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The Role of Communications in Response Systems

Chairman: John Cubberley, Director of Telecommunications, Home Office

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SYMPOSIUM ON POLICE TECHNOLOGY

Session 3   22nd November 1977

THE ROLE OF COMMUNICATIONS IN RESPONSE SYSTEMS

CHAIRMAN: JOHN CUBBERLEY, DIRECTOR OF TELECOMMUNICATIONS, HOME OFFICE

Paper No.1 POLICE COMMUNICATION REQUIREMENT - D.A. EAST, 65496
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Paper No.2 CURRENT PHILOSOPHY - J.N. HALLETT,
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SYMPOSIUM ON POLICE TECHNOLOGY

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Paper No.1

POLICE COMMUNICATION REQUIREMENT

D.A. East

The development of Police radio systems in Great Britain started in 1923, and by 1934 a philosophy had evolved whereby the wireless resources, now using two-way v.h.f. vehicle radio, were controlled from one central control room or information room. This system of centralized control merged well with the 999 emergency telephone system, and centralized Police information rooms were established throughout the country to receive 999 calls from the public and to despatch vehicles by means of v.h.f. radio to provide a prompt response.

After the war years the traditional method of policemen patrolling the streets was slowly but inevitably being superseded by quick response Police resources directed from Force Headquarters.

It was felt in many quarters representing both Police and public that the traditional Police patrolling presence should be re-established and revitalized. In addition, many Forces were suffering from serious manpower deficiencies and a means was required to maximize the use of the resources available. It was not surprising, therefore, when the Home Office Working Party on Police Manpower and Efficiency produced its report in 1967, that it recommended that the flexibility of the traditional foot patrol be increased by the greater use of vehicles and radios. This recommendation led, for practical purposes, to the introduction of the Unit Beat Policing Scheme which came to be adopted by all Forces, the hallmark of which is now the familiar Panda car in the distinctive blue and white livery.

The Panda car thus extended the role of traditional patrolling policemen and with the introduction at the same time of a pocket-sized personal u.h.f. radio, instant communication was provided between patrols and the local station. The controller in his local station, therefore, was able to despatch his local resources to incidents independent of Force Control.

This, of course, meant that Police Forces then had two tiers of communication, as indeed they do to this day. The first tier is the v.h.f. system based

on the ..

on the Central Information or Control Room transmitting to, for the most part, incident cars, traffic cars, dog vans and CID vehicles. The majority of Police resources forming the ground cover for an area, however, had personal radios on the u.h.f. system, and these could only communicate with the local station. This two-tier system of communication led to severe difficulties centrally when deciding where patrols were located and whether or not they were available to respond to calls for assistance.

If an emergency call was received in a centralized 999 system, the only information possessed centrally concerned those v.h.f. mobiles under Central control, and therefore there was no means of knowing which local patrols with personal radio were able to respond to the incident. To pass a message to u.h.f. resources required a telephone or radio call and then repetition of the message over the u.h.f. network.

In police operations the v.h.f. vehicle could not talk to the u.h.f. Panda and vice versa. With the public telephone network increasing year by year, and 999 calls in excess of a million annually, the v.h.f. mobiles controlled by the Central Information Room could not cope without the assistance of local u.h.f. stations and the Panda cars that they control.

The u.h.f. scheme was ideal for the Panda and foot patrol operated from local centres, and the v.h.f. scheme was equally suitable for centrally co-ordinated and deployed resources. What then was needed was some acceptable, effective, interface equipment which could enable u.h.f. and v.h.f. to be operated by one control. This was a major problem which the Police Service with the help of the Home Office presented to industry and which has been to a large extent solved.

Another associated problem of the centralized 999 system was the need for effective data transmission between the Force Headquarters and its territorial stations. In larger Forces there was a need to broadcast simultaneously messages over the teleprinter networks. If one station was engaged transmitting teleprinter traffic to another, this caused queueing problems and an increase in operator time. A fully integrated, automatic message switching system with the capability of storing messages and forwarding when receivers were free, was needed to overcome these and other operational problems.

SECURITY

The transmission of a large amount of information via v.h.f. radio sets and the adoption of v.h.f. wavebands for BBC radio broadcasting gave the public access through their normal domestic radio sets to some Police v.h.f. channels. In addition, it is fairly easy for a professional criminal to obtain a v.h.f. receiver and by this means to acquaint himself with Police movements. Thus a serious defect in the confidential aspect of Police radio transmissions came to light. This problem had not been apparent whilst the confidentiality of radio transmissions was protected when the BBC operated only on medium, long and short wave frequencies. Many forces adopted the United States ten code procedure, but although much of the radio message was in a very simple code, the main element of the message, namely the location, was still easily identifiable. This problem in recent years has been heightened with the advent of Police computer records. Security procedures are well established when the computer is interrogated from a terminal, but once this information is passed to the man on the ground, for whom the system is designed, then anyone tuning in to the appropriate v.h.f. wavelength can receive that information deliberately or accidentally.

