The Bawdsey Beacon Monitoring Project

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Abstract

This article proposes a novel application to increase utilisation of beacons especially in the microwave bands, by enabling both short term and long term data presentation. The project is envisaged to have applications in both amateur radio and also in science and maths education as a source of data for teaching and research purposes. Additionally, the proposal includes making use of a site with special historical significance – the Bawdsey Manor Park, where early British Radar development took place.

Introduction

Few British radio amateurs will be unaware of the historical links between picturesque Bawdsey Manor, on the Suffolk coast, and the development of radar that took place there in the years before the Second World War, under the leadership of Robert Watson-Watt and Arnold Wilkins. Although the development work was moved away from Bawdsey in the late 1930's for security reasons, as international tensions escalated towards hostilities, Bawdsey remained as a key operational radar site through the war years, and continued as an RAF base up until 1991. There are many books and documents which chart the military history of Bawdsey Manor (eg Woods, 2004; Bowen, 1998), and more material is available on-line (see websearch). This article gives a brief glimpse of the background, and presents some of the activities now taking place on the site.

A brief History of Bawdsey Manor

Although built to look rather older, the Manor building itself (Fig 1) was constructed by the first Baronet Quilter, Sir William Cuthbert Quilter over the period 1873 to 1893. He was a Victorian industrialist, philanthropist and politician, and in addition to the Manor house and estate he also instituted the steam ferry between Bawdsey and Felixstowe Ferry to facilitate access to the new railway connection from Felixstowe town. The estate was the family country seat until it was requisitioned by the MoD during the First World War, when the Devonshire regiment was stationed there; after the war it was handed back to the family. In 1936, the MoD purchased the Manor estate from the family, and it then remained MoD property until mid 1994.

Following the experiment at Daventry in 1935, in which Watson-Watt and Wilkins demonstrated to A P Rowe of the Tizard Committee that the presence of a reflecting object (in this case a plane) could be detected by observing the effects on radio signals, Bawdsey Manor was designated as the development location for military radar systems - in part this was due to the close proximity of the RAF Aeroplane and Armaments Experimental Station at Martlesham Heath (the location of the BT Adastral Park Development Laboratories, since 1975). Watson-Watt was made the senior engineer, with Wilkins as his deputy, and their main brief was to convert the existing technologies for radar systems into something which could be incorporated into aircraft - the development of airborne radar. At the time, this was a challenging task, given that the equipment was around the size of a medium garden shed, and weighed about 2 tons! The work,

which was centred around wavelengths of 1.5m (200MHz) is documented in a number of books, including Woods (2004). From an interest perspective, the lab used by the team was on the second floor of the 'White Tower', which can be seen in Fig 1.

Other work on the site developed the use of longer wavelengths for radar detection - from around 10m downwards. As a consequence of this effort, a network of transmitter and receiver stations were established around the UK during the lead up to, and the early years of, WWII. These were the Chain Home (CH), and later the Chain Home Low (CHL) and Extra Low (CHEL) to provide detection at lower angles of elevation that the initial CH system. Transmitter sites generally had four 350' steel towers between which the multiple dipoles were suspended (of varying lengths to provide a broadband capability between about 30 and 60MHz). Receiver sites had installations of four 200' wooden towers, with curtain arrays suspended between them. Bawsdey became a key operational installation, with both transmitting and receiving facilities - see Fig 2, in which the two sets of antenna towers can clearly be seen.

To this day, a few of the towers used can be seen at some locations - the author is aware of a single remaining tower at Gt Bromley (Essex) and one is maintained by the Marconi Co at Baddow, nr Chelmsford. However, the majority of the towers have now been demolished on the grounds of safety, since there are few current applications that justify their upkeep. The last tower at Bawdsey, one of the transmitting masts, came down in 2001.

At Bawdsey, as at other CH sites, blast-proof buildings were constructed to house the transmitters and receivers, and underground reserve facilities (with separate stand-by antennas) were also built. Both above-ground blocks still stand at Bawdsey, with the Transmitter Block now being used as a publicly accessible museum dedicated to the memory of the work carried out at the Bawdsey site - see websearch. In the 1980's, as the military needs changed, the Manor at Bawdsey was no longer considered strategic, and along with a sizeable estate was sold off into private ownership - some of the original site was retained by the MoD, and RAF Bawdsey continued as an operational station until the early 1990's as a Bloodhound missile base and radar station.

