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The HIPROTECT System

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HIPROTECT (pronounced High-protect) is a system designed to protect national archaeological and natural treasures from destruction by vandals or looters. The system is being developed jointly by the Lawrence Livermore National Laboratory and the University of California at Riverside under the DOD Legacy Resource Management Program.

Thousands of archaeological sites are located on military bases and national park lands. Treasure hunters or vandals are pillaging and destroying these sites at will, since the sites are generally located in remote areas, unattended and unprotected. The HIPROTECT system is designed to detect trespassers at the protected sites and to alert park officials or military officials of intrusions. An array of sensors is used to detect trespassers. The sensors are triggered when a person or vehicle approaches the site. Alarm messages are transmitted to alert park officials or law enforcement officials by way of a cellular telephone link. A video and audio system is included to assist the officials in verifying that an intrusion has occurred and to allow two-way communication with the intruders.

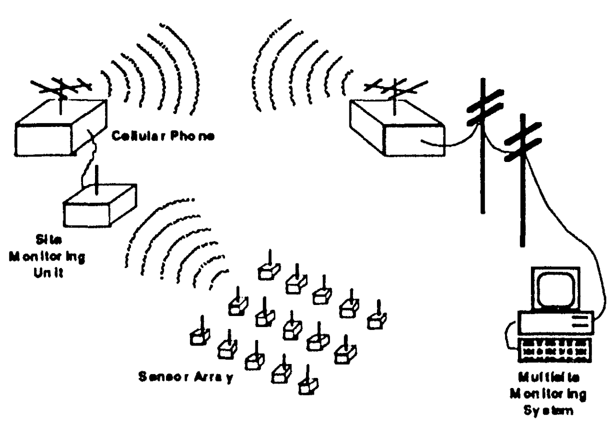

Fig 1. Overall System

The system consists of four main subsystems: the array of intelligent wireless low power sensors, a central monitoring unit, the cellular telephone link and the alarm and control system at the park or base headquarters. Fig 1 shows the overall system. Only one site is shown but the Multisite Monitoring System can handle alarms from multiple sites.

At a typical site, the sensor array will consist of approximately ten to twelve sensor modules deployed over an area of roughly 10,000 to 40,000 square feet. The sensors will be disguised or camouflaged and deployed strategically to detect persons walking or driving to the site. A birds-eye view of a fictitious site with a "Designated Protected Element," a pictograph, and a possible array of sensors is shown in Fig 2.

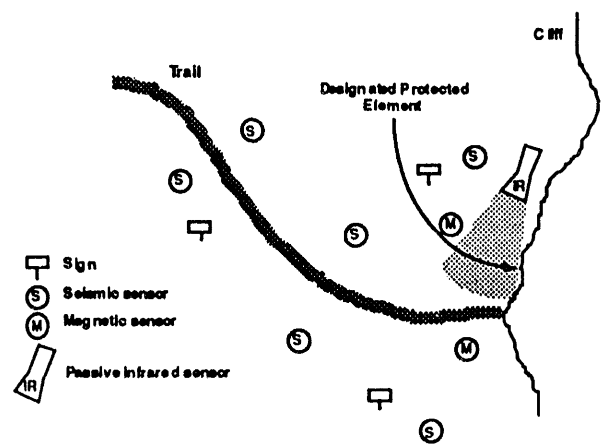

Fig. 2. Bird's-Eye View of Possible Sensor Array

The typical site would have a trail leading to the site of the protected element, perhaps a pictograph or a burial site. Signs posted along the trail and near the protected element will warn visitors that the site is protected by a surveillance system. Sensor units along the trail or other routes to the site will detect persons and vehicles approaching the protected element.

Sensor Units

Three different types of sensors are used to detect persons approaching the site: seismic or geophone sensors, directional magnetic sensors and directional passive infrared

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sensors. Persons walking or driving to the site or digging at the site will cause vibrations in the ground that will be detected by the seismic sensors. The magnetic sensors will detect steel or iron tools and vehicles, motorcycles or bicycles. The passive infrared sensors detect persons or vehicles by the difference in temperature of the person or object compared to the surroundings.

