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REPORT

The 'CARFAX' road traffic information system

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Summary

This report describes the development work and the field trial which led to the successful completion of the "CARFAX" project. Due to the fact that a suitable operating frequency cannot be negotiated the system as developed is not being implemented, and prospects for the future are discussed.

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1. Introduction

For many years broadcasting authorities throughout Europe have transmitted traffic information announcements to help drivers. There is little evidence regarding the tangible benefits of this form of communication, but the costs of road transport are now so great that even a very modest contribution could lead to substantial savings. For example, in the United Kingdom the Consumers' Association estimated in 1982 that it costs about £35 per week to run a typical family car assuming an average use of 18,000 kilometres per annum. Thus the direct cost of private motoring alone in the United Kingdom exceeds twenty thousand million pounds per annum and the costs of commercial transport are probably greater. About one half of this is spent on fuel, so it is reasonable to expect that the broadcasting of traffic announcements saves significant sums of money by helping the motorist to avoid traffic congestion. Furthermore, by providing the driver with information they probably lower his stress level and hence the risk of his exposure to accident – an intangible benefit which could be very important.

The procedures for broadcasting traffic information in European countries have been developed to meet national requirements within the resources available. The general approach is to insert announcements into the normal programmes and obviously, the number must be limited if the non-motoring listener is not to be annoyed. The amount of information needed will depend upon the area covered, and the quantity of traffic. An extreme example of the requirement is a single transmitter providing nationwide coverage – a full service for all road users would frequently monopolise the output of the station for long periods. Each listener would have to endure this in the slight hope of hearing something relevant to him. At the other extreme a local radio station might only need to offer a few minutes of air time a day to pass announcements describing its few traffic incidents, although where such local stations cover large busy conurbations the amount of traffic information might still threaten to overwhelm the total output of the station during rush hours. Another problem of "channel sharing" is that unless definite priority procedures are established, significant delays can occur before a suitable programme break can be found for traffic announcement. The problems can be reduced if a programme is designed with a primary object of serving the motorist. This however, pre-supposes that he will listen only to this source in the hope of receiving a useful announcement i.e. he is deprived of the freedom of choice. Again, this difficulty can be overcome by the ARI technique (Autofahrer Rundfunk Information) in use in West Germany. This provides for a receiver which automatically selects stations transmitting traffic announcements and switches then only when such transmissions occur. But this approach still means that a national v.h.f. programme outlet has to be set aside for the specialised requirements of which is essentially a minority audience. Furthermore, the service must be directed through the existing v.h.f. broadcasting network, the coverage of which may not be ideally matched to the requirements of the traffic authorities.

The idea of establishing a dedicated traffic information service outside the normal domestic networks was first proposed by the BBC in 1971. Such a network would transmit only traffic information, and linking material would not be used to fill in the gaps between announcements. The motorist's special receiver would switch automatically to any announcement affecting his area, returning to his previous choice of listening when the transmission was completed. The system, known as "CARFAX", employs a single m.f. channel, and involves a new network of low-powered transmitters which would operate in time division multiplex to provide traffic announcements. The reception of these announcements would be limited to defined areas thereby avoiding unnecessary interruption to listening elsewhere. This report describes the evolution of this proposal, the tests and trials which have been carried out, and concludes with a discussion of the present situation.

2. General features of "Carfax"

It is not proposed here to discuss the reasons for the introduction of a dedicated traffic information service. This has been dealt with more fully elsewhere[1]. This section outlines the general features of the "CARFAX" system which enable it to use a single m.f. channel to provide announcements to road users throughout the United Kingdom, and indeed it is postulated that technically a single channel could provide a service throughout Europe. It was designed from the outset to provide information only to those who need and can make use of it, i.e. those in the vicinity of an incident. The ability to focus upon local problems is achieved not only by using a network of low-powered stations each having a range of about 30 km, but by also ensuring the motorist receives just those announcements from the transmitter serving the area through which he is travelling, the receiver being inoperative for any other announcement.

It is the spasmodic nature of traffic information that makes it feasible to employ only one frequency for the entire network. Stations could be operated in a selected sequence either automatically or on demand, and simultaneous transmission by those within mutual interfering range would be prohibited. This simple concept is illustrated by Fig. 1 which shows a theorectical lattice of stations covering the United Kingdom. Each cell of the lattice has sixteen stations and the length of the side of each cell defines the distance between stations (having the same letter) allowed to operate simultaneously. This distance is approximately 200 kilometres, and is established by the protection ratio required.

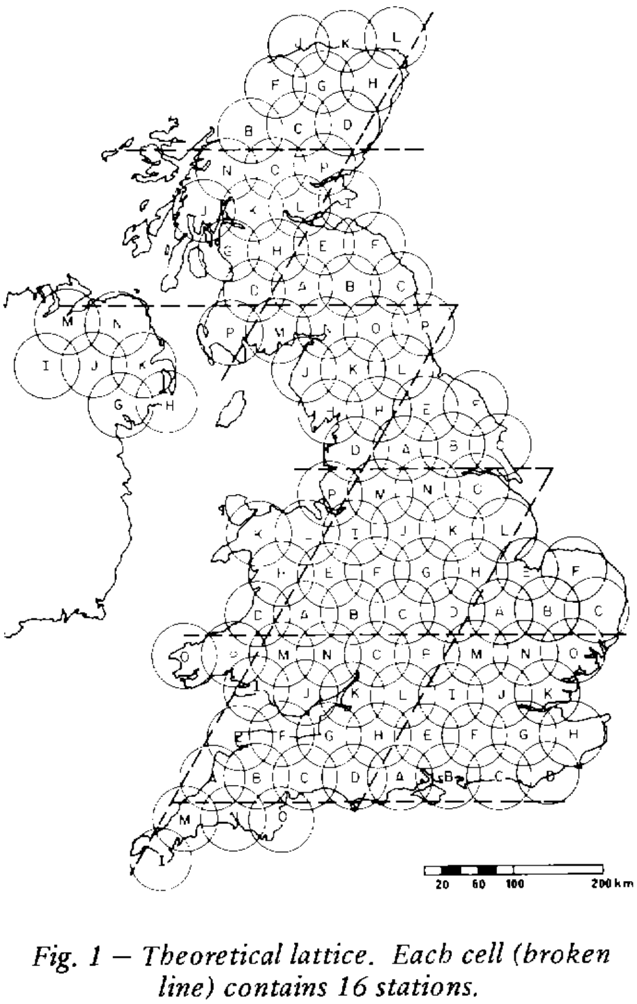


Fig. 1 – Theoretical lattice. Each cell (broken line) contains 16 stations.

An important feature of the system is the restriction of reception to defined areas. Early work proposed a technique whereby field strength was used to mute the special receiver and so determine the boundary of the service from each transmitter,[2] but this proposal was abandoned in favour of a better solution. The basic principle of operation which was finally developed by Research Department[3] can be understood by reference to Fig. 2 which shows part of the idealised lattice of "CARFAX" stations. Each transmitter can operate in one of two modes, i.e.

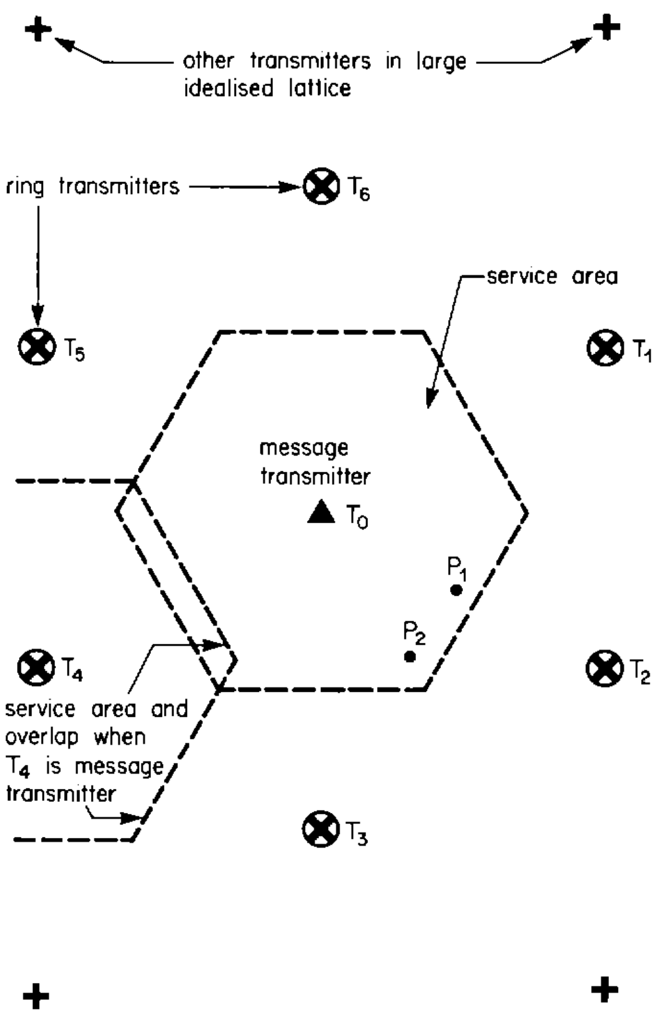


Fig. 2 – Basic arrangement of the ring system.

they can either be used to pass a message, or they can be employed to limit the range of the message station - to "ring" it. In the example shown in the figure, transmitting T_0 is the station carrying the message; the six surrounding transmitters T_1 to T_6 are serving as ring stations.

Fig. 3 – shows the sequence of events. The message transmitter radiates a START code to precede its announcement. This code, whose detection is necessary before the receiver will

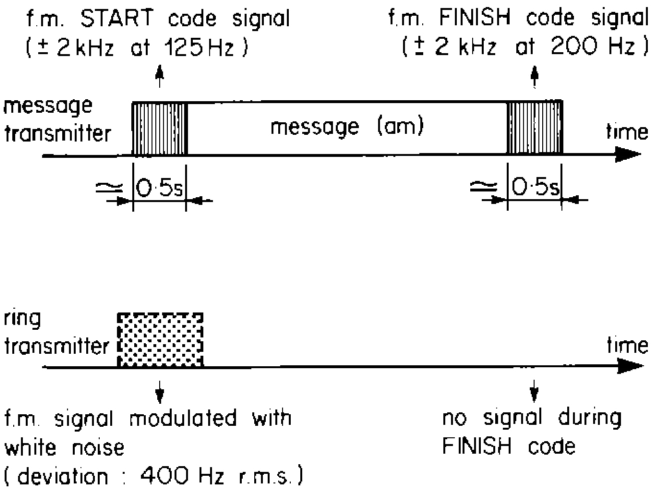


Fig. 3 — Sequence of events in the ring system.

relay the announcement, consists of frequency modulation of the carrier by a 125 Hz tone with a peak deviation of ± 2 kHz. Simultaneously, unmodulated (c.w.) short RING signals are radiated from each of the six surrounding transmitters. These signals begin just before the commencement of the START signal from the message transmitter and end just afterwards.

Consider a receiver located in the region of P_1 (Fig. 2). This will receive signals predominantly from transmitters T_0 and T_2. If the carrier level from the ring transmitter T_2 is sufficiently strong, f.m. capture effect will suppress the reception of the 125 Hz modulation of the T_0 START signal. Alternatively, if the signal from the ring transmitter T_2 is not strong enough, the START signal will not be suppressed and the receiver will be activated. Where more than one ring transmitter contributes significantly to the received signal such as at P_2 in Fig. 2, the capture effect still operates but is less pronounced.

Thus it will be seen that receiver activation is determined by the ratio of the message to ring signal strengths rather than their absolute values. The encircling ring of transmitters creates a well defined limit to the service area of the message transmitter — a kind of controlled jamming — which inhibits reception of the START signal so that outside the service area receivers are not activated and the message is not heard.

To overcome the difficulties that might arise with particular carrier phases of the c.w. signals from the ring transmitters, these signals are frequency modulated with an rms deviation of about 400 Hz by psudo-random noise band-limited to 100 Hz. This ensures that during the START code decision period in the receiver, the signals from the ring transmitters can be averaged satisfactorily.

With the "CARFAX" receivers activated within the selected area, the traffic announcement is then radiated by the message transmitter, using conventional amplitude modulation. At the end of the message, a FINISH signal is transmitted to de-activate or mute the receivers. Again, frequency modulation of the message transmitter is used for this signal with a peak deviation of ± 2 kHz but at a modulation frequency of 200 Hz. During transmission of the FINISH signal the ring transmitters remain off and reception of the FINISH signal is then possible down to very low signal strengths and under conditions of heavy interference. This is thought to be a valuable feature to minimise the the number of receivers inadvertently left activated after reception of a previous message. This might occur, for example, because the vehicle was passing under a bridge during the transmission of the FINISH signal and failed to detect it.

Two basic forms of "CARFAX" receiver were originally envisaged. The first was an add-on unit which could either operate alone or could be added to an existing car receiver installation. In the latter case, separate or split aerial feeds would be required and arrangements have to be provided for automatic change-over of the loudspeaker connections to the output from the "CARFAX" receiver whenever it is activated, and vice versa. The second type of receiver was an integrated unit which would operate in a similar manner to the add-on model but would, of course, be more compact and cheaper if the additional cost of the complete car radio is considered. Fig. 4 is a block schematic showing the basic features of an integrated receiver. Of course, the "CARFAX" component could readily be added to normal domestic receivers, thereby providing the service to motorists in their homes before they undertake a journey.

