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Wide area continuous offender monitoring

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ABSTRACT

The corrections system in the U.S. is supervising over five million offenders. This number is rising fast and so are the direct and indirect costs to society. To improve supervision and reduce the cost of parole and probation, first generation home arrest systems were introduced in 1987. While these systems proved to be helpful to the corrections system, their scope is rather limited because they only cover an offender at a single location and provide only a partial time coverage. To correct the limitations of first-generation systems, second-generation wide area continuous electronic offender monitoring systems, designed to monitor the offender at all times and locations, are now on the drawing board. These systems use radio frequency location technology to track the position of offenders. The challenge for this technology is the development of reliable personal locator devices that are small, lightweight, with long operational battery life, and indoors/outdoors accuracy of 100 meters or less. At the center of a second-generation system is a database that specifies the offender's home, workplace, commute, and time the offender should be found in each. The database could also define areas from which the offender is excluded. To test compliance, the system would compare the observed coordinates of the offender with the stored location for a given time interval. Database logfiles will also enable law enforcement to determine if a monitored offender was present at a crime scene and thus include or exclude the offender as a potential suspect.

KEYWORDS: house arrest, parole, probation, positioning

1. INTRODUCTION

It is estimated that crime contributes $425 billion annual direct and indirect costs to the US economy[1]. $90 billion of the amount is a direct cost to the criminal justice system. Today, the number of offenders on parole and probation exceeds 4,000,000, and their number in correctional facilities and jails is over 1,000,000. Police and Sheriff departments employ nearly 840,000, and corrections employ approximately 400,000. From 1985 to 1990 crime increased by 31.4% while the number of incarcerations increased by 60%. During that same time, research and development in the criminal justice system and law enforcement declined by 19%.

The number of inmates incarcerated in 1993 was 1,373,000. Of these, 923,000 were in state and Federal correctional facilities, a doubling in 10 years, while 450,000 were in local jails, a tripling in 10 years. Approximately 4 million offenders today are in the parole or probation system.

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DISCLAIMER

The correctional system is a significant cost component of the criminal justice system. For example, the cost of maximum-security correctional facilities in the United States is now approaching $75,000 per inmate per year, with an initial investment of $100,000 for a single correctional facility cell infrastructure. The city and county jails now average $18,000 per year for each inmate sentenced for a misdemeanor or awaiting trial on charges. Overall, disregarding the cost of prison construction, the average cost per inmate per year in the United States is $23,500. Building new correctional facilities and maintaining inmates costs $21 billion per year. Since 1970, over $42 billion has been spent on building correctional facilities. The questions are: Can we afford this massive expansion of correctional facilities? Are there less expensive alternatives for those who pose less danger to society? Department of Justice and FBI statistics indicate an ongoing pattern of 5 percent of criminal felons being responsible for 80 percent of all crimes committed.

Although much attention is given to the staggering growth of prison populations, a full eighty percent (80%) of the offenders within the criminal justice system are supervised outside of the prison walls. It is usually the probation and parole agencies that are saddled with this awesome responsibility. Despite this, only a small fraction of corrections budgets ever finds its way to probation and parole agencies. However, a growing number of progressive administrators who believe that by investing in more specialized community based programs and by developing new technology[2], a significant boost in public safety and offender rehabilitation can occur. Also, by implementing these ideas, even more of the incarcerated offenders could be safely moved to a more cost effective community setting.

Some innovative programming has already emerged. Traditional probation and parole services over the years had been limited to officers who provide supervision to offenders by meeting with them in an office setting and occasionally in the field. Assistance in locating appropriate counseling and employment have always been provided by the probation and parole offices. However, the times have changed, and many new challenges have surfaced. The emergence of insidious drugs, such as crack cocaine, the proliferation of violent street gangs and the escalation of weapons on the street have caused administrators to rethink the way offenders in the community should be supervised. Community Corrections, Intensive Supervision, and Electronic Monitoring are examples of programs that have been developed to address these concerns. These innovative programs all attempt to make the offender more accountable for his actions, to provide increased services to the offender, and to protect the safety and well-being of the community.

Despite the renaissance of technology during the second half of this century, there has only been one significant technological advancement which has been applied to supervising criminals. In the 1970's a New Mexico judge, Jack Love, conceived the idea of attaching an electronic transmitter to an offender's leg and placing a receiver in the offender's home[3]. His entering and leaving the residence could be monitored by linking the receiver to a central computer via a standard phone line. With this data, probation and parole authorities can schedule and enforce curfews and house arrests.

