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Draft Report

Options for Emergency Communications

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NRA EMERGENCY COMMUNICATIONS STRATEGY STUDY

Preliminary findings

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NRA Note

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FOREWORD

PURPOSE OF THE NOTE

The purpose of the Note is to describe the results and recommendations of a strategy study for emergency communications in all regions of the National Rivers Authority (NRA).

The note is presented in four sections. The first is an Executive Summary. Section 2 describes the findings. Section 3 is a review of existing communications technologies, Section 4 a review of emerging technologies which may be of future interest.

1. EXECUTIVE SUMMARY

1.1 Background

Since its formation in 1989, the NRA has undertaken a number of studies to develop a coherent strategy for its information systems and telecommunications. This study is concerned with emergency communications.

1.2 Study Methodology

The study consisted of two activities carried out in parallel:

1. A series of interviews and questionnaires were held/completed by NRA staff. The purpose of these activities was to review current communication facilities for emergency incidents in all functional areas of NRA regions and to determine:

- o the nature and requirements of emergency incidents;
- o communications and control facilities available during an incident;
- o user attitudes and ideas.

2. A review of telecommunications technologies currently available or expected to be available soon, to determine which technologies are relevant and to identify strategic options for further consideration.

The results of these activities are described in detail within the document. Conclusions are drawn about strategic options and are presented in the following section.

1.3 Summary Of Findings

The principal findings and conclusions are summarised below.

1. No statistics are currently available on emergency incidents, making investigation of control room structures and system choice subjective.

   Further research is required.

2. User confidence in Private Mobile Radio Schemes is generally poor, as a result of bad design and poor operations of existing old technology systems.

A well designed correctly managed PMR Scheme would meet the general requirements for mobile communications.

3. A mobile communications centre would offer versatility and a degree of resilience.

This philosophy should be considered and costed.

4. No single system can offer a complete solution to all emergency communication problems. Utilisation of PMR and commercially available cellular telephony would offer:

- resilient service options;
- increased availability;
- flexibility in operation.

2. STUDY FINDINGS

2.1 Introduction

A study into communications during emergency incidents requires three main areas to be addressed;

- Control room structure.
- Fixed communications systems
- Mobile communications systems.

This section reviews each of the above in light of the statistics and comments gained from the first phase of the project and provides strategic options for both the present and the future.

2.2 Control Room Structure

It is clear from the statistics obtained that the number and disposition of control rooms varies considerably between one region and another. From these figures no correlation can be found between the number of rooms and the number/type of incidents occurring in the various regions. This makes a review of current structures difficult as the reasoning behind any hierachy is individual to particular areas. Certain points however can be made;

- There is currently no resilence in control room structure. Failure of major services or evacuation of the room can be catastrophic. what is a control room i.e. comms centre ?
- Availability of fixed services appears good but does rely on normal office systems which may be prone to congestion.
- The control of incidents in terms of the dissemination of information is remote from the incident, hence increasing the probability of failure of the lines of communication to field staff.

2.3 Fixed Communications

Utilisation of fixed communications systems is high nationally, and forms the major system in control room operations. User perception of these systems is generally good, they are seen as reliable with good availability. Certain points should however be considered;

1. **Congestion**

   Due to the structure and capacity of the public telephone system, congestion is rarely encountered. However, exceptional circumstances such as the Hungerford shooting incident, caused the local exchange to block all incoming trunk service.

   Congestion is far more likely at the subscriber local connection where an insufficient number of lines is available for the quantity of traffic generated. In the case of NRA emergency incidents this could involve;

- Inability to receive incoming calls from the public or any other body with information relevant to the incident.
- Inability to receive incoming calls from NRA field operatives
- Inability to make outgoing calls.

To relieve this situation several steps have been taken:

- Installation of dedicated lines for various points of contact; NRA, Emergency Services, etc;
- Configuration of PABX systems to ensure outgoing access is available even during periods of heavy traffic;
- Recorded announcements on public lines, providing details on the incident status and where contact should be made when this is not sufficient.

2.4 Mobile Communications

2.4.1 Introduction

Mobile communications is the main point of contention for all parties involved both in general operations and particularly during emergency incidents. The requirement is simply defined as;

- The ability to communicate with a reasonable degree of certainty to operatives in the field.
- Communications achievable with minimum delay in setup.
- Communications to be possible to both internal "same system users" and external parties.
- Open channel capability for "awareness" broadcasts.

The major point for consideration in the above being availability of the system.

2.4.2 Systems Availability

Systems availability is a combination of several factors; coverage, traffic loading and system reliability.

1. **Coverage**

   Confidence in any radio scheme is greatly enhanced if coverage is maximised within the area of operations.

   The coverage of the mobile systems available to the NRA is limited. Design and control, is achieved through joint arrangements as either service provider or user within other water industry groups.

2. **Traffic loading**

   Any commercial mobile communications system operates on the basis of revenue generation by system loading, either in terms of calls processed or subscribers registered. In order to maximise returns the system must be designed to provide an adequate service under normal operating conditions, the quality of service provided can therefore vary widely under high traffic loadings.

Water industry PMR systems whilst operating commercially by acting as service provider to several industry groups do not operate under quite the same commercial constraints. Thus allowing by virtue of internal system management the ability to control loading and hence access under emergency conditions.

This control of access is also offered by cellular telephony service providers by Access Overload Control (ACCOLC). This is a control programme to ensure that in an emergency the emergency services, relevant utilities, and others, can gain priority access to cellular radio systems. Police primacy is assumed with service providers looking to the relevant Force to co-ordinate request for service.

2.5 Strategic Options

2.5.1 Introduction

Several options exist for communications in emergency situations

- Use of normal communications channels and systems.
- Use of normal communication systems supplemented by additional resources operating within a set of defined emergency procedures.
- Use of dedicated systems and communication channels outside those used on a day to day basis.

  This could be achieved with a mobile communications vehicle.

Option selection should be based on:

- Incident parameters for which statistics were requested.
- Cost, both capital and revenue.

This section utilises the overall finding of the study to suggest strategic options, for both short and long term consideration.

2.5.2 Available Options

1. **Control room structure**

As statistics are not available a review of current control room structures has proved impossible to achieve. It has however been noted that the use of dedicated national control structures is generally not considered appropriate, with the majority of incidents which occur being handled successfully by the current local structures in place.

2. **Communications systems**

No single communications system offers a complete solution for all the emergency incident problems currently encountered by operational staff. It is however considered that a correctly designed and managed PMR scheme offers the Regional authorities a cost effective system providing;

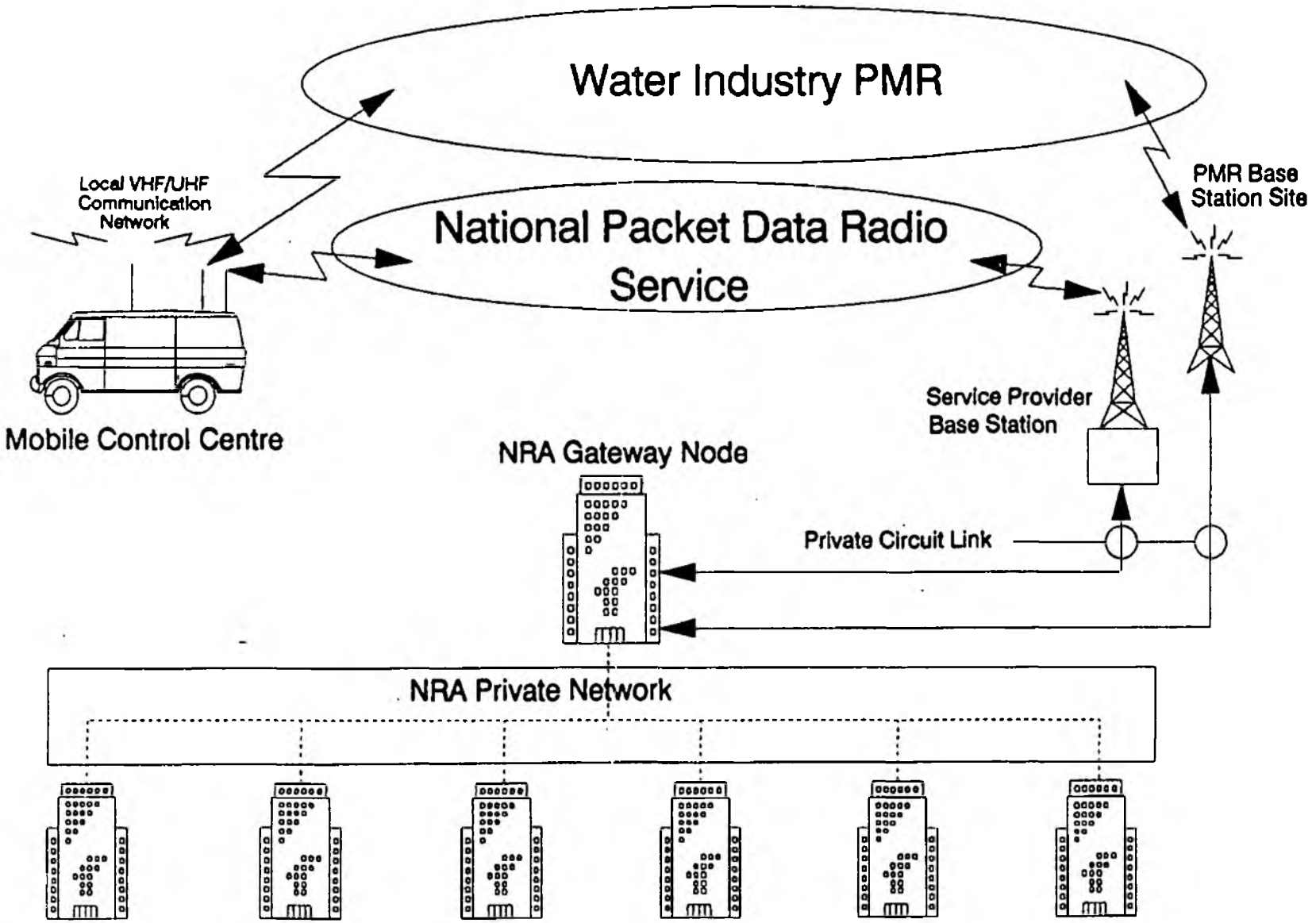
- Good general communications for operation staff.
- A first line emergency communications system with reasonably availability and hence user confidence.

Such a system supported by commercial voice and data services offers the means by which resilient "in the field" control and communications can be provided. Such a system can be seen in schematic form in Figure 2.1, where;

- Control resilence is provided by means of private network connections to required voice and data services.
- Water industry PMR operated in conjunction with a communication vehicle offer in the field operator communications.
- Introduction of a localised UHF/VHF radio network allows emergency incident control at a local level.

Figure 2.2 extends this option further to a point where the utilisation of satellite communications provide the mobile communication vehicle with the bandwidth connectivity to allow full in the field of control of emergency incidents, namely;

- Full telephony services, both internal and PSTN.
- Access to any centralised database or information system.
- Control of localised trunk radio networks dedicated to emergency operations.



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NRA EMERGENCY COMMUNICATIONS STUDY
MOBILE CONTROL CENTRE
EXISTING TECHNOLOGY
FIGURE 2.1

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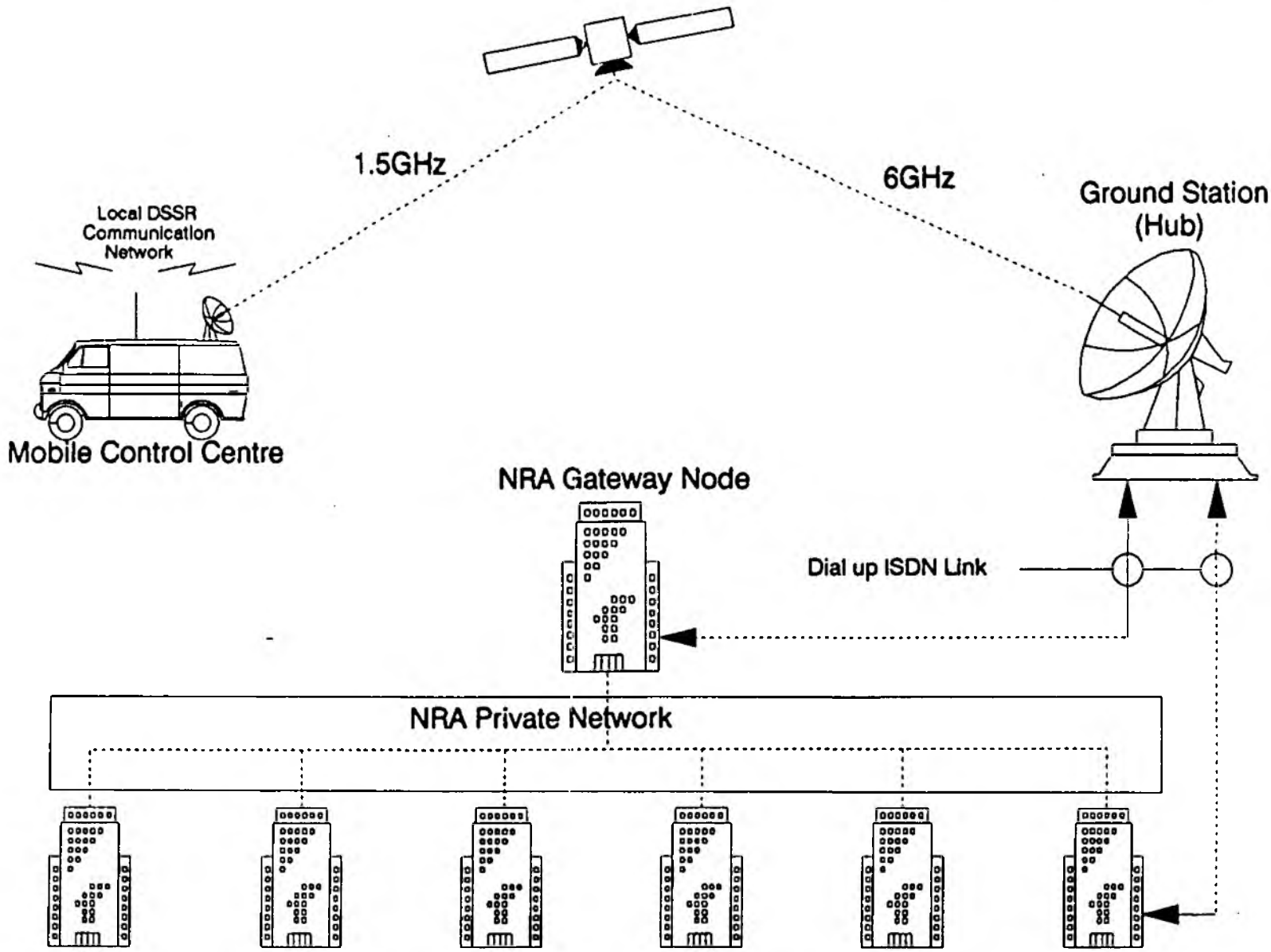

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MOBILE CONTROL CENTRE
FUTURE TECHNOLOGY
FIGURE 2.2

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3. REVIEW OF NRA OPERATIONS

3.1 Introduction

As no compiled information was available on emergency events a questionnaire was produced, and a copy sent to each of the ten NRA Regions with instructions for individual Areas and Functional Groups within the Regions to make duplicates and submit them separately if appropriate. A copy of the questionnaire can be found in Appendix A.

Completed forms were received as shown in the following Table.

Region	Area	Functional Group
North West	Central	Pollution Control
North West	North	Environment Quality and Pollution Control
North West	Central	Flood Defence
North West	North	Fisheries
North West	Headquarters	Cross-functional
North West	South	Fisheries/Conservation/ Recreation
Yorkshire	-	Regional 24 hour Emergency Centre
Yorkshire	Northern	Flood Operations and Flood Warnings
Welsh	South West	Flood Defence
Welsh	Northern	Flood Defence
Welsh	All	Environment and Quality
Welsh	South Eastern	Flood Defence
Welsh	St. Mellons	Flood Defence
Severn Trent	Headquarters	Services (Emergency Planning and Communications Section)
Northumbria	Head Office	All
Wessex	All	All
Thames	All	Catchment Control
Anglian	Headquarters	Systems
Southern	All	Flood Defence

3.2 Control rooms

3.2.1 Requested Details

Respondents were asked to give details of control rooms within their Region, Area or functional group. Details requested were:

1. Whether the room is dedicated, for the sole use of the relevant staff during an incident, or shared, by staff on other duties.

Figures 3.1 and 3.2 detail the numbers of dedicated and shared control rooms nationally and broken down by region.

