Cover sheet for response to an Ofcom consultation

BASIC DETAILS

Consultation title: More Radio Spectrum for the Internet of Things

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Name of respondent: Martin Allen

Representing (self or organisation/s): Heritage Broadcasting Ltd.

Address (if not received by email):

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Name Martin Allen Signed (if hard copy)

HERITAGE BROADCASTING LIMITED

An incorporated company, limited by guarantee, with exclusively charitable objects

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The Heritage Broadcasting Limited submission to the Ofcom consultation: 'More Radio Spectrum for the Internet of Things' 03 November 2015.

Company Overview

Heritage Broadcasting Limited (HBL) is a non-profit incorporated company, limited by guarantee, with HMRC 'small charity' status. It exists to research, revive, promote and celebrate the history and heritage of British television at Alexandra Palace in London, and elsewhere in the United Kingdom; and to educate the public in the history of television.

Our aim is to set up a regular, part-time heritage television service (using a modern transmitter complying with modern spectral masks) as an educational resource, as an aid for research into early forms of television transmission, and as a catalyst to help preserve surviving allied vintage TV equipment.

There are other projects related to early television, such the planned television museum at Alexandra Palace - currently undergoing a £26 million refurbishment - with which we hope to establish links. However no other television history organisation proposes to resurrect a vintage system to demonstrate the complete chain from transmitter over-the-air to receiver - including authentic propagation characteristics. The progress made to date by HBL in running several Band I test transmissions under an Ofcom T&D licence makes us ideally placed to set up and operate such a system, safely and to high technical standards.

HBL has the support and encouragement of many high profile like-minded organisations such as The Alexandra Palace Charitable Trust, The National Media Museum, and the Science Museum in London.

Introduction to Heritage Television

The world has been changed immeasurably by the growth of screen-based information and entertainment. A wealth of devices nowadays present a screen-based message.

Besides television itself, there are computers, smartphones, eBooks, electronic games, closed-circuit public surveillance, public transport information displays, ticket vending machines, radar, PDAs, industrial plant control, medical micro-surgery, and many more.

All of these applications have been made possible by the advent of display screens linked to suitable transmission systems – and it all began in the mid-1930s with a fledgling television service at Alexandra Palace in London.

In 1936, 405-line television was a great achievement for its time, with electronic valve technology being pushed to the limits of its capabilities, and the whole system being a feat of engineering that was the envy of many other countries.

Several generations have now grown up watching television – enthralled by each new development – struggling to 'keep up with the Joneses' – and grappling with aerials and receiver adjustments in pursuit of

that ‘perfect picture’! Television, its rituals, and all its paraphernalia, has had a profound effect on the British psyche and our social history. Moreover, much of the early technology was developed in Britain.

In 2015, as analogue broadcasting is closing down all over the world – and the way people receive and ‘consume’ television content is changing more quickly than ever – we are determined to ensure that what has gone before should not be lost and forgotten.

We aim to open a part-time heritage television service, using the historic 405-line monochrome TV system, which will be receivable directly over-the-air on vintage TV receivers without modification.
A ‘world first’, based in London, this project will demonstrate early British technological achievements; be of particular benefit to education; provide a resource to historians, engineers and the general public; and hold a fascination for tourists - as no similar venture will exist anywhere else in the world.

To deliver this objective, HBL requires some Band I spectrum, and has been in discussion with Ofcom for a number of years to identify and license this.

In 2011, after successfully gaining a 12-month Ofcom Test and Development Licence for the 60.75 to 65.75 MHz band, we carried out a series of 405-line analogue TV tests across north London and south Hertfordshire from a (155-metre asl) site at Bentley Priory, Stanmore, Middlesex.

The tests were a success, but we were unable to renew the spectrum licence, as all spare Band I capacity was subsequently reserved by Ofcom for the anticipated spectrum requirements of the London 2012 Olympic and Paralympic Games. Spectrum reservations for the Commonwealth Games (with venues in southern England) then followed in 2014, and at the same time a migration of Water Industry telemetry began, from older fixed wire links, to RF wireless links in the 60 to 62 MHz range in Band I.

