Electronic Communications Committee (ECC)
within the European Conference of Postal and Telecommunications Administrations (CEPT)

PRACTICAL CONSIDERATIONS REGARDING REMOTE MONITORING STATIONS

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0 EXECUTIVE SUMMARY

This report provides practical experiences related to designing, establishing, operating, maintaining and decommissioning remote unmanned monitoring stations.

The intention of this report is to share the knowledge gained by countries operating remote monitoring stations between themselves and also with countries that are in the process of building up a remote network.

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Practical considerations for Remote Monitoring Sites

1 INTRODUCTION

There is a desire in many countries to deploy monitoring (and possibly direction finding) equipment in remote locations in order to observe the radio spectrum over different parts of the country. There is a desire in many countries to deploy monitoring (and possibly direction finding) equipment in remote locations in order to observe the radio spectrum over different parts of the country. A monitoring facility can range from a large fully manned building down to a compact box located in the corner of a room. Large and small manned monitoring stations are already well documented in the ITU Spectrum Monitoring Handbook and other publications therefore the aim of this document is to concentrate on practical elements relating to unmanned facilities.

Note: All references to the 'Monitoring Handbook' relate to the ITU Spectrum Monitoring Handbook

The main body of this document consists of a high-level overview of the issues surrounding the development and operation of remote monitoring stations. The annex contains greater detail on many individual topics and the electronic version of the document contains hyperlinks to the appropriate annex section.

There are different types of monitoring stations each with diverse frequency capabilities although they all perform some common tasks. Whilst many countries may have the desire to operate radio monitoring stations, experience shows that they have adopted a number of approaches regarding how this outcome is achieved.

The aim of this document is to highlight some practical issues which should be taken into account if a network of remote monitoring stations is being considered and also to share 'best practice' from those countries already operating remote monitoring systems.

This document does not cover the business case or justification for a remote network as it is assumed that this has already been agreed. Not every topic discussed will apply to each country however it is useful as a checklist of topics so that each element can be considered and discounted if necessary.

This document is built up in a logical order starting with the initial guidelines regarding the scale and different types of sites plus the equipment considerations. This is followed by selecting the monitoring site, the processes and contracts necessary to acquire the site, plus the build and installation of the equipment to complete the acquisition phase. Operational considerations then follow including maintenance guidelines and considerations for eventually decommissioning the site.

2 THE REMOTE NETWORK

The magnitude of a remote radio monitoring network will depend greatly on what is trying to be achieved.

This is generally a compromise between three main factors:

- Measurement tasks and the frequency range to be supported
- Geographical region to be covered
- Available budget for building and maintaining such a network

Depending on the priorities, resources and available budget there are several options in managing the development of a new radio monitoring site, ranging from performing the work using existing staff to awarding the complete acquisition and construction process as a single contract to a chosen company.

3 EQUIPMENT

In some cases the choice of radio monitoring and ancillary computer equipment may already have been made since existing equipment is already in service. If possible, certain key elements should be taken into consideration when selecting equipment for installation in remote sites.

Alongside the antenna and feeder considerations and radio equipment, further supplementary equipment and other factors should be considered to ensure the successful operation of the remote monitoring station.

At this stage, consideration should also be given regarding the necessity to include a back-up means of communication between the control centre and the remote site in case the normal method of communications fails. Low-bandwidth wireless technologies such as GSM/GPRS may be acceptable for back-up purposes.

4 SITE LOCATIONS

Before the selection of the future remote site it is essential that the business objectives are known in order to apply the correct criteria on site selection. Of prime concern for the suitability of a site is the acceptable level of field strength generated from co-sited and nearby transmitters in the frequency ranges of concern. This level cannot be quoted directly as it is partially determined by the performance of each item of equipment and influenced by the antenna choice and physical layout.

In general, remote sites take one of two forms – installation on the rooftop of an existing building or erection in an open space, both of which have their benefits and disadvantages.

Similar equipment and antennas could be used in each scenario however this document will mainly concentrate on open space sites as these are more complex to establish and require a greater detail work to complete the project. Rooftop installations will follow a similar route however it may be possible to establish less formal agreements with building owners or even ignore some steps completely depending on the size of equipment and guarantees wanted on both sides.

Within the nominal area of interest, choose around 3 possible locations of interest on a map which appear accessible.

Each potential location should be visited and a site-survey undertaken to make sure the location is suitable for a remote site. If suitable, contact the local authorities and establish if there is any future building or infrastructure plans like railways, buildings or motorways planned. Also check planning permission procedures and local rules and regulations which may be in place regarding site sharing obligations.

The owner of the possible locations will need to be identified and the interest in a rental contract established. Make sure that proposals are discussed with the actual land owner and not just tenants who may be living on the land as they cannot make key decisions.

If the chosen site is in a remote location it is also useful at this time to contact the suppliers of energy and communications services to check the availability and approximate cost of services at the chosen location.

5 NECESSARY PROCESSES

After the choice of the geographical site-location has been made there will be a large amount of paperwork.

First step in the process is to get a general agreement with the building/landowner on the general terms surrounding the site such as the annual rent for the required amount of space and any other rental conditions. When this has been completed the design stage can commence and drawing plans based on the agreed requirements can be produced. These may require a few revisions before the final drawings are settled with the owner. Consideration should be given at this stage to external items such as fencing which may need the consent of the land owner.

Once agreement has been reached on the site design, planning permission should be applied for from the local government or council if required. Formal legal agreements should also be drawn up at this stage including any insurance or other financial arrangements.

Based on previously agreed equipment and antenna requirements a detailed civil works document must be prepared, including environmental considerations.
Additional mitigation measures should be considered for sites in locations which are expected to operate in extreme conditions.

When all the contracts are signed, the orders for services, such as communication lines and power, have to be made and a tender can then be sent out to select a builder.

6 CONSTRUCTION

The actual construction of the remote monitoring site (or substantial elements of it) will almost certainly be carried out by qualified building contractors. This element of the process can either be managed internally or handed over to a project manager to deliver a completed 'turn key' site. However if it is contracted out regular progress meetings (and site visits) should be undertaken.