This infusion of technology into the traditionally low-tech world of probation and parole was met with great enthusiasm. Lower risk inmates could safely be moved to a much less expensive house arrest setting. Also, an intermediate sanction for probation and parole violators was created. Technical violators could now be tethered with a bracelet rather than being sent to prison.

Although this technology has been a giant step forward in corrections, there are many inherent limitations to the system. Probation and parole officers would know, for example, that an offender had an approved leave from his residence to go to work, but that officer would have no idea if he actually went to the job site. Because of problems like this, the idea of a second generation electronic "tracking" system emerged. Officers needed more information about offender location than the first generation system provided. By developing a system that would continuously monitor the location of offenders over a wide metropolitan area, officers could greatly enhance their ability to account for and control the activities of the offenders under their supervision.

2. FIRST GENERATION SYSTEMS

Since 1986, the U.S. criminal justice system has been expanding its use of electronic bracelets to keep offenders under house arrest. First Generation systems, known also as house arrest systems, help verify compliance of the offender with the parole and probation curfew directives. The system is comprised of a radio transmitter connected via a telephone modem to a central receiving station. The transmitter is attached to an offender's ankle and sends signals to a receiver that is connected to the telephone. When the transmitter goes out of a 45-meter range, which usually implies that the subject left the residence, the receiver sends an alert over the phone lines to the central station. Upon receiving the signal, the central station queries its data base to determine whether the offender was permitted to leave his or residence at that time.

More than 70,000 such systems are in use in the US. Although their application is growing, as shown in figure 1, first generation house-arrest systems have serious limitations. For example, once an offender leaves the monitored residence, verification of his or her movements is intermittent at best. Periodic checks on the subject at his or her work-site and therapy group are typically made by a parole officer, but do not account for an individual's whereabouts at other times. The officer is also burdened by the time and travel needed to monitor clients in the field. Given the inadequate verification of their location and a discontinuous monitoring schedule, the offenders may choose to violate their parole or probation directives.

3. SECOND GENERATION SYSTEMS

Second generation systems are currently being considered as a significant enhancement of first generation systems. Much work, however, remains to be done to determine the actual requirements and design the eventual systems. The ability to track the offender at any time and any place over a wide geographic area distinguishes second-generation monitoring systems[4] from the present setups. Second-generation systems would continuously monitor the offender outdoors, indoors, and in motor vehicles with about the reliability of the current cellular telephone communication system.

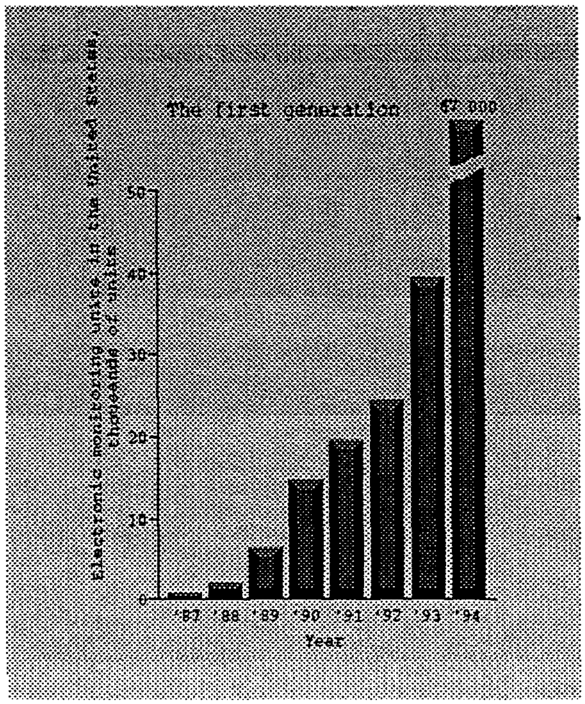

Figure 1. The growth of first-generation monitoring units in use in the United States since 1986 (© IEEE 1995).

In the following paragraphs, we will discuss various requirements that may apply to specify these systems. A thorough requirements analysis has yet to be funded. Yet, it is considered an essential step in order to develop systems that meet national needs. Such a requirements analysis is a significant undertaking in its own right. Therefore, caution should be exercised in examining the following hypothetical requirements.

For example, these systems should be able to locate the offender in an open area to within, let's say, 30 meters. In a built-up area the error should not exceed perhaps a city block. While various system architectures are possible, they are all likely to include base tracking stations linked to the offender locator units via some means such as radio frequency (RF) communication as shown in figure 2.