However, in conjunction with Ofcom, we then identified an alternative range below 60 MHz - and negotiations for the use of this range were reaching a conclusion when the present Ofcom review began into spectrum provision for the future expansion of the IoT, leading to this consultation.

The proposals set forward by HBL will use modern filtering arrangements at the transmitter, along with generous guard bands to ensure that no other wireless service will be affected by spurious radiation from the transmitter. Our aim is to exceed the spurious emission requirements of the already restrictive Business Radio licence by around 20dB.

HBL Response to the Ofcom consultation

Of particular relevance to this consultation is the body of engineering knowledge and experience within HBL, gained from working with Band I for television transmissions from the 1950s to the 1980s - and more recently in the Ofcom-licensed HBL analogue television tests in 2011.

HBL contends that Band I spectrum (55.75 MHz to 68 MHz) is unsuitable for the uses proposed in this consultation, for the following reasons:

Transmit power

The consultation proposes that lower transmit powers might be used at VHF than at UHF for the same outcome. Whilst transmitter powers for analogue television were indeed lower at VHF than for UHF, the relative vision channel bandwidths (across which the power was distributed) differed - from 3.0 MHz to 5.5 MHz respectively. Furthermore, UHF required a significantly better carrier-to-noise ratio (due to the colour subcarrier) of 25dB, compared with the 12dB that was quite sufficient for VHF. Once this is taken into account, the presumed advantage of VHF over UHF for economy of transmission power disappears. Therefore from a TV perspective there has been no evidence that lower transmit powers can be used at VHF than at UHF.

Signal availability

The *availability* of a signal on Band I is around 95 per cent. That is to say, the wanted signal is only receivable at sufficient power to defeat any interfering signal for 95 per cent of the time. This is the realistic limit at Band I before transmitting powers need to be stepped up significantly to overcome interference. But when you step up your power, you give more interference to others, so they in turn have to step up their power - and then any relative advantage disappears and everyone is back to 'square one'.

However, the availability of Band I signals *in practice* for many television viewers in the past was significantly worse than 95 per cent. It is worth noting that the original television broadcasting evidence for Band I was gathered as long ago as the 1940s, with some additional work done up to the mid-1950s. Thus the 'service threshold' for Band I television was set a long time ago, when relatively few transmitters existed in the UK or Europe. The thresholds set at that time were then used and reused over the years, and not subsequently re-surveyed to obtain a fresh set of data.

The concept of 'availability' did not exist when the original Band I field strength limits were defined - and there was no added margin for interference - or indeed noise. This caused problems later on for viewers in many secondary service areas and fringe areas, which on paper should have benefited from an adequate field strength from the appointed main transmitter, but when combined with noise and interfering signals from abroad, resulted in a less than 50 per cent availability of the wanted signal. Kingston-upon-Hull and the surrounding area, which was considered to be serviceable from the main Holme Moss transmitter, is just one instance of this. Following prolonged suffering by viewers, this resulted in a question being raised in Parliament.
See: http://www.theyworkforyou.com/debates/?id=1964-07-07a.202.2

With a modern understanding of Band I, it is easy to conclude that the Hull area should never have been served from Holme Moss in the first place.

Another problematic area for viewers of BBC TV on Band I was Nottingham, which was largely covered by a wired-distribution system (Rediffusion). This state of affairs usually only prevails where there are difficulties in off-air reception. Nottingham also had a trolley-bus system (the 'Trackless') which was notorious for the amount of arcing-type interference that it radiated from its overhead electrification system - not helpful in a large city at the limit of the TV transmitter service area.

Many other areas of the UK were known for poor reception of BBC TV on Band I, including the locality around Brighton in Sussex. See: http://www.theyworkforyou.com/debates/?id=1954-12-22a.2747.2&s Here we read that the low-power Band I relay station for Brighton (Truleigh Hill) had its radiated power reduced in 1954, causing problems for viewers, in order to avoid interference to the new medium power station at North Hessary Tor in Devon, over 170 miles away!

By contrast, ITV - on Band III - attracted few, if any, complaints about availability of the signal within the service areas of its transmitters. It is revealing that some significant later BBC1 transmitting stations (from 1964 onwards) used Band III, even though Band I frequencies could have been reused locally, with or without polarisation and directivity constraints. The 'Hull and East Riding' problem was eventually solved by the installation of a medium-power Band III BBC transmitter at Belmont.