Figure 3.1 - Control Rooms National

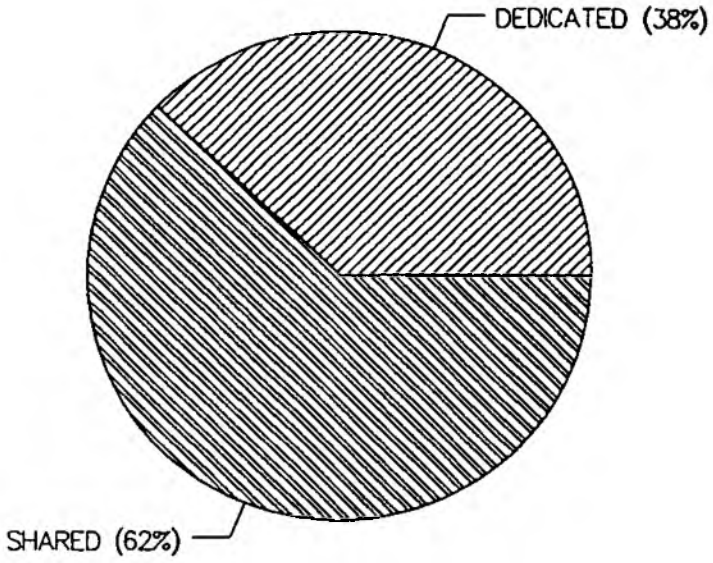
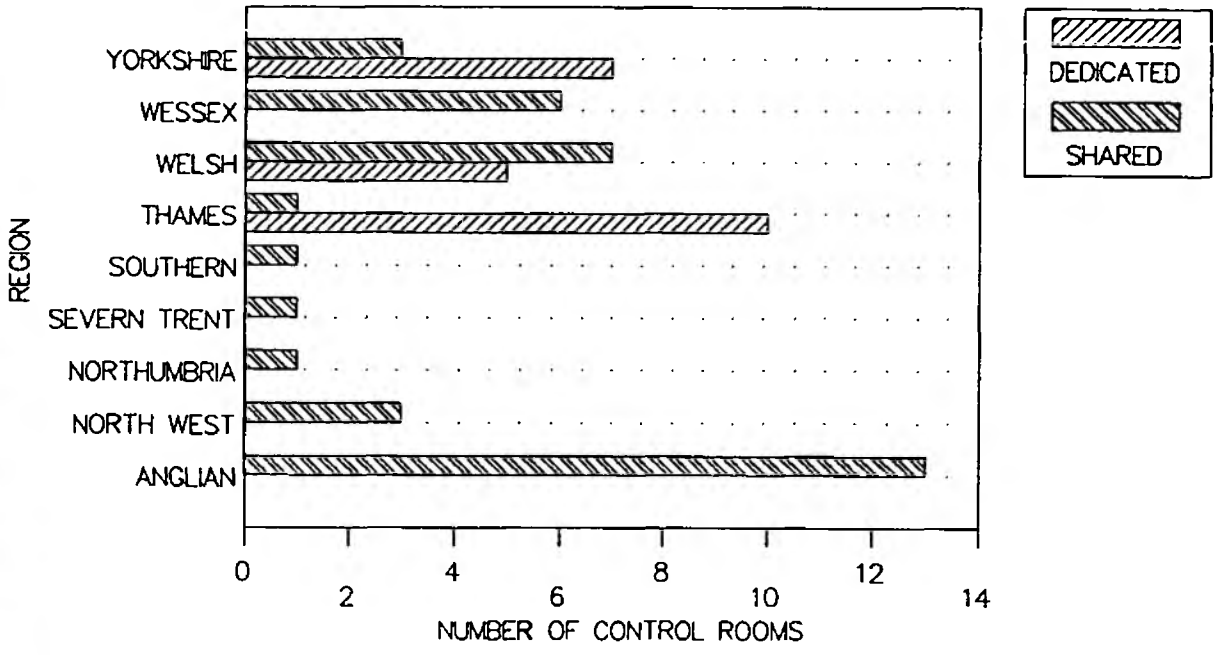


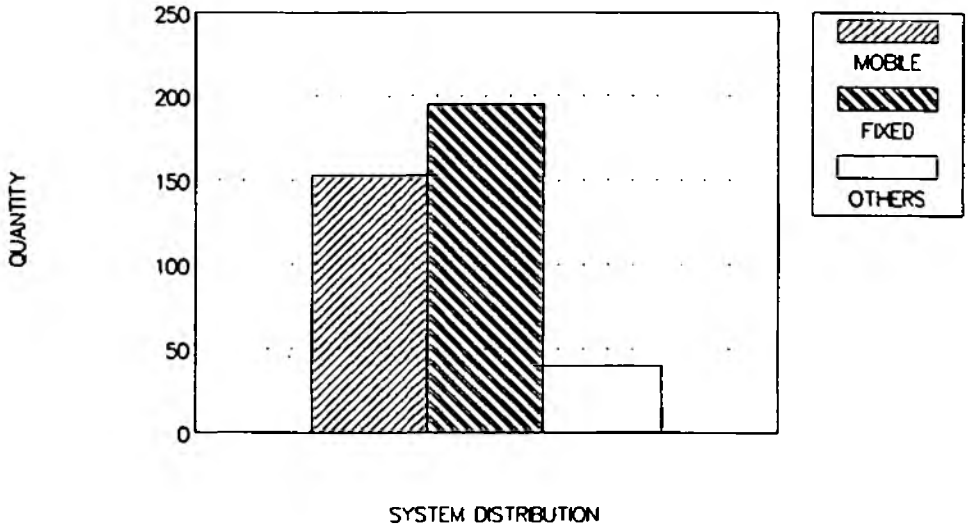
Figure 3.2 - Control Room Regional



2. Communication systems available to control room operators.

The percentage availability of various communications systems is plotted as a national average in figure 3.3.

Figure 3.3 - Communication Systems Availability



3.2.2 Comments

1. Only 38% of control rooms are dedicated in their function, this number being built up from only three regions.

2. Availability of fixed communications systems is high (50%); followed by access to mobile systems (39%) and other automated or database/information systems(11%).

3.3 Incidents

3.3.1 Requested Details

Respondents were asked to give details of emergency incidents in the following geographical size categories;

- Localised within Area, ie involving territory less than the whole Area.
- Area-wide.

- Inter-Area, ie larger than an individual Area, but not involving the whole Region.

- Region-wide.

- Inter-Region.

The details requested where as follows:

1. Number of incidents in the last 12 months.

   Figures 3.4 and 3.5 detail on national and regional basis the numbers and distribution of emergency incidents.

Figure 3.4 - Emergency Incidents National

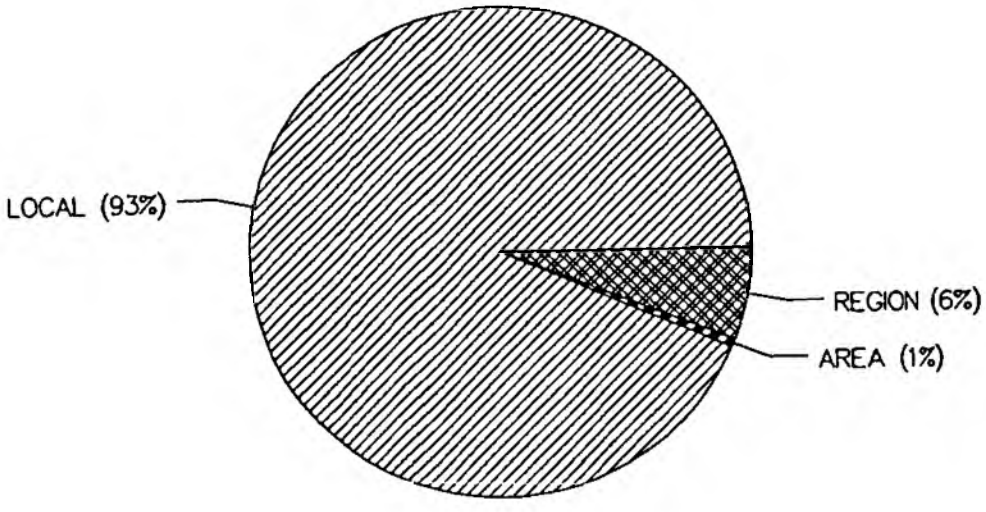
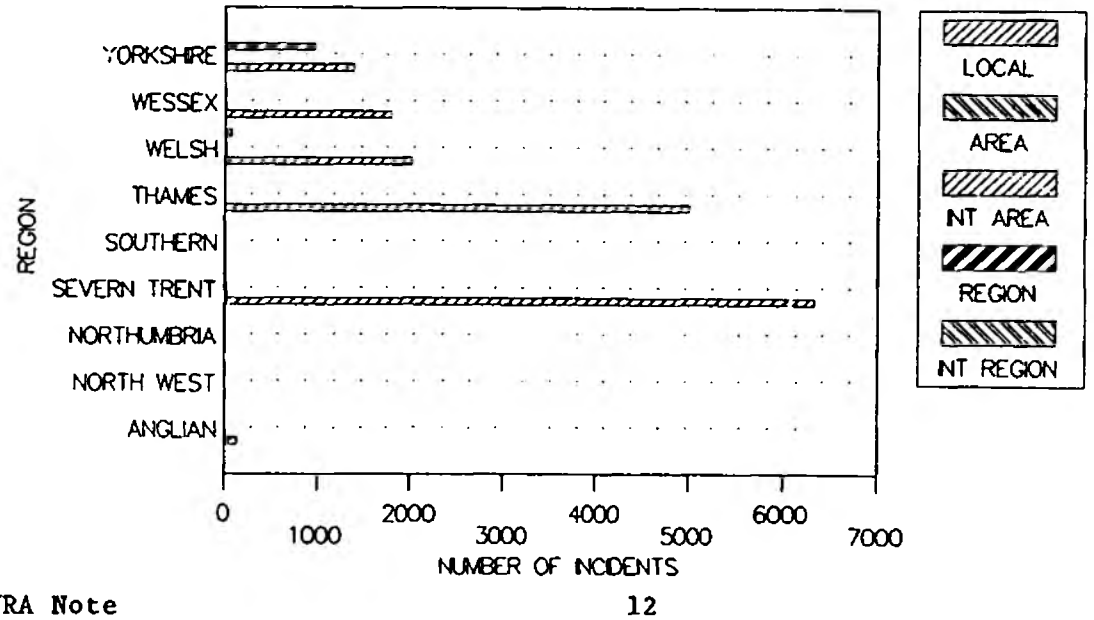


Figure 3.5 - Emergency Incidents Regional



2. Average number of NRA staff involved.

The number of staff involved in the various incident types is plotted both nationally and regionally in figures 3.6 and 3.7.

Figure 3.6 - Staff Number National

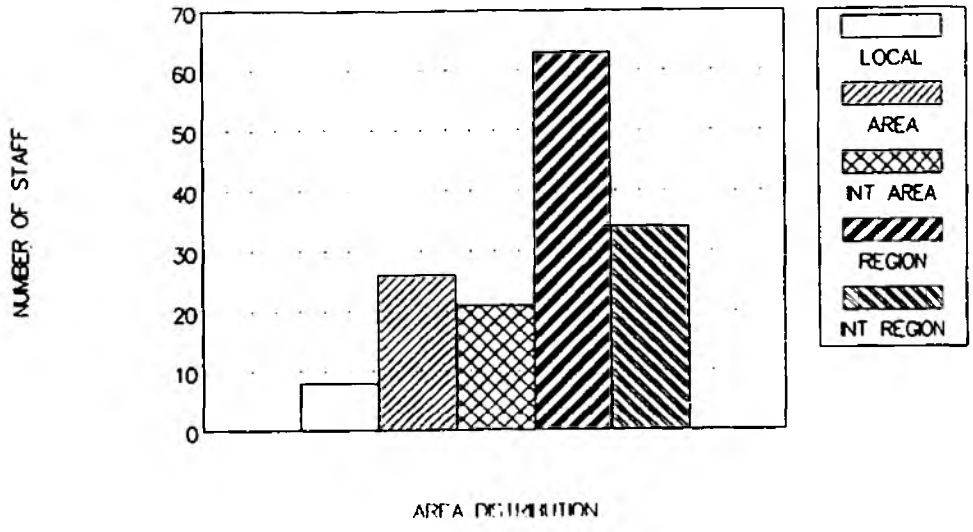
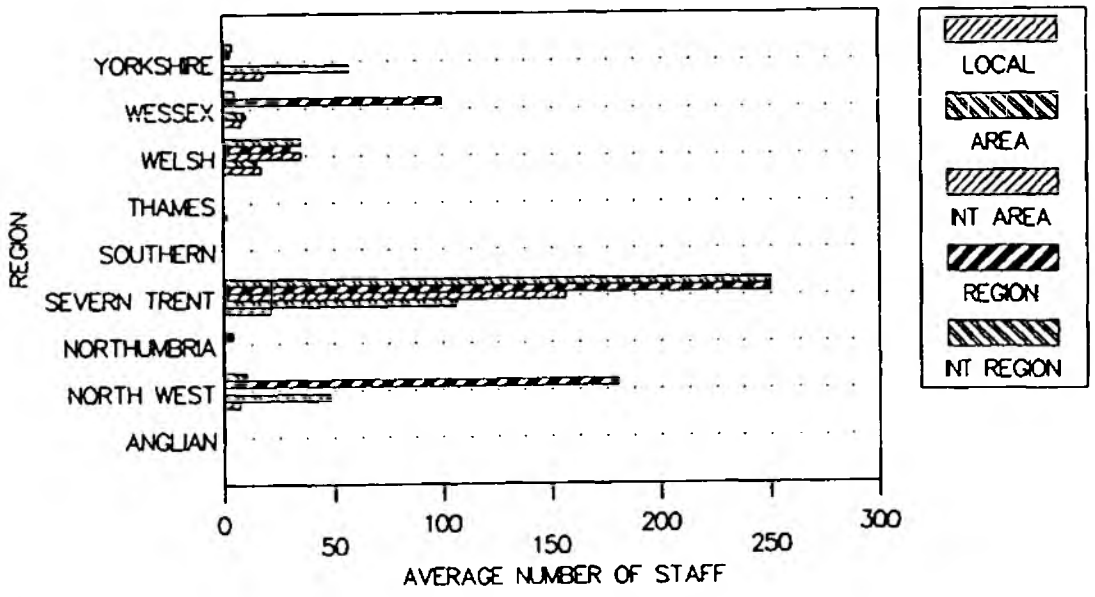


Figure 3.7 -Staff Number Regional



3. Average incident duration

Figure 3.8 details average duration of the incident types considered nationally with figure 3.9 providing a regional breakdown of the same.

Figure 3.8 - Incident Duration National

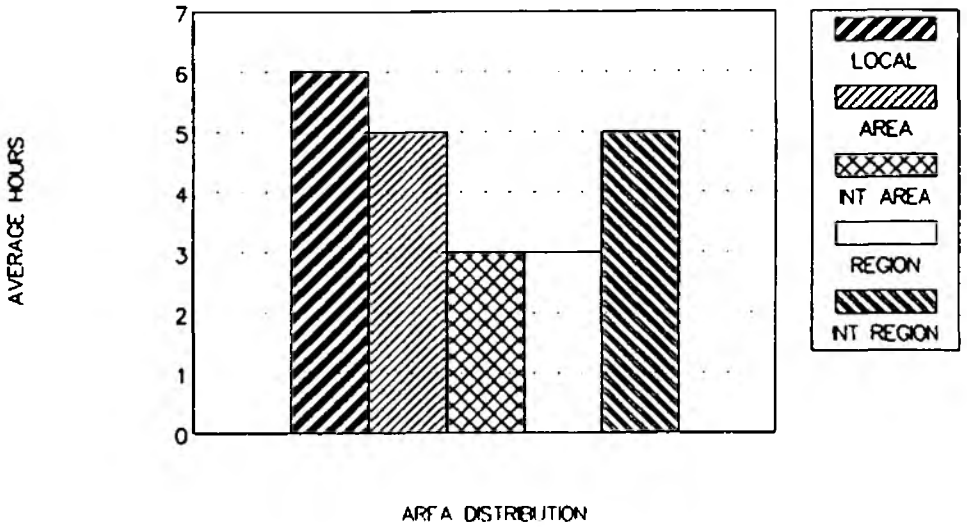
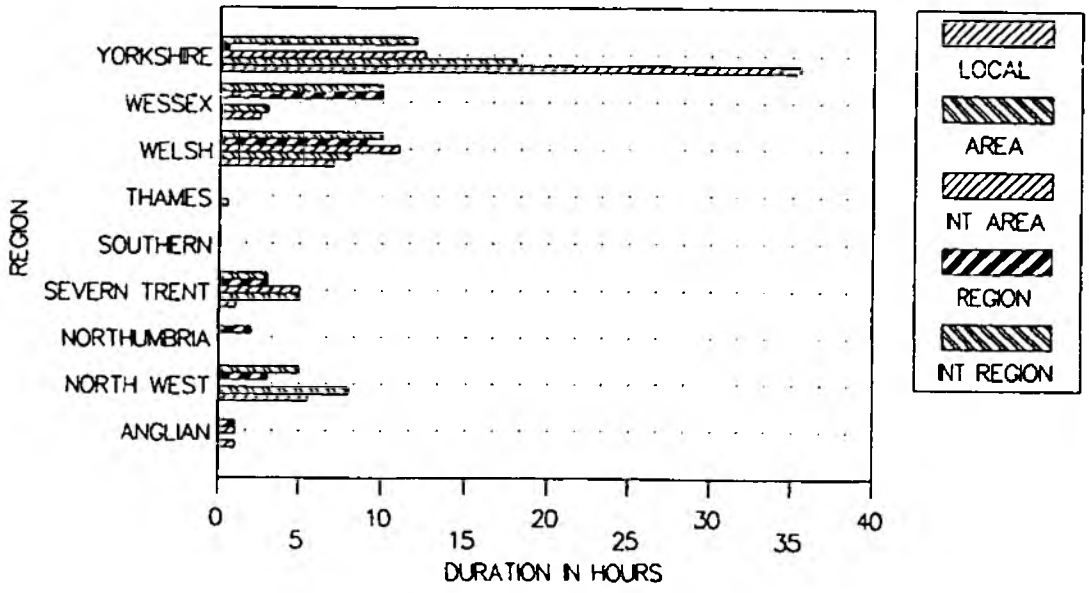


Figure 3.9 - Incident Duration Regional



3.3.2 Comments

1. As would be expected localised emergencies account for 93% of the total number of incidents, however region-wide incidents exceed area or inter-area totals.

