

# **The GCS Monitoring System. An Overview.**

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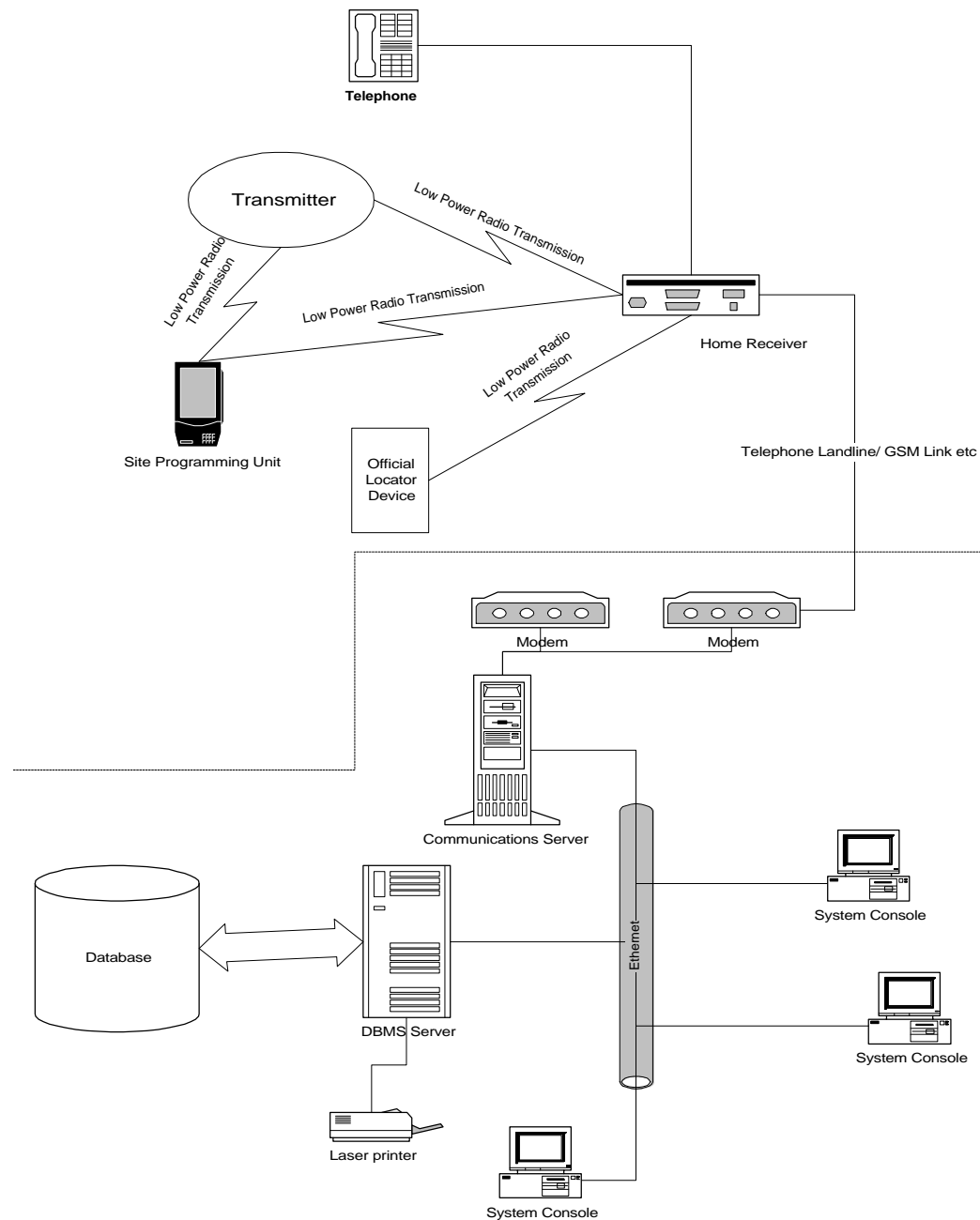
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## 2 Introduction.

The offender monitoring system has a simple task to perform. It must allow an enforcement agency to verify that a court-imposed curfew is being observed.

As much of the day to day running of the monitoring must be automated. This allows the minimum of agency intervention with the offender and keeps the agency staff at a central monitoring site down to a minimum. All these factors keep the cost of providing the service to a minimum.