Although the Transmitter Block now has a modern purpose, which assures a degree of basic maintenance, the Receiver Block has not been so fortunate. The Bawdsey Manor Estate has been the home of Alexanders International School since 1994, and the Receiver Block is used for non-essential storage only - and is therefore rather neglected. Both blocks are of similar construction and size, with the Transmitter Block being the larger. Red brick outer walls support a blast proof roof, approximately 2.4m thick, with upper and lower concrete slabs sandwiching layers of shingle and sand. Around the outside of each building is a thick concrete blast wall, piled up with earth on the outer side for extra protection and camouflage. Fig 3 shows a view of the Receiver Block.

Internally, the block has a number of small rooms and a large room which was the Operations Room - here the WAAF operators would receive the radar signals and interpret them onto the plotting maps locally, as well as relaying the information to Command HQ. Fig 4 shows a view of the Ops Room in its heyday. It is worth noting here that it was Watson-Watt who realised that a very efficient communication and processing system to handle the data was essential to an effective defence service.

Back in the 1980's, as engineers at BT Research Labs (as it then was), Sam Jewell G4DDK and myself harboured ideas of putting a 9cm band beacon on the remaining Transmitter Tower at Bawdsey, using the callsign GB3RWW to commemorate the work that took place there - 9cm would have been quite appropriate, since as development progressed, the higher frequency radars were operating around 3GHz (although this development did not take place at Bawdsey).

It was not to be - enquiries about access to the tower indicated that it's life was very limited as it was corroding, and would therefore have to be demolished before too long.

Much more recently, potential access to the Receiver Block has become possible, as I am a part-time member of staff at the International School. Initial discussion with the estate owners were positive, and some ideas have been developed for using the facility. At first, Sam and I went back to our thoughts of the 1980's, but of course time has moved on, and there are now beacons for all bands from 23cm to 24GHz on the tower at nearby Martlesham Heath (GB3MHL, MHS, MHZ, MHX and MHK respectively). We did consider the potential value of installing 'near sea-level' beacons for 10GHz and 24GHz, since although the MH beacons are close by, they are also at around 60m agl. This can mean that the beacon may be audible remotely via propagation mechanisms which do not support contacts with stations in the proximity of the beacon site, simply due to altitude differences. Siting some lower level sources for the higher bands would provide perhaps a more realistic indication of when contacts might be possible for those who occasionally hear the beacons. With that proposal would come all of the issues of transmitter regulation - frequency co-ordination, radiation concerns, and shut-down management, etc.

During a journey to collect some items of useful equipment that had been donated to our new 'project' we had the opportunity for a long conversation about how we could use this opportunity best. On the basis of the foregoing issues surrounding transmitting sites, we turned our attention to the potential for setting up a beacon monitoring facility - in other words, returning the block to something akin to its original purpose! This would also avoid all of the issues (except power consumption!) of setting up a transmitting site. An additional synergy is that when the UK Microwave Group was established some 10 years ago, a stated objective was to instigate beacon monitoring capabilities.

Preservation Interests

We also were aware that anything we were likely to do would be required to meet the requirements of various planning and preservation groups and committees - the entire Bawdsey Manor Park site is Grade II listed, and in addition to planning concerns, the English Heritage Foundation also take a keen interest in maintaining the main buildings, and those with military history, in as near 'original' form as possible. Whilst there is great synergy in our proposed ideas as compared to the original use, there would need to be some differences - the antenna structures that once existed are no longer there, nor would they be appropriate to what we need. Small antennas, sited preferably on the flat roof of the block, would be ideal - but not in keeping with original form. Due to the years of neglect of the building, some renovation work will also be required - this too, will need to be carried out sympathetically, and with the concurrence of the various interested groups. So this is definitely not going to be a purely technical project - see Fig 5!

A Short Term Plan

The Bawdsey Receiver Block is very well sited for microwave band beacon monitoring - it is at just about the highest point on the promontory, overlooking the sea. Although there is some local tree clutter, there are no solid obstructions, manmade or natural, over the full 360°. With the presence of the MH beacon stack nearby, a reference source for each band is also available. So we decided firstly to look at 10GHz, and establish a receiver to provide an output across the beacon band. Using an SDR receiver as the IF makes this relatively straightforward, and an outline design concept using one of G4HJW's 'BernieBox' 10GHz satellite LNB based Rx's (see Fig 6) was drawn up (see References and Websearch). For this application, using a standard LNB was not really suitable, so an adaptation to a slotted waveguide antenna, to give the omni-directional coverage, was developed, with a 10dB waveguide coupler to allow the local oscillator

signal to be injected. Bernie himself agreed to take that part of the project forward, and with the help of several other kind volunteers, this system should be available around the end of September 2009. A borrowed SDR-IQ Rx will be used to provide the 190kHz wide output. It is our hope that initial measurements and data will be available for presentation at the 2009 UK Microwave Group Round Table event at Martlesham Heath in November.

