Baldock radio monitoring station

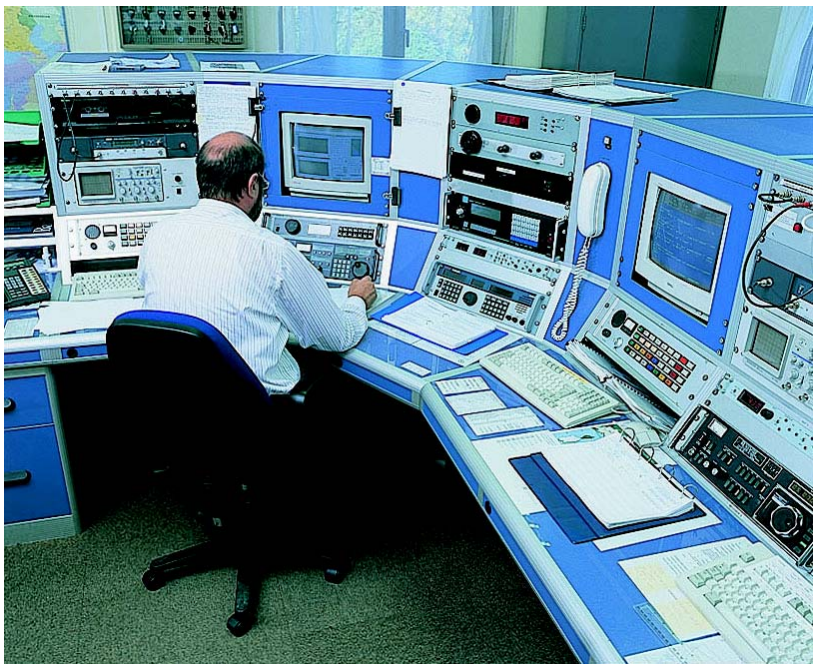
1. Introduction

With the ever increasing demand for radio based services, monitoring of the radio spectrum plays a vital role today in keeping the spectrum clean for authorised users, particularly the emergency services. It is also an essential and integral part of the spectrum management process, producing and evaluating data to aid spectrum managers in their day to day work. The radio monitoring station, located near Baldock in Hertfordshire is Ofcom's "listening ear" on the radio spectrum.

The monitoring station today has a much broader spectrum monitoring capability than when it began life in 1929. Its original role was to monitor the international HF radio circuits operated by the General Post Office (GPO), which followed on from historic first trans-Atlantic radio telephony services received at the site from New Jersey, USA.

2. On-site monitoring facilities

The primary role of the Operations Room is to provide a service for the clearance of interference to UK licensed users of the radio spectrum. Within this work, a significant proportion of calls for assistance concern safety-of-life services. The team also makes a major contribution to the International Monitoring System of the International Telecommunications Union (ITU) by offering reciprocal monitoring information to overseas administrations, particularly for the investigation and resolution of interference to international radio circuits at high frequencies (HF).



The HF part of the radio spectrum has a number of

advantages for users. It permits propagation over short or extremely long distances, equipment is relatively cheap and the services provided are flexible. On the other hand, the propagation medium is extremely variable and the band of frequencies available for use for a particular communication circuit changes with the time of day, season and the epoch of the sunspot cycle. Signals that propagate well during daylight hours will not be heard at night and vice versa. In order to be able to resolve interference complaints the emission source has to be identified as quickly as possible through contact and negotiation with foreign monitoring stations, and this is one reason that the Operations Room is manned 24 hours a day, 365 days a year.

The Operations Room provides Ofcom's 24-hour focal point of contact for out-of-hours interference reports to all other UK radio services and, depending on the priority, the shift engineer will pass on the safety-of-life reports to colleagues throughout the United Kingdom around the clock.

Clearance of international interference will also involve liaison with government departments, foreign administrations and other monitoring stations. The work of the Operations Room therefore is international. Routine monitoring of the HF frequency bands is carried out in support of Ofcom's spectrum reviews and also to provide usage information for planning purposes and to meet Ofcom’s obligations to the ITU and other international fora.