A photographic record of the site condition should be made before any work commences to assist in possible future disputes over land or damage claimed to have taken place during the building phase. These photographs should be stored in a safe place as they may also be required when the land is returned to its original condition as the site reaches the end of its useful life and is finally decommissioned.

The scale of work required during the construction of a remote site is dependant on the size and type of installation which will be different for each site/location so it is only possible to discuss the generic steps involved. Development of a complete new site will need major groundworks which could include improvements to the ground conductivity of the site whereas installations on existing masts will generally only require negotiation with the mast owner and existing users. In-building sites can be relatively straightforward in comparison especially if the monitoring equipment and antenna are small.

The final construction should be inspected and the civil works accepted only if the build meets with the original design plans. Major problems should result in the rejection of the site and minor issues should be noted on a snagging list for later resolution.

Services installed at the site should also be checked to ensure that they are all fully operational and meet with the design requirements.

Once the groundwork has been completed the installation of the radio monitoring equipment and support infrastructure such as the mast/tower, antenna(s), RF Feeder(s), control cables and monitoring equipment can be performed.

Suitable signage should be displayed on the completed site to identify your organisation as users and provide emergency contact numbers.

Once all construction and installation work has been carried out the completed site should be commissioned and placed into service.

7 OPERATIONAL CONSIDERATIONS

As previously mentioned, there are many operational factors surrounding running a remote monitoring site.

Reliable equipment is essential for remote use as a visit to the site for even a minor problem can cost a great deal in time and resources. Even the most reliable equipment, control hardware/software or communications between the control centre and the remote station can occasionally go wrong so it is extremely useful to be able to reset the remote station as a last resort.

Separate from the normal operation of the monitoring equipment there is also a possibility that alarms can be activated (or fail) or security measures such as remote cameras will need observed on a regular basis.

A number of different organisations may require access to the remote site for operational, maintenance and repair purposes. A procedure to allow all access to site keys should be in place.

Reliable power and communications are essential to keep a site operational therefore any back-up services (if used) should be checked on a regular basis.

The measurement equipment in an operational site should be verified at regular intervals to provide confidence that the measurement results being collected are correct. Most manufactures provide a basic self test function which will check that key basic parameters are within tolerance but do not necessarily check the whole signal path.

Additional arrangements may also be required for site visits.

8 MAINTENANCE

The ongoing maintenance of a remote site is important for the reliability and accuracy of the equipment and also required to ensure that all requirements of national laws are observed.

All measurement equipment has to be calibrated on a regular basis (often yearly) to ensure that results are accurate.

In addition to the measuring equipment, the maintenance should include the tower/mast, antennas, security systems, air conditioning, and general operating environment such as the host building, fencing, road and access control.

An easy way to manage this task is to create a maintenance schedule for each site detailing the required checks and the intervals involved.

Depending on the situation, all (or part) of the ongoing maintenance could be carried out by internal staff or handed over to external contractors.

9 DECOMMISSIONING

The time will come, for various reasons, when each site reaches the end of its useful life requiring a termination process not too dissimilar to the reversal of the original acquisition process.

In most cases the site owner has the power to insist that his property is returned to the original state before the remote site was established meaning that everything has to be removed from the site. Restoring a site to its original condition can often entail large costs therefore it is worth considering offering to transfer the site and basic infrastructure (mast, cabins etc) to the site owner to use for other purposes as this may be more financially beneficial to the monitoring organisation.

It is essential to cancel all contracts in place for the site to ensure that all future liability has ceased.

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ANNEX 1: INTRODUCTION

Monitoring Stations

Guidance is already available in chapter 2 of the Monitoring Handbook regarding how to establish a fixed remote monitoring station. This document (and others) also provide a great deal of information on issues which are also important in this case therefore they are only briefly mentioned here allowing us to concentrate on the topics specifically relating to remote monitoring stations.

The required capabilities of the monitoring facility ultimately dictate the type of monitoring site required. In general, equipment which offers direction-finding facilities using an angle of arrival (AOA) principle requires fairly substantial antenna arrays which need to be elevated clear of local obstructions. This often requires dedicated tower arrangements away from building clutter. Establishing such a complex remote site can be a significant and complicated task often taking a long time to complete. It must be noted that this time can be reduced if all monitoring and direction finding equipment are installed directly on the mast itself together with the antenna, allowing the possibility of In-Building installation.

Although the general considerations mentioned above also apply to monitoring systems which do not have direction finding capabilities and concentrate more on gathering occupancy data where it is possible to achieve satisfactory results with a smaller installation by deploying monitoring equipment in the corner of a room and erecting a simple antenna such as a discone. Future monitoring developments utilising Time Difference of Arrival (TDOA) techniques may possibly allow emitter location capabilities using smaller equipment. This type of site is less complex than a large site and therefore could be established quite quickly if all parties involved are in general agreement. However, it must be considered that the number of sites for TDOA applications may be higher than for AOA applications to cover a large area.

Although not specifically covered in this document, some of the points outlined also apply to establishing temporary/transportable short-term monitoring facilities using a trailer-mounted system or semi-permanent sites where a small set of equipment may be set up for short durations to manage specific problems.

Open space site

In-building site

In-building site

Trailer mounted

ANNEX 2: THE REMOTE NETWORK

Measurement Tasks

Some measurement tasks, which could be performed by remote monitoring stations are:

- frequency measurements
- interference detection
- channel/spectrum occupancy measurements
- field strength measurements
- direction (and/or location) of emission
- perform 24 hour automated measurements (when not being used manually)
- measurement of analogue and digital modulation parameters
- audio recording
- polarisation measurements
- verification of compliance with license conditions
- detection of unauthorised frequency use
- identification of transmitters
- demodulation and decoding of digital transmissions

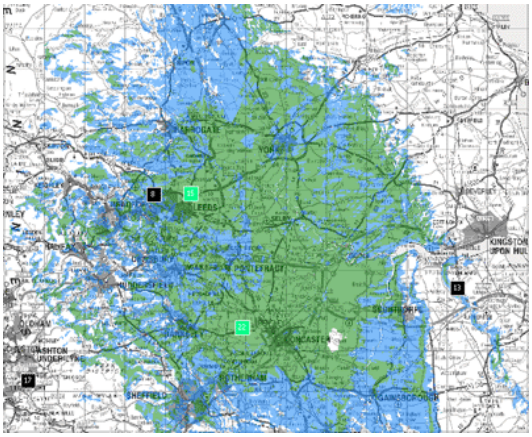
Frequency Range

Stations dealing with frequencies below 30 MHz normally require quite extended land for antenna fields. Antennas for frequencies above 3 GHz are usually very directional and have low transmitted power outside the beamwidth of the antenna therefore the potential interference sector is quite small and best achieved by portable monitoring equipment placed directly in the area of interest. For these reasons, present remote controlled stations are mostly used for VHF and UHF monitoring covering the frequency range 20 to 3000 MHz.

