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1. INTRODUCTION

The JRC Band provides 76 two-frequency channels for the Fuel and Power Industries operating under the parameters set out below:

- Base Station Transmitter Frequency Range - 139.5 to 140.5 MHz
- Mobile Station Transmitter Frequency Range - 148.0 to 149.0 MHz
- Performance Specification - MPT 1323 (JRC) October 1985
- Minimum Field Strength to be protected -20 dBuV/m
- Minimum Design Signal to Interference Ratio -19 dB.

A regular re-use strategy has been implemented based on a standard cell having a nominal radius of 23 km operating in a 9-cell cluster. Eight channels are available within each cluster, four channels for the Electricity Supply Industry and four channels for British Gas plc. Further details can be found in the 1988 Seminar Handbook – *“Transfer of Mobile Radio Services to the JRC Band”*.

The Coal Industry operates on 4 channels outside the cellular plan. However, Coal systems will be designed to provide a similar re-use distance (measured between service area boundaries) to that available in the cellular plan. In exceptional circumstances, Coal channels are available for use by ESI and Gas companies in areas where interference to the coal companies can be controlled.

This memorandum sets out the procedure to be followed when applying for JRC Band Channels and is based on parameters specified in the 1998 JRC Seminar Handbook.

2. FREQUENCY RE-USE STRATEGY

Appendix 1 shows the channels available within the JRC Band. Each channel number is prefixed by the letter J to denote that it is a JRC Band channel. Interleaved (Interstitial) channels on this list are

designated “K” channels. The planning rules for these channels are contained in JRC Publication “*Interleaved Channel Planning Rules*”.

Appendix 2 shows the cellular structure for the UK with cells identified by the letters A-K and clusters by the numbering sequence 1-33. Co-channel cells appear every third cell when moving along the line at right angles to the cell side, providing a nominal re-use distance of 120 km. The cellular geometry is such that any cell has two non-adjacent cells such as cells D and K when considering cell B in Appendix 3. This enables further channel sharing to take place by creating inset cells and using channels from non-adjacent cells within a primary cell. Additional channels can therefore be provided to meet the higher traffic requirements associated with the major urban areas. Up to eight additional channels may be provided in any one cell but it should be noted that with the reduced re-use distances involved, special engineering will be required in both donor and recipient cells. The alternative method is Interleaved (Interstitial) channel planning, which is mutually incompatible with Inset Cell Planning but allows full power to be used on all channels on the same site. The methods are described in JRC Handbook “*Interleaved Channel Planning Rules*”.

3. Planning Tools

Parameters for base stations operating in the JRC Band will be assessed using the planning tool RF Designer. Exported interference to co-channel cells outside the applicant's Company or Region must not exceed -147dBW for 90% of the locations in those cells and must not exceed -138dBW at any location within the cell. Under certain circumstances, it may be possible to relax these limits and this is discussed later in this Memorandum.

4. Applications for JRC Band Channels

All applications for JRC Band channels will be submitted to the appropriate Industry Coordinator and will comprise:

- A covering letter
- Licence application form(s) JRC RA1
- Cellular maps
- RF Designer results for each base station required
- Traffic details (where inset cells are required)

4.1. Covering Letter

The covering letter should describe the proposed network or individual base station in sufficient detail to enable the ESI PMR Coordinator (and the JRC) to understand how the network or individual base station will be used to meet the operational requirements of the Company or Region. Details of the control channel and switching arrangements should be provided together with a description of any provision made for data transmission. If necessary, relevant technical specifications may be included, in which case the covering letter should refer to the appropriate sections of the specification when describing the network.

4.2. Application Form RA1 (JRC)

The standard application form for all mobile radio licence applications is shown in Appendix 4. It should be completed as shown in Figure 1:

4.3. Cellular Maps

Cellular maps shall be provided showing the following:

- The location of base station sites in each cell;
- The location and identity of co-channel cells within 120km (i.e. two cells distant) of main cells; and

- Company/Regional boundaries.

RF Designer may be used to provide this information and Appendix 5 shows a cellular map for a base station located in cell 16E.

4.4. RF Designer Results

For each base station, a copy of the RF Designer screen dump shall be provided. This analysis will show the exported interference into co-channel cells located in adjacent Companies or Regions satisfies the requirements set out in Section 4 of this memorandum. Appendix 6 shows the RF Designer results for a Base Station located in cell 16C. In exceptional circumstances, it may be possible to extend the percentage of locations where this figure may be exceeded. Applications to extend the limit must be accompanied by written evidence that neighbouring users are prepared to accept the higher level of interference.