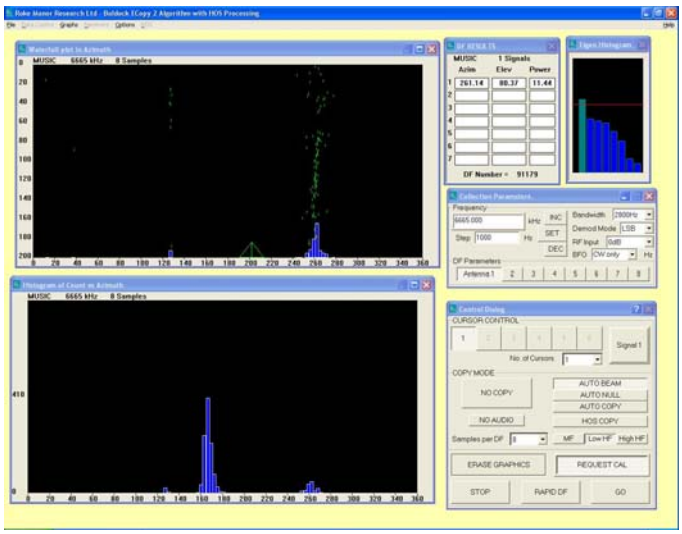
Although the team was originally set up to provide monitoring for HF frequencies, over the years VHF and UHF monitoring facilities have been added and recently a comprehensive network of remote monitoring and direction finding sites has been established. These new facilities will enable the rapid elimination of interference at VHF and UHF.

Frequency Coverage

The frequency range covered by work in the Operations Room is 9 kHz to 3 GHz; the frequency measurement range on amplitude modulated and plain carrier signals, to an accuracy of ± 1 Hz, is from 9 kHz to 30 MHz. For frequency modulated signals the measured results are given to the nearest 10 Hz over the same frequency range.

Field Strength Measurements

Field strength measurements using inverted cone and loop antennas can also be made on any type of signal in the range 9 kHz to 30 MHz within an uncertainty of ± 2 dB.
The inverted cone antennas used for these measurements have been built to an ITU-R design, providing predictable characteristics at HF frequencies. These are complimented by loop antennas used for measurements at the VLF, LF and MF frequencies. Calibration correction curves are available to enable true field strength measurements to be made.

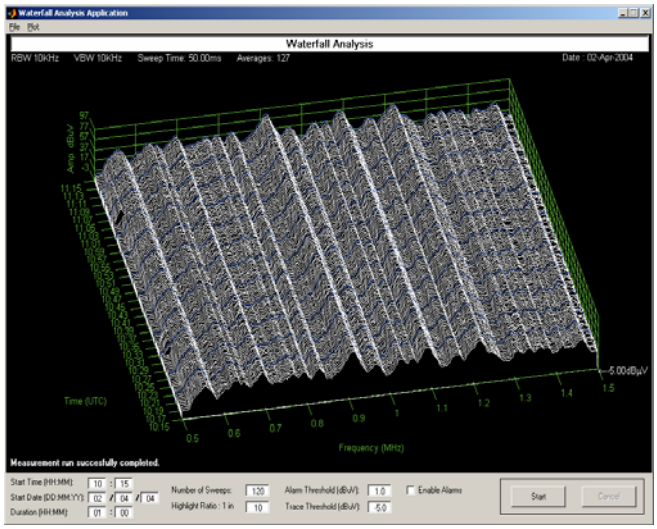


Direction-Finding

Direction-finding on-site is available in three ranges; 100 kHz to 2 MHz, 2 MHz to 8 MHz and 8 MHz to 30 MHz, using three corresponding wide aperture monopole antenna arrays in conjunction with super-resolution digital direction finding and powerful

signal processing techniques using the MUSIC algorithm. As mentioned, remote direction-finding capabilities at VHF/UHF are also now available enabling the shift engineers to access a number of the remote stations for interference position-fixing purposes. This comprehensive facility will enable the shift engineers to more closely pinpoint the origin of interfering signals up to 3 GHz around the country.

