker in the emergency or critical care areas of the hospital as well as in the out-of-hospital ambulance program.

Training of this sort undoubtedly will not be generally available in the near future, and certain adjustments will need to be made to conform to present realities. To provide quality instruction at present, the physicians who see the patient initially in the emergency rooms must be recruited and proselytized to act as preceptors in a continuing in-service program for all attendants. This type of training should continue even when more formal educational facilities and opportunities become available. Refresher courses eventually should be required for renewal of the technician's license.

For the present, the minimum requirements should include basic and advanced Red Cross training or a recognized equivalent and a minimum additional program of instruction designed and administered by the state medical society. Attendants should be licensed only upon the successful completion of these courses and after passing written and oral examinations. Standards could be raised as improved training methodology is designed and made available so that adequate emergency care could become generally available.

Although some ambulance operations designate ambulance personnel as either drivers or attendants and prescribe differing pay scales, it is our opinion that, because of unavoidable errors of scheduling and illnesses, all personnel should be trained to perform in both categories. If this were not done, it is conceivable that two drivers or two attendants could find themselves on duty at the same time.

THE EMS SYSTEM

To effectively and efficiently utilize the resources available, the state should be divided into EMS regions without regard for current political boundaries. A hospital in the center city of each region would serve as the coordinating base for all emergency services in that area. It is hoped that this hospital would be staffed with all necessary specialists and would have appropriate equipment. The EMS region could include 10 to 20 counties. Within each region, smaller ambulance districts consisting of two to eight counties could be organized so that each could have at least a minimally equipped and staffed emergency or first aid station. The basic unit of ambulance service would be the local unit, which should service an area with a radius of approximately 20 miles.

In time of disaster, district and regional areas would function in the coordination of services, routing patients where facilities and other support were most available. On a routine basis, each county within a district could act as a backup organization for neighboring counties. Obviously, district operations will need to be relatively fluid so that assistance and support can go where needed without depleting any one area completely. Such elasticity is practicable only with a well-planned and coordinated communications system.

Inasmuch as tax rates and other resources vary from county to county and even within counties, the EMS system should logically be set up as a statewide operation quite similar to the state police arrangement. Under these circumstances, there would be no contra-indication to the crossing of city or county limits, which at present has a deleterious influence on the provision of care. In actuality, a national system in which state boundary areas would no longer be roadblocks could provide high-caliber emergency service. Although a national system is theoretically workable, a basic obstacle is the scarcity of local physicians and emergency rooms. Until more regional centers are developed, this drawback will have to be overcome by a well-organized communication system.

Despite the fact that an ideal EMS system may be years in the future, proper planning and state supervision can ensure that the present situation be improved with a very modest investment of time and money.

THE EMS AMBULANCE

An ambulance must be an extension of the emergency room in terms of life-saving equipment and trained personnel. The vehicle has two compartments: one for the driver and the other for patient care. In the patient compartment, sufficient space is required for two or more victims, a seat for the attendant, adequate room (both height and width) for rendering care and for medical supplies and equipment. Because accident victims may require extrication by the ambulance crew prior to initial treatment, the ambulance should contain some basic equipment for this in areas of the state where there are no rescue squads. If equipment is placed where access can be gained from the outside of the vehicle, the limited storage space within the vehicle can be increased.

In 1968, the Emergency Health Services Branch of the U.S. Public Health Service (PHS) published a list of minimal requirements for the internal dimensions of an ambulance. These were listed as height, 54 in.; width, 72 in.; and length, 110 in. It is obvious from these minimum dimensions that the vehicle loses the sleek look of the limousine. Of the vehicles currently available, the chassis-mount camper truck and the van type of truck are those most easily converted for ambulance use. The vehicle should be chosen based on whether the terrain to be used is urban or rural, so that with proper internal design for load placement the patient may have a comfortable ride. In addition, the vehicle should provide the driver the room and power (two- or four-wheel drive) that may be required by local topographic considerations (poor secondary roads or off-the-road operation). The disadvantage of such a vehicle is its length. This could be reduced if a cab-over-engine vehicle were manufactured for the class of weight chassis required. The eye height of the driver would be raised advantageously, but over-cab storage would be reduced.