For many Police operational purposes some form of secure speech or data transmission direct to a vehicle was now required. Secure speech is essential for important operational and surveillance work where the possibility of criminals being in possession of v.h.f. listening equipment cannot be overruled. In other cases the need for messages to be sent to a vehicle and recorded in the absence of the patrolling officer was realized. In order to combat this particular problem the Home Office and industry are now proceeding with the MADE (MOBILE AUTOMATIC DATA EXPERIMENT) project which not only provides a secure form of transmission between the Control Room and Police vehicle, but is capable of sending a printed message to that vehicle when the Police officer is temporarily absent. On his return to the vehicle the message(s) are awaiting the officer's attention. This system has particular advantages in large rural areas where the Police officer would be expected to leave his vehicle for short periods.

Effective Police communications are now considered the major factor in modern policing and with practically all operational Police officers in possession of some form of communication, it is essential that the most effective deployment of resources is achieved. It is vital that the Police officer on the ground retains confidence in the system. He is not interested in the niceties of area coverage or technical problems. The modern Police officer has been brought up to rely on his personal radio, and therefore efficient radio communication is an essential.

CONTROL

Decisions concerning the deployment of Police resources are usually vested in a controller, often of supervisory rank. The controller needs an effective system to tell him where his resources are deployed and whether or not they are able to respond to an incident or are available for a particular assignment. In controlling a large number of Police resources over a wide area it is often impossible to know where each resource is located and its state of availability. Incoming emergency calls from the public will be identified by type and location and the controller will need to know the nearest and most suitable Police resource to send. If he has to ask by means of direct speech which vehicle is available, and then await a reply and perhaps consider competing resources, clearly a delay occurs which mitigates against Police efficiency. One effective way of achieving this requisite knowledge is by adoption of a vehicle location and availability system. Industry has devised a means whereby a coded tone generator signal transmitted by the vehicle over the v.h.f. radio can update a Control Room or Information Room of that vehicle's whereabouts in a fraction of the time and a fraction of the air space required for a manual speech update. There are two main types, a semi-automatic system requiring a manual update by the officer in the vehicle, or an automatic update system whereby the position of the vehicle is constantly transmitted to the display at the Force Control Room or Information Centre. Both systems can indicate the position of the vehicle and its state of availability. The display showing this information concerning all Police v.h.f. mobiles can be transmitted to the controller enabling him to select the most suitable Police resource to deal with an incident in the quickest and most effective way. In addition, these systems go some way to resolving the security problems posed by direct speech to which I have already referred.

Whilst speaking of the controller, both the Home Office and industry are seeking means of resolving the environmental problems with which he is faced. The controller usually remains static at his work, surrounded by his equipment and records. The more expedients adopted the greater and more bewildering becomes the array of lights, buttons, switches and so on that he has to operate.

Additional equipment tends to generate more heat. The use of loudspeakers to enable operators to hear several channels to obtain a necessary overall view,

creates more ...

creates more noise. The greater the noise the more the operators tend to shout, and this problem is not resolved by the use of head sets which can be uncomfortable when worn for long periods. The controller needs a comfortable and calm environment in order to perform his decision making function properly. Therefore, technological facilities designed to resolve many of the problems which have been raised above may in themselves create extra difficulties for the controller. Therefore, the design of new equipment needs to be considered in its entirety as it affects all those called upon to operate it.

A high standard of efficiency in communications is the life-blood of an effective modern Police Force. With the difference of function of elements in Police resources, there is a need for a comprehensive communications system within which sub-systems may operate and relate. The system must be capable of co-ordinating the sub-systems when necessary in order to maintain operational efficiency. The overall design must be flexible to ensure the utmost inter-operability throughout the organization.

SUMMARY

What, therefore, is required is an integrated operational communications system which includes radio and line facilities. The system should be built upon a coherent overall philosophy and not just a hotch-potch of expedients made to work together. The system should incorporate the following features.

a) <u>COVERAGE</u>: The system should be able to reach out to all the areas required. This often presents major problems where the geography of an area is not conducive to a radio network. Whilst there may be an abundance of technical reasons for 'black-spots', from the man on the ground's point of view the fact that he cannot communicate with his Control Room is frustrating and unacceptable.

b) <u>RELIABILITY</u>: Having emphasized the role played by communications within the modern Police Service, to have a system which fails to operate is not only operationally inefficient but extremely bad for morale.