2. Staff distribution follows incident size, increasing with the increase in geographic size of the incident.

3. Incident duration nationally appears at odds with the other findings within this section. However when regional figures are examined it can be seen that the majority of incidents follow the same trend of duration increasing with the incidents geographic size.

3.4 Communications Systems Usage

3.4.1 Requested Details

Respondents were asked to put communications technologies in order of preference, and list advantages and disadvantages for the top three.

3.4.2 Comments

1. The most popular technology by far is telephony via the PSTN, its main advantages seem to be reliability of service.

2. Radio systems tend to come low down in order of preference, with poor coverage and performance being quoted as the main disadvantages. Where the above disadvantages do not exist radio systems do however score higher than any other system.

3. The main requirement is for voice communications person to person, with a high degree of mobility, whether the person is in a vehicle or on foot. In flood defence, telemetry is also important, eg for monitoring water levels.

4. Facsimile is popular, because it provides a paper record and because it enables maps and diagrams to be transmitted. A major disadvantage is lack of mobility.

5. Where PMR is popular, an advantage is often seen in the open channel "conference" aspect, where people involved can maintain an overall mental picture of an incident as it develops. However this can produce noise nuisance in control rooms which are shared.

6. Cellular telephony is popular, and its access to the PSTN is seen as an advantage. Disadvantages are cost, inability to place calls even where coverage exists, and lack of security.

7. Paging is also popular, probably because of the high portability of the pager. Lack of feedback (Was the message received? Has the user switched the pager off? Have the batteries failed?) is a problem, and it is generally felt that pagers can only be used in conjunction with other communication methods.

4. COMMUNICATIONS SYSTEMS

4.1 Introduction

The following sections provide a general introduction to the communication systems and technologies that are currently available.

4.2 Private networks

A Private Network is a system which allows a communications device on that network to interconnect and interwork with any other compatible communications device on that network.

To achieve this we can consider the constituent parts of a network to be:

1. **Bearers**

   The bearers are the communication links between centres on the network. They could be single physical circuits or multi-circuit links such as co-axial/fibre cable or microwave radio. They carry signals in a coded electronic form to convey information over long distances.

2. **Nodes**

   They may be either:

   - o static and prominently correct bearers on a channel by channel basis; or
   - o dynamics having the capability to switch the interconnection of channels; or
   - o a mixture of both.

3. Link control

The link controller is a system which controls which channel or channels interconnect for a particular application.

The link control system reacts to addressing signals originated by the calling terminal device in order to establish a communications link.

4. Application control

Although this has been included for completeness, the application control system is not necessarily part of a telecommunications network unless one of its functions is to monitor signals to ensure they pass unaltered from calling to called device.

In simple terms the application controller can be thought of as the system which permits one device to interwork with another, ie a protocol.

5. The OSI Model

Having now decided what constitutes a private network it is necessary to consider its functionality in order to fully understand the network's purpose. The International Standards Organisation (ISO) seven layer model for Open System Interconnection (OSI) is used for this comparison.

OSI Reference Model

1 Is the Physical Layer which deals with physical attachment to communication lines.

2 Is the Data Link Layer which provides transfer and control of data over communication lines, error correction etc.

3 Is the Network Layer which adds destination switching, routing and relaying functions, and presents these in a manner which is independent of the actual network in use.

Thus, these 3 layers provide reliable interconnection across a variety of inter-linked networks - both wide and local are.

4 Is the Transport Layer which provides user-to-user services, including multiplexing, to make the most effective use of the network facilities: it enhances the quality of the service to that necessary for the application.

5 Is the Session Layer which controls the dialogues between the users and supports synchronisation of their activity etc.

6 Is the Presentation Layer which allows for the selection of the representation of data resolving differences including between systems.

7 Is the Application Layer, providing the interface to user applications and common services such as file transfer and terminal support.

The underlying principle of the OSI Model is to specify each layer in such a manner that it is independent of all other layers. This principle will ensure that equipment designed to provide the functionality of a single layer will be compatible with equipment designed for other layers.

Examination of the model will reveal that layers 1 to 3 are concerned purely with interconnection. Layer 4 is concerned with both interconnection and interworking and layers 5 to 7 with interworking. The model can be divided into:

- Layers 1 to 4 - Transportation
- Layers 5 to 7 - Application.

The function of the network dictates the layers involved. For example, if the network is designed as a transport network only ie. to achieve interconnection between two peripheral devices and, once interconnection is achieved, to permit the free flow of information, then it need only comply with layers 1 to 4. so, for a telephone speech network all that is necessary is compliance with layers 1 to 4. This is because compliance with higher layers is left to the two telephone users on each connection.

If however the network is designed to ensure that the information flowing between the two devices is understandable to both, then compliance with all seven layers is necessary.

For example if the two terminal devices are dissimilar data equipment, then in order for interworking to be possible the network must ensure compatibility. This is usually achieved by either ensuring that both devices use the same application protocol or alternatively arranging for the network to convert the protocol of one to that of the other i.e involving the networks with levels 5 to 7.

4.2.2 Private network regulation

Since the introduction of the first stages of liberalisation of the telecommunications market, operators of public and private telecommunications networks have been authorised to conduct these activities by means of Licences issued under the Telecommunications Act 1984.

Operators of private networks are licensed by means of a Class Licence, the Branch Systems General Licence (BSGL) which Licences anyone to set up and operate a private telecommunications network.

The Telecommunication Act 1984 which gives authority for this can be considered to have four aspects:

- the authority for Licences to be issued;
- the legal basis for requiring apparatus connected to the networks of public telecommunications operators to be approved for the purpose;
- the approval of apparatus which is to be connected to public telecommunications networks;
- the Code of Practice for the Design of Private Telecommunications Networks (NCOP).

The fourth aspect, NCOP, is to assist the network designer to ensure that the performance of voice calls which pass to or from the public network is satisfactory and meets the appropriate Recommendations of the Consultative Committee on Telephony and Telegraphy (CCITT).

Compliance with the limiting and preferred values of impairments recommended in the Code is voluntary, and what may be regarded as satisfactory in one private network may differ from what may be regarded as satisfactory in another.

This relaxation in terms of the voluntary nature of NCOP compliance has required certain changes applicable to the second aspect of the BSGL namely removal of restrictions on carriage of Public Switched Telephone Network Traffic (PSTN) in private telecommunications networks. This de-regulation is however subject to two conditions:

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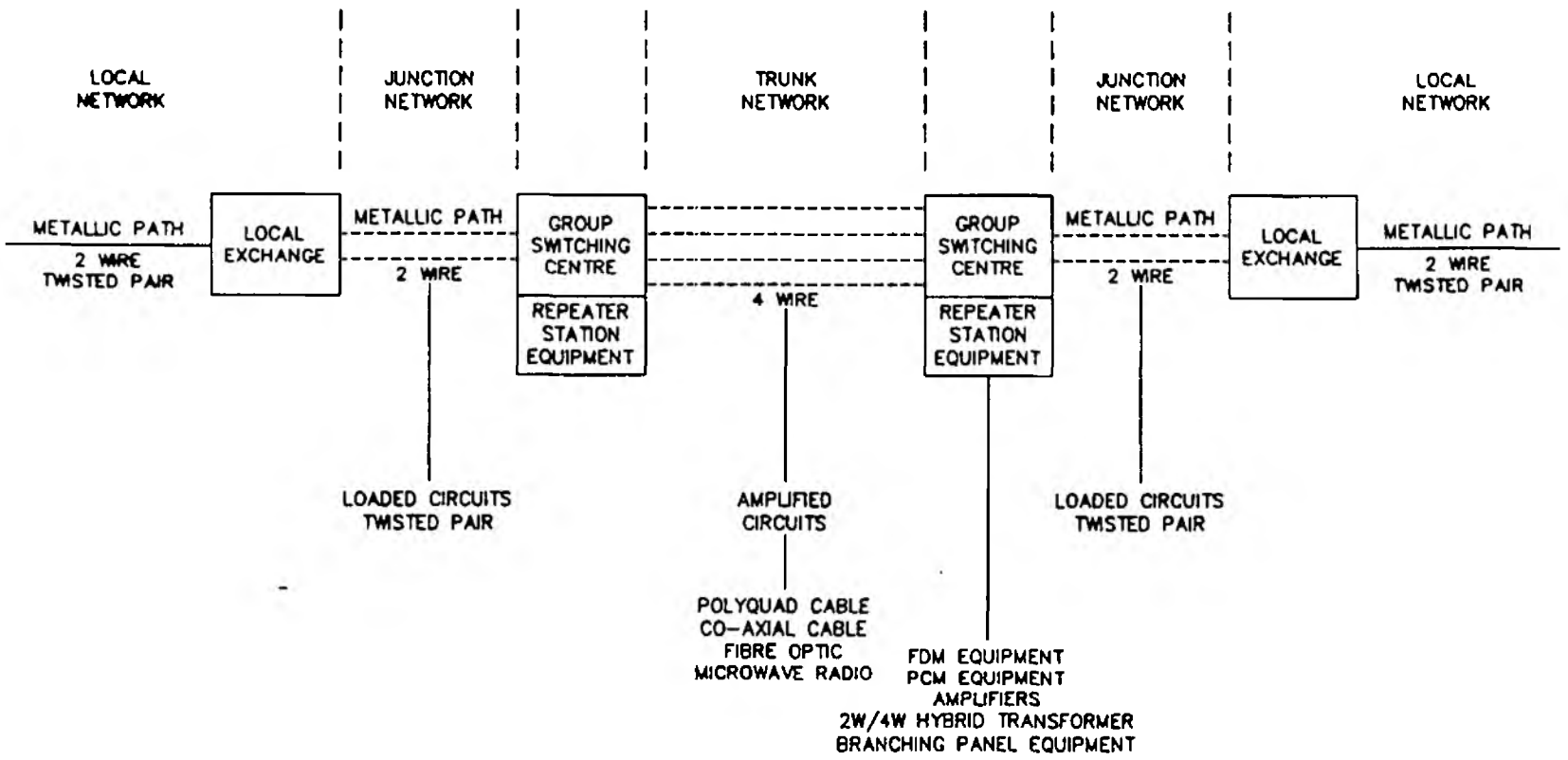

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NRA EMERGENCY COMMUNICATIONS STUDY
UK PSTN (ANALOGUE)
FIGURE 4.1

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- o connection is not allowed to any service other than those for which the apparatus is currently approved;

- o for new apparatus manufacturers or suppliers must provide necessary information or transmission performance.

4.3 Telephony systems

4.3.1 Public telephone systems

Public switched telephone services are operated by three licensed organisations within the UK, British Telecom, Mercury Communication and Kingston Communications (Hull).

This section provides an overview of the structure and development of the Public Switch Telephone Network (PSTN) by reviewing the British Telecom network.

1. The UK analogue network

Originally the network was built for speech communication. In the early days of telephony simple pairs of wires carried individual conversations. The development of electronic techniques in the 1930's and 1940's led to the use of cable systems in which several telephone conversations could be carried on a single pair of wires using frequency division multiplex (FDM) techniques. Use of co-axial cable revolutionised the capacity available by this method and formed the basis for the current extensive trunk networks, with microwave radio providing even more capacity for major routes. The PSTN is therefore constructed in a hierarchical nature based on population density for both domestic and business usage.

Three main areas can be identified in the network structure (Figure 4.1). These are:

a. The Local Network: Where connection is made from a subscriber's premises to his local exchange.

b. The Junction Network: Where the local exchanges are connected to group switching centres for onward access to other group switching centres.

c. The Trunk Network: For high capacity routes between major centres for volume traffic.

The analogue telephone network has a restricted signalling capability. National calls take from 5-25 seconds to set up, following which a duplex transmission path of about 3kHz bandwidth, with ill-defined group delay and attenuation characteristics, is available for customer use.

Despite these limitations the PSTN has been used to support telephony and a limited set of non-voice services, eg. Datel and Prestel. However the inherent constraints present in the analogue network make it increasingly unsuitable for emerging data transmission applications. This has been partly overcome by the introduction of service dedicated networks such as the "Packet Switched Network" and the "National Private Circuit Digital Network".

The following table is a summary of the main differences between analogue and digital networks. From the comparisons drawn between analogue and digital networks it is obvious that the future lies with digital technology.

Analogue - digital network comparison

NETWORKS

ANALOGUE	DIGITAL
Designed for speech. Separate networks for Telex and packet switched data.	Digital encoding of all transmissions. Unified network.
Multiplexing, wasteful of bandwidth (FDM)	Full utilisation of bandwidth (TDM)
Amplification necessary at frequent intervals.	Regeneration at wider intervals.
Noise amplified with information content.	Noise not successively regenerated.
Line-up tests for each cct.	No line-ups necessary.

Signalling functions on per cct basis.	Full-function signalling on common-channel basis - DASS, DPNSS.
Unit costs per cct cannot be lowered.	Lower unit costs than analogue.
Modems necessary for data ccts	Rate adapters only needed (NTE).
Low data rates on standard line plant - 9.6 Kbps max. long distance.	High data rates on standard line plant - 64 Kbps max.
	Utilisation of optical transmission
	Low size/weight of cable Vast potential capacity Immunity from electrical fields/interference.
	Managed network - monitored continually 24 hours/365 days.
Switched network adequate for speech - limited for data.	Switched digital network at 64 Kbps - speech or data.
	Switched network at 2 Mbps under development.
Proven analogue technology and satisfactory operation for many years.	Increasing functionality and cost effectiveness of digital techniques have justified a complete change to a digital hierarchy.

2. The UK digital network

Having established that a public network of the future must cater for much more than basic voice communication, and that analogue techniques are not ideally suited to non-voice applications, British Telecom is committed to the introduction of an Integrated Services Digital Network (ISDN).

The ISDN is tomorrow's version of the PSTN, ie. a network capable of supporting voice and non-voice applications with capability to offer enhanced services (Figure 4.2).

More precisely CCITT describe an ISDN as having the following capabilities:

a. A network common to both voice and data.

b. Digital access, control, switching and monitoring.

c. Enhanced common channel signalling.

d. Integrated access to services.

e. Gateways to other network services.

This in effect gives one circuit switched, digital network for routing all telecommunications services such as voice, data message, text, facsimile and image. These services are seen as vital to the future success of information technology and forecasts show that development will be extensive during the next few years.