Other requirements as listed by the PHS are separate driver and patient compartments, illumination adequate for medical treatment, separate temperature control of patient area, two-way radio, warning devices, and design and equipment that permit treatment of at least one patient during transportation. The ideal vehicle should reflect, in its size and equipment, the capability for life saving and a reduction of morbidity. It is envisioned that, as more sophisticated medical emergency equipment becomes available and training in its use is more extensive, the present minimum dimensions will not be adequate. Nationally, we face the problem of designing and manufacturing the variety of vehicles that will be needed for the different types of terrain encountered in this country.

THE RADIO COMMUNICATIONS SYSTEM

The radio communications system for EMS should be a reliable link of the ambulance to the emergency room, law enforcement agencies, and physicians in remote rural areas. Unfortunately, radio communication is limited to approximately a 20-mile radius from the base station, and changes in topography can severely restrict transmission and reception. The local radio system functions to direct the ambulance to the scene of the emergency, to relay calls to and from law enforcement agencies, to contact various emergency rooms in the areas regarding available facilities, and to indicate the number and time of arrivals of casualties. It can also be life saving when used to direct the treatment given by the attendant at the scene and en route to the emergency room.

Extreme care must be taken in the selection of a radio system inasmuch as overzealous salesmen may attempt to sell a product far too powerful for the needs of the area. This can result in poor local reception and even "skipping" into distant areas with a resultant block of their systems. Before any system is purchased, it is preferable that the alternatives be discussed with groups who already have installed a program. The state government also may have consultants who can serve as advisers.

One of the prime defects in present EMS systems is the lack of treatment facilities at the local level. At the present time, there are 39 counties in Missouri without a hospital, and there are 26 counties with hospitals with less than 50 beds. Realistically, an adequate emergency room in a hospital of this size cannot be expected; therefore, in at least half of the state, emergency care will not be readily available locally. It follows, therefore, that, in cases requiring more sophisticated immediate medical attention than that that the attendant can render, some provision will need to be made for stabilization of the patient's condition prior to transportation to the medical center. In these areas, physicians could be equipped with pocket radios, and the ambulance attendant could then arrange to meet the physician at his office or in the first aid center where initial treatment could be begun. As soon as the patient's condition is stabilized, he could then be transferred to the hospital for definitive care.

It is apparent that, in any EMS system, smooth functioning of the operation is to a great extent dependent on the communication system. In metropolitan areas, paid operators will be needed to operate the radio on a 24-hour basis. In rural areas, however, the dispatcher can readily be based in the local sheriff's office or at the telephone company. No matter what the size or the population of the area involved, it is imperative that the EMS operation be on a continuous 24-hour basis.

Ambulance drivers will be aided greatly in reaching the site of an emergency if they are furnished with maps with coordinates. In this manner, "an accident on Route 7" is translated to "13-C," which pinpoints the site to which the vehicle is directed.

Each EMS communication system should be equipped with four frequencies: the first for routine day-to-day operations within the system, the second for routine between-service operations, the third for contact with law enforcement agencies, and the fourth reserved for disaster operations only. This last frequency would be common to all emergency services within the area. Although such a system would initially be more expensive, subsequent savings realized from such a coordinated service would soon offset the initial investment.

ROUTINE MEDICAL TRANSPORTATION

To complement the emergency transportation service and to secure continuous utilization of its components require that the use of the ambulances for the nonemergency patient on routine trips from home to hospital or clinic and the transfer of patients between hospitals and convalescent homes be readily and profitably incorporated into the operation. In these circumstances, the patient could be of the semi-ambulatory, wheel chair, or stretcher case. In more densely populated areas, this service might require two or more special vehicles: a van type for the walking and wheel chair outpatients and an ambulance similar to that used by the local EMS for the stretcher patients. In less densely populated rural areas, backup ambulances would be needed to ensure that transportation would be available for the EMS patient when the prime vehicle is involved in other services. All of these ambulances should have a radio, medical supplies, and equipment.

Assigning routine scheduled medical transportation to area morticians permits the development of a local EMS system initially without great expense. Unfortunately, the time required for transportation of individuals for tests, treatment, or admittance at a medical center is often excessive. Experience in rural areas indicates that the round trip usually requires 2 or 3 hours, and often almost one working day is consumed because of waiting time at the center. Proper planning must incorporate arrangements to either hospitalize, treat, or discharge the patient within a given length of time; otherwise, the waiting time will increase the cost of the services.