Each of the sensor units includes the detector, a microcomputer, a low power radio transceiver and a battery pack. The microcomputers provide the intelligence to the sensor unit that determines the type of intrusion. For example, the seismic sensor provides a signature of the ground vibrations that will be analyzed by the microcomputer to determine if the disturbance was caused by a vehicle or perhaps one or more persons walking to the site. Digging and hammering can also be detected. In the two-axis, directional magnetic sensor unit, the microcomputer will analyze the magnetometer signals to determine the direction the object was moving and estimate the size of the magnetic disturbance. Each channel of the magnetometer produces a large signal for vehicles and correspondingly smaller signals for motorcycles, bicycles and steel tools or weapons. No size information, only directional, is obtained from analysis of the passive infrared sensor system. The radio transceiver communicates alarm messages to the Site Monitoring Unit (SMU). The SMU relays the alarm messages to the headquartersMultisite Monitoring System by way of the cellular telephone link.

Figure 3 depicts the seismic sensor showing the geophone and the microcomputer, amplifier and radio interface printed circuit boards in a rectangular 4" x 5" x 6" watertight polycarbonate housing. The transceiver is housed in a separate watertight polycarbonate housing to minimize radio frequency interference (RFI) from the microcomputer module. The sensor system polycarbonate housing is coated on the inside surfaces with a conductive paint to minimize RFI. When deployed at the protected site, the sensor units will be disguised in an artificial rock or some other means to blend in with the site environment.

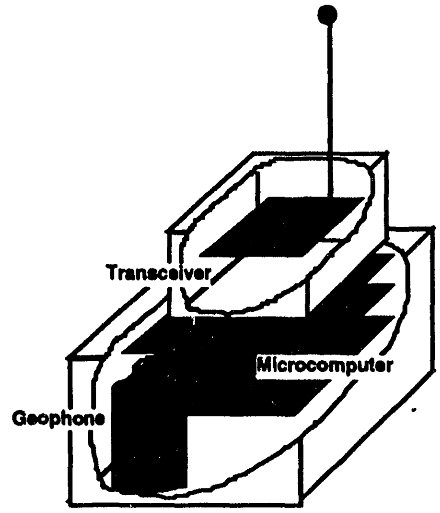

Fig 3. Cutaway View of the Seismic Sensor

The sensor microcomputer module uses a Philips/Signetics 87C552 CMOS microcontroller to acquire and process the sensor data. The 87C552 is a derivative of the 8051 microcontroller with the addition of an 8 channel 10-bit analog-to-digital converter (ADC). A 32K byte EPROM is used for program storage and a 32K -byte static RAM is used for temporary data storage. A clock/calendar IC is also included. To conserve battery power, the microcontroller is normally be in a sleep mode, powered up but not running and consuming only a few microwatts of power.
Sensor interrupts, radio transceiver interrupts and clock/calendar alarms cause a reset to restart the microcontroller from the sleep mode. When the sensor signal is detected, the micrococontroller is awakened to acquire and process the sensor data and to send an alarm message if appropriate. The microcomputer is programmed in the C language.

Very low power CMOS operational amplifiers are used in the two-channel programmable gain sensor amplifiers. They have a bandwidth of approximately 0.2 Hz to 79 Hz. The amplifier gain is programmable from 1 to 10,000 in a 1, 3, 10 sequence by way of DIP switches. A low-power DC regulator is included on the amplifier module. It provides regulated five volt power from the seven volt battery pack.

The geophone used in the seismic sensor and the directional passive infrared detector are commercially available high-sensitivity devices commonly used in security systems. However, the magnetic sensor is an LLNL developed very low power high sensitivity directional magnetometer. It is a pulsed "flux-gate" type device with a sensitivity of 0.1 gamma.

When triggered, the sensors communicate alarm messages to the central SMU system by way of the low-power RF transceivers. Wireless RF data communication was required to eliminate any need for cables and associated trenches. In order to conserve battery power, the transceivers are normally turned off. When the sensor is triggered, the microcomputer awakens, analyzes the sensor data, powers up the transceiver and transmits the alarm information to the SMU. The transceivers are digital communication units, operating at 2400 baud in a half-duplex mode.