A typical system is shown in fig 1.



**Fig 1.**

Fig 1 shows a typical configuration of equipment for monitoring an offender at a single place of curfew.

Other configurations need to be catered for in the design of the system.

The site-programming unit is now called a Hand Held Unit.  
The Home Receiver is now called a Monitoring Unit.

### 3 General System Requirements.

The system must meet the following requirements.

**The system must be able to curfew multiple offenders at a single site.**

This allows bail hostels or halfway houses to be used for tagging of early release prisoners, also it is not unheard of to have two members of the same household under a curfew order.

**The system must be able to curfew single offenders at multiple sites.**

This allows offenders to be under a curfew order that enforces attendance to a drug rehabilitation unit etc.

The two requirements above show that there is a many too many relationship between the curfew, site and offender.

**The system must allow exclusion orders to be placed on offenders.**

In the United States exclusion orders are quite often placed on husbands who beat their partners. It is conceivable that a wife could be subject to a curfew order and the husband subject to an exclusion order AND curfew order at his place of residence.

In this case the home unit in the wife's house is managing two transmitters. One with an exclusion order placed on it and one with a curfew order placed on it. The husband's home unit is managing the husband's transmitter with a curfew order.

**The system must report any tampering with the agency equipment.**

Any unauthorized tampering with any of the agency equipment must be reported as soon as possible. The offender transmitter should check that the strap is intact and has not currently being, or has been, tampered with. A skin proximity check should also be carried out to ensure that if the device is removed, then this should be reported.

The home unit should report any interruption of the mains supply as this could indicate that an extension lead or portable supply is being connected. If the unit is supplied with a low voltage AC supply this makes it much more difficult to splice into the supply feed.

Motion sensors should report any movement of the unit.

Checks should be made to ensure that the antennae are connected and not removed.

Attempts to 'jam' the radios should also be detected.

The home unit should be able to check to see that the radio signals received are not recording's that are being played back.

A dial back to the central site should occur at regular intervals to make sure that the equipment is at the site.

The system should have a radio range sufficient to cover most dwellings.

**The system must able to store events if the communication link fails.**

Most units on the market can store several thousand events.

**The system should store curfew/exclusion order information locally.**

By storing the curfew data locally, the number of phone calls is reduced to a minimum as only the exceptions are reported.

**The system should operate for a periods of time if site power fails.**

The home unit should be able to operate for at least 24 hours if the power fails.

The system should be able to report the arrival and departure time of agency officials.  
The ability to record the arrival and departure times of the agency officials could prove invaluable in court proceedings.

The system should encrypt all data that is transmitted between various components of the system.  
This is for security reasons. It should be impossible for people to simulate any part of the system.

The system should perform self test functions and where possible aid in the diagnosis of faults and production testing.  
If the units can diagnose and, wherever possible, report these faults, agency confidence will increase.  
If, with the aid of automated diagnostic and test software, complete system test can be performed in a short time, production costs will be reduced.

## 4 System Components.

The requirements detailed above allow the system components to be identified.  
To meet the above requirements five main components can be identified.

### 4.1 The offender transmitter(PID).

This is the device that is worn by the offender. This device transmits a signal at regular intervals containing a unique identification number and current status information.

### 4.2 The Monitoring Unit.

This unit reports on the state of the transmitters that it is monitoring. It also checks to see that no tampering is taking place with the radios and the unit itself. The arrival and departure times of agency officials is also reported by monitoring the official transmitters.

### 4.3 The Hand Held Unit.

This unit is used to help the officials in the field install and configure the equipment. Range settings can be determined by making a radio survey with this unit and the home receiver unit. The transmitter devices can also be configured with this device. The unit can act as a roaming receiver to enable agency staff to verify the location of an offender.