Current Progress

A brief test was run with a 3cm CW 1W transmitter on the site to make measurements in the surrounding area. A number of fixed stations were also advised of the test and asked for listening reports - the best DX was from Wolverhampton (G4PBP) by RS - the English weather was kind to us, providing plenty of rain on the second day! The next step is to produce, integrate and install the initial Rx system for 3cm.

The First Receiver Stack

Work is now in hand to implement the initial receive system, as outlined above - see Fig 7. A 2 x 12 slot waveguide antenna, using the Taylor slot distribution, is being machined up by David, G6XGK - this will be fitted with wings to optimise the azimuthal response. Beneath that will be a 10dB Riblet waveguide tee-slot coupler to inject the 10,350MHz LO signal for the Rx. A standard flange mount satellite LNB (9.75GHz LO) will complete the outside stack. Both the LO signal and the IF will be cabled back to our Equipment Room below. Here for the initial measurements we will site the rest of the G4HJW 'BernieBox' Rx and the SDR Rx, with a USB connection to the PC for data collection. Our plan it to have this in place by the end of September 2009, for first measurements.

The 'BernieBox' 3cm Rx

Of necessity, only a brief functional description will be provided here - see Bernie's site (websearch) for more detail. The concept is very simple - to use a standard European dual LO satellite LNB (without any modifications) to downconvert narrowband 3cm signals for detection in an HF Rx. A 10,350MHz LO is generated, from a 10MHz OCXO (or external ref), and is applied to the signal path into the LNB. Thus with a 10,368MHz incoming signal present as well, there will be two signal components generated into the IF output: 10,350-9,750MHz (600MHz) and 10368-9750MHZ (618MHz). The final stage of the Rx mixes these latter two together to produce an 18MHz nominal IF. Whilst the DRO's used in sat LNB's are not noted for their narrowband stability, the frequency generation scheme cleverly removes dependency on this - the generation of the two nominal 600MHz components from the 9.75 DRO, and the subsequent mixing of those two to produce the final IF, means that wherever the main LNB DRO drifts to, the separation between the 600MHz signals remains constant. See Fig 8 for the block schematic diagram.

What happens then?

Installing the first receiver and getting some results marks the end of our first phase of feasibility - we will be able to answer some of the questions to enable us to move forward. For example, we don't yet know whether the gain available from the slotted waveguide antenna will be high enough, and which beacons (if any) besides Martlesham, we can hear under flat conditions. We do know that there will be an approximate 20dB penalty between the omni-directional antenna and a home station equipped with a small dish system (ie 60cm diameter or so). At least we should be able to obtain the information necessary to implement a long term monitoring solution for 3cm.

Beyond the 3cm Rx system, it is hoped to introduce other microwave bands as funds and time permit, thus increasing the usefulness of the archived data - as more bands are added, the ability

to study relationships between propagation events and causal occurrences, such as weather systems, improves. In addition to microwave bands, it would also be interesting to collect data on lower frequencies, some of which would have particular synergy with work that took place at the site in the late 1930's - 5MHz (close to the original 49m wavelength used), 10m (close to the 30 - 60MHz range used in the first CH system) and 2m (the closest EU amateur band to the final 200MHz used for the airborne radar systems). On the lower bands mentioned above, observing the changes as the sunspot cycle rises would be particularly interesting. Of course, since this is a receiving facility, we are not restricted to amateur bands, either, and certainly at HF there are plenty of broadcast stations which could be used as 'beacons', in addition to the beacons within the amateur bands. Using the amateur beacons, maintains amateur links and interest with the facility, though.

We will also be able to examine the first data, and decide how best to process it for onward use via the internet. There are several options here, not all of them mutually exclusive:

1. Provide a streaming waterfall spectral display, on which the full beacon band can be seen - typ 190kHz
2. Provide a wideband waterfall display (up to 1MHz) on which both the beacon and narrowband segments are visible, with user options to view a smaller bandwidth.
3. Provide audio streaming capabilities when a signal is selected
4. Capture a time-stamped data file on a regular basis (5 min, 15min?) for the band showing the average noise level in the Rx, and the frequency and level of carriers visible above that. This file would probably be held in CSV format, to allow processing in Excel or similar applications. As the development of the facility progresses, weather data will also be captured in a file at the same time providing a data source for correlation examination between radio events and weather conditions

To support these objectives, we need to consider how we will construct the IF part of the station - it needs to be capable of supporting the desired bandwidth of data, and also must be scalable, so that as we add new bands, there are no major changes required in the architecture. This is ongoing work!