3. The field trial

3.1. General

Having established the principles of the "CARFAX" system the BBC put forward its proposal to the appropriate sub-group of the Technical Committee of the EBU for international consideration. The subject was intensively discussed at various meetings, where the objective was to agree to a system suitable for use throughout Europe, but no clear decision was taken. There was support from a few countries for

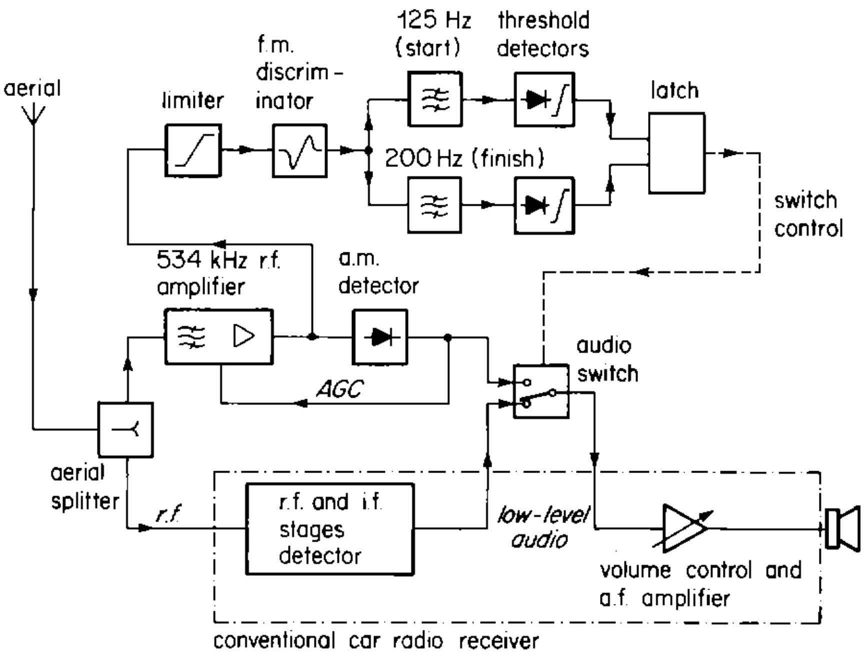


Fig. 4 – Basic features of an integrated receiver.

the ARI (Autofahrer Rundfunk Information) technique[4], which came into use in West Germany in 1973/74, because this satisfied the immediate objectives at comparatively small cost to the broadcaster. Although the BBC proposal was more ambitious and, it was contended, a single channel could provide extensive international coverage[5], there was obvious concern that it depended on the availability of a suitable medium frequency. Furthermore, there was no clear consensus amongst the European countries regarding their requirements for a traffic information service despite protracted efforts by programme groups to achieve such a decision. An international "CARFAX" system would certainly need agreement regarding the objectives if only because the operation would require substantial technical liaison. But objectives and means could not be agreed, and indeed this situation persists today.

Recognising the international difficulties the BBC pursued the possibilities of introducing the system within the United Kingdom. It was felt that, if a successful launch could be obtained here, support for the technique could then be forthcoming from other countries and there was evidence to support this assumption. Discussions were held with traffic authorities in this country, including the Transport and Road Research Laboratory (TRRL), the motorists' organisations, the police and the Home Office. These culminated in a seminar jointly organised by the TRRL and the BBC in July 1976; as a result, a working group was set up under the chairmanship of the TRRL to study the broadcasting of traffic information. This group produced a report in 1979[6] which recommended that a field trial of "CARFAX" should be conducted. It envisaged a trial would have three stages. The first intended to demonstrate the effectiveness of the information collection and handling procedures to obtain maximum benefit from a new system. The second stage would be designed to confirm the technical performance of the broadcast system and could involve test transmissions from four or five transmitting stations. The third, which would only be undertaken upon successful completion of the first two, proposed an extension of the transmitter network needed for the second stage and the transmission of real traffic information Public participation of this third stage was also proposed.

Under an agreement finalised with the TRRL in August 1979 the BBC was financed to carry out the second stage of the investigation and field work was conducted during the period January 1980 to May 1981.

The broad objectives of the second stage as defined in the TRRL supplementary report[6] were to demonstrate the coverage of the system and permit the engineering design to be finalised. The objectives were given in more detail in the trial schedule and these are summarised below:-

1) To produce a coverage map of the transmitter network set up for the trial showing the positions of the service area boundaries,

2) to define the "communications efficiency" i.e. to state the proportion of listeners provided with a service of specified grade, and

3) to report on any aspect of the field trial which would influence further development.

For reasons of convenience and economy it was decided that the trial should be undertaken in the London area. Furthermore, in order to keep the costs of the trial down it was decided to use existing sites for the transmitters wherever possible. It was assumed that this would save the time otherwise needed to plan, acquire and equip new sites. This was indeed so, but the resulting configuration of transmitting stations produced a less-than-optimum result in terms of service area boundaries. This aspect is discussed later.

3.2. Transmitter network

To satisfy the various requirements of the operation a centralised control was needed which would allow the appropriate signals and modulation to be applied to the transmitters. Such an arrangement might approximate to the final situation of an operational "CARFAX" network in which a central control would perhaps act as the interface between the traffic information input and the broadcast ouput. The development work was centred at Kingswood Warren and, to reduce the demand for connecting lines to the transmitters, a location in or near Broadcasting House was favoured for the control. Lines radiate from this centre to BBC premises and the whole process of interconnection would be simplified with such a solution. Eventually adequate space was found in Designs Department at Western House near Broadcasting House. Fig. 5 shows the control desk which was developed and Fig. 6 gives its block schematic.

For the purposes of the engineering trial the transmitter control could have been operated by an automatic unit provided with a timer which would have switched the stations in a pre-determined sequence. However, it was thought advisable to make some provision for manual control by an operator/announcer, and the prototype equipment was designed and constructed with this additional objective in view. Basically, the desk provided a means of originating the signals required for transmitter operation and these were sent via land lines to the various stations. In the manual mode the main decision required from the operator was transmitter selection i.e. he must select the appropriate station which is to be used to pass a message. This action automatically connected the message transmitter to the message bus and, via a diode matrix linked the appropriate ring transmitters, to the ring bus. When connection was completed a cue light appeared advising the operator that the selected mode was available i.e. the transmitters had radiated the appropriate START and RING signals and it could be assumed that "CARFAX" receivers in the area selected were open to receive the transmission. When the announcement was completed, operation of an "off" button initiated the FINISH signals from the message transmitter and this would de-activate the receivers. Apart from the manual operation, provision was included for an autosender which sent out recorded announcements on a pre-set sequence. This facilitated various aspects of the survey operation. A development of this feature was a survey pulser which operated any or all of the transmitters and provided tone modulation to identify individual stations. This component cycled rapidly through the network and when used in conjunction with equipment fitted in the survey vehicle this allowed rapid assessment of communications efficiency. A full description of these facilities is available in the unpublished report to the TTRL committee on the first part of the trials.

To test the operation of the ring system it was desirable to have a network consisting of a central transmitter surrounded by an outer ring of other stations. Initially, this arrangement could not be achieved and it seemed as though the trial would have to be somewhat inadequately carried out using only four transmitters, each serving a quadrant of the London area. However, the availability of the site in London at Lots Road meant that a station could be provided in this central position, although it will be seen from Fig. 7 that the exact locations of the sites do not provide an optimum solution. In the "CARFAX" system factors which influence the position of the service area boundaries include the following:—

(i) transmitter station siting
(ii) message/ring ratios during the START signal
(iii) propagation paths
(iv) transmitting aerial horizontal radiation pattern
(v) receiver performance

Dealing with (i), in using existing sites in the trial there was an inevitable departure from the ideal lattice in which six stations surround the message transmitter, and this is illustrated by Fig. 7. Furthermore, both Crowthorne and Hoo are well removed from the centre of the area, and this difficulty was aggravated by the fact that the effective radiated powers from these two stations were significantly less than those available at the other three. Additional complications were caused by vagaries in the horizontal patterns of the trans-

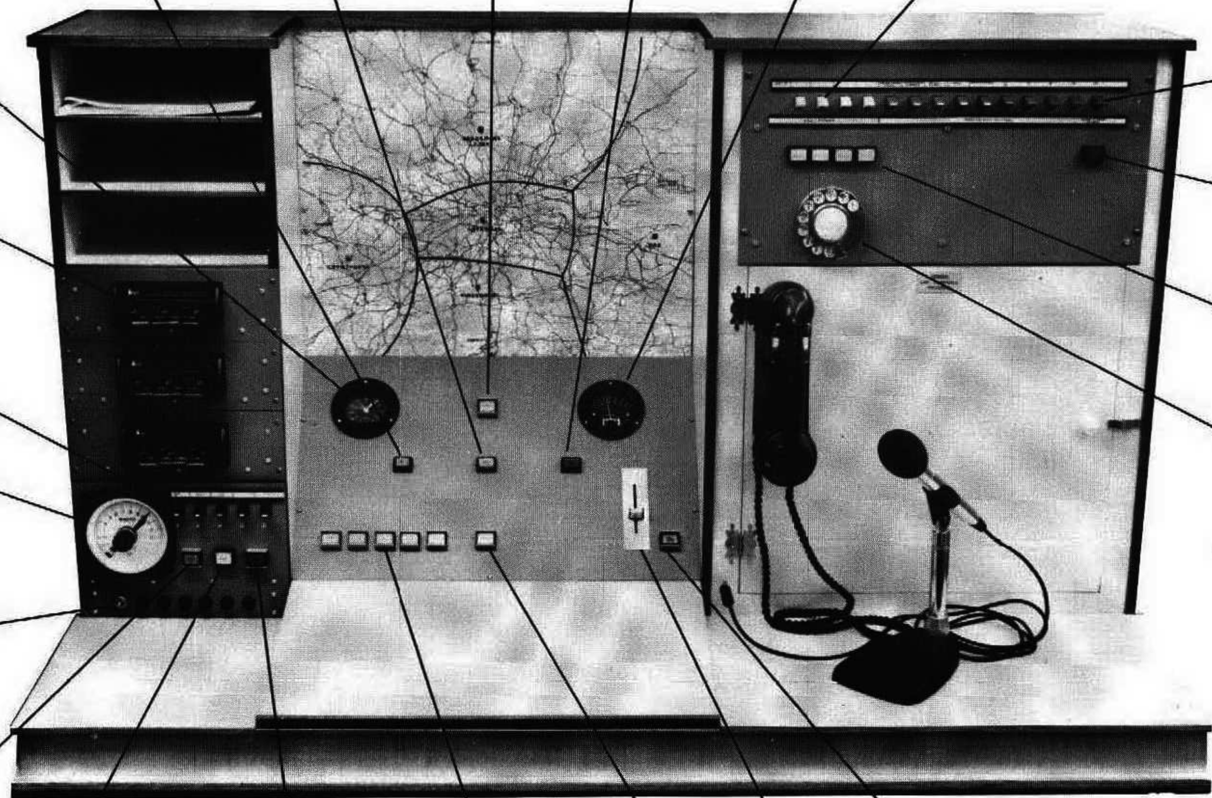


Fig. 5 — Control desk.

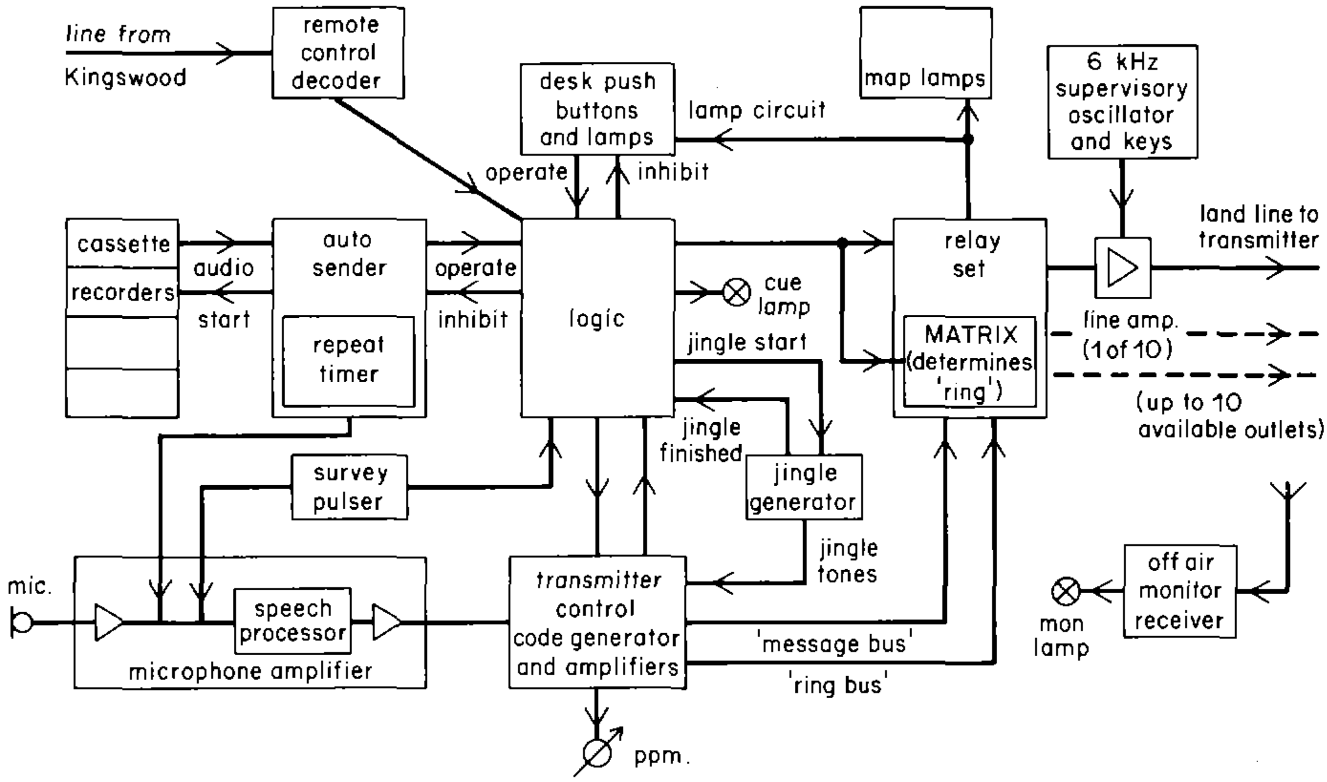


Fig. 6 — Block schematic of the Control desk.

mitting aerials and in the varied nature of the propagation paths. A number of delays were also experienced in bringing the transmitters into operation and here the most troublesome site was Lots Road. Although this particular "CARFAX" transmitter was actually brought on early in 1979 on an experimental basis, it came off the air soon after and remained off for most of the ensuing 12 months, due to various troubles. A serious problem was created by the need to accomodate the BBC Radio 4 London relay on 720 kHz, which involved the development of combining equipment, since this service had to share the "CARFAX" aerial. Furthermore, the advent of the Radio 4 transmission demanded additional lines from Broadcasting House and more delay was caused.

As far as the transmitting equipment was concerned each station was initially equipped with two RCA ET4335 transmitters which operated in parallel. These transmitters were readily available within the Corporation although some were not in operational condition. They were about 40 years old and all had been removed from service some time ago. Despite, this, the transmitters were restored without too much difficulty and proved very reliable. To make them suitable for this particular operation, special interface units had to be made in Research Department which allowed the transmitters to be switched on and off upon receipt of the appropriate logic signals. These units also incorporated all the overload trips and high-tension delay circuits needed for unattended operation.

The ET4336 has a switchable low-power condition and when two transmitters are combined it is possible to arrange switching such that the output power can be varied in 2 dB steps down to 8 dB below full power. This facility was used when the transmitters were brought on in the ring mode, because different message/ring ratios were used to test the overlaps in the service areas. The maximum combined output power available at each site was about 500 Watts but low transmitting aerial efficiency meant that the final power radiated averaged about 50 watts.