3. **Digital network services**

a. Telephony

Full interworking with analogue network until ISDN is complete. The new network will give:

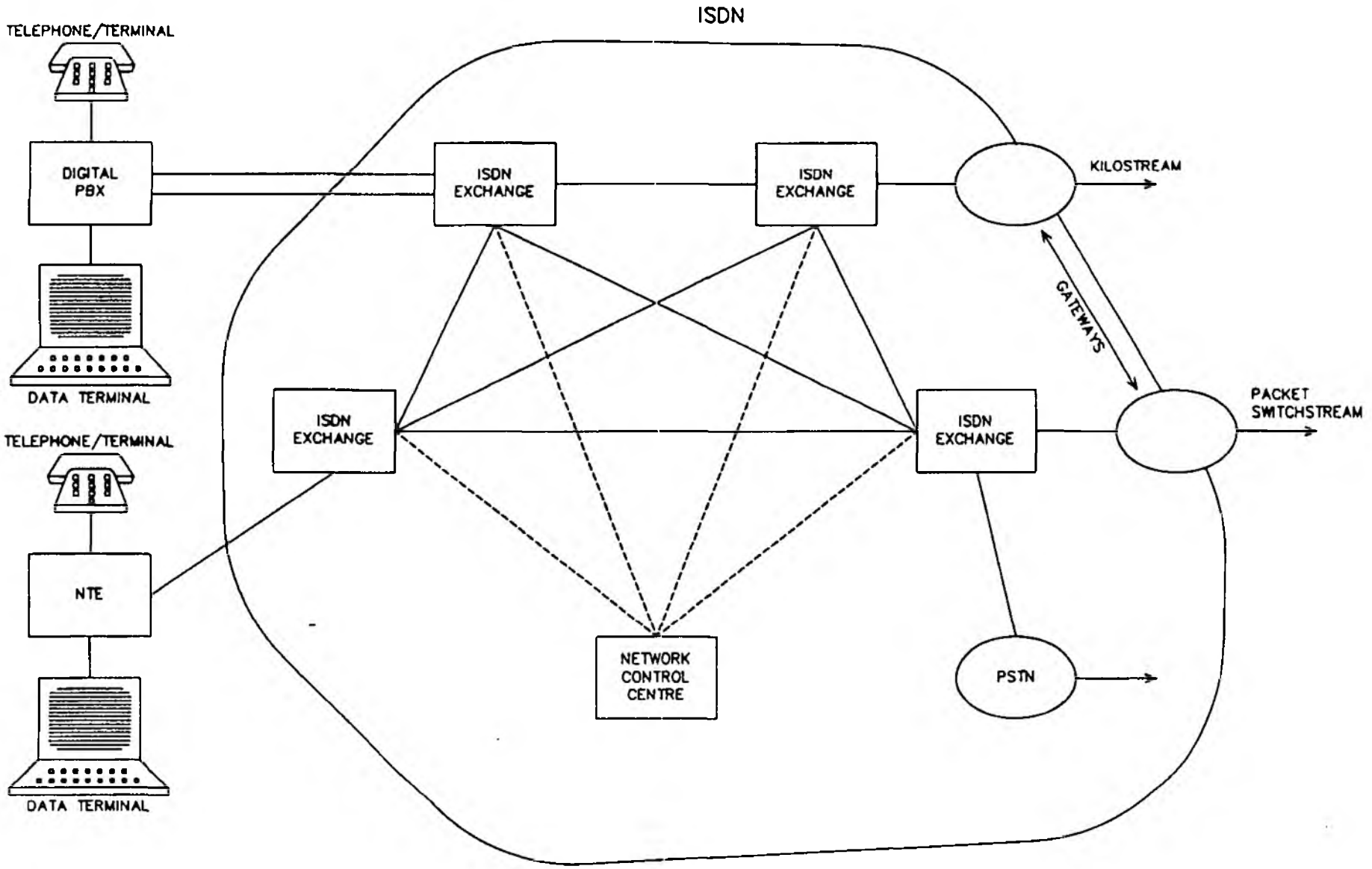
- o improved performance
- o improved reliability
- o clearer speech - fewer misunderstandings
- o fast call set-up - within 2 seconds.

b. Circuit switched data service

Circuit switched data at user rates up to 64 kbits synchronous and 9.6 kbits asynchronous.

c. Private circuit data service

Ability to cater for private circuit needs, eg. Kilostream.



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Costain Telecommunications and Systems Ltd.
Manchester

NRA EMERGENCY COMMUNICATIONS STUDY
BT ISDN NETWORK
FIGURE 4.2

SCALE	DWG. No.	REV
	CT649/904	0

CES/3 - A3

d. Teletex

National text service at 2400 bps transmission. Higher rates up to 64 kbits between compatible devices.

e. High speed facsimile

Digital facsimile rates of 8, 48 and 64 kbits to CCITT group 4. Typically at 64 kbits an A4 page is transmitted in 5 seconds.

f. Slow Scan TV

High resolution TV transmission with 4 seconds refresh for security, surveillance and audio visual conferencing.

g. Photo-Videotex

Text service enhanced with graphics and pictures. Similar to picture Prestel and used by Travel Agents, Estate Agents, Mail Order companies etc.

h. Future services

Future developments will enable even more services to be accommodated such as:

Video phone	Colour television
Video conference	High definition television
Video library	Hi-fi stereo
Mobile services	

i. Facilities

Additionally, supplementary services will be provided and marketed under the "Star Services" banner.

o Code Calling	: Stored number calling
o Call Diversion	: Transfer of calls to other numbers
o Three Way Calling	: Hold one call and make another - then have 3-way connection
o Call Waiting	: Notifies users of another call
o Repeat Last Call	: Last number called can be repeated without dialling full number

- o Call Barring : Restricts outgoing or incoming calls
- o Charge Advice : Exchange notifies charge after call
- o Reminder Call : Alarm call
- o Ring Back : Exchange continues to call engaged number and advises when connection is made.
- o Credit Call : Account code charging
- o Message Call : Record a message in the exchange for transmission at a later time.

4.4 Private telephone systems

4.4.1 Introduction

There are two basic types of telephone systems:

1. **Key systems**

   Key systems are considered to have a typical capacity of up to 24 terminals (extensions) and have only recently adopted digital switching technology.

   Key systems are perfectly suitable for stand-alone voice communications systems in small organisations; or as departmental systems, when they are 'piggy-backed' onto a PABX to provide a dedicated telephone system within an organisation, with access to the outside services via the PABX. The smallest of these systems can, in a single exchange line configuration, provide chief/secretary arrangements, or small business and domestic applications.

   Generally speaking, key-systems do not have an operator console and have supplier proprietary telephones with push-button direct access to the public network.

2. **Private Automatic Branch Exchange (PABX)**

   These are available from as little as 20 lines up to networked installations of 20,000 lines. They also offer a far wider range of features and facilities than key systems.

   There are a number of Hybrid Key System/PABXs available providing some PABX facilities within a Key System.

Most modern PABX's use digital technology, making them suitable for data and text transmission as well as voice. However, the majority of traffic will be voice, with only light or medium users of the other forms of communications connected to the PABX.

The use of a Private Network as described in Section 3.2 enables the linking together of telephone systems located on different sites within an organisation via inter-PABX tie-lines. The main advantage is the elimination of call charges over the public network between these sites.

A network configuration can be based on a single PABX with central control and switching units connected to remote peripheral nodes located at the sites. To these remote nodes are connected the extensions for each site plus the exchange lines for the site. The nodes can vary in size.

The major benefit of these single-supplier networks is full feature transparency ie. all facilities are available across the network while users can transfer their extension numbers from one site to another, should they move.

Networks of large telephone systems from a mixture of suppliers are now possible through DPNSS (Digital Private Networking Signalling System), a new signalling standard. This, however, cannot guarantee full feature transparency.

Electronic technology enables a large number of facilities to be incorporated into telephone systems providing a more efficient and simple service for users.

The list is long, but includes for example call diversion, abbreviated dialling, automatic call forwarding, camp-on busy, conference calls, follow-me, last number re-dial and group-hunting.

These, and the many others, should be explained, and their operation described, in handbooks provided by suppliers.

4.5 Facsimile

4.5.1 Introduction

Facsimile equipment is a means whereby paper-based documents can be copied and sent by a telephone line to distant telephone subscribers both in the United Kingdom and overseas, who have similar equipment. Distance is not important but quality of line is.

4.5.2 Current standards

The current international standard for facsimile is known as group 3. Group 1 and group 2 machines are no longer made, but a number remain in service. Group 3 machines can transmit a full page of A4 text in about 30 seconds.

A further standard, group 4, has more recently been agreed by the CCITT. This standard is based upon digital transmission at speeds of 64 Kbits per second, enabling an A4 page to be transmitted in five seconds. Group 4 machines are now available but, because they require digital circuits, their application will be limited largely to private networks until ISDN becomes much more widely available.

Group 4 machines are fully compatible with group 3, and group 3 can communicate with most in group 2. Group 1 machines are generally limited to communication among themselves.

4.5.3 Facilities and benefits

1. **Speed**

   Except for very short messages, text can be transmitted faster by facsimile than by telex.

2. **Availability**

   Because facsimile can use the public telephone network it can be used from almost any location.

3. **Versatility**

   Any black and white image can be transmitted and an identical image will be produced at the receiving end. This makes facsimile suitable for handwriting, including signatures, drawings and diagrams, as well as typewritten or printed text.

4. **Error resilience**

   Corruptions suffered during facsimile transmission will usually be apparent, and it may still be possible to interpret text if enough of a character or word is received correctly. This compares with telex, over which corruptions may produce incorrect characters.

5. **Low cost**

Prices of machines are relatively modest and the cost of transmission is only that of a telephone call. This makes it generally cheaper than mail or telex.

6. **Ease of operation**

No special training or skill is needed. Anyone can send a document after the very minimum of instruction.

4.5.4 Disadvantages and problems

1. **Destination address identity**

Unlike Telex (see Section 3.4) facsimile doesn't require a mandatory exchange of answer back before and after transmission. Most machines have the facility to confirm their identity during initial handshake but this is a user programmable option.

2. **Security**

Many fax machines are in offices to which access is relatively unrestricted. Even if the sending terminal is in a restricted area, there is no guarantee of the machine at the destination being protected in the same way. One solution is the use of passwords, if a mailbox feature is available, to limit access, for both transmission and for the retrieval of incoming traffic, to those authorised. If the machines in an organisation's facsimile network are equipped with a secure polling feature it is possible to use password protection to allow authorised users to retrieve traffic from remote terminals having mailboxes assigned for their use.

3. **Junk fax**

This refers to unwanted mail over facsimile, sent by direct mail and marketing organisations, and even by charity fund organisers. It consumes expensive paper and occupies the line. It is a serious problem in the United States and a growing one in the United Kingdom. Legislation is being introduced in the United Kingdom to require sending organisations to stop transmitting such traffic to users who request it to be stopped.

4.6 Telex

4.6.1 Introduction

Telex is a method whereby users equipped with suitable equipment may send text messages normally via keyboard input to validated receiving equipment.

4.6.2 Network description

The BT telex network has been in place for many years and has developed from electro-mechanical exchanges to the point where by 1992 the whole of the network will be based around digital Stored Program Control switches.

This development has required the upgrading of signalling technology from Simple DC 80 volt state changes to Single Channel Voice Frequency (SCVF). This in itself has made redundant, due to upgrade cost, much equipment purchased prior to 1983.

4.6.3 Telex use

In many applications facsimile is superseding telex, but it is unlikely to replace it entirely. Telex still has the advantage of much greater universal availability particularly within the under-developed countries, and is at present the only means of electronic transmission acceptable for legally binding documents.

4.7 Water industry Private Mobile Radio - PMR

4.7.1 Introduction

Nearly each area has a different situations depending on:

- o the age and technology of existing systems;
- o the facilities and design features of systems currently being planned;
- o the availability of PMR in certain regions;

This section therefore provides general background into PMR systems. And in particular the engineering and performance of systems planned and managed to the guidelines provided in the "Manual of Spectrum Allocation and Systems Management".

4.7.2 System overview

All radio systems, mobile or fixed, make use of the frequency spectrum,a finite resource. The spectrum is allocated by the Radio communications Agency, which is part of the DTI. In the case of the water industry, and subject to the terms of the "Agreed Agreement", DTI has appointed the Telecommunication Advisory Committee (TAC) agent to perform certain functions in relation to the allocation of the radio spectrum for the water industry.

The purpose of these arrangements is to allow the water industry to self regulate the use of channels as a means of enabling the provision of PMR and Scanning Telemetry Services. DTI and the water industry both require that the systems providing these services use the channels efficiently, effectively and equitably.

The efficient use of the radio spectrum in basic terms means the minimum allocation of channels considered workable. To understand how this can be achieved certain points require consideration.

4.7.3 Spectrum allocation and national frequency plan

Water industry PMR operates within the low band frequencies. At these frequencies, radio waves propogate in nearly straight lines. This limits the maximum communications range that can be achieved from a single radio site to about four thirds of the maximum line-of-site distance. This range may be reduced by local obstructions such as trees and buildings. To get the maximum coverage from a single radio site, the obvious solution is to make it as high as possible, giving a clear view to its surroundings. In coverage terms, that is the ideal situation, however, it is desirable to be able to use the frequency again at some other site. Traditionally, this has been achieved by re-using frequencies large distances apart, forming a patchwork quilt effect of frequency re-use. This is inherently inefficient. A common method of improving frequency re-use is to have a Cellular Re-use Plan (CPR).

In a CPR the country is divided up into large number of continuous polygons or cells (normally hexagons). These are then grouped into clusters, and each cell is allocated a frequency or set of frequencies. This cluster pattern is repeated in a regular manner over the country such that cells with the same frequency groups (co-channel cells) are separated from each other by a regular amount (the reuse distance). The size of the cells is often related to the normal coverage that can be expected for a single radio site at the cell centre under a clearly defined set of conditions. With this regular framework in place, the radio sites are chosen very carefully so that they do not cause interference to their co-channel cells but still cover their allocated cell. Often, more than one radio site may be needed in a cell.

The Water Industry National Mobile Radio Frequency Plan has been developed in light of the above in order to identify the number of channels required by the water industry to continue with the existing services and develop additional services now made necessary by modern operational practises.

The industry requirement is for low-band coverage, and separate signalling channels, across the whole country with provisions for higher levels of traffic during emergency incidents, which may occur anywhere at any time. The requirement is to hold three simultaneous conversations, but not for the continuous availability of three speech channels plus a signalling channel. This would require a large number of channels.

A cell distribution arrangement was therefore required which would provide the required traffic capacity and sufficiently large reuse distance. This is achieved by channel sharing. Two methods are available:

1. provision of an overlay of wide area channels covering a number of cells;

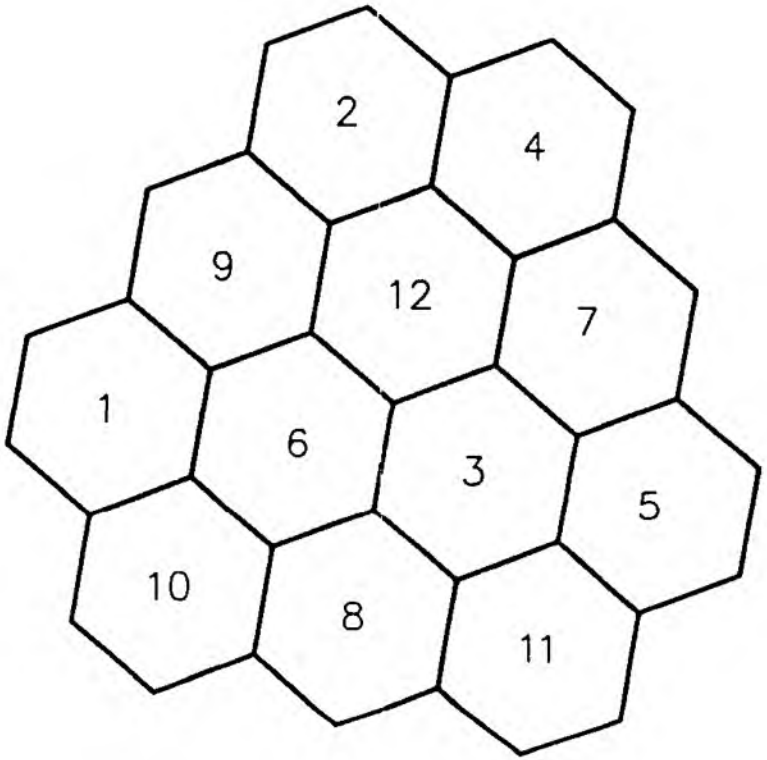
2. utilisation and enhancement, where practicable, of the overlapping cover of adjacent cells.

Adjacent cell overlap will require some flexibility in cell size and/or location. By careful system design these overlapping areas can concentrate capacity where high traffic is expected. Flexibility in cell location will also allow systems to be designed so that high noise areas, where stationary vehicles are likely to be encountered (i.e. city centres) fall well inside cell boundaries.

Investigations undertaken have led to a 12 cell repeat pattern with 20km radius cells, the channel distribution arranged so that adjacent channels are not located in adjacent cells, see Figure 4.3. This ensures that adjacent channels are separated by a cell diameter and thereby reduces any adjacent channel interference effects.