A side issue here is that whatever equipment is supplied, industry must always bear in mind the need to make it 'policeman-proof' and of a sturdy design.

c) <u>SIMPLICITY</u>: The whole communications system and its equipment must be simple to understand and operate. The number of switches and buttons should be kept to a minimum and it should be possible to put information into the system and to receive the same without undue effort or technical expertise. If the information is visual it must be easily read, if aural it must be clearly heard.

The majority of Chief Police Officers in this country are unable to foresee any immediate sign of an increase in manpower. Therefore the Service is relying more and more upon advanced technology in order to make a fuller and more effective use of existing resources.

EAA - HOME OFFICE

SYMPOSIUM ON POLICE TECHNOLOGY

Session 3   22nd November 1977

Paper No.2

CURRENT PHILOSOPHY

J.N. Hallett

1 As you will know from its name, the Home Office Directorate of Telecommunications has responsibilities for the communication facilities of the police service of England and Wales: that is, for meeting the communication needs just outlined to you by David East. (It also has similar responsibilities for the fire and prison services, and for Home Defence - sometimes called Civil Defence - but it is with police service that we are particularly concerned today).

2 To carry out its function the Directorate has a complement of about 1,250 people, all of whom are civil servants - servants of the Crown, and not members of industry. The majority of them are engineers and technicians, the others are administrators and clerks.

3 It is organized into four Sections under its Director, who in turn is responsible to the Head of Technical Services. As I go along I will tell you what each Section does.

4 First in logical order is the Research & Development Section of which it happens that I am in charge. Our function is to look as far ahead as is practicable - two or three years at the least - to try to ensure that our police service then has the maximum benefit from advances in telecommunication engineering. It is quite a small section - 26 engineers and technicians - but can of course call for support from the rest of the Directorate and indeed from the police service itself. My budget is about £1m per year.

5 When I have discovered what it is that needs to be done, I generally put the actual work out to contract with industry - or, perhaps, advise industry what they themselves ought to begin designing.

6 When I consider that I have finished my part, then I pass the work on to the Current Engineering Section - to whom of course it comes as no surprise.

7 Their main function is to plan - to decide which equipment ought to be bought, when, and how much, to meet the needs of the individual forces. Their

principal enemy ...

principal enemy is the calendar: they have to make the availability dates of the equipment match the needs of the forces - perhaps match the building programme for a new force headquarters or the commissioning of some piece of computer equipment which needs telecommunication facilities over a force area.

8 We all rely heavily on the Administration Section because they are the people who have the most money. They dispose of about £9m a year towards improving and updating the telecommunication facilities of our police forces. They are responsible for letting contracts, for equipment accounting, and for fixing rentals - of which more later.

9 The largest part of the Directorate is the Field Service Section. They have about 1,000 of our 1,250 people, most of whom are spread across the country in small parties because they are responsible for the installation and maintenance work.

10 I won't go into the whole detail of their organization, but they work in a hierarchy of three areas, controlling in all 11 depots, controlling in turn about 60 outstations - many of them located at police headquarters. They run three maintenance units which look after the bulk repair of things like the police personal radios - the ones which officers carry with them on foot. They never have enough people and they never have enough time!

11 Well now, that is how the Home Office Directorate of Telecommunications is organized. Now for some of the things we do.

12 David East has mentioned some of them and I know that Ian Alexander is going to mention others, but there is still a good deal left.

13 On the mobile radio side a major difficulty is the sheer size of the areas to be covered - and as far as possible completely covered. The police force areas run up to more than 4000 square miles, sometimes of rugged country, and there is no way of covering such an extent from one transmit/receive site on the frequencies we use. We achieve the required area coverage by using several base-stations - usually mounted on hill-tops or tall buildings - with the aim of giving a signal from at least one of them to any point in the area.

14 The trouble begins when a signal from more than one base-station arrives at a point, and the two or more signals interfere with each other. We have over the years developed various modulation techniques for improving the situation, of which the latest to come into service is quasi-synchronous amplitude modulation: a.m. with the carrier frequencies from the base-stations held with a few hertz of each other. We find this a useful and not too expensive improvement on earlier a.m. techniques, but we shall not of course leave it at that - we have a double sideband diminished carrier technique also under study.

15 This may be the moment to refer - very cautiously - to the great a.m./f.m. controversy. We are sometimes accused of being a.m. fanatics and this is just not true. Some of our users prefer f.m. and we provide it - indeed all the police personal radios we provide use f.m. We are, however, inclined to believe that if we are to go to narrower and narrower frequency channels then there is more scope for improvement by a.m. than by f.m. (I will now drop that subject!)

16 On the multiple base-station arrangement, the other problem is of course that more than one base-station sometimes receives a signal from a vehicle and the best signal has to be chosen for the operator in the control room. A UK manufacturer has an equipment to do this, which we use.