Before the main survey work was started the effective radiated power of each transmitter and the horizontal radiation patterns were measured. The measurements revealed that the transmitting aerial efficiencies were as follows:—

Kingswood	33%
Lots Road	15%
Brookmans Park	25%
Crowthorne	6%

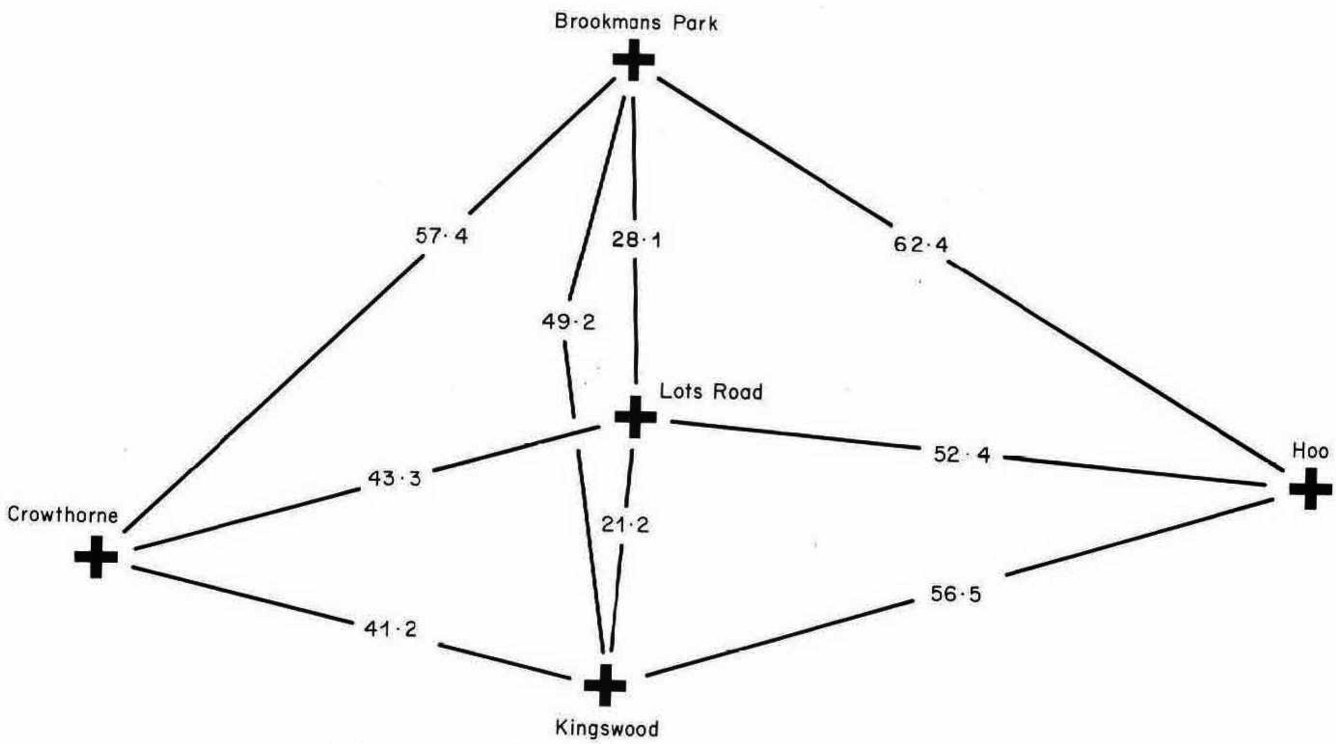


Fig. 7a — Bearings and distances between sites.

Fig. 7b — Site locations and target boundaries.

Hoo	11%

As mentioned before some of the aerial patterns showed considerable departures from omni-directional. To compensate to some extent for these irregularities and for the different efficiencies the transmitters were adjusted where possible so that the e.r.p. from each transmitter in the direction of the service area boundaries of adjacent "CARFAX" stations was about 50 watts. The measured horizontal radiation patterns of the five transmitters appear in Fig. 8 to 12 (overleaf).

3.3. Receiving equipment

As far as the receivers were concerned, the experimental "CARFAX" transmissions on the frequency selected for the trial – 526.5 kHz – could be picked up by most conventional car radio receivers, but proper reception of the proposed service, of course, demanded the use of the specially designed dedicated receiver which responded to the START and FINISH signals broadcast with each traffic information message. The need for a low-cost receiver was a paramount consideration throughout the technical development of "CARFAX". This objective was achieved through the use of a single m.f. carrier frequency whereby receivers could be fixed tuned, and the ring techniques which provided area discrimination without the need for precision circuitry. Thus, the receivers were automatic in operation, no user controls being required except for some form of on-off switch, and perhaps a volume control. It was also considered desirable to introduce a three-position switch on each receiver which provided the following listening options:

(1) ordinary listening without interruption. The ordinary listening under these circumstances may be from any source, such as the car radio tuned to any chosen station or a cassette player.

(2) ordinary listening as above, interrupted by "CARFAX" announcements when they are received.

(3) "CARFAX" announcements only.

About 500 experimental receivers were required for the trial, and a number of UK based receiver manufacturers were invited to participate by producing these. As a result of this invitation five manufacturers provided receivers to a BBC performance specification[7]. When these receivers were obtained from the suppliers, their performance was checked in the laboratory using BBC designed test gear, and in general their performance was found to be good, although some were returned to the manufacturers usually for relatively minor reasons, such as incorrect alignment. Subsequent experience in trial conditions revealed a particular fault which was common to all the early experimental receivers. This was a condition of false activation which appeared to be caused by interference from two adjacent transmissions in particular. Firstly a normal broadcast transmission on 531 kHz from the Swiss broadcast transmitter at Beromunster, and secondly a f.s.k. teleprinter channel operating on 524 kHz from Kristiansands in Norway. It was found that the problem could be substantially reduced by a simple modification to the receivers although occasionally the f.s.k. interference, which was virtually able to mimic the start signal, continued to cause false activation. A means of overcoming this was eventually proposed and this is described in the next section.

A Ford Fiesta was used as the survey vehicle and the survey equipment installation is shown in Fig. 13. The basic requirements of the survey equipment were that it should:–

(1) provide an indication each time the "CARFAX" receiver demuted and interrupted normal listening.

(2) identify the "CARFAX" transmitter causing the demuting.

(3) indicate the presence of any "CARFAX" transmission.

(4) display all this information on a multichannel chart recorder.

(5) provide a normal audio output for listening tests.

In addition to the equipment shown in Fig. 13 the vehicle was also provided with a field-strength measuring receiver.

Under normal circumstances the "CARFAX" transmissions consisted of speech announcements which named the source, but as this provided no means of identification which could be automatically detected the messages were replaced by bursts of tone modulation for part of the survey period. These were unique to each transmitter and were generated at the control desk. The audio output of the receiver was taken to a tone decoder which identified the source. This decoder also drove a multi-channel chart recorder which recorded the events as they occurred. A separate

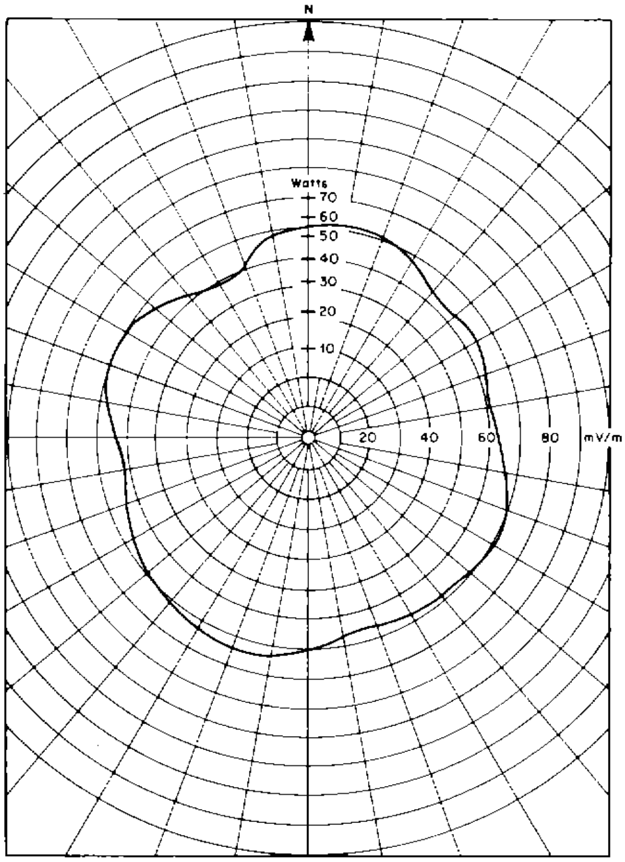


Fig. 8 – Kingswood HRP

Measured at 1 km

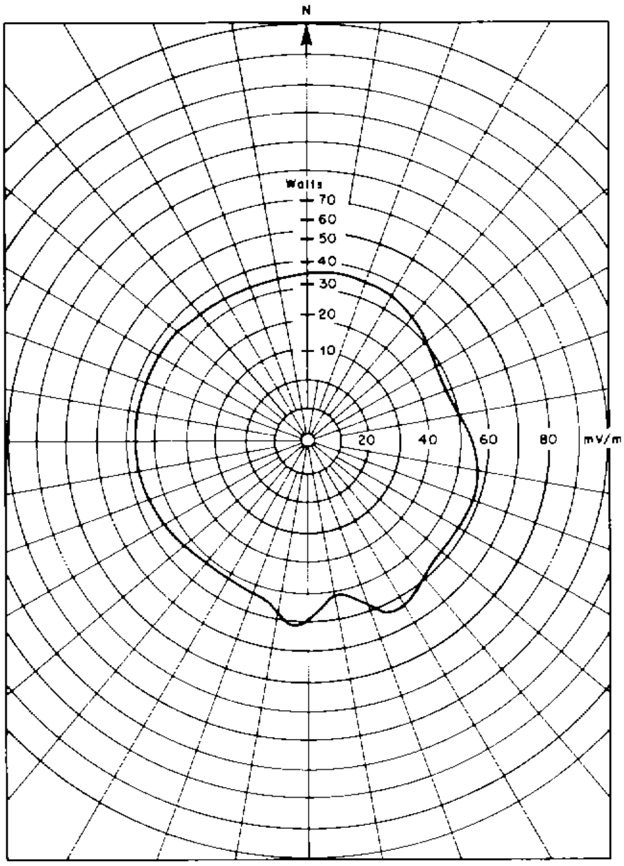


Fig. 9 – Lots Road HRP

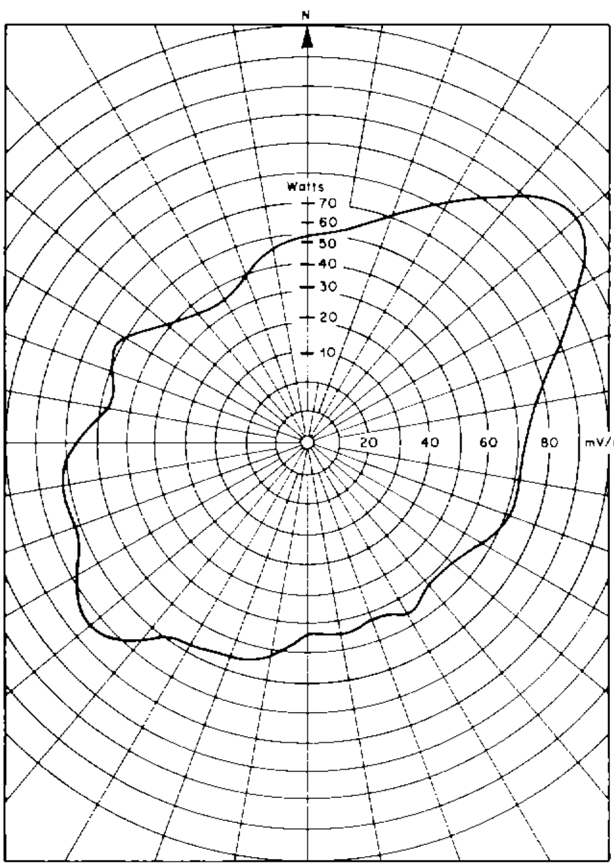


Fig. 10 – Brookman's Park HRP

Measured at 1 km

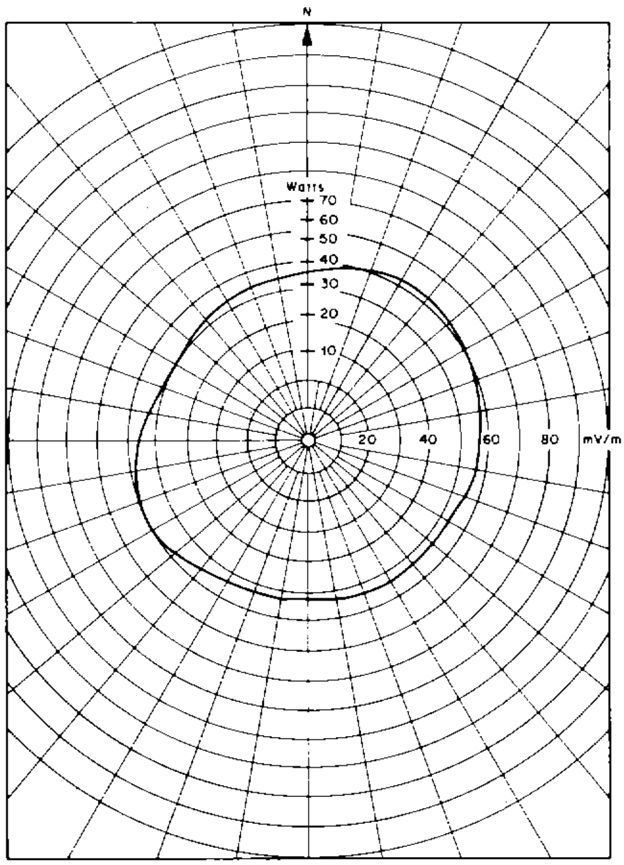


Fig. 11 – Crowthorne HRP

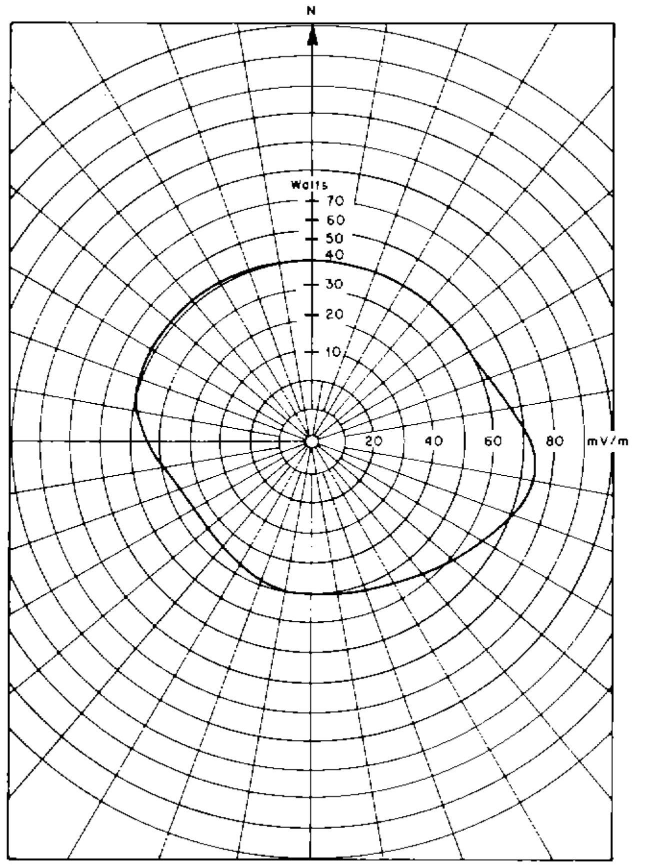


Fig. 12 – Hoo HRP measured at 1 km.

circuit was also used to monitor the AGC line of the "CARFAX" receiver so that whenever a signal of more than one millivolt per metre was present, a record was made on the chart. This served to indicate that a "CARFAX" transmission had taken place irrespective of whether the receiver had demuted or not. A typical section of the recorded chart obtained during the survey is shown in Fig. 14.