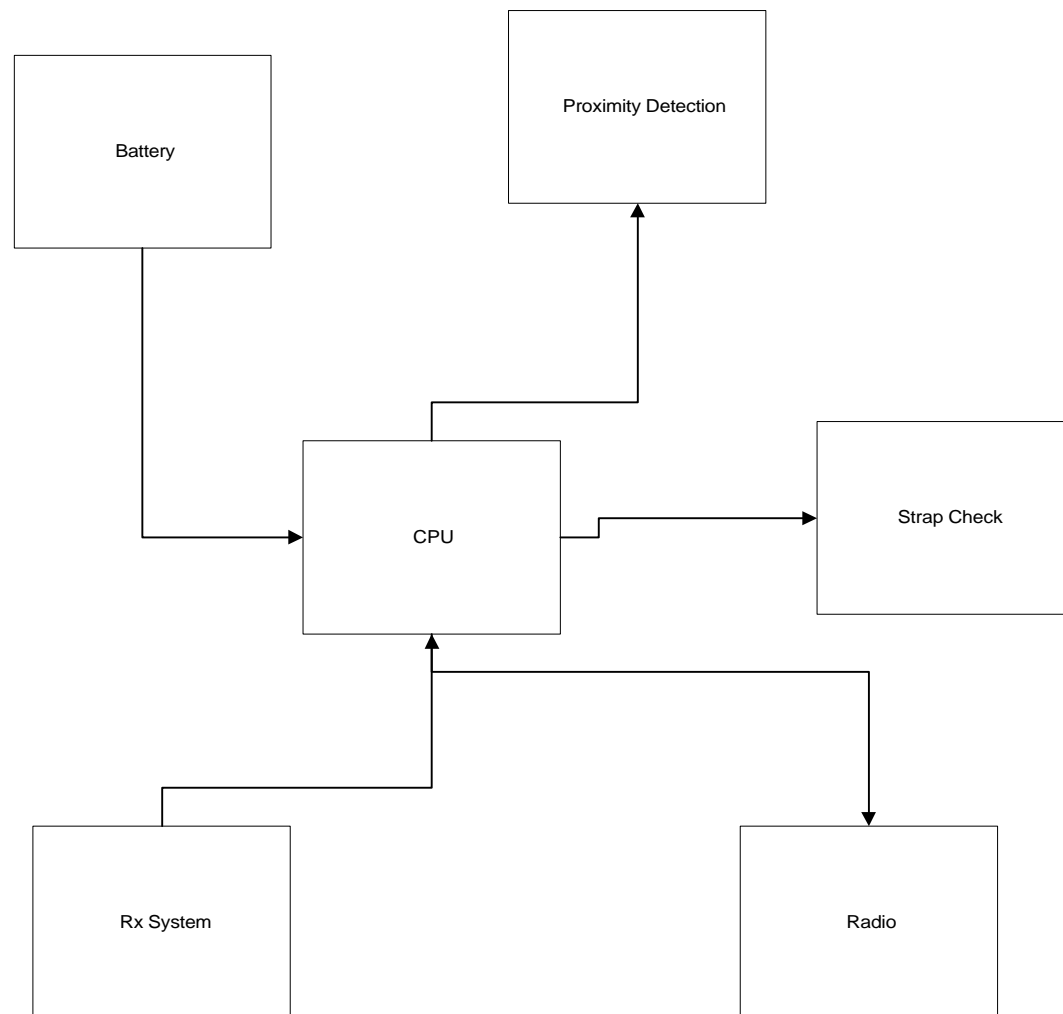
### 4.4 The central site system.

The central site system is a complex database system that manages the curfew information, remote reporting and agency requirements to provide curfew violation reports and system status reports. The exact nature of the system is dependent on agency requirements.

## 5 The Transmitter Unit.

The function of the transmitter unit is to report, at regular intervals its status. This allows the system to determine whether an offender is present, which offender it is and the condition of the transmitter.

The transmitter unit consists of seven major components. Six of these components are internal to the case.



**Fig 2. The Transmitter Unit.**

### 5.1 Battery.

The battery for the offender transmitter unit is capable of operating the unit for at least 12-18 months in normal use. Small lithium coin cells are used for this task. (CR2036). Two of these cells give a 6V supply.

### 5.2 Central Processor (CPU).

An atmel 8535 running at 1mhz is used as the cpu. This family has a wide operating voltage (2.5-6.0V) and uses little current in standby, it is cheap and has a small footprint. A low power 32khz oscillator is used to wake the device from sleep mode once a second.