Bureaucracy

As previously mentioned, although the site is private, and has no public access, it is still subject to the normal planning considerations, and because of its past, the English Heritage foundation also take a close interest in the preservation of the facility. Due to this, the Bawdsey Monitoring site is not just a radio project - it is equally a project about preserving the building. The nature of the building does not suit adaptation to any 'normal' use, such as conversion into a usable part of the school, since regulations require that certain natural light and air conditions are met, along with normal 'comforts'. These could not be provided without substantial changes to the building, both internally and externally – given the Heritage interests, this is extremely unlikely.

Thus without an application along the lines of the current proposal, it has little future other than remaining as an extra storage facility, and therefore is unlikely to receive any significant maintenance attention. Consequently, further decay is more likely than preservation. Although the project group are, of course, focussed on the establishment of the monitoring facility, and the scientific data it has the potential to generate, we are also very much alive to the sensitive issues of adaptations to the building. In order to provide our facility, we must restore one window, and provide some roof maintenance, by way of removing vegetation which has built up over the years and is now blocking water channels; the financial costs of our efforts will increase as we progress, both in radio equipment and building maintenance expenditure.

Once the feasibility stage is completed, in late 2009 or early 2010, we must move into some serious negotiations with English Heritage and the planning authorities, to investigate how we can work together to preserve the building, by at least preventing further decay, and to provide the technical resource that we are working on.

In conclusion, it is our hope that we can provide a useful facility for amateur radio operators, both in terms of spectral displays of beacons, and also the ability to 'spot' your own signal if you are within range of the site. We also hope to provide an archived resource of band propagation data to support investigations by amateurs and others, and that with the extra data we want to capture (weather and potentially solar and wind power source performance), the data will also have applications in the maths, science and environmental areas of education. Although the technical path before us is new and will have its challenges, the bureaucratic path is also new, and will definitely have many challenges too!

References

Bowen EG, (1998) *Radar Days* London; Taylor & Francis ISBN 978-0750305860

G4HJW - Simple 3cm Receiver – Scatterpoint – UK Microwave group

Wood, K. A, (2004) *Echos and Reflections* London;Serendipity ISBN 1843941007

Websearch

http://www.subbrit.org.uk/sb-sites/sites/b/bawdsey_radar/index.shtml - historical information source on Bawdsey (and other) radar sites in the UK

http://www.bawdseyradarmuseum - site of the Radar Museum in the old Transmitter Block

http://www.earf.co.uk/3cm_conv.html G4HJW 3cm Rx converter using standard Satellite LNB

Biography

Dave Powis has held amateur licences for over 40 years, initially as G8BPJ from 1968, and since 1979 as G4HUP. Additionally, he has been DL4MUP for several years while working in Munich, and also holds ND8P as a regular visitor to the US. His radio interests have always been in VHF and above, and at one time or another he has been active on most bands between 50MHz and 10GHz. More recently he has been producing Direct Frequency Synthesisers and other products available via his website http://g4hup.com Instigating the project to establish a long term beacon monitoring facility at Bawdsey is currently absorbing his attention!

Professionally, Dave is now a lecturer in Electronic Engineering at West Suffolk College, Bury St Edmunds, England, and part time teacher at Alexanders International School Bawdsey, Suffolk, after nearly 40 years spent in the telecommunications industry.