The 12 basic channels will form the first choice traffic channel in each cell. For additional traffic, an overlay of wide-area channels is provided to supplement the 12 basic channels. Each will cover a cluster of cells and can only be allocated to one cell in the cluster at any one time.

Wide-area clusters will also be distributed in a regular pattern and must be separated by sufficient distance to allow the wide-area channel to operate anywhere in its cluster at any one time; this is achieved by the use of 3 cell clusters distributed in a 7 cluster pattern. This arrangement is shown in Appendix B together with the 12 traffic channel distribution pattern. Three basic traffic channels are therefore supported by a wide-area traffic channel to carry excess traffic as a second choice. Additional traffic in a cell which cannot be accommodated by the basic cell channel or the overlay channel must be carried on an overlapping channel from an adjacent cell.



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Manchester

NRA EMERGENCY COMMUNICATIONS STUDY
NATIONAL FREQUENCY PLAN
FIGURE 4.3

SCALE	DWG. No.	REV
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C&B/2 - A3

The plan provides for dedicated signalling channels for trunking systems (see Section 4.7.4). Other types of system will be able to use these channels for traffic. To minimise channel requirements it is proposed that time-shared, wide-area signalling channels are used and that these are distributed in the same cluster pattern as traffic in the wide-area channels. Each cluster will therefore contain one signalling channel, one wide-area traffic channel and three basic traffic channels.

The seven signalling channels together with the 19 channels already identified provide a total plan channel allocation of 26.

The following table details the channels allocated and their use.

National Frequency Plan channels

Channel Number	Base Transmit	Base Receive	Use	NFP CH. Number
L3	85.0375	71.5375	WA	13
L8	85.1000	71.6000	WA	16
L9	85.1125	71.6125	WA	14
L17	85.2125	71.7125	WA	19
L19	85.2375	71.7375	T	1
L29	85.2500	71.7500	T	2
L21	85.2625	71.7625	T	3
L22	85.2750	71.7750	T	4
L23	85.2875	71.7875	T	5
L25	85.3135	71.8125	T	6
L26	85.3250	71.8250	T	7
L27	85.3375	71.8375	T	8
L29	85.3625	71.8625	T	9
L30	85.3750	71.8750	T	10
L31	85.3875	71.8875	T	11
L33	85.4125	71.9125	T	12
L35	85.4375	71.9375	WA	17
L36	85.4500	71.9500	WA	18
L37	85.4625	71.9625	WA	15
L46	85.5750	72.0750	C	20
L93	86.1625	62.6625	C	21
L?	86.XXXX	76.XXXX	C	22
L?	86.XXXX	76.XXXX	C	23
L?	86.XXXX	76.XXXX	C	24
L?	86.XXXX	76.XXXX	C	25
L?	86.XXXX	76.XXXX	C	26

Use: WA - Wide area traffic channel
T - Single cell traffic channel
C - Control channel

4.7.4 Trunked radio systems

In a conventional mobile radio system, with perhaps three frequencies available, a typical strategy for their use would be to allocate one frequency to each user group. Each group would then have its own radio system with a control point and a radio base station, perhaps on a hilltop radio site to ensure good coverage. This strategy is normally rather inefficient in terms of frequency usage as each group is unlikely to have the same amount of radio traffic. Those groups with little traffic will have a channel lying dormant for much of the time while a busy user group may constantly have people queueing to use the channel.

With trunking, users share a pool of channels and are allocated temporarily a vacant channel to make a call. It achieves a reduction in waiting time for the users as a consequence of the decreasing probability that all channels will be in use at the same time the more of them there are. Once the number of channels in the pool exceeds three, the gain from trunking compared with single channel operation can be significant.

Channels from the pool are allocated, on demand, for the duration of a call and as calls are completed the channels are returned to the pool for allocation to other users. The important principle behind this concept is that any user has access to any free channel within the pool.

Several system benefits exist:

1. **Spectrum utilisation**

   For trunked systems more mobiles per channel can be accommodated, or a better grade of service can be provided, ie a reduced average time to establish communication, resulting in an improvement in spectrum utilisation. A single trunked scheme will have a higher capacity and better efficiency than is possible with an equivalent number of single channel systems.

2. **Operation**

   Operation, as far as the user is concerned, may be extremely simple. Selection of channels is automatic and a call could be initiated, for example, by lifting a handset. The call would be placed, without operator intervention, as soon as a free channel became available.

3. **Reliability**

Short term loss of a channel, due to interference or maintenance, will result only in a reduced grade of service and not in a complete loss of communication.

4. **Privacy**

A degree of privacy is obtained. Conversations between users or groups are not overheard by third parties in the group. Privacy in this context should not be interpreted as secrecy.

5. **Expansion**

New users can be accommodated more easily in a trunked system than in one of several single channel schemes, all of which may be nearly full. Similarly, additional channels can be made available to all participants in a scheme, without the need for modifications to existing mobile or portable equipment.

Figure 4.4 shows in schematic form the structure of a trunked radio scheme.

4.8 Analogue cellular telephone services

4.8.1 System overview

Analogue cellular telephone services were launched in 1985 with the Licensing of two network operator companies: Cellnet, owned by BT and Securicor; and Vodaphone, owned by Racal Telecom, the shortage of available radio spectrum and consequent network efficiency effectively preventing the licensing of more than two operators.

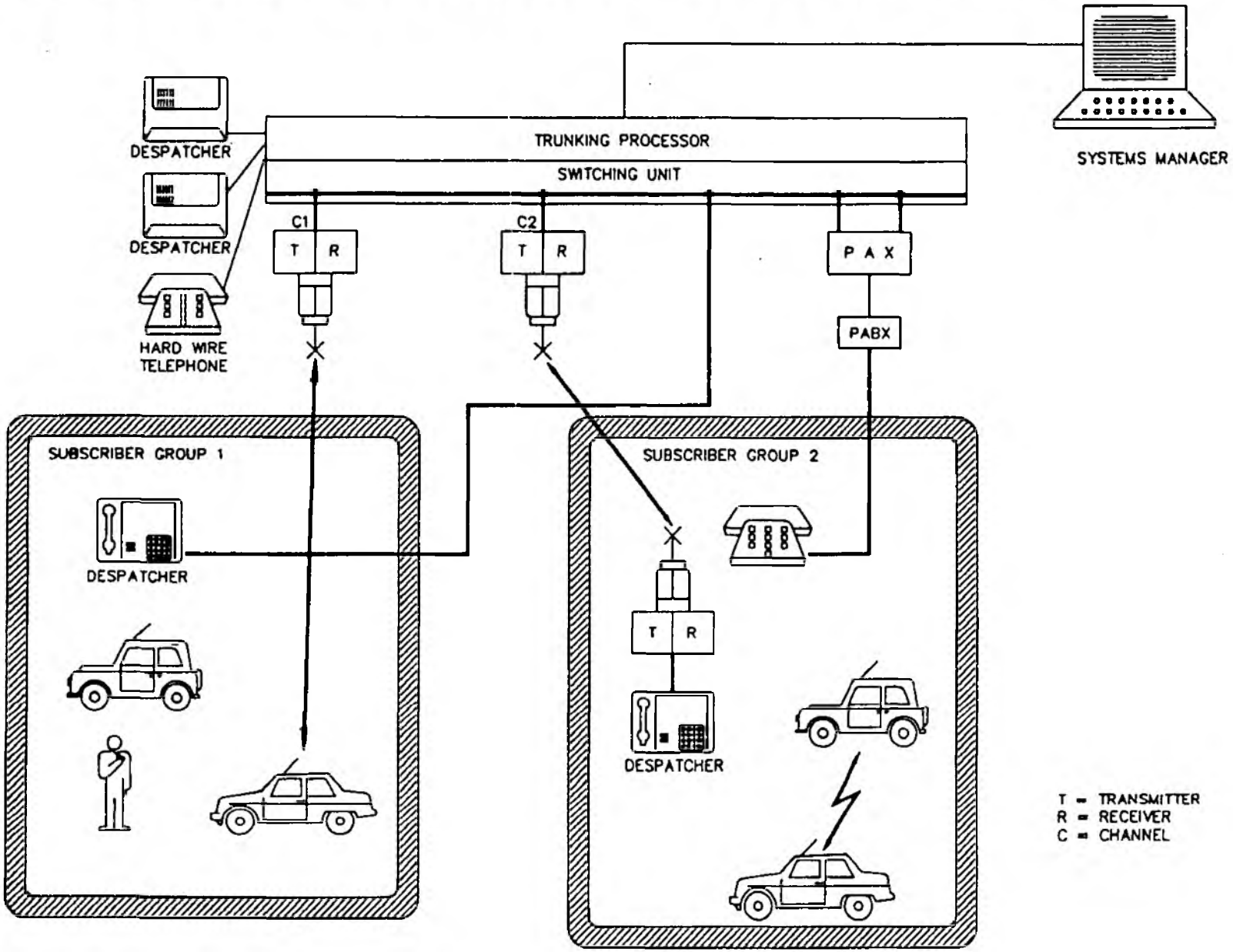
One of the main considerations by Government in the development of the industry was market competition.

There are three levels of competition in the industry, due to Government stipulation that neither network operator could deal directly with end users.

Thus Cellnet and Vodaphone are left as wholesalers of airtime with two levels, Service Providers and Dealers, below them.

Of the Service Providers, about sixty supply airtime and subscriber equipment, with some thirty of these suppliers offering both Cellnet and Vodaphone Service.

At the third level there are at least 2500 organisations acting as Dealers with bonus incentives from Service Providers for signing up new subscribers. These bonuses are used to subsidise equipment prices thus giving rise to 'free equipment' dealer incentives.



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Manchester

NRA EMERGENCY COMMUNICATIONS STUDY
TRUNKED PMR SCHEMATIC
FIGURE 4.4

SCALE	DWG. No.	REV
	CT649/902	0

CE8/3 - A3

Both Cellnet and Vodaphone have achieved their licence obligation to allow 90% of the UK population access to their services by 31 December 1989, with over 95% of the population now accessible.

4.8.2 Network description

1. Network coverage

Analogue cellular radio technology as a basic feature divides its coverage into a honeycomb of smaller areas called cells - typical cell diameters range from 2Km in city centres to 50Km in open country.

Each cell is equipped with low power receivers and can handle up to sixty simultaneous calls. Mobility between cells is achieved by the use of advanced polling of signal quality from adjacent cells with an automatic 'hand-off' of calls which is imperceptible to users on voice calls.

Current coverage of both services is detailed on coverage plans in Appendix C. As can be seen Cellnet and Vodaphone coverage is virtually the same, important differences occurring due to Cellnet's monopoly in the Channel Islands and the Isle of Man.

In general the "poor coverage" areas which exist are due to simple economics of provision against return. The areas specified are sparsely populated and due to their topography difficult to serve. Expansion of service into such areas is unlikely to continue, as both operators are concentrating on relieving network congestion within existing coverage areas and developing the new GSM system (see Section 5.1).

2. Utilisation/Grade of Service

Both Cellnet and Vodaphone suffer network congestion largely due to user demand outstripping forecasts and hence initial system design regarding traffic handling capability.

The original fixed allocation of 300 Total Access Communication System Channels (TACS) was increased in 1987 by a further 200 Extend-TACS (ETACS) channels to relieve severe congestion in central London. This extended channel utilisation was increased in 1989 to cover the area within the M25 London Oribital Motorway and some other urban areas.

These new channels have failed to relieve all congestion problems, indeed the measurement of this problem and its user perception is hard to quantify.

In the short term it is fair to say that both networks will continue to experience congestion at peak periods and in high usage localised cell situations. As a result any advantage one network has over the other is likely to be transitory.

3. **Equipment availability**

Due to the astonishing popularity and growth of cellular telephony in all areas of business, trade and personal communication, the style, type and availability of equipment is extremely good.

Equipment is readily available from lightweight compact "pocket phones" through "transportable" units to fully hands free mobile sets with handportable adapters.

4. **Network development**

The popularity and growth in services has led to the development of both providers' networks in several areas of user importance.

a. Links to private networks

Both network operators provide private wire services which enable cellular telephones to be linked directly into an organisation's PABX network.

These connections offer significant benefits:

- o reduced post-dial delay;
- o direct extension dialling;
- o less load on public network operators;
- o call charge cost savings.

The above can generally be considered to integrate the cellular phone into a company's telecommunications network.

b. Call control

By its nature cellular is particularly open to abuse by staff who misuse their employers phone by making unauthorised calls.

Two methods are available to control such misuse:

- o call barring;
- o itemised billing.

Using these features, calls to specific destinations can be barred and calls made can be scrutinised by virtue of a listing of time, date, duration, cost and number dialled.

c. Data and facsimile transmission

Both networks enable users to transmit data and facsimile, following the recent development of protocols which cater for the signal strength and 'hand-off' problems particular to the cellular networks.

Cellnet's service is called 'Celldata' and Vodaphone's VMACS (Vodaphone Mobile Access Conversion Service).

5. **Taxation proposals**

It should be noted that, assuming current proposals are included in the forthcoming Government Finance Bill, employees using a hand portable or mobile telephone as part of their employment will be deemed to have been given a benefit in kind of £200 and will pay income tax on it, provided that the telephone can be used privately and that costs of such calls are not reimbursed to the company.

4.9 Band III Public Access Mobile Radio (PAMR)

4.9.1 System overview

Two national and seven regional Band III licences were awarded in 1987, to operate in a spectrum allocation between 174 and 225MHz.

All Band III networks use trunked PMR technology with private circuits to link individual transmitters each providing single site coverage of about 50Km diameter.

The two national licences were awarded to Band 3 radio (owned by a consortium of Philips, Racal, Securicor and Digital Mobile Comms) and GEC National One (owned by GEC), with regional licences being held by National Mobile Radio, Zycall and Relcom. These network operators market their services through a network of services providers and dealers as in cellular telephony, however many network operators also own or are associated with Service Providers.

Both national network operators were obliged, under the terms of their licence, to provide coverage which will allow 80% of the UK population to have access to their services by 1991.

4.9.2 Network description

1. Network coverage (See Appendix D - Coverage maps)

Both Band 3 Radio and GEC National One divide their coverage into regions each of which is comprised of a number of single sites; the coverage of each single site is defined by the range of the base station transmitter.

The regional operators, as mentioned previously, are limited in coverage by their Licence provision, and at present operate in, London, the Midlands, Manchester/Merseyside, Humberside, North Lincolnshire and Yorkshire.

As can be seen from the coverage maps enclosed availability is predominantly limited to areas of high population and major motorway routes.

2. Utilisation/Grade of Service

Band III technology has been designed to address the three problems inherent in traditional PMR and CBS (Common Base Station) services, to provide:

- o better quality of service due to bandwidth allocation;
- o privacy due to the signalling system not requiring user channel availability monitoring;
- o wide-area coverage, with national and regional coverage options.

As discussed in the previous section the system's current coverage is limited to areas offering best economic return.

All network operators limit call length to ease network congestion. This limit is network dependent and in certain cases variable on network traffic present. Both national operators limit call length to sixty seconds. Connection through to the PSTN is NOT available, however Data messages in the form of rapidly transmitted short sentences or "Radiotext" relayed messages stored or printed at terminals are available.

3. Equipment availability

Due to the nature of its intended use Band III equipment is based around vehicle mounted mobile sets and fixed dispatcher units.

The limited requirement for such equipment when compared to the mass market for cellular telephones makes any rapid development of limited usage equipment less likely.

4. **Network development**

The service is at an early stage in its development and unlike cellular its development is not being driven by such great and widespread user demand.

4.10 Paging services

4.10.1 System overview

Public paging services have been available since 1972 when the Post Office launched a trial service. This was gradually extended to cover the whole country.

In 1983 and 1985 the UK government issued several radiopaging Licences in competition to BT at regional and national level. Eight operators are presently operating.

Paging Network Operators do not rely on Service Providers to market their services, but either sell direct or through Dealers. Paging Dealers sell or rent equipment to users and sign them up with a Network Operator.

Coverage of radiopaging services within the UK ranges from 85% to 97% of UK population. BT provide the greatest level of service.

4.10.2 Network description

1. **Network coverage**

   The liberalisation of the industry was intended by increase in competition, to force operators to provide good coverage. This has proved correct, with all operators claiming to cover at least 85% of the UK population.

   Each of the main national operators divides its national coverage into smaller zones and regions, coverage being purchased by build up of areas into the required coverage plan.

   BT currently divides the country up into 6 regions and 40 zones, with 97% of the UK population included.

   However, in the face of continuing pressure from its competitors, it is understood a major re-shuffle of its zone structure is underway, the plan being to reduce the number of zones to 4 or 5 in line with other major players, who have been seen to offer a similar coverage service at savings of between 20% and 40% on BT prices.