### 5.3 The Receive Port.

The receive port enables the transmitter unit to be configured by the Hand Held Unit. This is a simple IR phototransistor. The baud rate used is 2400bps

### 5.4 The Radio Link.

All outgoing data is sent using the radio link.

A small loop antenna is used.

Outgoing data is sent at 7000bps

### 5.5 Strap Check.

Three tamper mechanisms are used to verify the integrity of the strap.

#### 5.5.1 Switch Tamper.

The switch tamper is activated when the sizing plate is moved away from the strap with switch in it. As this can only happen when the main clip has been removed, this indicates the unit has been interfered with.

#### 5.5.2 Proximity Check.

The proximity works by checking the capacitance between the two straps. When the value changes, the Transmitter checks for other tampers.

#### 5.5.3 Continuity Tamper.

When the strap is physically cut the continuity tamper is activated.

### 5.6 Strap And Case.

The case is a cheap injection moulded item. This enables the units to become a cheap throwaway/refurbishable item.

The two sections of the case are bonded together using ultrasonic welding. The strap requires no tools to fit.

The transmitter is waterproof to a depth of 5M.

### 5.7 Data Transmission.

A single transmission of data occurs every 60 seconds. The data burst lasts for about 30ms

#### 5.7.1 Data Content.

The content of the message includes the following.

Identification

Status

#### 5.7.2 Identification.

The identification component is a unique id. This will identify the transmitter to the monitoring unit.

#### 5.7.3 Status.

The status bits give an indication of the current and past status. All status bits have an active flag and a latch flag. Devices could be tampered when they are out of range of the monitoring unit.

### 5.8 Modes Of Operation.

There should be at least four modes of operation.

Sleep



Normal

### **5.9 Sleep Mode.**

Sleep mode is an inactive state where no checks or transmissions take place. This mode is the normal storage mode and requires the minimum of battery power.

### **5.10 Normal Mode.**

Normal mode is normal operating mode of the device when fitted to an offender.

The device will transmit once approximately every 60 seconds.

The tamper devices will be checked once approximately every second.

If a change of state is detected then the unit will transmit immediately.

## **6 The Monitoring Unit.**

A block diagram of a Monitoring Unit is shown in fig 3.

