Response to a CB Radio Driver Aid Network

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The need for a method to provide surveillance of roadways has generated research for many agencies, including the General Motors Research Laboratories (GMR). The Detroit Department of Streets and Traffic is currently operating the GM-sponsored CB Radio Driver Aid Network. This system makes possible the reporting of traffic-related information such as accidents and traffic flow interference. On the basis of earlier demonstration efforts, the system has been expanded to cover the entire Detroit system of surface streets and freeways. The specific functional aspects of the system and a description of its major technical equipment are given.

The paper discusses the results of the earlier operations, presents data on current operational activities, findings of a questionnaire survey, and reactions and conclusions resulting from these efforts. The system is viewed as providing a feasible interim solution to the problem of roadway surveillance, incident reporting, and action implementation to provide safe and efficient traffic flow.

•THE importance of being able to survey dynamics on roadways is a significant problem that has received much attention in the last several years. Specifically, it has been deemed not only desirable but necessary to provide a means of two-way communication with road users. Clearly, communications, taken in the broadest sense, are vital not only for effective and efficient traffic flow, but also for the protection of life and property.

A variety of methods of implementation of surveillance and communications techniques have been suggested. Many of them have been implemented on an experimental basis. These have ranged from simple systems of human observers to highly complicated fixed and mobile systems with varying degrees of complexity and costs. To date, no one system has evolved that meets adequately and simultaneously the technical, economic, and functional requirements of street, highway, and freeway surveillance. The general requirements of such a system have been identified as a need to:

1. Detect situations,
2. Be able to verify the fact that a need for some form of action exists,
3. Be able to establish the criticality of a need,
4. Be able to determine the type of assistance, if any, that is required,
5. Facilitate the dispatch of appropriate aid or initiate necessary control actions, and
6. Acquire data for statistical analysis and research purposes.

The perfect system to satisfy these needs lies in the future. However, it is felt that a meaningful interim solution of the problem for roadway surveillance and two-way communication has been attained by the General Motors-sponsored Citizens Band (CB) Radio

Paper sponsored by Committee on Freeway Operations and presented at the 48th Annual Meeting.

Driver Aid Network that has been operated by the Detroit Department of Streets and Traffic since July 1966. This system meets, to a greater or lesser degree, the surveillance-communication requirements stated.

Fundamentally, the system consists of CB radio-equipped vehicles whose drivers report observed incidents to a single base station where an operator is in two-way communication with the incident reporter (CB vehicle operating on CB Channel 9). The base-station operator then transmits action needs via telephone to the appropriate authority or agency that, in turn, dispatches the type of assistance required (Fig. 1).

The fundamental needs of a surveillance-communication system are met by this project in the following ways:

1. The detector is the collection of motorists who are knowledgeable about the system and are equipped to make reports. Clearly, the detection capability of the system is a function of the number of people on the road at any given time with CB units and an interest in reporting their observations, the hours when the base station is monitoring, and the amount of radio traffic and static.

2. The verification function is initially accomplished by the observations of the person reporting, further established by possible additional two-way communication with the base operator, and the judgment of the operator in his decision to report an incident to a given authority. In some instances, the Police Department makes it own additional verification of needs, such as those for a police wrecker to tow away a stalled vehicle. It does this by its "drive-by-and-verify" procedure, in which a patrol car is dispatched to the scene and the officer then makes his own verification and calls his dispatcher.

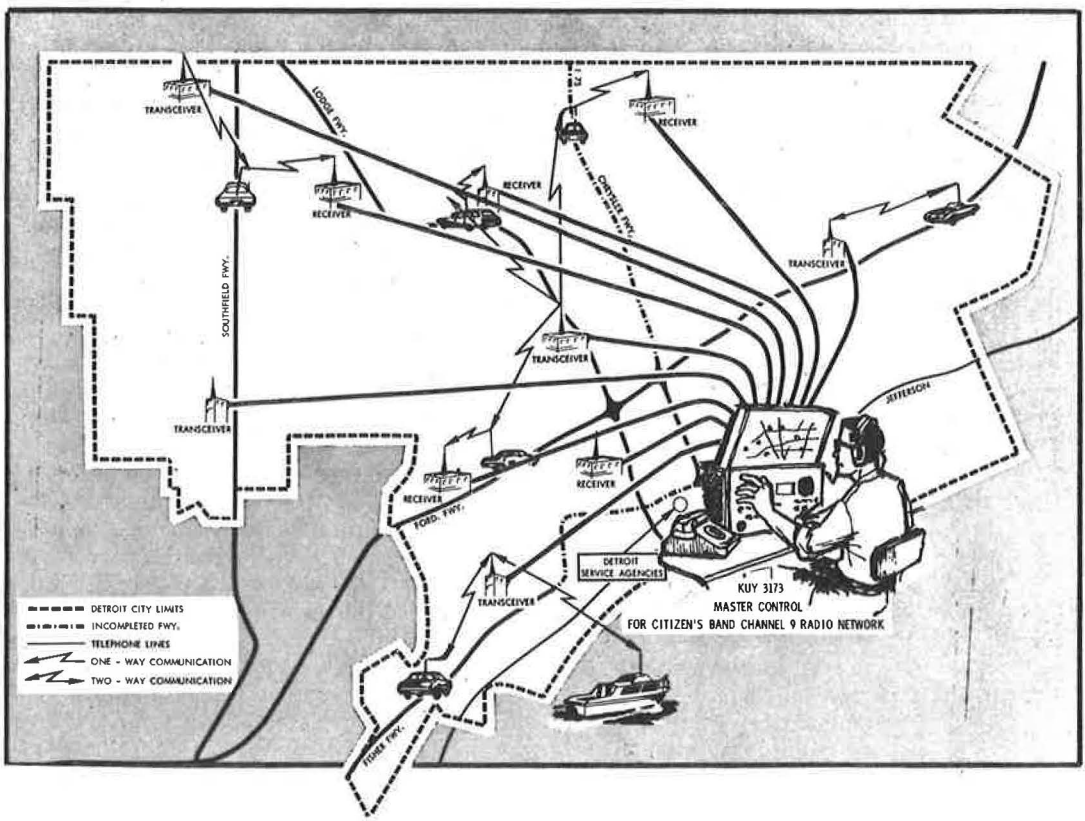


Figure 1. Basic equipment distribution in the project area.

3. Need criticality is established as an integral part of the verification function by the observer, the base-station operator in his inquiries, and, as just stated, in some instances by the responding authority.