4.5. Traffic Details

When inset cells are to be used, traffic details must be supplied to support the need for additional channels in the recipient cells. Total traffic levels should be substantiated in terms of the number of messages, types of operational traffic carried, mixture of voice/data etc. This analysis should clearly indicate the current and forecast levels, where possible the forecast levels should be shown in terms of yearly growth. Finally, the design grade-of-service for the network should be stated and used to calculate the number of channels required.

Written agreement that the operator of donor cells outside the applicant's Company is willing to protect the inset cells must be included with the submission. The use of inset cells necessitates very careful RF design to enable the channels to operate satisfactorily with reduced separation.

5. General

All applications for JRC Band networks will require the approval of the MRTSC. The Sub-Committee meets every 6-8 weeks and the failure to provide the information identified in this Memorandum may delay the consideration of the application by the Sub-Committee. Should applicants be in doubt about the provision of supporting information for their application, they are advised to consult the Secretariat.

END

Appendix 1

J-Band Channel plan

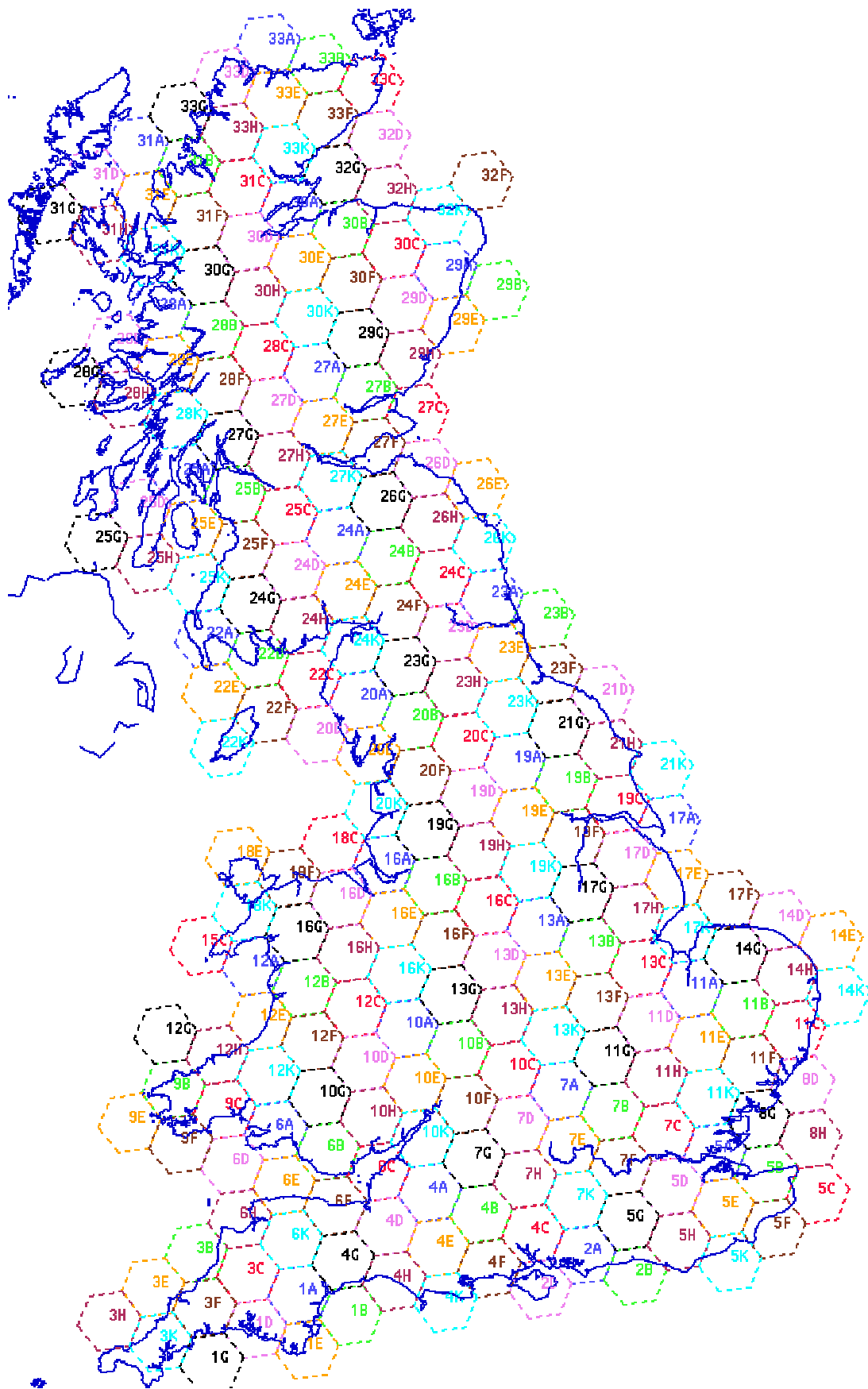
Showing Base and Mobile transmit frequencies in MHz, JRC, RA and JRC Cell Cluster Letters.