4. Results of the field trial

The majority of the field work was concerned with detailed reception surveys in the area served by the network although some time was also spent providing test announcements to a limited number of motorists in order to assess subjectively the receiver performance and transmitted quality. The project has been fully documented in a Research Department report to the TRRL committee but the following summarizes the main features of the work.

4.1. Service area boundary investigations

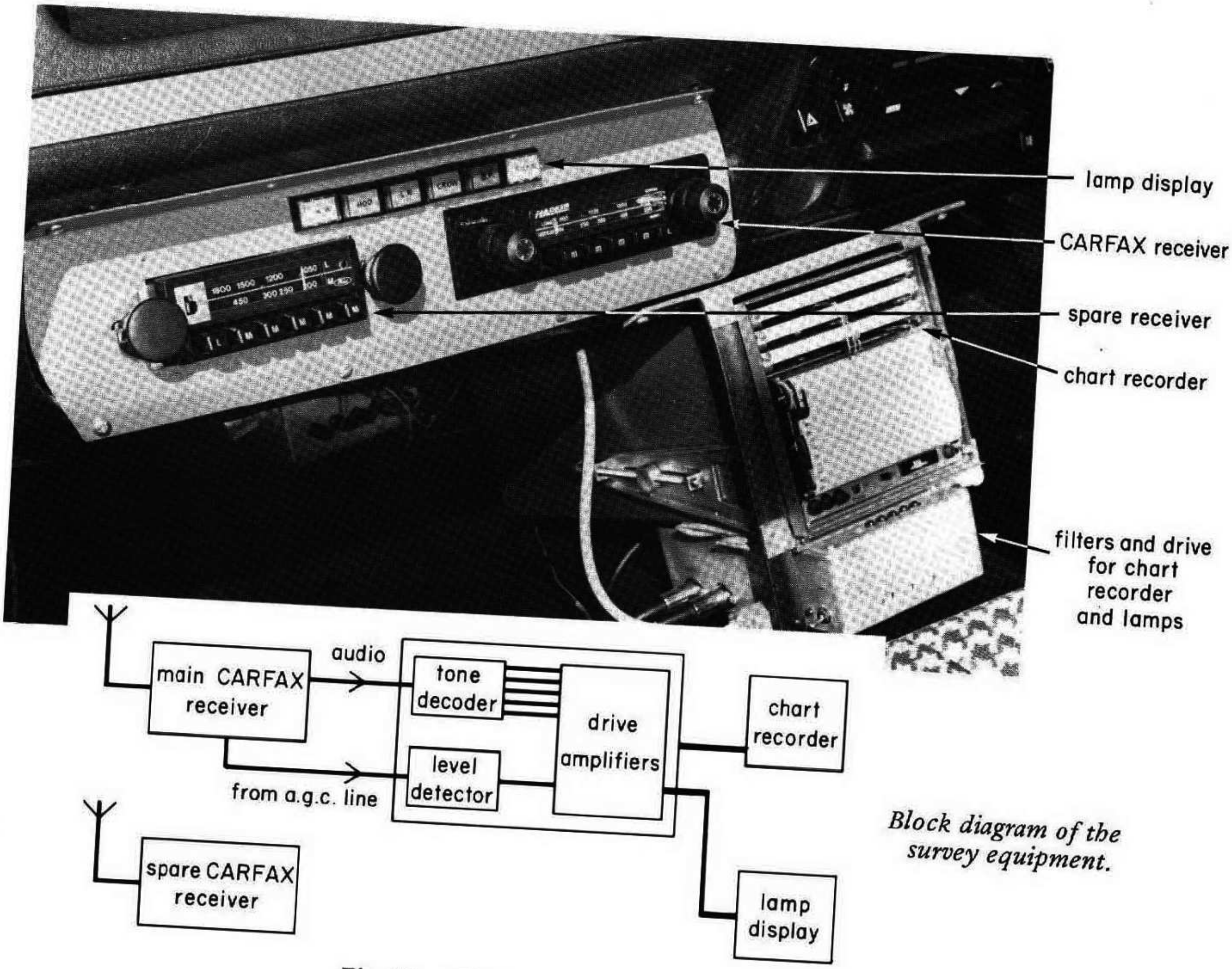
The bulk of the measurement programme was concerned with investigating the boundary areas between transmitters for various combinations of ring transmitters and ring powers. Initially, field strength measurements were made at regular intervals along lines drawn between the transmitters. Using these profiles the positions of the boundaries were predicted. The technique for investigating the system was to radiate from each transmitter approximately five seconds of identification tone with the requisite START and FINISH signals. Rather than survey all the boundaries at once, the work in the early stages was confined to the Lots Road, Kingswood and Crowthorne interfaces. As stated in the previous Section the power of a transmitter in the ring mode could be pre-set from 0 to − 8 dB relative to the message transmitter in two decibel steps. The first stage, therefore, was to investigate the boundary condition with equal ring and message powers, and then to repeat the survey work with progressively lower ring powers.

Under the condition where the ring power equals the message power it would be expected that the service areas would not overlap each other, especially, since the received ring signal is the resultant of three or four signals. It can be seen from* Fig. 15 that this is the case and also that there is a much larger gap on the western boundary than on the southern one. It should be noted that points where transmissions were not received i.e. where the receiver was not activated, are indicated on the map by red dots.

During this part of the survey an investigation was being made into the prediction of message service areas. Previous work[8] had indicated that when one ring signal predominates, capture effect is very pronounced and results in a clearly defined service boundary largely independent of receiver characteristics. However, when there are two or more ring signals of similar level the capture curve becomes less steep and, in general, there is a shift in the ratio of the message carrier to the r.m.s. sum of the ring signals corresponding to receiver activation. These effects, generally referred to as "capture dilution", tend to make service boundaries less distinct, but they can be minimised if the receiver is set to activate when the level of the demodulated START tone is −8 dB with respect to its maximum value. Further work on capture dilution resulted in a relationship being established between the number of ring signals, the optimum receiver activation threshold (−8 dB) and its tolerance.

A comparatively simple program developed by Mathematics Unit in Research Department permitted prediction of the service boundaries on the basis of equal field points by comparing

* Figures 15 to 21 (incl.) appear after page 23.



Block diagram of the survey equipment.

Fig. 13 – CARFAX survey vehicle installation.

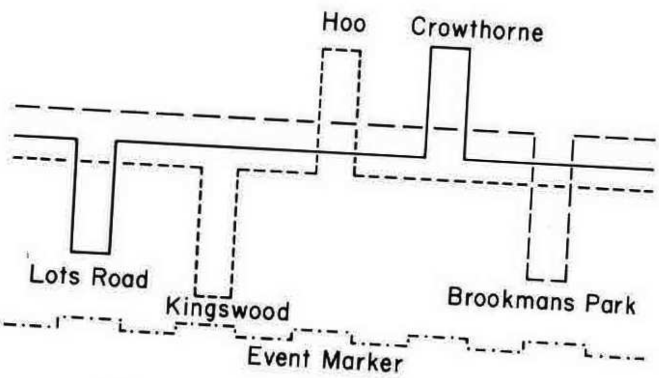


Fig. 14 – Output of chart recorder.

the level of message signal with the level of the combined ring signals calculated on the assumption of power addition. It also contained provision for an alternative prediction in which a correction was applied to the level of the combined ring signals to take account of the apparent effects of capture dilution. Fig. 15 shows the basic prediction in solid contours whilst that including the correction is depicted by dashed contours. However, the survey work confirmed that whilst the existence of capture dilution was apparent as far as the prediction was concerned this correction was unnecessary. In the particular example of Fig. 15 it can be seen that the large gap on the western boundary is better represented by the solid contours than the dashed ones.

The survey then proceeded to investigate other values of relative ring power. Fig. 16 shows the survey results produced for a condition of ring power of –2 dB relative to the message power. It will be seen that the area was surveyed in more detail with part of the northern boundary now included and there was also a brief excursion into the Hoo service area. Here again, it is apparent that the prediction based on the simple power addition of the ring signals more closely represents the situation especially on the western boundary. In subsequent investigations for ring powers at

−4 dB relative to message, the predictions were based on power addition without correction for capture dilution.

In Fig. 16 the prediction fits the survey results quite well on the western and southern boundaries, but some discrepancies are apparent in the northern and eastern areas. For instance, the actual interface between Lots Road and Brookmans Park is south of the predicted boundary. Such errors are bound to occur with the factors involved. In order to predict a position of a boundary it is first necessary to calculate the field strengths from the transmitters in the area. To do this with any precision demands very detailed information on ground conductivity and the aerial radiation patterns. In the area examined, ground conductivity is far from constant, being relatively high around the Thames esturary and falling to lower values elsewhere, especially in the heavily built up parts of London. The computer prediction program uses a uniform conductivity of 10 mS/m per metre for the whole area because a highly detailed ground conductivity data bank could not have been prepared in the time and with the resources available. Similar inaccuracies were inevitable with the horizontal radiation patterns used in the prediction program, which were based upon the measurements made at one kilometre from each transmitter, and which are shown in Fig. 8 − 12 of this report. This method of h.r.p. determination works quite well in open country, but is subject to error if a transmitter is sited in a dense urban area, such as is the case with Lots Road. Greater precision in the prediction to define the position of "CARFAX" boundaries could, therefore, be a costly and time-consuming exercise. Considering the relatively simple method used here it was encouraging to see how close the prediction boundaries were to the survey results.

Fig. 17 shows the results for a ring power of −4 dB relative to message. It can be seen that the gap along the western boundary has now disappeared whilst the overlaps, at least on the northern and southern boundaries are approaching a reasonable width commensurate with the distance between transmitters. It must be noted that when the −4 dB condition was first established Brookmans Park transmissions were received in the Kingswood service area. This was because the combined ring signal in this area was below the level of the message signal from Brookmans Park due to Crowthorne and Hoo being too far apart. The solution in this case was to make Kingswood also a secondary ring transmitter. This prevented receiver activation to the south of Lots Road, but had negligible effect on the Brookmans Park/Lots Road boundary to the north. To prevent a similar situation developing in North London with Kingswood message transmissions, Brookmans Park was also made a secondary ring transmitter.

In the light of the results so far obtained it was considered that −4 dB was the optimum ring power for the trial transmitter configuration, and the next stage was to have been the survey of the remaining eastern half of the area. However, events conspired to prevent this happening. The Lots Road transmitter with its T-aerial strung between two chimneys of the London Transport power station was a continual source of trouble due to its ouput power varying in discrete two decibel steps, apparently at random. Despite considerable efforts the reason for this was never properly identified, although it was thought that the complex earthing system of the power station was partly to blame. Whilst this was a considerable inconvenience to the survey it had been possible to correct for these power variations by means of field strength monitoring at Kingswood. However, it was learned that the aerial would have to be temporarily re-positioned to allow repair work to be carried out on the power station chimneys. This would change the h.r.p. and consequently the service area boundary positions, making comparison between the existing results and any further work virtually impossible. It was therefore decided to abandon the idea of further use of the Central London transmitter for the trials since it was felt sufficient information had already been obtained regarding the operation of the ring system. All that remained was to provide a stable, reliable network for the purposes of assessing the communications efficiency and general receiver performance. Without Lots Road the remaining four transmitters could do this, although under these circumstances there was an overlap between the north and south transmitters which lay across Central London. This fact was used to an advantage, however, since the system could be tested under the most adverse conditions i.e. in a dense urban area where the signals were comparatively weak and subject to large variations.

Fig. 18 shows the survey results for the four transmitter network with ring power −4 dB relative to message. In general the overlap areas agree with the prediction, although Brookmans Park in certain areas does tend to come further south than might be expected. It is also apparent that the −4 dB ring condition is still a reasonable ratio to use since the overlaps are not excessive and there are no gaps in the overall service. For comparison with the prediction, service area limits were drawn, enclosing points of reception from each transmitter, although any which were well outside the service area, such as an isolated pocket of Brookmans Park reception in Esher, were ignored. There were relatively few of these, and they were attributed to re-radiation by local overhead wires, railway lines or similar sources. The service contours so derived are in Fig. 19 together with the computer predicted boundaries.

The survey provided much information regarding the operation of the ring system in terms of service area definition and network planning and control. The most important factors can be summarised as follows:—

1) service area assessment based on current m.f. field strength prediction techniques gives a good first approximation regarding the position of boundaries and the size of overlap service areas.

2) it has been stated elsewhere that a 60° lattice network with transmitters spaced 50 km from each other will give optimum coverage of the UK. This network is based on the assumption that a minimum spacing of 200 km is required between transmitters operating simultaneously. The survey work revealed there is a further reason for transmitters to be aligned on the 60° lattice. In such a network any message transmitter when not sited on the coast will be surrounded by six ring transmitters. If these ring transmitters do not have equal 60° angular spacing or are not at equal distances from the message transmitter then an irregular shaped service area will result. This may be acceptable in certain cases. Varying the ring powers can to some extent adjust the service area as well as the size of an overlap. It is also conceivable that horizontal radiation patterns of transmitters might be tailored to compensate for non-ideal transmitter siting or reduce field-strength deficiencies in certain directions. Such possibilities were mentioned at an early stage in the "CARFAX" development, although the calculation and achievement of a solution might be complex.

3) Whilst a ring power of −4 dB provided a reasonable overlap of service areas with the transmitters used, it must be remembered that neither the five station network nor the later four-station layout was typical of the full "six ring plus one message" transmitter configuration which should be found in a national network. Nevertheless, these limited tests confirmed that in any final system the ring power used should be in the range −4 dB to −6 dB relative to message. The actual value used at any particular site would be dependent to a large extent on ground conductivity and local structures.