4. What has been stated with regard to verification and criticality is applicable in meeting the need for being able to determine the type of assistance or response to be made, and by what authority, agency, or functionary it ought to be made.

5. The dispatch of aid or control action is initiated in the system when the base-station operator makes the telephone call to the appropriate authority or agency. In the case of incidents requiring police response, the base-station operator has at his disposal a direct-line police telephone that is an extension of the police telephone system. Thus, in calling for police response, it is not necessary for the call to be made through the public telephone system. For contact with agencies such as private electric power companies the public telephone system is used.

6. Feedback can be attained, in some cases, by the base-station operator or by further contact with CB mobile units. It can also be obtained by a return call to the authority or agency to whom the report was forwarded. Verification is not a base-station operator need, but a need of the responding action-implementing group, such as a fire department. It is they who must know whether or not a situation has been remedied. This they do in the normal course of their regular routine.

7. Data acquisition is accomplished in this CB radio system by log-keeping. Pertinent data are recorded on cards that are later punched and submitted to computer manipulation.

It is apparent that, while not totally foolproof nor completely satisfactory, the system does meet to a significant degree the fundamental needs of a roadway surveillance system. Some of the shortcomings, such as certain technical imperfections, can be remedied by increasing receiver and transmitter locations, by Federal Communication Commission assignment of a clear channel exclusively for this type of service, and by round-the-clock, seven-days-a-week monitoring. Perhaps the most remarkable attribute of this system is that it does so much toward solving the surveillance problem with relatively unsophisticated equipment.

EARLY DEMONSTRATION SYSTEM

The CB Radio Driver Aid Network concept had its inception as part of the GM Research Laboratories' continuing research effort for safer and more efficient highway travel. Since 1958 highway communications systems projects have been under way (1). In early 1966 the Laboratories proposed a cooperative program with the Detroit Department of Streets and Traffic, the Detroit Police Department, and the National Proving Ground for Freeway Surveillance. The program plan was agreed to and a special Federal Communications Commission (FCC) Class D Citizens Radio Service licence (and later waivers) was obtained. The Citizens Band was used for this project because FCC authorized frequencies are available that may be used with inexpensive, reliable, solid-state transceivers operating directly on power supplied from a 12-volt DC vehicle battery. Channel 9, while in some respects not the most desirable channel, was selected as the operating frequency because the majority of CB'ers are equipped to operate on this channel, and because by original intention this channel was designated as a national "calling channel" when it was established by the FCC. For these reasons Channel 9 was the most logical choice for the demonstration project. On July 26, 1966, CB radio station KUY 3173 and its mobile units began to function. Phase I of the three-phase program was under way.

The original activities were intended to provide coverage only for the John C. Lodge Freeway from Cobo Hall near the Detroit River to Eight Mile Road, a distance of about 12 miles. One transceiver was used. Although transmission was adequate under this arrangement, reception from mobile units was inadequate over approximately 50 percent of the Lodge Freeway due to high RF (radio frequency) interference and the below-ground-level structure of the roadway. Therefore, Phase II was initiated (2). Three additional remote receivers were installed at strategic locations, all feeding via telephone line to the base station. The patterns of coverage, as based on a 2½-mile reception radius, are shown in Figure 2.

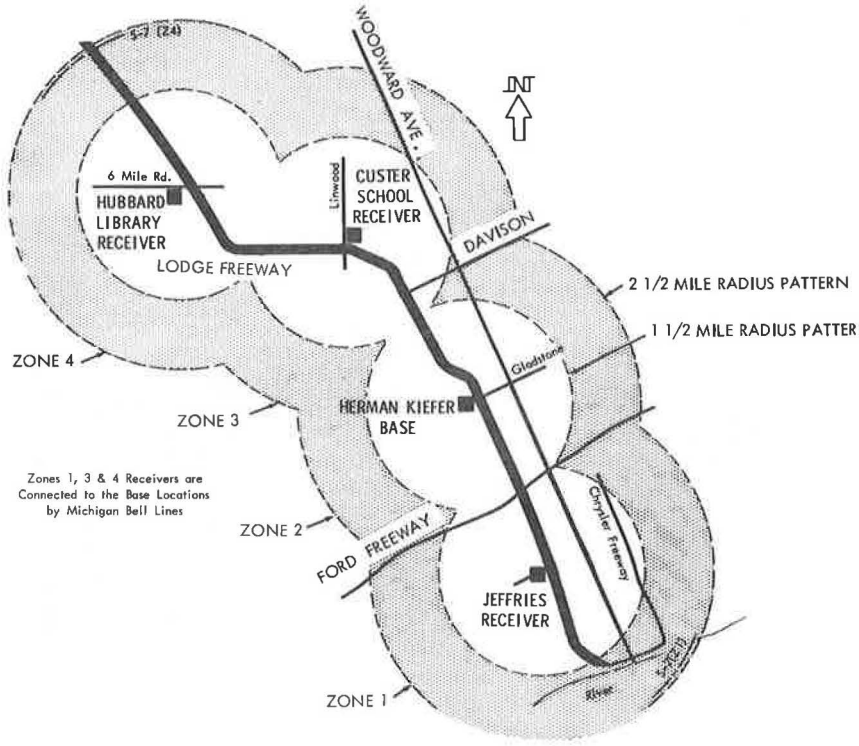


Figure 2. Equipment location and area coverage on Detroit's Lodge Freeway during Phase II operations.

The initial participants of the program, i.e., the "reporters" of incidents, were comprised of approximately 20 City of Detroit employees and about 80 employees of General Motors. Their cars were equipped by GM Research Laboratories with mobile CB transceivers (Fig. 3). Participants were selected primarily on the basis of how frequently they traveled the Lodge Freeway and their willingness to participate in the program. The base station was manned from 6:00 a.m. until 8:00 p.m. 5 days a week.

By coincidence, rather than design or specifically organized publicity, the CB radio community in general soon concluded correctly the purpose and functions of Station KUY 3173 and its mobile units. They spontaneously became an unofficial part of the network and the demonstration program.

PHASES I AND II RESPONSE AND EFFECTIVENESS

The initiation of Phase III was dependent upon the outcome of Phases I and II. A few salient statistical facts are of interest here (3). From August 1 through December 31, 1966, the average number of calls made to the base station was 121 per month. During the same period in 1967 the base was called on the average of 206 times per month. The total number of calls received from the first full operating month of the program through December 1967 was 2,888, or an average of 169.9 calls per month. This volume was not influenced by any public announcement of the system.