2. **Utilisation/Grade of Service**

Messages may be sent to a pager either via a telephone call to the network operators message bureau or voice mailbox or via direct input from the senders terminal. On receiving a message for a particular user, the operator broadcasts a message from transmitters serving the chosen zone(s). Interference is avoided by phasing or engineered location of transmitters.

One national pager channel can support up to 100,000 pagers due to the efficient use of the spectrum by means of the POCSAG digital signalling standard. Scarcity of spectrum, and hence congestion, offers no problem for paging services.

3. **Equipment availability**

Users of public paging services can choose between tone, numeric or alpha-numeric pagers.

Tone pagers simply provide a number of different tones or 'alerts'. Numeric pagers provide a numeric message, with alpha-numeric pagers enhancing this ability by supporting text messages.

In addition to these services, hardware is available for both silent 'vibrating' pagers and intrinsically safe devices.

4. **Network development**

National UK paging services can be considered for practical purposes to have reached their target levels of service availability.

Developments within the radiopaging industry are now tending towards the ERMES standard for European roaming, which due to requirements for scanning pagers, and hence increased costs, is not likely to replace national systems but rather to become a secondary service should it be adopted.

4.11 Two-way messaging services

4.11.1 System overview

Three licenses to provide packet mode mobile data services have been awarded within the UK to Cognito, Mobilex, and Motorola.

Of the three licences only Cognito is currently offering a service, Emissary two-way messaging, a pilot scheme being underway in the M25 area, with national coverage envisaged towards the middle/end of 1991.

The Emissary service enables individuals in a head office to exchange text messages with mobile personnel who cannot be contacted by conventional means and whose current location may not be known. Conversely, the mobile user can send messages to the company's central site for delivery to individuals at that location.

In addition to the message traffic between a company's fixed locations and its mobile staff, the service also supports message interaction between mobile users.

Using the Messenger, Cognito's portable hand-held terminal, people on the move are able to receive messages and respond immediately or at their leisure. The sender receives automatic confirmation from the network that the message has been safely and legibly received by the recipient. At the mobile end, message reception is secure and non-intrusive.

4.11.2 Network description

1. **System features**

The major features of Emissary are:

- Hand-held portable terminal. Mobile users are equipped with the Messenger terminal.
- Message Management Centre. An integral part of the service is the use of an industry standard PC with application software enabling a single supervisor to control and manage a group of mobile users.
- Confirmed message delivery. The sender of a message is advised by the network when the message has been delivered.
- Message storage in the network. If the Messenger is temporarily out of range of the service, the message is stored in the network and automatically delivered when the Messenger comes within range again.
- Print capability. Hard copy printout of messages and supervisory information is available as an option at both the Message Management Centre and the Messenger.
- In-building coverage. In addition to normal mobile coverage, messages can be sent and received from buildings in the major business centres of the UK.

2. **Network coverage**

The marketing strategy of the Cognito Emissary service requires it to compete with both cellular telephony and one way paging services; directly with regard to network coverage, and as a competitive trade off with regard to facilities offered against cost.

Thus although in its very early stages the service is being designed and engineered for a coverage level of the order of 90-95% of UK population.

3. **Equipment availability**

The service will be offered at a fixed rental including the terminal equipment, this equipment being of a proprietary nature.

4. **Network development**

An obvious development of the Emissary service is the utilisation of the network for extended access to office based computer systems to off site staff.

This will be achieved using a Radio Terminating Unit and probably a Laptop or portable computer running appropriate communications software.

A further possibility of service options comes from the recent Government White Paper "Competition and Choice Telecommunications Policy for the 1990s" which states that the government is now willing to consider applications from mobile operators to offer fixed services using their radio networks. This makes it possible for Cognito to be able to offer services such as telemetry, electronic funds transfer etc.

5. EMERGING TECHNOLOGY AND SYSTEMS

5.1 Introduction

This section provides an overview of the emerging technologies and systems may provide service options in the future.

5.2 Digital Cellular Telephony (GSM)

5.2.1 Introduction

Communications are vital to the success of the European Community's promotion of a 'Common Market' in 1992.

At present, nearly all the countries of Western Europe offer a mobile (cellular) service. The quality, capacity and area of coverage vary widely, but almost universally, demand has outstripped original estimates.

All national systems use a variety of technical standards. Indeed, some countries now offer a choice of network operators, not always using the same technology.

The Pan-European digital cellular system, due for launch in July 1991, is set to be the largest ever co-operative European telecommunications project. Spanning all twelve countries of the European Economic Community (EC) and five of the six member countries of the European Trade Association (EFTA).

The concept was begun by the 26 members of the European Conference of Posts and Telecommunications (CEPT), and developed through a task force known as Groupe Specials Mobile. Therefore, it is frequently referred to as the GSM system.

5.2.2 Network description

Cellular has been a victim of its own success in that frequency spectrum is scarce and there are already severe capacity shortages in Europe's prime metropolitan areas.

The GSM system addresses this and other considerations. Technology has moved forward meaning that significantly better cellular networks can be built using digital technology. The advantages of digital include:

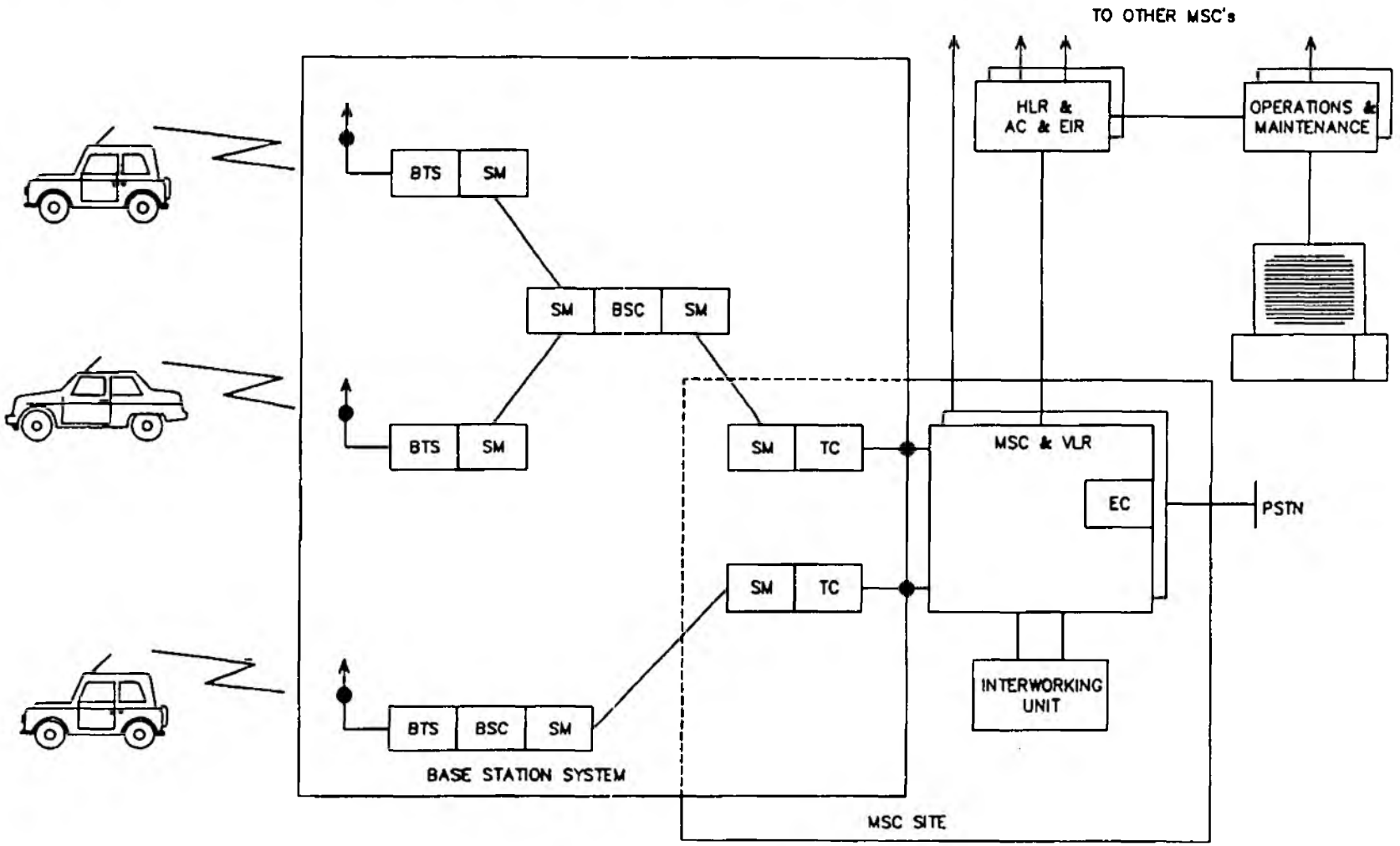
- Smaller size, weight and power budgets for subscriber equipment;
- A revolution in computing power which facilitates the complex administration and billing activities which are required to effectively run a 17-nation system;
- Better speech quality and more features, the parallel growth of the Integrated Digital Network, based on digital telephone networks, and its support of the Integrated Services Digital Network (ISDN) concept.

GSM architecture is similar to that of current cellular systems (Figure 5.1) but adds two components:

1. Home Location Register
2. Visitor Location Register

These two registers, coupled with CCITT Common Channel Signalling (CCS) No. 7, provide the technical means necessary to pan-European roaming.

The system will operate, at least initially, in channel pairs drawn from the 890-915MHz and 935-960MHz bands, a 50MHz allocation. The system is based on narrow-band time division multiple access (TDMA), which allows eight simultaneous conversations on a single radio frequency-radio multiplexing. This makes it radically different from current cellular systems which are based on frequency division multiple access (FDMA) which requires a separate frequency pair for each conversation.



BTS	BASE TRANSCEIVER STATION	BSC	BASE STATION CONTROLLER	EC	ECHO CANCELLER	HLR	HOME LOCATION REGISTER
EIR	EQUIPMENT IDENTITY REGISTER	TC	TRANSCODER	SM	MULTIPLEXER	MSC	MAIN SWITCHING CENTRE
AC	AUTHENTICATION CENTRE						

REV	ENGINEERS CHECK	REV	ENGINEERS CHECK
0	PROJ MAN APP'L		PROJ MAN APP'L
	REVIEWED BY		REVIEWED BY
DWN		DWN	
ORIG DSN		ORIG DSN	
DATE 10.08.91		DATE	

Costain Telecommunications and Systems Ltd.
Manchester

NRA EMERGENCY COMMUNICATIONS STUDY
GSM NETWORK STRUCTURE
FIGURE 5.1

SCALE	DWG.No.	REV
	CT649/905	0

CES/3 - A3

5.2.3 GSM services

Due to its digital technology the list of services envisaged is extensive and novel.

1. **Telephony**

   Normal voice telephony is supported with the ability to send or receive calls to a fixed or mobile subscriber throughout the world.

   Supplementary facilities should include:

   - Call forwarding unconditional
     Mobile subscriber busy
     No reply
     Mobile not reachable.

   - Call barring
     Outgoing
     Outgoing international
     Outgoing international except to home country
     Incoming
     Incoming when roaming abroad.

   - Call waiting
     Call hold
     Three party service.

   - Advice of charge.

2. **Emergency calls**

   Calls to the local emergency services can be made using a standard procedure in any country.

3. **Data transmission**

   Data transmission to a choice of popular standards may be sent or received, at all standard rates up to 9600b/s.

   Examples include asynchronous data to a standard modem or a packet switched network via a P.A.D. Similarly, synchronous connection may be available to a modem, or directly to a packet switched network.

   In all these cases, no modem is required at the mobile - a suitable data terminal or laptop computer directly to the mobile phone - a great advance over previous systems, and much more convenient to use.

   When used in error correcting mode, extremely low data error rates are guaranteed, even under badly fading conditions.

4. Facsimile group III

Telefax messages may be sent to, or received from, a standard Group III machine anywhere in the world. Rates up to the Group III maximum of 9600b/s are supported, so a high speed service is available.

5. Connection to other data services

By using the data transmission described above, a wide range of services may be obtained. These include:-

Electronic mail - including the new X400 standard
Videotex
Teletex
Telex

5.2.4 GSM network installation

The transition from the existing analogue TACS network to GSM is not a simple exercise either technically or commercially.

At a technical level Cellnet have gone on record as saying that in line with the recent Nordic cellular operators experiences of transition from their NMT454 to NMT900 system coverage is the key factor. And accordingly, Cellnet will provide full network coverage to meet consumer demand.

The second major point, the availability of terminal equipment, is also vital. It is recognised that initial offerings will be both bulkier and more expensive than the TACS equivalent, however, it is hoped that the economies of scale will impact rapidly on the marketplace to make GSM equipment price competitive.

At a commercial level the operators will be keen not to appear to be deserting current TACS subscribers. Hence actual plans for migration are unclear in an attempt to retain their subscriber base through any transitional phase.

It is however clear that both systems will run in tandem with "national coverage" of GSM concentrating on major areas of population and commerce.

5.3 Personal Communications Networks (PCN)

5.3.1 Introduction

Personal Communications Networks (PCN) are the latest mobile communications system to be licensed by the Government.

Three licenses have been granted to:

- o Mercury Personal Communications; a consortium of Cable and Wireless, Telefonica and Motorola Inc.
- o Unitel; a consortium of STC, Thorn EMI, US West Inc, and Deutsche Bundespost Telekom.
- o Microtel; a joint venture company of British Aerospace, Pacific, Telesis Millicom and Mantra Communications.

All of the companies are scheduled to begin operating in 1992 with a license target of 90% coverage of UK population achieved by 1998.

5.3.2 Network description

PCN's will be microcellular systems operating on a similar basis to GSM cellular telephony, under its own recognised European Telecommunications Standards Institute (ETSI) standard DCS 1800.

Operating in the 1.7 to 2.3 Gigahertz (GHz) band opposed to GSM 900 Megahertz (MHz) PCN will employ base stations with a cell service area varying in diameter from 1km to 16km. Thus in order to achieve license obligations several thousand base stations will be required. Mercury envisage by 1998 to be operating some 2500 base stations (current cellular operators have on average 550) offering 5 times the unit coverage and 90% access for potential users.

Given the remit of the 3 licensees to provide "personal communications" it should be understood PCN is not an additional cellular telephone service. It is a wireless alternative to the current BT and Mercury fixed networks, requiring investment from operators of the order of one billion pounds on infrastructure over the next 10 years, market surveys commissioned by the Licensees indicating a subscriber base of ten million by the year 2000.

5.4 Land Based Radio Communications

5.4.1 Digital Private Mobile Radio

This is a proposed new generation of digital private mobile radio system, with equipment conforming to a common European (ESTI) standard. The proposed launch date is 1991. The equipment is likely to provide at least two fold increase in the capacity over conventional FM units utilising 12.5KHz channel spacing, but with similar coverage area. Voice transmission will be in digital form giving inbuilt security. It is not yet clear whether new spectrum will be available for this service in the UK and as such it is difficult to to predict whether geographical coverage will or can be significantly improved at reasonable cost.

At the present time, there is no specification for the modulation technique or channel bandwidth although the majority of proposals are geared towards 25KHz channel spacing with 3 or 4 voice channels time division multiplexed on to each RF carrier. The modulation format is likely to be a form of QPSK or 16-QAM. Trunking will be an integral part of the system.

5.4.2 Digital Short Range Radio (DSSR)

A self trunking short range digital voice communications systems which can give rapidly deployed local communications. The DSSR systems uses an automated multi-channel access technique which operates without the assistance of a central controller in its single frequency simplex mode, or under control of a master base station unit when operated in half duplex mode. Limited protection and prioritorisation of the frequency band is available. Intended use is for closed user groups such as building site crews, maintenance teams, etc.

The specification allows for handportable units, base stations and repeaters, all of each can operate on a single call or group call basis. Operating range is likely to be a few kilometers without recourse to repeaters.

- Operating Frequency - 888 - 890MHz & 933 - 935MHz.
- Format - 2 control channels, 77 traffic channels.
- Channel spacing - 25KHz.
- Data rate - 16 Kbps for traffic channels (4Kbps for control channels).
- Modulation format - GMSK.
- Transmit Power - 4W.

5.4.3 Linear Private Mobile Radio

A proposed new generation of trunked (or non-trunked) PMR equipment operating in a 5KHz channel spacing within existing user channels or new spectrum within Band III. This technology allows more channels to be made available from the existing block of 12.5KHz channels, giving greater system capacity.