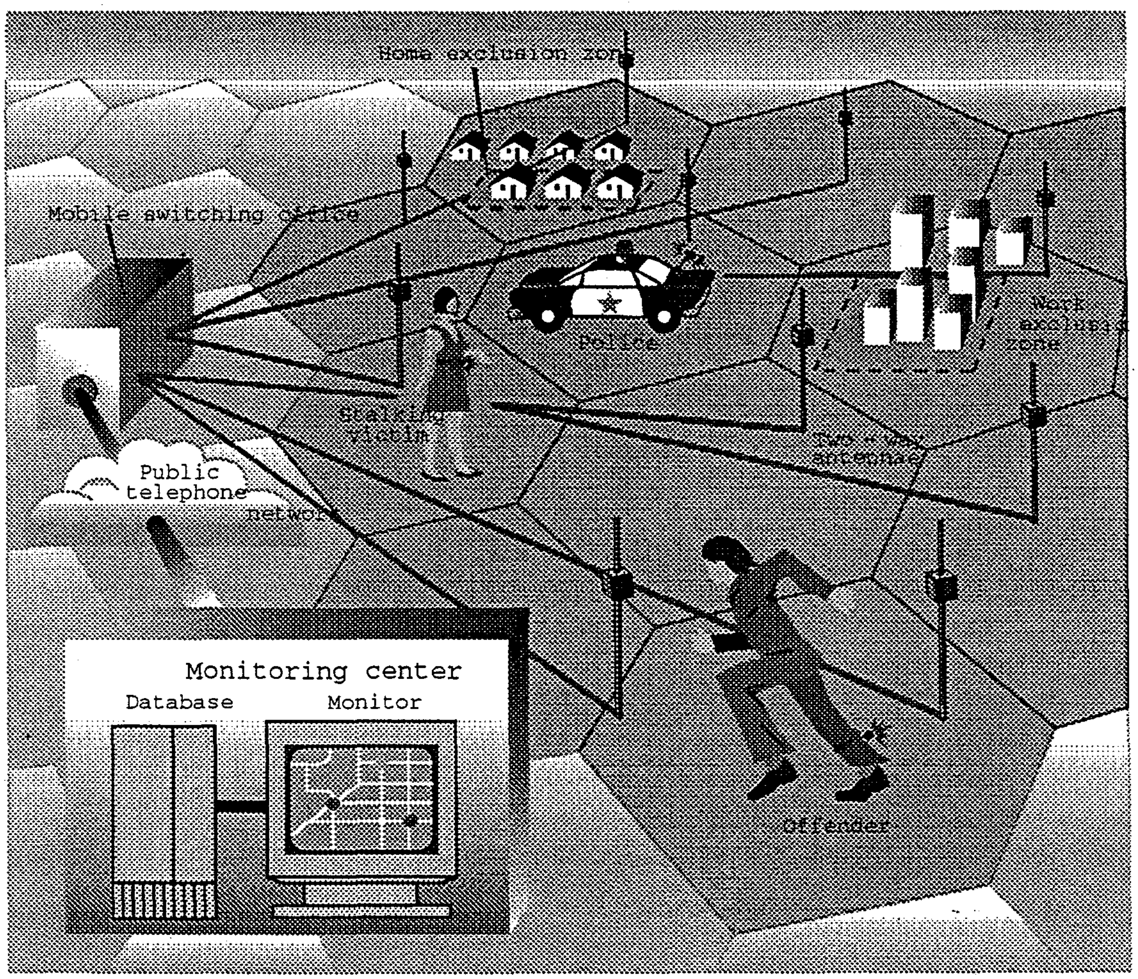

Figure 2. This illustration depicts a view of a second-generation system covering a wide geographical area using a wireless cellular approach. The antennas, used in the system to locate offenders, are connected through a mobile switching office and a public networks to a monitoring center. It focuses on stalking scenario where a stalker is excluded from the victims home and workplace areas. In addition, the victim could be equipped with a locator unit that would detect and alert the victim and police of a potential stalking incident (© IEEE 1995).

A database system in the base station would control communications with the locator units and maintain pertinent information about the monitored individuals. It should reflect the parole or probation directives for monitoring the offenders. It should specify the areas open to the person and the zones off limits. Examples of exclusion areas are bars, schools, and parks; in the case of a stalker, the exclusion zone would include the victim's home and workplace and the surrounding areas. Exclusion zones could also be used to exclude the offenders from potentially RF "dead spots" that cannot be adequately covered by the system. The database should keep a log of the offender's whereabouts and also store information on the whereabouts of active police units, or provide electronic links to other such systems, and potential victims so that they could be alerted.