It was stated previously that the general CB radio operator community availed itself of the use of the services afforded by the network. Tabulations revealed that during the first 6 months of operation 35.9 percent of the calls to the base were made by persons other than the "official" (GM and City employees) participants in the project.

During April 1968, the Transportation Research Department of the General Motors Research Laboratories sent a two-part questionnaire to the official program participants. One part of the questionnaire required that the respondents identify themselves

Figure 3. Typical CB radio (transceiver) mobile installation.

because it dealt, in part, with technical matters relating to their GM-furnished equipment. Two points gleaned from the identified portion of the questionnaire are worth noting. The 112 participants questioned were asked if they wished to withdraw from the project. Only one individual chose to withdraw! It became apparent from the responses to the questionnaires that many persons made calls—some successfully, others not—from regions well beyond that originally designated as the test area. Their inclination toward wider coverage seemed to be implied.

The second portion of the questionnaire was to be responded to anonymously in order to obtain frank opinions. Virtually everyone suggested that:

1. The monitoring hours to be increased—many wanted 24-hour coverage;
2. Weekends be included in the monitoring schedule; and
3. The geographic area covered by the system be increased.

One section of this part of the questionnaire made provisions for unstructured, voluntary comments. With few exceptions, the comments were very laudatory of the program and/or suggested other functions that the network might assume (Fig. 4).

NETWORK DESCRIPTION

The encouraging results obtained during the first two phases of the Lodge radio reporting project and the enthusiastic support of the Detroit Department of Streets and Traffic and participating drivers led to a proposal by the GM Research Laboratories that the system be expanded to monitor all of Detroit from a master control site with emphasis on the freeways.

This proposal was based on experience with the especially designed control console used for the Lodge network where 4 receivers and one transmitter are monitored and controlled via telephone lines by one operator. Experience with this network had also determined the reception and transmission ranges that could be expected on below-ground-level freeways and in areas of high radio interference. These findings were:

1. Reception range from an average 5-watt mobile on CB Channel 9 to a fixed receiving site of average antenna height of 50 feet, under the stated conditions, is approximately 3 miles.

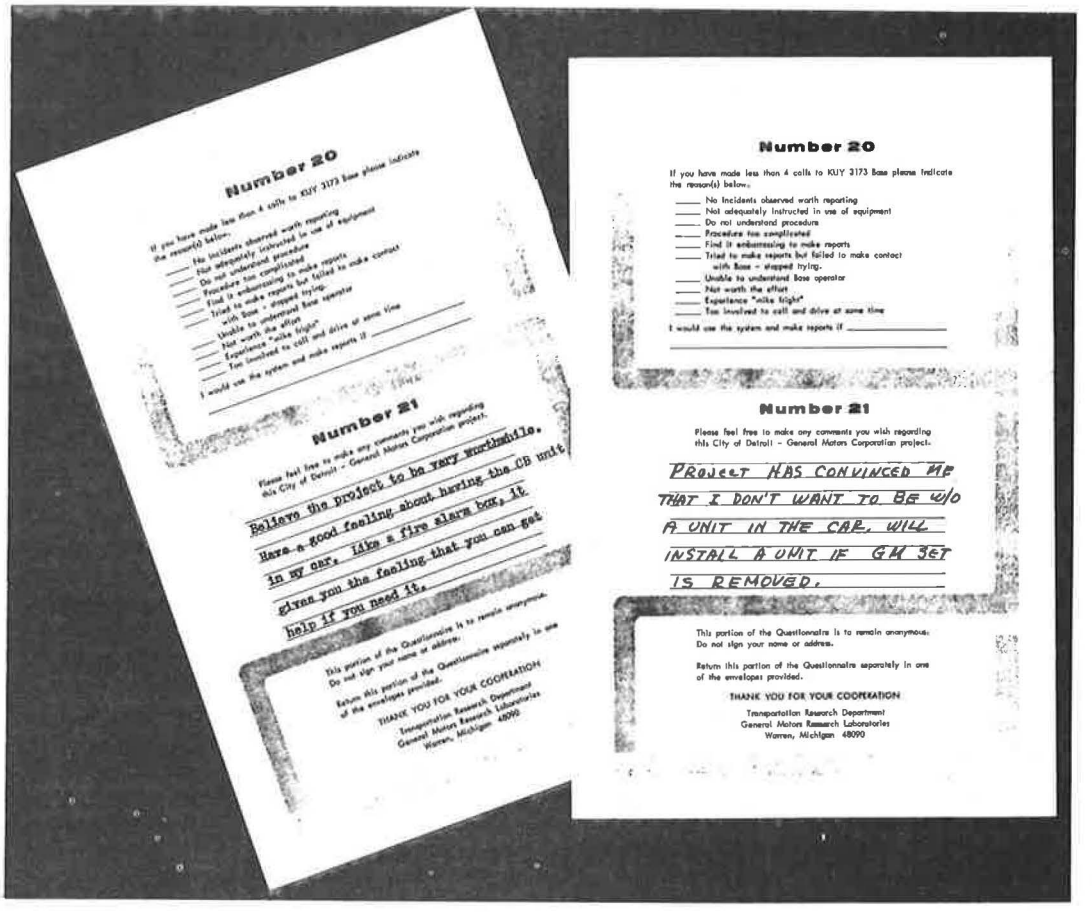


Figure 4. Samples of responses to item 21 of the General Motors questionnaire regarding user opinions of the CB radio network.

2. Transmission range from a fixed location with an average antenna height of 50 feet to a mobile station under the stated conditions is approximately 4 miles.

Based on these criteria and with emphasis on coverage of the Detroit freeways, the city-wide network was laid out on the basis of using city-owned buildings where power and telephone line facilities were available for control and audio transmission purposes. It was determined that in addition to the existing Lodge Freeway system, 6 receiving sites and 4 transmitters would be required. Reception and transmission coverages obtained under the present 10-receiver/5-transmitter arrangement and locations are shown in Figures 5 and 6.

To substantiate the projected network coverage, a radio survey was made from the new sites using city-owned buildings of the Detroit Board of Education and Detroit Fire Department located as near as possible to the proposed locations. The survey indicated that with reasonable freedom from diathermy and CB traffic interference, the projected network would provide satisfactory Detroit freeway coverage as well as covering about 90 percent of the Detroit area surface streets.

