BAND I – AN OVERLOOKED RESOURCE?

Richard Rudd
Aegis Systems Ltd, United Kingdom

INTRODUCTION

The term ‘Band I’ is generally taken to refer to the lowest portion of the VHF spectrum allocated, in the Radio Regulations, for broadcast use (47-68 MHz). In practice, and in this paper, the terminology is sometimes stretched to refer generally to the lower VHF frequencies.

This spectrum came into widespread use in the years preceding the Second World War, as technology supported the generation of useful power, sensitive receivers and stable oscillators at these frequencies. In the UK, the first major application of these technologies was for television, in the band 41 – 48 MHz. After the war, the UK television service expanded to use the entire band 41-68 MHz. In the meantime, the first mobile radio services were developed in spectrum at around 70 MHz.

The technological progress, which had permitted the use of these frequencies, soon allowed higher frequencies to be employed, and for reasons discussed below, these were often preferred. In 1984, the use of Band I for television ceased in the UK. In the intervening decades, few applications have replaced it, and the entire portion of spectrum below 68 MHz appears to be rather under used. Figure 1 illustrates the occupancy of this spectrum as measured at the Aegis Systems offices near London, and it can be seen that usage is light, especially between the large local noise spectrum around 50 MHz and the Private Mobile Radio (PMR) ‘low band’ allocation at 68-88 MHz. The high power broadcast transmissions above 88 MHz are clearly seen. The apparently light usage is particularly noteworthy in the context of the demand for (and in some cases, cost of) access to other parts of the spectrum.

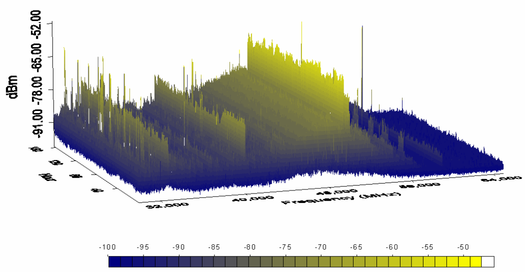

Figure 1a: Power-time (30-65 MHz)

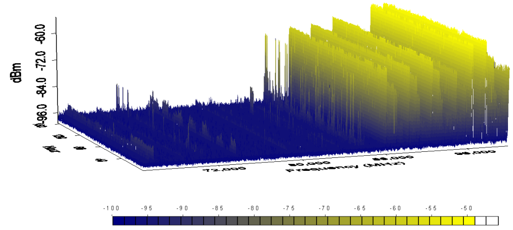

Figure 1b: Power-time (65-100 MHz)

This paper examines some of the reasons for this unpopularity, and examines ways in which the spectrum might be more efficiently used.

PROBLEMS…

Antenna dimensions

One reason often cited for the unpopularity of Band I spectrum relates to the physical size of even simple aerial systems. A quarter wavelength whip antenna at 60 MHz is some 4 feet high, making it somewhat unattractive for handheld applications.

Even for fixed applications, the necessary dimensions of antennas pose problems. A directional, Yagi-type antenna will add considerable wind loading to any structure, and the necessary mast aperture is likely to be rare and expensive. These factors make it difficult to engineer antennas with great gain (to minimise transmitter power) or directionality (to improve network self-interference). It is interesting to note that only one of the original Band I television transmitters had a directional aerial, while the majority of band III stations were able to achieve gains in the order of 15 dBd by stacking and horizontal directionality. One of the major problems found by PMR operators, using this spectrum on a trial basis, was that only a single band I antenna might be accommodated in mast space that would have allowed several ‘high band’ aerials.

A further point to note is that, due to the low wavelength involved, clearance of the first Fresnel zone is almost never achieved.

Man-made noise

From the earliest days of broadcast television, the high levels of man-made noise present in this band have caused problems for users.

A decade or so ago, when the introduction of terrestrial Digital Audio Broadcasting was being discussed, the use of Band I was eventually ruled out partly on the grounds of the high man-made noise levels in the band. (Though the use of band I is still part of the specification, and a single band I allotment was made in the Wiesbaden T-DAB plan.)

There is surprisingly little data on the statistics of man-made noise available, however. The information given on man-made noise in the relevant ITU-R Recommendation (P.372-7) is based largely on data originally measured in the USA in the 1970s.