Fig 1 – Bawdsey Manor

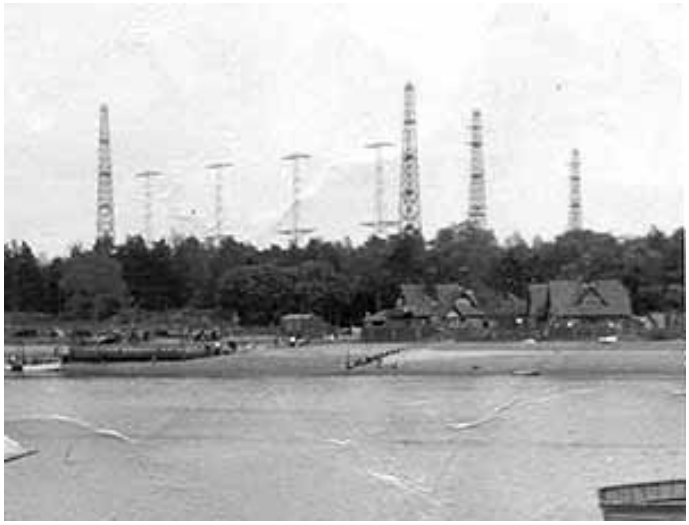

Fig 2 – Bawdsey Antenna View

Fig 3 – Corner view of Receiver Block with Blast Wall

Fig 4 – View of Operations Room

Fig 5 – Restoration Work required!

Fig 6 – Standard G4HJW 3cm Rx (BernieBox)

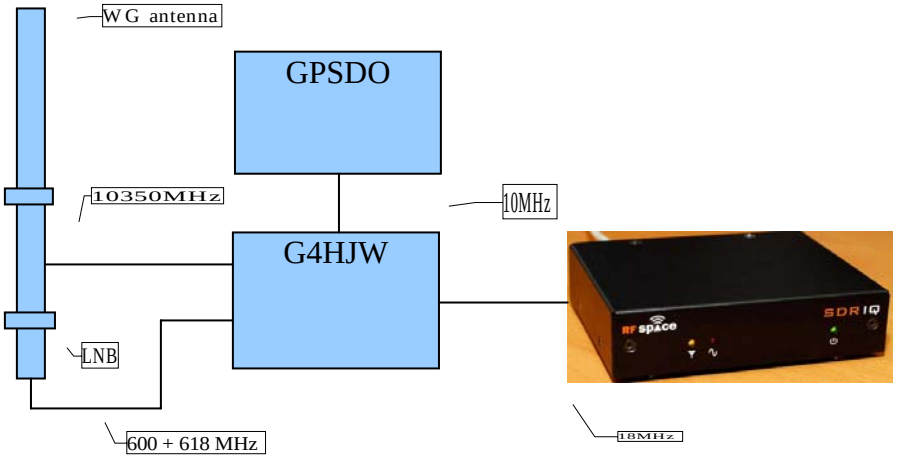

Fig 7 – outline of 3cm RX at Bawdsey

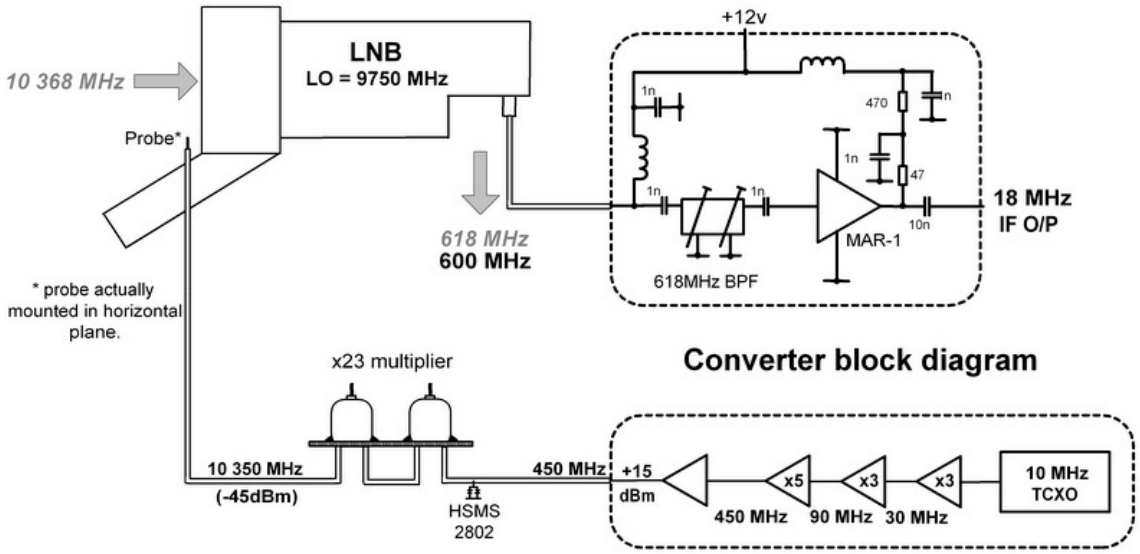

Fig 8 – 3cm Rx using satellite LNB – G4HJW