Although many authorities wish to separate routine and emergency medical transportation completely, we feel that this is only feasible in the large metroplitan areas. The routine transportation vehicle affords vital backup in any instance when more than the usual number of emergency vehicles are needed.

Two accidents occurring simultaneously at opposite ends of the district or a single accident in which three or four persons are injured can easily overwhelm almost any emergency system. It is mandatory, therefore, that morticians be encouraged to provide standby equipment and coverage for the emergency service should they not desire to continue actively in emergency care themselves. It should be stressed that all

Table 1. General requirements for emergency medical service.

General Requirement	Items
Medical bag	Drugs and IV fluids deemed necessary for treatment of burns, blood loss, and shock
Medical equipment	Oxygen and masks, airways, sphygmomanometers, stethoscopes, splints, stretchers, back boards, surgical instruments
Medical supplies	Bandages, adhesive tape, IV fluids, surgical gloves, urinals, emesis basins
Radio communications and administration	Portable transmitter and personal portables, patient tag forms, supply forms
Power and lighting	Generator, light bulbs, cables, light and power sockets, battery chargers
Personnel equipment	Coveralls, hard hats with head lamps, work gloves, boots
Rescue equipment	Ropes, short scaling ladders, portable-power tool kit, sledges, pry bars, basket litters
Other	Water supply, electric heater, coffee pot and coffee

personnel, in routine or emergency transporation, should be as well trained as circumstances permit.

THE MOBILE EMS STATION

A medical disaster may be defined as any event resulting in injury or death to more persons than can be accommodated easily by a local emergency room. A disaster situation occurring in a small hospital would be no more than routine in a larger facility. Disasters are caused not only by hurricanes, atom bombs, and airplane crashes. Bus wrecks, fires, or even food-poisoning in a nursing home can mean disaster to a small treatment facility. In short, any event that suddenly and completely overwhelms the emergency facilities is a disaster. Certain disasters have occurred because of lack of coordination of facilities, when all patients were brought to one medical center while other centers were not used at all, even though they were closer to the accident scene. To avoid such a calamity, we propose the construction of a light trailer, designed and equipped to act as a triage station. A trailer, equipped with a power generator, rescue tools, radio communication, and medical supplies, could be pulled to the accident scene by either the ambulance or an automobile and also could serve as a base for search and rescue and coordination of patient flow into surrounding medical centers, as well as a triage operation.

The crew, including volunteers, would be responsible for the power, equipment set-up, search and rescue, communication, clerical, transportation, and supply operations. Due to the variety of specialties needed and the high probability that at any one time some members of the team might not be available, three times the needed complement should be trained. It would be advisable to have hospital personnel not connected with the emergency room to be trained for this operation, since they would be more readily available. All ages and sexes could be employed, and, if needed, a 24-hour operation could be maintained if all members responded to call on a shift basis. Dual training would reinforce manpower needs. It would be necessary in remote areas to request that distant emergency medical centers send supplies in returning ambulances or on their initial trips. The equipped trailer should be suitably housed, the generator frequently checked, and supplies rotated at specified intervals to prevent deterioration. A quarterly or semi-annual drill for training purposes would be suggested. The housing of the trailer would be the responsibility of the ambulance organization, on either a district or regional basis. The vehicle itself could be stored by either the organization or an appointed individual in a heated enclosure that would be available for immediate access by the person responsible for towing it to the accident scene. The supplies might vary, but Table 1 gives a list indicative of what might generally be required.

SUMMARY

A general plan for organizing and initiating a medical emergency service program has been outlined. For competent and economical operation, it is imperative that preliminary planning of the entire operation be carried out on a statewide basis to prevent wasteful duplication and to ensure that each area has adequate facilities available. The

selection of personnel, their training, and their salaries will be the largest single item of the service. No system can function efficiently without well-trained, career personnel.

The system is dependent on a coordinated communications system with links from the local areas to district and regional bases. Intercommunication with law enforcement and other emergency personnel is also vital.

An outline for vehicle design has been presented in addition to suggestions for an auxiliary trailer to be used in disaster conditions.

With proper overall planning for emergency care and with integration of existing facilities, we believe that any given area in this country can move smartly ahead in the rendering of adequate aid to its accident victims.

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