The system would also provide a user-friendly interface through a computer screen to access this data. The user would interact with a system through a Graphical User Interface (GUI). The user could monitor the offenders in real time, perhaps in an exception mode where only problems are presented to the user, on a city map, and could define permitted and excluded zones via a mouse-like device. The system would produce reports on the system's performance and individual offender activities. Individuals' reports could be used to include or exclude them as potential suspects in crime scenes.

A very important requirement for these systems is that their installation and operating costs per-offender must be significantly lower than the cost of incarceration and that it should be comparable to the cost for the first-generation systems.

4. THE TECHNOLOGY OF POSITIONING

Location technology is a critical element needed for second-generation systems to succeed. Such technology is based on accurate measurements of RF propagation time and/or propagation direction. In either case, we are interested in calculating the unknown position of a transmitting portable tag given the known position of several receiving stations. In an alternate setting, the tag could be the receiver and the known fixed position stations would be the transmitters.

At present, the Global Positioning System (GPS) is the most widely used radio positioning system. In GPS transmitters are located aboard a constellation of orbiting space satellite. The system enables aviation, marine or other open-air users equipped with GPS receivers to determine their position anywhere on or near the surface of the earth. However, GPS signals are relatively low power, 35 W, as compared to 50,000W of a typical FM radio station. They also operate at a great distance, approximately 20,000 km above the earth surface at RF frequencies of 1227.69 and 1575.42 Mhz. Thus, they are subject to inadequate transmission through urban structures, and therefore, do not appear to be a likely candidate for personal locator system.

Unlike GPS, terrestrial system can achieve an adequate RF building penetration that is needed to track people who spend much of their time indoors. Existing terrestrial RF locating systems can be grouped into three general categories:

1. Time of Arrival (TOA) - These are very similar to GPS, except that the locator tag is a transmitter rather than a receiver. The tag is tracked by fixed position receivers. The

receivers measure the time a signal arrives at their antennas. Using the difference of time of arrival at various receivers, the location of the mobile transmitter is determined. A minimum of three fixed position receiver stations is required to determine location. Some positions would require a fourth station to resolve ambiguities[5].

2. Direction of Arrival (DOA)- The direction of arrival, known also as the angle of arrival (AOA), method uses two fixed position receiver stations to measure the angle of arrival of a signal from an unknown mobile transmitting tag. Given the known position of the receiver stations and angles of arrival of the transmitted signal, the position of the transmitter is determined by elementary geometry.

3. FM Transmitters - This approach utilizes commercial broadcast radio stations as beacons in a GPS-like radio location system where the positions of the transmitters is known and the location of the receiver, the mobile tag is unknown. In this method the signal phase of the 19 Khz pilot tone difference between sets of pairs of FM transmitters is determined. The phase difference can be translated to time difference, which then allows one to compute the position of the receiver using the computational techniques of the TOA method. The high power rate of 50,000 W and low frequency in the 100 Mhz offers high building penetration.

C. J. Driscoll & Associates compile a comprehensive list of terrestrial location technology providers[6]. Most providers employ the TOA method in their systems. We shall describe some of these systems:

1. Motorola's campus system - A TOA system designed to provide campus security. When the user is threatened, the user pushes the unit's alarm button to generate an alert signal. The signal is then picked up by a network of receivers located throughout the campus.

2. Teletrac's vehicle tracking system - A TOA system to track vehicles. The locator units can be either polled by the central station or they can automatically send an alarm signal as a result of an external event such as breakage into the vehicle. In the polling mode it can be used to continuously locate the positions of vehicles in a fleet.

3. Terrapin's Position, Information Navigation System (PINS) - A FM transmitter system designed to track vehicles.

4. KSI's Directions Finding Localization System (DFLS) - A DOA system designed for 911 emergency call locating.

The Federal Communication Commission (FCC) proposed requirement for accuracy of locating wireless 911 calls is 125 meters with .67 probability[7]. This is a theoretical value for cellular like signals has not yet been proven experimentally. It is also above the 100 meters, which many experts feel would be required for the offender tracking systems. So while cellular telephone signals may not be suitable for tracking, the cellular and other wireless services infrastructure might be shared for the offender systems; thus, reducing the overall cost for location services.