17 We are also active in static communications - in control room equipment (including the system for allowing v.h.f. and u.h.f. users to interwork which

David East ...

David East mentioned) and teleprinter working. On this latter, we commissioned and have working in the South-East of the country the first teleprinter message switch to be used by the UK police. This of course does away with all that tiresome handling of punched tapes for message retransmission and speed up the whole handling of this type of traffic.

18 In all this, we function in three ways.

19 First of all, we are in the <u>rental business</u>. We buy equipment in bulk (at what our friends in industry assure us are ridiculously cheap prices) and provide it to the individual police forces complete with a maintenance service, in return for a rental charge. The forces are not obliged to take our service, but of the 43 in England and Wales 40 do take it - and of the others, one is the Metropolitan Force in London who are big enough to have their own telecommunication engineering branch. We do this amount of business not because we are perfect - we are not! - but because we are independent. We do not ourselves make anything and so when we give advice it can be impartial.

20 Similarly, we are well placed to be <u>consultants</u>. Even if a force is thinking of getting some telecommunications equipment not from us - perhaps because we happen not to handle it - they still can and do come to us for our professional opinion and we give it carefully. This includes advice, for example, on fixed telephone facilities, which in this country are by law provided only by the Post Office.

21 I hope I have not bored you too much with all this background information. We do find, however, that people from other countries sometimes find it difficult to see where we fit in. If you do now see where we fit, then you may see how we can help you - and if we can then we shall, of course, be very happy to do so.

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EEA - HOME OFFICE

SYMPOSIUM ON POLICE TECHNOLOGY

Session 3 22nd November 1977

Paper No.3

THE STATE OF TECHNOLOGY

I.B. Alexander

This Paper presents an Industrial overview of Police Telecommunication requirements and describes some recent technical advances which will help these requirements to be met.

THE RADIO NETWORK IN POLICE COMMUNICATIONS

A modern Police Force cannot operate effectively without a very efficient communication system and within that system perhaps the most vital part is the radio communication network. These networks must provide a wide range of communication facilities and it is the purpose of this section to discuss some of their present limitations, to examine how some of these are being overcome and how modern technology will improve communications in the future.

There is a formidable list of communication requirements which includes communication to and from any of the following fixed and mobile stations.

a) The centralized Police Headquarters
The Regional Police Headquarters
The Local Police Headquarters

b) The policeman in a car, on a motorcycle, in a helicopter and of course, by far the largest number, the policeman on the 'beat'.

The information transmitted and received can be in many forms including:

i) Clear speech
ii) Scrambled or encrypted speech
iii) Data on availability/status
iv) Data from central or local police records
v) Data on location

Much of this information is required to be sent and received at any hour of the day by a large number of police personnel so there must be adequate traffic capacity to meet emergency conditions if unacceptable delays are to be avoided.

Let us examine some of the limitations to the realization of an ideal system where information of any sort could be sent by and to all police personnel without restriction. (There might be some who would argue that this would not necessarily be ideal - but this section is not intended to comment on how information is used).

Main limitations are:

i) The ability of the mobile equipment to send and receive information within the service areas

ii) The capacity of the network and hence the number of usable channels to which quick access can be gained

The very simplest network is where a local station requires to communicate to its officers who may be in cars, on motorcycles and on foot. The first major constraint is one of 'coverage' to the foot patrols which have a radius of operation limited to any one fixed site due to the lower effective height of the portable antennas, body losses and the lower transmitter power available. If we add to this losses incurred when the patrolman is inside a building, then operating radius may be reduced to as little as two or three miles.

Typical equipment currently available for clear speech communication to the policeman on foot is now in widespread use with small hand portable sets, largely in the 450MHz band for urban use, but with some v.h.f. equipment for rural and special application where inter working with vehicle mobile equipment is required.

There are a number of ways in which coverage problems can be overcome to a lesser or great extent.

The basic way to increase range is to increase the effective power transmitted at both base and mobile ends. The base station presents few problems with higher power output stages and increased antenna gain and height generally possible. Power from the portable set and weight are generally problems. If not equipments are available which give close to vehicle mobile performance such as an equipment developed by a British company for the Home Office which gives 12W of f.m. or 5W of a.m. for a 2kg set.

Further reduction in weight depends on the continued development of more sensitive receivers with improvements in semiconductors or for the future use of 'Double Side Band Diminished Carrier' equipment where wasteful transmission of the carrier as well as the sideband information is saved. Research has been carried out for many years at the Universities of Swansea and Bath into this new technology and a contract is about to be placed with industry to produce trials equipment to turn experimental results into practical reality. Ultimately it is hoped to obtain from a pocket set a performance equivalent to that currently obtained from a portable set.