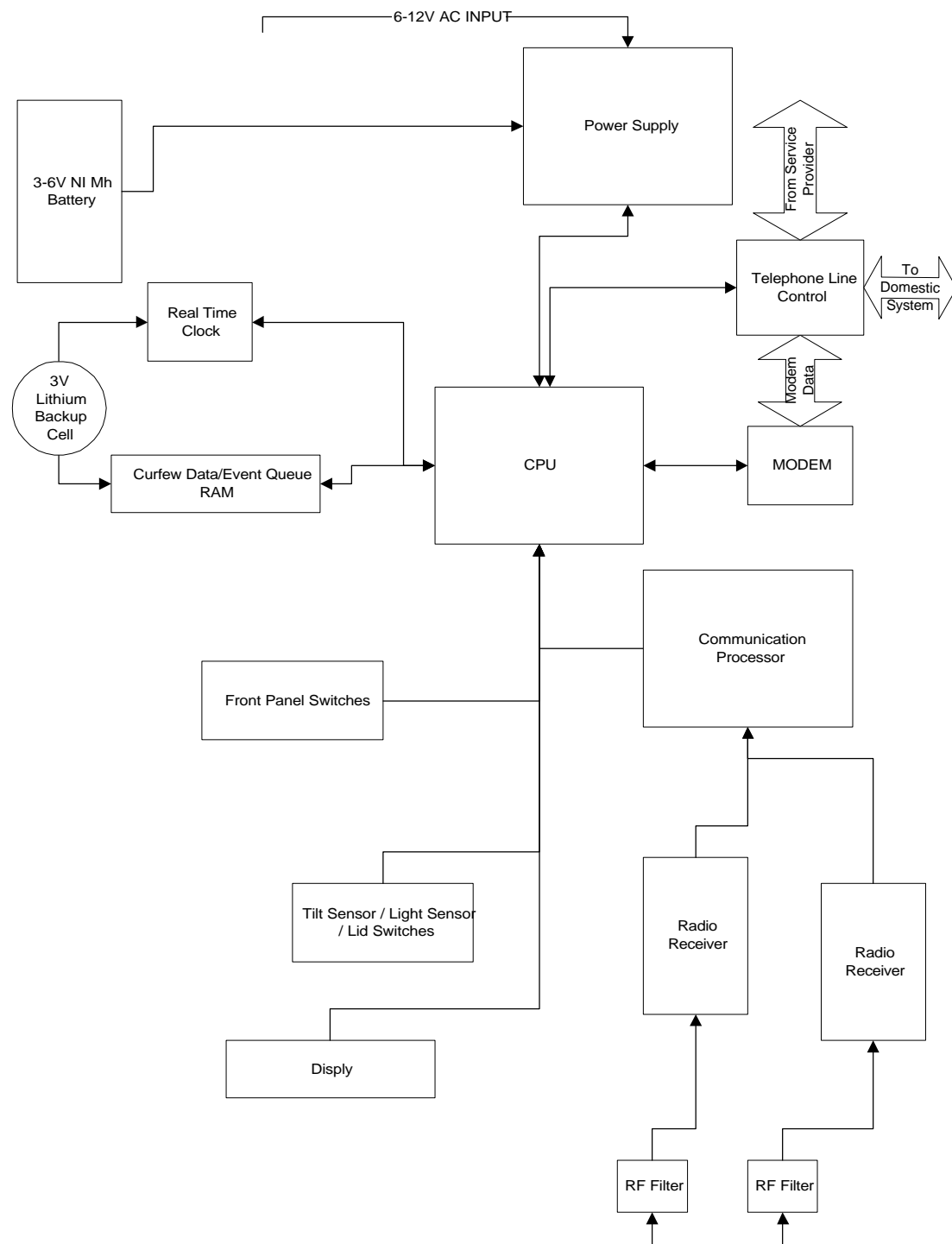


Fig 3.

The monitoring unit a number of functions that it performs.

Curfew checking and exclusion orders are be verified by checking arrival and departures against details stored in the battery backed RAM. This information is down loaded from the central site via the modem.

When an exception is detected, such as an unauthorised absence, a report is be made to the central site. This is done via the modem.

## 6.1 Central Processing Unit.

The main cpu is an Atmel AT103Mega. This has a 6Mhz clock.

## 6.2 Power Supply.

The power supply is able to use a wide range of supply types. An input voltage range of 9-14 AC/DC is used. The external power supply used is a US approved item

The on board power supply system has to supply numerous sub systems. By careful design most of these operate on a single supply of 5V.

The control of the power supply when the unit is running from the battery should be under processor control. This allows the graceful shutdown of the unit when the battery becomes exhausted.

The power supply should also be able to charge the on-board battery. This is under processor control, as the charge current and battery temperature need to be controlled. Ie switch to a trickle current.

## 6.3 Main Battery.

The main standby battery is able to run the unit for at least 24 hours.

The cells used are of nickel metal hydride type. The single pack is a 6v pack and has a capacity of 8Ah.

## 6.4 Back-up Battery.

The back-up battery is a simple lithium coin cell. The back-up battery maintains the data in the battery backed RAM and real time clock.

The cell used is a CR2036.

The battery is protected from reverse currents.

## 6.5 Real Time Clock.

The real time clock is used to maintain the accuracy of the internal clock when the unit powers down. It is updated every time the unit connects to the central site. The unit is driven by a low power watch crystal this runs at 32KHz.

## 6.6 Battery Backed RAM.

The battery-backed ram is used to store the curfew/exclusion data and the event list.

## 6.7 Modem.

The modem is used for all communications with the central site.

## 6.8 Telephone Line Control.

The receiver is able to control the connection of the household phones to the telecommunications network. There are two pairs of wires on most standard networks.

## 6.9 Radio Receivers.

The unit has two radio receivers fitted. This allows a degree of redundancy in the unit. The radios detect when the antennae are being tampered with and when a fixed carrier signal is being received ie jamming.

Signal strength is also available to give a degree of range estimation.

A separate CPU is used to decode the data on the radio links.

A single PIC17C756TQFP is used. This has a crystal of 4 MHz attached to it.

## 6.10 Programmer Communications Ports.

A communications port is provided for configuration data to be loaded into the home receiver from the hand held unit. An irda link is used. The UART uses a 3.6864MHZ crystal.