5. SYSTEM VIEW

One view of a possible system is presented below. Once more, caution should be exercised in examining this, since the best answer is yet to be investigated by a dedicated team of knowledgeable people. Clearly as requirements are better defined, the following view will change to better meet those requirements.

In this view, offenders being supervised electronically would wear an RF monitoring locator unit on a wrist or ankle, just as they do today. Such units would both resist tampering and detect tampering attempts. These tags would contain miniature computers exchanging data packets by radio with a central database system. The database would poll offenders' locator units by sending them data packets, each of which would contain a unique offender ID. The locator unit would read these packets and pick those that matched its ID. The polling technique is not only an efficient means of using high-bandwidth radio frequency it would also make it possible to communicate with different offenders at different rates because not all offenders need the same level of monitoring. Furthermore, the system could increase the polling rate dynamically if an offender were to violate the monitoring directives.

After the offender's locator unit received a poll, it would immediately send the database an acknowledgment packet. This packet would also enable the tracking system to pinpoint the position of the offender via triangulation. The database would be at the heart of this system, storing information on where the offender should be at any given time. For example, it could specify where an offender's home, workplace, and the route of the commute between them are located, and the times at which the offender should be found in each. It would also specify when the offender should be at home, work, or on the road.

From the database point of view these locations would be defined as polygon coordinates. The offender could be required to be inside the polygon or excluded from it. The database would compare the observed coordinates of the offender with the stored location for a given time interval.

The offender would be in compliance as long as his/her coordinates fall within the boundaries of the stored location for that time interval. In the case of stalkers, the location defined in the database could also be a zone from which the offender is excluded. Boundary deviations are considered a violation that could trigger an immediate law enforcement reaction, if desired. Law enforcement could choose to have an automatic reaction by having the database application call the police unit that is nearest to the offender. This monitoring system will be designed to track a variety of offenders, and help law enforcement intercept and prosecute such offenders. Under this feature, the database tracks the stalker, the prey, and, if desired, mobile police units through the locator units provided to them. The system alerts both the quarry and the police if the stalker either moves too close to the potential victim or commits a zone violation. Furthermore, the system could identify the mobile police units that are the closest to the person stalked and automatically dispatch them to protect the possible victim and intercept the stalker.

The ability to perform wide-area continuous monitoring is a key element of second-generation offender-monitoring systems. It is essential to continuously monitor offenders. First-generation systems allow offenders to get out of electronic monitoring range for an extended period of time; for example, when monitored offenders are permitted to work. While at work there is a window of vulnerability, where the offender can get involved in illegal activities without being monitored. This is a very serious flaw in the existing system. .

The second-generation system described here prevents such a situation as long as the database system defines bounds on the permitted location of the offenders. For example, it is insufficient to just define an exclusion zone for a stalker. In this situation the stalker is essentially 'permitted' to get out of monitoring range. He could then tamper with his locator unit without being detected. Then he could enter the exclusion zone and attack whomever he is pursuing.

If we do not wish to limit the boundaries for some offenders, we may need to eventually extend the system to cover the entire nation. This is becoming possible because of the ever extending wireless networks. Offender monitoring would become just another database service in these huge networks. While the first systems will certainly be built as self-contained local systems, maintaining a future look will help ensure that we don't built systems lacking extendibility and compatibility.

6. EARLY BIRDS

In October, 1994 the National Institute of Justice awarded the Westinghouse Corporation 410,000 dollars to develop a prototype second generation system.. We should point out that this is the first time the US government has given financial support to such an endeavor. The Westinghouse system uses spread spectrum time of arrival radio location method, operating in the ISM RF band, to determine the location of the offender. The prototype was tested for technical feasibility in the Pittsburgh, Pennsylvania down town area[8].

Some companies started advertising wide area offender tracking systems. For example, Pro Tech Monitoring of Florida is promoting on the Internet its SMART System for monitoring an offender's location 24 hours every day. Pro Tech Monitoring states, "The SMART System can provide the entire gamut of offender supervision at any time from basic "house arrest" to continuous real-time surveillance tracking and control."

In addition, to the early work for the location equipment -- and frankly in sore need of federal funding for adequate development -- simultaneous work needs to be done to develop the underlying software management system and the GUI interfaces that will make the operators effective. In addition, the training, the procedures, and the basic response plans for what to do when offenders violate their probation or parole conditions must be developed if the system is to eventually be effective.

7. CHALLENGES

Clearly, many challenges face the development of second-generation electronic offender monitoring systems. These are technical, legal, sociological and political in nature.