Under Part 95 of the Citizens Radio Service Regulations, wire-line control of a transmitter is permitted only if all the equipment is located on the same premises. It was at this point that the GM Communications Section negotiated with the FCC for a special waiver of the rules to permit wire-line control of 5 transmitters at different locations. Control is interlocked so that only one transmitter can be on the air at any given time.

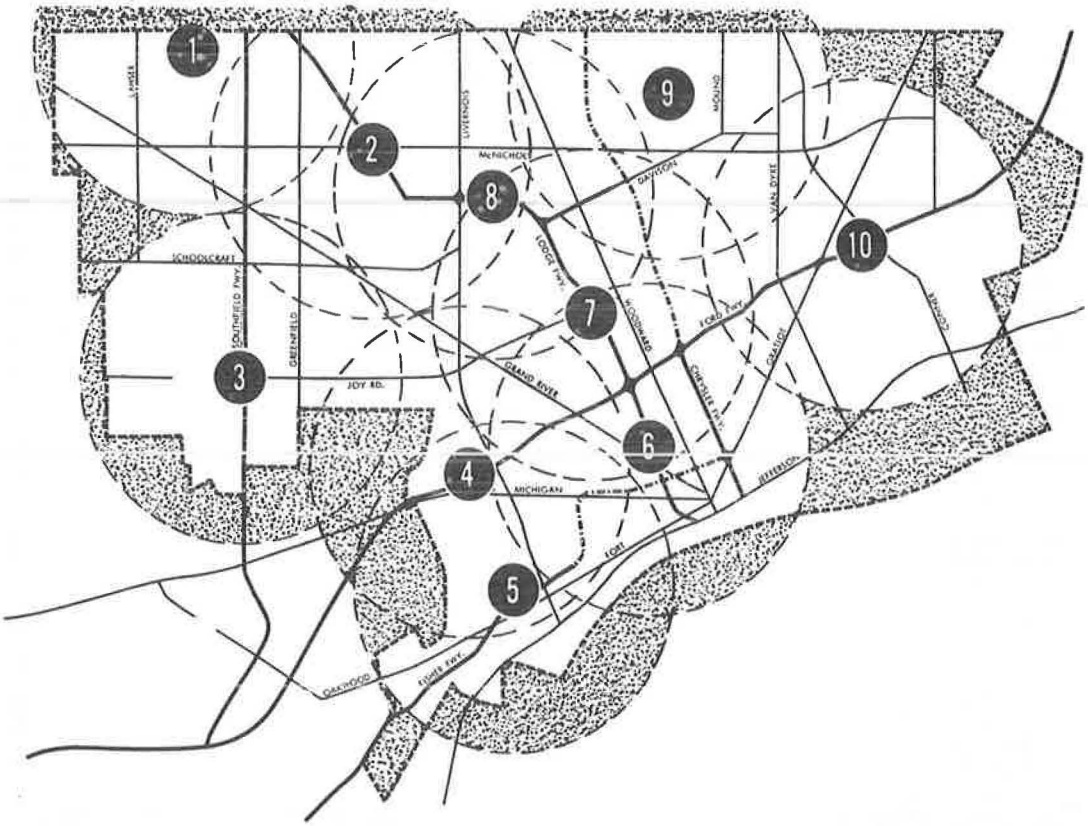


Figure 5. Location and reception zones of the 10 receivers.

With the FCC waiver and remote site approvals in hand, design of the master control console was undertaken and the reworking of commercial transceivers for use in the remote locations and installation of antennas at the sites was begun.

Even to the uninitiated, it is obvious by observing the maps in Figures 5 and 6 that to monitor the 10 receivers located throughout the city and to employ the proper transmitters to answer incoming calls require that the master control console have operator aids. Emphasis had to be placed on simplicity of controls, with the number of operator controls held to a minimum.

EQUIPMENT

Master Control Console

The master control console designed by General Motors Research Laboratories is shown in Figure 7 (4). The unique design provides the operator with aids for orienting himself in relation to the city for visually indicating which remote receiver is picking up a message and to locate the nearest transmitter to employ for answering the caller. Conventional speakers and headphones are provided for hearing the incoming messages.

The upper section of the console is comprised of an illuminated map showing the freeways and principle surface streets in the city. The 10 receiving zones are divided in half by North-South Livernois Avenue. The left group of 5 receivers is heard on the left speaker or headphone and vice versa (Fig. 7). Also shown are the transmitter coverage patterns and pilot lights for the 5 transmitters. This is similar to Figure 6. Selection of any zone receiver for answering a caller illuminates a series of green dots on the map outlining the receiving zone. By observing the map, the operator can determine the closest transmitter to employ for answering the caller.