4.2. The effects of interference upon "CARFAX"

The various aspects of interference to a "CARFAX" service are discussed in detail elsewhere[5,9,10]. The London area trial provided a useful opportunity to examine some of the problems in greater detail. Basically, the interference to the system can be categorised into two types according to its effects.

(a) that which caused degradation to the service through impairment of message intelligibility and reduction in service area, or

(b) that which results in unwanted receiver activation or de-activation either by sky-wave propagation of distant "CARFAX" transmissions or through mimicking of the START and FINISH signals by non-"CARFAX" emissions.

With an operating frequency of 526.5 kHz there were several likely sources of the type (a interference in the London area. There were a number of continental broadcasting stations operating on 531 kHz which became audible during the hours of darkness due to sky-wave propagation. The combined night time field strength on this frequency was typically 50-60 dBμ, comparable to the minimum field strength of the "CARFAX" signals at its service area boundary in a dense urban area, for the transmitter powers used in the trial. During service area boundary investigations made during late afternoons in Winter, this interference was definitely noticeable although with the station identification tones transmitted from the "CARFAX" network during the message period, it was not possible to make any observations regarding impairment of intelligibility. Later, when taped announcements were being radiated it was considered that despite the relatively high level of interference, intelligibility of the "CARFAX" message was not significantly affected. Various reasons were postulated for this and although these findings indicate that intelligibility would not suffer with the transmtter powers and spacings used in the trial, it is nevertheless quite likely that this type of interference would be considered objectionable, especially in urban areas where the "CARFAX" signals are attenuated. Because of this it was recommended that in a national network the effective radiated power for the message transmission should be about 250 watts where the service area boundaries are likely to lie in an urban area and/or where ground conductivity is poor, i.e. equal to or less than 3 mS/m per metre. Elsewhere, in suburban or rural environments somewhat lower e.r.p.s (down to 50 watts) would be adequate, depending on local ground constants and other factors.

It is appropriate at this point to consider one aspect of co-channel interference which has given rise to concern within West Germany concerning the international operation of a "CARFAX" system. In a report published by the Institute fur Rundfunktechnik" it is pointed out that the calculations regarding station spacing assume a ground conductivity of 10mS/m. The report emphasizes that there are large areas of Western Europe where the conductivity is 1mS/m or less, and coverage here would require many more transmitters. A number of observations must be made in response to this objection.

1. Only about 15% of the land mass of Europe to the west of longitude 30° E has a ground conductivity as low as 1mS/m.[12] These generally mountainous areas contain less than one per-cent of the road lengths in Western Europe, and a far smaller proportion of the total traffic.

2. There can be no doubt that traffic information will be valuable in these areas, which are often remote from assistance, and where warnings of difficulties will be needed. Equally, compared with the busier areas, the demand will be small, but a few strategically placed transmitters can go a long way towards meeting it.

3. It would often be inefficient to plan a total "CARFAX" network on the assumption that ground conductivity is poor, and hence that the transmitter density must be high. The network design should be flexible to accommodate not only organizational aspects such as changes in regional demands for information and the amount required, but also to take account of the technical constraints.

Because of the obvious need to conserve resources, these problems have not been studied on a European scale but examination of the situation within the United Kingdom where a wide range of ground conductivities exist reveal no grounds for concern.

As mentioned earlier, with regard to the type (b) interference, it was noticed in the preliminary stages of the trial that the "CARFAX" receiver in the survey vehicle was being frequently activated and de-activated by signals other than those transmitted by the trial network. Since these effects had not been observed on the receivers at Research Department the problem was originally thought to be a receiver fault or a problem caused by vehicle ignition interference. In fact, receiver activation did sometimes happen during engine starting, but the false triggering referred to here would occur with all vehicle electrics switched off. Foreign interference in the form of a Norwegian teleprinter signal on 524 kHz had been noticed, but discounted, since again it had produced no effects on receivers at Research Department. However, when it became apparent that this false triggering occurred more frequently near the East coast, and in particular along the Thames estuary, more attention was paid to its exact nature.

Signal analysing equipment and a selection of "CARFAX" receivers were taken to a point in East London where false activation frequently occurred. A spectrum analysis of the signal present at the discriminator output of a "CARFAX" receiver showed that occasionally, depending on the data being transmitted from the Norwegian station, peaks did occur at 125 and 200 Hz. As expected, these peaks coincided with receiver activation and de-activation. In the evening the signal strength started to increase due to sky-wave propagation, but with the simultaneous appearance of the much stronger continental broadcast transmissions on 531 kHz the teleprinter signal was rapidly over-ridden. The discriminator output of the receiver now represented the combined modulation of these broadcast signals with the result that there were no components at 125 Hz or 200 Hz of sufficient strength or duration to activate the receiver. This explained why false triggering had not been observed on the receivers at Research Department; during the day the teleprinter signal was too low to cause any trouble and during the evening, although the signal would have increased due to sky-wave propagation, it was exceeded in amplitude by foreign broadcasts and so rendered ineffective. A re-examination of the receiver characteristics by Carrier Systems Section of Research Department led to the proposal to increase the time constants of the START and FINISH detectors.

This was carried out, after which false triggering due to the teleprinter signal ceased to be a problem in the trial.

The "protection" created by interference from foreign broadcasters led to the suggestion that a single low power "blanket" transmitter in the "CARFAX" network could serve to protect receivers in quiescent areas from distant START signals. This proposal was tested by using a BBC transmitter at Shrewsbury to provide a CW signal on 526.7 kHz with an effective radiated power of about 15 W. Shrewsbury was a good location since it was 200 km from the London area network, a distance at which sky-wave signals would be at their maximum. However, at night time these sky-wave "CARFAX" signals did not appear due to the much higher levels of interference from the foreign broadcast stations on 531 kHz. Fortunately, during daylight hours ground wave signals from the Brookmans Park and Crowthorne transmitters provided reliable receiver activation in the area immediately south of Shrewsbury. Then by using the CW transmission from the Shrewsbury transmitter it was found that this receiver activation was effectively suppressed provided the blanket signal was about two decibels higher than the unwanted interfering signal. Thus it was suggested that in an active network such blanket signals could be provided either by a small number of relatively high power transmissions or by making every "CARFAX" transmitter in the network, when not in the message or ring mode, radiate a low-power blanket signal. In this case the type of modulation would be identical with the ring transmissions. An examination of the requirements revealed that the blanket power required would range from 1 – 16 watts depending upon the ground conductivity. For most of the country two watts would be adequate.

4.3. Communications efficiency measurements

An important part of the field trial involved the examination of the so-called "communications efficiency" (C.E.) for each transmitter. This defines the number of transmissions received from a particular transmitter as a ratio of the number actually radiated. Fig. 20 shows the distribution of a number of sampling frames, each 2.5 km square, which were selected for investigation. The network transmissions used in this part of the test were the same as those used in defining the service area boundary i.e. short identification tones broadcast from each of the four transmitters in turn with each tone bracketed with the usual f.m. START and FINISH signals.

The C.E. results were obtained by driving the survey vehicle around each of the 2.5 km test squares. The initial measurements consisted of counting the transmissions that both triggered and inhibited the receiver in the survey vehicle and noting the source transmitter for 25 full cycles of the network. If 23 or more transmissions from the service transmitter and 2 or fewer transmissions from other transmitters were received the vehicle moved on to the next square. If these conditions were not satisfied then the measurements were repeated in the square until 50 full cycles of the network had been recorded.

All of this work was dome in daylight hours in the absence of serious interference from foreign broadcasts. In order to access the effects of interference the survey was repeated during the night. The results of both daytime and nightime work are displayed graphically in Fig. 21.

Under the terms of the TRRL specification for the system the centre of an overlap region which can be regarded as the service area boundary is defined as the point at which the proportion of listeners hearing messages from adjacent transmitters is equal. The edge of an overlap region is defined as the point at which the proportion of listeners hearing messages from the unwanted transmitter drops to 20%. In the region between a transmitter and the centres of its overlap region at least 80% of the total listeners should receive the wanted message.

Referring now to Fig. 21a – the summary of results for the main North-South strip—it can be seen that the boundary overlap based on the above specification is about 12.5 km wide or 25% of the distance between the transmitters. The centre of the overlap region is about 30 km from Brookmans Park; at this point the C.E. is about 90% and does not fall much below this figure from the centre to either transmitters. This is for an overlap region in a fairly dense urban area typical of many towns and cities in the United Kingdom. From the inner edges of the overlap area to the wanted transmitter the C.E. is never less than 98%. The other North-South strip running south from the city area and illustrated in Fig. 21e displays the effects of the highly dense urban area on the centre of the overlap where the C.E. falls to 70%; however, once clear of the city, the C.E. rapidly rises to greater than 90%.

Results in the East-West strip shown in Fig. 21c are not completely satisfactory because of the distance between the Crowthorne and the Hoo transmitters. It lies to the north of the centre of the overlap between Brookmans Park and Kingswood and so Brookmans Park provides the major contribution.

Reference to the North-south night time survey Fig. 21b reveals that the centre of overlap is unchanged from the daytime situation although the boundary width is reduced to 20% of the distance between transmitters. Again it can be seen that the C.E. from the centre of overlap to the transmitters never falls below 90% at this boundary. The results shown in Fig. 21d are not reliable because of a reduction of radiated power of the Kingswood transmitter. The effects of this are apparent in the night-time measurements where the C.E. for Kingswood in some survey squares is much less than recorded in the day time.

It will be seen that both the day time and the night time results from the North-South direction (Figs. 21a and 21b) give C.E.'s in excess of the recommended minimum of 80% and therefore meet the TRRL specification. The East-West measurements represent the most critical test because the survey traversed the whole length of the North-South overlap area and crossed the adjacent East and West regions where three transmissions are received. Because of the Hoo/Crowthorne separation, the distance was excessive but even so, a C.E. figure of less than 80% was only recorded in four squares. This represents only 10% of the distance between Hoo and Crowthorne and reduced to a figure of 5% during the night time survey. When comparing day and night time measurements small variations in the C.E. should not be regarded as significant. They can be attributed to the interference but are just as likely to be due to the greater distance travelled in some survey squares at night. At that time the traffic density was less and the measurements were distributed more evenly in the survey area. Bearing this in mind it is clear that the levels of night time interference experienced during the trials would have negligible effect on a "CARFAX" service operating on 526.5 kHz.

The final phase of the field trial involved an assessment of the quality of reception by a number of drivers. "CARFAX" receivers were issued to approximately 40 volunteers, half of which were BBC staff and the remainder from the TRRL. The transmissions used for this part of the trial were recorded speech announcements. Each message lasted for about 15 seconds and was repeated from each transmitter at regular 10 minute intervals. This test lasted for two weeks and drivers were asked to record details of every journey made and their observations on the quality of "CARFAX" broadcasts received during their journey. They were also asked to record instances of false triggering of the "CARFAX" receiver, failure to cancel and any interference problems. The receivers which were used were made by several commercial manufacturers to the BBC specification[7]. Some of the designs were similar to the original prototypes using active tone filters to detect the START and STOP signals. Other designs favoured the use of a phase locked loop tone detector, mainly to save on component costs.

The majority of receivers operated satisfactorily, responding correctly to the "CARFAX" START and FINISH signals. Any false triggering that did occur amounted on average to roughly one false activation or de-activation for every 15 hours of "CARFAX" transmission. This user trial showed that despite the high professional standards of the drivers sampled – which would heighten their criticism – general reaction to the "CARFAX" system was favourable. Receiver activation and de-activation worked well although poor performance was experienced with some of the add-on receiver units. In terms of audibility and quality of announcement, however, there was room for improvement. Increasing the transmitter powers from 50 to 250 watts would undoubtedly help to overcome the audibility problem which was reported in urban areas, and strict adherence to the original AGC specification for the receivers would reduce the difficulty. It also became clear that further research was necessary into voice analysis and signal processing to improve intelligibility, particularly in this case where communication with motorists was being attempted with a restricted-bandwidth broadcasting system. For the purposes of the trial on 526.5 kHz a r.f. channel width of 7 kHz was used in order to minimize effects of adjacent channel interference.

4.4. Conclusions of the trial

In general terms the trial confirmed the technical feasibility of the "CARFAX" system. It also revealed some features which were worthy of further investigation. One of these was the concept of message addressing or labelling. This would require the transmission of a short digital code between the end of the START code and the MESSAGE period which with the aid of a suitable decoder in the receiver could allow the user to opt for different priorities or categories. For instance the receiver could be programmed to accept new messages and to ignore subsequent repeats. Alternatively, messages could be transmitted in different languages. Depending upon the degrees of sophistication the additional costs could be relatively small.

Other uses of the "CARFAX" transmitter network were also postulated. Due to the sporadic nature of traffic information, the "CARFAX" channel would be quiescent for a substantial part of the time. It has been estimated from existing and forecast traffic statistics that a national network would only occupy the channel for about 25% of the total transmission time. The resulting spare time might be attractive for other uses, e.g., radio paging, data transmission, weather forecasts, beacon and general navigation purposes. Such services need not be put at jeopardy by short delays and could well fit in with a traffic information system. Thus the allocated channel could be seen as satisfying a number of requirements for different types of information which could be broadcast, but uniquely addressed to particular users.

One obvious feature of the "CARFAX" network is the ability for the service areas to expand to occupy a pocket created by the operational failure of a transmitter. This advantage means that stand-by equipment is not essential at the transmitting station. Conversely, applying the same feature, it is possible to provide for additional small areas, on either a temporary or permanent basis, having their own dedicated traffic information. Examples are approaches to airports or ferry terminals or short-period requirements near exhibitions, sports events, demonstrations etc. These requirements could be easily met by low-power transmitters, possibly transportable, with the main network providing ring signals. For instance a transmitter with an e.m.r.p. of 1 watt could cover a radius of 3km.

An important further application of this principle is the provision for motorways. A length of motorway can be treated separately by using a conductor running along the sides. Appropriate starting signal and ring signal combinations can provide for

(a) reception of a message on the motorway only,
(b) reception in the surrounding area but not on the motorway, or
(c) reception in the area including the motorway.

This would have obvious advantages for dealing with information important only to motorway users or only to the surrounding area.

Many features such as those outlined above were identified during the course of the trial but, although regarded as technically feasible, none of them were examined in depth. Nevertheless the result of the tests that were undertaken showed that, given a clear channel. there would be considerable scope for development of the original idea.

5. The present situation

Following the completion of the field trial, two barriers had to be surmounted before steps could be taken to introduce an operational network. The first of these concerned the financial backing and, as this is non-technical aspect, it is not discussed here. It is sufficient to record that there was evidence that adequate money would be made available to implement at least a partial service, although there was clear concern that future expansion and revenue costs might present difficulties. Without some form of regular income, derived either from manufacturing and/or receiver licences, future operation might be in jeopardy. However, discussion of this aspect was rendered unncessary by the overriding technical problem which had accompanied the project since its inception, namely, the allocation of a suitable frequency.