Alternative strategies are to equip patrol radios with a low threshold signal decoding facility so that the effective radius of calling is increased and when 'bleeped' the patrolman holds the portable unit at head height so that his

talk back ...

talk back efficiency is improved. This implies the need for a higher main station power which further restricts the simultaneous use of the channel in neighbouring areas.

Another solution is to use a number of lower power stations at several points throughout the area and whilst this is effective it is more costly in equipment and more wasteful in channel space.

A further restriction in communicating to the patrolman is that he cannot conveniently record data such as can be achieved in a car. He will, however, increasingly in the future transmit data concerning his status, availability and position but unlike the car operator he must still manually input data on his position. At present, certain police forces use separate frequency bands for vehicle and personal communication and this sometimes poses further problems when communication is required between patrolman and vehicle. This is overcome by using vehicle repeaters which can also provide a longer range portable-to-portable 'talk thru' facility. It is likely to be more efficient if a national Police network operated all its services in the same frequency segment (perhaps within the v.h.f. band) and of course with the same modulation system which could have quick access to any of the channels in that band. With the increasing use of microcircuit technology this is becoming a very real possibility and combined with improvements in portable radio efficiency will result in major improvements in communication.

This technique, designated channel demand assignment, is used in certain satellites to ensure maximum utilization of channels, where a calling channel is used initially with messages of established priority. A channel is assigned and using frequency agile synthesized sets this channel is taken over for the period required.

For the motor cycle patrol there is not the same restriction on communication range until the patrolman has to leave his motorcycle to deal with an incident. In such circumstances he may either take the radio with him, if it is in a lightweight transportable form, or use a small handportable with the motor cycle radio operating as 'talk thru' repeater. The control station can interrogate the motorcycle radio and automatically obtain data concerning his status, availability and probably, in the future, his position.

Communication with Police vehicles is the most efficient from a coverage point of view when using an efficient antenna system, with room to install equipment for the recording of a large amount of data and for transmitting information on location, status and availability. As a result of the generally good communication path between the control room and vehicle, use can be made of high-speed data rates which will allow a large fleet of vehicle to be interrogated in a very short period of time.

A 'wide area' or regional communications network has additional problems posed by geography and topography. Amongst the most effective solutions in recent years is the use of quasi-synchronous or 'common frequency' transmissions. By use of modern high-stability oscillators transmitter frequencies can be held to within a few Hz of a common frequency and avoid destructive beating of signals in overlap areas. A number of such systems have been implemented and their operation is proving to be very effective for use on the wide area coverage systems needed by Police networks. In particular such systems allow the widest possible coverage on the fewest number of channels and with the least distortion in the overlap areas.

Let us now look in more detail at some of the new techniques available which help to increase the efficiency of police forces. A measure of the technology offered stems from the defence industry which is appropriate in a war against crime.

SYSTEM FOR SECURE MOBILE RADIO TELEPHONY

Speech Scrambling

Speech scramblers have been with us nearly as long as the telephone; they are a direct extension of the codes and cyphers that man has used to protect his messages ever since the dawn of war, trade and diplomacy. A scrambler, like a code or cypher, improves communication since, hopefully, it ensures that a group of people can communicate freely, confident that even if someone is eavesdropping he will not understand what is said. Scramblers are really needed for those situations where the speed and efficiency of telephone or two-way radio cannot be sacrificed to secrecy, so that written codes and cyphers are of little use.

Over the centuries cryptography has developed from simple substitution cyphers to the more sophisticated systems such as the one-time pad, which can, for a limited period, provide almost complete security. Continuous development has been needed to stay one step ahead of the cryptanalysts, who have always shown a remarkable flair for finding subtle and oblique ways of breaking a code. Analogue speech scramblers are far less secure than the best codes, and are of limited use to strategic military or Foreign Office users. However, the latest developments in scrambling techniques can provide adequate security to satisfy many police needs and perhaps tactical military needs as well. It is now possible to provide real privacy against an inquisitive, eavesdropping public, and against the transistor-radio-equipped petty thief or rioter who can listen to the police radio messages which are placed so conveniently in the broadcast f.m. band. The considerable investment in analogue telephone and radio equipment is an added incentive to use an analogue scrambler.

To be compatible with existing radios the scrambled speech must retain many of the properties of normal speech; it must have a similar bandwidth, tolerance to noise, distortion, fading and so on. It must be possible to descramble the signal and obtain speech of the same quality, or nearly the same quality, as the channel would normally give.

Time Division Scrambling

An effective but simple system of speech encryption is time division scrambling which keeps speech secure by dividing it into short periods, typically between 40ms and 80ms. These short periods, called elements, are of about the same duration as the syllables in speech.

During the scrambling process the elements are arranged in a new sequence, each element being shifted by a few places relative to its neighbours. If the shifts given to the elements are sufficient then the scrambled speech is unintelligible. The descrambler divides the scrambled speech into elements and rearranges them into their original relative positions, restoring the speech to an intelligible form.