The Radio Communications Agency (RA) is currently preparing a specification for 5KHz equipment - MPT 1376, and a number of manufacturers are designing equipment for 5KHz use. Recent trials undertake of RA by 5KHz equipment using 'Linear Modulation' have shown that the range and performance is equivalent to, and in many cases better than that of existing 12.5KHz FM.

- o Modulation Format - Analogue voice (SSB)
  Digital Voice/Data (QPSK, 16-QAM,)
- o Channel Spacing - 5KHz
- o Trunking Format - MPT1327 or similar.

5.5 Mobile satellite radio communications

5.5.1 Introduction

With the rapidly increasing capacity of satellite transponders as newer and bigger satellites are launched, there is a corresponding explosive growth in the number of satellite based communications services on offer. In particular there is a dramatic increase in the number of mobile satellite services available or near commission, encouraged by the on-going process of deregulation of their use both within Europe and the USA, coupled with growing availability of so called very small aperture (VSAT) terminals (antenna dimensions below 1m -1.5m).

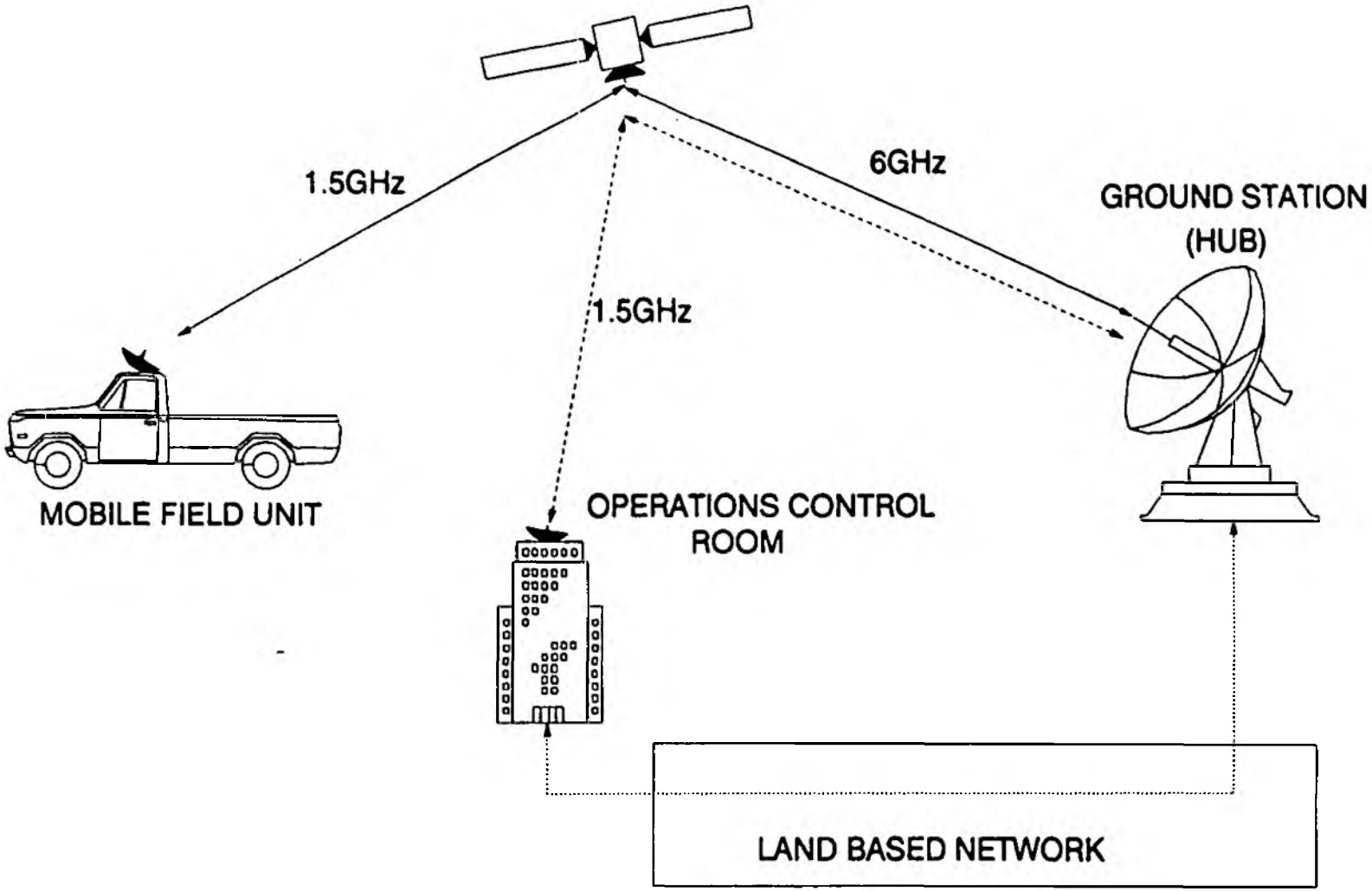
As technology improves and the transmit power of the satellite is increased, the gain of the receiving antenna on the ground based terminals can be correspondingly reduced, which directly reduces antenna size. In the near future, the truly handportable satellite terminal will be a reality. The 'Irdium' project outlined by Motorola is one example of such a system designed to supplement the existing land based cellular systems.

The major attraction of satellite communication for emergency applications, is the potential of complete coverage within the UK. As long as the terminal can be positioned to give a line of sight path to the satellite, then a communications link can be established.

The availability of the current mobile satellite services, INMARSAT-A, INMARSAT-C, etc is claimed to be about 99% and likely to improve with the new generation of satellites to be launched.

In a typical system configuration, the mobile unit communicates on a given set of frequencies with the satellite, which then transposes this signal to a new frequency set for communications with the fixed earth station, (the hub). The signal can be sent via conventional land based networks to its destination, or via a second satellite link to further fixed or mobile satellite terminal. This process is illustrated in Figure 5.2

Currently with most VSAT type services for use on land, the location of the transportable satellite terminal must be made known to the regulatory authorities and clearance given before transmission can commence. It is claimed that this procedure need take no longer than 1 hour.



REV	ENGINEERS CHECK	REV	ENGINEERS CHECK
0	PROJ MAN APP'L		PROJ MAN APP'L
	REVIEWED BY		REVIEWED BY
DWN	KR	DWN	
ORIG DSN	KR	ORIG DSN	
DATE	20.08.91	DATE	

Costain Telecommunications and Systems Ltd.

Manchester

NRA EMERGENCY COMMUNICATIONS STUDY
MOBILE SATELLITE COMMUNICATIONS
SCHEMATIC
FIGURE 5.2

SCALE	DWG.No.	REV
	CT649/908	0

CES/3 - A3

At present the satellite owners sell capacity to a small number of licensed operators (such as British Telecom International), who in turn manage and sell this service to the user. In the near future, a number of these services, including VSAT systems are to be deregulated, allowing individual users or groups of users to have a much greater influence on the use and management of their own satellite communications service.

The following sections detail a number of existing and proposed mobile satellite communication services which may have an application in emergency communication systems.

5.5.2 Standard - A

This is an INMARSAT service providing duplex voice and communications and in the near future, full duplex 64Kbps data communications. The service is primarily intended for Maritime use, however there are cases where it has been licensed for use in land based communications within the UK. For example, the broadcasters and police are permitted to use the system for emergency communications when there are no alternative communication facilities available. With the current deregulation of satellite services, it is likely that this facility will be extended to the other user groups should it be requested. Coverage in the UK is good with the satellite at an angle of approx 20°.

5.5.3 Standard - C

This is an INMARSAT service which gives a satellite based store and forward system for short data messages, allowing transmission to and from a portable terminal via satellite. The service is now available on a subscriber basis. There is excellent UK (and global) coverage providing that the satellite is not obscured , but because of the store and forward nature of the service, response time is slow (several seconds). It may have application in remote monitoring of water levels, contamination levels , etc to act as a warning of an emergency situation arising. A new facility is soon to be launched - the land mobile emergency service, which will guarantee message transmission within 30 seconds.

- Data Rate:600bps
- Operating Frequency: 1.5GHz
- Guaranteed Response Time: 30 seconds

5.5.4 Standard - M

This is an INMARSAT service providing a satellite based real time voice and communications systems with 'portable' terminals envisaged (not handportable due to the need for a high gain directional antenna). The service is scheduled to start in 1992 - 1993. There should be reasonable coverage if the satellite is not obscured by buildings, heavy foilage,etc. Capacity will be limited compared with terrestrial based PMR systems and call costs will be correspondingly higher. Its use as an emergency link may prove economical, but in view if the limited portability of the equipment may best serve as a means of connecting a local based radio network such as DSRR to a remote control site or data base. The service will support both full duplex voice communications and data services (including Group 3 FAX).

- Vocoder Rate: 6.4kbps (including channel coding)
- Data Rate: 2.4kbps (V.24 standard)
- Channel Spacing: 10KHz
- Operating Frequency: 1.5/1.6 GHz
- Modulation Format: Offset-QPSK

5.5.5 Low earth orbit satellites

There are currently a number of proposals, spear-headed by the Irdium proposal from Motorola, for worldwide satellite based voice and /data communication system using low earth orbiting satellites. By virtue of the low orbit, and consequent range reduction, it is intended that the system be able to support small (cellular type) hand portable terminals with unidirectional antennas.

The Irdium system is likely to give excellent UK (and global) coverage, and involves a grid of 77 satellites covering the entire earths service with 100% availability. The anticipated start of the service is in 1996, however there are a number of regulatory and spectral issues that need to be resolved before the system can engineered in any detail.

Other systems such as Ellipsat and ORBCOMM are aimed at providing data only services in a similar manner to the Irdium network.

APPENDIX A - QUESTIONNAIRE

This Appendix is a sample of the questionnaire which was sent out.

NRA EMERGENCY COMMUNICATIONS STRATEGY STUDY

NRA

1. RESPONDENTS DETAILS

NAME: TEL. No.:

REGION: AREA:

FUNCTIONAL GROUP:

(Please copy document if completed by more than one person)

2. REGIONAL INFORMATION

A) EMERGENCY CONTROL ROOMS

1) INDICATE & NUMBER ON THE TABLE BELOW THE LOCATION OF CONTROL ROOMS, THEIR AREA OF RESPONSIBILITY AND IF THEY ARE DEDICATED TO YOUR FUNCTIONAL GROUP.

No.	CONTROL LOCATION	RESPONSIBILITY (REGION/AREA)	DEDICATED FUNCTION (Y/N)
1.			

2) INDICATE FOR THE ABOVE ROOMS WHAT COMMUNICATIONS SYSTEMS/SERVICES ARE AVAILABLE TO CONTROL ROOM STAFF.

SYSTEM/SERVICE	CONTROL LOCATION (1,2,3 etc)
INTERNAL TELEPHONE	
EXTERNAL TELEPHONE – SHARED LINES	
– DEDICATED LINES	
RADIO DISPATCH/CONTROL	
CELLULAR TELEPHONY	
PAGING SERVICES – TONE PAGE	
– DISPLAY PAGE	(DIRECT / DIAL)
(NOTE 1) – MESSAGE PAGE	(DIRECT / DIAL)
FACSIMILE	
EXTERNAL DIRECT CONNECTIONS	
AUTOMATED SYSTEMS (LIST)	

NOTE 1. IS THIS PROVIDED BY DIAL UP SERVICE OR DIRECT TERMINAL INPUT?

B) EMERGENCY INCIDENTS

1) INDICATE ON THE TABLE BELOW THE AVERAGE NUMBER OF INCIDENTS OF THE PARTICULAR SIZE WHICH HAVE OCCURED IN THE LAST 12 MONTHS.

INCIDENT SIZE	QUANTITY
LOCALISED WITHIN AREA	
AREA WIDE	
INTER AREA	
REGION WIDE	
INTER REGION	

NRA EMERGENCY COMMUNICATIONS STRATEGY STUDY

NRA

2) INDICATE FOR THE ABOVE INCIDENTS THE AVERAGE NUMBER OF NRA STAFF INVOLVED.

INCIDENT SIZE	No. STAFF
LOCALISED WITHIN AREA	
AREA WIDE	
INTER AREA	
REGION WIDE	
INTER REGION	

3) WHAT HAS BEEN THE AVERAGE DURATION OF THE ABOVE INCIDENTS

INCIDENT SIZE	DURATION
LOCALISED WITHIN AREA	
AREA WIDE	
INTER AREA	
REGION WIDE	
INTER REGION	

C) COMMUNICATIONS SYSTEMS

1) PLEASE PUT THE FOLLOWING LIST OF SYSTEMS IN ORDER OF PRIORITY I.E 1 GREATEST IMPORTANCE – 10 LEAST. ADDING ANY ADDITIONAL SYSTEMS AS REQUIRED.

SYSTEM	PRIORITY	SYSTEM	PRIORITY
RADIO SYSTEMS			
CELLULAR TELEPHONY			
PUBLIC TELEPHONE			
INTERNAL TELEPHONE			
PAGING			
FACSIMILE			

NRA EMERGENCY COMMUNICATIONS STRATEGY STUDY

NRA

2) FOR THE TOP THREE SYSTEMS INDICATED IN 1) PLEASE LIST THEIR MAJOR ADVANTAGES AND DISADVANTAGES

SYSTEM 1.
ADVANTAGES
DISADVANTAGES

NRA EMERGENCY COMMUNICATIONS STRATEGY STUDY

NRA

SYSTEM 2.
ADVANTAGES
DISADVANTAGES

NRA

SYSTEM 3.
ADVANTAGES
DISADVANTAGES

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NRA

D) EXTERNAL COMMUNICATIONS

ON THE LIST BELOW INDICATE TO WHICH EXTERNAL ORGANISATIONS COMMUNICATION IS REQUIRED, AND IN WHAT FORM.

ORGANISATION	CONTACT Y/N	SYSTEM
WATER PLC WATER COMPANY EMERGENCY SERVICES – POLICE – FIRE – COASTGUARD OTHERS (LIST)		

NRA EMERGENCY COMMUNICATIONS STRATEGY STUDY

NRA

E) COMMUNICATIONS OPTIONS

1) WHICH FORM OF COMMUNICATION DO YOU CONSIDER AS MOST IMPORTANT

COMMUNICATIONS OPTIONS	TICK BOX	
	VOICE	DATA
PERSON TO PERSON		
OR		
PERSON TO VEHICLE		

2) FROM THE ABOVE OPTIONS, WHAT METHOD OF COMMUNICATION DO YOU CONSIDER MOST IMPORTANT (TICK BOX)

	VOICE	DATA
INCOMING ONLY		
INCOMING AND OUTGOING TO NRA RESOURCES		
AS ABOVE WITH OUTGOING NO RESTRICTIONS		

NRA EMERGENCY COMMUNICATIONS STRATEGY STUDY

NRA

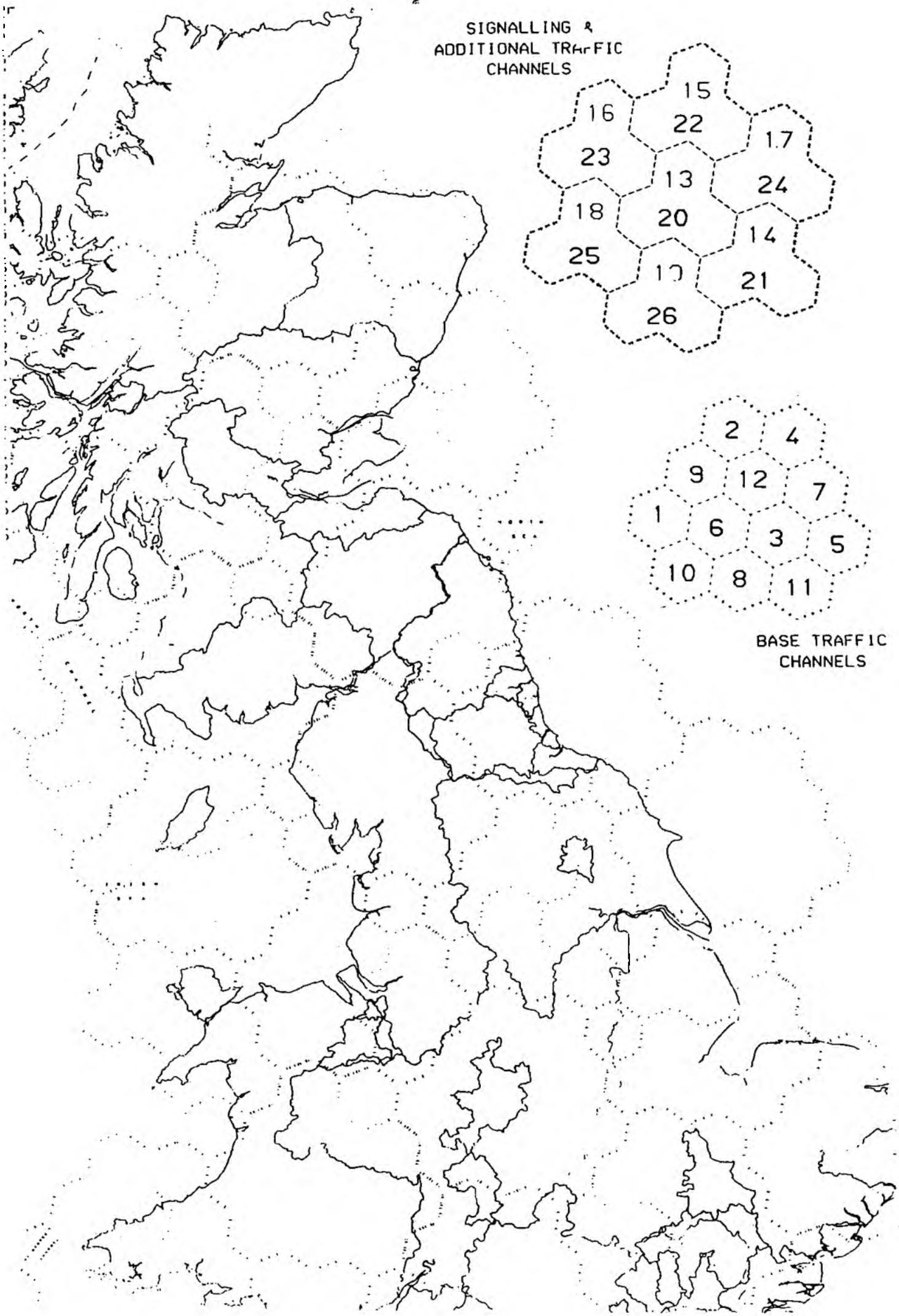
F) ANY ADDITIONAL COMMENTS YOU MAY WISH TO ADD PLEASE DO SO IN THE SPACE PROVIDED BELOW:-