Mobile TX	Base TX	JRC	RA	Cell
148.01875	139.51875	J22	802	A
148.02500	139.52500	K22		
148.03125	139.53125	J23	803	B
148.03750	139.53750	K23		
148.04375	139.54375	J24	804	C
148.05000	139.55000	K24		
148.05625	139.55625	J25	805	D
148.06250	139.56250	K25		
148.06875	139.56875	J26	806	E
148.07500	139.57500	K26		
148.08125	139.58125	J27	807	F
148.08750	139.58750	K27		
148.09375	139.59375	J28	808	G
148.10000	139.60000	K28		
148.10625	139.60625	J29	809	H
148.11250	139.61250	K29		
148.11875	139.61875	J30	810	K
148.12500	139.62500	K30		
148.13125	139.63125	J31	811	A
148.13750	139.63750	K31		
148.14375	139.64375	J32	812	B
148.15000	139.65000	K32		
148.15625	139.65625	J33	813	C
148.16250	139.66250	K33		
148.16875	139.66875	J34	814	D
148.17500	139.67500	K34		
148.18125	139.68125	J35	815	E
148.18750	139.68750	K35		
148.19375	139.69375	J36	816	F
148.20000	139.70000	K36		
148.20625	139.70625	J37	817	G
148.21250	139.71250	K37		
148.21875	139.71875	J38	818	H
148.22500	139.72500	K38		
148.23125	139.73125	J39	819	K
148.23750	139.73750	K39		
148.24375	139.74375	J40	820	A
148.25000	139.75000	K40		
148.25625	139.75625	J41	821	B
148.26250	139.76250	K41		
148.26875	139.76875	J42	822	C
148.27500	139.77500	K42		
148.28125	139.78125	J43	823	D
148.28750	139.78750	K43		
148.29375	139.79375	J44	824	E
148.30000	139.80000	K44		
148.30625	139.80625	J45	825	F
148.31250	139.81250	K45		
148.31875	139.81875	J46	826	G
148.32500	139.82500	K46		
148.33125	139.83125	J47	827	H
148.33750	139.83750	K47		
148.34375	139.84375	J48	828	K
148.35000	139.85000	K48		
148.35625	139.85625	J49	829	A
148.36250	139.86250	K49		
148.36875	139.86875	J50	830	B
148.37500	139.87500	K50		
148.38125	139.88125	J51	831	C
148.38750	139.88750	K51		
148.39375	139.89375	J52	832	D
148.40000	139.90000	K52		
148.40625	139.90625	J53	833	E
148.41250	139.91250	K53		
148.41875	139.91875	J54	834	F
148.42500	139.92500	K54		
148.43125	139.93125	J55	835	G
148.43750	139.93750	K55		
148.44375	139.94375	J56	836	H
148.45000	139.95000	K56		
148.45625	139.95625	J57	837	K
148.46250	139.96250	K57		
148.46875	139.96875	J58	838	COAL
148.47500	139.97500	K58		
148.48125	139.98125	J59	839	E
148.48750	139.98750	K59		
148.49375	139.99375	J60	840	F
148.50000	140.00000	K60		