All the development work which had taken place on the "CARFAX" project had used frequencies in the lower part of the MF broadcasting band. The need for a low MF channel stems from the concept of the system. In order to achieve the coverage required a frequency having a propagation loss inversely proportional to distance and significantly unaffected by terrain was necessary. Without exception, all of the otherwise suitable broadcasting channels have high levels of night time interference which would seriously limit coverage. After extensive study and discussion the frequency of 526.6 kHz was chosen for the field trial – it was not co-channel with any other broadcast transmitter, although as reported above it did suffer adjacent channel interference at night from high power broadcast stations on 531 kHz. To reduce the effects of "CARFAX" interference to adjacent users its channel width was, as reported earlier, limited to 7 kHz.

Prior to the World Administrative Radio Conference of 1979 the lower limit of the m.f. broadcasting band was 525 kHz. However, realignment of the limits at the Conference transferred the primary allocation of the band up to 526.5 kHz to the maritime mobile (radiotelegraphy) services, thus the boundary coincided with the carrier frequency being used for the trial. In an attempt to secure some recognition for "CARFAX" the U.K. delegation to the 1979 WARC proposed an assignment for a "public information service" between 519.5 and 526.5 MHz.

Unfortunately this was achieved for the U.K. alone and with only secondary status but, combined with successful operation of the trials network in co-existence with broadcasting assignments on one side and aeronautical and maritime installations on the other, it supported the hope that a long term solution could be engineered for a permanent network on 526.5 kHz. However, in April 1981 provisional proposals were published by the Home Office for the use by Maritime mobile services of the spectrum right up to the limit of the band[13]. These proposals envisaged the introduction of a narrow band direct printing (NBDP) facility between ships and shore stations. Paired working was foreseen with 20 channels in the Band 469.5 – 479.75 kHz assigned to shore stations, and 20 ship-station channels in the Bands 514.5 – 517.5 kHz and 518.5 – 526.5 kHz. In addition the gap between 517.5 and 518.5 kHz was to be used by shore stations to provide NBDP meteorological and navigational warnings.

On the face of it the latest proposals completely ruled out any possibility of instituting a traffic service on 526.5 kHz. However, the Home Office agreed to examine the situation further and in order to do this the BBC formally submitted proposals for a "CARFAX" network in late 1981. Fig. 22 illustrates the plan which included 98 stations. There then followed a period of discussion with the Home Office on various technical aspects of the proposals.

Whilst acknowledging the prior rights of this part of the spectrum to the maritime users, the argument for "CARFAX" was maintained on the grounds that it was in effect the only chance to establish what could be seen as "safety of life" allocation for road users. This emotive phrase is often used in the argument for channels for aeronautical and maritime services and whilst their needs cannot be denied the fact that no such communication channel exists for drivers must be noted. One statistic which underlines this deficiency can be quoted from accident records. For example, in 1980 the number of deaths caused whilst using water transport in and around the U.K. totalled 75; the equivalent figure for road transport was in excess of 6000. Such results seem strong arguments for finding some way of improving communication between the motorist and the authorities responsible for providing traffic information.

It was technically apparent that some degree of sharing with mobile interests could be achieved. For example, in the course of the field trial French aeronautical beacons were expected to suffer interference from the "CARFAX" operation and a separate test was carried out to examine this. A particular case studied in late 1981 involved an installation at Amiens (Glisy) which was in operation on 524.5 kHz as a locator beacon, 2 kHz below the "CARFAX" frequency. Tests carried out in a light aircraft fitted with an ADF receiver tuned to Glisy showed that "CARFAX" transmissions from the Hoo station in Kent produced no detectable error in the airborne equipment at the published limit of the beacon's service (25 nautical miles). Under these circumstances the power of the "CARFAX" transmitter was about 65 W and was producing field strengths in Northern France typical of stations in the final "CARFAX" network.

Three possible solutions were suggested to the Home Office to enable "CARFAX" to continue. The first of these requested that NBDP services should avoid those channels affected by "CARFAX" – effectively a reduction of their proposed service. This was plainly an unpopular suggestion so that two other solutions postulated means of sharing:–

(i) by re-arranging NBDP assignments to accommodate the "CARFAX" service, or

(ii) by designing a combined maritime/road traffic service, whereby the number of NBDP assignments might be reduced, and space released for this new proposal.

In the case of the first alternative it was suggested that the proposed NBDP ship/shore assignments might be interchanged, so that shore stations would use the higher channels in the range 514.5 to 526.6 kHz. The operation of these stations could then be programmed in the TDM sequence used for the road traffic installations. Estimates of the demand for traffic information by the "CARFAX" network suggested that at most this would be for 25% of the air-time, so this was felt to be a minor constraint on the NBDP operation.

For the second alternative, a network was proposed in which the coastal transmitters would provide a shared maritime/traffic service. The transmission requirement for traffic would be speech, but there was no reason why a multiplex system providing both telephony and telegraphy for maritime purposes should not be incorporated. The coastal stations would be able to cover shipping up to a range of about 75 km, and they could provide meteorological reports and general navigational warnings. Such a service could also

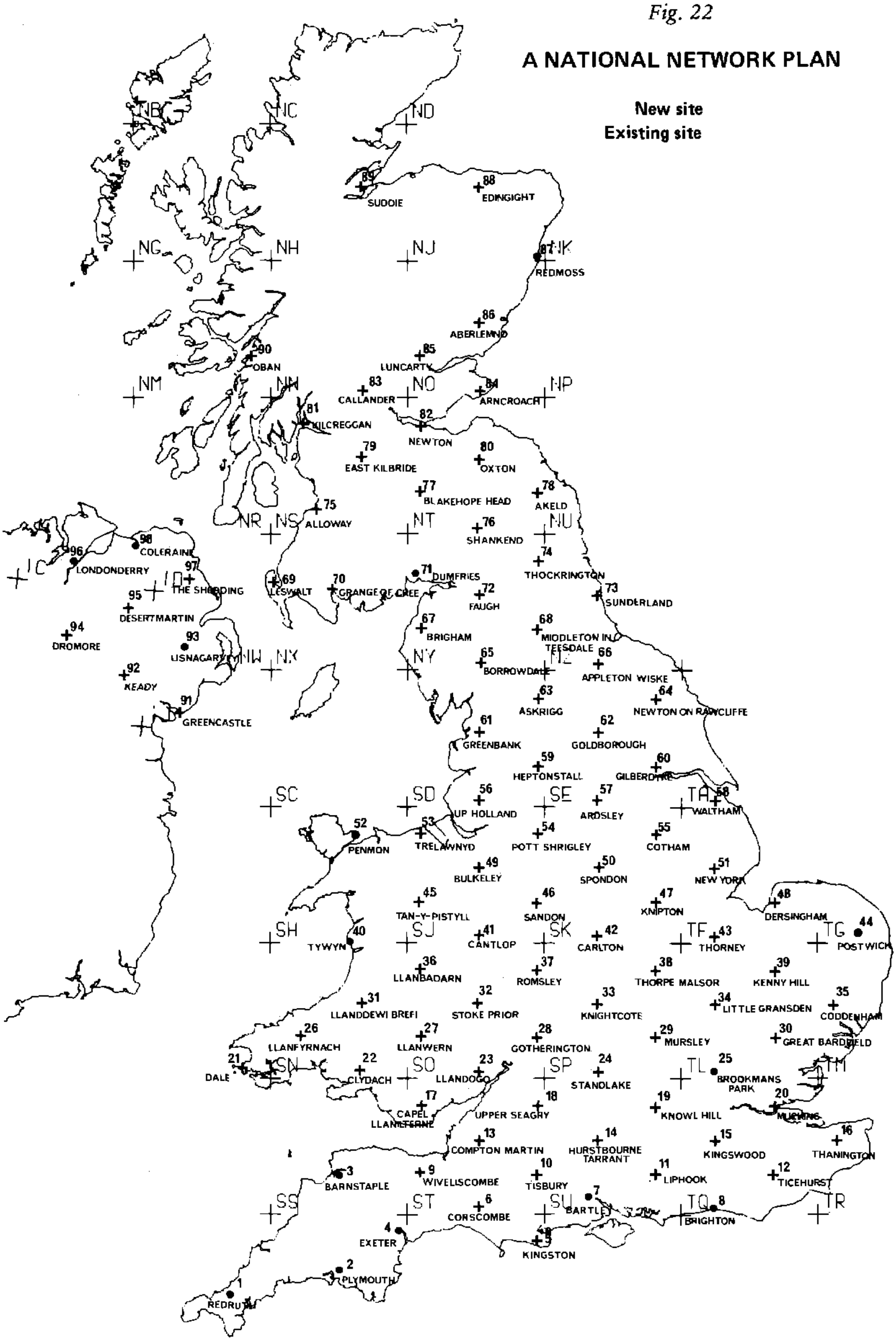


Fig. 22

A NATIONAL NETWORK PLAN

provide a commentary on shipping movements – a desirable feature in the congested sea lanes off the French and English coasts. In addition, for both maritime and aeronautical interests, a network of transmitters operating on TDM on a single frequency could provide better position-fixing facilities than those offered by the present MF beacons.

However, little if any progress was made with these constructive suggestions. In an attempt to obtain some Continental backing for the ideas, discussions were arranged by the Home Office with the French Administration, but although they were sympathetic, little tangible progress was made. These discussions and others did reveal possibilities of joint work in the design of a system based largely on "CARFAX". Work in France on the PAAC system[14] had made some progress, but the "CARFAX" ideas were apparently attractive. However, the international non-availability of a frequency prevented further co-operation.

The final stage in the frequency discussion was reached in December 1982. At this time activity was building up on the preparation for the Mobile Conference, scheduled to be held in 1983 at which the maritime allocations would be cleared. A final approach was made by the BBC to the Home Office, with the intention of examining with the maritime authorities the sharing possibilities outlined above. A meeting of the Steering Group of the WARC Mobile Telecommunications Conference was attended, but unfortunately the technical aspects of the subject were not analysed because of the administrative barriers. It was felt that, as the U.K.'s proposals for the band had been published internationally, any alteration at this stage would weaken the U.K's credibility. It was clear that without even national agreement the secondary status of the broadcasting assignment on the channel 519.5 to 526.5 kHz was worthless. The Home Office emphasised that they were immediately concerned with an allocations conference in which bands of spectrum would be allocated to specific services internationally; the possibilities of national sharing arrangements might be opened up again in a few years' time when assignments to stations were decided. But this was felt to be a very remote chance, and in any case further delay of the project would certainly mean that it might well be overtaken by recent developments. Accordingly, hope of finding a suitable medium frequency for "CARFAX" was abandoned.

6. Prospects for the future

As mentioned in the previous paragraph, any consideration of "CARFAX" must take account of other technological developments in the same area. Assuming, however, the original concept of a dedicated service has much to offer, the question arises of finding an alternative frequency. This question has, of course, been studied many times, and the conclusions remain unchanged. The use of a channel in the l.f. band has been ruled out on the grounds of cost of the transmitting installation alone. Even if the costs are ignored, the technical opportunities are slight. The eventual clearance of the band 255 to 285 kHz for broadcasting might offer some chance of finding an assignment, but there are clear signs that there will be considerable demand to use these channels for new high-power stations. There is also the present U.K. assignment on 227 kHz, but high interference levels render this unattractive. The situation in the m.f. broadcasting band has been thoroughly explored. There is no doubt that gaps could be found where daytime operation would be feasible, but at night interference levels on the best channels are between 70 and 80 dB(μV/m). Even with extremely optimistic protection ratios the night-time service radii of "CARFAX" stations would shrink to the order of a kilometre. Re-arrangement of domestic m.f. broadcasting assignments might yield a channel, but this would involve much study, with no certainly of an acceptable result. It would also impose another round of confusing changes on the listening public. From the m.f. to the h.f. band, rapid decay of the ground wave especially over built-up areas is an unattractive feature, as is the enhanced sky-wave situation.

Consideration has also been given to the possibility of using a VHF channel. The extensive changes planned for Bands I and III following the 1979 WARC provide an opportunity to negotiate a new service. A vertically polarised transmission on a channel at v.h.f. - say in the 50 to 60 MHz region - would give interesting possibilities with somewhat more consistent reception than in Band II. The receiver would, however, be more expensive than one for m.f. not only because of the v.h.f. front end, but also because the field strength variations require a more complex receiver and a different transmission system to ensure reception in the desired area. Field-strength ratios would be perturbed more than at m.f. so that frequent errors of selection would occur, especially near area boundaries, if the original principle of starting and muting were to be used. A time-delay principle would probably be necessary; preliminary work on a system[15] has been carried out and suggests that this approach is quite practicable. Nevertheless a development period of some 18 months would be needed and a new transmitter network costing of the order of £3M would be involved.

"These considerations have led to the proposal of an alternative which uses a form of data transmission from existing transmitters. Within the European Broadcasting Area agreement has been reached on the standardisation of parameters to be used for the transmission of radio data on the v.h.f./f.m. services. The total net channel capacity in the unified system is likely to be about 700 bits/second, of which about two-thirds will be used for basic tuning information. Therefore about 200 bits/second might be made available (on one programme network) for traffic information. It has been estimated that, making allowance for repetition to cover errors and to improve reception reliability, a speech rate of about 100 words/minute could be reproduced by a voice synthesiser in the car. Thus messages could be entered via a conventional keyboard, sent to the v.h.f. transmitter serving the appropriate area and so form part of the data stream modulating the 57 kHz sub-carrier.

The main disadvantage at present affecting such a system is the inability to limit individual broadcasts to motorists in zones within the service area boundaries of the v.h.f. stations. In the U.K., busy areas – in terms of traffic – tend to be those which are heavily populated, and these are almost invariably covered by high-powered transmitters which produce large service areas. A great deal of traffic information is therefore needed to satisfy road users in such areas, and here it is useful to illustrate the situation by quoting the situation in the London area served by the v.h.f. station at Wrotham. It has been estimated that a full traffic information service from this station would require the transmission daily of over 400 announcements. Most of these would need to be packed into four rush hours, and during these periods traffic information would occupy about 45% of the total time.

There are two problems with the radio data approach arising from this. The first is the danger of overloading capacity at peak periods and the second is the problem that only a small proportion of the numerous announcements may be relevant to a particular motorist within a large coverage area. The former problem might be helped by sending standard types of message in an abridged or coded form, which is possible when using a voice synthesiser approach, and the latter could be helped by having header codes for different subdivisions of the coverage area and allowing the motorist to select one of them. A third problem affects the choice of radio listening by the driver. There may be a need to carry traffic information on all v.h.f. transmissions serving the area concerned so that there is a choice between the programmes available in the f.m. band. Otherwise, a free choice of programme will require a dual-channel receiver that can obtain the data from one transmission while tuned to receive the programme from another.