Automatic Spectrum Occupancy



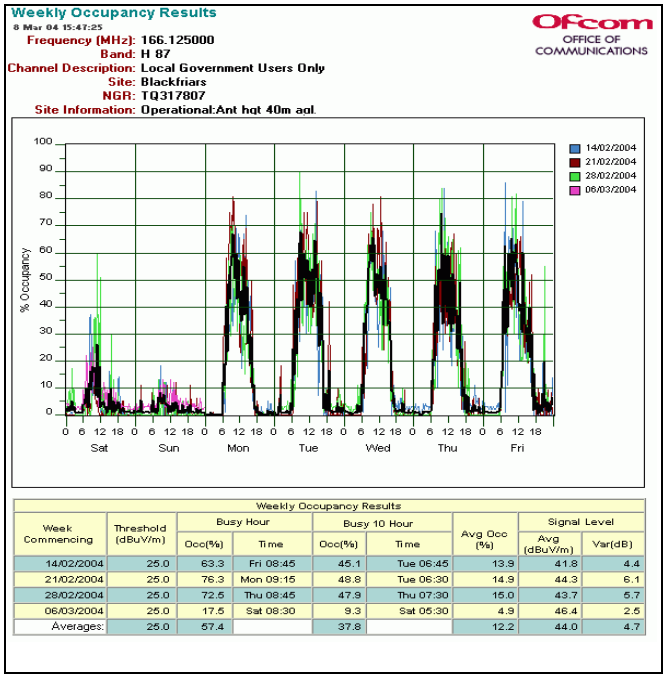
Spectrum occupancy information provides evidence to spectrum managers of the use of the radio spectrum being monitored during various time periods. Trends can be easily identified, aiding the characterisation of interfering signals. Spectrum occupancy information in the frequency range 100 kHz to 1.5 GHz is produced automatically using three dimensional "waterfall" plots. Signals can be displayed as max-held to show all emissions occurring during the scan period - essentially aimed at emphasising short term events. Alternatively, the display can be programmed to show video average, which will emphasise the long-term signals. This latter facility is particularly useful in analysing signals over relatively long periods of up to 7 days. The spectrum analysers are fully computer controlled and the occupancy plots can be individually tailored to the requirements of the signal environment and other emission parameters.

Demodulation

Demodulation facilities available cover almost all types of emissions found in the HF bands with specialist equipment used together with associated software. Modes covered include AM, FM, PM, CW, and SSB/DSB/ISB. Systems covered include RTTY (FEC, ARQ etc), Facsimile, Morse, and numerous data modems, as well as the digital radio broadcasting standard, DRM.

3. Remote monitoring facilities

Unattended Monitoring Systems



Weekly Occupancy Results

Week Commencing	Threshold (dBuV/m)	Busy Hour		Busy 10 Hour		Avg Occ (%)	Signal Level	
		Occ(%)	Time	Occ(%)	Time		Avg (dBuV/m)	Var(dB)
14/02/2004	25.0	63.3	Fri 08:45	45.1	Tue 06:45	13.9	41.8	4.4
21/02/2004	25.0	76.3	Mon 09:15	48.8	Tue 06:30	14.9	44.3	6.1
28/02/2004	25.0	72.5	Thu 08:45	47.9	Thu 07:30	15.0	43.7	5.7
06/03/2004	25.0	17.5	Sat 08:30	9.3	Sat 05:30	4.9	46.4	2.5
Averages:	25.0	57.4		37.8		12.2	44.0	4.7