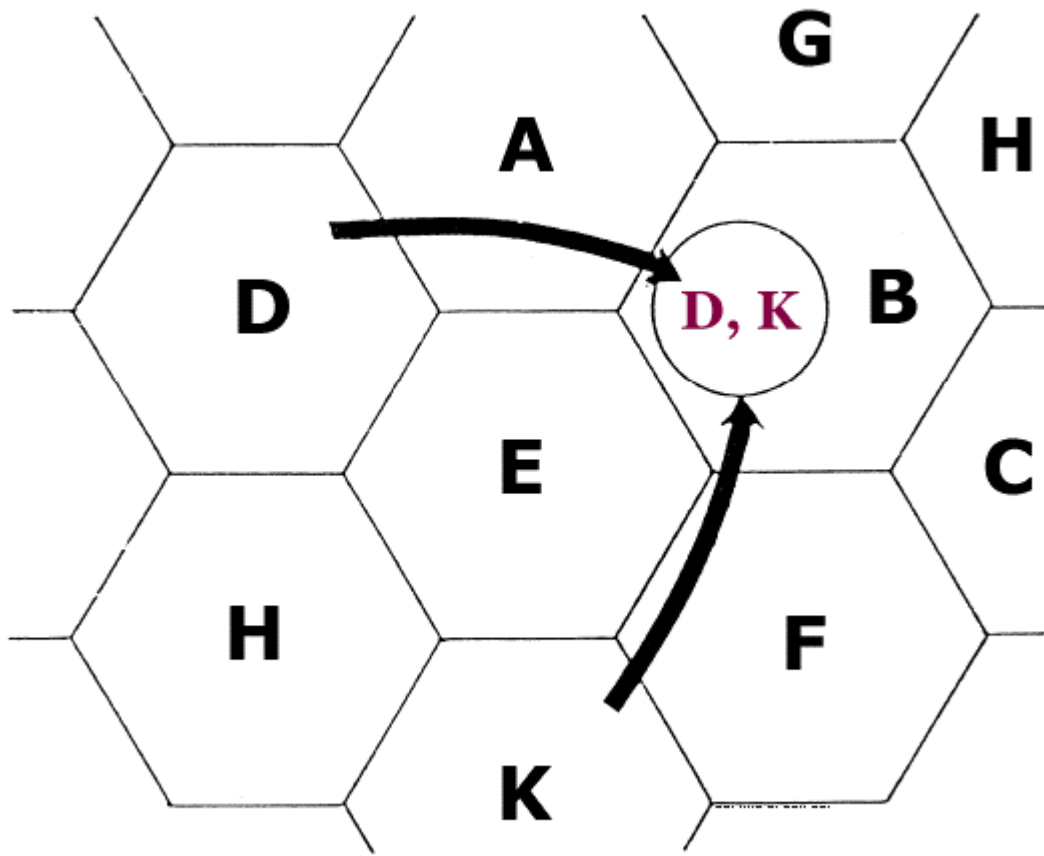
Mobile TX	Base TX	JRC	RA	Cell
148.50625	140.00625	J61	841	G
148.51250	140.01250	K61		
148.51875	140.01875	J62	842	H
148.52500	140.02500	K62		
148.53125	140.03125	J63	843	K
148.53750	140.03750	K63		
148.54375	140.04375	J64	844	A
148.55000	140.05000	K64		
148.55625	140.05625	J65	845	B
148.56250	140.06250	K65		
148.56875	140.06875	J66	846	C
148.57500	140.07500	K66		
148.58125	140.08125	J67	847	D
148.58750	140.08750	K67		
148.59375	140.09375	J68	848	COAL
148.60000	140.10000	K68		
148.60625	140.10625	J69	849	E
148.61250	140.11250	K69		
148.61875	140.11875	J70	850	F
148.62500	140.12500	K70		
148.63125	140.13125	J71	851	G
148.63750	140.13750	K71		
148.64375	140.14375	J72	852	H
148.65000	140.15000	K72		
148.65625	140.15625	J73	853	K
148.66250	140.16250	K73		
148.66875	140.16875	J74	854	A
148.67500	140.17500	K74		
148.68125	140.18125	J75	855	B
148.68750	140.18750	K75		
148.69375	140.19375	J76	856	C
148.70000	140.20000	K76		
148.70625	140.20625	J77	857	D
148.71250	140.21250	K77		
148.71875	140.21875	J78	858	COAL
148.72500	140.22500	K78		
148.73125	140.23125	J79	859	E
148.73750	140.23750	K79		
148.74375	140.24375	J80	860	F
148.75000	140.25000	K80		
148.75625	140.25625	J81	861	G
148.76250	140.26250	K81		
148.76875	140.26875	J82	862	H
148.77500	140.27500	K82		
148.78125	140.28125	J83	863	K
148.78750	140.28750	K83		
148.79375	140.29375	J84	864	A
148.80000	140.30000	K84		
148.80625	140.30625	J85	865	B
148.81250	140.31250	K85		
148.81875	140.31875	J86	866	C
148.82500	140.32500	K86		
148.83125	140.33125	J87	867	D
148.83750	140.33750	K87		
148.84375	140.34375	J88	868	COAL
148.85000	140.35000	K88		
148.85625	140.35625	J89	869	E
148.86250	140.36250	K89		
148.86875	140.36875	J90	883/886	SX
148.87500	140.37500	K90	887	Note 1
148.88125	140.38125	J91	885/888	SX
148.88750	140.38750	K91		
148.89375	140.39375	J92	872	H
148.90000	140.40000	K92		
148.90625	140.40625	J93	873	K
148.91250	140.41250	K93		
148.91875	140.41875	J94	874	A
148.92500	140.42500	K94		
148.93125	140.43125	J95	875	B
148.93750	140.43750	K95		
148.94375	140.44375	J96	876	C
148.95000	140.45000	K96		
148.95625	140.45625	J97	877	D
148.96250	140.46250	K97		
148.96875	140.46875	J98	878	F
148.97500	140.47500	K98		
148.98125	140.48125	J99	879	G
148.98750	140.48750	K99		