Such developments, however, are beyond the scope of the present report, and work in refining the methods of using the radio data system for traffic information is still in progress. It is apparent that an important advantage of using the radio-data system is that much lower investment is required by the broadcaster at the transmitter end". However, on present evidence the scope of radio-data for traffic information inevitably falls short of what could be achieved using the fully-dedicated "CARFAX" system. Having regard to the very tangible advantages, the non-availability of a suitable frequency for "CARFAX" is regrettable.

7. Acknowledgements

This report outlines the work which has been carried out by many BBC engineers. In particular the field trial presented many difficult problems but complete and willing co-operation brought the project to a technically successful conclusion. Mention must also be made of BBC staff in the programme area, particularly the Motoring and Travel Unit, who provided much helpful advice. There was substantial co-operation from engineers at the Transport and Road Research Laboratory, and much assistance was also provided by the car radio industry, particularly Smiths Industries (Radiomobile).

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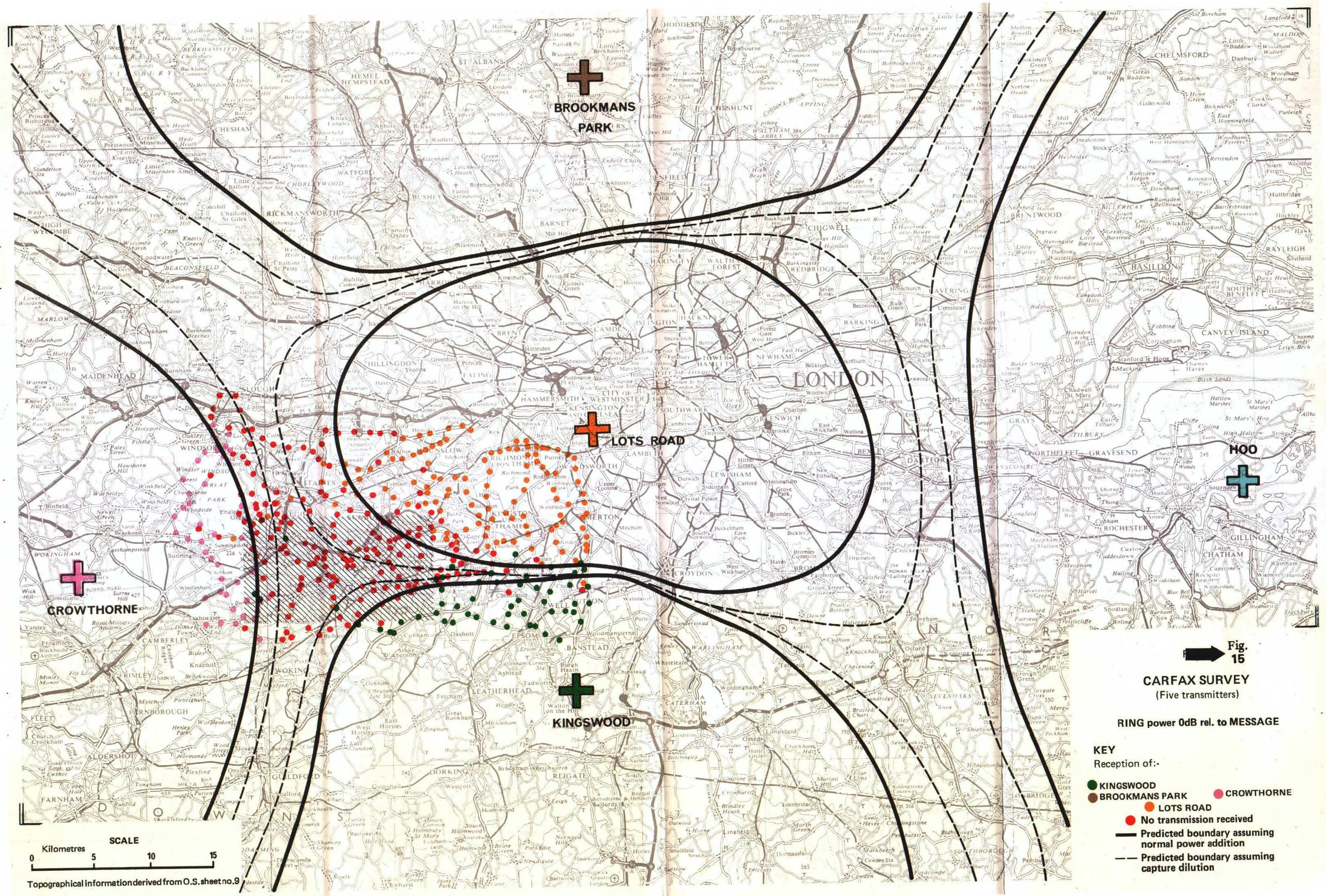
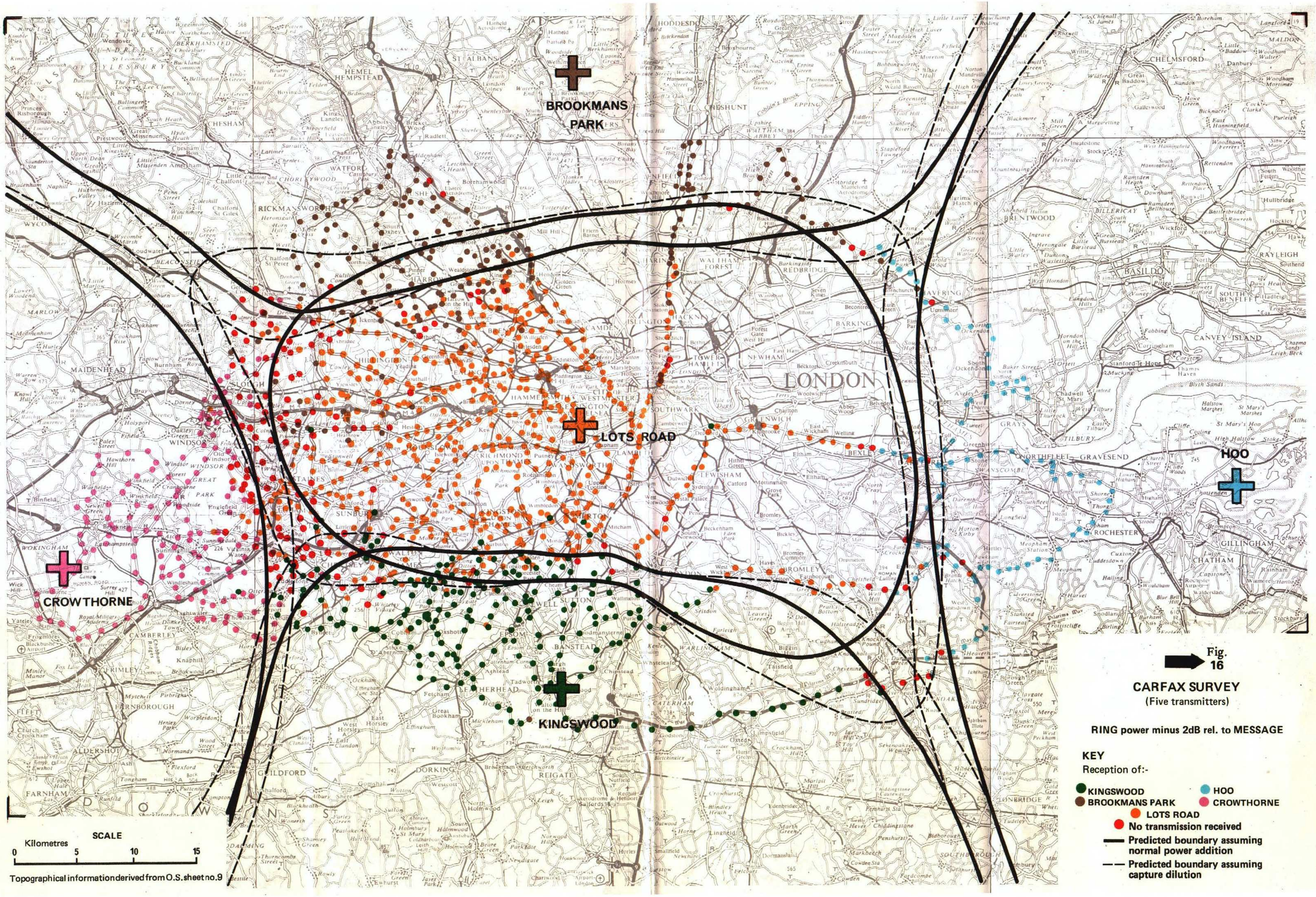


BROOKMANS PARK
LOTS ROAD
HOO
CROWTHORNE
KINGSWOOD
LONDON
Fig. 15
CARFAX SURVEY
(Five transmitters)
RING power 0dB rel. to MESSAGE
KEY
Reception of:-
KINGSWOOD
BROOKMANS PARK
CROWTHORNE
LOTS ROAD
No transmission received
Predicted boundary assuming normal power addition
Predicted boundary assuming capture dilution
SCALE
Kilometres
0 5 10 15
Topographical information derived from O.S. sheet no.9


BROOKMANS PARK
LOTS ROAD
HOO
CROWTHORNE
KINGSWOOD
LONDON
Fig. 16
CARFAX SURVEY
(Five transmitters)
RING power minus 2dB rel. to MESSAGE
KEY
Reception of:-
KINGSWOOD
HOO
BROOKMANS PARK
CROWTHORNE
LOTS ROAD
No transmission received
Predicted boundary assuming normal power addition
Predicted boundary assuming capture dilution
SCALE
Kilometres
0
5
10
15
Topographical information derived from O.S. sheet no.9

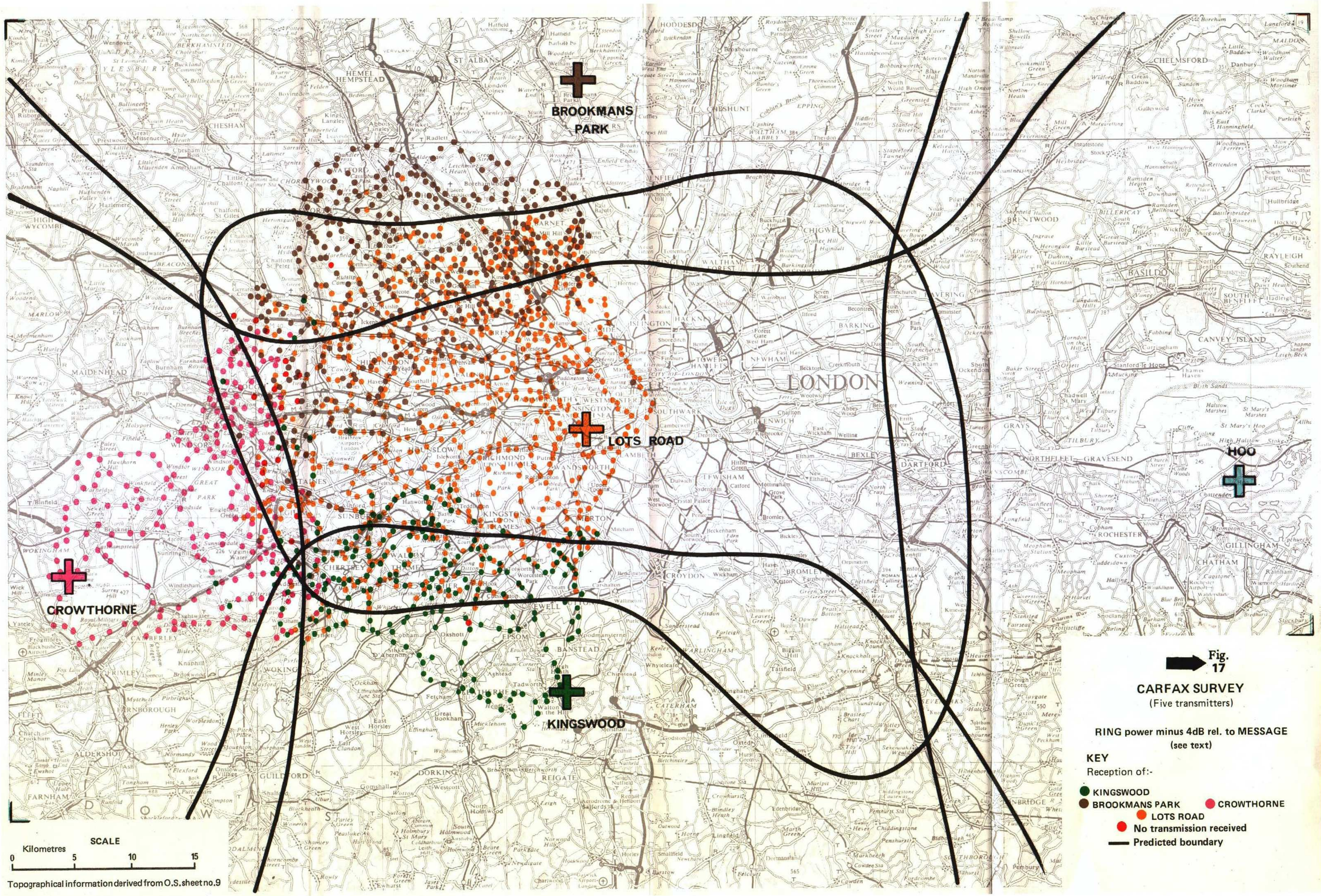
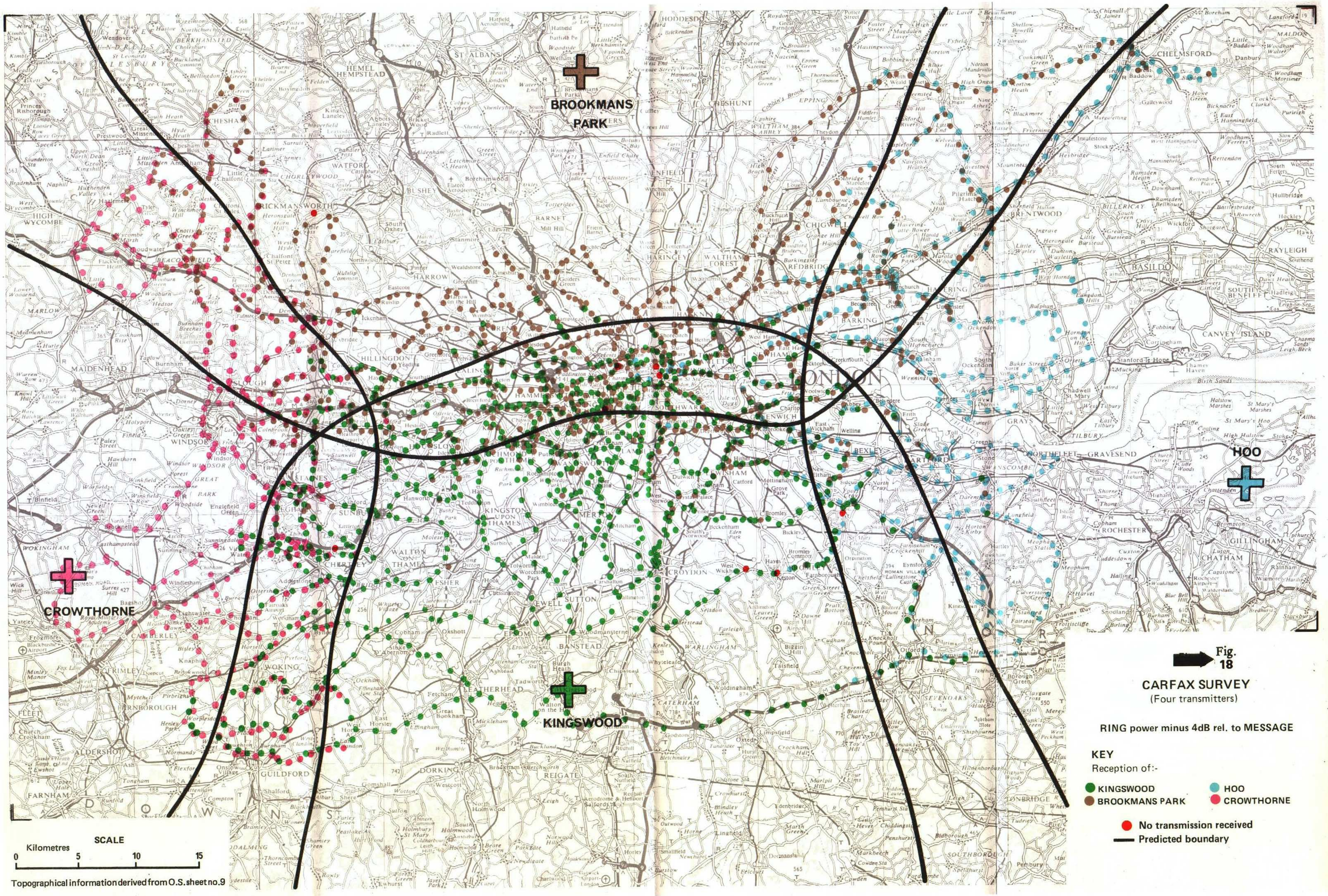