(Indeed, one option considered by HBL for its heritage television service was to apply for Band III spectrum instead of Band I, but it was soon realised that the band was too popular - due to its favoured propagation traits - and thus probably too congested with other services to accommodate analogue television nowadays.)

The (analogue) UHF TV network in the UK was as similarly resilient as that of Band III - and appears to have been planned with a good threshold for interference, perhaps because lessons had been learned from the experience of VHF Band I. Also, most UHF transmitting arrays featured 'down-tilt' (which accounts for the apparent reduction in theoretical range), because it was realised that this significantly reduces the amount of interference generated domestically among stations operating on the same frequencies. This explains why the worst interference on UHF was from continental stations, where 'down-tilt' was not used.

It follows from all the foregoing that at VHF there is a difficulty in planning networks. Prime coverage is typically only quite a small area, but the required 'sterilisation distance' between transmitters is huge. This means that opportunities for re-using frequencies several times over is very limited.

In 1956, the BBC carried out some comparison tests between Band I and Band III over the same geographical areas.
See BBC R&D Report K-111 [1956-13] http://downloads.bbc.co.uk/rd/pubs/reports/1956-13.pdf
See BBC R&D Report K-116 [1956-31] http://downloads.bbc.co.uk/rd/pubs/reports/1956-31.pdf

From the latter, under *'7. Conclusions'*, we read that:
"For a viewer having an average receiver with the types of aerial used in present day practice in a fringe area a Band III field strength of between 0.4 and 0.5 mV/m is required to obtain pictures similar to those obtained for a Band I field strength of 100 uV/m in the absence of interference, i.e., second class service. Field strength values to provide the higher grades of service, however, will be similar to those for Band I because of the rather lower level of ignition interference and the greater directivity of Band III receiving aerials in general use."

In other words, whilst 100 uV/m is adequate to obtain a picture, a significantly higher level of field strength is needed to obtain a *reliably good* picture for the viewer, thus a significant amount of signal 'in reserve' is needed for a high grade of service in Band I, whereas this is not required in Band III.

In summary, the only two things that Band I has in its favour is the abundant spectrum (because as a direct result of all the adverse issues, it is unpopular among spectrum users) and its ability to travel beyond the line-of-sight (which is a double-edged sword). This therefore makes Band I good for amateur or hobby-type use, special projects that celebrate its characteristics (such as HBL), very short range use (less than 50 metres) - or medium-haul links/mobile applications *where big aerials are acceptable*.

The timing and duration of co-channel interference

Broadcast television migrated to UHF to gain space for additional transmitters and services, but also to reap the benefit of the far higher 'availability' of each service - around 99.5 per cent. By contrast, as we have seen, the availability of a service carried on Band I is only 95 per cent at best - and often much lower. For the remainder of the time, some form of degradation exists due to atmospheric conditions.

In the days of VHF television, Band I would suffer co-channel interference due to 'atmospherics' for a significant part of almost every summer, although this varied in severity from day to day. Band I would be most liable to degradation from about 1pm to 5pm, centred around 3pm. And in the very worst instances, it was possible for TV reception to be so degraded as to be unwatchable for days at a time.

By contrast, the same issue at UHF frequencies is typically caused by temperature inversion, which by its nature occurs during the cold hours of the night, making UHF most liable to degradation between 1am and 4am - a much less important time of the day for communications. (Incidentally, however, this caused problems with overnight video-recording of schools programmes, which is why these remained in the daytime TV schedule for a long time after video-recording equipment [for time-shifting] became affordable and commonplace in schools.)

Finally on this issue, Lower Band I is far more affected by F2 ionospheric propagation effects than higher Band I or 70+ MHz. Generally, we would say that 68 MHz and below is not suitable for IoT use, due to unpredictable propagation effects.

VHF Band I television timeline

The following timeline charts the fate of television on Band I in the UK:

1936 - 39 : Receiving a television picture at all was a 'miracle' to most people. Any propagation problems in fringe areas were accepted by viewers and happily tolerated.