||| Note 1: 140,375 MHz is used for onward paging.

Appendix 2



Appendix 3



Appendix 4

Part 1	Applicant Details
Name and address of organisation	Organisation and address to which all correspondence relating to the licence should be addressed.
Name, E-Mail address and telephone numbers of contact	Planning engineer responsible for licence application.
Signature	Principal Engineer (ESI), C & I Engineer (Gas)
Part 2	Base Station and System Requirements
Site Name	Normal designation for site (care should be taken to avoid the use of more than one name for the same site)
Site identity/Cell Ident	JRC use only
Callsign/CallCode	A Callsign is a licence requirement. Don't use a geographic name or anything that could be considered inappropriate but anything else will do.
Operational area	Hand portable to hand portable use only
Grid Reference	Two letters and six figure NGR
Control	by Land line or radio
Ground height	Ground height in metres
Antenna height	Antenna height in metres above the local ground level
Antenna type	Type 1-5 or polar diagram details (or use Omni)
Antenna gain	Gain in dB relative to dipole (dBd)
Direction of maximum radiation	Degrees east of grid north – if Omni, leave blank
ERP	Effective radiated power in watts
Talk-through required	Yes/No, i.e. Is this a repeater or not?
Pip-Tones, PABX, PSTN(Emergency), PSTN(General)	Fill in as required
CTCSS/DCS	The frequency or the DCS Code required – It will be assigned automatically if not specified and it is a licence requirement to use it for on-site systems or talk-through repeaters.
Duplex Operation	This does NOT mean Talkthrough, this means FULL DUPLEX, i.e. proper telephone-style operation from both the base station and the mobile. Not usually required.
Non-Prescribed Data	Trunked Systems only. For data communication not mandated in MPT1327
Part 3	Equipment
Type approval numbers	Enter for base and mobile stations
Quantity	Show number of mobile stations
ERP	Show effective radiated powers for mobile and handportable stations Not RF Power Output. If unsure, enter RF Output and Antenna Type used in Comments box instead.
Part 4	Frequency Assignment
Frequency Band	Tick JRC Band box for the band required
Channels previously approved for this site	Show channel numbers already approved for use at this site

Leave all remaining boxes clear.

Complete one application form for each site

FIGURE 1 – Completion of Form RA1(JRC)

3. Equipment

	Base	Mobiles	Handhelds
Type approval number:	<input type="text"/>	<input type="text"/>	<input type="text"/>
Quantity:		<input type="text"/>	<input type="text"/>
ERP – NOT power output (watts):		<input type="text"/>	<input type="text"/>
Comments:	<input type="text"/>		

4. Frequency assignment

	(tick)	Channels already used on this site
High Band (169.050 MHz):	<input type="checkbox"/>	<input type="text"/>
JRC VHF band:	<input type="checkbox"/>	<input type="text"/>
JRC UHF bands:	<input type="checkbox"/>	<input type="text"/>
Comments:	<input type="text"/>	
Channels requested	<input type="text"/>	

4.1 Recommended frequencies (The JRC will fill this in)

RA Channel number	Base TX	Mobile TX
<input type="text"/>	<input type="text"/> MHz	<input type="text"/> MHz
<input type="text"/>	<input type="text"/> MHz	<input type="text"/> MHz
<input type="text"/>	<input type="text"/> MHz	<input type="text"/> MHz
<input type="text"/>	<input type="text"/> MHz	<input type="text"/> MHz

5. Authorisation

"Authorised on behalf of the Joint Radio Company Ltd."