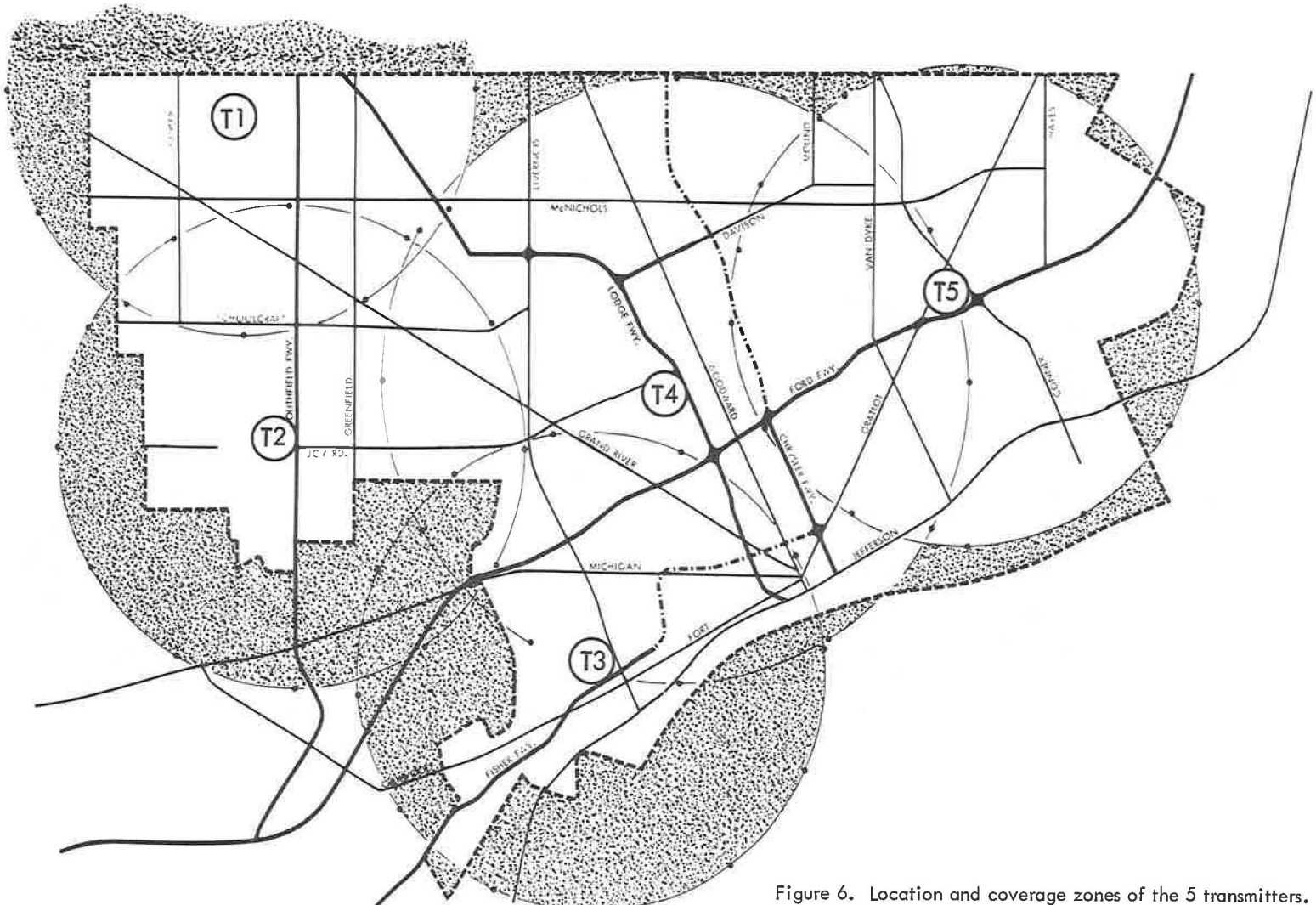


Figure 6. Location and coverage zones of the 5 transmitters.

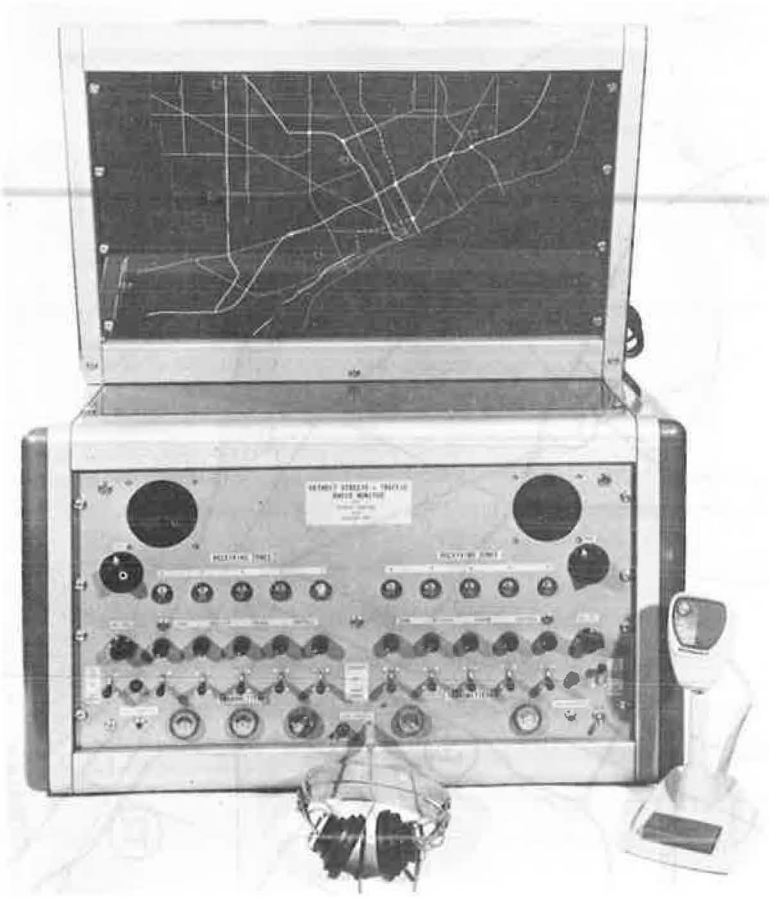


Figure 7. Base station operator's console for control of the 10 receivers and 5 transmitters.

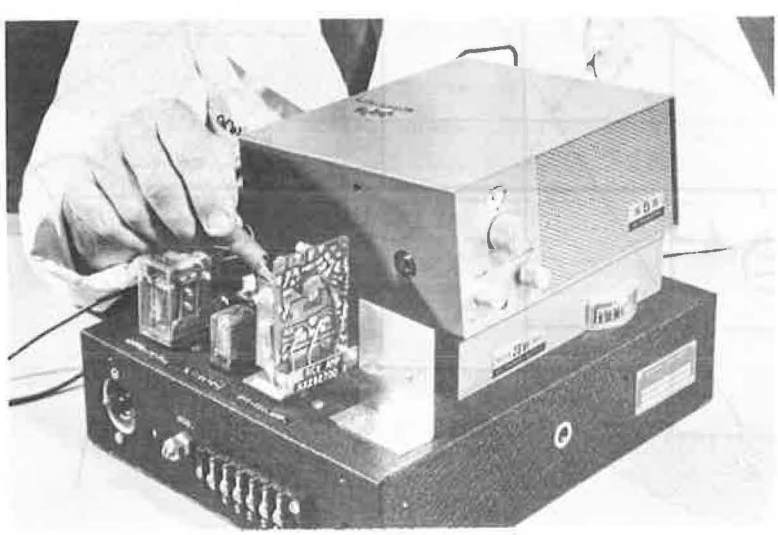


Figure 8. Remote fixed equipment transceiver assembly (cover partially removed) showing relays for wire-line control of power and mode.

The lower section of the console contains the solid-state amplifiers and power supplies. The functional controls are mounted on the front panel of this chassis. Outboard controls on each side of the panel select the mode and adjust volume and tone for each group of 5 receivers feeding individual speakers or phone units. A neon lamp at the top of each zone control group flashes when a voice signal or other modulation is received. An individual zone selector switch mutes all other zones, selects the zone mode, and illuminates the green dots outlining the zone on the map. The bottom row of 5 push-buttons is used one at a time to activate the remote transmitters. Connections for the telephone lines to the remote units are made to the rear of the chassis.