1946 - 52 : In the immediate post-war years, television was still regarded as a miracle and a novelty - and there were only a few transmitters across Europe competing for the available frequencies.

1953 - 55 : Television receiver ownership took off exponentially - due to the Coronation of Queen Elizabeth II, and Britain emerging from post-war austerity.

1955 : BBC colour television tests (using the NTSC system adapted for 405 lines) were carried out in Band I, in anticipation of using Bands I and III for future UK colour broadcasting.

1955 - 56 : ITV started on Band III - and for the first time a better transmission system was available, more resilient to propagation problems, with which BBC TV on Band I could be compared.

1957 - 58 : As more and more transmitters opened in the UK and Europe, it was observed that the summer period could give rise to severe and persistent co-channel interference on Band I.
But it was not yet known how regularly this would occur, year by year.

1958 - 59 : Plans for prospective 625-line services in the UK included not only UHF, but also an eventual re-assigning of TV channels in VHF Bands I and III to accommodate the new services.

1959 - 60 : The BBC started to realise that *every* summer was giving rise to bad conditions on Band I, not just one year in every five or ten, as had been hoped.

1960 - 63 : Extensive UHF testing ahead of the launch of BBC2 showed that UHF was far superior to Band I for TV. And the continued expansion of ITV showed that Band III was also superior.

1963 ← At this point it was realised that Band I was not capable of providing a reliable TV service.

1964 - 65 : The BBC started using Band III for its new high power 405-line stations, opening three Band III transmitters at sites within planned service areas for Band I, simply in order to overcome the atmospheric disturbances that plagued Band I.

1966 - 67 : The plan to re-assign Bands I and III for eventual 625-line TV use in the UK was scrapped.

The level of noise in Band I today

In our experience, the noise floor in VHF spectrum becomes a significant factor below about 62 MHz. During the HBL low-power analogue television tests in 2011, many of our members commented on the high noise level present in the band compared with thirty years earlier - and mention was made of seeing novel 'noise patterns' on the received picture that were unlike anything witnessed in the past.

Our reception reporters measured their AGC voltages and typically found that although the picture was 'noisy', the AGC voltage was high, which would normally indicate a reasonably high signal level. This would seem to indicate that the noise in Band I has risen considerably in the period since the end of the BBC and IBA 405-line TV services in the early 1980s.

With a new award of spectrum in Band I, HBL would be able to resume its work of testing and developing the band - and to continue its research into noise and propagation issues, leading to possible solutions.

Interference arising from other sources - 'transients'

Interference from developing communication technologies such as VDSL2, G.fast and PLT all threaten low frequencies in the future. Low frequency transmitters are far more likely to give EMC issues to other devices. Historically - as is well known - reception of Band I television was much troubled by transient interference arising from motor vehicle spark plugs, until a massive national programme of car interference suppression was carried out, backed by legislation. (By comparison the effect of even unsuppressed spark plugs on Band III and UHF is much less marked.)

Conclusions - suitability of Band I for the IoT

In the past, satisfactory television coverage in Band I was only achieved with very high transmitting aerials, precisely tuned - and very high transmitting powers.

Mast or tower heights of up to 800 ft were required. (The reason for subsequent UHF transmitting arrays being even higher was that mast-building techniques had improved, allowing VHF and UHF aerials to be accommodated on the same structure, either by extending an existing structure or by building anew.)

Domestic TV reception is of course a 'fixed link'. In terms of power per unit of spectrum, broadcasting in Band I could be considered comparable to Business Radio (BR) at, for example, 25W per 12.5kHz channel. For broadcasting, as for base-station BR, high masts are needed to achieve a commercial grade of service. Thus, a reliable commercial IoT service is not going to be possible using small aerials perched on buildings.

In the past, most consumers of Band I broadcasting required an outdoor receiving aerial to achieve consistently satisfactory picture quality. Set-top aerials, even in strong signal areas, were susceptible to all manner of ambient influences – from people moving around the room to electrical noise from domestic appliances (vacuum cleaners, hair-dryers, food mixers, electric fans, drills, etc.). Moreover, attempts at designs for a 'loaded' set-top aerial, with the elements reduced in size for compactness and the unit being tuned 'electrically' rather than 'mechanically', were even less successful at delivering good clean signals to the receiver.