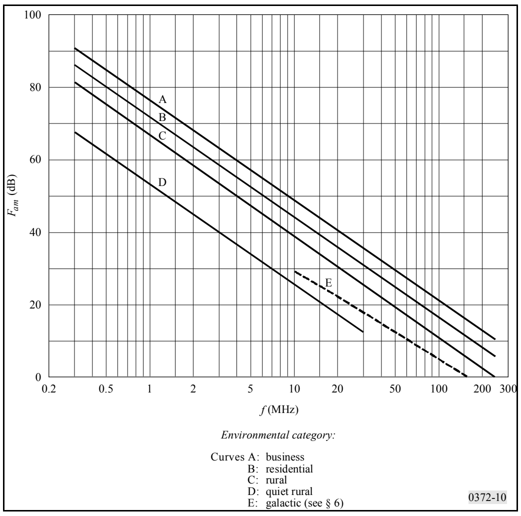

Figure 2: Median values of man-made noise power (from ITU-R P.372-7)

A figure from this Recommendation is reproduced above and it can be seen that the noise levels fall by some 14dB between 50 and 150 MHz. While this trend has been confirmed in many measurements, the statistics given take no account of the amplitude or temporal distribution of the noise, nor of the enormous growth in interference due to radiation from digital circuitry.

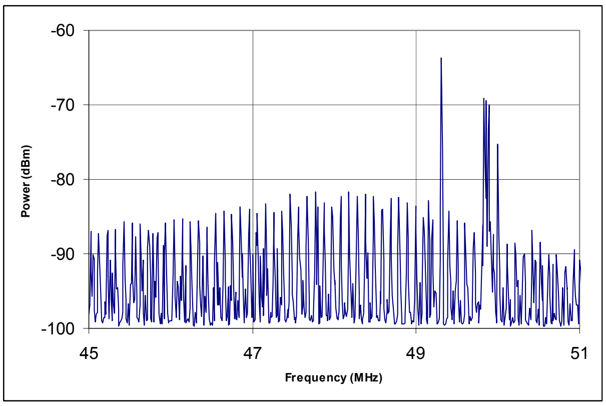

Figure 3: man made noise spectrum

The spectral plot shown in Figure 3 (an expansion from the data in Figure 1a) shows that at least some of the man made noise measured at the Aegis Systems offices is due to radiation from relatively local digital equipment. It seems important to quantify the characteristics of such noise further.

Ionospheric interference

A regular cause of complaint by TV viewers in the summer months was the interference caused by propagation, via sporadic ionisation of the E-layer, of signals from very distant (~1000km) TV transmitters. The mechanisms responsible for such Sporadic-E propagation are still unclear, but a strong seasonal trend [1] is evident (the TV interference generally seemed to coincide with the coverage of Wimbledon!).

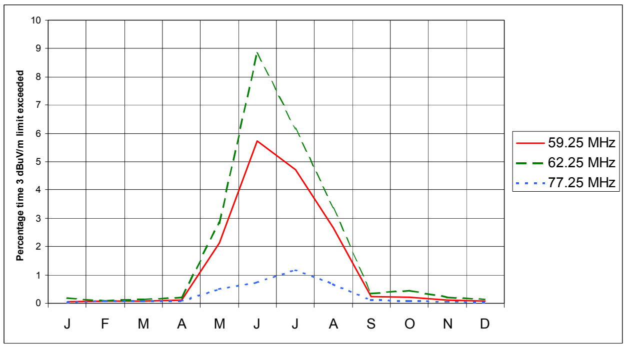

Figure 4: Incidence of Sporadic-E propagation [1]

The enhancement of interfering signals by this propagation mode is quite dramatic, with field strengths approaching free-space values. Propagation by this mode is strongly frequency dependent, with frequencies in the higher part of the band being far less susceptible.

BUT SOME ADVANTAGES…

The catalogue of problems listed above would seem sufficient to deter anyone from making use of this spectrum. These frequencies, however, also offer some distinct advantages.

Diffraction losses

The most appealing characteristic of this part of the spectrum is that the diffraction losses over typical terrain are small compared to higher frequencies in the spectrum.