Each of the sensor units are powered by a long-life seven-volt battery pack. Because of the power conservation techniques mentioned above, the battery pack lifetime is more than one year.

<u>Site Monitoring Unit (SMU)</u>

The Site Monitoring Unit (SMU) is the central hub of the site monitoring system. The SMU receives intrusion alarms from the sensor modules and communicates through a cellular telephone link with the Multisite Monitoring System located at the park or base headquarters. The SMU relays the sensor alarm messages. A microcomputer is included in the SMU, programmed to analyze the sensor messages in order to make a judgment of the type of intrusion such as person walking with or without tools, person driving a vehicle, etc. A law enforcement official at the headquarters, alerted to the intrusion, can display a sensor map of the protected site on a monitor screen to determine which of the sensors were triggered. The official can then command a video camera in the SMU system to transmit images of the intruders at the protected site. The video system sends images in a "freeze-frame" mode at a rate of five images per minute. Also, an audio channel can be opened to communicate with the persons at the site to determine their intent and to warn the intruders not to disturb the site. Communication with the video and audio systems is also by way of the cellular telephone link. In locations where the cellular system coverage is sparse, a cellular repeater can be employed to extend the communication range between the protected site and the headquarters.

The SMU consists of a central microcomputer, a low-power RF transceiver, a video subsystem, an audio communication channel, the cellular telephone subsystem with a modem for data communication and a solar panel/battery power unit. The RF transceiver receives the sensor alarm messages and passes them on to the microcomputer for analysis and retransmission through the cellular telephone system. The video system uses sensitive, low-power, low-cost commercially available video cameras connected through a video multiplexer. An infrared light source is used for illumination at night. Freeze-frame video images at the rate of five images per minute are transmitted through the cellular telephone link back to the headquarters monitoring system upon command. Normally, to save power and telephone system costs the video system is powered down. When an officer at the headquarters site requests video images from the protected site, the video system is powered up and video transmissions are begun. At the same time, an audio communication channel is opened to permit two-way communication with persons at the site.

The microcomputer used in the SMU unit is similar to that used in the sensors except for modifications required to communicate with the cellular telephone module and for triggering the video system. It includes the microcomputer module, the radio interface module and the amplifier module with the low-power 5V regulator.

Power for the SMU is provided by a lead-acid battery pack recharged by a solar panel. The SMU will be disguised and installed up to 200 feet from the sensor array.

Multisite Monitoring System (MMS)

The Multisite Monitoring System (MMS) is the command and monitoring station for the HIPROTECT system normally located at a base or park headquarters. By way of the cellular telephone link, the MMS receives intrusion alarm data messages from the multiple protected sites. When alarm messages are received at the MMS, the officer on duty is alerted by an audio tone. Icons of the triggered site sensors are displayed on the MMS computer screen, giving the officer a view of the triggered sensors in a site map. The officer can command the video system to begin sending freeze-frame images from the protected site to be displayed on a video monitor and recorded. Also the officer can open an audio communication channel to talk with the trespassers and warn them not to disturb the site. Command and control of the video and audio system at the protected site are also by way of the cellular telephone circuit. Depending on the number of intrusions at each site, one Multisite Monitoring System can handle the alarm signals from ten or more remote protected sites.

The MMS consists of an IBM compatible PC computer system along with a video display system and an audio communication system. Video and audio recorders will record freeze-frame video images and audio communications from the site.

Other Potential HIPROTECT Applications

The HIPROTECT system with its low-power wireless intelligent sensors and cellular communication system has many other possible applications. The system can detect persons walking or bicycle, motorcycle and automobile traffic. Direction of traffic is indicated by the passive infrared sensors and the magnetic sensors. Because the sensors require no wires to interconnect them to the central communication system they can easily be deployed. In addition, the sensors are low-power modules resulting in a long battery lifetime.

Obvious applications are intrusion monitoring in the protection of outlying facilities for commercial organizations or for residential security.

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