Geographical Region

Remote controlled stations should be deployed so that regions with a high density of radio licenses/usage, population, or a previous history of radio problems are covered. Additionally locations of special interest or economic importance e.g. busy airports and harbours should be taken into account.

Frequency planning tools can be used to optimise the coverage of the remote stations with two or more monitoring stations covering each region if transmitter location is required.



The number of receivers per site depends on the type of measurement tasks, the number of licence holders in the region and the number of licensed operators. If tasks such as the measurement of occupancy which uses a receiver for quite a long time, it is recommended to dedicate one receiver for these tasks. If this is not possible you should ensure that for urgent measurements the operator has at least the possibility to temporarily interrupt an on-going measurement. For very important sites, often used by many members of staff simultaneously, a greater number of receivers will be required.

Budget

Typical investment costs involved to build up a remote network include:

- Monitoring equipment (antennas, receivers, HF switches, direction finders, servers, etc.)
- Technical infrastructure (Electricity source, communications infrastructure, equipment racks, power supplies, cables, air condition (if needed), etc.)
- Construction & installation (Legal documents, mast, antenna support, lightning protection, building, security/alarms, fire prevention systems, cabin, etc.)

It is quite possible that the yearly operating cost will have a bigger impact on the budget than the initial investment cost as this ongoing expense includes:

- man power for maintenance
- equipment maintenance costs
- telecommunication/network infrastructure fees
- site rent
- security costs e.g. security patrols
- energy costs

The cost involved of building and maintaining a large network will be a major factor in dictating the final number of sites. An estimation of the total costs is not possible in this document due to the huge variations in site costs, legal requirements and building restrictions in each individual country

Development options

The whole installation management process can be awarded to an external company to provide a turnkey solution. This option is more costly but has the advantage of not requiring a great deal of in-house resources other than in an overseeing role. At the other extreme, if sufficient expertise is available in-house then this could be used to establish the site. A combination of these methods may be employed where limited local resources are used for some functions and certain elements are outsourced as defined packages.

ANNEX 3: EQUIPMENT

Antenna and feeder considerations

No single antenna design is ideal for all monitoring situations therefore a wide range of antennas reflecting the broad operating frequency range should be used at remote monitoring stations or a small selection of antennas and accept that reception of some frequencies will be less than ideal. Antennas designed to cover the higher frequency ranges are generally smaller and therefore easier to establish.

The antennas used on remote sites can be divided into the following categories:

- Omni-directional
- Multiple fixed directional antenna
- Directional antenna(s) (usually used with rotator)
- Direction finding arrays

Most signals in the VHF/UHF bands are vertically polarised however signals which are horizontally polarised can also be taken into account by installing an additional antenna or an antenna which covers dual polarisation.

If long term monitoring is planned as part of a campaign then it may be beneficial to install an additional dedicated antenna for that task so that the normal monitoring antennas remain available for general use.

It should be noted that in general equipment which operate in the HF bands demand a large area of land for the antennas which introduces additional problems related to the management of this land.

In addition to the specific considerations mentioned above, other general antenna specifications can be found in the Monitoring Handbook chapter 3. Good quality low-loss antenna feeder cable is required especially when operating at higher frequencies. If one antenna has to be used by multiple receivers simultaneously, a power splitter or remote controlled switch has to be inserted in the signal path. If the loss introduced by a passive splitter (at least 3 dB) is not acceptable, an active splitter with an amplifier can be used however a major disadvantage of this active solution is the possible reduction in useful dynamic range and potential for strong local emissions to generate intermodulation products.

Radio equipment

Frequency range:

The frequency range of the receiving equipment is dictated by the monitoring requirements. Remote monitoring stations commonly operate in the VHF and UHF frequency bands although some remote HF stations may also be desirable.

Direction Finding facilities:

A remote monitoring station which has directional capabilities will have a larger space requirement and greater complexity than one which just contains a simple receiver. In areas with both strong and weak co-channel radio signals, a steerable dual polarized antenna which could be orientated to the wanted signal, is often an alternative and cheaper solution to an electronic direction finder and may produce better results though the reliability of the rotating mechanical parts need to be considered.

Receiver performance:

This document is not aimed at detailing receiver specifications however it is important to remember that it is quite likely that the remote site will be in a location which is (or could be in the future) relatively close to other transmitters therefore equipment with a good specification in harsh RF environments should be used. Consideration should also be given to demodulation capabilities, IF filtering, scanning speed etc. Further details on receiver performance can be found in the relevant ITU-R recommendations.

Filtering:

It may be possible to install external band reject signal filtering into the RF path in order to reduce the levels of strong local emissions, which could cause degradation in the receiver performance, and provide additional protection from intermodulation products. Filters will however reduce the ability to receive signals in the filtered band and the characteristics of the filter will need to be taken into account when determining signal level measurements.

COTS or custom built solutions:
Commercial off-the-shelf (COTS) equipment is a term for software or hardware (generally technology or computer products) that are ready-made and available for sale, lease, or license to the general public. Commonly used software can have the advantage of a well-known interface and general functionality which is usually well documented but if specific features are required then a custom solution (or an adaptation to a COTS system) will be required. It's often necessary to buy COTS products because of the financial advantages.

Good Reliability:
The main drawback of remote sites is the lack of immediate access therefore the equipment chosen must be reliable. Corrective actions which are simply irritating when using the equipment locally (such as a PC reboot) can be extremely frustrating, time consuming and expensive when the same equipment is placed at a remote location and a visit to cure the same problem can take a day or more.