Figures 5a and 5b compare the coverage available in a rural area of Southern England from transmitters (located some miles to the West of the map) operating at UHF and at Band I. It can be seen that coverage of the three main towns in the area is not achieved at UHF, the towns lying, as is often the case, in valleys. The low diffraction losses experienced at Band I allow near contiguous coverage to be achieved.

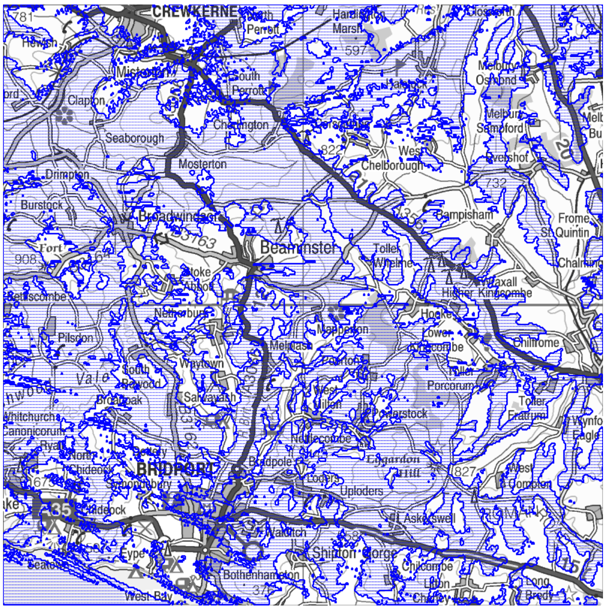

Figure 5a: Coverage at 450 MHz

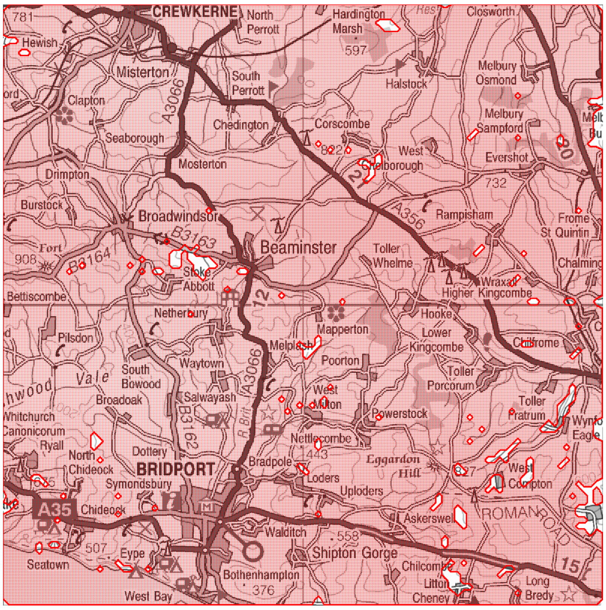

Figure 5b: Coverage at 55 MHz

Such excellent area coverage may be attractive in an environment in which the establishment of transmitter infrastructure is increasingly costly and unpopular with the public.

Anomalous propagation

There is no doubt that the propagation of interfering signals by Sporadic–E was a major limitation in the efficient planning of Band I television services. Indeed, such was the severity in some areas that it was necessary to establish additional transmitters largely to protect against this interference mode. It must be borne in mind, however, that the protection ratio required for analogue television is rather demanding. The old UK 405 line service required a protection ratio of some 45 dB, while typical digital services are likely to require a far lower figure. It is also worth noting that there re now very few high-power TV transmitters operating in areas adjacent to the UK.

Anomalous propagation, such as sporadic-E is generally seen as a problem for radio systems. In some cases, however, it can offer great advantages. One example would be in the use of frequencies in this part of the spectrum for meteor scatter communications links.

Such systems rely on the scattering of power from the ionised trails left by meteors to establish momentary point-to-point links. While visible meteors are rather infrequent, the continual rain of very small particles into the Earth's atmosphere is sufficient to allow quasi-permanent, albeit low bit-rate links to be established over a large area. The optimum frequencies at which to operate such links are around 30-50 MHz.