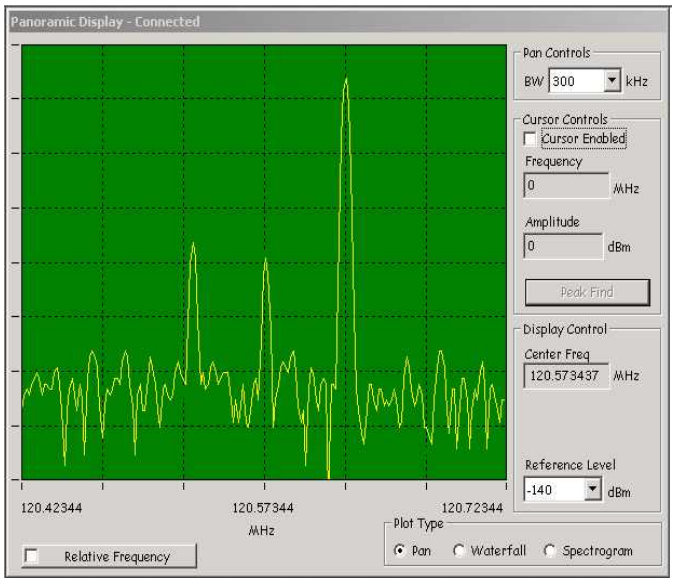
Unattended Monitoring Systems (UMS) cover the frequency range 20 MHz to 3 GHz. Each system is capable of measuring field strength, occupancy, Continuous Tone Controlled Squelch System (CTCSS), Digitally Coded Squelch (DCS), MPT 1327. Audio can be digitally recorded and listened to via the normal telephone network. A large number of channels can be monitored simultaneously, with a scan rate in excess of 2,000 channels per second.

Setting up the frequencies to be monitored and making configuration changes on each UMS is done using a dial-up modem, with the subsequent occupancy results down-loaded daily and processed at Baldock. The UMS webserver allows Ofcom's spectrum managers and assignment engineers to view the occupancy results through a graphical user interface. This approach provides a cost-effective monitoring solution for regular tasks and is easily adapted for more specialised jobs.

The CTCSS and DCS decoders allow occupancy to be apportioned to a variety of licensees on a shared channel to derive 'user profile' for each type of business user.

The UMS occupancy information is invaluable for future planning and frequency management and helps "work the spectrum harder". In particular it provides usage profiles to support spectrum pricing and to provide an accurate picture of actual spectrum usage in areas of high density radio usage. The UMSs are typically deployed in city and town centres where spectrum usage is high.

UMSs are currently being rolled out across the UK to ensure that spectrum occupancy data is available for all cities and other areas of high spectrum usage.



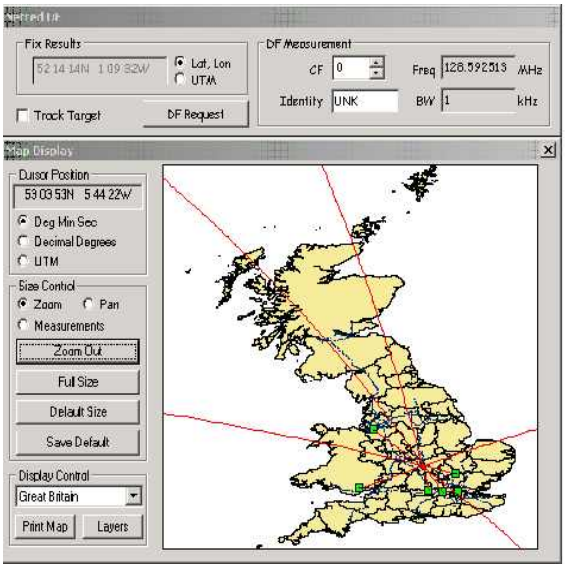
Remote Monitoring and Direction Finding Systems