Size and weight:
Remote sites, particularly on existing buildings, often are rented with the rent calculated based on the size of the installed equipment. It is also necessary to keep the size and weight of the equipment small to be flexible during installation and servicing.

Supplementary equipment
Control of equipment:
The remote radio equipment is generally controlled locally by PC based applications. In a variety of modern equipment an embedded PC within the measuring instrument can also be used to control the instrument.

Software control application(s):
The software controlling the remote equipment should have the desired functionality but should also be uncomplicated and intuitive if the system is to be used by staff on an irregular basis. This will also reduce the need for staff training.

Self-monitoring system:
To ensure good operation of the remote monitoring station it is advisable to have a monitoring system watching the functionality of the station. This can be done automatically on several levels such as testing the IT network or routine calibration/self check of measurement equipment.

Local Area Networking:
Each remote site will have a local IT network to connect the controller PC to the receiver and other ancillary equipment. The options for Wide Area Networks are discussed below.

Communication with remote station:
While most remote monitoring stations can perform monitoring tasks when unattended it is still necessary to have network access to these sites. For example:
- for collecting the monitoring data;
- for changing the measurement process (new order);
- for access to real time spectrum and/or audio signals;
- to receive status details providing information on the operating characteristics of the monitoring station.

A wide range of fixed communication technologies to communicate with remote stations exist such as:
- Standard telephone modem
- ISDN Line
- xDSL
- Fixed links (microwave point–to–point)
- Leased lines

The availability and cost of each option depends on several factors. Take into account that modern spectrum monitoring systems can generate a lot of data therefore the bandwidth of the medium must be suitably matched to this.

Mobile connectivity with the remote station is also an option using:
- GSM
- GPRS
- UMTS (3G)
- HSDPA/HSUPA
- Wireless LAN

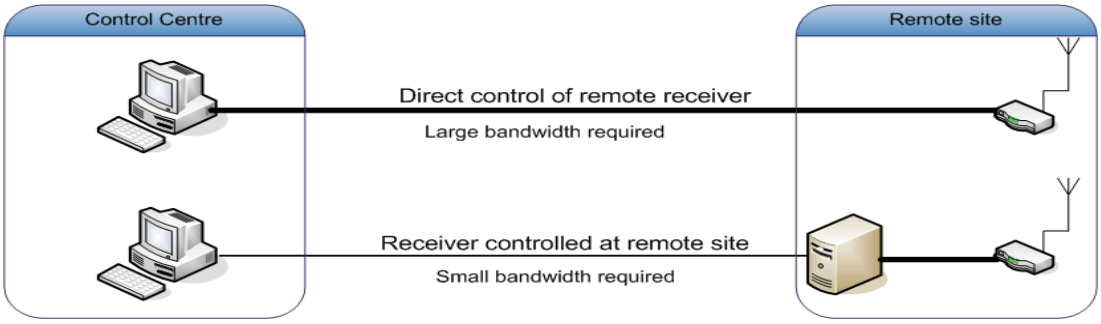
Use of these technologies will have a negative impact on monitoring the frequency band used.

Remote control of computers:
There is a great advantage to have total control over the remote PC for servicing purposes, updating or upgrading software etc. Several commercial products are available which replicate the look and feel of the PC from a remote site.

Power control of remote devices
In certain situation it is necessary to switch off/on the power to equipment at remote sites. Consideration should be given to installing a remote AC power management switch. This enables remote control of power sockets using interfaces such as internal web site.

Uninterruptible Power Supply (UPS)
To ensure continuous operation during short power cuts or power dips a UPS can be used. Keep in mind that these systems use batteries and therefore they can only deliver power for a certain time and require the batteries to be changed at specific intervals.

Other factors
Availability of services:
The speed and availability of connection between the central and remote monitoring sites is dependant on the amount traffic generated. It is possible to control a remote receiver directly from the central control centre however this will generate a great deal of traffic over the wide area network. Control and data processing at the remote site can greatly reduce this network traffic so that smaller processed files are transferred between sites.



IT Security:
A monitoring site connected to a (public) communication infrastructure can be vulnerable. Authentication systems, firewalls, VPN connections etc are necessary to overcome this vulnerability and protect the IT network against electronic attacks.

EMC:
The electro magnetic environment surrounding the monitoring station is, as already mentioned, important but so are the EMC aspects of the monitoring, controlling and supplementary equipment itself. Mounting the equipment in a good shielding case is advisable to overcome unwanted signals coupled in via the antenna.

ANNEX 4: SITE LOCATIONS

Acceptable level and protection
In common with manned monitoring installations, remote monitoring stations must also have suitable RF conditions. The Monitoring Handbook section 2.6 provides guidelines on sources of interference which can affect the operation of a monitoring station.

Some countries can implement a 'protection radius' which provides a safeguard against construction of new buildings or close-by transmitters and is written into their national law therefore they can prevent potentially damaging events within a certain distance from the monitoring site. This procedure may be incorporated into the radio licensing process or local planning regulations.

Other countries must rely on the good will of potential interferers as they do not have any legal power to prevent such operations. Co-location with transmitters may be a possibility through filtering however this will reduce the effectiveness of the site. Remote switching of filters may be possible.

As the sites are remote it is essential that notifications of significant changes around the monitoring site which may affect the operation are made to a central address such as the monitoring control centre. A regular 'scan' of the full receiving spectrum will highlight any new local transmitters although by this time it may be too late for any preventative action if this is causing interference.

The performance of the monitoring equipment will dictate the protection required against strong signals so it is not possible to define a fixed maximum value. As a rule of thumb during a site survey particular attention should be given to emissions which register a terminal voltage of > 70dBuV. A lower signal level may be appropriate if an active antenna is to be used.

The cumulative power of received signals should also be taken into account as several moderately strong signals could have a greater impact on the receiving equipment than an isolated strong emission.

