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Offender Wide Area Continuous Electronic Monitoring Systems

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Executive Summary

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This report focuses on technical, theoretical and computational problems associated with wide-area continuous electronic monitoring of offenders. Such systems are also known also as second generation offender monitoring systems. Unlike second generation systems, first generation offender monitoring systems have had major drawbacks because their technology is not adequate to track the individuals, other than when they are in their home or place of employment. By providing continuous monitoring, it will be possible to tighten the supervision of parolees and probationers while increasing the level of public safety. This could potentially save significant cost through reduction of the number of criminals in the prison system.

This project has been motivated by:

1. The need for an appropriate system to enable corrections officers to continuously monitor location of offenders and receive timely emergency situation alerts.
2. Identifying Radio Frequency (RF) location methods that could be applied for second generation offender monitoring systems.
3. Investigation of the effects of reflected signal on the solutions to the positioning problem.

Work in these areas has linkage with several of the NIJ's strategic initiatives as described in the document "NIJ Research Plan, 1995-1996," for example:

- *Reduce violent crime:* Potential to increase the safety of stalker and child molester victims by monitoring offender "exclusion zones" which could include the stalker victim's residence and schools or play areas, among others;
- *Reduce drug & alcohol related crime:* Potential to monitor and thereby reduce offender visits to high drug traffic areas;

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- *Improve effectiveness of crime prevention programs:* By monitoring location of offenders' whereabouts, they will be deterred from committing new crimes since their whereabouts will be known at all times, and the chances of their being caught are greatly increased;
- *Improve law enforcement and the criminal justice system:* By keeping records of the whereabouts of offenders at specific times, police will be able to rapidly identify suspects of a crime by review of these records, and evidence for prosecution to validate a suspect's alibi will be readily available.
- *Identify new geolocation technologies for Law Enforcement & criminal justice system:* Emerging geolocation technologies could significantly improve the effectiveness of offender monitoring and reduce the overall cost to the correctional system.

In early 1996 at the time when this study was proposed, continuous wide area offender monitoring was only a concept. A February 1995 IEEE Spectrum magazine article, titled "Keeping tabs on criminals", by Hoshen et. al. describes the use of personal locator systems in the criminal justice area. In contrast to the restricted nature of first generation systems, second generation systems track offenders, which are equipped with tamper proof personal locator bracelets, continuously over a wide geographical area. The goal of second-generation systems is to verify that parolees and probationers comply with the place and time directives imposed on them by the corrections system. The directives specify where and when the offender should be and should not be during the day and night. For example, if the offender is a child molester, the offender is excluded from school areas. Similarly if the offender is a stalker, the offender is excluded from areas near the home and workplace of the victim.

To enable verification of corrections directive, the second-generation system continuously compares the position of the offender with database entries that define areas and times where the offender should or should not be present (inclusion and exclusion zones). These areas are usually defined in terms of polygons. If the offender violates the location and time directives stored in the database, the system alerts the appropriate corrections or law enforcement agencies. The system also alerts these agencies if the offender tampers with the locator device.

In 1997 two companies, Advanced Business Sciences (ABS) of Nebraska and Pro Tech Monitoring of Florida were the first to introduce GPS based continuous monitoring systems for criminal offenders. These systems are deployed among others, in some localities in Michigan, Minnesota, Florida, Colorado, Wisconsin, Pennsylvania, South Carolina, Arizona, Ohio, Texas and Nebraska. More recently BI Inc. the leading manufacturer of first generation offender tracking system began testing their version of GPS based system.

To explore some of the underlying computational problems for second generation, a computer simulator was developed. The simulator employs a graphical display to show the whereabouts of monitored individuals. It enables the user to develop a database for a collection of monitored offenders by specifying in terms of polygons where they should and should not be at any given time. The user can also specify simulation scenario scripts where each scenario may include one or more participant. The participants are usually offenders. However, they could also be victims of stalkers and members of law enforcement. A script also specifies the movement of the participant at a given time. When the simulation is running, the movements of the participants are displayed on a graphical display. When a scenario creates a violation, such as an offender being in an exclusion zone, an alert is displayed on the screen indicating the violation. The simulator is provided with a sample of eight simulation scripts that include offenders violating inclusion and exclusion zones. The scripts also include simultaneous monitoring of multiple offenders, as well as monitoring of a stalker and its victim in two different scenarios.

The simulator was developed for the Microsoft's Windows operating system. It was written in Visual Basic version 6 using Access[®] database. It also uses map display and manipulation software by PepperWhite Street. The simulator and its documentation are available on a CD-ROM. The wide availability of map handling software, such as PepperWhite, simplified and expedited the task of software development in this area. The simulator is to be shared with corrections officers to gain their ideas and feedback on the development of better requirements for second generation products.