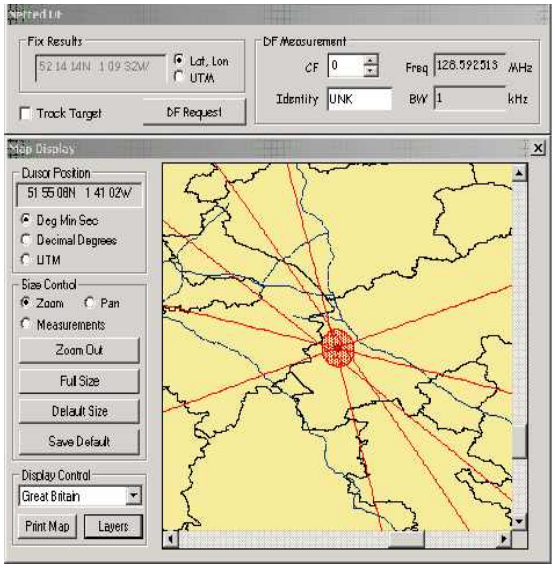
A network of fixed remote monitoring and direction-finding (RMDF) systems has been established at strategic locations around the UK. These stations can be controlled from Baldock and provide monitoring and direction finding capabilities which are shared with other Ofcom users. When networked together, the stations provide accurate position-fixing capabilities. These resources are used to investigate interference complaints, thereby helping to “keep the spectrum clean”. Typically, shift engineers in the Operations Room are able to monitor around the UK at any time day or night, allowing them to provide a swift initial response to affected customers particularly

those providing safety-of-life services. This also allows us to support our colleagues in Nations and Regions in their detailed interference investigations.

The RMDF systems operate over the frequency range 20 MHz to 3 GHz. As well as being available for real time manual remote monitoring, they can also be scheduled for automated monitoring and measurement tasks to capture intermittent interference activity for later processing. They can make accurate measurements of frequency, bandwidth, modulation depth, frequency deviation, field strength level and angle of arrival.

In addition to the fixed systems, a number of transportable systems are available to deploy to specific areas nation-wide, wherever a concentrated monitoring requirement is identified.





4. Field monitoring facilities

The field teams operating from Baldock have at their disposal a number of specialist mobile monitoring vehicles and EMC mobile laboratories. These purpose built monitoring vehicles are available for spectrum monitoring, specialist interference investigations and EMC measurements between 9 kHz and 105 GHz. They have been optimised for radio spectrum monitoring and are completely self-contained. The 10 metre pneumatic masts can carry a 60 kg head load and the vehicles can be equipped for most monitoring and measuring requirements occurring in the field.

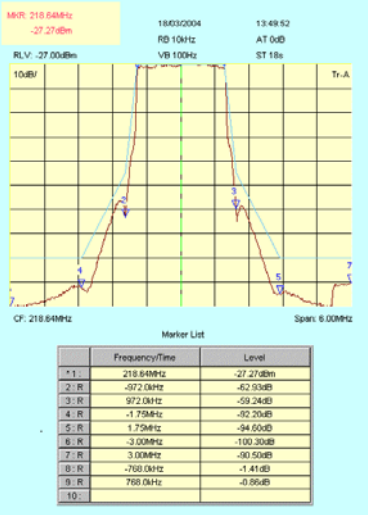
Power is provided by either an onboard diesel generator, which can run continuously for up to 5 days, or a high capacity battery powered mains invertor. These provide a nominal 240 VAC power supply that is conditioned by a high quality uninterruptable power supply, providing a continuous sinusoidal 50Hz supply for the electronic equipment. 12 Volt DC supplies are also available to ensure an extremely quiet RF environment. Automatic spectrum monitoring equipment is employed to record parameters such as signal strength level and occupancy data for the frequency bands of interest. Sophisticated processing software can control the receivers or spectrum analysers, record the frequency band measurements and allow graphical manipulation and display of the rf spectrum data. Such techniques are used to survey and audit frequency bands of interest for spectrum managers providing evidence of actual spectrum usage at various stages in the spectrum management process

Measurements can be made in the range 9 kHz to 18 GHz using a wide range of high quality measuring receivers meeting CISPR requirements. The vehicles can also be used as temporary UMS or RMDF stations, taking such resources to precisely where they are required in the UK.