Existing Building

Advantages	**Disadvantages**
Easier for small equipment as usually some choice is available	Specific details relating to building structural loading could be required if the equipment or antenna to be installed is very heavy
Services (power/communications) usually available locally within the building	Access to the building can be a problem particularly out of office hours
Can be a relatively cheap option	It is difficult to prevent other users to also use 'your' roof such as UMTS or GSM operators
Lower removal costs at end of life	Generally greater proximity to local man-made noise than an open space site
Lower cost therefore it is economic to install several sites in an important area and thus improve measurement capabilities	
Cheaper infrastructure maintenance costs	

Open Space

Advantages	**Disadvantages**
Greater geographical area to choose the 'ideal' location	Site negotiations must usually follow full legal process and can take a long time
Usually installed in own cabin therefore independent access possible	Expensive to plan and build
Usually larger distances from other radio transmitting stations	

Site Accessibility
The use of web based mapping sites can often help to narrow down the choice of sites which will require a visit. In addition to general mapping information, these sites often provide satellite views (which may be a few years old) and other helpful views such as 'birds eye' and 'street views'.

Potential monitoring sites should be accessible all year round both under normal conditions and also during periods of construction and maintenance when heavy plant such as cranes may need to be used. Factors which will determine the accessibility of a site include the width and gradient of the proposed access road, proximity to overhead power lines etc.

In addition to the normal method of access during the life of the site, heavy duty access for construction traffic will be required. This may involve laying down a temporary or permanent access road.

Site-survey
The Monitoring Handbook section 2.6 annex 1 contains a site visit report listing all the necessary items to be checked.

An initial quick site survey should also note any visible nearby antenna and include a ground suitability study. The location and power output of local broadcast transmitters should also be established to ensure that they will not cause Intermodulation products within the monitoring equipment.

An assessment should also be made regarding the feasibility of creating a monitoring site with building options, potential costs and security issues.

In addition to nearby radio emissions other external factors such as wind turbines, local airfields, restricted areas or evidence of manufacturing processes such as arc welding should also be taken into account particularly if the proposed site is close to an industrial area.

Local clutter from trees etc may provide some shielding) particularly during the summer months.

An appropriate correction factor should be applied to any site survey results to compensate for the fact that the final antenna height will probably be greater than the height of the survey antenna.

Energy and communications services
The site will require an electrical supply as well as a communications connection. The location of the site will have a bearing on the choice of supply method. Considerations should include:

Cost to provide a supply – Countryside locations often require long power routes that may only be available from a single electricity supplier and can therefore be very expensive.

New installations can often only be supplied by the regional electricity company who have to survey the site in order to provide an estimate of cost. If this is accepted any permissions or wayleaves need to be acquired from adjacent property owners to route cables over their land. If the adjacent property owner is unhappy with the idea of a tower close to his property he may not agree to the wayleaves and force an alternative (usually more costly) route to be adopted. Additional line plant may also need to be obtained and the work scheduled which can take 9 months or more to complete.

It is worth exploring the possibility of taking a power supply from the land or building owner. This is quicker and often more convenient however it leaves the equipment vulnerable to being 'switched off' by an external party especially should a dispute develop.

Small compact radio monitoring units with a low power consumption may be able to use renewable energy sources such as wind or solar although these alone may not guarantee H24 operation of the remote unit.

Some power outages to remote stations which gather occupancy data may be acceptable but key sites may justify the additional complexity and expense of an on-site generator especially if the external power supply is unreliable. Consideration should also be given to the fact that a generator needs fuel and the tanks will need checked and filled as necessary and may demand certain safety requirements.

For the communications connection there are also several options possible although the availability of each possible option should be established as part of the site choice process. An overview of communication possibilities can be found in annex 3 of this document and also in the Monitoring Handbook section 2.5.

Finally, the building or room to place the equipment for the remote monitoring station should be very simple and often one room will have enough area. The choice for the accommodation of the monitoring equipment is as follows:

- *Buildings owned by the government/own organisation*
  These buildings could have easy access and on-site RF protection can be closely controlled ensuring that no other radio users like GSM and UMTS operators are allowed to install their equipment.)
- *Buildings where a separate locked room can be rented*
  For optimised usage and maintenance of the remote controlled site it is recommended to fix some special conditions in the rent contract as discussed in annex 5.
- *Buildings with a shared room with the possibility to install a rack*
  Same points as mentioned above and additionally check security of room and establish need for protection against dust, humidity etc.
- *Cabin on a roof*
  A good solution due to short cable runs although larger cabins may require a structural survey to establish building load points. Maintenance space can be a problem in very small cabins.
- *Cabin in the field*
  Can be an expensive option if services such as electricity, water and road access is not available.
- *Equipment installed directly on an antenna mast*
  Cabin on a roof may be reduced in some cases to its minimum or even suppressed when all the necessary equipment are installed directly on the antenna mast.

ANNEX 5: NECESSARY PROCESSES

Agreement with the landowner
After the site has been selected, it is necessary to begin the formal negotiations with the site owner, a phase that can take a considerable amount of time to complete as consideration should be given to:

- Determining the owner of the property or land
- Negotiating the key facts relating to the lease for the land (see terms below)
- Stressing that the monitoring equipment is 'receive only' and does not transmit any electromagnetic radiation
- Reach agreement not to permit other transmitters in on the same building or in close proximity
- Agree reasonable access to the site for maintenance visits

Discussions with the site provider will provide the basis for a formal legal agreement.

Terms
The legal Agreement should at least contain the following items:

- Duration of lease - The total period of the lease. This should be as long as possible to ensure that maximum return is obtained from the investment in the site. Periods of 20 or 25 years are not uncommon.
- Break clauses - The time period where it is possible for either side to terminate the agreement. A short initial period will allow early withdrawal if the site does not live up to expectations but equally may result in early termination by the landlord. Break periods every 3 or 5 years are a good compromise.
- Annual rent – the annual payment for the site. It should also state if any local or national tax is applied to this figure
- Review period and mechanism for rent – This should detail a time period when the annual rent should be reviewed and how this review should be decided. A common settlement is every 3 years and a rent increase in line with a published government economic indicator such as Retail Price Index. An arbitration process should also be stated in case of disagreement.
- Insurance – the amount of liability that the Administration must have to cover any public liability claims.
- The other factors agreed with the site owner such as access, restrictions on future transmitters, should also be included.
- Standard legal clauses will also be incorporated including:
    - The site should only be used for the installation and use of the remote monitoring station;
    - The land owner is allowed to install the necessary facilities to allow them to continue with their work;
    - The Administration can perform modifications to their installations at any time or within agreed hours;
    - The land owner must allow the transit of persons and vehicles over their land;
    - The Administration can access the remote monitoring station freely at any time or within agreed hours on any day with any instrument needed;
    - The land owner only can access the installation if escort by a representative of the Administration;
    - The land owner cannot perform any construction that could reduce the capacity of the remote monitoring station without the prior approval of the Administration;
    - Special services (housecleaning, emergency support, power reset etc) need to be negotiated.