If the element shifts are small in comparison to the duration of speech phrases, the flow and rhythm of the speech is not obscured; if the plain text is available, the scrambled speech can be followed against it, although tests have shown that without a text it proves virtually impossible to decipher by casual listening.

With the aid of modern semiconductor technology the degree of security offered by the time division scrambling technique has been enhanced by the use of constantly changing pseudo-random rearrangement of the speech elements, as described in the next paragraph.

Pseudo-random-code scrambling

This technique of scrambling depends on the use of a synchronized pseudo-random number generator at each end of a telephone circuit. As with time division scrambling the speech is chopped up into short periods of around 60 milliseconds duration, which are then stored and transmitted in a different sequence to that in which they were spoken. In time division scrambling this sequence, which is of short length and therefore frequently repeated, remains constant during any telephone conversation. By using synchronized pseudo-random number generators at each end of a telephone channel the order of the transmitted sequence can be varied in a virtually non-repeating pattern. As the means of descrambling depends on a knowledge of the transmission sequence of the time period packets into which the speech has been broken up, the use of a continuously changing delay pattern makes interception virtually impossible without a complete knowledge of the pseudo-random sequence generator.

Variability

Where further increases in security are needed, as for example when an eavesdropper may be in a position to obtain or duplicate the descrambling or decrypting equipment, this can be achieved by introducing variability in the form of adjustable code settings. When introducing variability into an encrypting system three design rules should be applied:

(a) There must be so many code settings that the interceptor in possession of a captured machine must be presented with an impossibly large task to find the correct code setting by experiment, even when aided by a computer.

(b) The encryption process must be such that a marginally incorrect code setting produces absolutely no decrypted intelligence.

(c) As a corollary of (b), the interceptor must not be able to discover the correct code setting by successive approximation.

Fully Digital Encryption

The requirements for high security and variability can be most conveniently met by using fully digital encryption. The message to be transmitted is first converted into digital data, resulting in a continuous stream of binary 'bits' at a rate dependent upon the type of message to be transmitted. Typically speech is transmitted at 16,000 bits per second.

The encrypting sequence generator is arranged to produce a quasi-random continuous stream of bits at exactly the same rate. This sequence should be of immense length and complexity, and much of the skill in designing encryption machines centres around the ability of this generator to produce sequences which are totally unpredictable unless the controlling code setting is exactly known. This sequence is combined with the digitized message to form a continuous binary stream at the same rate as the digitized message, the output being binary ZERO if the two inputs are the same and binary ONE if they are different. It will be appreciated that the interceptor can gain absolutely no information from the transmission if the encryption sequence is unknown.

At the receiving station an authorized recipient, in possession of the correct code setting, is able to generate a decrypting sequence identical to the encrypting sequence. The decrypting process is identical to the encrypting process.

Vocoder Digitization of Speech

In some instances it is necessary to encrypt speech to a high degree of security although the transmission channel cannot handle a data rate sufficiently high for conventional digitization.

In this case a specialized voice digitizer is employed, known as a Vocoder. This analyses the speech message before encryption, to obtain a continuous digital description of the speaker's vocal mechanism as it produces the various sounds. For example, the analysis includes a measurement of the larynx vibration frequency and a description of the spectral output of the mouth. After encryption, transmission and decryption, this digital description of the speaker's vocal mechanism is used to control an artificial voice, thereby reproducing the original sounds at the receiving station.

Because individual spoken sounds are of comparatively long duration, a low data rate suffices for the digital description, and 2,400 bits/second is normally used. Thus it is possible, by using this sophisticated technique, to achieve the unlimited security of fully digital encryption over many radio and line links which could not otherwise be used for digital voice communication.

CHANNEL DEMAND ASSIGNMENT TECHNIQUES FOR MOBILE RADIO

Large scale mobile radio telephone users such as urban police forces need and use a multiplicity of v.h.f. channels to provide an adequate service through their operating area. With the passage of time the traffic carried becomes so great that under peak demand conditions operators experience delay in establishing calls. If no additional channels can be made available to a user he must then either accept the fact that sometimes delays will be experienced or, find ways of increasing the efficiency with which the available channels are used. One obvious method is to insist that all conversations are pruned to their bare essentials. Many Police forces have already introduced measures to this end but have still encountered overdemanding traffic situations. In such circumstances dynamic channel management may offer attractions.