Signed:

Name:..... Date :.....

"Authorised on behalf of the Secretary of State for Trade and Industry"

Signed:

Name:..... Date :.....

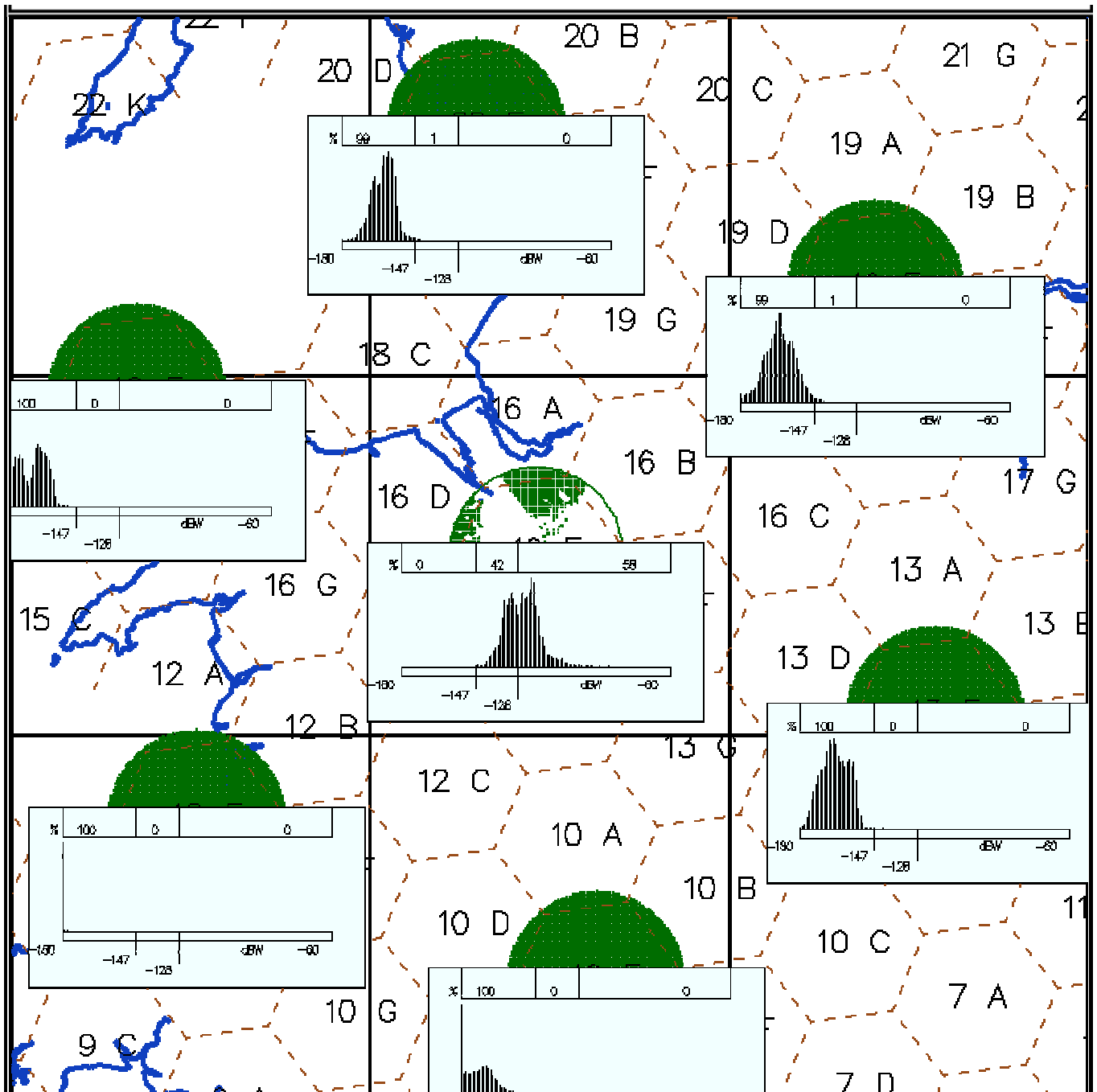
JRC Reference:

RA Reference:

This JRC form constitutes an essential part of the licence application process carried out by the JRC on behalf of member companies. As such, it forms part of the legal documentation leading to the issue of a WT Act licence or licence amendment. The operating conditions detailed in this form constitute the agreed operational parameters of the system/site and override those quoted on the schedule issued by the Radiocommunications Agency where those exceed those stated on this form.