The best known application is probably the North American SNOTEL network, which gathers snowfall data from hundreds of sensors over twelve states. More recently networks have been established [2] in the UK, typically for data gathering associated with remote installations of water companies.

Meteor scatter systems typically transmit a probing signal. When this is received by an outstation via a transient patch of ionisation, a burst of data is transmitted. The ionised trails remain usable for up to around 1 second. Various combinations of redundancy, ARQ and other protocols are used, and the data rate is generally adaptive to the instantaneous quality of the path.

The terminals cannot, of course, distinguish between propagation modes, and sporadic-E events and tropospheric anomalies are often useful in providing transmission paths.

Interference between such systems is minimal, as the scattered signals have a relatively small footprint, a characteristic which has made the technology attractive to the military.

Technical simplicity

The generation of power at these frequencies is straightforward, and the losses in feeder systems are low. RF filtering is simple, and insertion losses are low. Low noise devices with excellent dynamic range are readily available.

Availability

A potential user of the radio spectrum seeking access to frequencies from around 100 MHz upwards would find little spectrum that is not already densely occupied (in some cases at great cost to the user).

The transition to digital or next generation systems only intensifies this shortage. Although new systems generally offer improved spectral efficiency, a lengthy period of transition is usually involved (e.g. Analogue broadcasting to

DAB/DVB-T, or GSM to UMTS) during which overall spectrum use increases.

The possibility of making use of a relatively underused part of the spectrum should be attractive to many users (though the total bandwidth available is admittedly fairly narrow).

OVERCOMING THE PROBLEMS

Antenna technologies

The simplest approach to the issue of the large antenna sizes demanded at these wavelengths is simply to ignore them. For fixed applications, or, perhaps, for use on vehicles a quarter wave of some 3'-5' may not be problematic.

For applications in which small antennas *are* required it is possible to make use of electrically-loaded elements or of H-field antennas, based around suitable ferrite cores. In both cases there will be a penalty to be paid in terms of efficiency, as well as for tuning where some frequency agility is required.

The use of H-field antennas for receive applications may be particularly promising. It may be possible to use orthogonal elements, under software control, to create an adaptive antenna, capable of rejecting some sources of man made noise, or other interferers.

The problem of the mast aperture required for transmitting aerials is less easily addressed; the areas in which spectrum is most congested are precisely those in which mast space is most limited. Some broadcasters have developed dual-band aerial systems that minimise demands on mast space, and this is an attractive approach in cases where the coverage requirement is similar on both frequencies.

Time & frequency diversity

It has been seen, in Figures 2 and 3 above, that man-made noise is likely to be one of the limiting factors in the coverage obtained by radio systems at these frequencies. Problems with anomalous propagation are also likely.

Given the cheap availability of software intelligence now available, adaptive systems should be able to make much better use of this spectrum than in the past.

Intermittent interference from discrete sources such as distant TV transmitters could be avoided in a frequency agile system, such as that defined in IEEE 802.11b and enjoying considerable success in the almost equally 'dirty' spectrum at 2.4 GHz [3].

Similarly, it has been noted above that meteor-burst systems make use of time diversity to *exploit* intermittent communications channels. The same technique could also be used to *avoid* intermittent interference sources.

SUMMARY AND CONCLUSIONS

Band 1 spectrum may be more useful than is generally assumed – in particular the benign diffraction characteristics are worth exploiting.

The key to exploiting this spectrum is probably to choose the application carefully. These frequencies will offer cost-effective wide area coverage, particularly in rural areas where noise levels are lower. Applications should be those requiring high reliability rather than the highest possible bandwidth. Broadcast–type applications (e.g. data download to PDA devices) may be attractive, as this would eliminate the need for a physically-large antenna at the user terminal.

A difficulty in developing applications for this band, however, may be the limited size of the market. However, although Band I is still intensively used for television broadcasting in some countries, CEPT policy is currently that such use be discontinued, albeit over a lengthy time frame.

REFERENCES

[1] Edwards et al., "Interference from sporadic-E propagation at frequencies around 70 MHz", ICAP 83 (IEE Conference Publication 219), 1983

[2] http://www.meteorcommunications.co.uk

[3] http://www.sss-mag.com/pdf/802_11tut.pdf