Channel Management

Normally in organizing a multi-channel v.h.f. mobile radio telephone system, channels are allocated on either a service function basis i.e. one for crime cars, one for maintenance cars etc, or, on a service area basis where the total operating area is broken into a number of parts, although in practice even large cities can be covered by single advantageously placed base station. The central idea in dynamic channel management is to make any channel within a mobile radio system, potentially available for use by any user, thereby gaining an advantage over the situation in which a vehicle crew is confined to less than all the channels in use some of which may be over-loaded at a particular time, resulting in delay. This end is achieved by employing one channel as a monitor by means of which channels are requested by mobiles and allocated by a base controller. In the simplest realization the base controller can be a person with demands for a channel and the allocation of a free channel being communicated verbally.

However, ...

However, such facilities can be readily automated, the message to the base controller being sent in data form whenever a vehicles handset is lifted from its cradle. The allocated channel is signalled to the requesting vehicle set by similar means, which can also be made to include the functions of switching the set to that channel. The techniques employed are similar to those used in selective calling devices.

Base Processor Facilities

At the base station/control room, a simple digital processor is employed to detect incoming demands for a channel from mobiles, and seeks an unoccupied channel the identity of which is then signalled automatically to the originating mobile via the monitor channel. The same processor is also capable of detecting when no free channels are available and forming a queue of requests and allocating channels according to the priority previously allocated to the requesting vehicle. Where queueing exists in emergency situations, a priority demand will be included in the data message signalled to base causing an occupied channel to be immediately switched to service the call. Normally, a multiplicity of operating positions are employed in a control room while the same processor can route incoming calls to free operators etc.

Operating Characteristics

The system outlined is a step towards providing mobile radio telephone systems with the same characteristics as public telephones. When a vehicle crew member takes up his handset, a demand for a call is signalled via the monitor channel. If a channel is available he will hear via his receiver a ringing tone as the base processor is signalling a control officer to deal with the call. Should a channel not be available this fact will be signalled back via the monitor channel and communicated to the caller as an engaged tone. In this circumstance when a channel becomes available the base processor, which has logged the demand, automatically sends a channel switching signal via the monitor channel which also causes an audible signal to operate in the requesting vehicle. Thus, on lifting the handset the crew member will hear either a ringing tone, indicating that a control officer is being signalled, or the voice of that official.

By this means calls can be spread over all available channels so relieving peak demand situations. Where queueing occurs, requests for calls are automatically recorded and serviced and, should emergencies arise a channel can be immediately allocated.

AUTOMATIC RADIO DATA SYSTEMS FOR POLICE APPLICATIONS

Some years ago the British Home Office considered the proposal that electronic aids might profitably be employed to increase the work capacity and effectiveness of police patrol cars. This proposal was to some extent initiated by the extensive success of mobile radio systems being produced by the Electronics Industry.

The Home Office decided to consider a number of experimental projects and to evaluate them under operational conditions. One such project was MADE (Mobile Automatic Data Experiment) in which a range of data aids installed in a number of vehicles in the West Mercia Constabulary and West Midlands Police Forces would make possible two-way communication, in data form, with control centres via a

mobile radio ...

mobile radio channel. This system should enable reductions in the occupancy of the limited mobile radio channels available to be made by transmitting routine messages, which constitute the majority of mobile radio traffic, in data form. As an approximate guide, a given quantity of traffic passed over a channel in this form will take less than 1% of the time needed for conventional speech transmission. Additionally, savings in time and effort should be obtained at control centres as messages arrive in data form so enabling, without manual intervention, type written outputs, and the updating of wall maps and control processor held data. Such time saving methods should enable police and other mobile radio users to respond more rapidly to emergency calls.

With the MADE concept on-board facilities include: teleprinter communication with base, the facility of sending and receiving short coded messages (mainly concerned with vehicle status) and vehicle location by a crew member occasionally touching a facia mounted map to indicate present position. Later work demonstrated the possibility that individual vehicles in a fleet could be accurately and automatically located by the control centre.

Data experiment

This installation is centred around a data transmission system designed to work with slightly modified mobile radio telephone equipment to meet a Home Office specification requiring that no more than one character in ten thousand should be received and displayed in error. This performance is achieved over mobile radio links operating at 1200 bauds by means of 'a hand shaking store and forward' technique in which messages entered into the system are transmitted along with error detecting codes, by the control centre polling each vehicle in turn. After completion of preliminary protocols, messages are transmitted by sending two characters at a time. Reception of the data involves checking for errors and requesting the next character or a repeat in response. Also it is essential that the system works reliably in conditions of fringe radio coverage i.e. where the mean signal input to the receiver is less than 2μV. In such circumstances transmission delay associated with the message may be longer, due to the possibility of some repetition, but the message will be received in an error free condition.