Remote Receivers and Transceivers

Commercially available transceivers were reworked and mounted in fireproof housings along with control relays and matching transformers for remote telephone line control (Fig. 8).

Interference

Monitoring a network of 10 receivers on Channel 9 is complicated not only by the continuously increasing CB radio traffic, but also by the large number of diathermy machines in the Detroit area operating at frequencies encroaching upon the citizens band. The machines are by far the worst source of interference because they not only have a strong carrier that varies in frequency to swamp nearby receivers, but also they are modulated by harmonics of the powerline frequency and remain turned on for 20- to 30-minute periods.

Figure 9. KUY 3173 base-station operator's area in the offices of the Detroit Department of Streets and Traffic.

OPERATIONAL CONSIDERATIONS

Operating experience during Phases I and II suggested that a more isolated and permanent location be provided for the base station. A separate and exclusive radio room has been provided in the Detroit Department of Streets and Traffic (Fig. 9). It is apparent that the utility of the CB Radio Driver Aid Network can be enhanced by extension of the monitoring hours and the number of days monitored. It is anticipated that, ultimately, such an expansion of operations will be implemented. As of November 1968, plans were under way to utilize the CB network as the communications backbone of a Department of Transportation project for providing emergency medical aid in roadway accidents. Monitoring hours of KUY 3173 will be extended in hours and days of coverage at least for this program.

Another conclusion based on past experience is a realization of the need for operator training. A specific training program has been initiated through the mutual efforts of General Motors Research Laboratories and the Detroit Civil Service Training Division. The course serves as a refresher for current operators, provides basic initial instruction to new employees, facilitates training "standby operators" from the Department of Streets and Traffic, serves to insure a maximum utilization of equipment potential, and provides a uniform, legal procedure for all operators.

It was also decided on the basis of Phase I and II operations to computerize the data recording (log-keeping) system. The system provides greater accuracy in data collection and facilitates data retrieval and manipulation, thus enhancing the routine use of collected information, as well as making research in depth more readily possible (5).

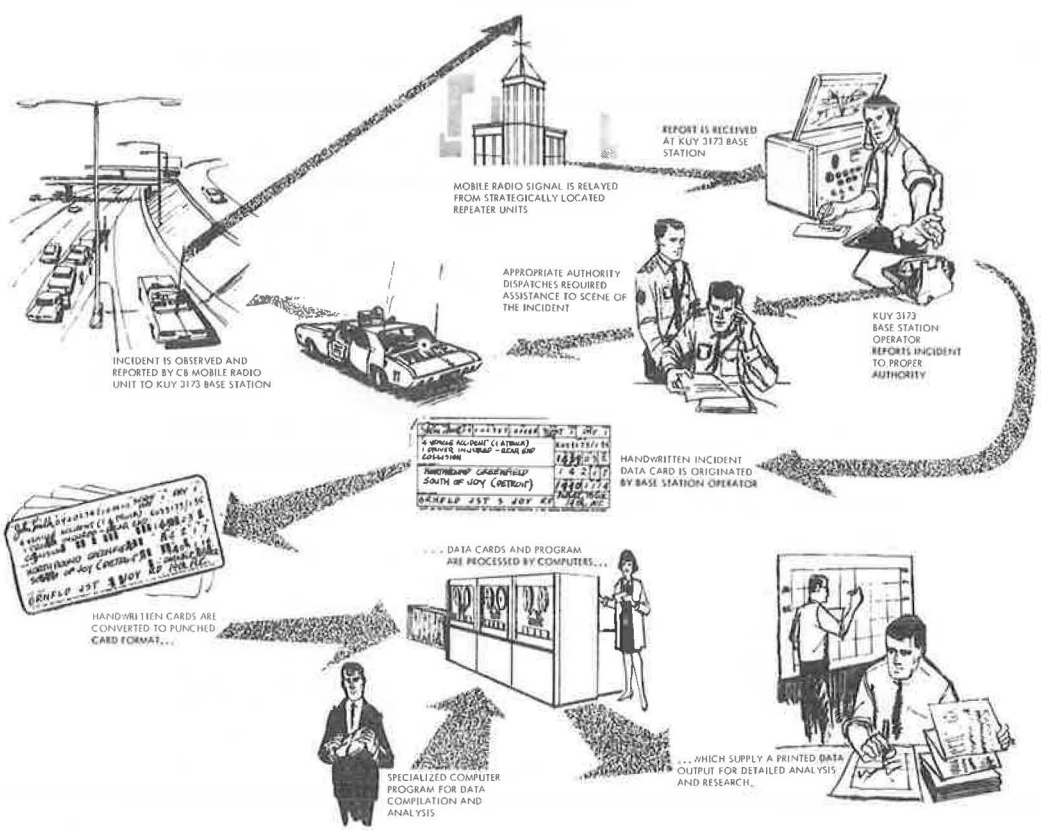


Figure 10. Functional flow pictorial of the network.

DETAIL OF CURRENT SYSTEM FUNCTION

The overall procedures and processes (Fig. 10) of the expanded, city-wide operation begin with the observation by a CB-equipped motorist of an incident that he believes merits reporting because of its influence on traffic flow or the safety of persons and/or property. The motorist calls KUY 3173. The call is received by the nearest receiver and is relayed via telephone line to the operator at the base station. Essentially, 5 basic incidents are of importance:

1. Accidents,
2. Vehicle-caused traffic flow interferences,
3. Non-vehicle-caused traffic flow interferences,
4. Hazardous roadway conditions, and
5. Public equipment or utilities failures.

Once the input information is received by the base operator, he makes a preliminary judgment about whether or not a city authority or particular department should be advised of the incident. A fundamental CB project-authority liaison exists with the Detroit Police Department, Fire Department, various maintenance departments, and public utilities companies, and all of these in Detroit's surrounding communities.

All the transactions and exchanges with the KUY 3173 base station are recorded on cards and, occasionally, on audio tape (Fig. 11). Included in the classes of information retained are:

1. Incident serial number,
2. Date,
3. Operator identification,
4. Weather and roadway conditions,
5. Type of roadway involved,
6. Incident location,
7. Nature of the incident,
8. Actions taken by the base operator, and
9. Technical and equipment-related information.

Some of the data are prerecorded while some information is added after the communications have terminated.