## 6.11 Extension Link.

A receive link on the power connector enables intelligent devices to be cascaded with the receiver unit. External battery boxes etc can be added to the system.

## 6.12 Event Reporting.

There are a number of events that are reported

Transmitter Events.

Curfew order events.

Start of unauthorised absence.

End of unauthorised absence.

Offender arrived outside curfew but was absent at end of curfew.

Exclusion order events.

Exclusion order transmitter is within range.

Exclusion order transmitter has gone out of range.

Official transmitter events.

Official transmitter is present at the receiver location.

Official transmitter has left the receiver location.

Official transmitter device has been panicked.

All devices

Status has changed.

Unexpected change in message number.

Home Receiver Events.

External Power Off.

External Power On.

Main battery flat.

Powered up ok.

Unexpected or abnormal restart.

Radio 1 antenna has been disconnected.

Radio 1 antenna has been connected.

Radio 1 has been jammed.

Radio 1 is not jammed.

Radio 1 receiver fail.

Radio 1 receiver ok.

Radio 2 antenna has been disconnected.

Radio 2 antenna has been connected.

Radio 2 has been jammed.

Radio 2 is not jammed.

Radio 2 receiver fail.

Radio 2 receiver ok.

Case has been opened.

Case has been closed.

Light has been detected in the case.

Light has not been detected in the case.

Movement detected.

Movement stopped.

System fault detected (includes 32 bit code)

RAM Failure.

Real time clock failure.

Modem failure.

RAM CRC fails on power up.

Power rail fail?

Call back verification failed.

## 7 Hand Held Unit

The Site Programming Unit is a multi function device. It has 3 main functions.

Offender Transmitter Configuration.

Home Receiver Configuration.

Portable Receiver & Logger.

The main processing unit should be based upon a commercially available, hand held terminal. A adaptor containing an infrared link, radio receiver and inductive coupler will need to be manufactured.

### 7.1 Radio Receiver.

The radio receiver should be a commercially available module approved for use in the given country.

### 7.2 Infrared Link.

An infrared link that conforms to the Irda standard would result in a high speed and robust infrared link.

#### 7.2.1 Offender Transmitter Configuration.

The unit should be able to change the mode and reset the status of the offender transmitter.

It should be possible to retrieve the identification number, the version number and the battery condition of the offender transmitter device.

#### 7.2.2 Home Receiver Configuration.

The unit should be able to configure the phone line type ie shared or agency line, pulse or tone dial.

It should be possible to enter list of phone numbers to dial to perform event reporting, call centre voice communication and emergency service calls.

It should be possible to enter list of acceptable phone numbers for incoming voice calls. This feature would only be used on dedicated lines with caller ID.

The call centre data line numbers should also be considerable on lines equipped with caller ID.

#### 7.2.3 Portable Receiver & Logger.

The unit should also be able to receive all transmitter types for logging and verification purposes.

The unit should be capable of logging 5000 events.

### 7.3 Hardware.

The hardware is essentially the same as the Monitoring Unit.

## 8 The Central Site System.

The central site is a complex database and event reporting system. Many aspects of the operation of the system are customer dependent.

For testing purposes only a minimal system is required.

If Windows NT4.x is used then the Telephony Application Interface (TAPI) can be used to control the modems that are used for communications with the home receiver units.

A database of events, curfews, equipment status information and changes made to any of the above must be maintained.

A facility to enter new offenders and there associated curfews and equipment usage must be provided

## 9 Oscillators Used.

This section lists all oscillators used in the system.

### 9.1 Offender Transmitter.

1Mhz clock for Atmel 8535L CPU. Active for about 6ms/second.  
32khz Low power clock crystal. Active continuously.

### 9.2 Monitoring Unit.

6Mhz Atmel AT103Mega.  
4Mhz PIC 17C756TQFP Radio processor.

2 \* 3.6864 Uart baud rate generator crystals.  
4.096Mhz Modem CPU Oscillator.  
32.768Khz Low power oscillator for real time clock.

### 9.3 Hand Held Unit.

6Mhz Atmel AT103Megga.  
4Mhz PIC 17C756TQFP Radio processor.  
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