In recent years, new geolocation technologies have emerged. These technologies are likely to have a significant positive effect on the developments of second generation systems. Most notably, wireless assisted Global Positioning System (GPS) holds much promise. Undoubtedly, it will help the current GPS second generation offender monitoring systems evolve to more efficient, reliable and cost effective systems. Assisted GPS, requires significantly less battery recharging than traditional GPS receivers. Furthermore, unlike traditional GPS receivers that function only in outdoors environment, assisted GPS receivers can operate in an indoors environment.

A driving force advancing geolocation technology has been the Federal Communication Commission (FCC) directive to provide E911 (Enhanced 911) services to the wireless telephone users in the US. These requirements mandate accuracy of 50-100 meters for 67% of the calls.

Though the focus of this report is on wide area offender monitoring systems, these systems should be considered in the context of similar systems. A general approach to

geolocation services is likely benefit offender monitoring systems because it will allow sharing the cost of the infrastructure among the services. Location based commercial services for mentally handicapped elderly, children, tourist and security personnel have been commercialized in Japan since 1998. Similar services are likely to become available in the US towards the end of the year 2000. Building a special infrastructure for location based services is not necessary and would be expensive. Rather, the existing wireless cellular infrastructure and location capabilities developed for E911 service could be used for offender monitoring.

Wireless cellular services have been expanding in recent years. Because continuous offender monitoring would require extensive use of the network (each offender locator tag is likely to be polled every 3-5 minutes), using cellular voice channels could be expensive. One approach to handle this problem is that locator device would check and store the location data in the device. The device would transmit the location data once or twice a day using a cellular call. This could work for some offenders for which the system is interested in recording the compliance with the corrections' directives. However, such approach may not sufficient in enhancing public safety. Even if the system detects that the offender is in violation and try to alert the correctional or law enforcement agencies through a cellular call, the offender may be able to disable the locator before the locator makes the call. It could be several hours before the system becomes aware of the violation when the scheduled data download call is not received. Only a periodic polling of the locator could guaranty tampering detection within minutes.

An alternative to the use of wireless cellular voice channel calls is to use data packet calls. Data packet calls could provide real-time monitoring at reasonable cost. The cost of such calls does not depend on the duration of the call but rather on the amount of data transmitted. Early estimates suggest that the cost per poll would be about one cent per poll. So if it is assumed that the offender is polled every 3 minute, the daily cost of wireless connection would be about five dollars. Such data communication is now available through Cellular Digital Packet Data (CDPD) services. Unfortunately, CDPD services are not widely available throughout the US. In 2001, new third generation (3G) wireless services will be introduced. Data packet services, which are major features of the new 3G systems, could become more broadly available.

This report also provides geometrical analysis of reflected signals known also as multipath interference, a major contributor to location determination inaccuracy in urban-like areas. In such areas direct-line radio signal propagation may be obstructed and other indirect paths, generated by signal reflection, are established between transmitter and receiver. It has been shown that the direct signal GPS problems is related to two solutions of the ancient Problem of Apollonius, which is to draw an unknown circle touching three given circles. This report's

appendix demonstrates that the entire 16 solutions of the problem of Apollonius can be related to the direct and indirect signals for the GPS problem. Unfortunately this theoretical relationship does not appear to have practical implication because of the geometry of the signal path under reflection is usually unknown.

In conclusion, we propose the following goals for second generation offender monitoring systems:

1. The system should be able to determine the offender position with accuracy of 50 meters 67% and 150 meters 95% of the time.
2. The system should be able to track the position of offender within the specified accuracy at all locations that can be reached by wireless communication.
3. The geolocation information should be available to the system in real time.
4. The locator tag should be able to detect tampering and alert the monitoring center to such event.
5. The locator device should be able to determine if it is out of communication range. If this happens, it should give the offender a distinct audible signal indicating to the offender to move to areas where the locator device can detect RF signals.

Though it is possible that the offender could disable the locator device before the device signals such a tampering event, the disabling of the device would have to destroy the ability of the device to transmit. In this case potential tampering would still be detected by the system because the monitoring center would not get responses from the device.

In 1995, Hoshen et. al. suggested in the IEEE Spectrum article that government support might be necessary to advance the technology required for the development of second generation systems. Yet, in light of recent advances in geolocation technology and wireless infrastructure such support is deemed unnecessary. An appropriate role for government in this area could be verification that emerging systems meet the basic requirements for providing reliable monitoring of offenders. Supporting trials by corrections agencies could be another important role for government. It could help in building confidence and gaining knowledge in operating these systems.

Exploiting the emerging infrastructures and geolocation technologies by the private sector is likely to lead to a fast track towards the development of new second generation offender monitoring services. Educating professionals, entrepreneurs and the general public of the potential commercial and social benefits in developing locator systems could stimulate this effort. To spread the knowledge in this area, J. Hoshen has collaborated with H. Koshima of the Locus

Systems on an article titled "Personal Locator Services Emerge". The article was published in the February 2000 issue of the IEEE Spectrum magazine. IEEE Spectrum is a highly respected professional monthly magazine with a worldwide circulation of 320,000. The article describes emerging geolocation technologies and services focusing second generating offender monitoring systems and mentally impaired elderly.