Fig. 17
CARFAX SURVEY
(Five transmitters)
RING power minus 4dB rel. to MESSAGE
(see text)
KEY
Reception of:-
KINGSWOOD
BROOKMANS PARK
CROWTHORNE
LOTS ROAD
No transmission received
Predicted boundary
BROOKMANS PARK
LOTS ROAD
HOO
CROWTHORNE
KINGSWOOD
LONDON
SCALE
Kilometres
0
5
10
15
Topographical information derived from O.S. sheet no.9


BROOKMANS PARK
KINGSWOOD
HOO
CROWTHORNE
LONDON
SCALE
Kilometres
0 5 10 15
Topographical information derived from O.S. sheet no.9
Fig. 18
CARFAX SURVEY
(Four transmitters)
RING power minus 4dB rel. to MESSAGE
KEY
Reception of:-
KINGSWOOD
BROOKMANS PARK
HOO
CROWTHORNE
No transmission received
Predicted boundary

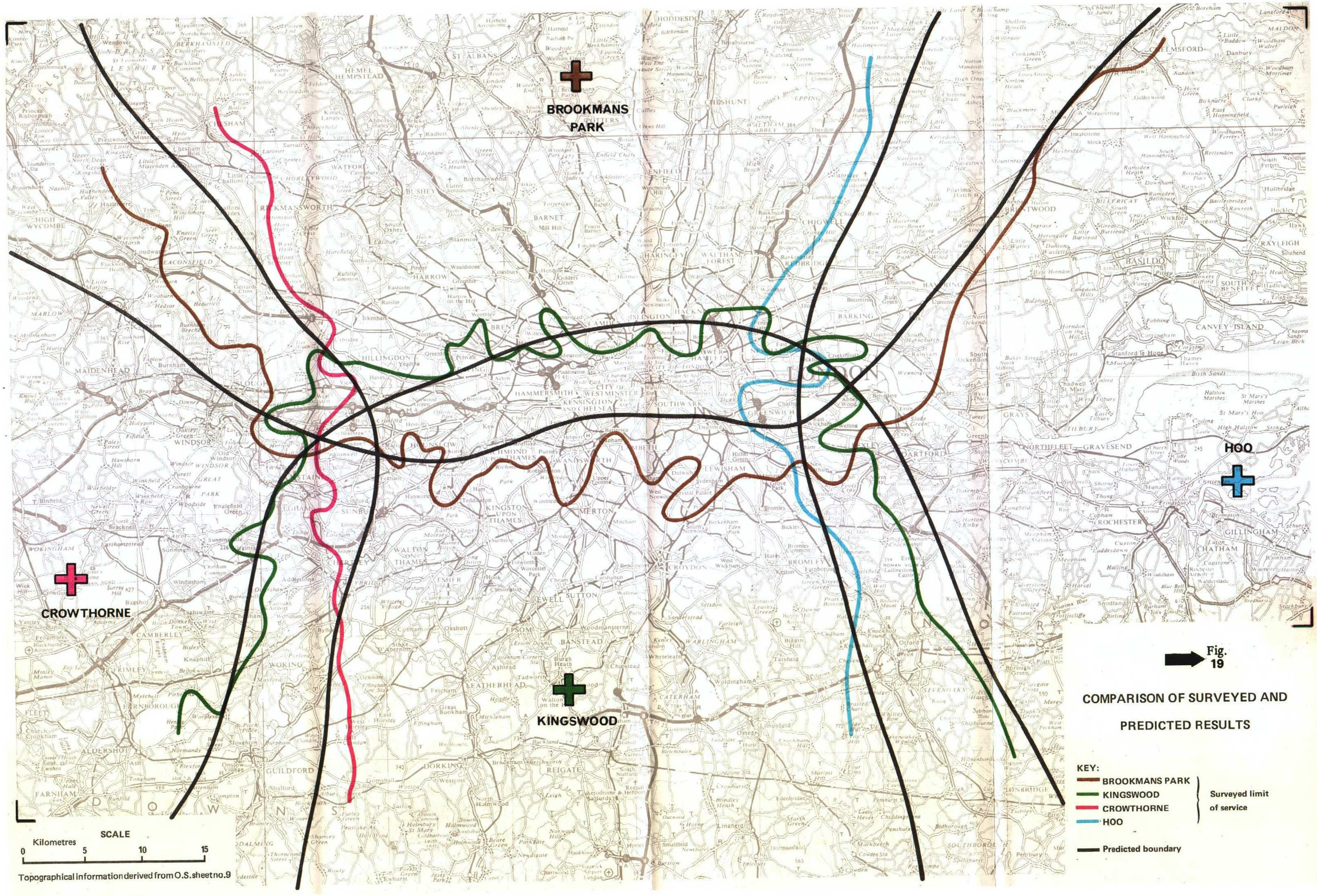


Fig. 19

COMPARISON OF SURVEYED AND PREDICTED RESULTS

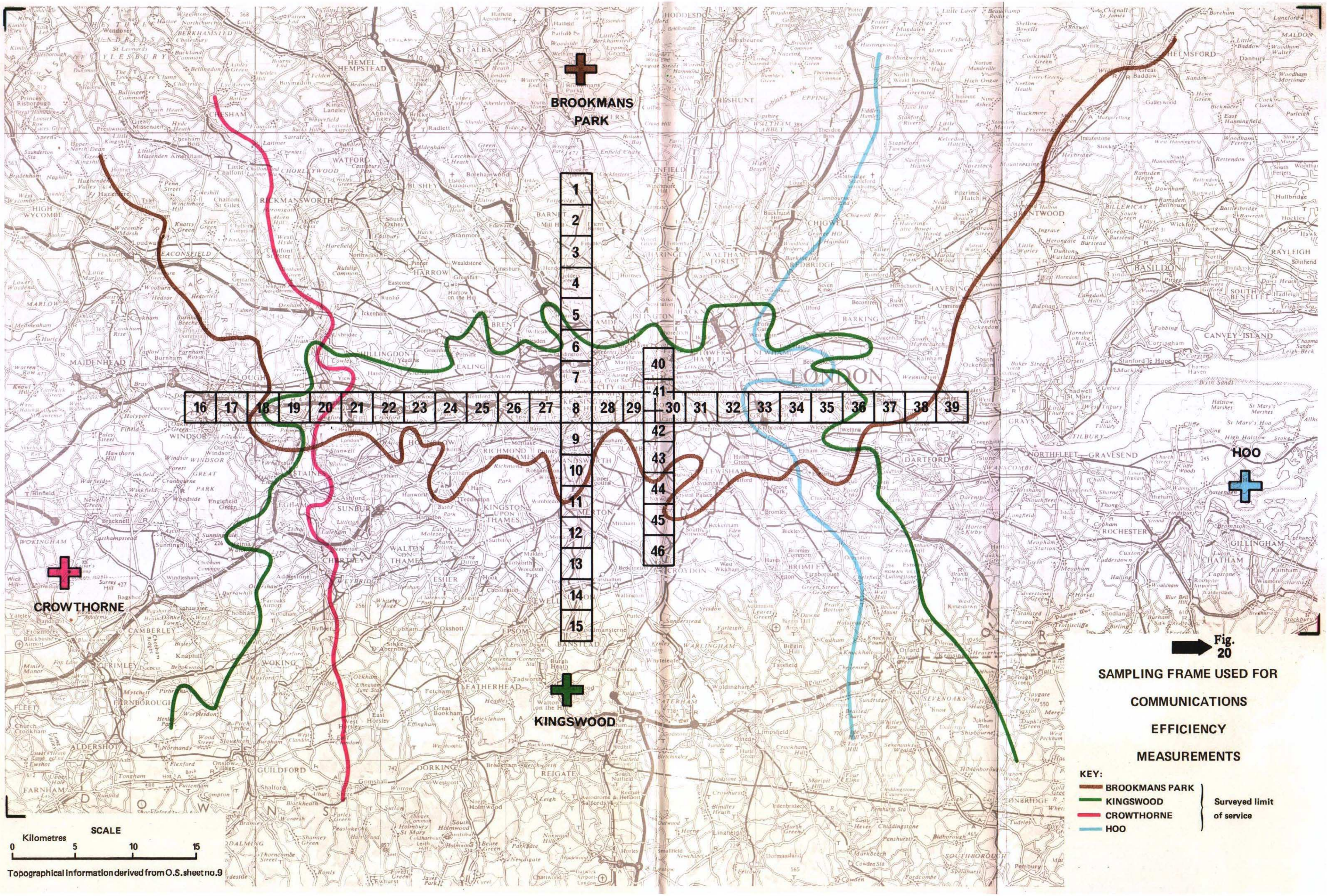


Fig. 20

SAMPLING FRAME USED FOR COMMUNICATIONS EFFICIENCY MEASUREMENTS

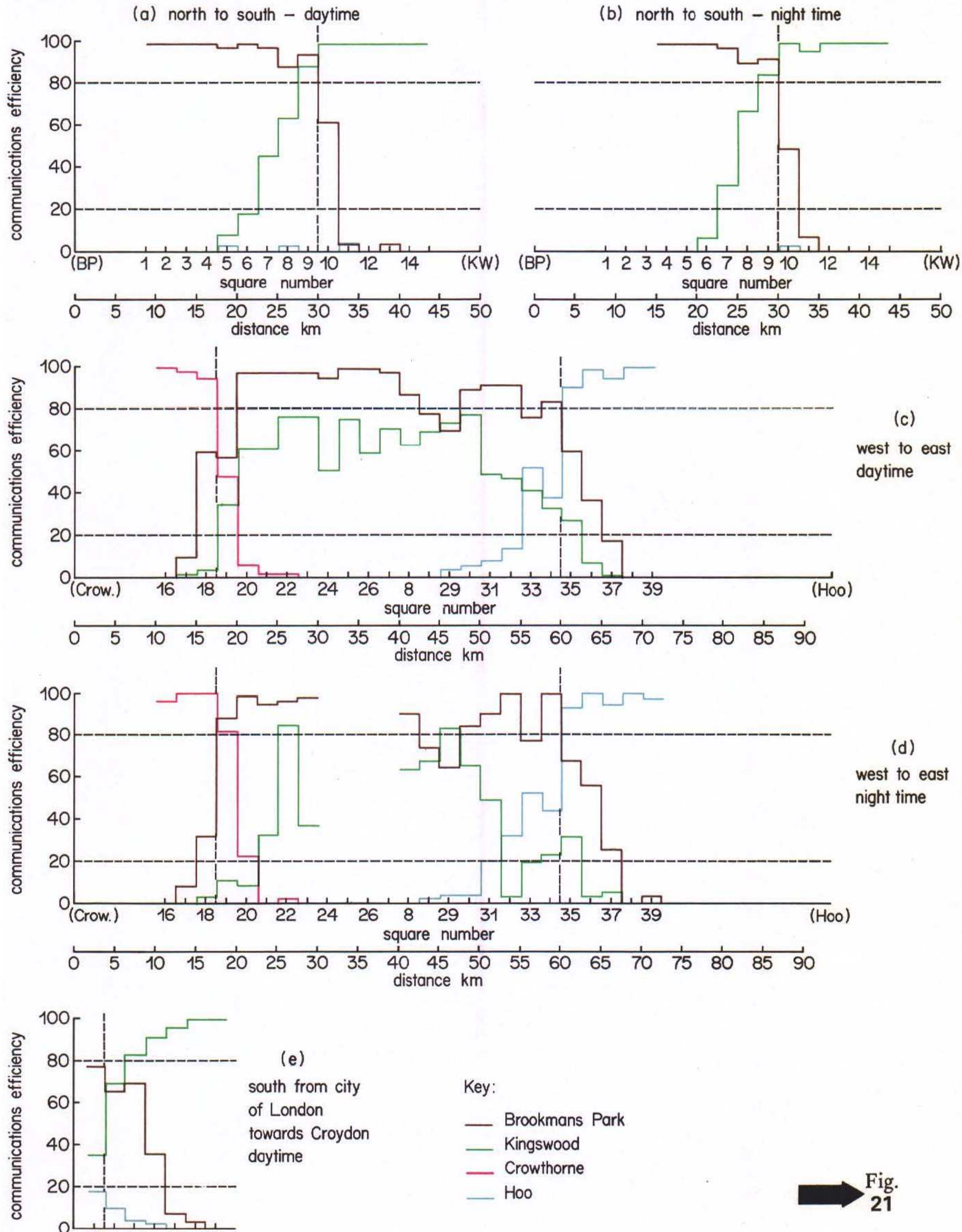


Fig. 21

COMMUNICATIONS EFFICIENCY MEASUREMENTS

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