In addition, the field teams take on a wide variety of reactive interference cases including those affecting the very low frequencies and the very high microwave and millimetre wave bands, where specialist equipment and techniques are used. As new services are being planned and introduced, Ofcom's spectrum managers require a clear picture of actual spectrum use and knowledge of the spectrum environment in a huge variety of locations. The teams pride themselves in being able to provide novel spectrum monitoring solutions in support of Ofcom colleagues and stakeholders.

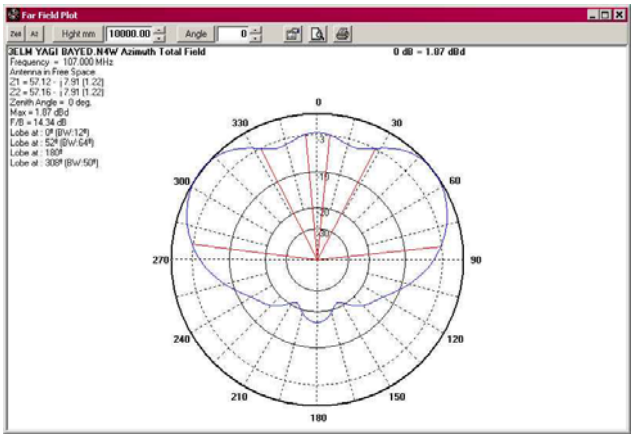
Broadcast radio commissioning inspections

One of the Baldock field teams specialises in broadcast radio transmitter commissioning compliance tests of MW, FM and DAB transmitters prior to on-air launch of new radio stations or following transmitter modifications and/or changes. Principal transmitter parameters are rf output power, operating frequency, frequency deviation and spurious emissions.



Very stringent measurement limits and methods are employed to ensure that sound broadcast transmitters do not exceed protection requirements in adjacent aeronautical radiocommunication bands where there are safety-of-life implications.

A sophisticated commissioning compliance procedure has been developed to record the key measurements in a database to speed up reporting and subsequent checks. The whole transmission chain is characterised in order to confirm that the effective radiated power (ERP) is as licensed.



Prior to commissioning, an antenna engineering design assessment using software antenna modelling techniques is undertaken, to ensure that the proposed antenna design will meet the coverage criteria prescribed in the licence conditions. Following commissioning, drive-by field mapping techniques are used to clarify that measured coverage is in agreement with that predicted.

The EMC mobile facility and its equipment

One of the Baldock field teams uses its mobile laboratory to carry out a diverse range of electromagnetic compatibility (EMC) work, as basic as the timing and level measurement of a humble boiler thermostat to as complex a matter as the measurement of spurious radiation from the most sophisticated radar system. Such work is necessary to solve complex interference problems occurring to radiocommunications systems anywhere in the radio spectrum. The team carries out detailed investigation and measurement, including calibrated EMC measurements, for which a UKAS accreditation is held qualifying measurement uncertainty and traceability.

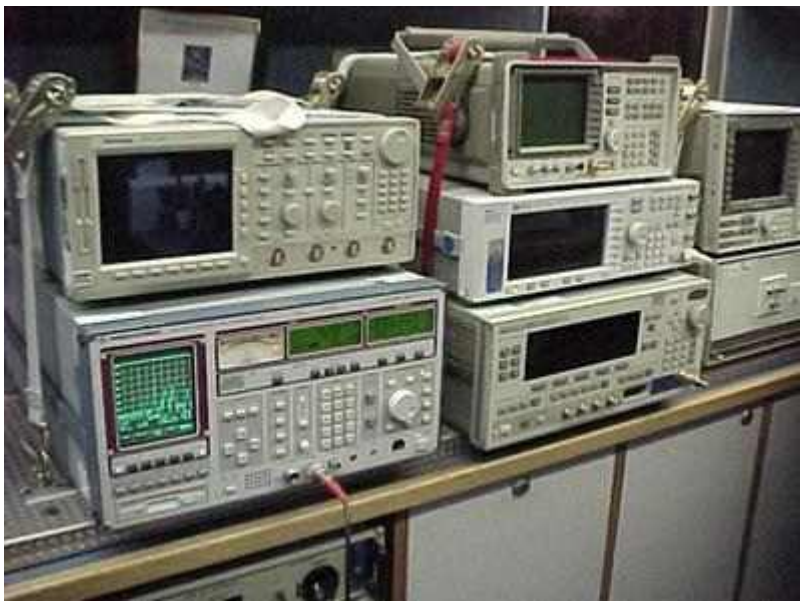
The EMC measurement equipment together with the broad experience of Baldock's radio monitoring specialists, permits mobile interference and EMC measurements to be made within the frequency range 9 kHz to 110 GHz although the bulk of the work is performed between 9 kHz and 40 GHz.