A great potential exists for statistical analysis and comparison. At given time periods, the handwritten cards are keypunched for computer use. A basic program exists that decodes the various entries and provides a computer-originated printed output. Many variations of the program are possible. Many combinations and varieties of data analysis may be undertaken for traffic engineering purposes, special events analysis, and research purposes.

OPERATING EXPERIENCE

Earlier, reference was made to the increasing number of calls made to the KUY 3173 base station. Figure 12 illustrates the growth. As network coverage expanded, more and more of the public CB community came to use the facilities of KUY 3173, and, we believe, to depend on it for reporting emergency traffic incidents and conditions. An unusual "high" occurred in June 1967, when there were several severe rainstorms in the Detroit area. In July 1967, the base station was inoperative for several days as a consequence of a local civil disturbance. Figure 12 reflects these facts.

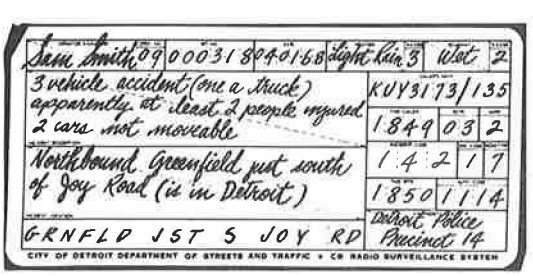
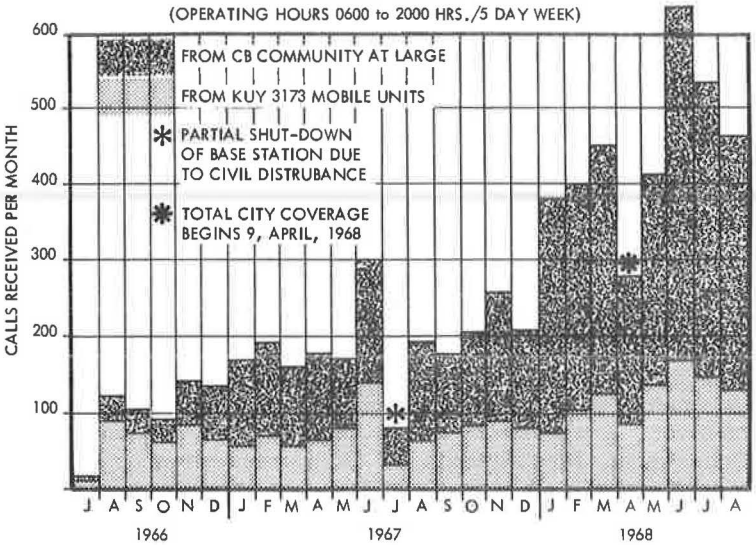


Figure 11. Computer card log record of KUY 3173 base station communication exchange.

As the demonstration program moved from Phase I to Phase II—from a single transceiver to 4 receivers and one trans-



Data obtained from Department of Streets and Traffic, City of Detroit

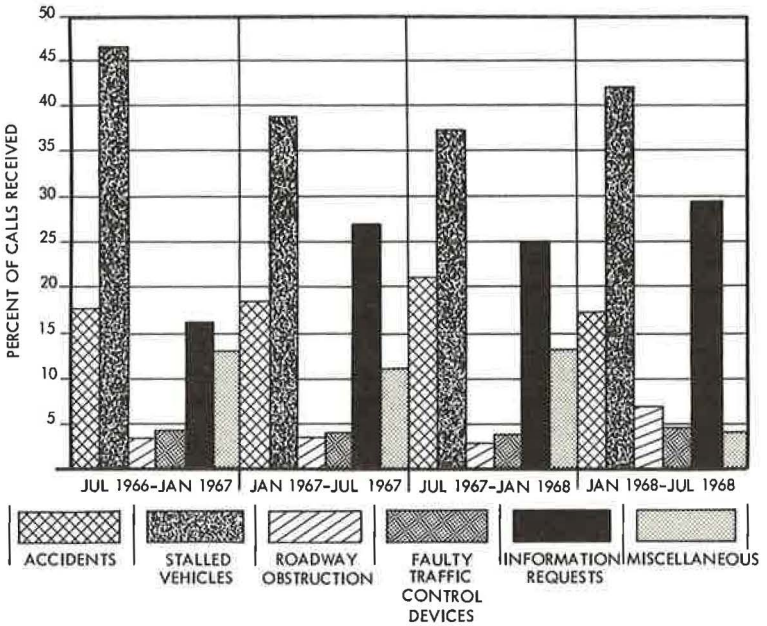
Figure 12. Total monthly calls received by KUY 3173 base station for period from June 1966 through August 1968.

mitter—the average number of calls per month increased from 142 to 255. Phase I ended April 2, 1967. Phase II ended April 8, 1968. Phase III—10 receivers and 5 transmitters providing city-wide coverage—went into operation April 9, 1968.

The bars in Figure 12 are a composite of two sources of calls: those from KUY 3173 mobile units, and those from non-KUY 3173 (other) CB operators. Throughout all phases of the demonstration program, the number of KUY 3173 mobile units has remained fairly stable and the traffic corridors and times of day traveled by these units has remained essentially the same. As would be expected, the number of calls from these units each month has remained fairly constant. By contrast, as other CB'ers became aware of the KUY 3173 operation and functional purpose, the percentage of calls from the general CB community changed from about 35 percent during initial operations to about 65 percent during Phase II. Presently, this source of calls is about 75 percent of all calls received.