The lease should only come into force once all necessary permissions for construction (such as planning permission) have been obtained. Should these permissions not be granted then it should be possible to withdraw from the lease with only minimal charges applied.

Design stage
The Monitoring Handbook section 2.6 contains details of the design considerations for a fixed site and a number of these also apply to remote sites. Items worth of particular mention are:

- Earthing considerations
- Lightning protection
- Security fencing
- Security camera
- Geo-study of land
- Suitable mast foundations
- Mast warning/safety lights
- Air conditioning (if thought necessary)
- Alarms (Intruder and fire)

- Power supply (including UPS and/or emergency generator if applicable.)

Drawing plans
Site drawings must be produced (or modified if an existing site) and agreed with the site provider and other site users if applicable. Initial drawings can be relatively high level showing basic structure and building dimensions however more detailed construction drawings will be required by the contractor should the proposed site proceed to the build stage. The site drawings will form an integral part of the legal and planning application documents.

The tower should preferably be close to the building or room and any loading calculations on the concrete base for the tower and/or antenna support should be based on manufacturer's specifications taking into account the geographical and climatic conditions.

Enough space should be allowed to cover the possibility of a small truck turning at the site if required. Ensure that there is sufficient space available to accommodate truck-mounted cranes which may be required for maintenance purposes.

Fencing
For security, fences around unmanned monitoring station may be necessary. If the station is located on the top of a building in shared room then some other form of enclosure is advisable. Due to the remote nature of the site an intruder will probably have a great deal of time to gain entry therefore all fences, building and doors should be of strong design and construction.
If the monitoring stations cover the HF band and metallic fences are installed then they should be sufficiently remote (>200m) from critical installations such as long-range direction finding and field-strength measurement installations to avoid possible interference to the normal operation of these devices.
Metallic fences should be well grounded to ensure that there are no floating conductors which may resonate and re-radiate stray electromagnetic energy.

Planning permission
Planning permission from the local authority is generally required for any new masts or modifications to existing structures unless the modifications or installation is small. Specific conditions may be set by the planning approval document or site provider which may include consultation with local residents. Some 'landscaping' such as planting trees or painting the mast or cabin a specific colour may be imposed as a condition of planning permission being granted.

Legal agreements
Arrangements should be formally agreed between all parties involved. For a small in-building site this can be a simple 'agreement' signed by senior members from both sides. Larger installations including open space construction will require a full legal lease/contract to be established drawn up by lawyers.

These legal agreements should include the items agreed during the negotiation of terms detailed previously and additionally:
- Start date
- Termination penalties/agreements
- Establish responsibilities for removing equipment at end of lease

Insurance
As in most cases, insurance should be considered to protect the installations, equipments and staff from the problems that may occur in a remote monitoring station such as:
- Fire
- Flood (from ground, burst pipes or leaks in roof)
- Vandalism (graffiti, breaking of roof-tile, shooting, stone throwing or forced entry)
- Theft (equipment, air-conditioning units, fence, cameras etc)
- Lightning strikes
- Staff injures

There may be a legal requirement to have Public Liability Insurance to cover the possibility of injury to members of the public (for example from a falling antenna element)

Some governments may have a policy to 'self insure' their equipment and property rather than pay a fee to an external company. In such cases the risk is accepted and the cost of any lost or damaged items will be met by the government.

Environmental considerations

The environment at the remote site should remain within the operating conditions of the equipment.

There is usually sufficient heat generated by the equipment itself to keep the temperature above the minimum requirement under most conditions however additional heating should be considered if the equipment is likely to be switched off for long periods or if the outside temperature is likely to fall to very low values.

The equipment enclosure should provide sufficient ventilation to allow air flow around the equipment. A method of air circulation such as extractor fans may be sufficient however in warmer climates full Air Conditioning may need to be installed.

In extreme locations which have exceptional snow, ice and wind it is recommended to protect steerable antennas with a radome.

Consideration should also be given to ingress of water. Equipment sited under water pipes or directly on the floor may require additional precautions to minimise the risk of damage in the event of a water leak.

Extreme conditions are typically excessive heat or cold when the following additional mitigating measures may be taken.

- Excessive heat:
  - Back-up air-conditioning unit
  - Automatic alarm or equipment shutdown if the temperature exceeds a trigger threshold
- Excessive cold:
  - A greater fenced off area around the site to protect the public from the possibility of ice falling from the antenna elements

ANNEX 6: CONSTRUCTION

Construction
All permissions such as legal agreements and planning permission must be obtained before any construction can take place.

The build may require the hire of specialist lifting equipment such as a crane and the services of staff with specialist skills such as qualified riggers will also need to be rented if not available internally.

To protect electronic equipment in the event of a lightning strike, the value of the ground resistivity should be as low as possible. Further information relating to earthing and lightning protection can be found in section 2.6 of the Monitoring Handbook.

Regular site visits during the build phase can identify issues in sufficient time to take corrective action therefore it is essential that these are carried out by staff with appropriate knowledge.

Inspection of build
Major problems should be rectified before equipment installation work takes place at the site. Minor issues such as cracks, bad workmanship etc should be brought to the attention of the builders and payment withheld until the faults have been corrected. This may not necessarily hold up progress in building the site. Any outstanding work such as erection of fence should be confirmed and payment withheld until completed.

Confirmation of suitable earthing points (usually at the mast base) for equipment and lightning protection should be made.

Services
A check should be made at the remote site that suitable power is available and it is capable of supplying the designed load. Any other services such as water or oil storage should also be checked if they are provided. Communications services should be checked if they have been installed at this time.

Installation of equipment
Once the building is deemed suitable for use the process of installing the support facilities and monitoring equipment can begin.