PLEASE SEND COMPLETED QUESTIONNAIRES TO:-

COSTAIN TELECOMMUNICATIONS & SYSTEM LTD
COSTAIN HOUSE
STYAL ROAD
MANCHESTER
FAO KEITH ROWSON

APPENDIX B – PMR NATIONAL FREQUENCY PLAN

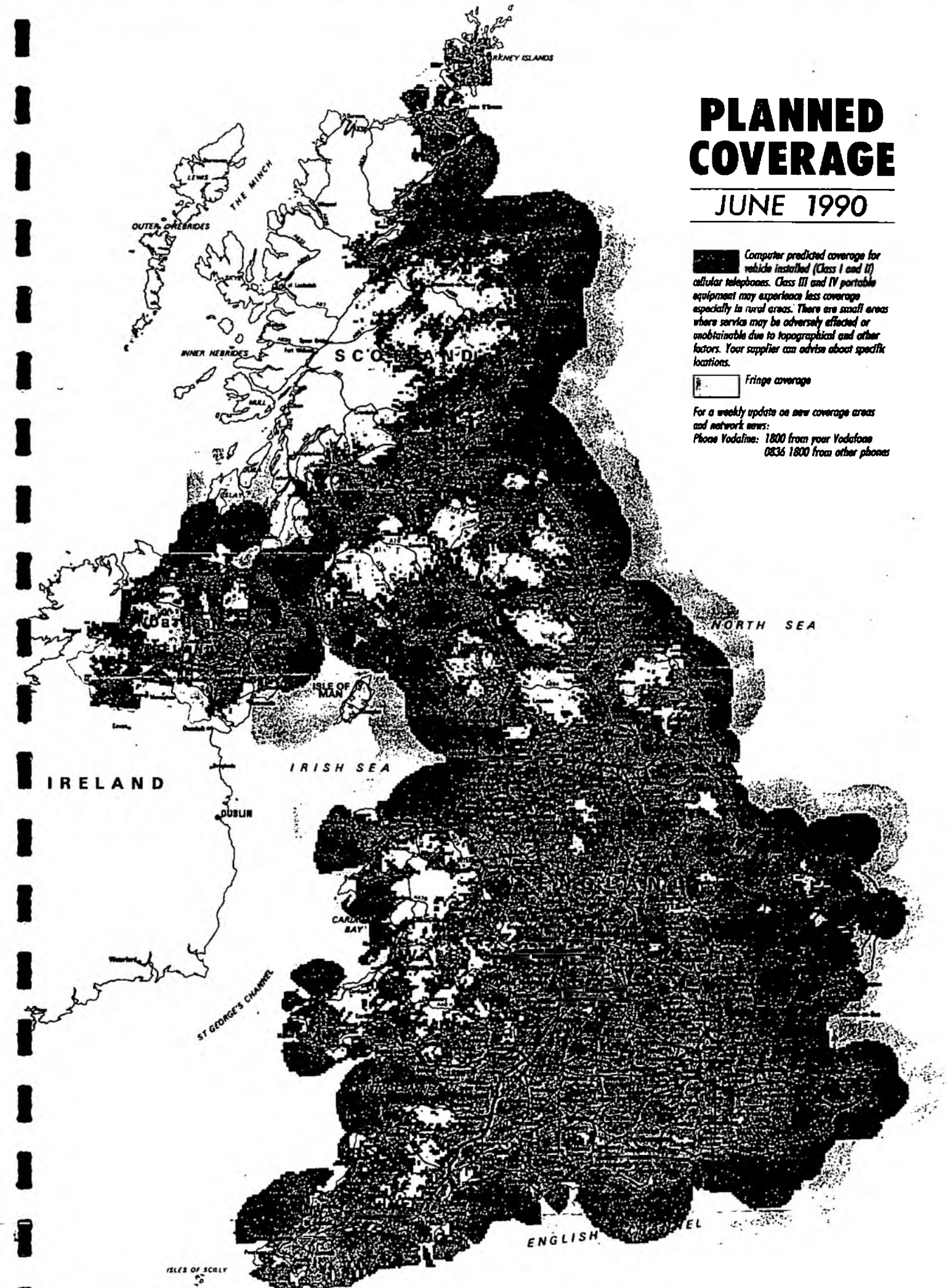
This Appendix details the PMR National Frequency Plan.


SIGNALLING &
ADDITIONAL TRAFFIC
CHANNELS
15
16
22
17
23
13
24
18
20
14
25
19
21
26
2
4
9
12
7
1
6
3
5
10
8
11
BASE TRAFFIC
CHANNELS

APPENDIX C - COVERAGE MAPS - CELLULAR TELEPHONY

This Appendix contains the coverage maps for current cellular telephony services.

VODAFONE



PLANNED COVERAGE

JUNE 1990

Computer predicted coverage for vehicle installed (Class I and II) cellular telephones. Class III and IV portable equipment may experience less coverage especially in rural areas. There are small areas where service may be adversely affected or unobtainable due to topographical and other factors. Your supplier can advise about specific locations.

Fringe coverage

For a weekly update on new coverage areas and network news:
Phone Vodaline: 1800 from your Vodafone
0836 1800 from other phones

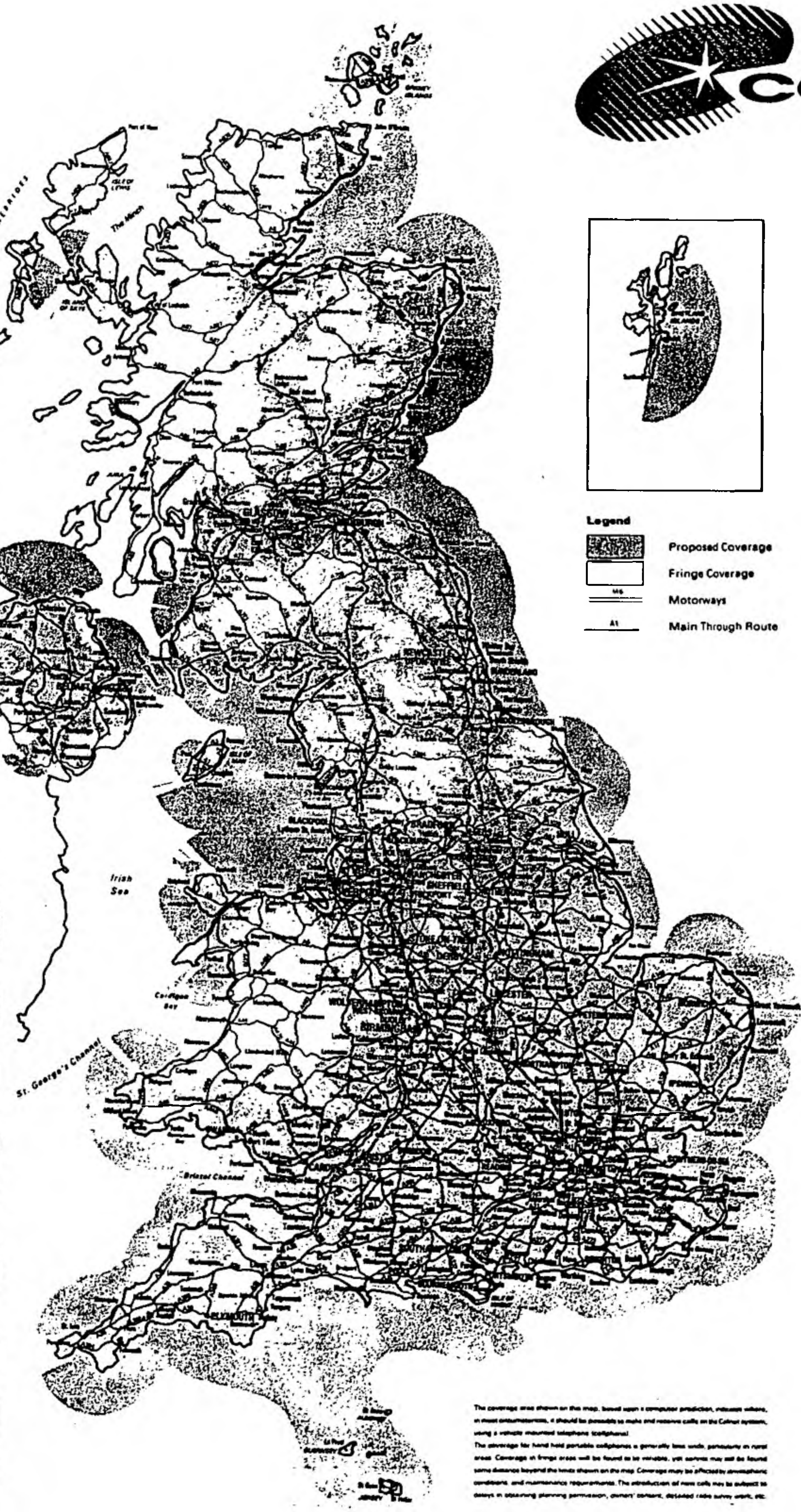
GEOprojects (UK) Ltd.

Map designed and produced by GEOprojects (UK) Ltd., Henley-on-Thames, Oxon. RG9 1HG

cellnet

mobile

Proposed coverage to the end of December 1990

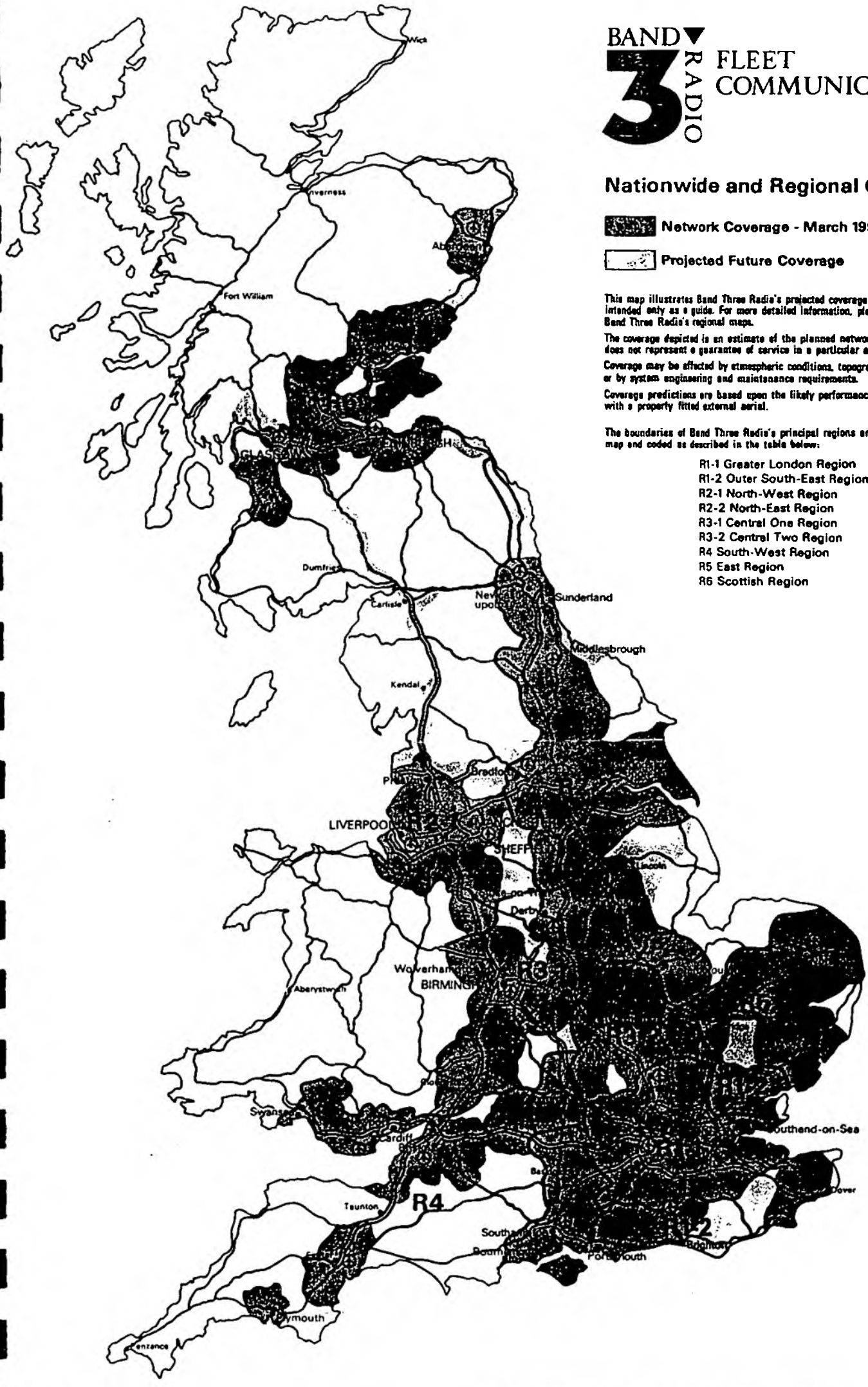


The coverage area shown on this map, based upon a computer prediction, indicates where, in most circumstances, it should be possible to make and receive calls on the Cellnet system, using a vehicle mounted telephone (cellphone).

The coverage for hand held portable cellphones is generally less wide, particularly in rural areas. Coverage in fringe areas will be found to be variable, yet service may still be found some distance beyond the limits shown on the map. Coverage may be affected by atmospheric conditions, and maintenance requirements. The introduction of new cells may be subject to delays in obtaining planning permission, owners' consent, detailed radio survey work, etc.

APPENDIX D - COVERAGE MAPS - BAND III

This Appendix contains a coverage map of the current Band III PAMR service.



BAND 3 RADIO FLEET COMMUNICATIONS

Nationwide and Regional Coverage

Network Coverage - March 1991

Projected Future Coverage

This map illustrates Band Three Radio's projected coverage of the UK and is intended only as a guide. For more detailed information, please refer to Band Three Radio's regional maps.

The coverage depicted is an estimate of the planned network coverage and does not represent a guarantee of service in a particular area.

Coverage may be affected by atmospheric conditions, topographical features, or by system engineering and maintenance requirements.

Coverage predictions are based upon the likely performance of a mobile unit with a properly fitted external aerial.

The boundaries of Band Three Radio's principal regions are identified on the map and coded as described in the table below:

R1-1 Greater London Region
R1-2 Outer South-East Region
R2-1 North-West Region
R2-2 North-East Region
R3-1 Central One Region
R3-2 Central Two Region
R4 South-West Region
R5 East Region
R6 Scottish Region

Cellular / 40% saving prepared by direct wire who Vodaphone
+ Cellnet / Google Late STR. / Visit ?

Dave Walton / Contains.
Keith Robson / Study document.
Forward control Vehicles Thames 4 tonner 3 / never used / scrapped @ 10 years.
— We are base for entire local Company.
Barry Wood is BT Customer Account Manager for Anglian