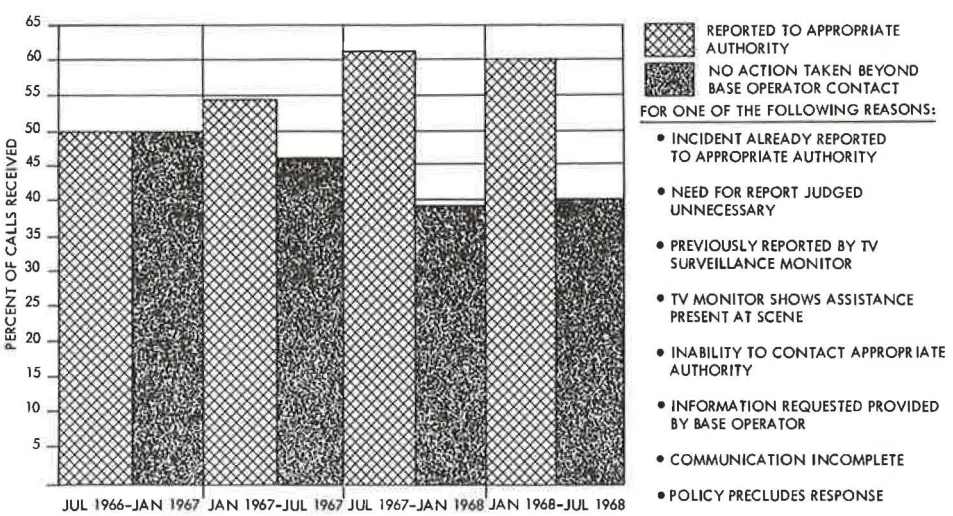
Although the present network covers the entire city, most of the calls received still involve incidents on the freeways. Figure 13 shows that most of the calls made to the KUY 3173 base involve stalled vehicles. On a freeway where traffic density is much greater than on surface streets, and where any interruption of traffic flow creates greater problems than on surface streets, stalled vehicles are a very serious and aggravating problem. Accident reports vary between about 15 percent and 20 percent of the total calls logged. Requests for information are primarily related to traffic conditions on the freeways. The incidents of such requests vary considerably in a given month, depending primarily on the severity of weather conditions during the period.

Not all of the calls received at the KUY 3173 base station are reported to some action-implementing authority (Fig. 14). The high incidence of requests for information has been cited. These do not require authority action, but are merely a relay of information already in the possession of the base-station operator. Obviously, a given incident, e.g., freeway accident, may be reported by several observers. Such redundant reports are not forwarded. In some cases the base-station operator must make a judgment regarding further transmittal to an authority and will, on occasion, decide that no authority action is required. He is equipped to make these judgments on the basis of the operator training program and his immediate experience.



Data obtained from Department of Streets and Traffic, City of Detroit

Figure 13. Distribution by type of incident of calls received by KUY 3173 base station for period from July 1966 through July 1968.



Data obtained from Department of Streets & Traffic, City of Detroit

Figure 14. Operator disposition of calls received by KUY 3173 base station for period from July 1966 through July 1968.

FOLLOW-UP STUDY PLANS

The present record system of the KUY 3173 operations can provide action data through the point of the reporting of an incident to a given authority for action. (The authority or agency to whom the report is made is recorded.) However, the record system does not indicate the nature of the action taken by an authority. Presently, it is not possible to obtain accurate follow-up information. However, it is intended that, to a certain extent, follow-up information will be available through the coordination between the Driver Aid Network functions and another Detroit project.

In July 1968, Detroit received a Department of Transportation grant to develop and evaluate an emergency response system for the care and transport of the injured in traffic accidents. An important part of this study is the evaluation of the various accident reporting systems. One of the major systems to be evaluated will be the CB Radio Driver Aid Network (KUY 3173). The investigators propose to develop models of various systems, structuring each component of the communications from the detection of the accident through the actions of the related authority. To obtain the necessary evaluative information, the investigators will study the records of the various dispatching and responding agencies to relate their actions to incidents reported to them by the KUY 3173 base-station operator.

To insure that the maximum benefits are being derived from this CB radio reporting system, the emergency medical project will evaluate the significance of various operating schedules, including hours and days of coverage not presently provided. Based on the results of this experience, schedules can be developed that should provide for the most efficient use of manpower and equipment.

In summary, incidents occur, they are reported by mobile CB radio to the base station where the information is screened, and, if necessary, the related authority or department is informed. The latter then makes the appropriate response. All the transactions and associated technical information are recorded on cards. These are keypunched at a later time and processed as desired through a card sorter or computer, thus making printed data on activities available.

CONCLUSIONS

The results obtained with this radio reporting program indicate a desire on the part of the motorist to have two-way communication with an authorized base station where he can report traffic problems and malfunctions as well as request aid from police or other services.

It is felt that this experimental program has shown a need for clear highway communications channels that are out of the band covered by general CB radio usage and diathermy interference and are restricted for uses such as those illustrated by the General Motors-City of Detroit CB Radio Driver Aid Network.

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Discussion

RICHARD A. PERRY, Systems Engineer, Texas Instruments Inc.—It is becoming increasingly evident that some form of two-way communication with road-user vehicles is essential to public safety and to the expeditious movement of traffic. The work described in this paper is significant in that it provides some of the first quantitative data about an operational system.

Two items brought out by the project are of special significance. First, the system was configured of relatively low-cost, unsophisticated equipment. This is of prime importance in gaining public acceptance of such a system. Even the base-station costs and expenses should not significantly affect the local tax rates. Second, the spontaneous participation of other radio operators points up the unfulfilled need for such a communication capability.

The second principal point of the report is well taken: a separate clear channel is needed for this particular service. The future will also require other additional channels for local road and traffic condition broadcasts and for general service location inquiries such as the location of motels and service stations.

It might be suggested that while vehicle location and route guidance systems could better operate through buried loops or other vehicle detectors, the present emergency vehicle dispatching could well continue to operate on the public safety radio channels. The result would be the three major communication functions: (a) emergency vehicle dispatch, (b) private vehicle communication, and (c) vehicle location and guidance, performed on a non-interfering basis by proper selection of new radio channels and utilization of the existing systems. This work adds significantly to the background of knowledge necessary to allow synthesis of a practical vehicle communication system.

CLARK E. QUINN, Closure—Although the Detroit CB Radio Driver Aid Network is accomplishing its intended purpose, i.e., communication with the driver (in January 1969, KUY 3173 handled 1,197 calls), the authors wish to add a word of caution regarding the establishment of a permanent system for public use where no secrecy of communication exists to protect the person in trouble on the highway.

It may be of interest to know that channels for two-way communication and audio signing have been under investigation by the G. M. Research Laboratories for over 10 years. Our early audio signing research indicated a need for at least two one-way channels to cover local and regional conditions with two extra channels for two-way radio traffic and miscellaneous information resulting in a total of 4 channels. As pointed out by Mr. Perry, these highway department services are now entirely feasible using low-cost HF equipment. Original requests for frequency allocations for highway communication were made by General Motors and the Automobile Manufacturers Association and to our knowledge are still awaiting action by the FCC. Frequencies have been allocated in the UHF band, but low-cost equipment with adequate range is unavailable for their implementation.

The authors feel that communication with the vehicle operator will follow the pattern of a simple two-way voice system at first, followed by audio signing, updating of the two-way system by some means of coding the requests or reports, and last by a driver aid routing system similar to the goal of the GMR DAIR System.