The building support services will most likely be installed by external contractors who specialise in this type of work. This will include:

- Air conditioning
- Heating and ventilation
- Uninterruptible Power Supply (UPS)
- Generator or external connection point for mobile generator
- Security (theft and vandalism)
- Alarms
- Security cameras

The complexity of installation can range from a relatively simple installation through to a fairly major task depending on the choice and functionality of radio monitoring equipment. The actual installation of the chosen monitoring equipment should be in accordance with the manufacturer's instructions

If installing equipment on an existing building it is important to be aware of the responsibility for any damage caused during the installation.

Signage
Typical signage at remote sites will include:
- An 'In case of emergency' sign giving site identification and 24 hour emergency contact details for your organisation.
- All appropriate Health & Safety signage as dictated by national laws
- Hazard warning signs (Step, head height etc)
- Fire procedures

Commission site
Check that the site meets the drawing requirements and that any specific conditions which may have been set by the planning approval document or site provider have been carried out according to the plan. These could include painting the mast and/or cabin an agreed colour or landscaping by planting trees or hedges for visual reasons
Check all backup facilities such as communications and standby power arrangements

Place into service
Once the site has been fully commissioned it can be made available to the end users. This process would generally entail informing the users that the new site is available including key parameters such as frequency range, antenna height, functionality and location.

All site paperwork and general maintenance schedules should also be updated to reflect the presence of the new site

ANNEX 7: OPERATIONAL CONSIDERATIONS

Equipment
In general receivers and direction finders are robust and should operate without problems as long as they are connected to a reliable power source. When the control hardware or software freezes, a total reset of the system could be necessary, including receivers and direction finders reinforcing the fact that you have to have a reliable method to control equipment at a distance.

It is also important that in the event of a power failure all equipment will restart automatically when the power resumes.

Communication
It is wise to include an alternative method of communication to the remote site which can be used as a backup in case the main communication method fails.

If you find that you cannot connect to your remote site then there is a requirement to determine if the fault lies with your own equipment or the network provider supplying the site. Network providers usually have methods to check their infrastructure (either automatically or through a fault reporting centre) and can advise if the problem lies with their network and initiate a repair call if necessary. If the network provider does not confirm a fault then it must be assumed that the problem lies with your equipment and a visit to the site scheduled. An alternative communication method is beneficial at this point as this could allow contact with the site and help to establish remotely the status of the equipment or initiate a total power reset of the site. Another possibility to reset the complete hardware is a local contact available to perform simple tasks as directed over the telephone such as cycling the power to the equipment or advising the status any indicators, displays or screens. This could be a colleague from a regional office or the owner of the building where the equipment is sited. It is possible to arrive at site to discover that the fault is with the network provider and their remote checks have not detected it.

Alarms
There are several types of alarm available in a standard remote site, such as:
- Equipment Temperature high/Low
- Room temperature high/low
- Humidity
- Fire
- Air conditioning status
- Doors open/close
- Gates open/close
- Power normal/backup
- Intruder
- Levels of alarms – automatic call to police/fire to just logging
- Testing of systems

Test to ensure that all equipment returns to its normal state when the power is restored following an interruption. Remember to consider supplementary equipment at the site such as air conditioning and communication units which may not be designed to automatically switch on when power is re-connected.

Security
It is possible to add security measures to a remote site such as CCTV cameras or Webcams in order to remotely view the site or install a standard intruder and/or fire alarm although the response to an alarm in remote locations will not be instant.

Another security measure is an automatic gate operated from the main operations centre and is used to control anybody going in or out. In case of a communications or power failure a side gate or manual override is necessary as a backup. If an alarm is triggered or when communications or power fails at the remote side make sure you have a local point of contact to check or reset the site.

Keys
Consideration should be given to who is required to have keys to gates. In addition to maintenance staff, local contacts and service providers may also require access from time to time often at short notice.

In order to only give entry to the specific areas required, the use of a master keying system for the gates (which may be common to all remote sites) is very useful. This will ensure that someone who needs to verify the electric meter has a key that only opens a pedestrian gate whereas the people who go there for cleaning have a key that can also open the a gate for cars. Maintenance staff and other trusted people who need full access to the station have a key that could open all the doors and even the tower access if implemented.

When collecting the key, the responsible person from the outside organisation should complete a form with their identification, company identification, address were the key will be kept, and a signature.

Every time someone visits a remote monitoring station they should contact the central monitoring centre where the alarms are observed. The phone number should be written in the protocol.

In the Central Monitoring Centre should note the date and time of the contact/entry and, if possible, the end of the visit. When completed, the alarm system should be checked to confirm the remote station alarm is active and all doors and windows are closed.

Backup services
The importance of the site will determine if it is necessary to install an Uninterruptible Power Supply (UPS) to cope with voltage and frequency fluctuations which can occur at the end of a long power run. Consideration should also be given to using power conditioning devices to smooth erratic supply variations. Depending on the importance of the site, an emergency generator may be considered to be an option.

Communications backups (discussed elsewhere) should also be considered.

Equipment self test
It is possible that the equipment manufacturer has included a way of self-monitoring the condition of the radio receiving and auxiliary equipment and has included a measure, such as a watchdog timer, which resets the equipment if a fault is detected. It may be possible to perform a similar function externally using PC based software and remote power control. The ability to self-monitor and control all the equipment is extremely useful in a remote situation.

Besides a built-in option for self test, the equipment should be manually tested on a regular basis by checking that the ‘normal’ values from known transmitters have not changed.

Miscellaneous items
Cleaners
It is unlikely that a remote monitoring station will need cleaned on a frequent basis unless staff are regularly working at the site. Suitable arrangements should be made to allow either staff to undertake basic housekeeping tasks whilst at the site or specific cleaners to visit the site as appropriate.

First Aid
Appropriate basic first aid supplies should be available at the remote site.

Record of site visits
A log book should be maintained which details visits to the site including the purpose and all actions undertaken.

ANNEX 8: MAINTENANCE

Ongoing maintenance
The ongoing maintenance of remote sites and the associated telecommunication network could be covered by dedicated internal maintenance staff. Alternatively this maintenance work could be undertaken by using external contractors.