Appendix 6

Appendix 7



- Note 1: The transmitter ERP used to assess exported interference must be that which will be used in practice – i.e. after any increase in power has been made to compensate for local clutter loss.
- Note 2: The mobile antenna height should be 1.5m

Appendix 8

Calibration of RFD

Eastern Electricity made some detailed comparisons of the predictions produced by RFDESIGNER1 and the actual service areas in the commissioned system. This resulted in the following suggested factors that would need to be taken into account when planning a network using RFDESIGNER1.

Comparison Against ESI Project Team Trial

The project team's measurements were intended to establish the principle of path reciprocity for which the ESI established the concept of 'normal power', whereby base station receivers were to be fitted with attenuation related to the transmitter power restriction at that base station (imposed by JRC planning rules) below the 12W nominal ERP. The 12W value was based upon a 25W mobile with -3dB antenna gain and it was assumed that the maximum range of a base station was related to the ability of a mobile to communicate with it, assuming that the outbound and inbound paths have an identical loss. This assumption was always dubious; various authorities (eg Macario, IEE Mobile Radio Summer School, Bath 1985) suggest that there is no correlation between go and return paths with 9MHz separation like the JRC band.

The ESI measured signal levels in phase one of our scheme, which was the first ESI system to be installed. To provide a check of RFD performance, I took each pair of values as two separate measurements, justified because of the lack of reciprocity. They were then compared to the path loss predicted using the path profile feature of RFD. Paper A shows the results. A simple interpretation of this paper is that the RFD mean prediction was 1dB optimistic, but that the sets of results have a standard deviation of 4.55dB. Diagram B shows the effect of this. The fading distribution is log-normal and so there is a probability that the signal level will be lower than the mean in 50% of locations. (The CCIR curves on which the drawing is based give a 7dB standard deviation as opposed to the measured 4.55dB). Using the standard deviation and normal distribution tables it is possible to establish a correction factor to give any required probability for the required signal to be available. I chose 90% which, given the lack of reciprocity, gives 81% probability of making the call from the limit of the service area (both inbound and outbound paths have to work!). The paper includes a statement of the effects of the variations in mute open and close points of the base station receivers, which affects the ability to sustain a call after being sent to a traffic channel (the ESI system has level operated mutes, rather than CTCSS or MPT1327 messages).

Using the above approach I modified the coverage plots on RFD by setting the mean higher to take account of the statistical correction for the level of service required. The resulting plots showed a good correlation with an independently produced map of user complaints, the 'black holes' on the user map coinciding with the areas of no-coverage predicted by the modified RFD plots. From this the service threshold settings and base station powers were modified.

Rayleigh Fading

The other effect that has to be considered and has not been incorporated into Eastern's planning is Rayleigh fading. Diagram D shows the effects of this and is taken from Lee's book on cellular and mobile system planning. This implies that at 1% of locations the actual signal level can be 20dB below the 'specified' level; as this is a separate mechanism it is additive with the effects of the log-normal fading described above. We have experienced an effect where a mobile is in service but unable to set up calls on our system, to the extent that no record of the call is available. However, the call attempts that we didn't see were registered on a SEEBOARD system using the same control channel, up to 100miles away. Opinions differ on the mechanism, but consider:

1. that there is no reciprocity between mobile-base and base-mobile paths, hence it is possible to be in service but for the mobile-base path to be up to 20dB below the local mean in 1% of locations; and
2. the Rayleigh fading pattern is set by path geometry and so the mobile-base paths to two different base stations can perform differently.

My view is that this is yet another effect that needs to be considered. The ESI say that the mobile is responding to the distant base station, despite the wrong SYS code. However, if that was the case it means that the mobile is receiving a signal above its in-service threshold in someone else's service area, which seems unlikely.

I hope that this throws a little light onto the various areas that need to be considered in establishing the accuracy of RFD. There is need to consider subjective effects, such as the expectation of the level of service, and the equipment characteristics, in addition to the performance of the planning tool. I will be pleased to talk you through the concepts if required, and no doubt, additional information will be available following Eastern's current review. One obvious further action is to compare the results from the current version of RFD against the available measurements.

R J Brannon