At present most EMC standards call for measurements between 9 kHz and 1 GHz. As more research, planning and assignments are being undertaken in the microwave spectrum the higher frequency capability of the mobile laboratory will come into play.

High quality measuring receivers can be programmed with antenna factor values and cable losses thus allowing incoming signals to be displayed directly as units of field strength.

Measuring

Receivers can be operated manually or automatically. The automatic process gives receivers a spectrum analysis facility allowing visual RF/IF scans to be displayed. These can be stored electronically or plotted for compiling reports.



These units also allow automatic EMC testing to be carried out and standard level limit lines to be displayed over a displayed emissions profile, giving a ready indication of over limit emissions.

In addition to spectrum analysers used to cover the microwave spectrum, an EMC interference-measuring receiver is available which covers 1 GHz to 40 GHz. The EMC microwave receiver can be coupled, via a serial interface, to a laptop computer, and by using appropriate software the receiver converts to a sophisticated spectrum analyser allowing automated measurement runs and in-depth signal analysis to be made. The results of spectrum scans can be saved and plotted for later inclusion in reports.

The mobile laboratories also have portable receivers and spectrum analysers that are mainly used for on-site source identification and for field mapping by using additional GPS (Global Positioning System) receivers and laptop computers.

These systems can also be used for long term unattended monitoring of the VHF and UHF bands.

Field strength mapping systems

Field mapping systems are used in the mobile laboratories' support vehicles and allow transmitter field strength profiles to be annotated directly onto a mapped route of the area of interest. These systems not only allow the mapping of transmitter field strength profiles, but also give a positive indication if a station's power output has changed since initial mapping.

The method of profile mapping has many advantages over manual techniques. It is fast, as the measuring vehicle can travel at normal traffic speeds, and many hundreds of individual measurements can be taken per km.

Other equipment

To supplement receiver capabilities the mobile laboratories also have frequency generating facilities from 100 kHz to over 40 GHz, which are an essential part of the UKAS measurement regime.

These units are used for equipment confidence testing, cable testing, cable calibration, RF field generation and spectrum marking.

The mobile laboratories also carry comprehensive calibrated antenna sets. These have the option of being mast mounted on the vehicle or tripod mounted remotely from the vehicle.

Satellite monitoring facilities

Experience gained over two decades of satellite monitoring at Baldock has shown that the vast majority of problems occur at specific satellite earth stations around the UK. The field teams together with their mobile laboratories and specialist microwave measuring equipment ensure that Baldock can respond to cases of interference to accurately identify and characterise the source.

When dealing with rare cases of interference between satellite systems or when making systematic regulatory checks, very precise and highly accurate measurements, such as power flux density and orbital position are required. Rather than maintain its own costly facilities, Baldock has entered into an agreement with several CEPT partners to share the use of the German regulator's satellite monitoring station at Leeheim, to investigate those cases.

5. Quality assurance

The Station's Technical and Quality Managers oversee the work of the EMC laboratory and ensure that all measurements are carried out according to procedures laid down in the UKAS Technical and Quality Manuals.

The Section has access to detailed RF propagation modelling software that can identify ideal monitoring sites and be used to give full coverage prediction to support the field mapping system. Such propagation software is used extensively during site selection of both UMS and RMDF monitoring locations to optimise coverage areas.

For further details of all sections of the station, please telephone 01462 428500