Ongoing maintenance should be planned in such a way that every site would be checked at least once yearly. The planning should take in account possible access restriction (snow, closed roads, seasonal interruption of cable trains, etc.).

For safety and efficiency reasons it is recommended to perform yearly checks with at least two people. Only people with appropriate training and certification should climb masts. Two or more competent people should always be present when mast climbing for safety reasons.

The amount of work involved in a site check depends heavily on the type of installation and specifics within the lease contract as some of the maintenance requirements could be the responsibility of the landlord

A set of appropriate test equipment should be available for each maintenance team. This equipment should be transported between sites in suitable containers.

Equipment
Pre-emptive maintenance of monitoring equipment installed on a remote controlled site is normally not essential however it is recommended that following installation all antennas, receivers and direction finders have check values established with acceptable tolerance ranges assigned.

Normal FM broadcasting or air traffic (ATIS) stations transmit a stable and permanently available signal which can be used for such check values. The check values should be measured at least once a month and maybe also prior to starting an important measurement campaign to ensure that the equipment is operating within normal limits.

Values as well as the date, time and the name of the operator should be noted. If a value is outside the tolerance range a decision has to be made regarding if the equipment has to be fixed immediately or if it could wait until the next site inspection.

Fault repairs (after 1st line maintenance) could be performed in-house or sent for repair under a warranty/service contract or pay-per-item basis. If the measurement results are to be used in a court of law, the equipment should also be calibrated regularly by an accredited laboratory.

Portable electrical equipment which falls under the 'Portable Appliance Testing' (PAT) rules should be tested at the specified intervals.

Tower and antenna support
The safety equipment for climbing should be checked yearly or as designated by the manufacturer.

Every 5 years (depending on national building and construction law) a specialist should inspect the tower construction for rust, loose screws; faulty rivets etc and issue any appropriate certificates.

Security systems
The security systems such as intruder prevention devices, fire alarm indicator, heat controller, etc. should be checked yearly.

Air condition
Quite often it is cheaper to outsource the check and the maintenance of the air condition. If not then at least the filters have to be cleaned and the water connections should be checked yearly.

Environment
General maintenance activities such as cutting the lawn, fixing fences or repairing access roads are tasks which should be outsourced if possible. A local 'gate-keeper' is a good way of collecting information regarding the status of several environmental items. This could be the site owner, building manager, local contact or a friendly neighbour

Maintenance schedule
The routine maintenance requirements related to the equipment and remote building will vary depending on the type and construction of the site along with the equipment installed.

The following table gives a broad indication of the type of checks which should be performed:

Equipment	**Interval**	**Calibration y/n**	**Internal staff y/n**
Receivers	Yearly	Yes	no
DF	Yearly	Yes	no
Computer	Yearly	No	yes
Tower	Visible yearly, professional check every 5 years	No	No
Painting of tower	As required	no	No
Tower 'safe to climb' certificate	As required by national law	no	No
Antennas including cables/connectors	Visible yearly, professional check every 5 years	Measure at yearly site check	Yes, only for cables and connectors, antennas in tower to be checked by external contractor.
Alarms	Yearly	No	No
Air conditioning	Every 6 months	No	No
Emergency power supply	Every 6 months	No	No
Building	Visible yearly, professional check every 5 years	No	
Fencing / road / environment /weed control	As required	No	Local contact person

ANNEX 9: DECOMMISSIONING

End of life

A site can reach the end of its life for many reasons including:

- the lease for the building/site has expired
- either party has invoked the lease break clause
- the sites usefulness has reduced perhaps due to other priorities
- a huge increase of the radio noise (industry and radio activity development) which prevents meaningful measurement

Leaving the site

It is usual that a clause in the initial lease requires the land to be restored to its original condition when the Administration vacates the site. This can be a very expensive undertaking therefore it is worth exploring several mutually agreeable alternatives before going down this route.

The easiest, cheapest and by far the best way to vacate a site is to 'pass on' the site to the land owner once the Administrations equipment has been removed. The Land owner would take over the ownership of the site and would be free to use it for any purpose. This would be on the understanding that the land owner is also taking over all responsibility for the site and that the Administration is no longer responsible for any element.

A fallback position would be to remove the mast and pass ownership of the building/cabin to the land owner for storage or other use.

If the land owner insists on the land being fully returned to its original state then the following processes will need to be followed:

- remove all user equipment from the site
- dismantle mast and remove from the premises
- take away any equipment cabins etc
- remove concrete base for cabin and tower
- performing any repairs to existing buildings to owners satisfaction
- remove fences and/or other security measures
- ground landscaping (pave/concrete, tarmac, grass etc)
- de-contaminate ground (copper feeders/earth mats under the ground etc)

Electronic equipment – For ageing equipment, the recycling of the electronic equipment should be performed according to the electrical and electronic waste European directive 2002/96/CE of the 27th of January 2003. Equipment records should be updated noting this disposal. If the monitoring equipment will be reused on another site, the removal, transport and the new installation (or storage location) can be planned. The transportation of equipment should be undertaken in suitable packaging and additional insurance may be taken out.

Antenna system - Special care is required for antennas and especially for Direction Finding antennas due to the size and the weight of all elements and the need to use a crane for this task.

Technical infrastructure – This involves the removal of items such as equipment racks, power supplies, cables, air condition units, electrical source and communications devices from the site.

Once these have been removed or disconnected the fixtures of the site can be dismantled including the mast, building, fencing which can be undertaken in a number of ways:
Whole package - The whole removal management process can be awarded to an external company to perform all the required tasks. This option is costly but has the advantage of only requiring a small amount of in-house resource to confirm that the process is running smoothly.

Outsource as packages - The advantage of this solution is to entrust different tasks to different companies whilst performing some smaller tasks using internal staff.

Cancel all contracts
When the decision has been made to vacate a site, all Legal and Service contracts in force should be terminated. These include:

- Lease (including any financial compensation that may be due)
- Rent
- Rates
- Energy
- Communications
- Water
- Maintenance arrangements (security etc)
- Insurance arrangements (public liability etc)
- All other arrangements made during construction (alarms etc)
- Any restrictions against building or transmitters should be removed.

[End of Annexes]