In view of this, we predict that a typical IoT M2M device, with its small physically-untuned aerial, will have an operable range of not much more than 50 metres. Therefore, we feel that the future need for spectrum to facilitate medium and long-range M2M cannot be met by using Band I.

Moreover, if international co-ordination of spectrum for particular applications is considered to be desirable, Band I is unlikely to be favoured for the IoT by France (nor possibly other European countries), due to the military use to which we understand this range is reserved in that territory. Without a common agreed spectrum range for the IoT across Europe, it will be difficult for manufacturers of IoT equipment to sell standardised products across the EU marketplace.

Responses to Consultation Questions

Q1. *Do you agree that the spectrum we have identified (in figures 4.2 and 4.3) is suitable for M2M applications for remote and rural locations? Please provide as much information as possible on likely applications.*

Figure 4.2 Spectrum availability in VHF ***Band One****:*

We do not agree that 55.75625 - 60 MHz, 62.75625 - 64.8 MHz or 64.8875 - 66.2 MHz Band I spectrum - or indeed any spectrum lower than 55.75 MHz that may become available - is suitable for M2M applications for remote and rural locations (nor indeed that it is ideal for urban locations either).

It is our belief that percentage-of-time interference occurs on the lower frequency bands, and the severity with which it happens will make these low frequency bands inferior to existing 'licence-free' bands in higher frequency ranges. These licence-free bands exist today, are harmonised internationally, and have known propagation characteristics, as opposed to the low frequency bands that can be unusable for weeks at a time if there is a 'bad summer', which can take several years to materialise.

We understand that on-site paging services in the lower frequency bands were once common and popular, but these have mostly migrated to 165 MHz VHF or to UHF for these reasons.

*Figure 4.3 Spectrum availability in VHF **Low Band**:*

There could be *some* merit in using the bands 70.5 - 71.5 MHz and 80.0 - 81.5 MHz for M2M. There was clear evidence that the higher TV channels in band I (up to 68 MHz) had better availability and lower atmospheric disturbance than the lowest channel (down to 41 MHz). There was also clear evidence from abroad that going even higher in frequency - up to 88 MHz (the threshold of Band II) - had further benefits.

In many countries that used Band I for television, the lowest channel - 'Channel 1' - was discontinued due to the problems with atmospheric disturbance. The lower frequency ranges have traditionally not had widespread deployment for Business Radio due to these problems.

The BHTV proposals that seek to use a relatively modest portion of the VHF band might perhaps allow innovative modern solutions to these problems to be developed by our technical team and partners, making Band I as a whole more usable. Our organisation comprises experts in transmission, transmitting antenna design, receiving antenna design, Band I TV antenna installation, TV receiver design, traditional TV receiver servicing, and others with allied experience. By allowing Heritage Television to occupy the most 'hostile' (i.e. lowest) part of the available spectrum, we will be best placed to use modern techniques to develop a compact solution to the interference issues that have plagued these lower frequency bands. We have already identified some promising lines of inquiry that sadly we had to discontinue due to the expiry of our previous licence.

***Q2.** Do you agree with our analysis that encouraging new IoT uses in the bands 55.75625-60 MHz, 62.75625-64.8 MHz and 64.8875-66.2 MHz, 70.5-71.5 MHz and 80.0-81.5 MHz should still leave sufficient spectrum to meet demands for Business Radio in the VHF range?*

We would answer this slightly differently, and say that we consider there is more than enough spectrum for Business Radio and other applications in appropriate parts of the VHF range, as well as the provision of a suitable block for Heritage Television.

Heritage Television has previously had a year-long allocation in this frequency range without any form of spectrum congestion being noted - and during this period (and afterwards) this spectrum remained largely unused, hence the reason it is available under this consultation.

***Q3.** Do you think the conditions associated with the current range of BR licences available now should change to facilitate new IoT services uses? If you do, what should these changes be?*

We have no comment.

***Q4.** Do you think we should create a new licence product specifically for IoT services?*

We have no comment.