Terminal equipment

The range of data terminal equipment used in the MADE system, all of which has to be evaluated in operational use, includes a mobile soft copy unit and a printer. The benefit of automatic equipment, enabling crews to report changes of status to their control centre, is welcomed by police forces who have computerized command and control systems, as its use obviates the need to obtain this information by the radio telephone for insertion via a video data terminal. As mobile teleprinters are a means of reducing the amount of writing done by a car crew and also offer a degree of privacy they were therefore included in the experiment. A mobile soft copy unit is a means of displaying messages of up to four lines of 32 characters each where a permanent record is not required.

A standard interface is employed which enables all the vehicle terminal units to be connected to the transmission system. This system is based upon the use of sub-carrier frequency shift keying (1200 and 2400Hz) and in MADE is used with f.m. radios. MADE uses the mobile radio channel in three different modes so as to effectively produce 3 sub-channels: firstly, polling, in which both outward and inward following messages involving particular vehicles can be announced, secondly, the sending of pairs of characters from outward messages (giving rise to a next character request or repeat response), and thirdly, the controlled

reception of ...

reception of inwards messages by requests for the next pair of characters or the repetition of the last. The system operation is such that data can be exchanged reliably even at signal levels which would make conventional mobile radio telephony only just readable.

At the control centre end of the radio data link, the MADE system connects with a central processor. This enables video data terminals to be used for the input of data messages, which are also recorded on printers. The central processor supervises the polling type operation of the transmission system, keeping a running log on all incoming and outgoing messages which can be searched to enable summary output to be generated in a variety of formats.

AUTOMATIC VEHICLE LOCATION

For a Command and Control System to assist in providing the most effective response to an incident requiring a police response, it is essential to possess reliable up-to-date data concerning the location and availability of all appropriate resources. For a mobile Police force of any significant strength the problem of maintaining an up-to-the-minute accurate knowledge of the whereabouts of all its resources is great, and the use of automatic systems for this purpose is being actively considered by several large urban forces. An Automatic Vehicle Location and Status System can be considered as being made up of two sub systems. Firstly, units fitted to each vehicle which enable status data to be entered by the crew, its location to be automatically determined, and to provide a data communication link with the Control Centre. Secondly, at the base/control centre, apparatus enabling data communication with each vehicle and the means of interpreting and displaying the incoming data. These last two functions may well form part of the Command and Control processing systems task.

COST BENEFIT CONSIDERATIONS

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Benefits can be expected in the more efficient use of mobile resources and control room staff. The primary improvement in the efficiency of mobile resources is the reduction in travel (and response) times which results from being always able to identify the best placed vehicles to service an incident. The benefit is equivalent to the cost of providing the additional resources needed to achieve a similar mean response time. Allowing for holidays, sickness and training etc, probably 5 policemen are needed to keep a single car manned. At an estimated salary of £3,500 p.a. and taking depreciation, fuel and maintenance into account it is calculated that the approximate annual cost in Britain of keeping a police car on the road is £20,000. Even at the level of 5% improvement in vehicle utilization the benefits of A.V.L.S. will exceed the production cost of any of the proposed systems, when realistically amortized, over less than a 7 year operational life.

The principal benefit to the control room is the reduction in time needed to locate and identify available vehicles which are nearest to the scene of an incident.

EQUIPMENT

veh. locator

A British Company has developed an automatic vehicle location system "LANDFALL", in which each vehicle in the system carries direction and distance travelled sensors, the outputs of which are interpreted by a small vehicle borne processor by comparison with a coded map of the service area carried in its store. The position of the vehicle, together with data referring to the present occupation (status) of the vehicle, is transmitted back to the control centre at frequent intervals via an automatic mobile radio data system.

CONTROL ROOM FACILITIES

In a police control room, concerned with responding to reported incidents, a major interest is the rapid identification of the best placed units to service each incident. There are two principal methods of achieving this end which can if necessary be used to complement each other.

The first takes the data arriving at the control room over the mobile radio link with the vehicles, and, interprets it is order to drive a geographic type display on which the location of each vehicle is shown together with its identifying code. In a separate data table beside the geographic display up-to-date details of the status of each vehicle are given.

In the second method, a much closer integration is provided with the command and control processor. It is assumed that when an incident is reported its details are entered into the system via a video data terminal. On the location of the incident being inserted, the processor searches the vehicle disposition and status file, which is continuously updated by the A.V.L.S. system, to identify and compute the type, position, status, call code and travel times of the nearest vehicles. This information is displayed in text form to the Officer concerned with providing a response to the reported incident.

CONCLUSIONS

This Paper is an amalgam of the present available with future possible. Everything discussed is within the realm of current technology but police forces have to make up their own minds how far andhow fast they move towards automatic systems which offer the possibility of greater efficiency with speed and lack of human error. They carry the penalty of increased capital investment and greater equipment complexity. It is only time, however, before all the systems described become a cost effective reality. Industry can offer them now and widespread adoption will bring costs down dramatically.

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