An over-riding concern is eventual system purchase price and operational cost. Corrections agencies are almost always looking for extremely cost effective ways to solve their problems. We believe that such a system would greatly reduce overall system cost, but a cost-benefit analysis needs to be performed during requirements determination and system design to verify this and to make appropriate design decisions.

There are several technical concerns for these systems to accurately and consistently provide location information. The foremost challenge is the accuracy of these systems in an urban environment. The question is, can we achieve accuracy of less than 100 meters in such environment? In these areas multipath effects, caused by multiple reflection of RF signals by buildings and other obstacles, is likely to significantly reduce location accuracy.

Also, second-generation tag units would have to be light weight and easily carried, as well as tamper indicating. For instance, they could be the size of a pager, weighing no more than 0.34 kg, and powered by a battery with a life of 90 days, or hopefully even more, and include the capability of sending a signal to the base station in the event they are removed by the offender.

Standardization is another critical issue because second-generation systems might someday be required to operate over a wide geographic area, even over the entire country. When a monitored offender moves from one jurisdiction to another, monitoring would have to continue. Without interface standards, comprehensive coverage will not be possible. Even without nationwide integration of such a system, standardization will help to keep quality higher and costs lower than with such standardization. Certification of systems might also help with overall assurance of reliability.

It was predicted that the legality of first-generation system would be challenged in courts, based upon privacy rights. Such challenges did not materialize. The second-generation system, however, may provide a bigger challenge because it invades all aspects of the offender's life. It would most likely have a complete log of the offender's activities, including those that are in compliance of parole or probation conditions but are preferred to be kept private by the offender. The legislative and judicial branches of government would have to develop consistent guidelines for electronic monitoring to avoid constitutional challenges. One solution might be to make electronic monitoring an option which the offender willingly chooses as an alternative of incarceration.

In addition to the technical and legal issues, we must concern ourselves with the human and economic aspects of developing these systems. The first question that requires an answer is which types of offenders would be candidates for these systems. Would such systems simply provide a better way for probation and parole officers to monitor their assigned offenders or would such systems lead to more violent offenders on the streets but adequately monitored, and if so, is that considered acceptable by society? Would such systems reduce the cost to society over the existing correctional facility system? How would the media treat such systems? Would inmates be charged for the monitoring service? Who would provide the monitoring service and how would probation and parole officers interact with the service?

Perhaps the most important issues would revolve around how to respond when offenders violate the conditions of their probation or parole. Lack of respond in a timely fashion would render the system practically useless, other than as a source of information about offender behavior.

It may be that the most important challenge is educating the public, government officials and politicians about such technology and possible systems and letting them form opinions about the value of such technology to the criminal justice system. A national champion, such as the National Institute of Justice, and a corresponding commitment are needed to promote and develop new systems in this area. More funding for technology transfer, development, and acquisition for the criminal justice system is required, as well as more government interagency coordination and knowledge of what is available and what is needed. For these reasons a cooperative endeavor between federal, state, and local agencies, private vendors of equipment and services, and research and development entities is required.

One federal agency, the National Institute of Justice, has shown interest in this topic and has provided funding for the Westinghouse demonstration project. At a recent meeting sponsored by NIJ[2] attendees "felt that electronic monitoring is not being fully utilized by the entire community corrections field. They also felt that current locator technology falls short of addressing all of their requirements and concerns. They added that electronic monitoring should not be thought of just in terms of the offender. For community corrections, it is extremely important that an affordable technology be developed that could track staff, as well as provide communication with them when they are in the field. This technology could also be utilized for crime victims who might be at risk from offenders."

8. CONCLUSION

Concepts, technology, and even infrastructure for the offender-continuous-electronic monitoring system described here could be used for other applications requiring position determination and monitoring of vulnerable individuals. Examples of individuals who could benefit from such tracking include Alzheimer and heart patients. It could also be used to increase security for newspaper delivery kids and students on campuses. If continuous electronic monitoring could be expanded to other applications, this would reduce the cost of each individual applications because they could all share a common infrastructure.

In our brief review, we have touched upon some of the technical, societal and legal issues pertaining to second systems Presently, we have only rough, and not always reliable estimates of the requirements for a second generation system, including such parameters as location accuracy, RF building penetration, battery power requirements, and the various parameter tradeoffs. Answers to these questions are critical to the success of such systems. Efforts to arrive at these answers need to be undertaken at the direction of a national champion, committed to coordinating teamwork to solve this national problem.

9. ACKNOWLEDGMENTS

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